Public Utility Commission of Texas

Volume 1. Statewide Energy Efficiency Portfolio Report Program Year 2019

TETRA TECH

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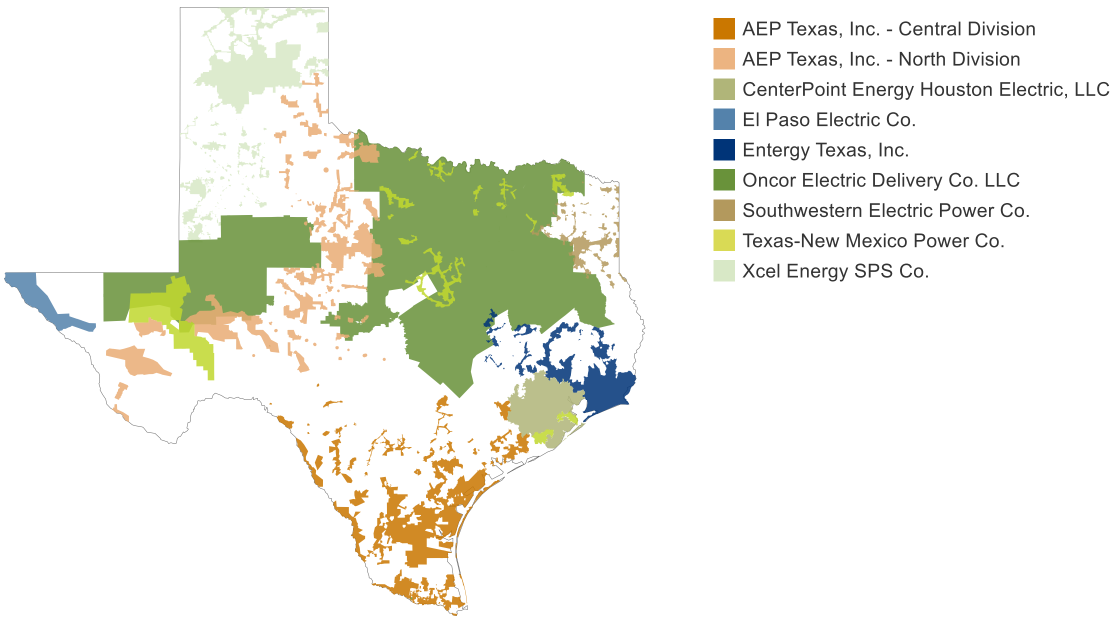
ACRONYMS

AEP TCC	American Electric Power Texas Central Division
AEP TNC	American Electric Power Texas North Division
C&I	Commercial and industrial
CATI	Computer-assisted telephone interview
CNP	CenterPoint Energy Houston Electric, LLC
CSOP	Commercial standard offer program
DI	Direct install
EEIP	Energy efficiency implementation project
EEPR	Energy efficiency plan and report
EESP	Energy efficiency service provider
EM&V	Evaluation, measurement, and verification
Entergy	Entergy Texas, Inc.
EPE	El Paso Electric Company
EUL	Estimated useful life
HTR	Hard-to-reach
kW	Kilowatt
kWh	Kilowatt hour
LI	Low-income
LM	Load management
M&V	Measurement and verification
mcf	1,000 cubic feet
MTP	Market transformation program
NTG	Net-to-gross
PUCT	Public Utility Commission of Texas
PV	Photovoltaic
PY	Program year
QA/QC	Quality assurance/quality control
RFP	Request for proposals
RSOP	Residential standard offer program
SOP	Standard offer program
SWEPCO	Southwestern Electric Power Company
TEESI	Texas Energy Engineering Services, Inc.
TNMP	Texas-New Mexico Power Company
TRM	Technical Reference Manual
Xcel Energy SPS	Xcel Energy Southwest Public Service, Inc.

1.0 EXECUTIVE SUMMARY

The Public Utility Commission of Texas (PUCT) oversees the energy efficiency programs delivered by the state's investor-owned electric utilities: AEP Texas, Inc.[1] (AEP Texas), CenterPoint Energy Houston Electric, LLC (CenterPoint), Entergy Texas, Inc. (Entergy), El Paso Electric Company (El Paso Electric), Oncor Electric Delivery, LLC (Oncor), Southwestern Electric Power Company (SWEPCO), Southwestern Public Service Company (Xcel SPS), and Texas New Mexico Power Company (TNMP). The utilities' service territories are shown in Figure 1.

Figure 1. Territories of Regulated Electric Utilities in Texas



The Texas electric utilities administer a variety of programs that improve the energy efficiency of residential and commercial customers' homes and businesses. Standard offer programs (SOPs) develop the infrastructure of service providers (e.g., contractors, distributors) and provide financial incentives to deliver higher efficiency products and services. Utilities select implementation firms to run market transformation programs (MTPs). MTPs provide additional outreach, technical assistance, and education to customers in harder-to-serve markets (e.g., small business, health care, schools, and local governments) and for select technologies (e.g., recommissioning, air conditioner (AC) tune-ups, pool pumps). All utilities provide energy efficiency offerings to low-income customers through hard-to-reach (HTR) programs that are delivered similarly to the residential SOPs. The utilities that are part of the Electric Reliability Council of Texas (ERCOT) also offer targeted low-income (LI) programs that coordinate with the existing federal weatherization program. Finally, the utilities manage load management programs, which are designed to reduce peak demand when needed.

[1] The PUCT approved the application AEP Texas Central Company (AEP TCC), AEP Texas North Company (AEP TNC), and AEP Utilities, Inc. to merge AEP TCC and AEP TNC into AEP Utilities, and then rename that corporate entity AEP Texas, Inc. AEP Texas reported 2019 energy efficiency programs by the legacy AEP TCC and AEP TNC territories, which are now referred to as AEP Texas Central Division and AEP Texas North Division.

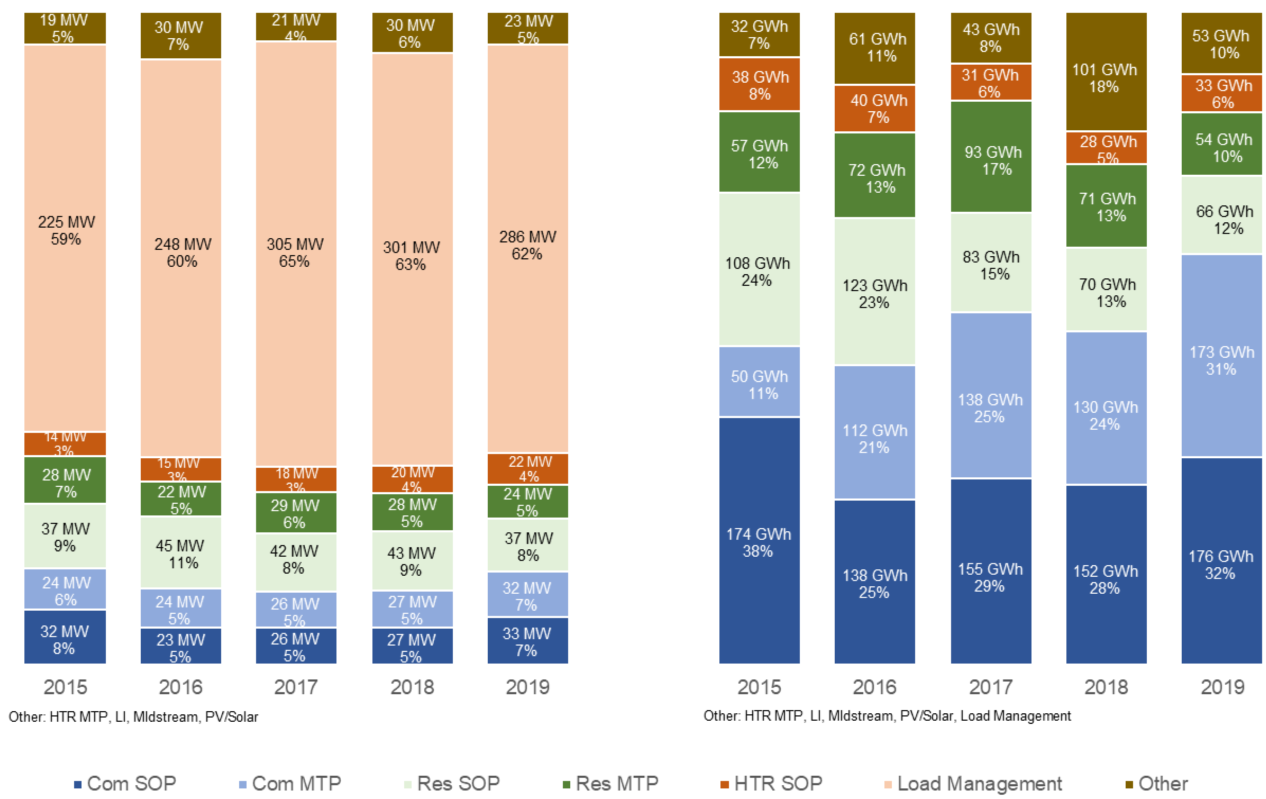
1.1 PY2019 ENERGY EFFICIENCY SUMMARY RESULTS

In program year (PY) 2019, the Texas electric utilities achieved statewide demand reductions of 479,912 kilowatts (kW) at a lifetime savings cost of $16.94 per kW[2]. The utilities achieved statewide energy savings of 651,950,467 kilowatt-hours (kWh) at a lifetime savings cost of $0.01 per kWh.

1.1.1 Savings

As shown in Figure 2, load management programs consistently account for approximately 60 percent of the statewide gross demand reduction (MW). Commercial SOPs and MTPs continue to account for the largest percentage of statewide energy savings, 32 percent and 31 percent, respectively, an increase from prior years.

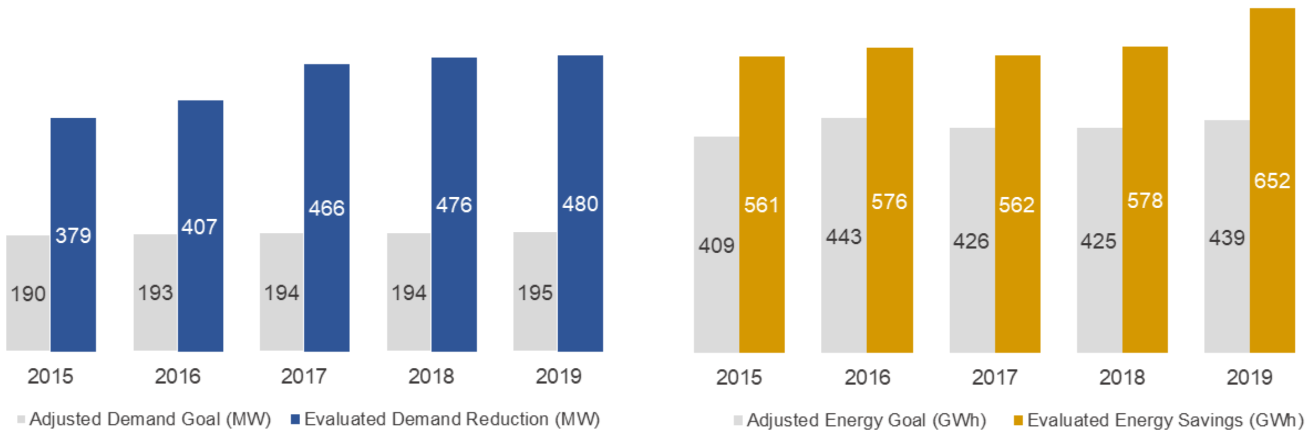
Figure 2. Evaluated Gross Demand Reduction and Energy Savings by Program Type



[2] Excluding load management programs, the lifetime savings cost is $15.41 per kW.

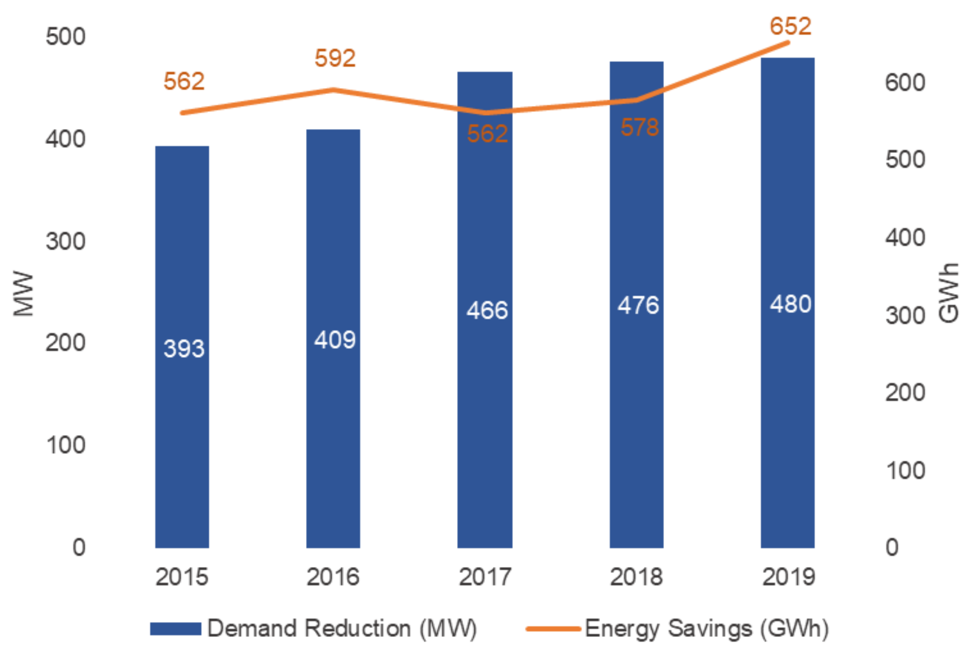
As shown in Figure 3, statewide, the utilities continue to significantly exceed demand reduction goals in large part due to the load management programs. The utilities also are consistently exceeding energy savings goals.

Figure 3. PY2015–PY2019 Legislated Goals and Actual Demand Reduction and Energy Savings



Evaluated gross demand reduction has increased every year since 2015. PY2019 achieved demand reductions of 479,912 kW. Evaluated gross energy savings were 651,950,467 kWh, which exceeds the previous highest savings of 592 gigawatt-hours (GWh) in PY2016 (Figure 4).

Figure 4. Total Statewide Portfolio: Evaluated Gross Demand Reduction and Energy Savings by Program Year



Energy savings and demand reductions from the energy efficiency programs persist beyond the program year they are installed based on the type of energy efficiency improvement made and how long it typically lasts. The cumulative savings the utilities have achieved since PY2012 are shown in Figure 5 (demand reduction) and Figure 6 (energy savings). Half of the demand reductions and energy savings achieved to date are expected to continue through 2030.

Figure 5. PY2012—PY2048 Lifecycle Demand Reduction by Sector (MW)[3]

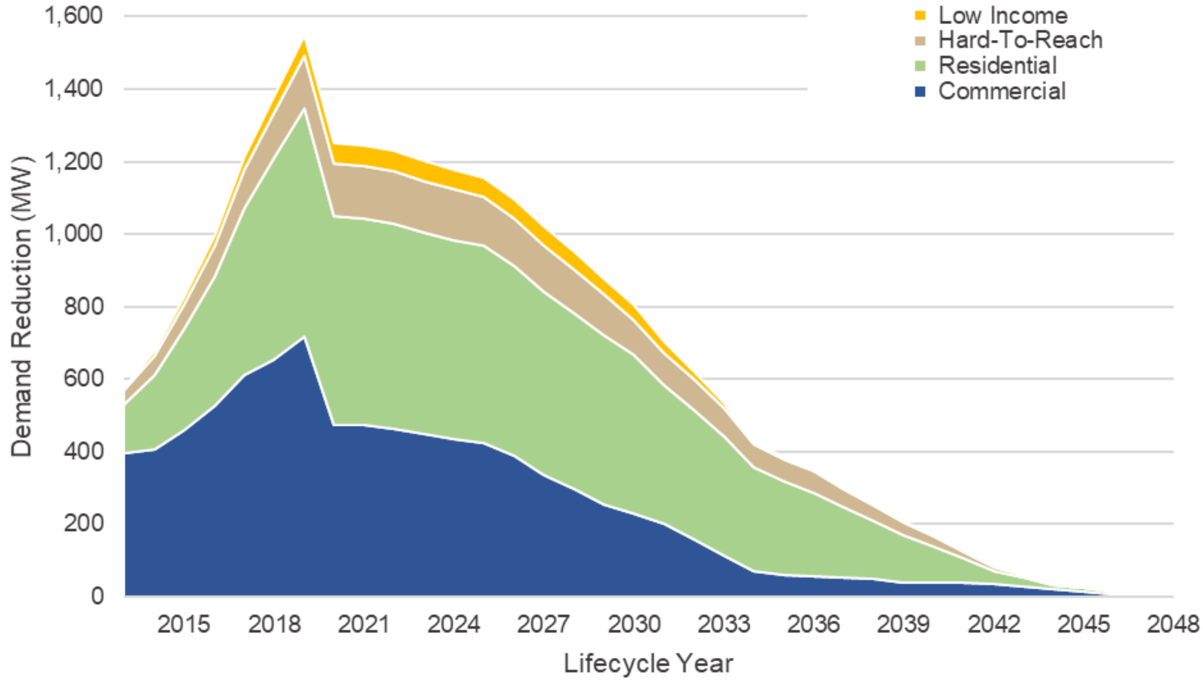
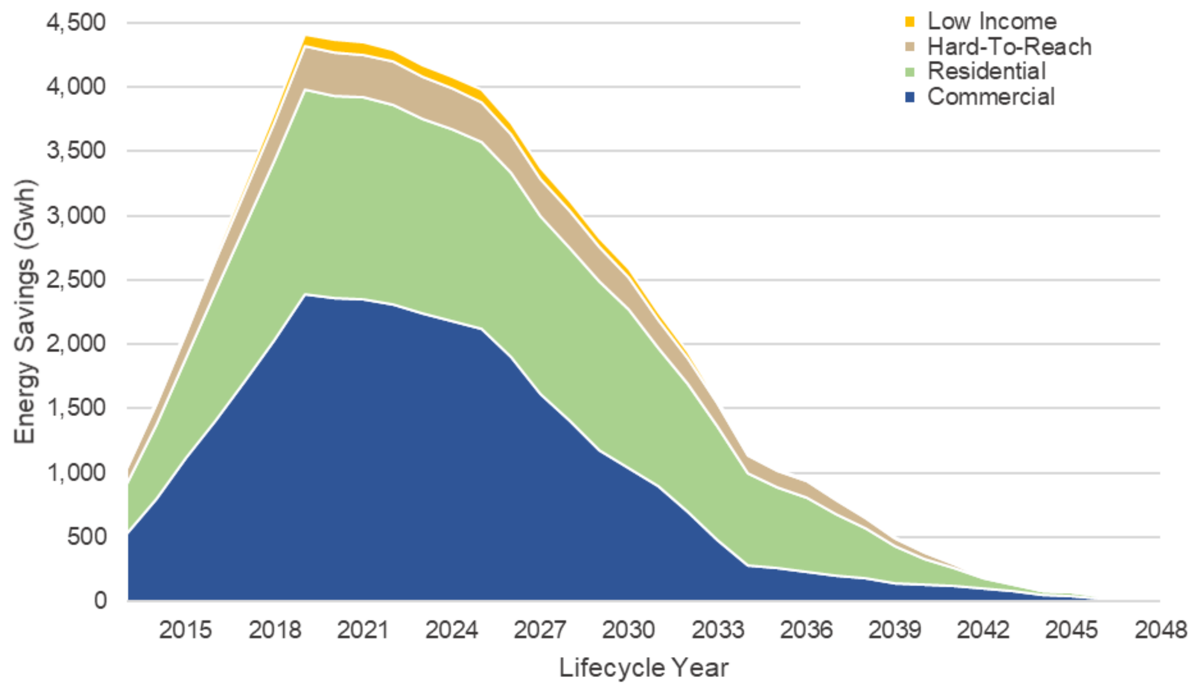


Figure 6. PY2012—PY2048 Lifecycle Energy Savings by Sector (GWh)



[3] Load management programs have a one-year measure life and represent the spike in kW reductions.

Figure 7 and Figure 8 show the types of measures the programs installed and how they contribute to lifecycle savings. Lighting, HVAC, and building shell improvements are delivering the most savings over time.

Figure 7. PY2012–PY2048 Lifecycle Demand Reduction by Measure Category (MW)[4]

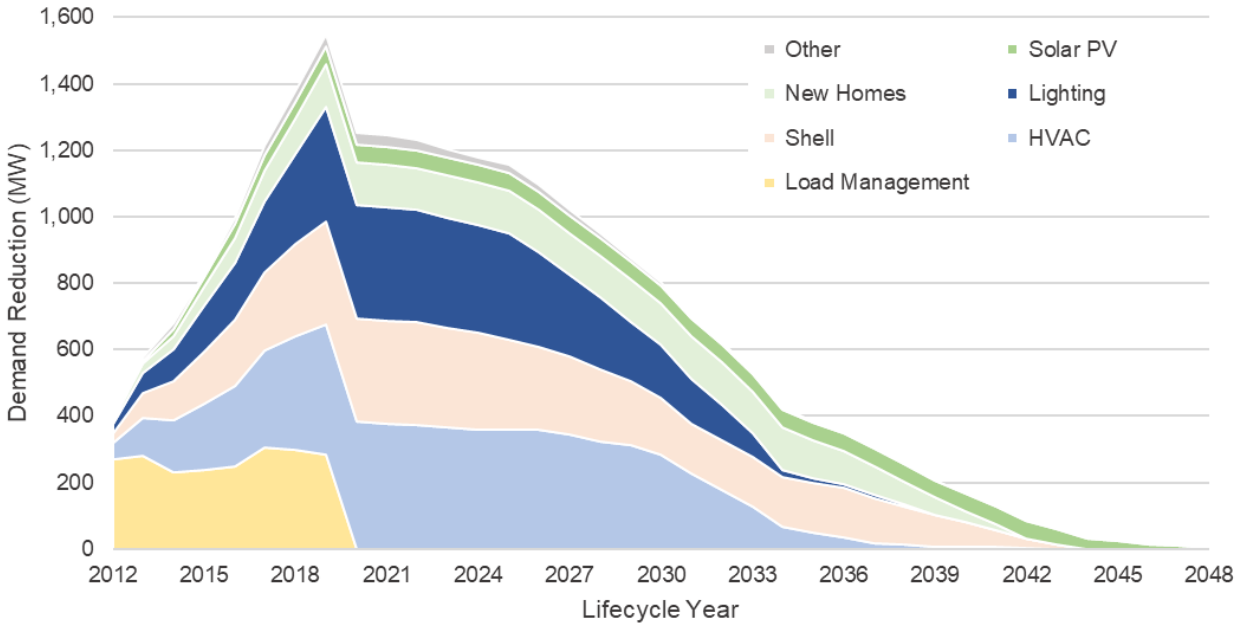
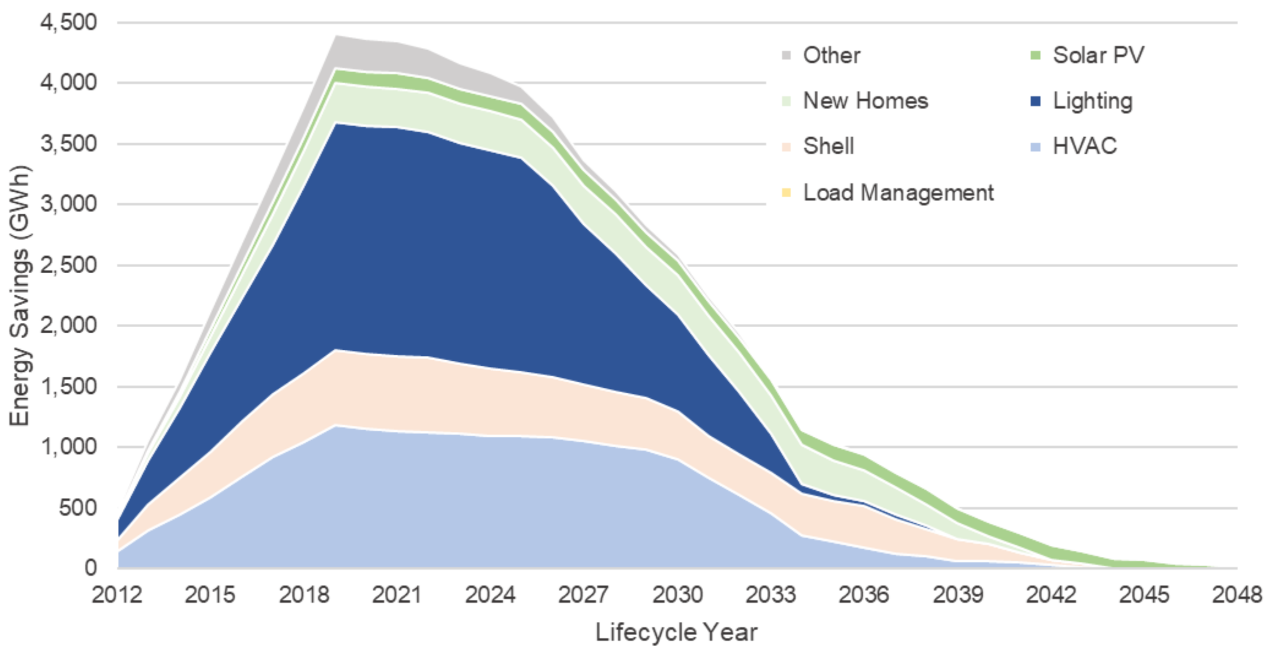


Figure 8. PY2012–PY2048 Lifecycle Energy Savings by Measure Category (GWh)



[4] Load management programs have a one-year measure life and represent the spike in kW reductions.

1.1.2 Cost-Effectiveness

The avoided costs and overall cost-effectiveness ratios from PY2015 to PY2019 can be seen in Figure 9. The statewide cost-effectiveness has consistently remained above 2.0 using the program administrator cost test (benefits divided by costs). Cost-effectiveness increased to 2.7 in PY2019. While the increased cost-effectiveness is somewhat a result of higher avoided costs, 2.7 is a better ratio than seen in 2015 and 2016 when avoided costs were comparable to 2019.

Figure 9. Statewide Evaluated Gross Cost-Benefit Ratio and Avoided Cost by Program Year

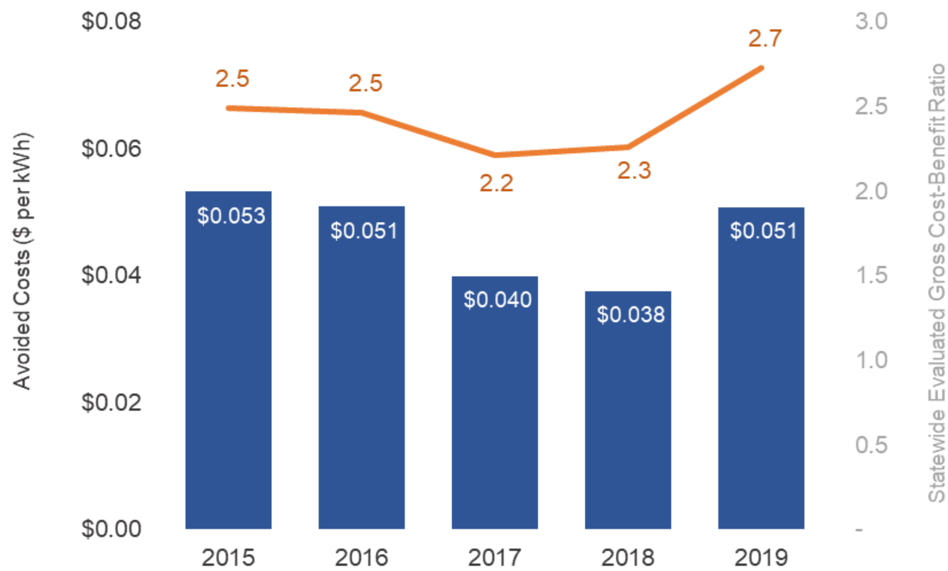
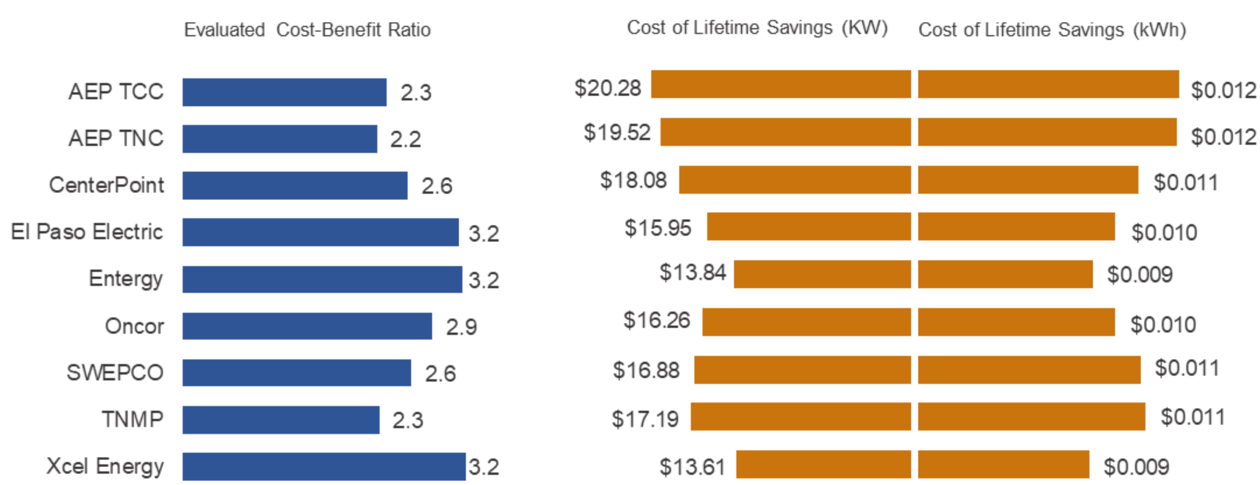


Figure 10 summarizes the cost-effectiveness of each utility's energy efficiency portfolio, including LI programs. All portfolios were cost-effective, ranging from 2.2 to 3.2. The cost per kW ranged from $13.61 to $20.28, and the cost per kWh ranged from $0.009 to $0.012. These costs provide an alternate way of describing the cost-effectiveness of a portfolio of programs. Portfolios with a higher cost-effectiveness ratio will have a lower cost to acquire savings and vice versa.

Figure 10. PY2019 Evaluated Savings Cost-Benefit Ratio and Cost of Lifetime Savings



1.2 EVALUATION, MEASUREMENT, AND VERIFICATION OVERVIEW

In 2011, the Texas Legislature enacted SB 1125, which required the PUCT to develop an evaluation, measurement, and verification (EM&V) framework that promotes effective program design and consistent, streamlined reporting. The EM&V framework is embodied in 16 Tex. Admin. Code § 25.181, relating to Energy Efficiency Goal (Project No. 39674).

The PUCT selected an EM&V team through the Request for Proposals (RFP) 473-17-00002, Project No. 46302. This team is led by Tetra Tech and includes Texas Energy Engineering Services, Inc. (TEESI) (hereafter, "the EM&V team").

Independent EM&V was conducted for Texas electric utilities' PY2019 energy efficiency portfolios. The objectives of the EM&V effort are to:

- document gross and net energy and demand impacts of utilities' individual energy efficiency and load management portfolios;
- determine program cost-effectiveness[5];
- provide feedback to the PUCT, utilities, and other stakeholders on program portfolio performance; and
- prepare and maintain a statewide technical reference manual (TRM).[6]

This Statewide Energy Efficiency Report presents the PY2019 EM&V findings and recommendations, looking across all eight electric utilities' portfolios. It addresses gross and net energy and demand impacts, program cost-effectiveness, and provides feedback on program portfolio performance. Also, it includes findings and recommendations related to savings to inform updates to the TRM.

The PUCT's EM&V independently verifies claimed savings across all programs through program tracking data that is received from the utilities. Additional EM&V activities (engineering desk reviews, on-site measurement and verification (M&V), interval meter data analysis, consumption analysis, participant surveys, and in-depth interviews) are conducted based on an evaluation prioritization of high, medium, or low by program type. The PUCT staff and the EM&V team revisit the prioritization each year based on considerations such as magnitude and uncertainty of savings, stage of the program, importance to future portfolio performance, PUCT and Texas utilities' priorities, prior EM&V results, and changes in the markets in which the programs operate.

Residential standard offer programs (RSOPs), HTR, and LI programs were a *high* evaluation priority for PY2019. These programs continue to comprise a substantial percentage of overall residential portfolio savings and have recently responded to various TRM updates to the envelope measures. Moreover, the EM&V team recommended expanding the measure mix in these programs as a result of prior evaluation research. The EM&V team completed a consumption analysis for the Electric Reliability Council of Texas (ERCOT) utilities' RSOPs, HTR, and LI programs, which is described in detail in Technical Appendix 1 of this report. The EM&V team also conducted surveys with residential service providers to gain insight into program processes from their perspective.

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[5] The EM&V team conducts cost-effectiveness testing by applying the program administrator cost test. For LI programs, cost-effectiveness is calculated using the savings-to-investment ratio (SIR).

[6] The maintenance of the TRM is informed by the EM&V research and coordinated with the utilities and PUCT staff through the TRM working group. Public input prior to filing is solicited through the Energy Efficiency Implementation Project (EEIP) at multiple stages in the update process.

Several residential market transformation programs were also a *high* priority in PY2019 as they were either re-designed or newer programs. First, new homes MTPs had an updated statewide energy code and TRM entry in PY2018. The EM&V team conducted a consumption analysis to compare to the programs' savings estimates, described in detail in Technical Appendix 1, to this report. The consumption analysis was complemented with builder and home energy-rater interviews to understand standard practices in the market and how the program is influencing them. Residential upstream lighting programs have increased in the last couple of years and reach a high number of customers through retail channels. A census impact review of these programs was conducted along with retailer interviews and benchmarking research.

Commercial standard offer programs (CSOPs) and the commercial MTPs continued as a *medium* priority in PY2019. These programs continue to represent the largest percentage of statewide savings and continue to explore new customer segments and technologies. While prior EM&V generally found evaluated savings to be similar to the utilities' claimed savings, it also resulted in several recommendations for changes to reported claimed savings.

Load management program evaluations returned to a *medium* priority in PY2019 after being evaluated as *high* priority in PY2018. These programs continue as a substantial contributor to demand reduction (kW) savings. The EM&V team conducted census reviews of all participants' interval meter data in PY2019 to calculate impacts independently following the TRM to compare against utilities' claimed savings.

All other program types are *low* priorities for evaluation because they are small contributors to portfolio savings, have little uncertainty in savings, or had EM&V results in recent years that had limited action items.

Finally, because one of the primary objectives of this report is to provide recommendations for 2021 programs, the EM&V team conducted research in May–June 2020 to provide the context of the impacts of the COVID-19 pandemic on the energy efficiency programs. The EM&V director interviewed utility program managers and directors to characterize how utilities are responding to COVID-19 in their energy efficiency portfolios. Utility interviews are complemented with information from residential program service provider surveys and secondary research of energy efficiency program developments across the country in response to COVID-19.

1.3 KEY FINDINGS AND RECOMMENDATIONS

1.3.1 Adjustment Summary by Utility

The utilities have demonstrated a willingness to work with the EM&V team to improve the accuracy of claimed savings, which includes (1) adjusting claimed savings in response to EM&V findings, (2) requesting M&V reviews or additional technical assistance throughout the program year, and (3) implementing several TRM or program changes. The PY2019 EM&V recommended savings adjustments to which utilities fully responded in PY2019 claimed savings are identified in Table 1.

Table 1. PY2019 Recommended Savings Adjustments by Utility

Utility	kW	kWh
AEP TCC	31	60,509
AEP TNC	-59	-254,696
CenterPoint	-52	-234,376
El Paso Electric	-10	-38,210
Entergy	6	10,020
Oncor	-5	-133,229
SWEPCO	-15	-106,311
TNMP	2	-5,019
Xcel Energy	15	72,555
Overall	**-87**	**-628,757**

1.3.2 Recommendations

The PUCT's EM&V recommendations are to facilitate more accurate, transparent, and consistent savings calculations and program reporting across the Texas energy efficiency programs as well as provide feedback that can lead to improved program design and delivery.[7] The PUCT and EM&V team worked with the utilities to establish a process to document utilities' responses to recommendations, referred to as "action plans." Utilities use these action plans, which are also vetted with the Energy Efficiency Implementation Project (EEIP), to respond to program savings, design, and implementation recommendations within the next program year consistent with § 25.181(q)(9). Recommendations made based on PY2017 evaluation research, which was completed in 2018, were expected to be fully implemented in PY2019. Likewise, recommendations resulting from the PY2019 EM&V completed in 2020 are expected to be implemented in PY2021. First, we report on utility progress in meeting recommendations that were to be implemented in PY2019 programs, and then we summarize recommendations from the PY2019 EM&V research to be implemented in PY2021.

1.3.3 Prior EM&V Recommendations

Table 2 through Table 5 summarize the status of PY2017 EM&V recommendations that utilities were to implement in PY2019. Utilities have been responsive to all recommended changes in their program implementation, savings calculations, documentation, communication, and reporting. Of the 22 recommendations, 12 are complete, and 10 are in progress; no recommendations have been left unaddressed.

Commercial recommendations addressed TRM updates and utility quality assurance and quality control (QA/QC) practices. QA/QC practices are noted as *in progress* since some minor discrepancies were found in PY2019.

[7] The EM&V team recognizes that there may be a trade-off between the objectives of the recommendations, program administration costs, and program participation barriers. The EM&V team strives to recognize these trade-offs by making feasible recommendations and working with the utilities to agree upon reasonable action plans in response to recommendations.

Table 2. Commercial Program Recommendations for PY2019 Implementation

Category	Recommendation	PY2019 implementation	Status
HVAC projects	Utilities should use the rated capacities of both the existing and new equipment.	The PY2019 TRM clarified the capacities listed in applicable tables are the rated capacities.	Complete
Lighting projects	Utilities should use the third-party certification agency's tested wattage instead of the manufacturer's rated wattage.	The PY2019 TRM clarified third-party tested wattage should be used, not the manufacturer's rated wattage. Some occurrences of manufacturer's rated wattage were found in the PY2019 EM&V.	In progress
	Fixture code lighting-type suffix descriptors should be properly selected in the calculators.	Utilities conduct QA/QC of fixture code suffix descriptors.	In progress
Building type selection	Differentiate the *supermarket building type* codes from the other codes intended for non-food retail stores.	The PY2019 TRM updated the *lighting building types* codes.	Complete
	Offer guidance for building type selections for lighting projects when the building type is not known, similar to the guidance available for HVAC projects.	The PY2019 TRM included an *Other* building type code for lighting projects to act as a conservative estimate in lieu of site-specific monitoring.	Complete
	Utilities should use the *Other* building category for HVAC and lighting projects when the building type is not in the TRM or request EM&V assistance in determining if a similar building type is appropriate to use.	Utilities conduct QA/QC of the building type and have actively sought EM&V input in several instances. However, some incorrect building type selections were found in the PY2019 EM&V.	In progress
	When multiple exterior lighting control schemes exist in a single project, utilize the *Custom Bldg.* worksheet.	Utilities had the lighting survey form (LSF) implementer create a new *Custom Bldg.* worksheet.	Complete
On-site inspections	Ensure representativeness of on-site inspection sampling by only grouping similar projects that are also implemented at the same building type and size, not just for the same customer.	Utilities are verifying that the projects' building type and size are also similar when sampling for site inspections from a large group of similar projects.	In progress

Residential recommendations focused on documentation requirements, which are all in progress (Table 3). While documentation has improved, there are still some inconsistencies or areas for improvement. Also, the PY2019 EM&V suggests additional requirements may be needed to improve deemed savings estimates.

Table 3. Residential Program Recommendations for PY2019 Implementation

Category	Recommendation	PY2019 implementation	Status
Baseline documentation	Utilities should educate contractors on the documentation requirements outlined in the TRM.	Utilities provided examples of required documentation; this is an item for continued discussion based on PY2019 EM&V results.	In progress
Infiltration test results	Utilities should consider collecting photos of test results to ensure the accuracy and method of testing adheres to BPI standards and the methods outlined in the TRM.	Utilities requested photos of test results; this is an item for continued discussion based on PY2019 EM&V results.	In progress
Direct install measures	Utilities should collect documentation for all direct install measures in addition to the other measures offered.	Utilities are to collect requested documentation or model numbers for direct install measures. The PY2019 EM&V did not review this item.	In progress
Insulation measures	Pictures should be required where insulation levels are visible. Assumptions made during the pre- or post-installation process should be documented and available for the verification process.	Utilities provided service providers with examples of required documentation; this is an item for continued discussion based on PY2019 EM&V results.	In progress

Load management program communication, data, and documentation recommendations were all fully met in the PY2019 EM&V (see Table 4).

Table 4. Load Management Program Recommendations and Action Plans

Category	Recommendation	PY2019 implementation	Status
Commercial	Continue ongoing communications with the EM&V team to resolve minor calculation differences, ensure continued performance, and streamline data provision and analysis efforts.	The utilities continued to work with the EM&V team to review their calculation systems to reduce the number of individual cases with savings variances.	Complete
	Continue to provide quality, on-time data to the EM&V team when requested.	The utilities provided the EM&V team all relevant program documentation and information that was needed to calculate savings.	Complete

Category	Recommendation	PY2019 implementation	Status
Residential	Utilities and implementers of residential load management programs should continue to engage the EM&V team proactively and collaboratively to resolve data and analysis issues.	The utilities worked with the EM&V team to review their calculation systems and supporting data.	Complete
	The utilities should provide documentation for all calculation decisions as they relate to applying the TRM.	The utilities provided adequate records for each meter for each event that streamlined calculations and reduced the cause of potential discrepancies.	Complete

Cross-sector recommendations ranged across measures and baselines that affect both sectors (see Table 5). The two *in progress* photovoltaic (PV) recommendations are noted as such due to the *low* evaluation priority for PV in PY2019. A more in-depth assessment is needed to determine if the recommendations were met entirely.

Table 5. Cross-Sector Measure Recommendations and Action Plans

Category	Recommendation	PY2019 Implementation	Status
HVAC tune-ups	The EM&V team continues to recommend using a rolling three-year average[8] of the efficiency losses to reflect potential changes over time and reduce the volatility from year to year.	Utilities and their implementers are using a three-year rolling average for HVAC tune-ups. The PY2019 EM&V discovered that New Mexico data was included. Going forward, only Texas data should be used.	Complete
	Collect at least a ten percent M&V sample for tune-up measures annually for the commercial and residential populations separately.	Utilities exceed the recommended M&V samples of 10 percent by sector. The PY2019 EM&V found 17 percent of M&V samples was achieved.	Complete
PV	Utilities should use the default values for *module type*, *array losses*, *DC to AC sizing*, and *inverter efficiency* while using PVWatts® to calculate the annual kWh production of a solar PV.	The PY2019 TRM clarified PV tracking and documentation requirements. The EM&V team issued a guidance memo in 2020 to provide further clarification for the new version of PVWatts.	Complete

[8] The three-year average should use M&V data from the most recent completed program years. For example, PY2018 efficiency losses are to be calculated from the average of PY2015, PY2016 and PY2017; PY2019 from the average of PY2016, PY2017 and PY2018; etc.

Category	Recommendation	PY2019 Implementation	Status
	Utilities should update final project energy savings for any changes in the original application.	Utilities will update project savings based on calculations using the final-installed PV system parameters.	In progress
	Processes should be reviewed to facilitate tabular breakpoints not occurring across ranges of typical system design.	Utilities will engage the EM&V team to discuss alternative breakpoints for system tilts.	In progress
Dual baselines	Re-assess the dual baseline methodology in the TRM.	The PY2019 TRM updated the dual baseline methodology.	Complete

1.3.4 PY2019 Key Findings and Recommendations

Based on findings from the PY2019 EM&V conducted across all the utilities, the EM&V team has provided key findings and recommendations for the commercial, residential, and load management programs. Issues that affect both residential and commercial sector programs are summarized in the *cross-sector* section.

1.3.4.1 Commercial Programs

Commercial key findings and recommendations are summarized in Table 6 using the following categories:

- Building type selection
- Major retrofits
- Lighting projects
- HVAC projects
- Recommissioning programs
- Small business programs

Table 6. Commercial Program Recommendations and Action Plans

Category	Key finding and recommendation	Action plan
Building type selection	Commercial interior lighting and HVAC project analysis requires proper *building type* selection as guided by the TRM. The EM&V team encountered several examples of potential conflicts in *building type*. The *building type* selection should match the predominant indoor facility-use type based on the surface area. Also, the exterior area should not be considered when determining the facility use based on multiple kinds of square footage.	Utilities will continue to conduct QA/QC of the *building type* selection and ask the EM&V team for input as needed; this was a PY2017 recommendation noted as *in progress*.

Category	Key finding and recommendation	Action plan
Major retrofits	Building renovations that change the building type are considered major retrofits. The TRM differentiates between new construction projects and retrofit projects for the baseline used in energy savings calculations. The TRM should include a *major retrofit* category different from *standard retrofit* and *new construction*.	The 2021 TRM will include guidance on energy savings calculations for a major retrofit project with a building type change.
Lighting projects	Lighting calculations had a significant amount of wattage adjustments for installed lighting wattage. The two reasons were: (1) the LED lighting manufacturer wattages were used instead of the third-party tested wattage, and (2) half-watt denominations allowed by the TRM were not utilized. Utilities should update the calculation process to ensure the use of the third-party listed wattages for installed equipment and continue to implement half-watt increment rounding.	Utilities will increase their QA/QC of lighting wattages; this is a PY2017 recommendation noted as *in progress*.
	Lighting retrofit projects may install new fixtures in locations where fixtures were not previously located. Some projects can allow the existing lighting fixtures to remain in place without impacting the performance of the new lighting fixtures. When the replaced fixtures are not removed, these fixtures should be counted in the *post-install fixture* inventory.	The 2021 TRM will state that the existing lighting fixtures that remain after the lighting retrofits are complete are still considered installed and should be in the *post-install lighting* inventory.
HVAC projects	Split systems require that a condenser and air handler be paired to determine cooling capacity and energy efficiency. The condenser unit is the key component and is typically listed with several air handling units on Air Conditioning, Heating, and Refrigeration Institute's (AHRI) listings. This efficiency and capacity should be used in the savings calculation.	The 2021 TRM will provide more guidance for determining the efficiency of split systems.
Recommissioning programs	M&V methods provide a framework to provide high-quality verified savings for recommissioning projects that cannot be readily isolated through engineering equations or modeling and provide significant energy savings. The EM&V team offers several recommendations on the appropriate M&V for recommissioning programs in this report as well as updates for the TRM Recommissioning M&V Protocol.	The PY2021 TRM Recommissioning M&V Protocol will be updated to increase the consistency of the calculation process and the accuracy of savings for M&V claimed energy savings. It will also consider a process to support continuous improvement.

Category	Key finding and recommendation	Action plan
Small business programs	The EM&V team was pleased to see an increase in weather stripping projects for small businesses. At the same time, it is crucial to recognize building envelope energy-efficiency measures, such as weather stripping, which are more dependent on the detail and quality of the installation compared to other equipment-based measures. The EM&V recommends TRM updates to ensure the proper installation of weather stripping.	The 2021 TRM will update the *non-residential entrance* and *exit door* infiltration measure guidance.
	The EM&V team noted that only a small percent of sampled small business projects claimed lighting controls savings. There is an opportunity to increase per-project energy efficiency savings by five percent or more by focusing on increasing the number of wall-based occupancy sensors installed.	Utilities will discuss the potential to increase the use of wall-based occupancy sensors with service providers.

1.3.4.2 Residential Programs

Residential key findings and recommendations are summarized in Table 7 using the following categories:

- Residential retrofit programs
- Hard-to-reach programs
- Low-income programs
- New homes programs
- Upstream programs

Table 7. Residential Program Recommendations and Action Plans

Category	Key finding and recommendation	Action plan
Residential retrofit programs	Residential retrofit programs are delivering substantial energy savings and winter and summer peak demand reductions. On average, across the ERCOT utilities, programs are reducing households' annual energy use by approximately eight percent. However, results ranged across utility programs from two percent to ten percent of annual consumption. Higher-performing programs are successfully including HVAC equipment. The EM&V team recommends utilities consider best practices from the highest-saving residential programs.	Utilities will identify best program practices and consider diversifying their residential measures mix as applicable for their unique territories.
	A comparison of the consumption analysis results at the measure level indicates the researched TRM deemed savings are overestimating actual savings. Central air conditioning (AC) deemed savings are closest to actual savings. Air infiltration is the most overstated. The EM&V team recommends updates to the TRM to increase the accuracy of the deemed savings.	The PY2021 TRM will include updates for AC, HPs, duct sealing, ceiling insulation, and air infiltration measures.
	The consumption analysis results demonstrating the TRM deemed savings systematically overestimates actual savings indicate that utility programs should address behavior. This includes both customer behavior such as *snapback* (consuming more energy when it is more efficient to do so) and service providers' implementation of measures.	The utilities will include education and training components for both customers and service providers as needed, considering if research and development (R&D) funds are necessary to support these efforts.
Hard-to-reach programs	On average, HTR programs are saving five percent of participants' annual energy use, with fairly consistent results across utility programs ranging from five to seven percent. HTR programs are saving less energy than residential and LI programs, and these savings have decreased since the 2015 consumption analysis. While not commonly implemented, wall insulation showed solid savings in the consumption analysis, and limited HVAC measures have been completed to-date for this sector.	Utilities will identify strategies to increase energy savings opportunities for the HTR sector and discuss these strategies with PUCT staff and the EM&V team.
Low-income program	LI programs are the highest savings residential program, with results across utilities ranging from 11 to 21 percent of participants' annual energy use. LI programs use the SIR cost test instead of the program administrator cost test and, therefore, can implement more measures. The EM&V team recommends that utilities share best practices across LI programs, including the innovative strategies employed by the implementer of the highest saving LI program.	Utilities should identify best practices from the highest performing LI program, which has employed unique approaches to serving this sector.

Category	Key finding and recommendation	Action plan
New homes programs	The new homes energy model approach in the TRM does a good job estimating gross energy savings compared to the statewide code, with slight variations by location and heating type. However, a comparison with non-participant homes and results from interviews with builders and raters suggests some level of market transformation is occurring. The EM&V team recommends that utilities revisit their new homes program designs to identify strategies that continue to push the market and maximize net program savings.	Utilities will update program designs to increase net savings. Modifications may include innovative technologies, targeting specific end-uses (especially HVAC), or outreach to segments where the market is not transformed considering the current code.
Upstream programs	Interviews with participating upstream retailer stores, manufacturer sales data, and benchmarking from similar utility programs indicate some level of market transformation of LEDs as well as a continued role for the programs in the near term. The EM&V team recommends a net-to-gross (NTG) of 50 percent is used to assess net savings of upstream lighting programs.	Utilities should assess the cost-effectiveness of upstream lighting programs based on net as well as gross savings to ensure they are cost-effective given some level of market transformation.
	The EM&V team found some incented lamps that were not ENERGY STAR®-qualified. For ease of implementation, utilities should consider requiring ENERGY STAR certification or third-party certifications for incentivized upstream lamps.	Utilities will monitor the LEDs promoted through the program to ensure they comply with TRM certification requirements.

1.3.4.3 Load Management Programs

Key findings and recommendations are presented in Table 8 for residential and commercial load management programs.

Table 8. Load Management Program Recommendations and Action Plans

Category	Key finding and recommendation	Action plan
Commercial	Utilities demonstrated strong capabilities in applying the TRM calculation method to savings. The EM&V team noted a minor discrepancy in one instance when selecting baseline days using the *high 5 of 10* method. Six days were chosen because of a tie between two days. The EM&V adjusted the savings calculation to use the five highest loads closest to the event as baseline days.	Utilities will keep active communications with the EM&V team to resolve minor discrepancies in savings calculations. In the case of a tie between the days used to calculate the baseline, utilities will follow the TRM guidance of selecting the five highest loads closest to the event.
	The total program savings can be calculated by averaging the sum of sponsor-level savings or adding the average sponsor-level savings. While, in theory, there should be no difference, the points at which rounding occurs can drive minor differences in calculation results. The EM&V team recommends that rounding occurs at the sponsor level for each event.	The 2021 TRM will update the rounding guidance for commercial load management programs.
Residential	Utilities demonstrated strong capabilities in applying the TRM *high 3 of 5 method*. Residential programs have a large number of participants, with the potential for rounding at the participant level driving substantial differences in savings at the event or program level. Continue rounding data only at the event level or program year level.	The 2021 TRM will update the rounding guidance for residential load management programs.
	One utility applies a deemed savings value. While *participant* language was clarified in the 2020 TRM, additional clarification may be helpful. Furthermore, the event-level savings calculation for the deemed savings approach can be simplified to avoid minor rounding discrepancies.	The EM&V team and applicable utility will review the 2020 TRM language to identify any needed updates for clarity in the 2021 TRM, including the participant definition and rounding for the event-level savings calculations.

1.3.4.4 Cross-Sector

Cross-sector key findings and recommendations are summarized in Table 9 for the following:

- Program tracking data
- Project documentation
- AC tune-ups
- Multifamily
- COVID-19 considerations

Table 9. Cross-Sector Measure Recommendations and Action Plans

Category	Key finding and recommendation	Action plan
Program tracking data	Some tracking data did not include the measure-level information required by the TRM measure, which resulted in the EM&V team being unable to verify savings for some measures due to insufficient data. The EM&V team recommends that all prescriptive measure tracking data includes the required fields outlined in the TRM.	Utilities will review program tracking data and make revisions as needed to include the required fields outlined in the TRM.
	Tracking data for upstream lighting programs were inconsistent in structure and content. The EM&V team recommends that commercial and residential savings are clearly labeled and include retailer, quantity, and savings information.	The 2021 TRM will clarify upstream lighting program requirements.
Project documentation	Across several utilities, the EM&V team found a decrease in program documentation scores due to missing or incomplete documentation. The EM&V team recommends that documentation, as specified in the TRM, is collected for each program.	Utilities will discuss how they will address programs that received less than a *good* program documentation score in PY2019 with the EM&V team and PUCT staff.
	An electronic TRM (eTRM) provides an integrated participant data management tool and energy savings calculator. Overall, this technology has the opportunity to enhance the accuracy and transparency of project savings calculations over traditional methods. However, if a utility is employing an eTRM, the EM&V team should review the structural procedures of the program tracked in an eTRM and agree on a list of documentation.	Utilities using an eTRM will provide the EM&V team with process documentation and supporting external documentation to be provided for each program.
	If a project was approved in a prior program year, but not completed (*roll-over* project), the TRM version at project approval may be used for claimed and evaluated savings. However, program tracking data needs to indicate these projects.	Utilities will inform the EM&V team of their program tracking indicator for *roll-over* projects approved under a prior TRM.

Category	Key finding and recommendation	Action plan
AC tune-ups	The EM&V team identified some contractors with a high number of completed projects with much lower average test-in data than the rest of the population. In particular, one trade ally was identified with one of the lowest average test-ins who also completed over 90 percent of the projects. Monitoring trade allies with potentially incorrect test-in results can help identify training opportunities.	Utilities should require their implementation contractors to monitor all trade allies' test-in data to identify and address abnormal trends from specific contractors.
	The EM&V team found that the efficiency loss factors used for the state of Texas were developed using M&V data from both Texas and New Mexico. The EM&V team recommends using only M&V dataset, from the state of Texas, to determine efficiency loss values to avoid any influence from other outside regions and weather zones.	Utilities will require their implementation contractors to utilize only M&V dataset from Texas to determine efficiency loss values.
Multifamily	Multifamily buildings can receive incentives from residential or commercial programs, depending on if they are individual or master metered. While Multifamily buildings receive incentives for a wide range of measures similar to single-family homes, the TRM does not currently differentiate between single-family and multifamily deemed savings; however, the consumption analysis found results varied considerably across the two.	The 2021 TRM will address multifamily and single-family eligibility and treatment across residential measures.

Category	Key finding and recommendation	Action plan
COVID-19 considerations	All utilities believe they will meet 2020 commercial goals. Robust project pipelines before the pandemic and customers taking advantage of unoccupied facilities to install energy efficiency projects are two primary drivers of continued commercial program success. Utilities who have already met commercial 2020 goals may want to encourage applicable projects to roll into 2021 so that a strong pipeline is established for the next program year given uncertainty is still expected.	Utilities will consider strategies for continued commercial program success in 2021.
	Small businesses have become more difficult to serve during the pandemic. Utilities should consider exploring low-cost and no-cost measure solutions specifically tailored to small businesses. Utilities should also consider exploring strategies implemented elsewhere in the country, such as leveraging COVID-19 remodels with energy efficiency upgrades.	Utilities will explore different strategies to increase small business participation in 2021.
	While the majority of utilities believe they will meet 2020 residential goals, they have generally seen more challenges. Residential challenges and successes are unique to each utility territory. Utilities may want to consider complementing traditional in-home retrofit services with other program delivery methods such as upstream and midstream venues or self-install options by homeowners and multifamily maintenance staff.	Utilities will assess their residential portfolio measures and delivery options for 2021.
	Utilities are employing remote QA/QC practices, including in-depth engineering desk reviews, phone audits, virtual inspections, and expanded photo documentation. Successful virtual QA/QC processes may decrease on-site QA/QC inspection costs in the future or utility-enhanced QA/QC desk reviews may reduce errors found during the EM&V reviews.	The 2020 EM&V should assess utility project QA/QC in terms of what was able to be feasibly accomplished remotely. A review of remote QA/QC should include an assessment of the value of new practices continuing.
	While all utilities report that their company has implemented health and safety practices for their staff, guidance provided to service providers has varied. The most common approach is the view that service providers are businesses that have their staff and their customer safety at top of mind and are implementing proper practices. The less common method was a required health and safety training for service providers.	Utilities may want to consider providing service providers with applicable health and safety protocols from reputable sources.
	Utilities report that customers are expressing high satisfaction with program services during the pandemic. If not already doing so, utilities should consider including a health and safety question in ongoing program customer satisfaction surveys or other follow-ups with customers.	Utilities will consider follow-ups with customers regarding health and safety satisfaction during the pandemic.

2.0 INTRODUCTION AND PORTFOLIO RESULTS

This Statewide Energy Efficiency Report presents the PY2019 EM&V findings and recommendations, looking across all eight electric utilities' portfolios. It addresses gross and net energy and demand impacts, program cost-effectiveness, and provides feedback on program portfolio performance. It includes findings and recommendations to inform updates to the PY2021 TRM as well as the PY2021 program design and delivery.

First, we overview the EM&V methodology in PY2019; this is followed by portfolio-level results related to program tracking and documentation. Sections 3 through 6 present the commercial, residential, cross-sector, and load management program results. Section 7 discusses research related to COVID-19 considerations in energy efficiency programs. Technical Appendix 1 details the residential programs' consumption analysis methodology. A separate Volume 2 of this report details PY2019 impact results for each utility's portfolio.

2.1 EVALUATION, MEASUREMENT, AND VERIFICATION METHODOLOGY

2.1.1 Overview

In 2011, the Texas Legislature enacted SB 1125, which required the PUCT to develop an EM&V framework that promotes effective program design and consistent and streamlined reporting. The EM&V framework is embodied in 16 Tex. Admin. Code § 25.181, relating to Energy Efficiency Goal (Project No. 39674).

The PUCT selected an EM&V team through the Request for Proposals (RFP) 473-17-00002, Project No. 46302. This team is led by Tetra Tech and includes Texas Energy Engineering Services, Inc. (TEESI) (hereafter, "the EM&V team").

Independent EM&V was conducted for Texas electric utilities' PY2019 energy efficiency portfolios. The objectives of the EM&V effort are to:

- document gross and net energy and demand impacts of utilities' individual energy efficiency and load management portfolios;
- determine program cost-effectiveness;[9]
- provide feedback to the PUCT, utilities, and other stakeholders on program portfolio performance; and
- prepare and maintain a statewide TRM.[10]

The PUCT's EM&V independently verifies claimed savings across all programs through program tracking data that is received from the utilities. Additional EM&V activities (engineering desk reviews, on-site M&V, interval meter data analysis, consumption analysis, participant surveys, in-depth interviews) are conducted based on an evaluation prioritization of high, medium, or low by program type. The PUCT and EM&V team re-visits the prioritization each

[9] The EM&V team conducts cost-effectiveness testing applying the program administrator cost test. For LI programs, cost-effectiveness is calculated using the SIR.

[10] The maintenance of the TRM is informed by EM&V research and coordinated with the Electric Utilities Marketing Managers of Texas (EUMMOT) and the Energy Efficiency Implementation Project (EEIP).

year based on considerations such as magnitude and uncertainty of savings, stage of the program, importance to future portfolio performance, priorities prior EM&V results, and changes in the markets in which the programs operate.

RSOP, HTR, and LI programs were a *high* evaluation priority for PY2019. These programs continue to comprise a substantial percentage of overall statewide portfolio savings and have recently responded to various TRM updates to the envelope measures. Moreover, the EM&V team recommended expanding the measure mix in these programs. The EM&V team completed a consumption analysis for the ERCOT RSOPs, HTR, and LI programs, which is described in detail in Technical Appendix 1 of this report. The EM&V team also conducted surveys with residential service providers to gain insight into program processes from their perspective.

Several residential market transformation programs were also a *high* priority in PY2019 as they were either re-designed or newer programs. First, new homes MTPs had an updated statewide energy code and TRM entry in PY2018. The EM&V team conducted a consumption analysis to compare to the programs' savings estimates, described in detail in Technical Appendix 1 of this report. The consumption analysis was complemented with builder and home energy-rater interviews to understand standard practices in the market and how the program is influencing them. Residential upstream lighting programs have grown rapidly in the last couple of years and reach a high number of customers through retail channels. A census impact review of these programs was conducted along with retailer interviews and benchmarking research.

Commercial standard offer programs (CSOPs) and the commercial MTPs continued as a *medium* priority in PY2019. These programs continue to represent the largest percentage of statewide savings and continue to explore new customer segments and technologies. While prior EM&V generally found evaluated savings to be similar to the utilities' claimed savings, it also resulted in several recommendations for changes to reported claimed savings.

Load management program evaluations returned to a *medium* priority in PY2019 after being evaluated as a *high* priority in PY2018. These programs continue as a substantial contributor to demand reduction (kW) savings. The EM&V team conducted census reviews of all participants' interval meter data in PY2019 to calculate impacts independently following the TRM to compare against utilities' claimed savings.

All other program types are considered *low* evaluation priorities because they are small contributors to portfolio savings, have little uncertainty in savings, or had EM&V results in recent years that had limited action items.

Finally, because one of the primary objectives of this report is to provide recommendations for 2021 programs, the EM&V team conducted research in May–June 2020 to provide the context of the impacts of the COVID-19 pandemic on the energy efficiency programs. The EM&V director interviewed utility program managers and directors to characterize how utilities are responding to COVID-19 in their energy efficiency portfolios. This is complemented with information from residential program service provider surveys and secondary research of energy efficiency program developments across the country in response to COVID-19.

2.1.2 Activities

EM&V activities:

- confirm that the measures installed are consistent with those listed in the tracking system;

- verify that the claimed savings estimates in the tracking system are consistent with the savings calculated in the deemed calculation tools or tables in accordance with the PY2019 TRM 6.0 or measurement and verification (M&V) methods used to estimate project savings;
- review savings assumptions and, when available, utility M&V reports gathered through the supplemental data request for sampled projects and EM&V team on-site M&V;
- recommend updates to project-level claimed savings if EM&V results indicate a variation in savings of at least ±5 percent; and
- inform updates for the PY2021 TRM 8.0.

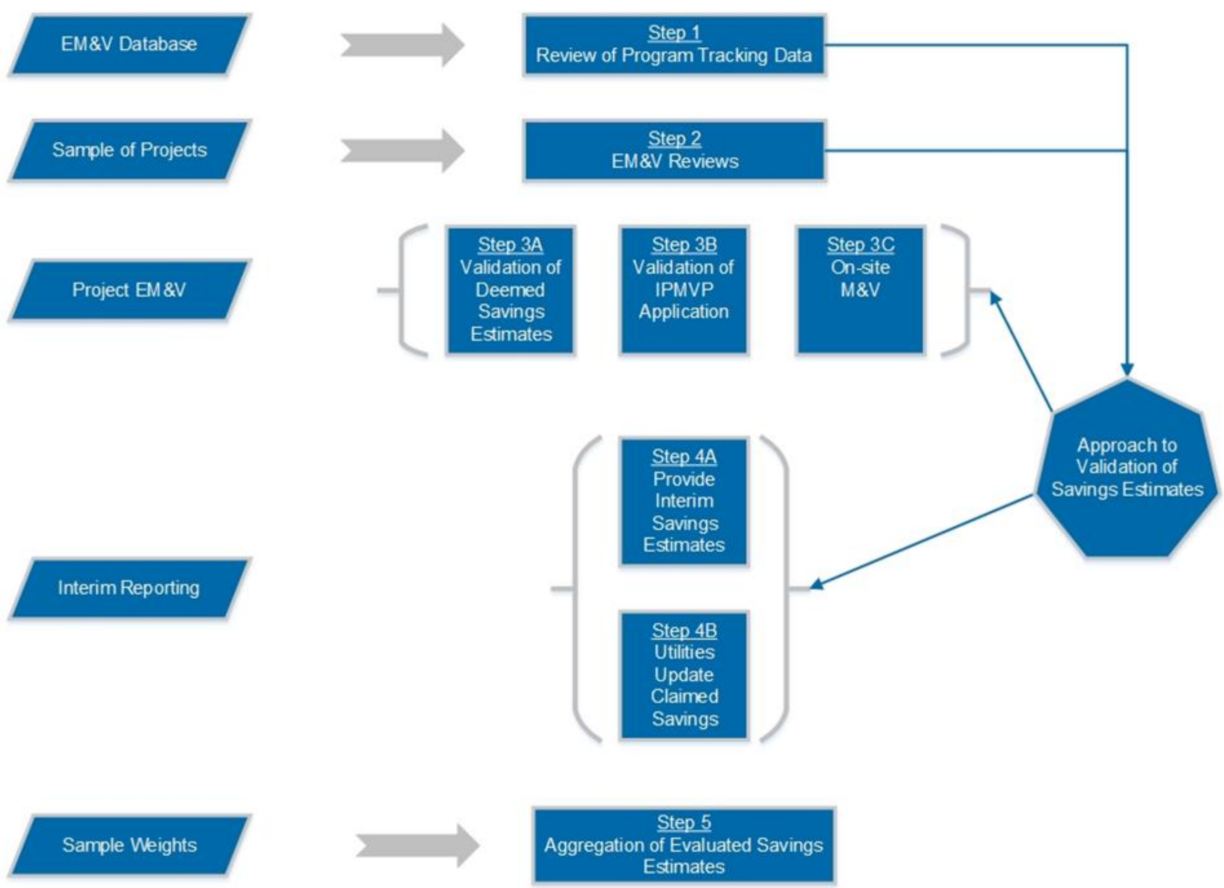
Table 10 shows the EM&V activities completed by program type and evaluation priority.

Table 10. PY2019 Evaluation, Measurement, and Verification Priorities and Activities

Program Type	Evaluation Priority	Claimed Savings Verification Approach	Participant/ Distributor Surveys	Project Desk Reviews	On-site M&V	Interval Meter Data Analysis
Commercial SOPs, Large Commercial MTPs, Retro-Commissioning (RCx)	Medium	Sampled (see desk reviews)	N/A	152	77	N/A
Small Business Programs	Medium	Sampled (see desk reviews)	N/A	50	25	N/A
Commercial Load Management	Medium	Census	N/A	N/A	N/A	Census
Residential Load Management	Medium	Census	N/A	N/A	N/A	Census
Residential SOPs, Hard-to-Reach, Low Income	Medium	Census	50	N/A	N/A	Participant Consumption Analysis
AC and HP Tune-Up	Medium	Census	N/A	N/A	N/A	N/A
Multifamily MTP	Medium	Sampled (see desk reviews)	N/A	10	N/A	N/A
Residential New Homes MTPs	High	Census	38	N/A	N/A	Participant Consumption Analysis
Upstream MTP	High	Census	13	15	N/A	N/A
All Other Programs	Low	Census	N/A	N/A	N/A	N/A

The evaluated savings are based on project-level realization rate calculations that are then weighted to represent program-, sector-, and portfolio-level realization rates. These realization rates incorporate any adjustments for the incorrect application of deemed savings values and any equipment details determined through the tracking system reviews, desk reviews, and primary data collected by the EM&V team. For example, baseline assumptions for hours of use may be corrected through the evaluation review and thus affect the realization rates. A flow chart of the realization rate calculations is illustrated in Figure 11. Realization rates for utility portfolios, and each utility's program may be found in Volume 2 of this report.

Figure 11. Realization Rate Flowchart



A complementary component of the realization rate is the sufficiency of program documentation provided to estimate evaluated savings—this was used to determine an overall program documentation score for each program with a *medium* or *high* evaluation priority in a utility's portfolio.

The EM&V team conducted cost-effectiveness testing using the program administrator cost test for claimed and evaluated results. LI programs were also calculated using the savings-to-investment ratio (SIR).

2.2 PROGRAM TRACKING

Tetra Tech collected, compiled, and reviewed program tracking data for all programs in PY2019. We used the data to support evaluation activities, including sampling, deemed savings reviews, and reporting. During the course of these activities, we identified several issues relating to program tracking data. Some of these were new issues for programs that were evaluated for the first time, while other issues were recurring.

Key Finding #1: Some tracking data did not include the information required by the TRM measure characterizations. This resulted in the EM&V team being unable to verify savings for some measures due to insufficient information.

Examples of this issue include:

- missing square footage for air infiltration measures;
- missing heating or cooling system type for a number of building shell measures;
- heating or cooling system type listed as *space* without clarifying fuel or technology; and
- missing fan speed for ceiling fans.

Recommendation #1a: Ensure that all tracking data includes the required fields outlined in the TRM.

Key Finding #2: Tracking data for upstream lighting programs was inconsistent in its structure and contents. One utility did not clearly label commercial and residential savings line items, while another utility did not include the retailer information where the lighting products were incentivized.

Recommendation #2a: Review tracking data for upstream programs and include the required information for EM&V to verify savings.

- Clearly label commercial and residential savings—this can be by separating line items for each sector or by including separate columns for residential and commercial savings.
- Include retailer information in the tracking data. At a minimum, this should include the retail chain and ideally should also include an identifier for the individual store, such as a store number or street address.

The EM&V team will update the TRM to ensure these requirements are clearly stated.

2.3 PROGRAM DOCUMENTATION

Key Finding #1: Documentation was delayed for many projects in small business programs.

The streamlined process in small business programs typically includes providing program documents (developed as part of the project scope) to the participant immediately after construction. The documentation for small business projects includes (1) a simplified calculator, and (2) documentation of baseline equipment, building type, location of installation, and proposed equipment. The documentation was provided for most projects immediately after installation, but a notable number of projects did not provide the documentation until after the program year. Some projects claimed energy savings with missing project documentation—which is an ongoing issue and a recommendation from PY2018—and therefore is not surprising to see again in PY2019. It is expected to be fully resolved in PY2020.

Recommendation #1a: Documentation should be complete and provided to the small business customer immediately after construction is complete. For projects with claimed savings, copies of the documents should be stored as implementation records.

Key Finding #2: Supporting documentation was limited when using an eTRM.

The eTRM is a form of software that manages participant data and calculates prescriptive savings. The documentation delivered to the EM&V team included participant data and final energy savings but appeared to be missing supporting documentation such as photos, calculation spreadsheets, invoices, and applications. Lack of supporting documentation is expected since the eTRM is software with direct entry of collected information in lieu of historical documents and spreadsheets. With a follow-up meeting and upon review, the EM&V team determined that project documentation was sufficient.

An eTRM reduces the risk of individual project inaccuracies while increasing the potential for system-wide inaccuracies that may affect many individual projects. A thorough program-by-program evaluation should include a review of the software procedures with supporting documentation, as requested by the EM&V team.

Overall, using an eTRM can improve the accuracy and transparency of project savings calculations over traditional methods.

Recommendation #2a: Program administrators (PAs) using an eTRM should provide the EM&V team software procedures and supporting external documentation for each evaluated program.

Key Finding #3: Documentation for commercial projects was inconsistent.

The EM&V team found that documentation was overall good; however, insufficient documentation was submitted for a portion of commercial projects. Missing or insufficient documentation included:

- invoices—25 percent of invoices did not include itemized equipment;
- photos—the incomplete photo sets typically included either equipment nameplate or install location (i.e., zoomed out), but not both;
- qualified products lists (QPL) certificates—25 percent of projects were missing QPL certificates, particularly in the small business and SCORE programs;
- project descriptions—projects that had multiple measures, used custom values (e.g., hours of operation), and other complicating aspects often used overly-simple project descriptions; and
- deficient post-installation notes—40 percent of projects were missing post-install notes, including SCORE programs.

Project documentation is an effective method to ensure project aspects are accurately represented, projects are completed as planned, and savings calculations accurately represent the final project.

Recommendation #3a: PAs should ensure that projects follow the documentation requirements outlined in the TRM.

Key Finding #4: Document, with EM&V prior approval, when using previous versions of the TRM to calculate savings.

PAs should use the current version of the TRM as a basis of savings calculations. If a project's savings calculations are based on a previous version of the TRM, the program administrator should request approval from the EM&V team and document the use of the previous version of the TRM. Without prior approval, the EM&V standard procedure includes calculating ex-post savings using the TRM when savings is claimed (e.g., TRM 7.0 for PY2020 projects).

Recommendation #4a: Update the TRM glossary (and general documentation section) to outline when a previous TRM can be used as a basis of savings calculations.

Key Finding #5: Document pre-inspection results when claiming electric resistance heat for residential projects.

Resulting from the consumption analysis, claiming electric resistance as a heating type is overestimating savings in central AC, heat pump (HP), duct sealing, ceiling insulation, and air infiltration measures. The EM&V team and utilities are investigating why this is happening (e.g., snapback, inaccuracies in claimed heating type).

Recommendation #5a: PAs should document pre-inspection results to ensure an accurate representation of heating type when claiming existing (or baseline) resistant heat.

3.0 COMMERCIAL ENERGY EFFICIENCY PROGRAMS

The EM&V team evaluated the commercial energy efficiency programs described below. There are two types of programs: SOPs and MTPs. An SOP is a program under which a utility administers standard offer contracts between the utility and energy efficiency service providers. These contracts specify standard payments based upon the amount of energy and peak demand savings achieved through energy efficiency measures, M&V protocols, and other terms and conditions. An MTP is a strategic program intended to induce lasting structural or behavioral changes in the market that result in increased adoption of energy-efficient technologies, services, and practices.[11] SOP and MTP programs continue to represent the largest percentage of statewide savings.

Commercial SOP: The Commercial SOP provides incentives for new construction and retrofit installation for a wide range of measures that reduce demand and save energy in nonresidential facilities. Incentives are paid to EESPs (project sponsors) based on deemed savings or verified demand and energy savings at eligible commercial customers' facilities. The utility has a limited group of participating project sponsors, which are determined through a selection process. This selection process is based on meeting minimum eligibility criteria, complying with all program rules and procedures, submitting documentation describing their projects, and entering into a standard agreement with the investor owned utility.

Commercial Solutions MTP: The Commercial Solutions MTP targets commercial customers that do not have the in-house expertise to (1) identify, evaluate, and undertake energy efficiency improvements; (2) properly evaluate energy efficiency proposals from vendors; or (3) understand how to leverage their energy savings to finance projects. Assistance from the program includes communications support and technical assistance to identify, assess, and implement energy efficiency measures. Financial incentives are provided for eligible energy efficiency measures that are installed in new or retrofit applications and result in verifiable demand and energy savings. Commercial Solutions MTPs can include midstream programs that provide incentives at the distribution point to installation contractors that have the intention of installing the equipment for eligible commercial or industrial customers.

SCORE MTP: The SCORE MTP helps educational facilities (public and private schools, K-12, and higher education) and local government institutions to lower their energy use—this is done by providing education and assistance with integrating energy efficiency into their short- and long-term planning, budgeting, and operational practices. Lowering energy use is also completed through assistance in areas such as energy master planning workshops, energy performance benchmarking, and identifying/assessing/implementing energy efficiency measures. Energy efficiency improvements include capital-intensive projects and implementing operational and maintenance practices and procedures. Financial incentives are provided to energy efficiency measures that reduce peak electricity demand.

Recommissioning MTP: The Recommissioning MTP offers commercial customers the opportunity to make operational performance improvements in their facilities based on low-cost/no-cost measures identified by an engineering analysis. Financial incentives are provided to facility owners and retro-commissioning agents for the implementation of energy efficiency measures and projects completed by approved project deadlines.

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[11] PUCT Order, Chapter 25: Substantive Rules Applicable to Electric Service Providers.

Small Business MTP: The Small Business MTP is designed to assist small business customers with identifying and implementing cost-effective energy efficiency solutions for their workplace. Small business customers are defined as business customers that do not have the in-house capacity or expertise to: (1) identify, evaluate, and undertake energy efficiency improvements; (2) properly evaluate energy efficiency proposals from vendors; or (3) understand how to leverage their energy savings to finance projects.

CoolSaver AC Tune-Up MTP: The CoolSaver AC Tune-Up MTP is designed to overcome market barriers that prevent residential and commercial customers from receiving high-performance AC system tune-ups. The program works through local AC distributor networks to offer key program components, including: (1) training and certifying AC technicians on protocols and tune-up and airflow correction services, and (2) paying incentives to AC contactors for the successful implementation of AC tune-up and airflow correction services. Contractors that wish to participate enter into a contractor partnering agreement that specifies the program requirements. Contractors are trained on the AC tune-up process and given incentives and discounts for the cost of field equipment designed to diagnose and quantify energy savings opportunities. Energy savings are captured through the correction of AC system inefficiencies identified during the tune-up activities.

Solar Photovoltaic MTP: The Solar Photovoltaic MTP offers financial incentives for the installation of eligible distributed solar energy generation equipment on the premises of customers served by the utilities. These programs are available to utility customers, including residential customers, businesses, and schools. The utility has a limited group of EESPs determined through a selection process based on meeting minimum eligibility criteria, complying with all program rules and procedures, and submitting documentation describing their projects.

The EM&V team conducted a streamlined EM&V effort that couples broad due diligence verification of savings for the first six programs described above with targeted in-depth activities including engineering desk reviews, on-site M&V, and interval meter data analysis based on the prioritization of the programs.

3.1 SUMMARY RESULTS

This section presents statewide summary results, followed by key findings and recommendations from the impact evaluations of SOP and MTP programs.

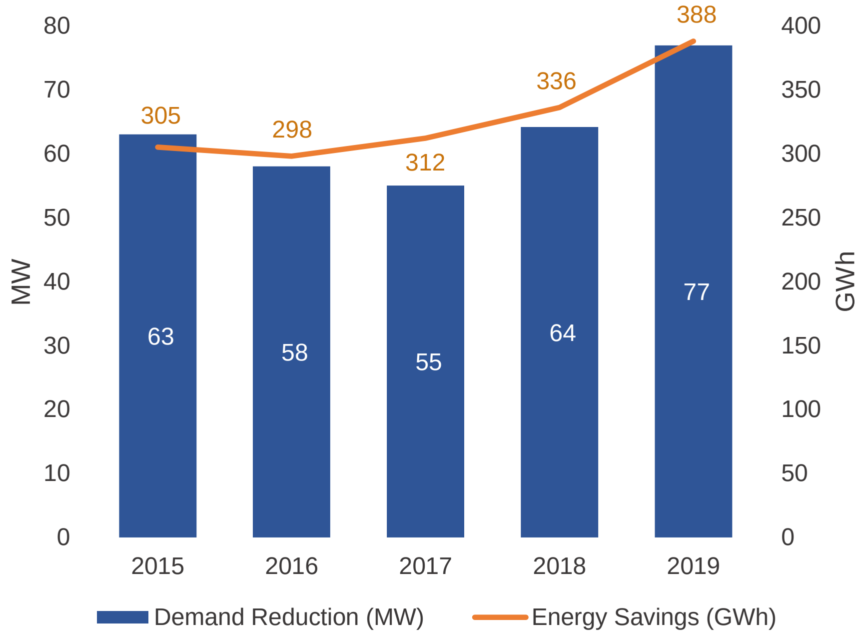
3.1.1 Savings

The statewide PY2019 evaluated gross savings from commercial sector programs were:

- 76,916 kW (demand reduction), and
- 387,866,543 kWh (energy savings).

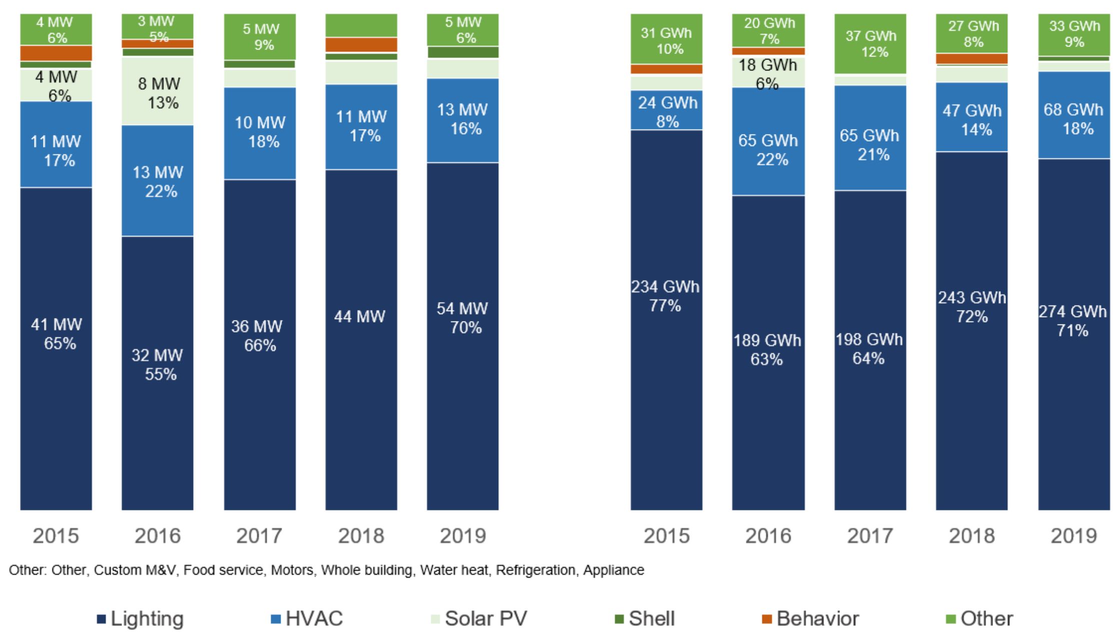
As shown in Figure 12, both of these results reflect an increase from PY2018. PY2019 also has the highest commercial sector results since EM&V started in PY2012.

Figure 12. Total Statewide Evaluated Demand Reduction and Energy Savings by Program Year—Commercial Programs PY2015 – PY2019



As indicated in Figure 13, lighting measures still account for the majority of the energy savings (70 percent) and demand reduction (71 percent). PY2019 saw HVAC and lighting measures making up approximately 86 percent and 89 percent of demand reduction and energy savings, respectively.

Figure 13. Distribution of Statewide Evaluated Gross Demand Reduction and Evaluated Gross Energy Savings by Measure Category—Commercial Programs PY2019 Excluding Load Management PY2015 – PY2019

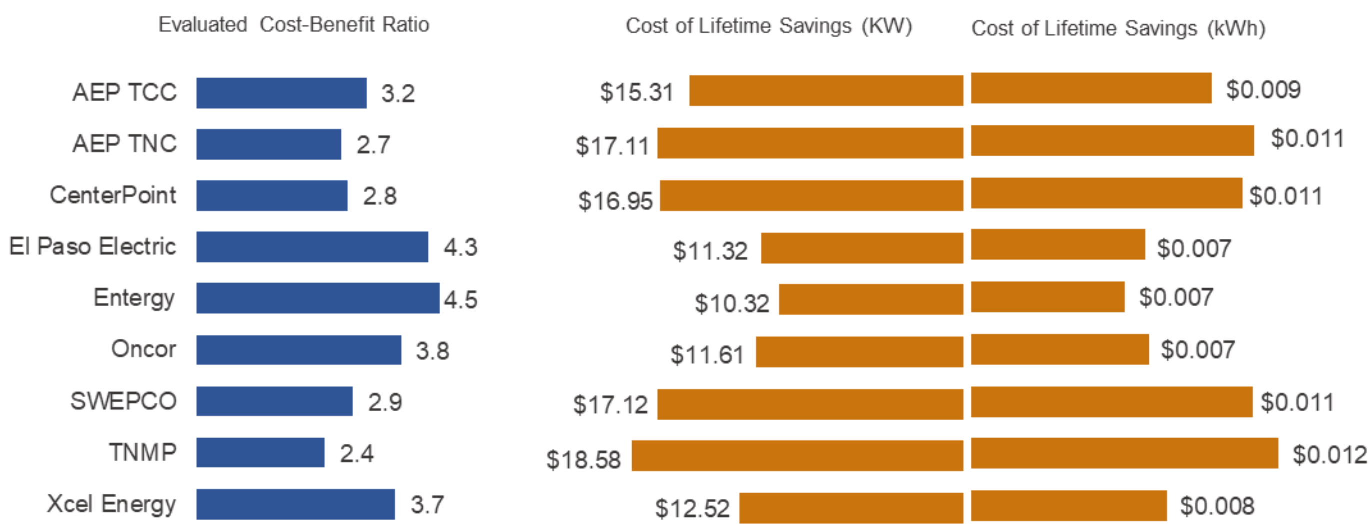


3.1.2 Cost-Effectiveness

Figure 14 summarizes the cost-effectiveness of each utility's commercial energy efficiency portfolio. Commercial sector programs were the most cost-effective with overall cost-effectiveness of 3.4 statewide based on evaluated savings, and 3.1 based on net savings. Utilities' results ranged from 2.4 to 4.5 based on evaluated gross savings, and 2.2 to 4.0 based on evaluated net savings. There is variation in the utilities' results in the commercial sector because of the diversity of program designs offered by the utilities.

Figure 14 also summarizes the cost of lifetime kWh and kW for each utility's commercial sector programs. The cost per kWh ranges from $0.007 to $0.012, and the cost per kW ranges from $10.32 to $18.58. These costs provide an alternate way of describing the cost-effectiveness of a portfolio of commercial programs. Those portfolios with a higher cost-effectiveness ratio will have a lower cost to acquire savings and vice versa.

Figure 14. Evaluated Cost-Benefit Ratio and Cost of Lifetime Savings—Commercial Programs PY2019

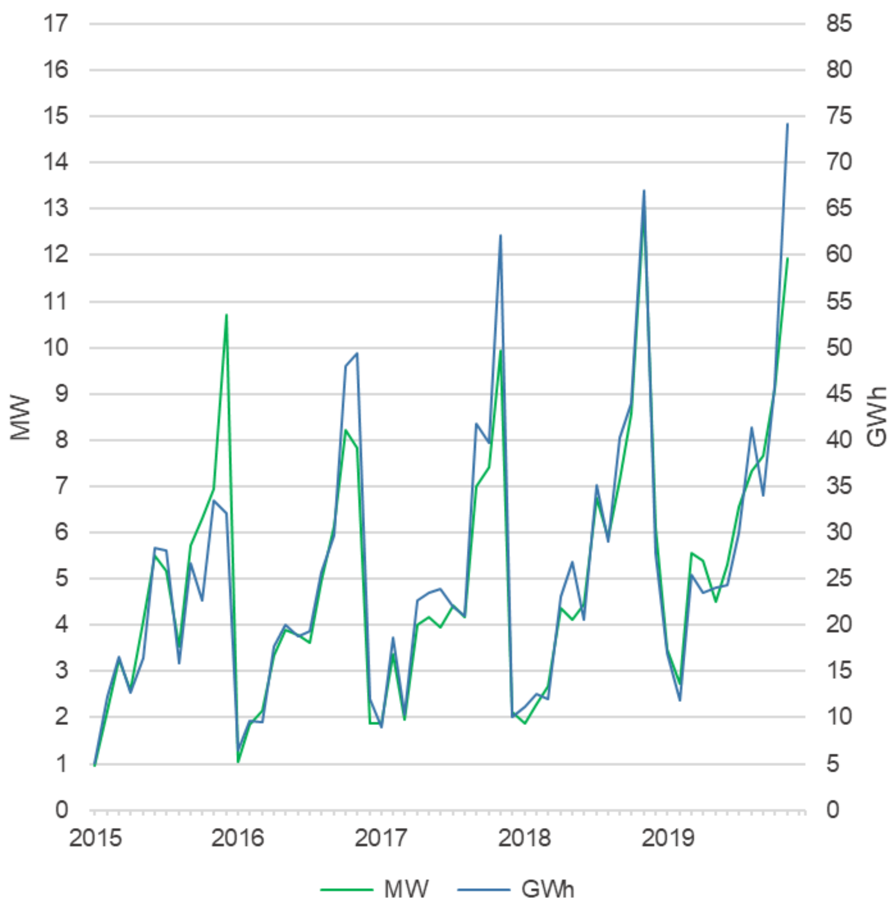


3.1.3 Timing of Project Completion

The commercial programs have a historical pattern that kW and kWh savings are closely linked and that the savings increase monthly as the year progresses, as shown in Figure 15. Each year, the first quarter has lower claimed energy savings as the programs launch the new initiatives. The second and third quarters have increasing savings as the programs gain momentum. The fourth quarter increases momentum further and accounts for more than one-third of the energy savings for the year.

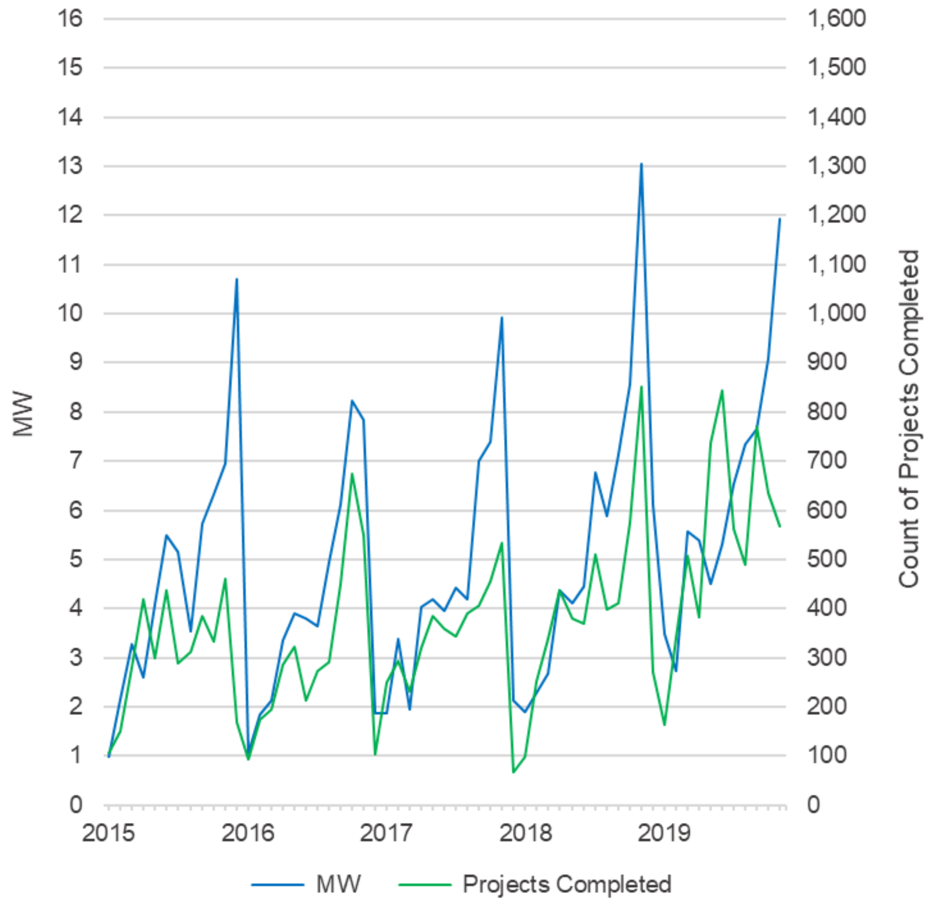
This pattern is typical for commercial programs on an annual cycle; however, the increasing disparity between the fourth quarter and the first quarter of the following year could be smoothed out. In the past four years (2016-2019), the share of the energy savings claimed in the fourth quarter is between 40 percent and 60 percent, which is significantly larger than the other quarters. The increased reliance on the fourth quarter may result in a slower start at the beginning of the next year.

Figure 15. Monthly Evaluated Gross Demand and Energy Savings Over Time—Commercial Programs PY2015-2019



One reason for the increased savings in the fourth quarter is the increased project size. In Figure 16, this is represented by the size of the gap between the *MW* and *project completed* lines in the graph. Larger projects tend to take longer to implement and tend to be finalized near the end of the calendar year to coordinate with participant budgeting cycles. Smaller projects can be completed more quickly at the beginning of the year once incentives are announced. This year many more projects were completed earlier in the year, and the larger projects were completed at the end of the year, which resulted in higher savings in the fourth quarter. This pattern supports the opportunity to more easily carry over projects and momentum into the first quarter of 2020 to reduce the historical first quarter slow down.

Figure 16. Monthly Number of Projects and Evaluated Gross Demand Savings Over Time—Commercial Programs PY2015-2019



If the programs can effectively raise participation in the first quarter, this will alleviate pressure to accelerate programs later in the year and allow for a more even delivery. Savings claimed in the first quarter will alleviate pressure for high performance in the fourth quarter and allow for better preparation for the January launch and increased early participation. Interviews with utilities found that a strong project pipeline in the first quarter of 2020 helped alleviate some program pressure due to the pandemic.

3.2 COMMERCIAL STANDARD OFFER PROGRAMS

3.2.1 Evaluation, Measurement, and Verification Overview

Commercial SOP programs were *medium* evaluation priorities in PY2019. These programs continue to comprise a substantial percentage of the overall statewide portfolio savings. The EM&V team conducted desk reviews and on-site M&V for a sample of projects from these programs.

For the desk reviews and on-sites, the EM&V team applied the method prescribed in the PY2019 TRM 6.0 to verify energy savings and demand reduction for each project sampled. Comparing the evaluated savings to the utility claimed savings showed agreement in most cases. The average realization rates across all SOP programs were 80.2 percent and 108.0 percent for demand and energy savings, respectively.[12] Based on the results of the evaluation, the EM&V team has outlined key findings and corresponding recommendations, described below.

3.2.2 Key Findings and Recommendations

Key Finding #1: The building type utilized in the energy savings calculation does not always reflect the predominant facility use.

Commercial interior lighting and HVAC project analysis requires proper building type selection as guided by tables within the TRM. For lighting, these tables provide guidance for operating hours and summer peak coincidence factor for a variety of building types. The HVAC building type tables provide guidance for heating and cooling estimated full load hours and demand factors based on the building type and HVAC system type. In some cases, facilities could reflect multiple potential building types, although only one should be selected for energy savings calculations.

The building type selection should match the predominant indoor facility use type based on the surface area. Below are several examples of potential conflicts in building type that have been encountered during evaluation:

- A medical clinic with a larger underground parking area is considered a medical clinic, not underground parking.
- An arts-based high school with many rehearsal and auditorium spaces is considered a high school, not public assembly.
- A manufacturing facility that has been augmented to be a warehouse with small custom adjustments to products should be considered a warehouse, not a manufacturing facility.

Recommendation #1a: Use the predominant building use based on the surface area to select the building type for energy savings calculations.

Key Finding #2: Major building retrofits that change the building type did not use the most appropriate baseline.

The Texas TRM differentiates between *new construction* projects and *retrofit* projects for the baseline used in energy savings calculations. A small number of retrofit projects also include a change in building use. For example, a conversion of (1) a warehouse to an indoor sports area, (2) a retail building to a religious building, or (3) a manufacturing building to a warehouse. These conversions require different HVAC loads and lighting requirements from the original facility type; however, the energy savings calculations should not include the adjustment in the baseline needs between the two facilities. The new facility energy efficiency potential is not that it is replacing a more or less energy-intensive business, but rather that it is more efficient than a standard option installed for that building use or type.

The Texas TRM does not include a major retrofit category different from a standard retrofit and new construction.

Recommendation #2a: Update the TRM to provide guidance on energy savings calculations for major retrofit projects with a building type change.

[12] These are realization rates prior to utilities adjusting savings based on evaluation results.

Key Finding #3: LED lighting wattage continues to need small adjustments to match DLC or ENERGY STAR-qualified product lists.

The lighting savings calculations had a significant amount of wattage adjustments for installed lighting equipment. The adjustments had two primary reasons: (1) the LED lighting manufacturer wattages were used instead of wattages from the DLC or ENERGY STAR-QPL, and (2) the half-watt denominations allowed by the TRM were not utilized. The half-watt adjustment was introduced in PY2018 affecting fixtures under 25 watts and has been extended in PY2019 to include all wattages for more accurate savings calculations and increased consistency. The use of the manufacturer wattage in the energy savings calculation should be corrected to match QPL-listed wattage. Most projects included documentation of the equipment, which lists the QPL wattage.

Recommendation #3a: Update the savings calculation process to ensure the use of QPL-listed wattages for installed equipment and continue to implement half-watt increment rounding.

Key Finding #4: Existing lighting fixtures that remain in place post-installation were excluded from post-install lighting inventory.

Lighting retrofit projects may install new fixtures in locations different from where the existing lighting fixtures are located. Some projects have the ability to allow the existing lighting fixtures to remain in place without impacting the performance of the new lighting fixtures. When the existing fixtures are not removed, these fixtures must be counted in the post-install lighting inventory.

In this situation, although the existing fixtures are intended to be off all the time, over the life of the new equipment, it is possible that the existing lighting fixtures may be switched on as part of the building's operations.

Recommendation #4a: State in the TRM that the existing lighting fixtures remaining after the lighting retrofits are still considered installed and should be included in the post-install lighting inventory.

Key Finding #5: Efficiency of split systems determined using the manufacturer's test results needs to align the published system efficiencies with a common condenser unit.

Split systems require that a condenser and air handler be paired to determine cooling capacity and energy efficiency. The condenser unit is the key component and is typically listed with several air handling units on AHRI's listings. The efficiency and capacity of the condenser and air handler pairing should be used in the energy savings calculations. When those values are not available, the manufacturer's test results are acceptable as long as they do not exceed the median of all AHRI-listed air handling units paired with the installed condenser unit.

In this case, the necessary documentation for an unlisted split system pair should include all AHRI-listed air handling units paired with the installed condenser unit and the associated efficiencies. Doing so will prevent having to rely solely on the manufacturer's test results and risking an overestimation of the energy savings.

Recommendation #5a: Update the TRM to provide more guidance for determining the efficiency of split systems. Split systems should use the AHRI-listed efficiency of the condenser and air handler pair installed. When a split system pair is not AHRI-listed, then the efficiency submitted by the manufacturer is acceptable with a maximum value of the median AHRI-listed efficiency of the pair, including the condenser.

3.3 COMMERCIAL MARKET TRANSFORMATION PROGRAMS

This section presents results for the Commercial Solutions, SCORE, Retro-Commissioning, and Small Business MTPs that were a *medium* evaluation priority in PY2019[13, 14].

3.3.1 Evaluation, Measurement, and Verification Overview

The EM&V team conducted desk reviews and on-site M&V for a sample of projects from the medium priority commercial MTP programs. For the desk reviews and on-sites, the EM&V team applied the method prescribed in Texas TRM 6.0 to verify energy savings and demand reduction for each project sampled. Comparing the evaluated savings to the utility-claimed savings showed agreement in most cases. The average realization rates across MTP programs that received desk reviews and on-site M&V are outlined in Table 11.[15] The statewide realization rates for the different MTPs are shown below to provide additional context to the key findings and recommendations.

Based on the results of the evaluation, the EM&V team has outlined key findings and corresponding recommendations, described below.

Table 11. Realization Rates for Market Transformation Programs

Program	Realization rate (kW)	Realization rate (kWh)
Commercial Solutions MTP	92.0%-100.7%	99.0-100.2%
SCORE MTP	78.7%-107.0%	83.0%-107.3%
Retro-Commissioning MTP	100.0%-100.1%	100.0-100.2%
Small Business MTP	91.3%-100.0%	90.3%-100.3%

3.3.2 Key Findings and Recommendations

3.3.2.1 Large Commercial Market Transformation Programs (Commercial Solutions MTP and SCORE MTP)

All key findings and recommendations outlined for the SOP programs in Section 3.2 are equally relevant to the Large Commercial MTPs (Commercial Solutions MTP and SCORE MTP). Some MTPs include the use of M&V methodology to claim savings for some projects, and the Retro-Commissioning MTP findings and recommendations are relevant to those projects.

The EM&V team identified an additional finding related to Key Finding #1 discussed in section 3.2.2:

Key Finding #1: Exterior area was considered when determining the facility use based on multiple kinds of square footage.

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[13] Solar Photovoltaic programs were considered a *low* evaluation priority and only received a tracking system review in PY2019.
[14] CoolSaver AC Tune-Up is discussed in section 5.0.
[15] These are realization rates prior to utilities adjusting savings based on evaluation results.

The building type selection should be based on interior square footage. Exterior square footage for specialty areas, such as fields or auditoriums, should be entered in the exterior lighting calculation and not affect the interior lighting calculation.

Recommendation #1a: Recommendation #1a, noted in Section 3.2.2, is still relevant here.

3.3.2.2 Retro-Commissioning Market Transformation Program

The M&V methodology is used to claim energy savings for retro-commissioning, behavioral, operational, controls, or custom energy savings. The M&V methods provide a framework to provide high-quality verified savings for projects that cannot be readily isolated through engineering equations or modeling and provide significant energy savings. This process opens energy efficiency programs to identify and claim savings from more complicated projects where the interactive effects or operation protocols do not match those described in the TRM. Improvements in M&V equipment and techniques are allowing this energy efficiency claiming type to be used more frequently, which can create more accurate claimed savings.

The projects include the M&V plan and results to determine a normalized baseline from previous consumption records and an improved normalized consumption based on consumption records after the improvement. The protocol, described in Volume 4 of the TRM, requires comprehensive projects to be compliant with IPMVP-Option C and should have the expectation of savings greater than 10 percent of utility bill (or sub-metered) energy use. The analysis should have a coefficient of determination (R^2) equal to or above 75 percent. The process includes tools for the M&V expert to help manage the data to support a clean and relevant equation to develop a normalized energy consumption.

Key Finding #1: M&V claimed savings modeling could be improved to enhance the accuracy of energy savings calculations.

The M&V methodology creates energy savings claimed for commercial and industrial (C&I) projects that are based on actual operations and can be very accurate. But, in the calculation process, the method requires custom decisions and assumptions for the modeling of each project. The EM&V team found that assumptions and modeling could be improved to increase the accuracy of the savings calculated, although there was not a consistent, identifiable decision which could be improved. Detailed below are the individual modeling assumptions and processes identified by the EM&V team that should inform modeling improvements in the future.

- **Electric consumption billing data detail.** The ideal electric consumption billing data measurement frequency is hourly or shorter to create a robust model of the facility operations. For C&I projects that have consistent daily or monthly profiles throughout the year, the daily and monthly measurement frequencies can produce consumption models that are of equal quality. However, for C&I projects that have non-consistent variables, such as weather or occupancy, the daily and monthly measurement frequencies can produce consumption models with variable accuracy.

  Furthermore, the peak demand calculation method relies upon electricity consumption during a critical hour. Daily or monthly data do not provide the detail necessary to measure demand reduction. When the detail is not available, the M&V analysis requires an engineering judgment calculation to correlate the peak demand at the top 20 hours, which introduces risk for both the baseline and improved peak demand values.

- **Match data collection frequencies and increments**. Electric consumption data, in many cases, are collected by multiple data collection meters or site meters throughout the project. The calculations require that the data used to develop each regression model needs to have the same frequency reading and increment of measurement.
- This year, the EM&V team identified projects which the billing meter data measured in 9 kW increments, which made the regression model highly dependent on the rounding of the actual measurement. Modeling the energy consumption increment created a different consumption pattern versus a smaller increment. In addition, the data collection increased the frequency of readings from once an hour to once every five minutes partway through the post-install measurement period. The increased frequency of the reading provided better detail to develop a regression model. Although when combining the data from the two meters, it is necessary to match the increment of measurement (once an hour) because the regression modeling evenly weights each measurement point. In this case, without the adjustment to the increment, the new meter readings every five minutes increased their importance by 20 times over the hourly readings (because there are 20 five-minute readings per hour) in the regression model.
- **Peak demand calculation from M&V projects requires relevant data for the top 20 peak demand hours.** Regression models identify statistically relevant energy consumption trends. This process eliminates the outlier data points so that they do not augment overall consumption, which is the ideal process to follow when determining annual consumption (kWh). However, the TRM definition of peak demand requires an analysis of the consumption during times that are considered outliers.

  The M&V analysis for the winter and summer peak demand (kW) is different from annual consumption analysis (kWh). Therefore, a different approach should be utilized to capture the peak period more specifically.
- **The peak kW calculation of RCx projects must evaluate the whole system.** M&V projects determine the peak demand savings of the entire system. For projects that claim savings only through the regression model, the whole system winter or summer peak is evaluated. Although when prescriptive projects occur within the M&V data collection period that claims savings separately, those values are subtracted from the modeled M&V savings to eliminate double counting. The peak demand savings periods, winter or summer, must match for both the prescriptive project and the M&V period to determine the peak savings for the whole system.

  Multiple measures at the same facility, including RCx and HVAC system interaction, should sum the summer peak or sum the winter peak. A combination of summer peak for one component and winter peak for another component claims more peak demand reduction than the project provides.
- **Baseline period consistency should be improved.** The TRM requires one year of pre-install data for a regression model baseline[16]. The TRM does not define the acceptable period for that data or how to handle non-routine events (NRAs) during that period.

  The baseline model should be developed from the pre-install data from the 365 days immediately before the start of the project. Adjustment should be allowed from the

[16] Where less than a year of data is not feasible, methodologies should be considered on a case-by-case basis and agreed upon with the M&V team.

previous 365-day measurement period and account for NRAs, as applicable. Required documentation must, however, include a clear justification of the adjustments in the M&V plan.

Recommendation #1a: Update the TRM (Volume 4, section 2.4, M&V Miscellaneous) to increase the consistency of the calculation process, and the accuracy of savings for M&V claimed energy savings.

Key Finding #2: On-site evaluation of RCx projects shows that the customers could benefit from follow-up after monitoring has started.

On-site conversations between the building operators and the EM&V team during M&V on-site visits identified improvements in energy efficiency that are still available after the project completion. Throughout the measurement period (12 months following project completion), equipment and controls can continue to be refined and new opportunities identified to increase energy savings over time, which is a typical continuous improvement process.

However, the current M&V process analyzes savings in the 12-month measurement period, then applies those savings to the five-year EUL (estimated useful life). Therefore, any continuous improvement actions that occur during the measurement period only receive partial value during the five-year EUL period. If continuous improvement occurs after the measurement period, no value is claimed by the energy efficiency program.

An alternative approach to encourage continuous energy improvement throughout the EUL will support best practices for participants in the program and may lead to more accurate energy savings calculations.

Recommendation #2a: Update the TRM (Volume 4, section 2.4: M&V Miscellaneous) to include an alternate calculation approach to encourage continuous improvement at the participant facility.

3.3.2.3 Small Business Market Transformation Program (Including Open Market Transformation Program)

Key Finding #1: More detailed documentation is needed to perform the calculations for the *weather stripping* measure.

Building envelope energy-efficiency measures, such as weather stripping, are more dependent on the detail and quality of the installation compared to other equipment-based measures.

The *non-residential weather stripping* measure is included in the TRM as the *entrance and exit door infiltration* measure; this measure applies to the installation of weatherstripping or door sweeps on entrance and exit doors for a contained, pressurized space. Entrance and exit doors often leave clearance gaps to allow for proper operation. The gaps around the doors allow for the infiltration of unconditioned air into the building, adding to the cooling and heating load of the HVAC system.

Weatherstripping and door sweeps are designed to be installed along the bottom and jambs of exterior doors to prevent air infiltration to conditioned space. When not installed properly, air can still flow through the remaining gaps limiting the energy savings potential. Therefore, care should be taken to ensure proper sealing for the entire length, as well as proper corner sealing at the joints, and the maximum coverage is achieved. Weatherstripping type and install location should be selected to minimize gaps.

The submitted documentation for weatherstripping should become more detailed. The EM&V team recommends using a 1/8-inch increment for all lengths and widths associated with this measure. Additionally, the building type, heating type, and cooling type should be clearly documented in addition to the calculation work and result.

The calculation of energy savings should evolve to account for the air movement through remaining gaps, as well as the air movement impeded by the weatherstripping.

Recommendation #1a: Update the *non-residential entrance and exit door infiltration* measure (section 2.3.3 in Volume 3 of the TRM) to account for the remaining open area and clearly indicate the detail of documentation collected on-site.

Key Finding #2: Lighting controls are rarely installed in small business projects.

The EM&V team noted that 4 of the 43 sampled small business lighting projects claimed lighting controls savings. Based on the evaluation of lighting retrofit projects, it is believed that there is an opportunity to increase per-project energy efficiency savings by five percent or more by focusing on increasing the number of wall-based occupancy sensors installed.

Recommendation #2a: Consider an increased use of wall-based occupancy sensors as a larger part of the Small Business program delivery.

Key Finding #3 and Recommendation #3a discussed in section 3.2.2 are equally relevant to small business projects.

4.0 RESIDENTIAL ENERGY EFFICIENCY PROGRAMS

4.1 SUMMARY RESULTS

This section presents the residential sector results from all relevant EM&V activities.

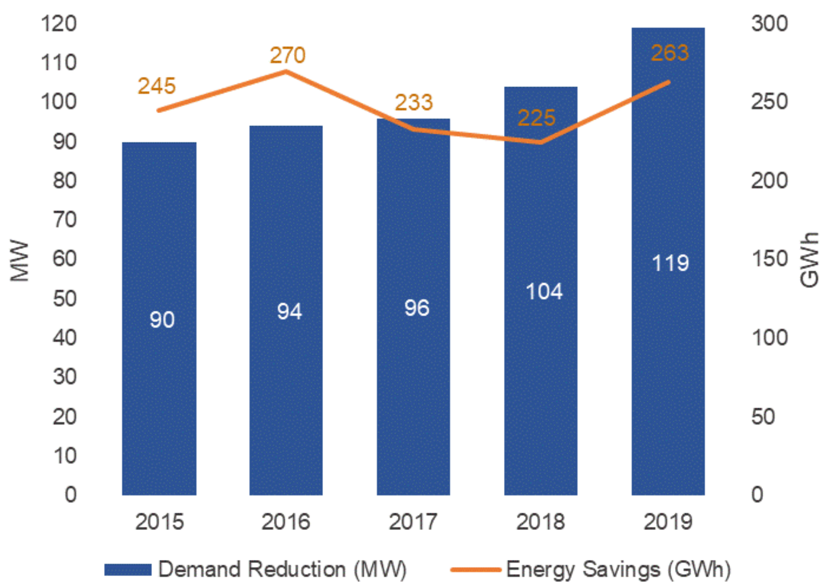
4.1.1 Savings

Statewide PY2019 evaluated gross savings from residential sector programs was:

- 118,911 kW (demand reduction); and
- 262,656,084 kWh (energy savings).

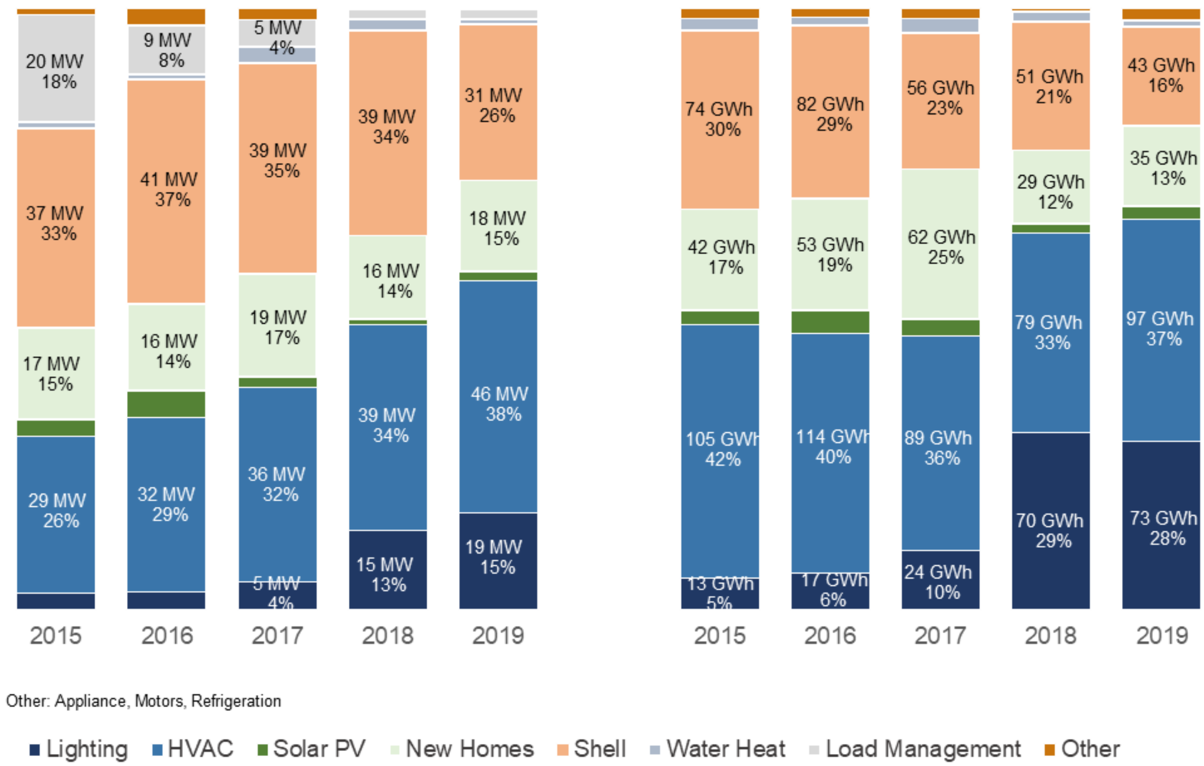
As seen in Figure 17, the demand reduction achieved in PY2019 was the highest since the evaluation started in PY2012. Energy savings were higher in PY2019 than in recent years. A TRM update decreasing residential envelope measures came into effect in the PY2017 TRM. PY2019 residential savings are approaching PY2016 levels prior to the TRM envelope measure update.

Figure 17. Total Statewide Evaluated Gross Demand Reduction and Energy Savings by Program Year—Residential Programs PY2015—PY2019



For PY2019, the majority of residential demand savings (excluding load management) was derived from HVAC. The majority of energy savings was also from HVAC (37 percent), closely followed by lighting (28 percent). New homes and shell measures make up a majority of the remaining savings (13 percent and 16 percent, respectively). Figure 18 presents the breakdown of savings by measure category and demonstrates that the utilities have been successful in diversifying their measure mix for residential savings.

Figure 18. Distribution of Statewide Evaluated Gross Demand Reduction and Gross Energy Savings by Measure Category—Residential Programs PY2015—PY2019

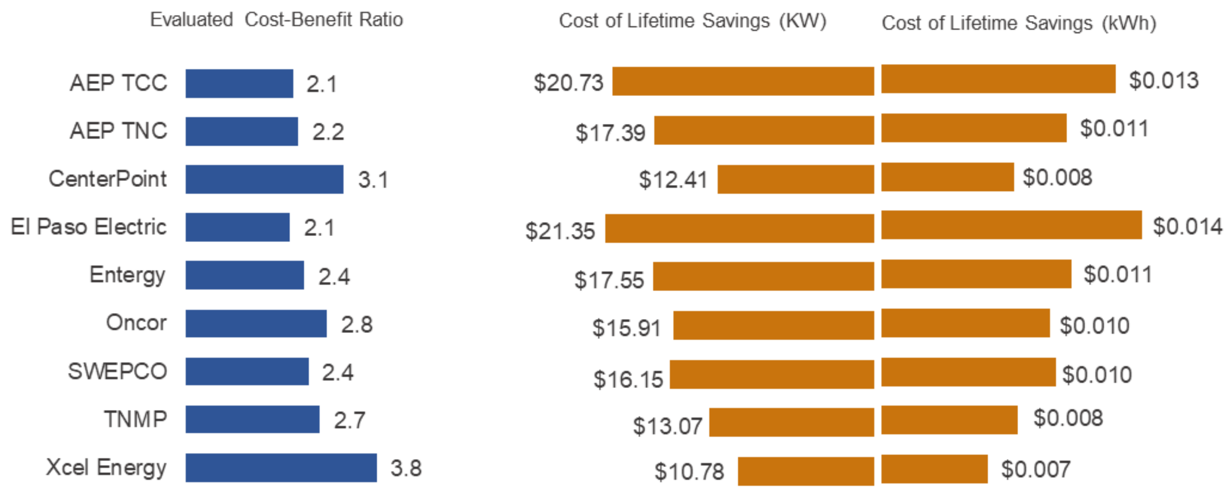


4.1.2 Cost-Effectiveness

Residential sector programs' cost-effectiveness statewide is 2.8 based on evaluated gross savings, and 2.4 based on evaluated net savings. Like the commercial sector, the residential sector cost-effectiveness varied among utilities, with evaluated gross savings results ranging from 2.1 to 3.8 and evaluated net savings results ranging from 1.9 to 3.5. As with the commercial sector, this is in part due to the differences in the types of programs offered by different utilities.

Figure 19 summarizes the cost-effectiveness of each utility's residential energy efficiency portfolio and the cost of lifetime kWh and kW for each utility's residential sector programs. The cost per kWh ranges from $0.007 to $0.014, and the cost per kW ranges from $10.78 to $21.35. These costs provide an alternative way of describing the cost-effectiveness of a portfolio of residential programs. Those portfolios with a higher cost-effectiveness ratio will have a lower cost to acquire savings and vice versa.

Figure 19. Evaluated Cost-Benefit Ratio and Cost of Lifetime Savings—Residential Programs PY2019



4.2 RESIDENTIAL STANDARD OFFER, HARD-TO-REACH, AND LOW-INCOME PROGRAMS

4.2.1 Program Overviews

The EM&V team evaluated the residential energy efficiency programs described below. Like the commercial energy efficiency programs, there are residential SOPs and MTPs. The residential SOPs provided by the Texas utilities offer standard incentives for a wide range of measures that are bundled together as a project to reduce system peak demand, energy consumption, and energy costs. The residential MTPs offered in Texas are designed as a strategic effort to make lasting changes in the market that result in increased adoption of energy-efficient technologies, services, and practices. MTPs are designed to overcome specific market barriers that prevent energy-efficient technologies from being accepted. On the residential side, HTR and LI programs are also offered and were developed to provide comprehensive energy efficiency retrofits for single and multifamily customers who meet the income guidelines of the program.

Residential SOP: The Residential SOP provides incentives to project sponsors for a wide range of retrofit measures that reduce demand and save energy in single-family and multifamily buildings. Residential SOPs target retrofit measures for residential customers, with incentives paid to project sponsors for qualifying measures that provide verifiable demand and energy savings. The program is open to all qualifying energy efficiency measures, including, but not limited to air conditioning, duct sealing, weatherization, ceiling insulation, water-saving measures, and ENERGY STAR windows.

Hard-to-Reach SOP: The Hard-to-Reach SOP provides incentives to project sponsors for a wide range of retrofit measures that reduce demand and save energy in residential buildings. This program is available to customers whose annual total household income is at or below 200 percent of current federal poverty guidelines. Incentives are paid to project sponsors for qualifying installed measures such as air conditioning, air conditioner tune-ups, duct sealing, weatherization, ceiling insulation, water-saving measures, and ENERGY STAR windows.

Residential Solutions MTP: The Residential Solutions MTP provides incentives to customers—through participating contractors—for a wide range of retrofit and new construction measures that reduce demand and save energy in residential buildings. The program also provides technical assistance and education on energy efficiency measures. This program is operated by one utility and is included in this section as it operates similarly to an RSOP.

Hard-to-Reach Solutions MTP: The Hard-to-Reach Solutions MTP provides incentives to customers—through participating contractors—whose annual total household income is at or below 200 percent of current federal poverty guidelines. Incentives are provided for a wide range of retrofit and new construction measures that reduce demand and save energy in residential buildings. The program also provides technical assistance and education on energy efficiency measures. This program is operated by one utility and is included in this section as it operates similarly to an HTR SOP.

Targeted Low-Income Solutions: The Targeted Low-Income Solutions program offers an energy audit to qualified low-income residents of Texas. Alternatively, the program offers a review of the home's energy efficiency and installation of weatherization measures to increase the energy efficiency of their home. A household qualifies if the income is at or below 200 percent of the federal poverty guidelines, and their home must be able to benefit from being weatherized. Then, after the audit is completed, the program gives financial and installation assistance to improve the energy efficiency of the home.

4.2.2 Key Findings and Recommendations

Key Finding #1: Residential programs are delivering substantial energy savings and winter and summer peak demand reductions, but results vary across utilities and program types.

On average, across the ERCOT utilities, RSOPs are reducing households' annual energy use by approximately eight percent. However, results ranged across utility programs from two percent to ten percent of annual consumption. Higher-performing programs are successfully including HVAC equipment.

On average, HTR programs are saving five percent of participants' annual energy use, with fairly consistent results across utility programs ranging from five to seven percent. HTR programs are saving less energy than residential and LI programs, and these savings have decreased since the 2015 consumption analysis. While not commonly implemented, wall insulation showed solid savings in the consumption analysis, and limited HVAC measures have been completed to date for this sector.

LI programs are the highest savings residential program, with results across utilities ranging from 11 to 21 percent of participants' annual energy use. LI programs use the SIR cost test instead of the program administrator cost test and, therefore, can implement more measures. The implementer of the highest saving LI program has implemented innovative strategies with service providers.

Recommendation #1a: Consider best practices from the highest-saving residential programs to increase overall savings delivered to customers statewide.

Key Finding #2: The consumption analysis performed by the EM&V team found that for the primary residential measures investigated, the deemed savings in the TRM are overestimated.

The EM&V team conducted a consumption analysis comparing the performance of implemented measures versus the TRM deemed savings values. A comparison of the consumption analysis results at the measure level, indicate the researched TRM deemed savings are consistently overestimating actual savings at varying levels as described below. The EM&V team targeted envelope measures including air infiltration and ceiling insulation as well as HVAC measures such as duct sealing and AC and heat pump systems. The results showed that residential AC deemed savings are closest to actual consumption, and air infiltration and ceiling insulation are the most overstated.

Generally, the AC measure roughly matched TRM savings at 75.7 percent of TRM energy savings. However, the HP measure only achieved 42.7 percent of TRM energy savings. The EM&V team found that the heating savings associated with an electric resistance baseline are the most overstated.

The EM&V team found that envelope measures such as ceiling insulation and air infiltration were achieving just 25.9 percent and 2.3 percent of TRM energy savings, respectively. The ceiling insulation TRM savings for existing insulation under R-5 is exponentially greater than the TRM savings for R-5 and above and may be overstated. Discrepancies in savings coming from the air infiltration measure are likely due to testing methods and differences in multifamily versus single-family. In addition, the EM&V team's prior research suggests that air infiltration may not be properly implemented as the EM&V team has found major air leaks during prior on-site inspections.

The EM&V team found that the duct sealing measure achieved 57.4 percent of TRM energy savings. Looking at the savings comparison of single-family homes versus multifamily homes, the EM&V team found the percent of TRM savings for single-family to be 60.4 percent and multifamily to be 22.6 percent. This difference is likely due to the probability that the ducts in a multifamily building are located within conditioned space and special considerations should be added to the TRM for multifamily savings.

The EM&V team is also considering behavioral differences as reasonable cause for a portion of the discrepancies in savings. The *snapback* effect is a phenomenon where energy efficiency reduces the marginal cost of energy; therefore, energy consumption will increase, offsetting any gains achieved by the efficiency measures.

Recommendation #2a: Update the PY2021 TRM to increase the accuracy of the deemed savings for residential retrofit programs. The TRM working group will update the following measures for the PY2021 TRM: AC, heat pumps, duct sealing, ceiling insulation, and air infiltration. The TRM working group will examine baselines, testing and documentation requirements, and special considerations for multifamily projects to improve the accuracy of savings.

Recommendation #2b: Develop and deliver customer education on energy conservation and the proper use of installed equipment along with the energy efficiency measures to address the *snapback* effect.

Recommendation #2c: Identify needs and support the training of implementation contractors to address measures that may be improperly implemented and, therefore, not delivering savings as intended.

4.2.3 Impact Results

Residential retrofit programs were designated as *high* evaluation priorities for PY2019. These programs continue to comprise a considerable percentage of residential statewide portfolio savings and have been responding to substantial TRM updates to the envelope measures. As part of the impact evaluation, the EM&V team conducted a consumption analysis of the ERCOT utilities' residential SOPs—including HTR and LI—to evaluate energy and demand impacts.

Similar to the consumption analysis conducted as part of the PY2015 evaluation activities, the goal of the PY2019 consumption analysis was to help the EM&V team, the PUCT, Texas electric utilities, and other stakeholders to better understand the savings resulting from the measures installed through the residential existing homes programs. The findings and recommendations previously discussed will inform updates to the TRM for PY2021.

Overall the EM&V team found that, while the programs are delivering substantial savings to customers, the researched residential measures in the TRM are generally overestimating savings. In addition, savings differ across program types and across utilities. The EM&V team conducted a consumption analysis of PY2018 RSOP, HTR SOP, and LI program participants. Technical Appendix 1 presents a detailed version of the consumption analysis methodology. This report section summarizes both the methodology and approach and readers interested in more detail should consult the Technical Appendix.

4.2.3.1 Methodology

The consumption analysis focused on major measures that contributed significant portions of the residential portfolio statewide. We included PY2019 participants in the analysis as a comparison group by analyzing changes in their meter data before receiving any measures.

We received 15-minute interval meter data for over 33,000 PY2018 participants covering January 1, 2017, through December 31, 2019. This time period ensured that we had at least twelve months of data before and after these customers received measures. We received meter data for over 29,000 PY2019 participants covering the same time frame, which we filtered down to the dates before they received a measure. We screened both groups for a number of criteria as part of our data cleaning process, resulting in approximately 65 percent of each group remaining in the analysis sample. The full details of the screening process are in Appendix 1-B: Screening Criteria Details.

Next, we combined the screened meter data with observed weather from the National Oceanic and Atmospheric Administration (NOAA) as well as typical weather from the typical meteorological year 3 (TMY3) dataset from the National Renewable Energy Laboratory (NREL). We used these weather data to weather-normalize metered energy consumption. This process estimates a household's energy usage under typical weather conditions, minimizing the impact of extreme temperatures on the resulting energy consumption estimates. We optimized each household's weather-normalized energy consumption using a series of regressions that model the home's response to weather under different temperature settings. The resulting weather-normalized energy consumption provides the basis for the remaining analyses. Appendix 1-A: Supplemental Information on Weather Data provides a detailed description of the weather-normalization process.

4.2.3.2 Consumption Analysis Summary Results

Using the weather-normalized energy consumption, we implemented a series of program- and measure-level fixed-effects models to estimate the energy savings and demand reduction resulting from the programs. The programs overall save between 4.9 percent (for HTR SOP) and 15.9 percent (for LI) of participating households' pre-treatment energy usage. These results are net savings and include a decrease from a comparison group that accounts for external factors to the program. See Table 12.

Table 12. Program-Level Consumption Model Results Compared to Pre-Treatment Usage

Program Group	n	Normalized Energy Consumption, Pre-treatment (kWh)	Model Savings (kWh)[17]	Savings as % of Normalized Energy Consumption
Residential SOP	13,988	16,067	1,228	7.6%
Hard-to-reach SOP	6,501	13,771	681	4.9%
Low-income	1,808	11,255	1,794	15.9%

While the analysis shows that the programs save a sizeable amount of energy for participants, we found that the consumption data analysis resulted in much lower savings than estimated by the TRM. All three program types are saving around a third of TRM deemed savings estimates, ranging from 30.1% for the HTR SOP to 38.6% for the RSOP. See Table 13.

Table 13. Program-Level Consumption Model Results Compared to TRM-Calculated Savings

Program Group	Average Model Savings (kWh)	Average TRM Savings (kWh)	Model Savings as a Percentage of TRM
Residential SOP	1,228	3,182	38.6%
Hard-to-reach SOP	681	2,263	30.1%
Low-income	1,794	4,700	38.2%

The results vary by measure. Central air conditioners (AC) are the measure with results where savings estimates between the consumption data model results and the TRM deemed savings are the closest. In contrast, air infiltration had the widest discrepancy between consumption analysis results and TRM deemed savings. See Table 14.

Table 14. Measure-Level Consumption Model Results as Percentage of TRM-Calculated Savings

Measure	RSOP	HTR SOP	LI
AC	75.3%	153.9%*	84.7%*
Air Infiltration	-4.6%	13.4%	18.3%
Ceiling Insulation	17.3%	32.7%	87.7%
Duct Sealing	57.3%	67.7%	135.1%*
Heat Pump	44.6%	43.2%	34.7%

*Result is based on fewer than 50 observations and should be treated as qualitative.

[17] The model savings are adjusted by the energy change seen in the comparison group across the same time period as the participant group.

The EM&V team applied the peak demand methodology described in the TRM, identifying the top 20 hours per weather station and comparing average demand across these hours between the pre- and post-treatment periods. These results show the programs are generating peak demand reductions even more effectively than energy savings, particularly in the winter peak period. See Table 15.

Table 15. Program-Level Consumption Model Peak Demand Reduction

Program	Peak Period	Weather-Normalized Peak kW, Pre-treatment	Peak kW Reduction	Reduction as % of Pre-Treatment Peak
RSOP	Summer	4.83	0.86	17.7%
	Winter	4.83	1.14	23.6%
HTR SOP	Summer	3.19	0.51	16.1%
	Winter	4.38	0.88	20.2%
LI	Summer	3.01	0.71	23.6%
	Winter	3.66	1.24	33.8%

The measure-level peak demand reductions are similar to the measure-level energy savings results, except for duct sealing. Either the TRM underestimates winter peak demand reductions for this measure or utilities are not claiming the winter peak for the measure. See Table 16.

Table 16. Measure-Level Consumption Model Peak Demand Reduction

Measure	Summer Peak			Winter Peak		
	RSOP	HTR SOP	LI	RSOP	HTR SOP	LI
AC	68.7%	74.2%*	47.1%*	n/a		
Air Infiltration	-9.4%	-0.1%	4.5%	-0.6%	5.3%	31.7%
Ceiling Insulation	6.5%	16.8%	25.0%	18.1%	27.7%	37.5%
Duct Sealing	18.3%	22.9%	133.7%*	172.6%	250.4%	247.8%*
Heat Pump	13.7%	9.5%	10.4%	53.8%	36.1%	23.8%

*Result is based on fewer than 50 observations and should be treated as qualitative

4.2.4 Process Results

This section summarizes findings from the process surveys completed with PY2019 participating EESPs for residential SOPs including HTR and LI.

Key Findings

- The energy efficiency programs have influenced the EESP's business practices towards energy efficiency improvements and recommendations for their customers.
- EESPs are satisfied with all program aspects. Highest satisfaction was for the support received (33 of 50 respondents). Responses to questions or concerns from the utilities saw the most mentions of *very satisfied* (30 of 50 respondents).

Study Methodology

The EM&V team pulled a list of all PY2019 participating RSOP EESPs from the EM&V database. Because the EM&V team was targeting 50 completed surveys and the total number of participating EESPs was 276, a census was taken to determine who will be contacted for this effort. A total of 50 surveys were completed between May 8, 2020, and June 22, 2020, with a response rate of 18 percent. The average interview length of the telephone surveys was 17 minutes. See Table 17.

Table 17. Residential Standard Offer Program Energy-Efficiency Service Provider's Survey Response Rate

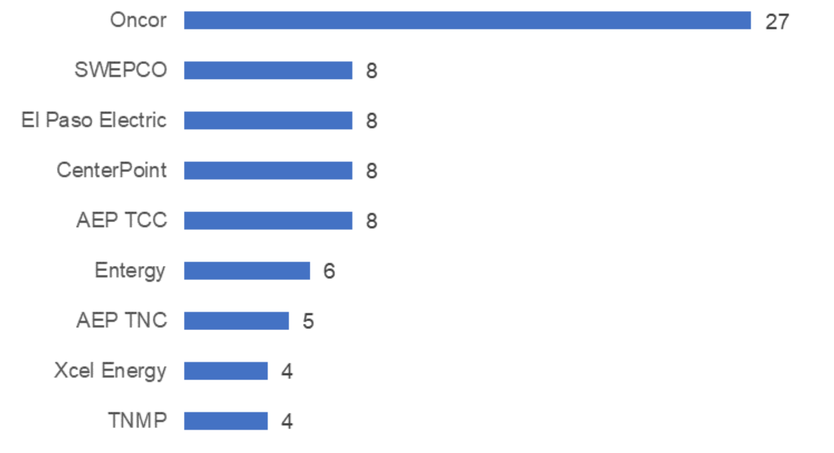
Dispositions	Overall
Sample	**276**
Not a utility customer	0
Affiliated with utility	0
Eligible sample	**276**
Does not recall participating	6
Incompletes (partial surveys)	10
Not completed	210
Completed	50
Response Rate	
Response rate (completed/eligible sample)	**18.1%**
Average survey length (minutes)	**17.2**

The EM&V team designed the survey around key researchable topics aimed to understand how the programs are operating from the EESPs' perspectives. Questions covered motivators and barriers to participation, satisfaction, needed improvements, and program influence. The surveys were first completed through a web survey (38 completes). Follow-up surveys were then completed in Tetra Tech's in-house survey research center (SRC) using computer-assisted telephone interviewing software (CATI) to achieve the total target of 50 completes.

Firmographics

All 50 surveyed EESPs have installed energy-efficient equipment or provided services through one or more of the nine electric utility companies shown in Table 18 below. Oncor saw the most reported participation, with over one-half of the respondents submitting projects through its RSOP programs.

Table 18. EESP Reports of Residential Standard Offer Program Project Submission by Utility Company (n=50)



*Source: EESP Survey Question P3. Results may exceed the number of respondents because more than one answer was allowed.

Figure 20 and Figure 21 show the services and products that the EESPs offer in Texas compared to the services and products provided through both residential and HTR SOPs. HVAC equipment and services were reported the most for residential SOP EESPs, whereas HTR SOP EESPs reported more weatherization-related services, such as insulation and air sealing. The majority of EESPs (35 out of 50 respondents) said they had qualifying projects completed without going through a utility program, which provides possible opportunities for increased program participation. It also supports earlier NTG research, which discovered spillover resulting from the programs.

Figure 20. Residential Standard Offer Program Service and Products Compared to Program Submissions (n=32)

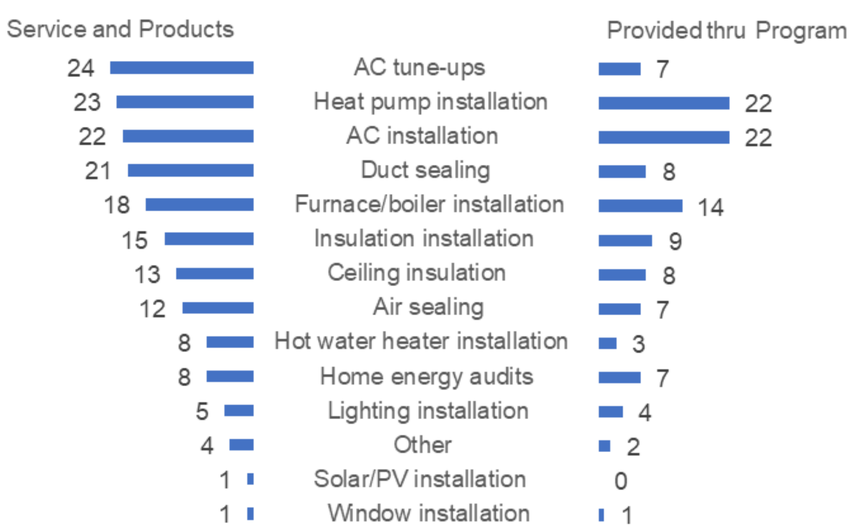
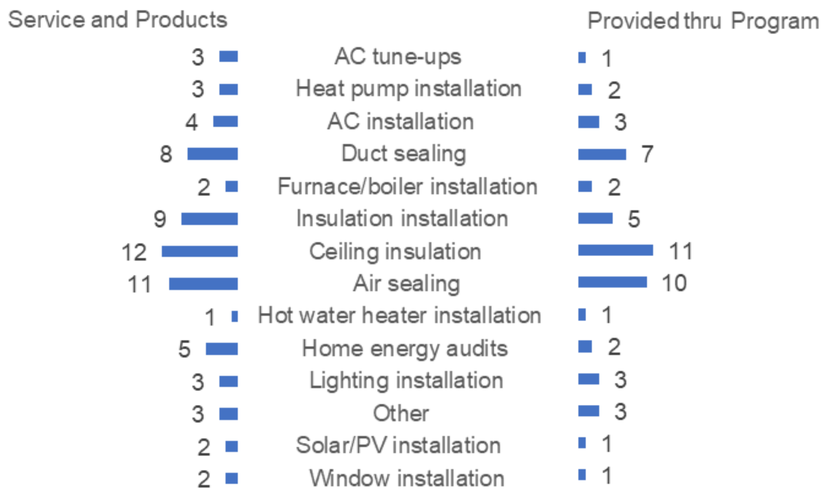


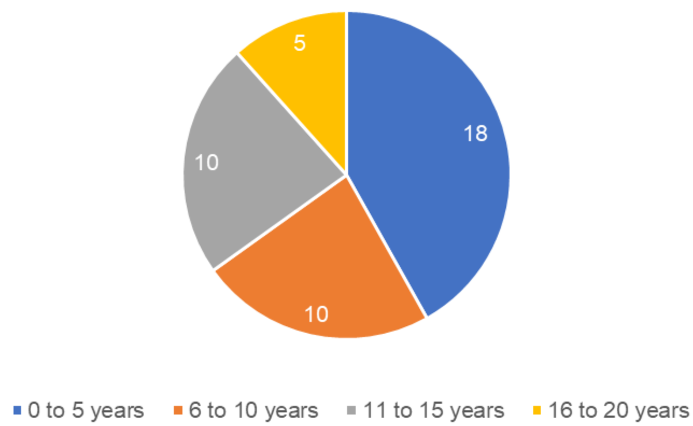
Figure 21. Hard-To-Reach Standard Offer Program Service and Products Compared to Program Submissions (n=18)



*Source: EESP Survey Questions P4a P4b.

Figure 22 shows that more than one half of the EESPs surveyed have been installing energy-efficient equipment or performing services through the RES and HTR SOPs for more than five years (25 respondents). Eighteen respondents have been participating for five years or less.

Figure 22. Number of Years Participating in the Residential and Hard-To-Reach Standard Offer Programs (n=43)



*Source: EESP Survey Question P2. *Don't know* responses have been excluded.

Program awareness

EESPs were asked how they became aware of the Texas RSOPs and HTR SOPs. The most mentioned source was utility program staff (12 respondents). Eight EESPs said they heard about the program through a vendor (8 respondents), and 7 respondents said they learned about it from a customer. From another program, discussions with account representatives, and utility websites were the next most mentioned sources (6 respondents each). Figure 23 shows all the mentioned sources of program awareness.

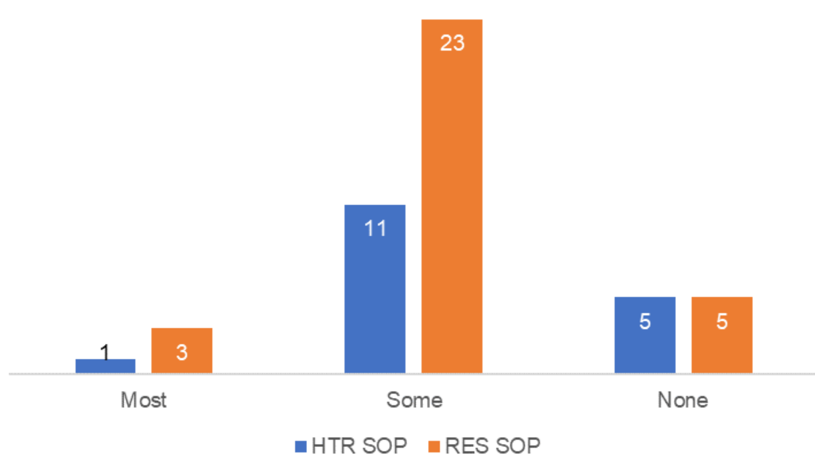
Figure 23. Energy-Efficiency Service Provider Source of Program Awareness (n=50)

*Source: EESP Survey Question P1.

Customer interactions

Of the 50 EESPs interviewed, all but one said they always inform their customers that the equipment or service is being incentivized through the RSOP or HTR SOP offered by their utility company. Only one EESP said they never mention it. Of the 49 respondents who do inform their customers, when asked if most, some, or none of their customers are aware of the program before they mention it to them, 39 said some or most customers were aware. Ten EESPs said that none of their customers were aware before hearing about it from the EESP. Figure 24 provides a visual on customer awareness.

Figure 24. Number of Customers Aware of the Program Prior (n=49)



*Source: EESP Survey Question P6b.

EESPs can pass the program incentives directly to their customers or use them to mark down the price of the project. Over half (27 respondents) of EESPs said they use the incentive to mark down the price of the equipment or service. One-third (15 respondents) said the incentive goes directly to the customer, and the remaining 6 respondents said they employ some sort of hybrid approach depending on the situation.

EESPs were asked what they see as the primary barrier to customers investing in energy efficiency improvements. Over one-half (27 respondents) said cost is the primary barrier. Eight EESPs said there are no barriers, and another eight said lack of awareness was the primary barrier. Six EESPs mentioned customer concerns noting the primary barrier being about the return on investment.

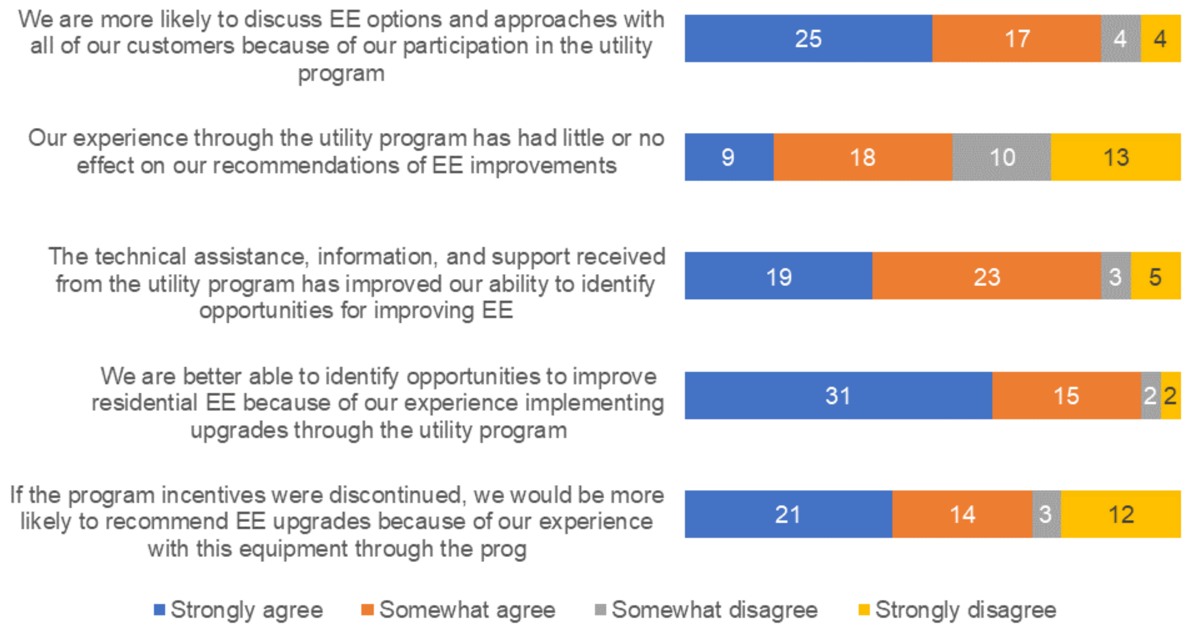
When asked what EESPs see as the primary barrier to customers participating in the program, the cost was again the most mentioned (13 respondents). Thirteen said the return on investment was the primary barrier, and eight said the incentives are too low. Twelve said there are no barriers to program participation, and seven said lack of awareness is the primary barrier. Two others mentioned the primary barrier is that it is not needed because the customer is already efficient, or that it is not offered everywhere in Texas.

Program Influence

The program has influenced EESP's business practices towards energy efficiency improvements and recommendations. EESPs were asked if they strongly agree, somewhat agree, somewhat disagree, or strongly disagree with five statements regarding the program to assess the program's impact and influence. Figure 25 shows the results of each statement. All 50 respondents said they either *strongly agree* or *somewhat agree* with at least one of the statements.

Most EESPs (42 respondents) *strongly agre*e or *somewhat agree* with the statement, "We are more likely to discuss energy-efficient options and approaches with all of our customers because of our participation in the utility program," with one-half saying they *strongly agree*. Just under one-half (23 respondents) either *somewhat agree* or *strongly disagree* with the statement, "Our experience through the utility program has had little or no effect on our recommendations on energy-efficient improvements." Only nine *strongly agree* with that statement. Most EESPs surveyed (42 respondents) said they *strongly agree* or *somewhat agree* that the technical assistance, information, and support they received from the program improved their ability to identify energy-efficient improvement opportunities. Almost all (46 respondents) said they are better able to identify opportunities to improve residential energy efficiency because of their experience with the program. Finally, EESPs were asked if the program incentives were discontinued, would they be more likely to recommend energy-efficient upgrades because of their experience with the program, and most (35 respondents) said they *strongly agree* or *somewhat agree*.

Figure 25. Agreement Statements about the Program (n=50)

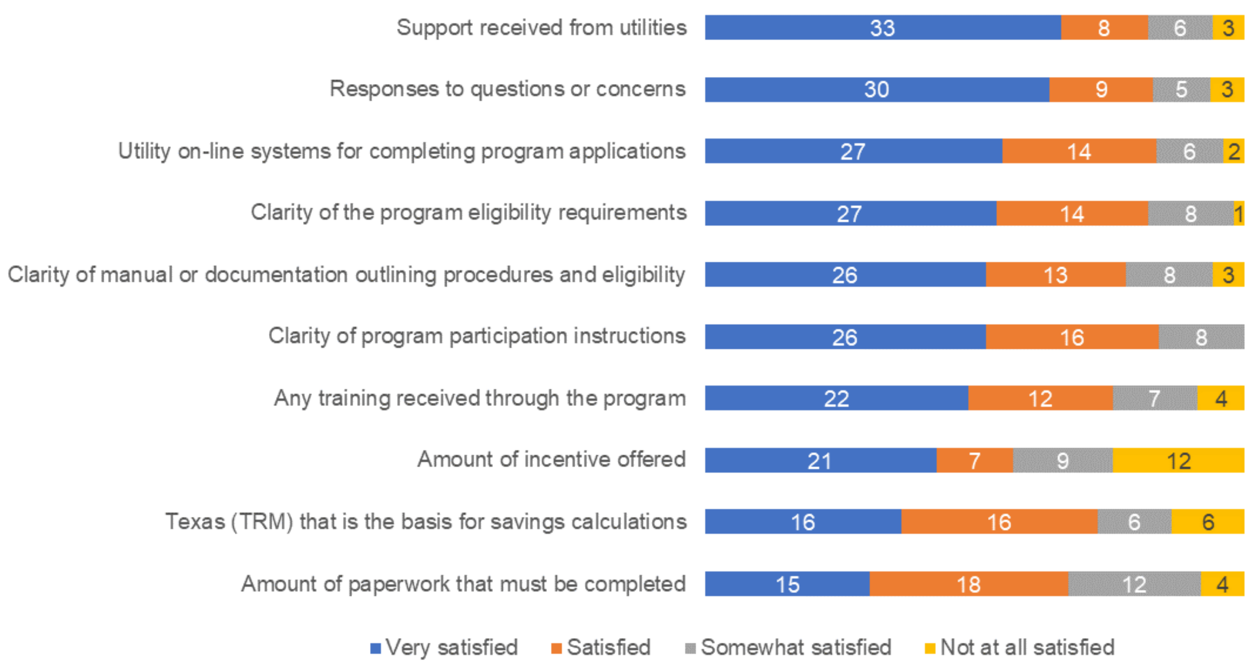


*Source: EESP Survey Questions P12a to P12e.

Program Satisfaction

EESPs are satisfied across all program aspects. The EESPs were asked to rate their satisfaction with specific program components using a four-point scale: very satisfied, satisfied, somewhat satisfied, and not at all satisfied. Figure 26 shows that respondents were consistently *very satisfied* or *satisfied* across all elements. Support received, and responses to questions or concerns from the utilities had the most responses of *very satisfied* (33 and 30 respondents, respectively). The incentive amount saw the most mentions of *not at all satisfied* (12 respondents).

Figure 26. Energy-Efficiency Service Provider Satisfaction with Program Aspects (n=50)



*Source: EESP Survey Questions P5a to P5j.

For all responses of *not at all satisfied*, EESPs were asked what improvements could be made to increase their satisfaction. Of the 26 respondents asked, *providing bigger incentives* was most mentioned (12 respondents). Next was *providing more program support* (3 respondents) and *reducing the administrative burden* (3 respondents). Two said *more communication*, and another said they *would like to learn more about the calculations of incentives*. The other five did not have any suggestions.

The survey also asked respondents why they said they were *very satisfied* or *satisfied* with any of the program aspects. The most mentioned responses were that (1) it helps people who otherwise could not afford it, (2) it makes more efficient equipment more affordable, (3) it helps increase sales, (4) it helps the customer save energy, (5) there is good program support, and (6) it is easy to use. Here are a few comments from respondents:

"[The program] a great channel for people who can't otherwise afford to invest in energy efficiency."

"Helps the low income and elderly."

"Helps homeowners understand importance of energy-efficient systems."

"Everything is easy to follow online."

"It helps us sell more jobs with the incentives that are offered."

"The utilities make every effort to ensure that low-income goals are reached."

4.3 NEW CONSTRUCTION MARKET TRANSFORMATION PROGRAMS

The EM&V team reviewed residential new construction programs as part of the PY2019 program evaluation. The evaluation for these programs included builder and rater interviews to research NTG and consumption data analysis to evaluate program impacts.

4.3.1 Program Overviews

The Residential New Construction MTP provides incentives to builders to increase the efficiency of new homes above minimum code efficiency. The programs partner with raters, who inspect homes and provide the programs with energy models to describe the program-sponsored homes. The utilities compare these energy models with code to estimate energy savings.

4.3.2 Key Findings and Recommendations

Key Finding #1: The energy models used by the utilities accurately estimate gross savings compared to code. The EM&V team compared weather-normalized energy meter data for PY2018 program homes with the estimates from the raters' energy models and found the results to be consistent.

Recommendation #1a: Continue to monitor updates to code and to energy modeling software to ensure the TRM is up to date and accurate.

Key Finding #2: The new homes market in Texas has some level of transformation.

New homes built outside of the programs display similar efficiency to those built through the program in many, but not all, areas investigated in the consumption analysis. This similarity was discovered by a comparison of meter data between participating and non-participating homes. While the interviews with builders support that about half of the market is transformed (a 52 percent free-ridership rate), it also supports a high level of spillover (a 15 percent spillover rate) that helps explain some of the limited differences found in the consumption analysis. The overall new homes NTG from the builder interviews is 64 percent, which indicates that program design updates to maximize net savings should be considered, but that there is still opportunity in the new homes market to affect change.

Recommendation #2a: Update new homes program designs to focus efforts on different segments and aspects of the new homes market that have not been transformed considering current code. These updates might include:

- focusing on particular end-uses such as HVAC, where builders report barriers to installing high-efficiency equipment;
- targeting areas or particular builders in a utility territory that have less efficient practices;
- incorporating distributed generation technologies such as solar photovoltaic systems; and
- promoting innovative building practices by pushing builders to increase home efficiency further through programs such as Leadership in Energy and Environmental Design (LEED) or Zero Energy Ready Homes.

4.3.3 Impact Results

New homes programs were designated as *high* evaluation priorities for PY2019. These programs continue to comprise a considerable percentage of overall statewide portfolio savings and recently went through a major TRM update as a result of the code adoption of the 2015 International Energy Conservation Code (IECC). As part of the impact evaluation, the EM&V team conducted a consumption analysis of the ERCOT utilities' new homes programs to evaluate energy and demand impacts.

4.3.3.1 Methodology

The EM&V team conducted a consumption analysis of PY2018 new homes program participants. Technical Appendix 2 presents a detailed version of the consumption analysis methodology that we summarize in this section.

The consumption analysis focused on comparing actual metered energy consumption with the modeled estimates that resulted from applying Volume 4 of the TRM. We analyzed a comparison group of non-participating homes that were constructed around the same time to determine whether the programs push the efficiency of new homes beyond standard market practice. We limited the comparison group to counties where there were participating homes, and we acquired property tax data to incorporate square footage since building size is a primary driver of energy consumption.

We received 15-minute interval meter data for over 14,000 PY2018 participants from when the meter went online (or January 1, 2017, if the meter went online earlier) through December 31, 2019. This time period ensured that we had at least twelve months of data following home construction. We focused the analysis on the latest 12-month period (January 1, 2019 through December 31, 2019) to look at a consistent time frame for all accounts. We also received meter data for over 56,000 non-program new homes covering the same time frame. We screened both groups for a number of criteria as part of our data cleaning process, resulting in approximately 97 percent of participants and 33 percent of comparison meters remaining in the analysis sample. The full details of the screening process are in Technical Appendix 2.

Next, we combined the screened meter data with observed weather from the NOAA as well as typical weather from the TMY3 dataset from NREL. We used these weather data to weather-normalize metered energy consumption. This process estimates a household's energy usage under typical weather conditions, minimizing the impact of extreme temperatures on the resulting energy consumption estimates. We optimized each household's weather-normalized energy consumption using a series of regressions that model the home's response to weather under different temperature settings. The resulting weather-normalized energy consumption provides the basis for the remaining analyses. Technical Appendix 2 provides a detailed description of the weather-normalization process.

The primary focus of the consumption analysis was to evaluate the accuracy of the TRM measure characterization in estimating energy savings resulting from the new homes programs. This measure characterization provides the utilities with guidance on how to configure energy modeling software to characterize the baseline (or reference) home as well as the program (or as-built) home. Energy modeling software focuses on the building's energy performance, especially the building shell, HVAC, and some major appliances. The software does not include additional plug loads that occupants install once they move in, such as additional lighting, small appliances, computers, and TVs and entertainment systems. These additional plug loads are included in the meter data provided by the utilities, so we implemented a plug load adjustment factor when comparing with TRM energy savings to account for this difference. However, because there is limited research on the extent of plug load energy usage, especially specific to either Texas or new homes, we specified a plug load factor of 15 percent of annual energy consumption based on the research we had available.[18]

4.3.3.2 Consumption Analysis Results

We compared the weather-normalized meter data with the energy consumption estimates based on the TRM methodology, removing plug load from the meter data as described previously. The TRM estimated energy savings within five percent of the weather-normalized results, which shows an extremely good alignment between the TRM approach and the weather-normalized meter data, especially given the limited research available to solidify the plug-load factor. While we saw some differences by different characteristics (heating system type and geographic location), the TRM is intended to average out over the entirety of projects completed.

We also compared weather-normalized consumption between the program homes and a comparison group of new homes that did not receive a program incentive. The results of this comparison are less straightforward since we had limited available characteristics about the comparison group. During this analysis, we found that, on average, program homes were larger than nonparticipating homes. Initially, this presented counterintuitive results that program homes used more energy. We calculated an energy use intensity (kWh per square foot) for each group. We then multiplied that by the average square footage per group to arrive at a square footage normalized energy consumption which resulted in some energy savings for program homes, but the savings calculated through this method were much lower than calculated by the TRM. While the TRM calculated an average of 1,672 kWh savings per home, the comparison group analysis resulted in only 674 kWh savings per home, or roughly 40 percent of the savings estimated by the TRM. This percentage suggests that non-program homes also exceed the efficiency levels required by code, which indicates that some level of market transformation has taken place. The market transformation may be, in part, due to the program incentives, but also other market factors. These factors are supported by the NTG study conducted as part of this year's evaluation, which the following section discusses.

[18] https://www.esource.com/es-wp-14/mind-gap-taking-comprehensive-look-plug-load-energy-use

4.3.4 Process and Net-to-Gross Results

In this section, we summarize the builder and rater interview results for the Texas new homes programs. We first provide an introduction to the objectives and sampling for the interviews, followed by key findings for each program statewide, and any applicable utility-specific findings.

Introduction

The EM&V team completed builder and rater (market actors) in-depth interviews for the Texas new homes programs in May and June 2020. The primary objective of these interviews was to gather information on program influence on market actors' recommendations and sales practices to inform NTG. Throughout the interviews, the EM&V team also captured process-related information provided by these market actors, such as:

- experience working with the utilities,
- satisfaction with various components of the program(s),
- perceptions of the market and barriers to adoption, and
- areas the program is working well and opportunities for improvements.

The EM&V team obtained the market actor sample from PY2019 program tracking databases, utilities, and implementation contractors. At a minimum, we received the market actor company name and telephone number. Some market actor data also included individual contact name, email address, projects completed, and associated savings.

The EM&V team completed a total of 15 unique market actor interviews—12 builder interviews and 3 rater interviews. Because all of the raters and almost all of the builders work with different utility programs, the 15 unique market actor interviews represent 38 utility program-level completed interviews—28 builder interviews and 10 rater interviews. Since the population of rater companies across Texas is small, the EM&V team attempted to contact almost all of the rater organizations. Builders were randomly sampled with a goal of obtaining representation from all utility programs, as well as some variance in the number of homes completed through the programs. Table 19 documents the number of completed interviews by utility and market actor type.

Table 19. Number of Builder- and Rater-Completed Interviews by Utility*

Utility	Number of Builder Interviews Completed (n=12)	Number of Rater Interviews Completed (n=3)
AEP	3	1
CenterPoint	10	3
Entergy	11	3
TNMP	4	3
Total	**28**	**10**

*The counts represent the number of market actors working within each utility territory. Market actors that serve customers in multiple territories are represented more than once.

Since the number of market actors interviewed for each utility program is limited, results are qualitative and may not be representative of the entire population of interest. All numeric results (e.g., satisfaction ratings) are presented in number of responses rather than percentages to reflect the qualitative nature of the data. Additionally, the information presented reflects the perception of the market actors, which may or may not accurately reflect intended program design and delivery.

4.3.4.1 Overarching Key Findings for New Homes

The EM&V team spoke with a sample of Texas home builders and raters. This section first presents the results of the home builder interviews, followed by rater interviews.

Builders

The EM&V team spoke with a mix of builders that work across the four new homes programs in Texas. Organizations included in the study vary by the number of homes built annually (under 10 to thousands) as well as the type of home (primarily production, but also semi-custom homes). All but one builder said that all of the homes they build are built in areas that enforce the IECC 2015 energy code and that their rater completes a full rating on all of their homes, whether the homes receive utility incentives or not. In addition to home ratings, raters provide various other key services for builders—they handle utility incentive paperwork and online submittals, as well as provide builders with code change information and training. Raters handle so much for builders that builders rarely use the training or technical support provided by the utility programs.

The majority of home builders interviewed have been building homes through the Texas programs for two to five years, with some (4 of 12) noting they have been participating for 14, 15, even up to 20 years. Because of the relatively long-standing experience with the program, most respondents could not recall how they first heard about the program.

Almost all builders interviewed service customers across multiple service territories. The interviews probed these builders on differences in program requirements, satisfaction, etc. by utility. Other than a few variations in program design, builders did not identify differences among the various utilities for this program.

Satisfaction

Builders were asked to rate their level of satisfaction with various elements of the program (very satisfied, satisfied, somewhat satisfied, and not satisfied). As reflected in Table 20, nearly all builders said they were *very satisfied* or *satisfied* with most of the areas discussed. Responses to questions and concerns received the most *very satisfied* ratings, and the *amount of incentive offered* received the most *somewhat satisfied* ratings.

Table 20. Satisfaction with New Homes Programs Components

Program Component	Number Very Satisfied	Number Satisfied	Number Somewhat Satisfied	Number Not Satisfied	Total Responders*
Support received from utility	16	12	0	0	28
Clarity of program eligibility requirements	20	6	2	0	28
Responses to questions/concerns raised	24	4	0	0	28
Training received	5	4	6	0	15
Amount of incentive offered	6	13	7	0	26

Program Component	Number Very Satisfied	Number Satisfied	Number Somewhat Satisfied	Number Not Satisfied	Total Responders*
Amount of paperwork required	11	14	2	0	27
Utility online program application process	7	11	0	0	18

* When the number of responders does not equal 28, responses were either *not applicable* or *don't know*.

Use of Incentives and Participation Barriers

Builders typically use the incentive to reduce their cost of building the home—whether that is using the incentive to mark down the home price or using it to offset the increased cost of more efficient products and practices. No builders said the incentive goes to the customer. Additionally, the EM&V team spoke with only one builder who said they always tell their customers that their utility is contributing funds to their home. The other builders said they *sometimes* (4 of 12) or *never* (6 of 12) inform their customers of the utility incentive. Not informing customers could be one reason why only one builder said that most of their customers are aware of the utility program.

Similar to past findings and other markets, builders stated that the most prevalent barrier to customers' purchasing program homes is cost. The cost barrier is an issue in a couple of different (but related), ways:

- The new homes market is a competitive one, especially the production home market; builders noted they could not afford to substantially upgrade the energy efficiency of their homes without additional incentives, or they will price themselves out of their markets.
- Even though energy efficiency has been around for many years, consumers are still generally not willing to pay more for this feature.

"It's probably a money barrier for them [consumer] to get more efficient equipment. [Builder] is putting in 16 SEER air conditioners. We cannot sell a higher SEER in homes because it's not tangible; it just doesn't make monetary sense."

Some builders said that consumers generally expect homes to be energy efficient, and even ask questions about ratings, appliances, etc. Still, knowledge does not always transfer to a willingness to pay. Builders also noted that talking to consumers about increasing their home's energy efficiency can be a challenging discussion to have, especially if it means a trade-off between energy efficiency and some other aesthetic (e.g., countertops, lighting, flooring upgrades). One builder did say, though, that they had customers come back to them to complain about high energy bills, so they did something about that:

"I think customers would maybe say that it might not be a good investment. But when they move into bigger homes, they start to care when they start seeing their utility bills. Generally speaking, if we were to tell them how much of the home building cost went to the energy efficiency side, they might think that was a lot of money. [Builder] made the change from green to energy efficiency in 2008. Our rater is part of Environment for Living, and they give every person a guarantee for their utility usage. So everyone knows what the vast majority of their bills will look like. We started a couple of communities

with a conditioned attic and did a comparison, and there's about an $800 to $1,00 difference. We show people that all the time."

Given this information, it is not surprising that the item rated lowest for satisfaction is the amount of incentive offered by the utility. In summary, there are a number of reasons for this including:

- A number of builders mentioned that, while the incentive is nice to have, the available dollar value is low compared with the additional cost to build a home according to the program's requirements.
- Though almost all respondents also said that, as a standard practice, they build homes that meet or exceed program requirements; many of the builders mentioned they have been building energy-efficient homes for so long, they would not do otherwise.
- There are a lot of other program influencers in the market that force builders to build more efficient homes if they want to stay competitive (e.g., ENERGY STAR, Environments for Living®, etc.). Some builders would like to see the utility programs include more innovation in achieving higher efficiency levels, but also noted that the incentive would need to cover the incremental costs to get there.

"A previous utility was aggressive in marketing their program (Good Cents), and the consumer would come in the door and know about the program; it's not that way now."

"I don't know any builders that are not energy efficient builders. Most everyone is doing some kind of ENERGY STAR deal. I think everyone's stuff is pretty energy efficient."

"Customers do not fully understand what energy efficiency all entails."

Training and Technical Assistance

The EM&V team asked respondents a series of questions related to training and technical assistance provided by the utilities, and their relative importance in the builder's decision to build energy-efficient new homes (using a 0 to 10 scale where 10 was *very important*, and 0 was *not at all important*). As can be seen in Table 21, many program elements were rated by builders as either *not important* (0, 1, 2, or 3 rating) or *moderately important* (4, 5, 6, 7 rating). These ratings are likely because builders said they rely on their raters to provide program information, training, and to complete many of the program requirements. The component that the greatest number of builders rated as *important* (8, 9, or 10 rating) was the *program incentive* (18 of 22), even though the incentive was rated lowest for satisfaction by most builders. The EM&V team's interpretation of this is that, while builders may say the incentive is too low, it is ultimately the incentive that keeps them in the program(s). One builder noted:

"The incentive for both of them [Utility1 and Utility2] is fair. It's a good amount of money if your homes can pass. For [Utility3], it's a seamless deal; they send me lots of money. The other ones kind of pick and choose through my houses. I'm not sure why I pass [Utility3], and I don't pass the others."

The low importance ratings reflected in the technical support and training seminars provided by utilities are largely due to builders relying on their raters for this type of information. Of the builders that said they do use utility-provided technical or training resources, it has mostly been either once a year or for questions related to navigating program requirements. One builder noted that the utilities need to be proactive about calling them to ask how they can help. Another builder suggested that the utilities could provide better information related to the incentives and the cost-benefit of participating; the utilities could do better at helping builders understand how they could truly benefit from the program.

Table 21. Importance of New Homes Programs Technical and Training Components

Program Component	Important (8 - 10 Rating)	Moderately Important (4 – 7 Rating)	Not Important (0 - 3 Rating)	Total Responders
Technical support provided by the utilities	5	8	9	22
Information provided by representatives of the utilities	9	11	2	22
Training seminars provided by the utilities	0	7	15	22
Information provided by the utility websites	12	0	10	22
Company's past participation in a program sponsored by the utilities	13	5	4	22
The program incentive	18	0	4	22

Attribution

The EM&V team is tasked with estimating net savings, which was accomplished by completing NTG research and producing NTG ratios statewide for the new homes programs. In Texas, net savings have been defined as "those savings that are attributable to the programs, inclusive of free-ridership and spillover"[19] based on the definitions of these terms in § 25.181 (c).

The EM&V team used a self-report approach through builder interviews to calculate NTG ratios.

Free-Ridership refers to actions taken by participants (builders) through a program that would have occurred in the absence of the program. In other words, a *free rider* is a program participant who would have made some amount of the program-rebated energy-efficient improvements if the program had not been offered.

Spillover refers to additional energy-efficient equipment installed, or actions taken due to program influences but without any financial or technical assistance from the program. The EM&V team relied on builder interviews to determine the spillover rate.

The final NTG ratio is then calculated using the following formula. The ratio can be applied to the population to determine the final net savings value.

NTG Ratio = 1 – (Free-Ridership Rate) + (Spillover)

As a simplistic example, if a program has a free-ridership rate of 20 percent, and a spillover rate of 8 percent, the NTG ratio would then be:

NTG Ratio = 1.00 – ((0.20) + (0.08))
NTG Ratio = 0.88, or 88%

[19] Evaluation, Measurement, and Verification Plans for Texas Utilities' Energy Efficiency and Load Management Portfolios – Program Years 2012 and 2013 (Final June 12, 2013).

A higher NTG indicates program influence on decisions and high attribution toward behaviors. A lower NTG factor indicates a low level of influence, which may be further indicative of market transformation, a need for incentive restructuring, etc. There are occasions where outliers exist in the data. Outliers are cases that provide responses that extensively deviate from the norm. While important to account for these cases, depending on the project size and the number and composition of survey completes, these data can significantly swing the results.

Within NTG research, the spillover calculation has the potential of capturing large outliers, which could then influence the overall NTG ratio considerably. While it is important to recognize these cases' spillover results, the EM&V team needs to be careful to manage the results such that NTG is not overstated due to potential self-reporting bias. Therefore, the EM&V team will cap the spillover rate calculated for individual market actors at 200 percent.

Summary of Results

Table 22 summarizes the statewide NTG results and the NTG methodology, which are then discussed in more detail below. As already mentioned, the results are based on builder interviews.

Table 22. Net-To-Gross Summary

Program Category	Program Type	Free-Ridership	Spillover	NTG Ratio	NTG Methodology
Residential Market Transformation Program (RMTP)	New Homes	49%	15%	64%	Market actor (builder surveys)

4.3.4.2 Methodology

The EM&V team used builder interviews as the only method to calculate free-ridership and spillover for the new homes programs. No customer surveys were completed for the new homes programs because the utilities do not collect end-use customer information for new homes completed through the programs; this is not surprising given that the programs' upstream implementation focus is working with builders.

Builder free-ridership and spillover results were weighted by the number of total energy-efficient projects completed by each builder and submitted to a utility program to account for a different level of builder activity.

4.3.4.3 New Homes Net-To-Gross Results

Free-Ridership

As mentioned earlier, the NTG approach for the new homes programs differs from other types of programs. While the customer may be aware of the benefits or be involved in the decision, the majority of the program's marketing, outreach, and education are directed to builders. The main intent is to encourage the builders to adopt above-code energy efficiency products and practices that meet each utility's specific requirements. Therefore, it is most important to understand, from the perspective of the builder, what their perception is of their building practice in the absence of the program.

We calculated a free-ridership rate of 48 percent for the new homes programs. The free-ridership rate is based on 28 builder responses.

Spillover

The EM&V team calculated the spillover rate for the new homes programs at 15 percent. The market actor results include responses from 12 unique builders. Several builders provided *don't know* responses to spillover-related questions, in which case we treated them as contributing zero spillover. While this is a conservative approach, it reflects that these builders do not have widespread practices that contribute to spillover like some other builders.

Benchmarking

For residential new construction, the EM&V team reviewed NTG ratios established by four different entities—Nicor Gas and ComEd in Illinois (implemented as one program), Public Service Company of Oklahoma, Oklahoma Gas and Electric, and the collective PAs in Massachusetts. NTG ratios ranged from 65 to 100 percent. The Texas utilities' new homes programs' NTG of 64 percent appears reasonable compared to the benchmarked utilities but also indicates more can be done to increase the NTG ratio and net savings.

4.3.4.4 Considerations for Program Design and Delivery

For the Texas new homes programs, a confluence of factors continues to affect the NTG ratio for these programs, including the fact that many of the builders have been around for a number of years, there are a fair number of production builders, and energy building codes differ across areas. As noted earlier, the majority of home builders interviewed have been building homes through the Texas programs for two to five years, with some (4 of 12) noting they have been participating for 14, 15, even up to 20 years. On the one hand, given the longevity of the Texas new homes programs and their focus on changing building practices, it seems reasonable to assume that it has affected practices in nonparticipating homes and thus has generated spillover. On the other hand, the longevity of the Texas programs virtually assures a substantial number of free riders in the program. In fact, the EM&V team heard during interviews with participating builders that they are generally committed to building energy-efficient homes, whether there is a program incentive or not.

Builder comments from the interviews conducted by the EM&V team reflect the lower NTG ratio:

"Such a hard question. Like I said, everyone feels the same; there's no way you cannot do energy efficiency and still sell a house."

"We didn't know what the incentives were - everyone was happy because we got a rebate on some of this, but we had already decided how we were going to build our homes."

"We have always tried to be a step ahead on energy efficiency; when SEER was 10, we put in 12, we have always done radiant barriers, etc. So we were already doing a lot of these items."

"We don't do this because of the program; we put the stuff in the homes that we do to due right by the customer; it's the right thing to do."

"I'm not really doing anything more than what the competition and market is requiring."

*“We've been building homes for so long this way,
we just might not strive for the top tier.”*

Another major factor for new homes programs to contend with is building codes. While Texas has a statewide energy code (IECC 2015), several municipalities have adopted higher codes than what is required at the statewide level. A key challenge surrounding building codes is the enforcement of these codes. Without enforcement, it can often be the case that builders that are not participating in energy efficiency programs are not building to code. Given these challenges, the Texas new homes programs should continue to have their programs evolve as building codes evolve. For example, a couple of the new homes programs have already shifted their focus to a code-based energy savings goal (e.g., new homes must save 15 percent more kWh than a home built to code).

Two critical components to the new homes market that the EM&V team was not able to assess was the nonparticipating builder market and code compliance. A statewide market assessment that includes these two items would strengthen the research and provide further insight into the market and NTG issues.

Raters

The EM&V team spoke with at least one rater representative for each of the four new homes programs in Texas. Rater organizations included in the study vary by the number of home ratings annually (hundreds to thousands), and work with anywhere from three to upwards of “dozens” of builders. All three raters said they anticipate about the same amount of new homes business in 2020, even given the current COVID-19 pandemic. Many of the builders that these raters work with are building to ENERGY STAR standards or similar types of programs (e.g., Environments for Living®).

All three raters we spoke with work with builders across multiple utility new homes programs. The interviews probed these raters on differences in program requirements, marketing, program interactions, etc. by utility. Other than a few variations in program design, raters did not identify differences among the various utilities for this program.

Satisfaction

Raters were asked to rate their level of satisfaction with various elements of the program (very satisfied, satisfied, somewhat satisfied, and not satisfied). As reflected in Table 23, nearly all raters said they were *very satisfied* or *satisfied* with most of the areas discussed. Similar to builder satisfaction ratings, the responsiveness of program staff received the most *very satisfied* ratings, and *the ease of filling out and submitting required program documentation* received the most *not satisfied* ratings.

Table 23. Satisfaction with New Homes Programs Components

Program Component	Number Very Satisfied	Number Satisfied	Number Somewhat Satisfied	Number Not Satisfied	Total Responders
Overall program satisfaction	7	3	0	0	10
Ease of filling out and submitting required program documentation	4	3	0	3	10
Responsiveness of program staff to questions	10	0	0	0	10
On-site inspection process	2	7	1	0	10
Technical support	4	6	0	0	10

Program Requirements and Interactions

Most raters indicated that communication related to program requirements has continued to be pretty clear. When asked about what program requirements builders or subcontractors find hardest to meet, one rater said, "None, as long as the program requirements stay the same." This rater mentioned that, "Sometimes a particular house is not suited well to a duct blaster, so it may not pass, but in general the majority of houses are fine." One rater mentioned that HVAC documentation could be a challenge for subcontractors, particularly smaller ones because they have to have staff to enter the information. Sometimes submitting the AHRI certificate or making sure the subcontractor is completing Manual J forms is a challenge. The third rater mentioned that, due the differences across programs, it could be difficult for builders to understand and adjust their construction to meet program requirements when working across service territories. This rater also mentioned that there are situations where builders make agreements with utilities, but the rater is left out of the communication loop—this can lead to issues in builders meeting their obligations to the utilities.

While raters told us that their builders understand the program requirements, the raters take care of almost all program activities for their builders, helping to ensure program requirements are met. Raters told us they enter all program information into the required portals, from both the builder and rater perspectives. One rater mentioned that they provide their building files to the utility, but then are also required to enter the data on a website. Submitting the information twice can create an environment for human error, which can result in a home being rejected and an unhappy builder. As a result, this rater mentioned that streamlining the program requirements so they can stay on top of their paperwork would be very helpful. All three raters mentioned that they are receiving the support they need within a timely manner, which is also reflected in the number of raters rating *responsiveness of program staff* as *very satisfied*.

Similarly, raters we spoke with told us that the process for certifying to the IECC 2015 specifications is going fine. This energy code has been in place for a few years now, so other than a few potential outliers, raters told us that almost all builders work in jurisdictions that have adopted IECC 2015. Additionally, raters said that subcontractors know what the IECC 2015 requirements are and that the only additional training needed would be training done in Spanish.

Future Challenges and Recommendations

When asked what they think the biggest challenges are for constructing or selling energy-efficient homes going forward, two of the three raters noted code changes, and the third rater said overcoming the perception that all new homes are energy efficient. Raters suggested that education is needed to change this perception and increase demand for energy-efficient homes.

“Just depends on where the code goes; foresee insulation of envelope of home will have to change.”

“Code changes. The builders will just have to deal with it, and decide whether to go with above code programs.”

“Perception that all new homes built these days are energy efficient; consumers take this for granted, and it's not true. Energy efficiency varies by builder. My company offers an energy guarantee."

When asked for suggestions about how the new homes programs participation process could be streamlined, one rater said that all three programs they work with are now allowing batch uploads. Because they work mainly with production builders, the batch upload process has been “really helpful.” One rater said the input system is “clunky,” and not working correctly. The third rater said their builders would like to have the ability to use "Docu-sign" documents; they don't want to have to print things out.

The most critical support the new homes programs could provide to raters in the near future is providing close communications related to programs and program changes.

“Help the raters communicate with their builders about how the programs are changing and have conversations about which path to compliance/best path to compliance for each builder. There have been times where program management staff tells the builders to do one thing, but the raters were telling the builders something else. Need to all work together more cohesively.”

“Just continue to provide information and updates as to what matters for claiming savings, and make database updates.”

4.4 UPSTREAM MARKET TRANSFORMATION PROGRAMS

Upstream market transformation programs were a *high* evaluation priority in PY2019 as they were relatively new in the Texas portfolio, but have been increasing as a percentage of statewide savings. EM&V activities included conducting desk reviews, gathering process information, and researching NTG ratios for these measures through retailer interviews triangulated with secondary research.

4.4.1 Program Overviews

Advanced Lighting MTP: The Advanced Lighting MTP offers point-of-purchase discounts to residential customers at participating retail stores for the purchase of qualified (i.e., ENERGY STAR-rated) high efficiency LED lighting products.

Retail Platform MTP: The Retail Platform MTP provides incentives to residential and small commercial customers through in-store discounts for qualifying ENERGY STAR-rated LED lighting and energy-efficient appliances.

Home Lighting MTP: The Home Lighting MTP offers customers in-store discounts for the purchase of LEDs through qualifying retailers.

Texas Appliance Recycling: The Texas Appliance Recycling program is designed to encourage customers to recycle old refrigerators and freezers.

Residential Recycling MTP: The Residential Recycling MTP offers customers no-charge pick-up services for old refrigerators and freezers and offers incentives for each unit picked up.

4.4.2 Key Findings and Recommendations

Key findings and recommendations are presented below based on the NTG research, tracking system review, and desk reviews conducted by the EM&V team.

Key Finding #1: The LED market is transforming but is not yet transformed.

Interviews with participating upstream retailer stores, manufacturer sales data, and benchmarking from similar utility programs indicate some level of market transformation of LEDs as well as a continued role for the programs in the near term.

Recommendation #1a: Use an NTG of 50 percent to assess net savings of upstream lighting programs to ensure they are still a cost-effective mechanism to deliver savings to ratepayers.

Key Finding #2: Lamp quantities and savings are not clearly tracked in the data.

Previous guidance from the EM&V team for upstream lighting programs recommended five percent of upstream lighting program benefits and costs be allocated to commercial customers, with the remaining 95 percent allocated to residential customers. It is not clear from the tracking data if utilities are implementing this correctly. In some cases, the total quantity is tracked alongside the commercial quantity, but in others, only a single input for quantity is tracked. The EM&V team also found that in some cases, there were no indicators as to whether savings were calculated using the residential or commercial methodology.

Recommendation #2a: Utilities should consider tracking total lamp quantity, residential quantity allocation, and commercial quantity allocation along with corresponding savings in separate columns to verify the residential and commercial allocation is applied accurately.

Key Finding #3: Documentation does not clearly match the tracked data.

In some cases, the EM&V team found that invoices provided did not line up with the tracking data.

Recommendation #3a: Invoices should clearly show the total quantity of each incented lamp sold per store. The utilities should consider linking stores and invoices with a tracking data ID in the database for quality control purposes.

Key Finding #4: Some of the incented lamps were not ENERGY STAR-certified.

While it is acceptable to incent lamps that are not ENERGY STAR-certified, lamps still need to be third-party tested and qualify under the ENERGY STAR requirements. To ensure only high-quality equipment is incented, the TRM calls for products to be ENERGY STAR-qualified as outlined in the latest ENERGY STAR specification. In some cases, the EM&V team found that the incented lamps were not ENERGY STAR-qualified.

Recommendation #4a: For ease of implementation, utilities should consider requiring ENERGY STAR certification for incentivized upstream lamps. In lieu of ENERGY STAR certification, utilities should collect test results or other third-party certifications.

Key Finding #5: A utility allocated five percent of upstream lighting savings to the residential sector, rather than five percent of quantity.

This utility under-claimed savings for the commercial sector by allocating savings, rather than quantity. The commercial sector can claim higher annual savings per bulb since it assumes that bulbs in a commercial setting are used for more hours.

Recommendation #5a: Review the methodology to allocate savings to the commercial sector from upstream lighting programs and verify that savings are claimed based on quantity.

Key Finding #6: The appliance recycling programs appear to be tracking and calculating savings accurately**.**

The EM&V team found that the appliance recycling programs are collecting and tracking data and documentation properly, leading to realization rates of 100 percent for both energy and demand savings for each program.

Recommendation #6a: Utilities should continue QA/QC practices as those appear to be working.

4.4.3 Impact Analysis

As part of the impact evaluation, the EM&V team conducted desk reviews for a sample of projects from the upstream lighting and recycling MTPs. The EM&V team applied the method prescribed in the PY2019 TRM 6.0 to verify energy savings and demand reduction for each measure sampled.

The EM&V team conducted a tracking system review on the upstream lighting MTPs. Savings adjustments were not recommended for these programs due to the new nature of the programs. The process recommendations are a result of findings during the impact analysis.

The EM&V team conducted desk reviews on the appliance recycling MTPs. Random samples of five desk reviews were drawn from each utility with appliance recycling programs. The realization rate for these programs was 100 percent for both energy and demand savings.

4.4.4 Process and Net-to-Gross Results

Next, we present detailed process findings from participating upstream retailer interviews.

4.4.4.1 Respondent Firmographics

All 13 interviewees held either a managerial or supervisory role within their company and had experience with or a responsibility for lighting stocking and sales. Experience with lighting stocking and sales varied among those interviewed, with two interviewees reporting having less than six months of experience, six reporting one to ten years of experience, and four reporting more than ten years of experience. Twelve respondents were responsible for the lighting stocking and sales for one location. The remaining respondent was responsible for 47 stores in total, all of which have participated in the 2019 upstream lighting program.

4.4.4.2 LED Stocking and Sales Trends

Retailer interviewees report that most of the shelf space for lighting is devoted to LEDs. Four retailers reported that 80 percent or more of their shelf space is devoted LEDs, three additional retailers said LEDs take up about 70 percent or more of their lighting shelf space, and the remaining retailers could not provide a breakdown. One retailer who could not provide a breakdown because it changes depending on the products coming in and out; but did indicate most of the shelf space was dedicated towards LEDs, but that also varies by bulb type. When asked if the amount of shelf space devoted to the different bulb types has changed over the past year, six of eight respondents said that it has, citing reasons such as the marketing moving towards LEDs.

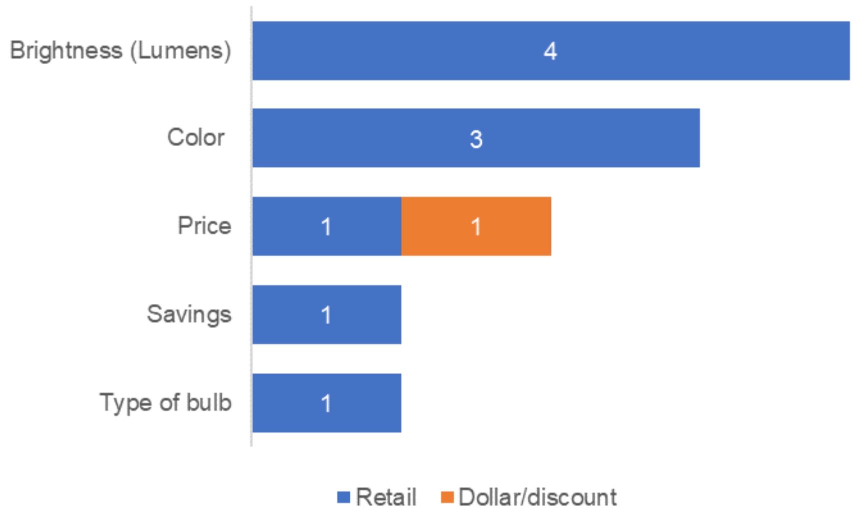
Most retailers (9 of 13 respondents) sold LED bulbs that were not discounted by the Texas upstream lighting programs, and some respondents also sell LEDs that are not ENERGY STAR-rated (6 of 12 respondents). As far as the sales of the bulbs, three respondents sold more ENERGY STAR-rated bulbs, two respondents sold more non-ENERGY STAR-rated bulbs, and one respondent indicated their sales of ENERGY STAR-rated and non-ENERGY STAR-rated bulbs were about the same.

Most respondents estimated that their sales of LEDs in 2019 were not discounted by the program, which ranged from 50 percent to 90 percent. Two respondents estimated sales of LEDs discounted by the program were 10 to 20 percent, and another two respondents were between 30 and 40 percent. Two respondents felt their sales were split in half between discounted and non-discounted. Five respondents had a hard time estimating the percentage of LEDs that were discounted by the program.

All eight retailers mentioned selling a wide variety of LED bulbs in 2019, including general use, spotlight, decorative, night lights, and holiday lights. Two respondents also mentioned selling fluorescent replacements, and one additional respondent also mentioned selling tubular LEDs.

Retailers identified the biggest factors customers typically look for in shopping for lighting products as the lumens or bulb brightness (4 respondents) and the color of the bulb (3 respondents). Other factors include the *price* (2 respondents), the type of lighting product needed (1 respondent), and the savings (1 respondent). Figure 27 shows factors determining customer lighting purchases as reported by different retailers.

Figure 27. Factors Determining Customer Lighting Purchases as Reported by Retailers



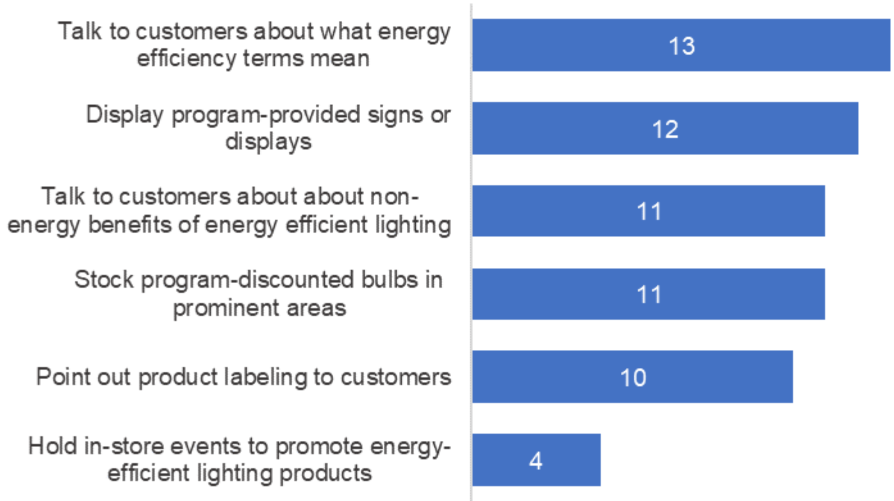
*Note: Multiple responses allowed.

4.4.4.3 Program Marketing

All but three retailers (10 of 13 respondents) mentioned receiving assistance from Texas upstream lighting programs to help sell energy-efficiency lighting by displaying program-provided signs and displays. One respondent indicated the program also aids through in-store promotional events as well as customer education via the in-store signage.

Most retailers reported taking several actions to promote and advertise program-eligible products in their stores. All 13 retailers said that they talk with customers about what energy efficiency terms such as *ENERGY STAR*, *lumens*, or *watt equivalence* mean, and all but one retailer displayed program-provided signs or displays. Most retailers also talk with customers about non-energy benefits of energy-efficient lighting such as reliability, light quality, or dimming ability, and stocking program-discounted bulbs in prominent areas such as endcaps, wings, or stack-outs (11 respondents each).

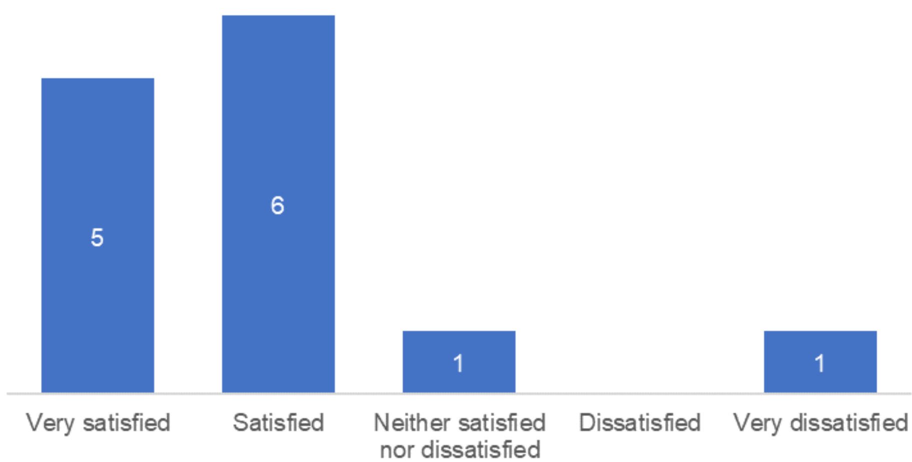
Figure 28. Activities Retailers do as Part of Program Participation (n=13)



4.4.4.4 Participant Experience and Satisfaction

Retailers reported high satisfaction with the program overall. Interviewees were asked to rate their satisfaction using the following scale: very satisfied, satisfied, neither satisfied nor dissatisfied, dissatisfied, or very dissatisfied. Eleven of the 13 retailers interviewed said they were *very satisfied* or *satisfied* with the program. Interviewees most commonly mentioned that customers received a discount (5 respondents), that the program helped increase sales (3 respondents), and that program staff was helpful (2 respondents). Other reasons mentioned included the availability of signage and that customers are drawn to the bulbs (1 respondent each).

Figure 29. Retailer Satisfaction with the Program (n=13)



The one respondent, who indicated they were *very dissatisfied* with the program overall, indicated they did not have any information or education about the program, and that the only reason the respondent knew about Oncor is because of, “the little stickers,” and the respondent thought they were, “not very explanatory.” The one interviewee who said they were *neither* *satisfied nor dissatisfied* with the program noted that they were not familiar with anyone coming in to discuss the program.

Four of the 13 respondents mentioned no changes were needed to the program. Of the remaining nine respondents who had a recommendation, the most common recommendation by retailers was the need for more or better signage or promotional materials (4 respondents). Three respondents mentioned more support from the project team by coming to the store to talk with the staff. Other responses included the need for training or better packaging due to products being broken upon arrival (1 respondent each).

Most retailers who indicated there were barriers to selling LEDs, identified the greatest barrier as understanding the technology (4 of 7 respondents). The aesthetic, price, and availability were also factors that prevented retailers from selling LEDs (1 respondent each).

Net-to-Gross Results

To support the LED NTG analysis, the EM&V team used a triangulated approach using telephone interviews with participating upstream retailer stores, a review of proprietary manufacturer sales data and benchmarking from similar utility programs.

For each of the evaluation activities, free-ridership rates were estimated, and NTG ratios were calculated using the following equation:

$$NTG\ Ratio = 1 - Free\text{-}Ridership$$

Based on the collective results of the evaluation activities, the EM&V team recommends an NTG ratio of 50 percent. Table 24 shows the free-ridership and NTG result estimates by analysis activity. The retailer interviews, when weighted by the number of bulbs sold, yielded the highest free-ridership (70 percent), while the retailer interview not weighted by bulbs sold also yielded the lowest free-ridership (42 percent). It is important to consider both given the limited sample size. The EM&V team also believes manufacturer sales data is an accurate gauge of market transformation and NTG. The EM&V team reviewed proprietary sales data from manufacturers and found the retailer 50 percent NTG recommendation is supported by recent data of halogen and LED sales. Interesting, further supporting this recommendation is very recent data of sales during the pandemic suggesting an uptick in halogen sales.

Table 24. LED Free-Ridership and Net-to-Gross Result Estimates

Method	Free-ridership estimate	Net-to-gross estimate
Retailer NTG* weighted	70%	30%
Retailer NTG* unweighted	42%	58%
Manufacturer data	40 to 50%	50% to 60%
Utility program benchmarking	33% to 81%	19% to 67%
Final recommendation	**50%**	**50%**

*NTG results are weighted by program savings at the retailer level and ranged between 8 percent and 100 percent between CenterPoint, Oncor, and Xcel Energy. Overall unweighted NTG results were 58 percent.

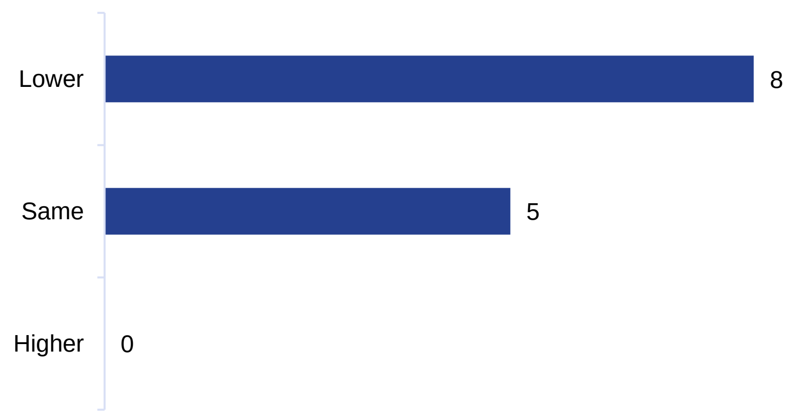
The following sections detail the NTG result estimates by evaluation activity.

4.4.4.5 Retailer Interviews

To assess free-ridership for participating retailers, thirteen retailers were asked to estimate what the change in their 2019 sales of program-qualifying equipment would have been if the program discounts had not been available. The survey asked, "If the price discounts and other assistance from the program had not been available, do you think your sales of these LED bulbs would have been the same, lower, or higher in 2019?" If the response was *the same* or *higher*, then the program did not influence sales, and free-ridership is 100 percent.

Eight of the 13 participating retailers reported program influence on LED sales in 2019 (see Figure 30below). After weighing the results using the retailer's annual savings, free-ridership was estimated to be 70 percent for an NTG ratio of 30 percent.

Figure 30. 2019 Sales Effect in the Absence of the Program (n=13)



Retailers that said LED sales would have been the same indicated this was because LEDs are now the primary option available for lighting purchases and because people already come in knowing what type of bulb they want. Comments from the retailers:

> *"I can point out that the sticker says these bulbs are at this price due to [utility]. I don't have one customer I can remember asking me, 'where are those light bulbs that are discounted by [utility]?' The general consumer that comes in here looking for bulbs, one way or another, they don't care about the [utility] discount. I mean, you can point it out to them, but they just want cheapness and a certain color. If they see an LED light bulb that costs $15 and one that costs $5, they're going to take the $5 one. GE makes three different bulbs: basic, classic, and HD. The people will often buy the basic because it's the cheapest."*

> *"I'm not saying they're not looking at the price; they want a certain type of bulb the one they have in their house. They don't care about the price; they want to get the same thing that they already have."*

> *"Because everything is going to LED. What really makes me think it would be the same is because you come in now, and the only selection that you have is LED. If 90 percent of our selection is LED, they're going to pick up LED, and almost all of our LEDs are ENERGY STAR-rated."*

4.4.4.6 Review of Manufacturer Sales Data

The EM&V team reviewed proprietary sales data from manufacturers and found halogen and LED sales data supports the 50 percent NTG recommendation. During the pandemic, manufacturers are also showing an additional uptick in halogen sales and suggest there may be longer-term effects from the pandemic.

4.4.4.7 Net-to-Gross Benchmarking

Benchmarking of other utility LED upstream lighting programs was conducted. The EM&V team looked at NTG results from nine utility programs with research from either PY2018 or PY2019. NTG results ranged between 19 percent and 67 percent. The benchmarking research supports the reasonableness of the EM&V team's NTG recommendation of 50 percent.

Table 25. LED Upstream Lighting Program Net-to-Gross Benchmark

Utility	State	Year	NTG Ratio	Program Type	Net-to-Gross Summary
Entergy Arkansas, LLC	AR	2019	53%	Lighting and appliances retailer programs	Price elasticity model found 77 percent free-ridership, retailer surveys yielded 47 percent free-ridership.
Southwest Electric Power Company (SWEPCO) Arkansas	AR	2018	67%	Lighting and appliances retailer programs	Price elasticity model found 33 percent free-ridership, recommended NTG ratio higher as spillover included.
Massachusetts Program Administrators	MA	2019	35%	PAs, EEAC consultants, and evaluators to review and discuss retrospective and prospective NTG estimates	Prospective results recommended an NTG of 30 percent in 2020 and 25 percent in 2021.
PECO Energy Company	PA	2019	51%	Lighting, appliances, and HVAC programs (standard LEDs)	Free-ridership for standard LEDs is 53 percent with a spillover ratio of 4 percent.
PECO Energy Company	PA	2019	46%	Lighting, appliances, and HVAC programs (specialty LEDs)	Free-ridership for specialty LEDs is 58 percent with a spillover ratio of 4 percent.
Duquesne Light Company	PA	2018	43%	Energy efficient products programs (standard and specialty LEDs)	Also had a free kit component (8 bulbs), estimated an installation rate of 75 percent.
FirstEnergy Met-Ed	PA	2019	32%	Energy efficient products programs (retailer survey)	Including results from a general population survey, NTG is 29 percent.

5.0 CROSS-SECTOR PROGRAMS

This section presents results found in the evaluation of the commercial and residential programs that apply to measures that are offered to both sectors as follows: multifamily and HVAC tune-ups.

HVAC tune-ups continued as *medium* evaluation priorities in PY2019 as savings recommendations from the PY2017 EM&V were to be fully implemented in PY2019. However, some additional changes were still identified in PY2019 as the mix of tune-ups has become increasingly residential and commercial instead of primarily residential.

This section summarizes the key findings and recommendations from the PY2019 evaluation of AC and HP tune-ups. The recommendations in this report are to be considered by the utilities for PY2021 implementation and will also be incorporated into the PY2021 Texas TRM 8.0.

5.1.1 Background

One of the key recommendations from the PY2016 Statewide Portfolio Report was that calibration of the model used to develop the stipulated efficiency losses[20] should be conducted annually by including the most recent year's M&V data. Additionally, the report also recommended using a three-year rolling average to include changes in the efficiency loss over time while also preventing drastic changes in program savings that can result from using a single year's values. The PY2016 efficiency loss values for the residential population were unexpectedly low, and recommendations were made to monitor the efficiency loss values on an annual basis to determine if (1) PY2016 reflected a decreasing trend over time or (2) if it was an outlier. Monitoring the efficiency loss values remained important because PY2016 data was still used within PY2019 calculations using a rolling average of the previous three years of program data. Since PY2016, efficiency loss values have been on an upward trend for all sectors and refrigerant charge adjustment status.

In PY2019, over 10,000 tune-ups were provided to residential and commercial customers through four Texas utilities across five different programs, as shown below in Table 26.

[20] Efficiency loss is the ratio of the air conditioner's measured efficiency before and after a tune-up.

Table 26. PY2019 Tune-Up Summary by Utility and Program

Utility	Market Transformation Program	Energy Savings		Tune-Up Count
		Reported kW	Reported kWh	
AEP Texas – Central Division	CoolSaver	3,845	9,162,373	4,057
CenterPoint	Retail Electric Provider CoolSaver	3,962	10,064,848	6,193
El Paso Electric	Residential Solutions	12	21,848	15
	Small Commercial Solutions	1	1,486	2
Entergy Texas	CoolSaver	38	95,744	63
Total		**7,859**	**19,346,299**	**10,330**

5.1.2 Key Findings and Recommendations

Key findings and applicable recommendations are presented below based on the information gathered in reviews across multiple utilities as well as discussions with the implementation contractor.

Key Finding #1: Test-in energy efficiency ratio (EER), on average, is lower than in previous years.

Recommendation #1a: Continually monitor all trade allies' test-in data to identify low EER trends from specific contractors.

Key Finding #2: M&V data from both Texas and New Mexico was used to develop the efficiency loss values used in reported savings calculations.

During the review of the PY2019 M&V plan, the EM&V team found that the efficiency loss factors used for the state of Texas were developed using M&V data from both Texas and New Mexico. The EM&V team requested that all efficiency loss factors be developed using only data from the state of Texas to avoid any influence from other outside regions and weather zones. The EM&V team re-calculated the efficiency loss values using only the 2016—2018 Texas M&V data, which was then used in the evaluated savings calculations. The Texas-only efficiency loss values were nearly identical to the Texas and New Mexico values presented in the M&V plan due to the small sample size of the New Mexico M&V data, which resulted in a minimal evaluated savings adjustment. The EM&V team recommends using only M&V data from the state of Texas to determine efficiency loss values in future evaluations.

Recommendation #2a: Utilize only M&V data from Texas to determine efficiency loss values.

Key Finding #3: Greater than 10 percent of tune-ups received both test-in and test-out M&V field measurements across all stratifications.

In PY2019, approximately 17 percent of tune-up measures in Texas collected both test-in and test-out M&V field measurements by the programs—referred to as *full M&V*—which is a slight decrease in percentage from the last evaluation in PY2017, but still well beyond the ten percent M&V goal. Despite the slight overall decrease in M&V percentage, the total commercial project percentage increased from 6 percent in PY2017 to 11 percent in PY2019. Both residential and commercial sectors achieved beyond their 10 percent goal, which imparts confidence in the calculated efficiency loss values for both sectors. The EM&V team recommends continuing to monitor M&V data collection quantities across sectors to maintain the ten percent M&V sample across both commercial and residential.

Table 27. Measurement and Verification Tune-Up Counts by Sector

Utility	Sector	Tune-Up Count	Measurement and Verification Count	Measurement and Verification Percentage
AEP Texas – Central Division	Commercial	2,144	249	12%
	Residential	1,913	320	17%
CenterPoint	Commercial	407	23	6%
	Residential	5,786	1,153	20%
El Paso Electric	Commercial	2	2	100%
	Residential	15	3	20%
Entergy Texas	Residential	63	7	11%
Total	**Commercial**	**2,553**	**274**	**11%**
	Residential	**7,777**	**1,782**	**23%**

Recommendation #3a: Tune-up measures should continue to collect a robust M&V sample for both commercial and residential projects.

5.1.3 Reported Tune-Up Savings Methodology

As part of the PY2016 evaluation, the M&V team recommended using a three-year rolling average of efficiency loss data obtained from tune-ups statewide in Texas by sector (residential and commercial), and by whether a refrigerant charge adjustment was applied. In PY2019, the implementer used data from both Texas and New Mexico tune-ups to develop the efficiency loss factors. After a discussion with the Texas PUC, tune-up data exclusively from Texas was required to be used for the evaluation. The reported PY2019 efficiency loss analysis is presented in Table 28. The reported efficiency loss factors include M&V data from both Texas and New Mexico, and the evaluated efficiency loss factors include M&V data from only Texas. When compared to the reported efficiency loss values, the residential sector—without a refrigerant charge adjustment—was the only sector whose efficiency loss value changed when analyzing data from only Texas. In discussion with the implementer, this was due to a small sample size from New Mexico, which did not impact the evaluated efficiency loss vales much when removed from consideration.

Table 28. Reported Efficiency Loss Values (PY2016–2018 Averages)

Sector	Refrigerant Charge Adjusted	Reported Efficiency Loss Factor	Evaluated Efficiency Loss Factor
Commercial	No	0.143	0.143
	Yes	0.204	0.204
Residential	No	0.110	0.109
	Yes	0.175	0.175

Approximately 10 percent of tune-ups are anticipated by the CoolSaver program to receive full M&V in a given year for use in the annual efficiency loss updates. Table 29 shows the total tune-ups and M&V quantities by utility that were completed in PY2019. All four utilities were above 10 percent on their tune-up projects, which helped bring the statewide average to 17 percent.

Table 29. PY2019 Measurement and Verification Summary by Utility

Utility	Tune-Up Count	Measurement and Verification Count	Measurement and Verification Percentage
AEP Texas – Central Division	4,057	569	14%
CenterPoint	6,193	1,176	19%
El Paso Electric	17	5	29%
Entergy Texas	63	7	11%
Total	**10,330**	**1,757**	**17%**

5.1.4 Evaluation, Measurement, and Verification Approach

As a first step, the EM&V team conducted a complete tracking system review for all four utilities that reported tune-ups in 2019. The review was then followed by an in-depth review of the M&V sample collected in the field by the programs and an analysis of the current program year's efficiency losses. The implementer provided a combined M&V dataset for tune-ups in Texas from 2016 through 2018. The efficiency loss factors calculated by the EM&V team were the key savings assumption for this measure.

As part of the EM&V team's evaluation, a comprehensive review of the full M&V sample from 2016 through 2018 was completed. The tracking datasets from 2016 through 2018 were combined into a single dataset for analysis. The combined M&V dataset included 5,229 individual tune-ups collected by the programs over the previous three program years. Each tune-up measure was tested to assure data validity before analysis of the efficiency loss values. Before the analysis of the full M&V sample, the EER_{pre} and EER_{post} values were validated as appropriate when they were greater than zero for both values. Seven tune-ups were found invalid per the EER check and were excluded from further analysis.

A total of 5,222 tune-up measures passed data checks and were considered valid. Next, the dataset was separated for tune-ups with an refrigerant charge adjustment (RCA) and without an RCA. This resulted in identifying 1,929 tune-ups without an RCA and 3,293 tune-ups with an RCA.

Both datasets were reviewed for outliers. Outliers can occur for various reasons, but one of the most common reasons is due to a unit that is not tested at full-load conditions in either the pre- or post-tune-up case. The outlier review was accomplished by calculating and comparing the pre- and post-tune-up compressor powers using the data fields for *CompressorVolts* and *CompressorCurrent*. Since all testing is supposed to occur at or near full-load conditions, a difference in the compressor power between pre- and post-tune-up measurements indicates one of the two measurements may not have been conducted at full load conditions. The differences between the compressor power values were then divided by the nominal tonnage of the units to normalize the differences by capacity. Finally, the statistical ranges of the resulting values were analyzed, and any value that was more than three standard deviations from the mean was excluded from the efficiency loss calculations. A total of 137 tune-ups were identified as outliers from the compressor power test and excluded from the analysis.

5.1.5 Results

The number of M&V tune-ups validated by year, including all M&V data, is presented in Table 30. PY2016 and PY2017 were the two years with the lowest exclusion rates since 2011 when data was available. PY2018 however, saw a substantial uplift in the number of exclusions and represents the highest exclusion rate since data collection began in PY2011. This uplift was primarily driven by one trade ally who completed 114 of the 126 projects and noted by the EM&V team.

Table 30. All Measurement and Verification Tune-Ups Validated by Year

Year	Total Measurement and Verification Projects	Passed Data Checks	Total Projects Excluded	Exclusion Rate
2016	1,265	1,255	10	0.8%
2017	1,614	1,606	8	0.5%
2018	2,350	2,224	126	5.7%
Total	**5,229**	**5,085**	**144**	**2.8%**

Table 31 below shows the average test-in and test-out EERs by program year along with the standard deviation. Average test-out EERs remained similar across all three program years. Test-in EERs for PY2018, however, saw a drastic decrease compared to PY2016 and PY2017. The PY2018 average test-in EER was 15.9 percent lower than the weighted average between PY2016 and PY2017. This decrease in average test-in EER was present across all participating utilities.

Table 31. Average Test-In and Test-Out Energy Efficiency Ratio by Year

Year	Total M&V Projects	Average Test-In EER (AHRI Corrected)	Test-In Standard Deviation	Average Test-Out EER (AHRI Corrected)	Test-Out Standard Deviation
2016	1,265	9.86	3.14	10.77	2.39
2017	1,614	9.42	2.80	10.71	2.25
2018	2,350	8.08	2.59	10.62	2.24
Total	**5,229**	**8.92**	**2.90**	**10.68**	**2.28**

Table 32 shows the PY2018 average test-in and test-out EERs by trade ally along with the standard deviation. The trade ally names have been removed to remain anonymous. The EM&V team identified trade ally #1 as being an outlier, which is the previously mentioned trade ally that completed 114 of the 126 projects that were initially excluded from the sample. They completed a large number of projects with a low average test-in EER.

Table 32. PY2018 Average Test-In and Test-Out Energy Efficiency Ratio by Trade Ally

Trade Ally	Total Measurement and Verification Projects	Average Test-In EER (AHRI Corrected)	Test-In Standard Deviation	Average Test-In EER (AHRI Corrected)	Test-Out Standard Deviation
1	369	6.53	2.00	10.19	1.82
2	31	9.08	1.43	10.50	1.38
3	259	7.95	2.84	10.62	2.85
4	265	8.74	1.75	10.52	1.49
5	5	9.79	2.37	12.71	1.67
6	25	6.86	2.51	10.82	1.74
7	47	7.36	2.51	9.40	1.54
8	8	4.90	3.05	9.26	2.76
9	3	10.86	1.08	12.13	1.53
10	5	10.42	2.71	13.08	1.33
11	1	12.18	N/A	12.50	N/A
12	1	7.44	N/A	8.19	N/A
13	35	8.93	1.74	11.00	1.67
14	188	9.68	2.16	11.65	2.38
15	3	11.93	2.90	12.22	1.95
16	268	6.46	2.32	10.29	1.98
17	69	8.42	2.26	10.29	2.05
18	54	9.20	2.42	11.20	2.53
19	7	7.61	2.60	10.02	1.65
20	2	9.30	0.91	10.17	0.09
21	2	9.39	1.33	14.17	2.57
22	1	9.05	N/A	9.68	N/A
23	4	8.69	4.26	11.92	3.11
24	316	8.71	2.22	10.78	2.11
25	56	8.14	1.82	10.38	1.60
26	23	5.98	2.82	9.17	2.22
27	7	10.43	2.76	11.91	2.29
28	4	10.81	4.49	11.58	4.66
29	5	7.74	0.88	10.51	2.19
30	2	8.49	1.29	9.27	2.29
31	1	8.87	N/A	10.20	N/A
32	72	9.47	2.33	11.41	2.33

Trade Ally	Total Measurement and Verification Projects	Average Test-In EER (AHRI Corrected)	Test-In Standard Deviation	Average Test-In EER (AHRI Corrected)	Test-Out Standard Deviation
33	212	8.92	3.13	10.73	3.01
Total	**2,350**	**8.08**	**2.59**	**10.62**	**2.24**

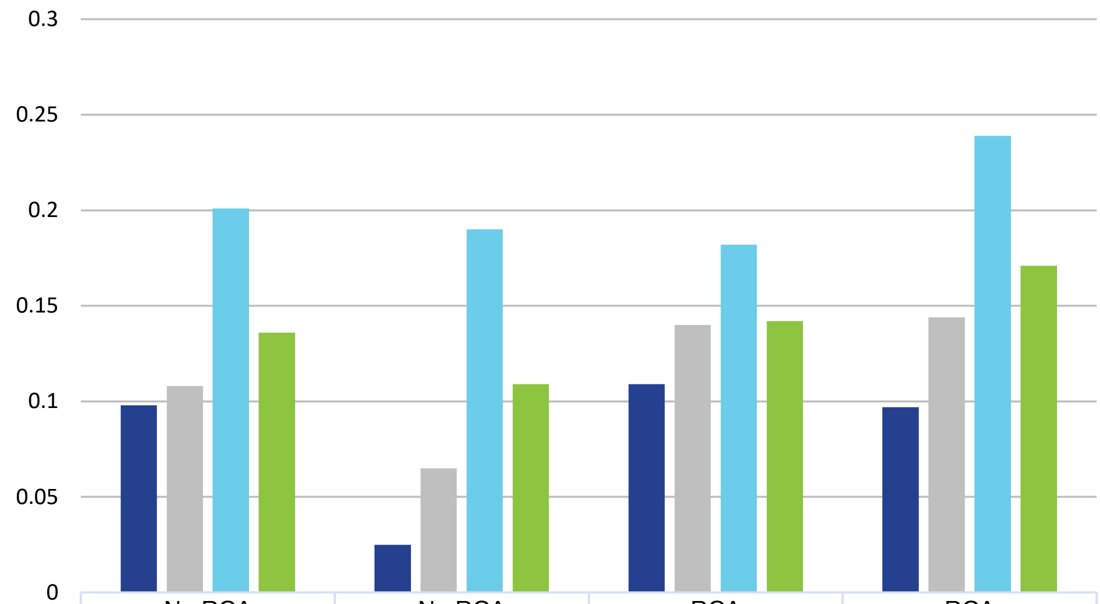
Because trade ally #1 was found to have an average test-in EER lower than the population average with a relatively small standard deviation, removing this trade ally reduced the total M&V projects in PY2018 to 1,981. The impact of removing this trade ally can be seen in Table 33. Removing this one trade ally impacted the mean and standard deviation of the entire PY2016 thru PY2018 sample, which impacted exclusions from all years.

Table 33. Final Measurement and Verification Tune-Ups Validated by Year

Year	Total M&V Projects	Passed Data Checks	Total Projects Excluded	Exclusion Rate
2016	1,265	1,249	16	1.3%
2017	1,614	1,598	16	1.0%
2018	1,981	1,945	36	1.9%
Total	**4,860**	**4,792**	**68**	**1.4%**

The 4,860 Texas tune-ups that passed the data checks were then analyzed by year, by sector (i.e., residential, commercial), and status. The results are shown in Figure 31. In all sectors and RCA status, the average loss value increased every year, with the largest increase observed in PY2018. This increase is attributed primarily to the lower average test-in results than observed in previous years.

Figure 31. Texas Average Efficiency Losses by Sector, Year, and Refrigerant Charge Adjustment



	No RCA Commercial	No RCA Residential	RCA Commercial	RCA Residential
2016	0.098	0.025	0.109	0.097
2017	0.108	0.065	0.14	0.144
2018	0.201	0.190	0.182	0.239
All	0.136	0.109	0.142	0.171

5.2 MULTIFAMILY

5.2.1 Program Overviews

Multifamily buildings receive incentives from both residential and commercial incentive programs using the residential and HTR SOP and MTP delivery. Multifamily buildings receive incentives for a wide range of measures similar to single-family homes. If the buildings are master metered, the energy savings and incentives are provided by the commercial programs, while units that are individually metered are included in the residential programs. The measures provided to any multifamily units are identical and include, but are not limited to, lighting, water-saving, envelope, and HVAC measures.

The evaluation of multifamily buildings this year was completed through the residential consumption analysis methodology described in Section 4 and through the commercial programs method described in Section 3.

5.2.2 Key Findings and Recommendations

Key Finding #1: The TRM does not differentiate savings for multifamily from single-family or manufactured homes.

The EM&V team conducted a consumption analysis comparing the performance of implemented measures versus the TRM deemed savings values. The detailed results in the *residential key findings and recommendations* section apply to the multifamily buildings in both the residential and commercial sectors.

The EM&V team isolated the results of the multifamily buildings compared to the single-family units. Several discrepancies were identified that impacted multifamily residences greater than single-family residences. *Air infiltration* and *duct sealing* were identified in the consumption analysis as larger discrepancies because the TRM deemed savings methodology does not take energy-saving advantages into account. Advantages may include shared walls, equipment within conditioned space, and fewer exterior walls than in single-family units).

The master-metered multifamily building desk reviews supported this finding by the commercial evaluation. The multifamily air infiltration improvements were measured at each apartment where there was infiltration both from the outside and adjacent units. Side-by-side apartment improvements would count both the infiltration from outside and infiltration between units, thereby overstating the reduction once added together.

Furthermore, a unique situation was identified when installing individual unit HPs (decentralized systems) to replace a centralized heating and cooling system. This type of project switches systems and requires that the baseline be adjusted to match the decentralized system. The TRM does not provide specific guidance for handling this in a multifamily building. The projects evaluated assumed an electric resistance decentralized heating system is the baseline. This assumption increases the electric consumption baseline over that of the actual baseline consumption and causes a disconnect between the results of the consumption analysis and the claimed savings. Improved guidance in the TRM will define the adjustment more clearly and provide the level of adjustment expected in future consumption analysis comparisons.

Recommendation #1a: The EM&V team recommends all residential retrofit measures are updated to increase the accuracy of the deemed savings. The TRM working group will update the PY2021 TRM to include guidance for claiming multifamily savings as well as updated testing guidance.

6.0 LOAD MANAGEMENT PROGRAMS

Load management programs were designated *medium* evaluation priorities in PY2019 due to their significant contribution to capacity (kW) savings and the new nature of the residential demand response programs, as well as recent changes in TRM methodologies for the commercial load management programs. This section documents key findings and recommendations from the EM&V team's results for both commercial and residential load management programs.

Commercial Load Management Programs: Commercial load management programs are designed to manage kW use during summer peak demand periods. These periods are defined in most utility programs as 1:00 p.m. to 7:00 p.m., weekdays, June through September. These programs are based on performance and offer incentive payments to participating customers for voluntarily curtailing electric load on notice.

While each utility operates a unique load management program, there are many similarities among them. In general, a dispatch event may be called at the utility's discretion 30 to 60 minutes in advance of a curtailment event, which generally lasts one to four hours. In most cases, the utility reserves the right to call a certain number of curtailment events per season, ranging from 5 to 15, based on utility. Customers must meet several eligibility requirements, including but not limited to: (1) taking service at the distribution level, (2) meeting minimum demand requirements, and (3) being equipped with interval data recorder metering. Customers are not permitted to participate in other load management programs using the same curtailable loads at the same time period (i.e., *double-dipping*).

Participants can either curtail their contracted load during a load control event or opt-out if they wish not to participate. Participants receive an incentive based on the kW that they curtail during the event. Savings for kW and kWh are calculated by following the methodology described in TRM 6.0, and an incentive is given to a participant based on the amount of kW saved. This incentive amount is specified in an agreement with the utility when enrolling in the program and ranges from $15 to $50 per kW saved.

Residential Load Management Programs: Residential load management programs are designed to manage kW use during summer peak demand periods. Three of the nine Texas utilities offer a residential demand response program to their customers. Of the three, two of the programs utilize a smart thermostat control strategy, and the other utilizes direct load control devices. Incentives for these programs differ by whether the utility's service territory is part of the ERCOT market or not. Utilities in the ERCOT market receive an incentive based on the evaluated kW savings that are achieved during the load control season. In contrast, non-ERCOT utilities pay a flat enrollment incentive and a flat incentive per program year. Participants are given the opportunity to opt-out of a load control event.

Participants in two of the three residential programs are evaluated individually with the *high 3 of 5* method described in TRM 5.0. In contrast, the other is evaluated using the new deemed savings value for residential demand response smart thermostat programs. The availability of AMI meters dictates the methodology that a utility will follow to calculate savings.

All utilities define their control seasons as June 1 to September 30, with possible load control events happening within the window of 1:00 to 7:00 p.m. on weekday non-holidays for ERCOT utilities and 2:00 to 8:00 p.m. on weekday non-holidays for non-ERCOT utilities.

Residential programs in Texas have seen dramatic increases in evaluated kW savings over the past few years as participation has steadily increased. This increase in participation and savings can be attributed to the adoption and successful marketing of programs that utilize smart thermostats.

6.1 SUMMARY RESULTS

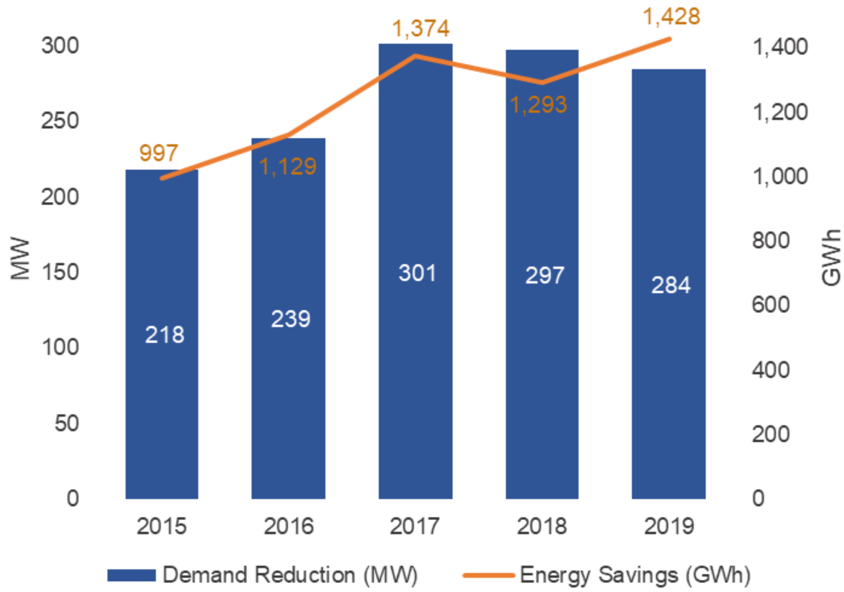
6.1.1 Savings

The total evaluated gross savings of the programs were:

- 284,085 kW (demand reduction), and
- 1,427,850 kWh (energy savings).

These results show a slight decrease compared to PY2018, by roughly 15 MW (15,000 kW). Figure 32 summarizes evaluated MW and MWh savings of all load management programs from PY2015 to PY2019.

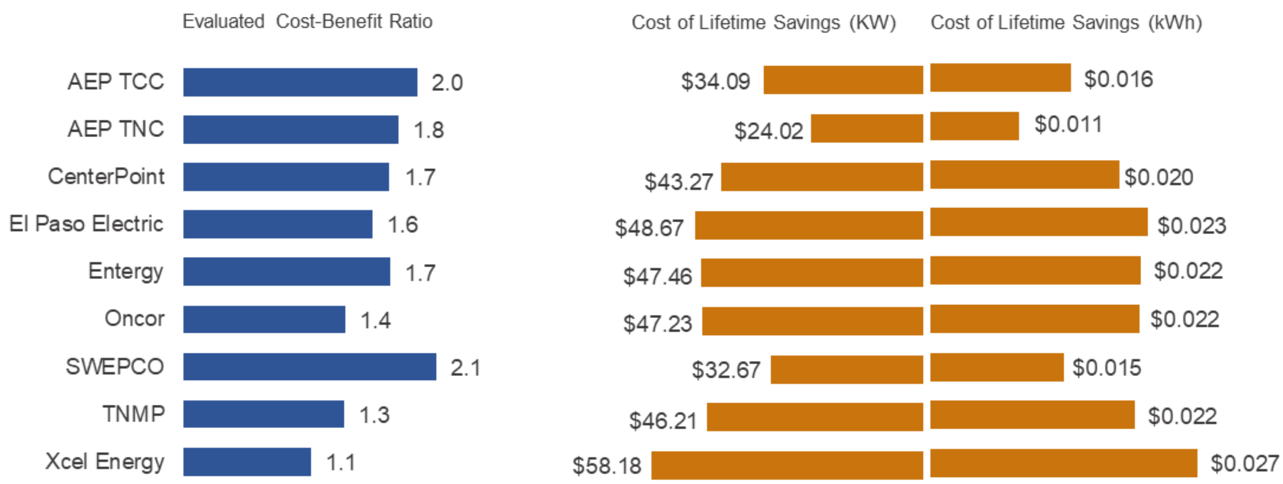
Figure 32. Total Statewide Evaluated Gross Demand Reduction and Energy Savings by Program Year—Load Management Programs



6.1.2 Cost-Effectiveness

Figure 33 summarizes the cost-effectiveness of each utility's energy efficiency portfolio based on evaluated savings of all load management programs in PY2019. All portfolios were cost-effective, ranging from 1.1 to 2.1. The cost per kW ranged from $24.02 to $58.18, and the cost per kWh ranged from $0.011 to $0.027. These costs provide an alternate way of describing the cost-effectiveness of a portfolio of programs. Those portfolios with a higher cost-effectiveness ratio will have a lower cost to acquire savings and vice versa.

Figure 33. Evaluated Cost-Benefit Ratio and Cost of Lifetime Savings—Load Management Programs PY2019



6.2 COMMERCIAL

This section summarizes the key findings and recommendations from the PY2019 evaluation of the commercial load management programs offered by the nine Texas utilities.

6.2.1 Program Overviews

The EM&V team applied the savings calculation methodology prescribed in the PY2019 TRM 6.0 on a census of records to calculate energy savings and demand reductions from interval meter data.

6.2.2 Key Findings and Recommendations

Key Finding #1: Utilities demonstrated strong capabilities to apply the TRM calculation method to savings.

PY2019 is the fourth year in which utilities and the EM&V team have applied the demand savings algorithm for commercial load management programs described in TRM 6.0. Now that the difficulties have been worked through in the previous years, and there is a mutual understanding of the *high 5 of 10* approach, the utility companies, implementers, and EM&V team were largely in agreement on final demand savings calculations.

Overall, the utilities applied the *high 5 of 10* method correctly to savings and matched the EM&V team's evaluated savings. The EM&V team noted, however, a minor discrepancy in one instance. When selecting baseline days using the *high 5 of 10* method for one site, six days were selected as baseline days because of a tie between two days. The EM&V adjusted the savings calculation to use the five highest loads closest to the event as baseline days.

Recommendation #1a: Continue implementing the demand savings algorithm described in the TRM and keep active communications with the EM&V team to resolve minor discrepancies in savings calculations. These recommendations will ensure consistency across utilities and enhance overall accuracy and transparency.

Recommendation #1b: In case of a tie between the days used to calculate the baseline, follow the TRM guidance of selecting the five highest loads closest to the event.

Key Finding #2: Texas commercial load management programs are effectively retaining commercial load participants.

Participation, as measured by the number of customers, has fluctuated annually in the past years but remained fairly stable over the past few years, with about 600 commercial participants. In 2019, participation increased to about 750, resulting in higher savings.

Recommendation #2a: Continue to assess the role of commercial load management programs as part of the utility's overall energy efficiency portfolio.

Key Finding #3: Minor discrepancies in savings calculation results were noted as a result of different rounding practices.

The EM&V team previously provided guidance on rounding practices to avoid minor discrepancies in savings calculations. The total program savings can be calculated by averaging the sum of sponsor-level savings or by adding the average sponsor-level savings. While, in theory, there should be no difference, the points at which rounding occurs can drive minor differences in calculation results. The EM&V team recommended that rounding occurs at the sponsor level for each event.

While rounding differences create only minor discrepancies in calculations, the differences have the potential to sum to a level that creates confusion or doubt. Using a standard practice or documenting differences will reduce the burden on the utilities and EM&V team (as discrepancies are investigated after initial calculations are developed) and will improve the consistency and transparency of savings calculations going forward.

Recommendation #3a: Data rounding should occur in only two instances—sponsor level savings and final program savings summaries. Without this standard practice, utilities should document when rounding is occurring in their calculations and inform the EM&V team.

Recommendation #3b: Update the load management guidance memo (TRM 7.0 Volume 5) to provide more details on when the rounding should occur during savings calculations.

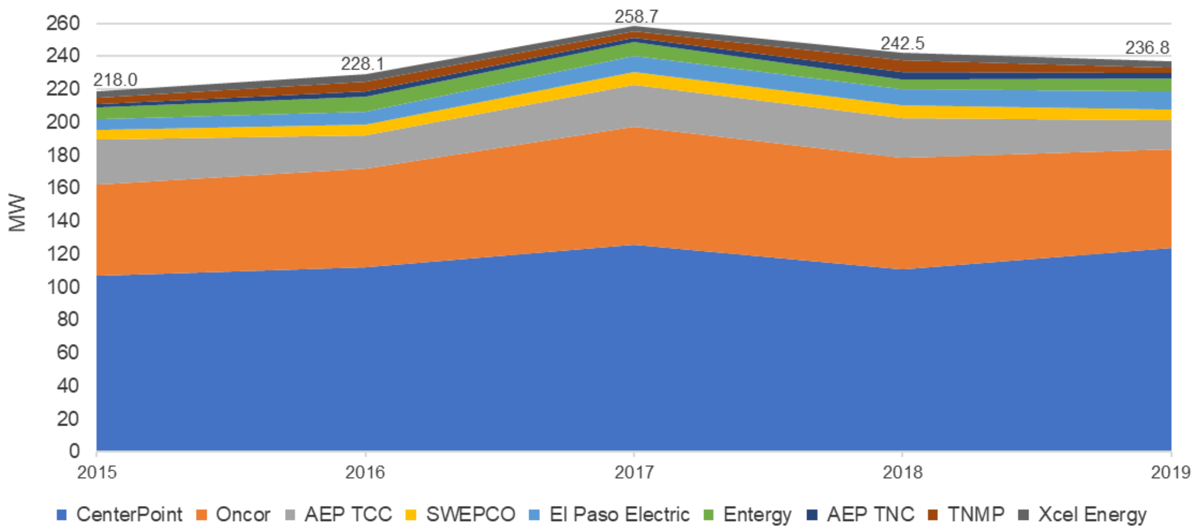
6.2.3 Impact Results

The total evaluated savings of all nine commercial load management programs were:

- 236,842 (demand reduction) kW, and
- 1,232,650 (energy savings) kWh.

These results show a slight decrease in savings compared to PY2018, by roughly 6 MW (5,680 kW). Figure 34 shows total kW savings from commercial load management programs by program year.

Figure 34. Evaluated Demand Savings of Commercial Load Management Programs (PY2015 – 2019)



Demand savings calculations from each utility were calculated largely the same as the evaluation calculations. There were no cases in which adjustments had to be made to individual meter savings calculations. This result supports the fact that both the EM&V team and the implementer and utilities are following the TRM algorithm for calculating saving precisely the same. While the TRM methodology was followed correctly by all utilities, realization rates for commercial load management programs were not 100 percent in PY2019. The reason for this discrepancy is that, when comparing individual meter savings for one of the commercial load management programs, it was found that the utility was following a conservative approach by not setting savings to zero in cases where the calculation methodology produced negative savings. Per TRM 6.0, in cases where the savings algorithm produces negative savings, the negative savings can be set to zero. As a result, commercial load management programs received a realization rate of 115 percent for kW and 109 percent kWh.

6.3 RESIDENTIAL

This section summarizes the key findings and recommendations from the PY2019 evaluation of the residential load management programs offered by three Texas utilities (El Paso Electric, CenterPoint Energy and Oncor). Other utilities did not offer a residential load management program.

6.3.1 Program Overviews

Two utilities calculated savings using interval meter data following the TRM 6.0 calculation methodology. The third utility used deemed savings from TRM 7.0.

6.3.2 Key Findings and Recommendations

Key Finding #1: Utilities demonstrated strong capabilities to apply the *high 3 of 5* method in TRM 6.0 to savings.

The two utilities that applied the *high 3 of 5* method to savings did so correctly and matched the EM&V team's evaluated savings.

Recommendation #1a: Continue implementing the demand savings algorithm described in the TRM and keep active communications with the EM&V team to resolve minor discrepancies in savings calculations—this will ensure consistency across utilities and enhance overall accuracy and transparency.

Recommendation #1b: Continue rounding data only at the event level or program year level. Residential programs have a very large number of participants, with the potential for rounding at the participant level driving substantial differences in savings at the event or program level. By consistently rounding only at the event level (summing individual participant savings), potential discrepancies between the EM&V team and utility calculations can be reduced.

Key Finding #2: There was still confusion surrounding language in the TRM 6.0 on how to apply the new deemed savings values.

PY2018 marked the first year in which utilities could calculate savings using a deemed saving approach if AMI meters are not installed on participating homes. One utility is following this approach. Upon evaluation of this program by the EM&V team and subsequent comparison to the utility calculated savings, the language in TRM 5.0 was found to be confusing regarding what qualifies a *participant*. The EM&V team, the utility, and the organization that produced the deemed savings value came to a consensus on how to apply the deemed savings value, and an evaluated savings result was agreed upon. This process involved excluding the meters that opted-out at the event-level and using a new deemed savings value (reflecting savings achieved by participants that did not opt-out of load control events) for future energy savings calculations.

Although the discussions and updates in TRM 6.0 clarified the exclusion of meters that opted out of the program, there is still confusion around partial participation. Per the TRM definition, participants are defined as *smart thermostats which participated no less than 50 percent time during the total event duration*. Therefore, partial participants that participated in an event for less than 50 percent of the event duration should be excluded from the savings calculation.

There will be clarifications in the next version of the TRM (8.0) to resolve this confusion and ensure a clear distinction between the different participation statuses at the event level (full participation, partial participation, or opt-outs) and how those should be treated in the savings calculations.

Recommendation #2a: Continue implementing the deemed savings value in TRM 7.0 and keep active communications with the EM&V team to ensure that there is a clear understanding of the TRM guidance and to resolve minor discrepancies in future program years.

Key Finding #3: Event-level savings calculations for the deemed saving approach can be simplified to avoid minor rounding discrepancies.

Per the TRM, event-level savings for the deemed saving approach are calculated by multiplying kW savings per device by the number of targeted devices and the participating ratio on that event. The EM&V team believes that the current calculation description has more complexity than needed, making it prone to rounding issues. Simplifying the description as follows will remove any rounding discrepancies:

"Event-level savings are calculated by multiplying kW savings per device by the number of participating devices."

Recommendation #3a: Update the TRM (Volume 2, section 2.2.10) to simplify the calculation of event-level savings.

6.3.3 Impact Results

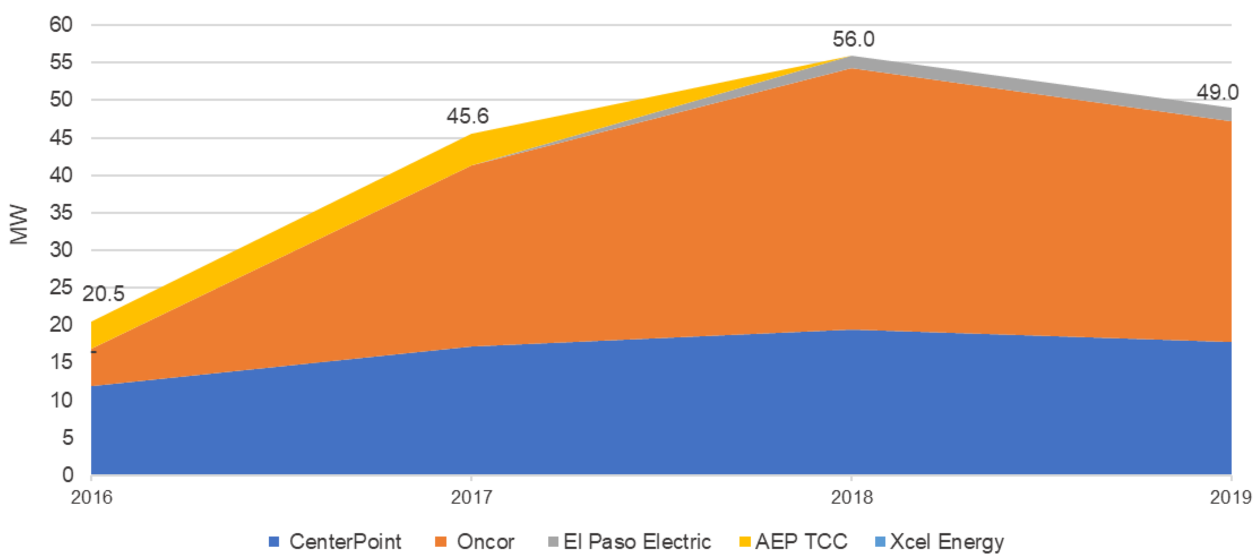
The total evaluated savings for the three programs were:

- 48,979 kW (demand reduction), and
- 239,897 (energy savings) kWh.

These savings are slightly lower than PY2018 by approximately 2,000 kW and 24,000 kWh.

Oncor's and CenterPoint's programs were in their fifth year of implementation in PY2019; El Paso Electric's program was in its second year of implementation. Figure 35 shows total kW savings from CenterPoint's and Oncor's residential demand response programs by program year. El Paso is not included at this time, as it is still operating as a pilot.

Figure 35. Evaluated Demand Savings of Residential Load Management Programs (PY2016 – 2019)



7.0 COVID CONSIDERATIONS

In March of 2020, COVID-19 was declared a global pandemic by the World Health Organization. Texas responded first locally with *stay home/work safely* policies at the city- and county-levels, followed by the issue of statewide orders by Governor Abbot. Texas' *stay home/work safely* order expired April 30, 2020, and Texas began a phased re-opening intending to minimize the spread of COVID-19 while re-opening the economy.[21] At the time of the writing of this report in July 2020, Texas has been experiencing COVID-19 spikes, and Governor Abbot has paused the re-opening process. The situation continues to evolve dynamically.

Because one of the primary objectives of this report is to provide recommendations for 2021 programs, the EM&V conducted research in May–June 2020 to provide the context of the impacts of the pandemic on the energy efficiency programs. The EM&V director interviewed utility program managers and directors to characterize how utilities are responding to COVID-19 in their energy efficiency portfolios. This information is complemented with information from residential service provider surveys and secondary research of energy efficiency developments across the country in response to COVID-19.

7.1 KEY FINDINGS AND RECOMMENDATIONS

Looking across these various sources of data, the EM&V team offers the following key findings and recommendations:

Key Finding #1: All utilities believe they will meet 2020 commercial goals.

Utilities reported that strong project pipelines before the pandemic and customers taking advantage of unoccupied facilities to install energy efficiency projects are the primary drivers of continued commercial program success. The pandemic has slowed down some projects due to supply chain issues, and some utilities are predicting a more pronounced *hockey stick* effect of project closings in the last quarter of 2020. However, all utilities still believe they will meet or exceed their goals.

While utilities have been primarily focused on meeting the 2020 program challenges, they have given some thought to 2021. In general, it is believed that the programs will continue to face challenges in 2021 on the commercial side, whether it is pandemic safety concerns or economic impacts from the pandemic such as state or local government budget cuts or business layoffs and closures.

Recommendation #1a: Utilities who have already met commercial 2020 goals may want to encourage applicable projects to roll into 2021 so that a strong pipeline is established for the next program year given uncertainty is still expected.

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[21] Texans helping Texans, The Governor's Report to Open Texas, April 27, 2020, https://gov.texas.gov/uploads/files/organization/opentexas/OpenTexas-Report.pdf

Key Finding #2: Small businesses have become more difficult to serve during the pandemic.

A combination of small business closures and low profit margins exacerbated during the pandemic, and other concerns generally have small business programs struggling to meet 2020 goals.

The secondary research found that some commercial programs across the country are exploring ways to deliver lighting, controls, and HVAC upgrades in partnership with COVID-19 renovation projects, such as dividers for open-space offices and improved air quality systems.

Recommendation #2a: Explore low-cost/no-cost measure solutions specifically tailored to small businesses as well as strategies implemented elsewhere in the country, such as leveraging COVID-19 remodels with energy efficiency upgrades.

Key Finding #3: While the majority of utilities believe they will meet 2020 residential goals, they have generally seen more residential program challenges during the pandemic.

Utilities who believe they will meet residential goals in 2020 generally credit their strong network of service providers for continued residential program success during the pandemic. In contrast, one utility who feels they may not meet 2020 residential goals cite limitations in their contractor infrastructure (i.e., lack of technology aptitude). Furthermore, multifamily and single-family projects complemented each other for utilities that have both sectors to serve, but not all utilities do.

Unlike commercial, there were fewer overarching themes statewide. Instead, residential challenges and successes are unique to each utility territory. Some utilities reported increased demand for HVAC with no demand for envelope measures, while others reported the reverse. Two of the nine utilities reported complete residential program shutdowns for a period of time; other utilities reported no shutdowns or slowdowns. The ERCOT utilities that coordinate with federal weatherization agencies did report shutdowns by the federal agencies that halted LI programs for a time.

The Texas utilities with upstream or midstream programs expanded those options somewhat to offset decreases in customer-direct programs. Moreover, utilities with new homes programs reported no decreases in activity. The literature review also found other utilities throughout the country emphasizing point-of-sale programs, online marketplaces, and refrigerator recycling programs where appliances are left curbside over in-house retrofits. Smart thermostats were found to be a popular item during the pandemic for the Texas utilities and other utilities throughout the country. Surveyed residential service providers recommended increased incentives and outreach during the pandemic.

Recommendation #3a: Utilities may want to consider complementing traditional in-home retrofit services with other program delivery methods such as upstream and midstream venues or self-install options by homeowners and multifamily maintenance staff.

Key Finding #4: Utilities are employing remote QA/QC practices.

All interviewed utility staff have been working from home since the pandemic began. They are employing a range of remote QA/QC practices, including in-depth engineering desk reviews, phone audits, virtual inspections provided through video, and expanded photo documentation. Remote QA/QC was also found to be the standard pandemic response in the secondary review of other utilities. One Texas utility in an area that was not experiencing a COVID-19 spike at the time of the interview has begun doing on-site inspections again in local areas. Some other utilities said they were looking forward to getting back on-site.

Both the Texas utilities and the secondary review found that some utilities are thinking toward the future, and if any of the new practices being deployed—even temporarily—will be beneficial to continue. The benefits of these new practices were discussed regarding conducting virtual inspections, especially for utilities with large service territories and distances between projects. Remote inspections could provide future cost savings if found to be effectively verifying savings.

Recommendation #4a: The 2020 EM&V should assess utility project QA/QC and documentation in terms of what was able to be feasibly accomplished remotely during the pandemic. Additionally, the 2020 EM&V's review of remote QA/QC should include an assessment of new practices to recommend if there is value in continuing any of these new practices. For example, successful virtual QA/QC processes may decrease on-site QA/QC inspection costs in the future, or utility-enhanced QA/QC desk reviews may decrease errors found during the EM&V reviews.

Key Finding #5: Utilities have taken different approaches to health and safety during the pandemic.

While all utilities report their company has implemented health and safety practices for their staff, guidance provided to service providers has varied. The most common approach is the view that service providers are businesses that have staff and customer safety at the top of mind and are implementing proper practices. In these cases, utilities are available to answer questions or provide help if requested. Utilities ask service providers to follow the local guidance in place. The less common approach found in Texas was a required health and safety training for service providers. One utility said the lack of health and safety protocols specific to the programs has been a major obstacle to their programs' activity. While most surveyed residential providers felt they were doing well in employing health and safety measures, responses did indicate receptivity to additional guidance from the utilities.

Recommendation #5a: Utilities may want to consider providing links to readily-available health and safety protocols from reputable sources, including national energy efficiency organizations and the Texas Department of State Health Services.

Key Finding #6: To date, customer complaints have not been an issue during the pandemic.

Utilities report that customers are expressing gratitude for program services during the pandemic as opposed to complaints. One utility has been following up on their service providers' health and safety practices and has found that the overwhelming majority of participants are reporting service providers are doing well in their safety practices. At the same time, utilities report that an essential piece of customer satisfaction during the pandemic is that they are not pushing customers out of their comfort zone if they want to cancel or delay a planned project. Utilities are only going into homes and facilities when the customer is comfortable with services being provided on-site.

Recommendation #6a: If not already doing so, utilities should consider including a health and safety question in ongoing program customer satisfaction surveys or other types of follow-up with customers on how well their service providers are performing during the pandemic.

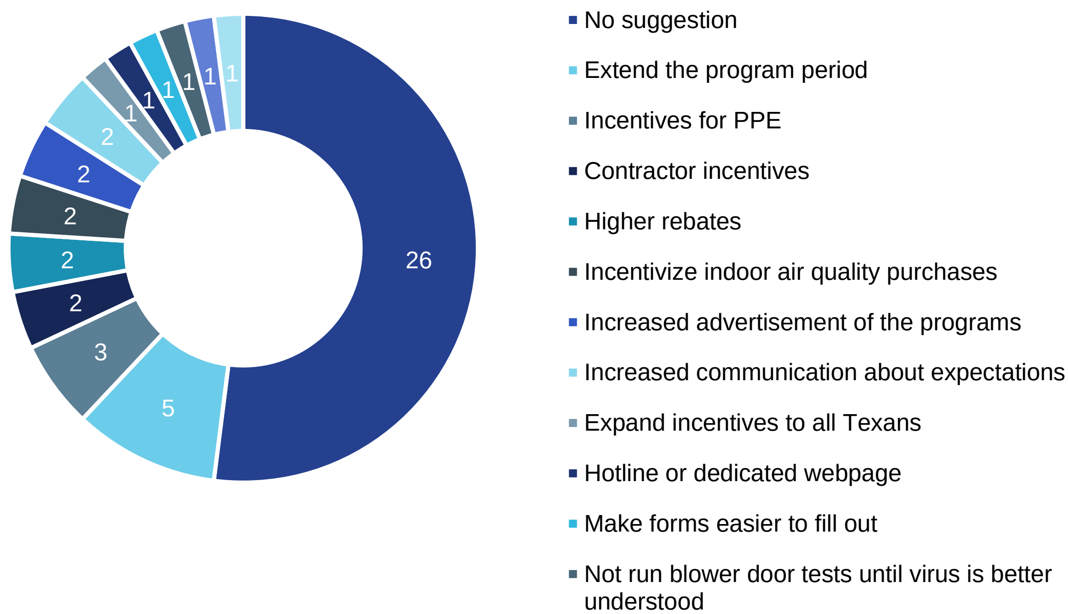
7.2 SERVICE PROVIDER FEEDBACK

The EM&V team surveyed residential service providers that participated in SOP, MTP, or HTR retrofit programs in 2019. While the purpose of the survey was to gather process information to understand how the programs are operating from service providers' perspectives, questions were also added to learn how the utility could help them during the COVID-19 pandemic.

Of the 50 service providers surveyed, most said they would not need additional support to implement the program once social distancing is eased (36 respondents). Half of the respondents did not have any suggestions for ways their utility can help during current *stay home/work safely* practices. The top three recommendations for providing help, either while the *stay home/work safely* order is active, or after, is to extend the program period, increase incentives, and increase marketing.

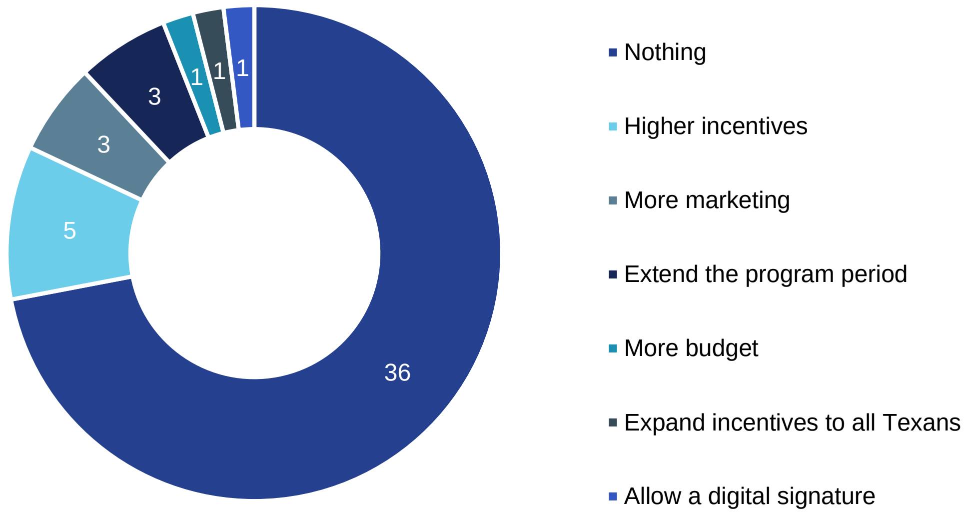
A total of 50 service providers were asked, "What support or program options would you like to see in the Texas utility programs to help your firm continue to implement energy efficiency projects given the current COVID-19 *stay home/work safely* practices?" A little over half of the respondents (26 respondents) said they had no suggestions for additional support. Five respondents said extending the program period would be helpful since projects are taking longer, given the slowdowns the COVID-19 has caused. Three said receiving incentives for personal protective equipment (PPE) would be helpful, followed by providing contractor incentives (2 respondents), higher rebates (2 respondents), incentives for air quality equipment (2 respondents), additional marketing (2 respondents), and increased communications to discuss program expectations (2 respondents). The full list of suggestions mentioned is shown in Figure 36 below.

Figure 36. Suggestions for Support or Program Options to Help Implement Projects During COVID-19 (n=50)



The same 50 service providers were also asked, “What support or program options do you think your firm will need to continue to implement projects after the easing of social distancing?” Most respondents said they would not need support after the easing of social distancing (36 respondents); five respondents said higher incentives would be needed to continue implementing projects; three said more marketing is needed; and three mentioned extending the program period. Also mentioned was increasing the program budget, offering the program to all Texas residents, and allowing for a digital signature when submitting paperwork.

Figure 37. Suggestions for Support or Program Options to Help Implement Projects During COVID-19 (n=50)



7.3 UTILITY PROGRAM STAFF FEEDBACK

The objective of the interviews was to characterize how utilities are responding to COVID-19 in their energy efficiency portfolios. The EM&V director conducted the interviews between June 15 through June 30, 2020. The interviews were semi-structured. Questions were not necessarily asked verbatim but followed the flow of the conversation with interviewees. Interviews ranged from 20 to 40 minutes in length. Specific interview objectives included:

- understand recent or proposed changes for programs due to the pandemic;
- characterize how program operations, including staffing, QA/QC, engagement activities, measure mix, and delivery strategies have changed in response to COVID-19; and
- identify strategies that can safely support program success as well as opportunities for improvement and program challenges.

Staff feedback was the primary foundation of the key findings and recommendations above, as results were synthesized across utilities.

7.4 SECONDARY REVIEW

Like all parts of our economy, energy efficiency programs have been up against substantial challenges as a result of the COVID-19 pandemic. Nonetheless, programs across the country have continued to provide at least limited services, some getting back into the field, and with leaders creatively pivoting to meet the challenge of a rapidly changing environment. By the end of March 2020, at least 19 states halted all retrofits to low-income homes under the Federal Weatherization Assistance Program. The Building Performance Association[22], which represents 9,500 home and building performance contractors, reported that virtually all residential energy efficiency work was suspended by utilities, states, service providers, and small businesses. While residential energy efficiency programs were hit the hardest, C&I energy efficiency programs also saw a substantial reduction in activity. As a result, utilities across the country took a variety of actions to try to continue to meet energy efficiency goals and lessen the impact on the energy efficiency workforce. Those actions generally fell into these categories:

- vendor communications and support,
- pipeline and backlog development,
- virtualization, and
- education, and marketing.

Below we discuss the various activities that utilities implemented within these categories.

Vendor Communication and Support

Program contractors and trade allies have been hit hard by the restrictions on direct customer contact. Some programs have been using this time to train program staff and contractors who are unable to work. Such training includes typical professional development and skills, as well as training on new guidelines and practices to ensure health and safety. For example, state officials in New York have developed guidelines and are coordinating free online training opportunities for clean energy contractors in response to the pandemic. Similar training and supporting resources are available to energy efficiency contractors serving utilities in Massachusetts, Rhode Island, Connecticut, and New Hampshire, as well as others across the country.

Pipeline and Backlog Development

A lot of program work can happen without direct customer contact, including planning and developing projects. Many types of energy efficiency measures can be installed, and many projects can move forward while adhering to public health guidelines. For example, some programs have targeted vacant schools and offices (where applicable) and mechanical rooms. One emerging idea has been for programs delivering lighting, controls, and HVAC upgrades to partner with COVID-19 upgrade projects, such as dividers for open-space offices and improved air quality systems.

Virtualization

Most utilities continued some programs while others paused completely; however, there was a near-universal suspension of on-premise energy efficiency programs. Instead, utilities moved to:

- accepting prescriptive applications, point-of-sale, and trade ally incentives (especially for emergency replacement or repair);
- emphasizing online marketplaces;
- continuing appliance recycling with curbside pick-ups;
- adjusting messaging for behavioral/home energy report programs;
- shifting to or creating virtual home audit programs; and
- using or ramping up virtual tools for commercial pre- and post-inspections.

[22] https://www.building-performance.org/who-we-are

Some utilities made incentive adjustments, including increasing incentives in recognition of economic hardship (or considering incentive increases once restrictions are lifted). Some utilities increased insulation rebates to 100 percent, and some extended or relaxed rebate deadlines.

On the residential side, utilities moved to virtual home audits, collaborating with technicians and customers. To perform virtual audits, some programs used facilitation tools such as FaceTime, Skype, etc., and some used lower-tech options such as phone calls and sending pictures. In many cases, customers took measurements and video for technicians. The virtual assessments typically have lasted 45 to 90 minutes each and have been free to customers. On the commercial side, programs have also been using remote and virtual audits and pre-inspections to move projects forward and increase cash flows. Some programs completed in-person *napping campus tours*, as it was acceptable (and sometimes easier) to do some site walkthroughs while buildings were not operational.

Education and Marketing

With so many people staying at home, programs have taken advantage of this unique opportunity to engage with their customers to educate, inform, and motivate them to take action to reduce their energy use and save money. Utilities in several states have sent their customers specific advice on saving energy while they are at home during the day. Programs have expanded and created new online resources, tools, and messages to increase their outreach to customers, identify and take advantage of immediate energy savings opportunities, and plan for longer-term improvements. For example, Xcel Colorado paired virtual audits with deliveries of no-cost do-it-yourself kits and virtual installation support, as well as follow-up virtual visits to confirm installations and plan the next steps. Consumers Energy is providing 100,000 smart thermostats to its customers during the pandemic through its online energy marketplace.

Most utilities have continued their home energy reports (HERs) program but have adjusted the messaging. For example, messaging has focused on the fact that behavioral change is free and easy to implement, and that efficiency is needed in light of higher residential occupancy. Some messaging has acknowledged COVID-19 and addressed customer concerns around topics such as power cutoffs. Other messaging has provided:

- specific advice for people spending more time at home and teleworking;
- tips that intersect both health and energy (e.g., washing hands and reducing hot water usage); and
- recommendations on easy, low-cost, or no-cost suggestions that customers can do on their own.

These messages have often increased in frequency, especially using email and online or digital tools (i.e., driving customers toward online account management tools). Similarly, some utilities have increased the emphasis on promoting programs through digital channels (e.g., blogs, email, social media). They have also used analytics to create targeted messaging, in part to build project pipelines and also to identify energy-burdened households, identify key drivers of load, and recommend and promote appropriate behavioral programs.

Table 34 highlights a few utility-specific examples of pandemic response to energy efficiency program implementation.

Table 34. Utility Response to COVID-19

Utility	COVID-19 Response

DTE Energy (DTE)	• DTE's programs that have direct homeowner and business contact were shut down (Appliance Recycling and Direct Install programs, in-home and in-business inspections, etc.). Even though retailers have remained open (e.g., big box stores, hardware stores), programs have suspended in-store outreach to them.
	• Programs and implementers have been continuing to process rebates, send HERs, and work through midstream programs (with contractors that are still running or operating), as there are contractors still working and offering no-contact visits.
	• DTE's call center continued to operate (remotely), though the implementer noted that call volume decreased dramatically (DTE call volume was down about 40 percent through April 2020).
	• DTE asked their implementers to begin working on recovery plans once *stay at home* orders are lifted. Because this is unchartered territory, no one knows if there will be pent-up demand or if it will kill demand. There is also concern that small businesses will not have funds to invest in energy efficiency for a while.
	• DTE has an online marketplace that has been holding steady—volume is up, and they are trying to move product through that channel. DTE had noted that the sales of actual items were up 35 percent, but dollars were less.
	• DTE focused its marketing messaging on promoting energy efficiency and energy education, specifically about how energy efficiency can help mitigate high bills while working from home.
	• DTE noted that no one is sure what the new *normal* will be, and who will drive that (contractors, the Center for Disease Control, etc.).
	  ○ Liability is going to be a concern, as even once the *stay at home* orders are lifted, COVID-19 will still be around.
	  ○ Programs will need to tie in with industry associations and what they decide to do; it is not the utility's place to impose rules for contractors.
	• The other big concern for DTE and implementers has been the performance metrics and incentives that are based on those, as well as the regulations that are in place for utilities (settlement agreements, etc.). DTE has encouraged everyone to do the best they can and document everything.

<table>
<tr><th>Utility</th><th>COVID-19 Response</th></tr>
<tr><td>Energy New England</td><td>
Efficiency audits conducted by video have helped municipal cooperative Energy New England (ENE) to avoid laying off staff, and officials say customer enthusiasm for the new approach may signal a permanent change in how business is conducted.
ENE provides efficiency services and other products to 25 municipal utilities in the Northeast and has been experimenting with virtual energy audits to keep workers on board and maintain a pipeline of projects for when the economy reopens. The group is exploring offering similar services to small business customers.
ENE engineers use either Facetime or Google Duo to complete the virtual audits. While it takes a bit more preparation to walk customers through the audit, they have seen more engaged responses from homeowners, though also note that the technology piece is not for everyone. So far, all homeowners who have completed ENE's virtual audit have indicated they intend to move forward with recommended changes and retrofits. The process typically takes between 45 and 90 minutes to complete, with the customer taking some measurements and capturing images that an efficiency engineer would typically do.
So far, ENE has managed to retain workers that specialize in efficiency work, but companies that do the actual construction work are facing bigger challenges.
</td></tr>
<tr><td>Eversource</td><td>
The Eversource service territory spans three states—Connecticut, Massachusetts, and New Hampshire. By the end of March 2020, Eversource had suspended in-home or on-premise services across all of its service territories. Restarting those programs all depends on re-opening plans. During the stay at home order, Eversource provided the following vendor communications and support:

created FAQs in all three states,
provided information on federal and state assistance programs,
supported joint webinars which summarize these federal and state assistance programs,
supported the Connecticut Technical Advisory Committee working group with the Connecticut Department of Energy and Environmental Protection (DEEP),
supported public input sessions (through DEEP), and
organized four state training plans for residential and commercial contractors through online learning modules (a joint effort with Connecticut, Massachusetts, New Hampshire, and Rhode Island and their PAs).

For residential and commercial programs, Eversource:

made progress payments or partial payments for measures installed or percent complete;
extended or relaxed rebate deadlines;
continued to process rebate applications;
continued to review and approve projects in the pipeline short of in-home and on-premise services;
developed enhanced offerings for when full program activity resumes (i.e., increased incentives for HPs, insulation); and
conducted virtual inspections and assessments through videos, pictures, etc.

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<tr><th>Utility</th><th>COVID-19 Response</th></tr>
<tr><td>Massachusetts Program Administrators (Mass Saves)</td><td>

In Massachusetts, the state's Department of Energy Resources suspended the majority of on-premise efficiency work but also shifted to more remote and virtual procedures, including virtual home energy assessments and virtual pre- and post-inspections for projects.

The state's Mass Save program has offered virtual home energy assessments through its vendors for residential customers and has been looking into options for virtual small business audits.
Mass Saves also waived the co-pay and is offering free training for the contractor community to continue to strengthen the workforce and keep contractors engaged. Additionally, measures and projects were identified that could be re-initiated when determined appropriate.
Due to public health and safety concerns, PAs decided to suspend on-premise energy efficiency activity:

PAs will not pay incentives associated with contracted on-site services during this period.
Exceptions will be permitted on a case-by-case basis for safety or emergencies.
PAs anticipate the temporary suspension will remain in place for the foreseeable future.
PAs will consider resuming on-premise services based on guidance from federal, state, and local public health officials and after the development of appropriate health and safety protocols.

Other energy efficiency services remain active, including:

online audits;
upstream and point-of-sale offerings;
retail rebates;
active demand response;
trade-ally-driven C&I incentives;
virtual pre- and post-inspections for C&I projects (in some limited cases);
refrigerator recycling pick-ups (permitted, as long as the refrigerator is left outside);
HEAT Loan availability (on-premise Home Energy Assessment (HEA) requirement temporarily suspended); and
Developing other remote options, including accelerating virtual HEAs.

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Utility	COVID-19 Response
Seattle City Light	• Seattle City Light has been taking steps to ensure efficiency contractors get paid for work completed or work that is in progress. The utility has been looking at projects that they believe to be awaiting payment, or close to payment, and are trying to expedite that. • In some instances, work is being verified through video or photographs or screenshots of energy management system outputs. Images from Google Maps have been used to verify pre-existing conditions of buildings. • Despite the creative efforts, Seattle is forecasting a seven percent reduction in energy savings this year. However, that reduction could be made up in the future if federal legislators can include efficiency measures in future stimulus efforts. • Seattle City Light typically covers 50 to 70 percent of the upfront cost of efficiency work. Federal funding could push that to 100 percent, similar to what was done during the Great Recession.

Are the new practices that are being deployed, even temporarily, beneficial to the construction of energy-efficient buildings? Will they continue to be used after the pandemic recedes? DTE, and other Michigan utilities and key stakeholders, have said they believe that things will be different for quite a while. DTE believes that how programs are implemented may change forever. Only time will tell, but there can be benefits to conducting virtual inspections, especially for utilities with large service territories and distances between projects. Remote inspections can provide cost savings by performing inspections and verifying the efficiency requirements in the building codes, saving time and money in the process. Physical building inspections will resume for all types of buildings at some point. Still, some of the innovations in M&V, building inspection, and code enforcement brought about by the COVID-19 pandemic are likely to persist. These innovations are enabling utility programs to ensure safe, resilient, and energy-efficient buildings in any type of environment.

TECHNICAL APPENDIX 1 RESIDENTIAL RETROFIT CONSUMPTION ANALYSIS

Introduction

This Technical Appendix provides the methodology and findings associated with the residential retrofit consumption analysis that was conducted as part of the PY2019 EM&V effort. The analysis aims to estimate the impact of the Residential Standard Offer Program (RSOP), the Hard-to-Reach Standard Offer Program (HTR SOP), and the Low-Income (LI) program, at both the program and measure level.

Table 35 presents a list of acronyms used throughout this document.

Table 35. Acronym Definitions

Acronym	Definition
RSOP	Residential standard offer program
HTR SOP	Hard-to-reach standard offer program
LI	Low-income program
TRM	Texas Technical Reference Manual Version 6.0
ASOS	Automated Service Observing System—the name of the network of real weather stations
TMY3	Typical meteorological year 3
PRENAC	Annual weather-normalized consumption in the pre-period
SEER	Seasonal energy efficiency ratio
CDD	Cooling degree day
HDD	Heating degree day
PDPF	Peak demand probability factor

The Data

We have four sources of data:

- **Program Tracking Data.** We received program tracking data that contained account numbers, participation dates, addresses, and measures received. Program tracking data also include the reported Texas Technical Reference Manual Version 6.0 (TRM) savings estimates for each measure received, the utility associated with the account, and the program in which the account participated.
- **Meter/Consumption Data.** We received 15-minute interval data from Oncor, CenterPoint, AEP TCC, AEP TNC, and TNMP for the period between January 1, 2017, and January 1, 2020. This data contained an account number, timestamp, and kWh consumption for each 15-minute interval. Some utilities provided data before the validation, editing, and estimation (VEE) process, while others provided post-VEE data.
- **Texas Weather Data.** This data was retrieved from the Automated Service Observing System (ASOS) network.[23] This data contained the hourly temperature readings for the period between January 1, 2017, to January 1, 2020. We used data from the station

[23] https://mesonet.agron.iastate.edu/request/download.phtml?network=TX_ASOS

closest to each TMY3 station, for a total of 59 weather stations. For more information on the Texas weather data, see Appendix 1-A: Supplemental Information on Weather Data.

- **Texas Typical Meteorological Year 3 Data (TMY3).** This file contains hourly temperature readings for the period 1991 to 2005 and was used by NREL to construct the typical weather for one year. Weather data was constructed by selecting each month that represents the most typical weather between 1991 and 2005 to form one full calendar year. This data was used to normalize energy use in the pre- and post-period of the analysis. There are 61 TMY3 stations; only 59 ASOS stations were used due to insufficient data at one station and one station being the closest ASOS station to two separate TMY3 stations. Due to a recent change, the link to this data source is no longer maintained.

Participant Group:

The participant group is defined as customers who participated in the RSOP, HTR SOP, or LI programs during the 2018 calendar year. We use the terms *participant group* and *treatment group* interchangeably.

Comparison Group:

We use a quasi-experimental design to estimate the effects of the programs on energy consumption. In this approach, we want to compare the change in energy use among the treatment group before and after their participation in the program (change due to the program) with the change in energy use over that same period among an equivalent group that did not participate. Change in energy use for the latter reflects what would have happened absent the program. Defining an equivalent comparison group is critical to establish internal validity. We follow the recommendation in the Uniform Methods Project for programs with non-randomized participant populations spanning multiple years and construct a comparison group of future participants.[24] Specifically, we define the comparison group as customers who participated in one of the same programs (RSOP, HTR SOP, or LI) in 2019. Comparing pre- and post-energy use of PY2018 participants with the pre- and post-energy use of PY2019 participants allows us to assess the effects of the program.

Final Participant and Comparison Group Samples:

This section describes the screening criteria used to qualify accounts for the analysis. We apply screening criteria to the analysis population to exclude accounts with data quality issues that could bias model results. The 2015 consumption analysis informs much of the screening criteria. We exclude accounts as described below (Appendix 1-B: Screening Criteria Details presents more detailed information on the screening requirements).

- Accounts that participated in both 2018 and 2019. If there were more than 12 months between the 2018 and 2019 participation dates, the account was still used as part of the treatment group.

- Accounts that have solar interconnect agreements. Since these accounts produce some or all of their own electricity, we would not have complete consumption data.

[24] Agnew, K.; Goldberg, M. (2017). Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol, The Uniform Methods Project: Methods for Determining Energy-Efficiency Savings for Specific Measures. Golden, CO; National Renewable Energy Laboratory. NREL/SR-7A40-68564. http://www.nrel.gov/docs/fy17osti/68564.pdf

- Accounts where meter data was missing entirely. It is not possible for us to include these accounts in the analysis.
- Accounts where the earliest or latest meter reading date was less than 365 days from the participation date. In other words, accounts are excluded when the pre- or post-installation period was less than one full year. Using one full year of pre- and post-data is standard practice and allows us to observe consumption in every season.
- Accounts that were missing more than the equivalent of one total day of consumption data (i.e., missing more than 96 15-minute meter data readings across the entire 730 days (365 pre- and 365 post-program, not necessarily 96 consecutive 15-minute readings). This rule allows us to retain accounts with relatively small amounts of missing data, thus preserving the size and heterogeneity of the analysis group while excluding those where large amounts of missing data could bias model coefficients.
- Accounts with at least one week (672 15-minute meter data readings) of continuous meter readings of zero kWh or at least one total month (2,880 15-minute meter data readings) of meter readings of zero kWh, in aggregate. Long streaks or large amounts of meter readings of zero kWh indicate periods of vacancy, meter reading failure, or other issues that could bias model results. Meter readings of zero kWh are somewhat common (about 98 percent of accounts in the treatment group have at least one zero kWh reading); therefore, retaining accounts with some zero kWh readings was essential to preserve the size of the analysis group. Appendix 1-B: Screening Criteria Details provides more detail on this screening step.
- Accounts with changes in consumption from the pre- to post-period in excess of ±70 percent. Changes in annual electricity usage of this magnitude are uncommon and are likely the result of non-programmatic effects.
- Accounts in which the estimated TRM savings were less than one percent or greater than 100 percent of the pre-period consumption. These accounts are outliers that will show very small savings due to a minor project or have estimated savings that are not actually possible.
- Accounts with total usage that was excessively high or low in the pre- or post-period (less than 1,000 kWh or greater than 70,000 kWh); these accounts are outliers. The average consumption in the pre-period is about 15,000 kWh, and these accounts represent uncommon situations of drastically high or low consumption, which could influence model results.

Table 36 shows the number of accounts represented by each utility in each program. Totals across programs may be slightly different than the total number of treatment group or comparison group accounts, as 38 treatment group and 294 comparison group accounts were noted as participating in multiple programs. Where analysis was conducted on individual programs, those accounts are included in both programs; however, an analysis conducted on all programs simultaneously included one instance of the account to avoid double counting.

Table 36. Accounts by Utility, Program, and Treatment/Comparison Status

Utility	RSOP		HTR SOP		LI	
	Treatment	Comparison	Treatment	Comparison	Treatment	Comparison
AEP TCC	2,498	2,648	797	802	126	36
AEP TNC	399	260	186	116	25	25
CenterPoint	229	56	367	58	717	0
Oncor	10,016	7,041	4,899	6,264	859	996
TNMP	846	981	252	190	81	217
Total	**13,988**	**10,986**	**6,501**	**7,430**	**1,808**	**1,274**

Table 37 provides details on the number of accounts removed from the analysis for reasons detailed previously, and Table 38 shows overall sample attrition and retention information by program and utility.

Table 37. Detailed Sample Attrition, Treatment and Comparison Groups

Screen	Treatment		Comparison	
	Accounts Remaining	Percentage Remaining	Accounts Remaining	Percentage Remaining
Census	33,567	100.0%	29,785	100.0%
In treatment and comparison	33,219	99.0%	29,785	100.0%
Solar	32,975	98.2%	29,700	99.7%
No meter data	32,963	98.2%	28,237	94.8%
Meter min/max <1 year	32,200	95.9%	28,012	94.0%
Missing data	28,783	85.7%	23,917	80.3%
0 kWh data	23,042	68.6%	19,816	66.5%
Percent change >70%	22,690	67.6%	19,429	65.2%
Project size <1% of pre-program	22,295	66.4%	19,429	65.2%
Total usage outlier	22,259	66.3%	19,396	65.1%
Final	**22,259**	**66.3%**	**19,396**	**65.1%**

Table 38. Sample Attrition by Program and Utility*

Program	Group	Account Attrition	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP
RSOP	Treatment	Original accounts	6,170	854	493	12,110	1,270
		Final accounts	2,498	399	229	10,016	846
		Percentage retained	40.5%	46.7%	46.5%	82.7%	66.6%
	Comparison	Original Accounts	5,637	549	295	7,834	1,312
		Final Accounts	2,648	260	56	7,041	981
		Percentage Retained	46.8%	46.7%	13.5%	88.8%	74.8%
HTR SOP	Treatment	Original Accounts	1,729	364	755	6,556	347

Program	Group	Account Attrition	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP
		Final Accounts	797	186	367	4,899	252
		Percentage Retained	46.1%	51.1%	48.6%	74.7%	72.6%
	Comparison	Original Accounts	1,585	310	552	8,755	270
		Final Accounts	802	116	58	6,264	190
		Percentage Retained	49.8%	36.9%	10.5%	71.5%	70.4%
LI	Treatment	Original Accounts	453	60	1,462	1,044	218
		Final Accounts	126	25	717	859	81
		Percentage Retained	27.8%	41.7%	49.0%	82.3%	37.2%
	Comparison	Original Accounts	219	72	1,441	1,370	266
		Final Accounts	36	25	0	996	217
		Percentage Retained	10.1%	34.7%	0.0%	72.6%	81.6%

*Note: Totals that do not match other totals in this report are due to accounts that participated in multiple programs.

Final Measure Distributions:

Table 39 shows the distribution of measures for the participant group accounts that were used in the analysis. As a guide to Table 39, 45 percent of the treatment group accounts that were included in the analysis of the RSOP received an air infiltration measure. In comparison, 54 percent of the population of 2018 RSOP participants received an air infiltration measure. With a similar format to Table 39, Table 40 and

Table 41 show comparisons of the measure frequency and average estimated TRM savings between the treatment analysis sample and the treatment population. These tables give context for understanding model results. The distributions of the measures and the average TRM savings are similar across the analysis sample and population, indicating the sample reflects the population. The main difference is that estimated heat pump savings are slightly higher in the analysis sample than in the population. Other differences in estimated savings can be attributed to the number of accounts being very small, making the difference between population and sample mean TRM savings volatile.

Table 39. Final Measure Distribution (Participant Sample vs. Participant Population) *

Category	Measure	Percentage of Sample			Percentage of Population		
		RSOP	HTR SOP	LI	RSOP	HTR SOP	Low Income
Shell	Air Infiltration	45%	68%	10%	54%	67%	8%
	Ceiling Insulation	13%	34%	17%	13%	30%	18%
	Floor Insulation	0%	<1%	<1%	0%	<1%	<1%
	Solar Screen	<1%	<1%	<1%	<1%	<1%	<1%
	Wall Insulation	<1%	<1%	5%	<1%	<1%	3%
	Windows	<1%	<1%	2%	1%	2%	1%
HVAC	AC	26%	<1%	<1%	19%	<1%	<1%
	Duct Sealing	14%	12%	1%	23%	17%	1%
	Heat Pump	18%	10%	81%	15%	14%	83%
	Window AC	0%	0%	<1%	0%	0%	<1%
Final Accounts		**13,988**	**6,501**	**1,808**	**20,897**	**9,751**	**3,236**

*Note: Percentages do not total to 100 percent since an account could have more than one measure.

Table 40. Final Measure Frequency (Participant Sample vs. Participant Population)

Category	Measure	Frequency (Sample)			Frequency (Population)		
		RSOP	HTR SOP	LI	RSOP	HTR SOP	LI
Shell	Air Infiltration	6,306	4,445	173	11,274	6,510	244
	Ceiling Insulation	1,778	2,222	300	2,719	2,888	571
	Floor Insulation	0	1	1	0	1	1
	Solar Screen	2	2	15	4	4	18
	Wall Insulation	3	7	97	3	15	108
	Windows	19	5	28	263	235	43
HVAC	AC	3,579	17	10	3,900	45	24
	Duct Sealing	1,970	775	21	4,722	1,640	47
	Heat Pump	2,496	659	1,467	3,185	1,323	2,700
	Window AC	0	0	1	0	0	1
Total Measures		**16,153**	**8,133**	**2,113**	**26,070**	**12,661**	**3,757**

Table 41. Average Estimated TRM Savings (Participant Sample vs. Participant Population)

Category	Measure	TRM Savings (Sample)			TRM Savings (Population)		
		RSOP	HTR SOP	LI	RSOP	HTR SOP	LI
Shell	Air Infiltration	1,363	1,328	613	1,242	1,303	655
	Ceiling Insulation	3,552	1,889	1,083	3,356	1,887	1,259
	Floor Insulation	NA	153	237	NA	153	237
	Solar Screen	136	166	352	147	180	374
	Wall Insulation	689	954	1,182	689	972	1,199
	Windows	813	383	440	395	346	450
HVAC	AC	2,961	1,345	2,211	2,923	1,374	1,592
	Duct Sealing	668	695	460	658	697	442
	Heat Pump	7,078	6,134	5,386	6,705	5,725	5,065
	Window AC	NA	NA	613	NA	NA	613

Regression Models:

Several different regression models were used to estimate energy impacts. For reporting purposes, we use the individual household weather normalizing models; these models provide the most in-depth analysis because they use hourly data and a separate regression for every account. The results of other models mirror those of the individual household weather normalizing models. The different models used are described below, and Appendix 1-C: Model Specifications, Details, and Results presents more detailed results.

Individual Household Weather Normalization Models. This model uses hourly weather data as an input to estimate the effect of weather on each household's energy consumption. It is an account level regression analysis for both the pre- and post-period of each account. The results allow us to compare consumption in the pre- and post-period for each account using normalized weather that removes the effect of different weather conditions between the pre- and post-periods. To estimate weather-normalized consumption, observed weather data from the ASOS stations are matched with observed consumption data to build models for each household. The ideal models (heating and cooling setpoints that produce the highest R^2) for each household are then fit to TMY3 weather data, which produces consumption estimates for the situation in which weather is the same in the pre- and post-period. Weather normalizing is an important step in the analysis because differences in weather in the pre- and post-period can confound our analysis and do not allow for a direct comparison between annual pre- and post-consumption. Results are averaged over all accounts to show savings at the program and measure levels.

Program-Level Fixed-Effect Models. Unlike the *individual household* models that are run for each participant, this model is run across all participants for each program. The model estimates the average savings of each account in that program, and includes a fixed effect, which accounts for differences between homes that do not change over time, such as home size or age. The model is estimated using observed daily weather data. Once model coefficients are obtained, the model uses daily TMY3 weather data along with household-level weather coefficients as inputs to estimate weather-normalized daily consumption.

Measure-Level Fixed-Effects Models. This model is similar to the *program-level fixed-effects* model, but it contains indicator variables for each specific measure group to estimate the savings associated with each measure group. The model is estimated using real observed weather data at the daily level. Once model coefficients are obtained, the model uses daily TMY3 weather data, household-level weather coefficients, and account measure information as an input to estimate weather-normalized daily consumption.

Individual Household Weather Normalization Demand Models. This model estimates demand impacts using the *individual household weather-normalization* models mentioned above, but it focuses only on the 20 peak hours of the year as defined by Texas TRM 6.0. Using the coefficients obtained from the *individual household weather-normalized* models mentioned above, this model uses hourly TMY3 weather data and household-level weather coefficients as inputs to estimate hourly demand for the peak periods in the summer and winter.

Findings and Energy Impacts:

This section presents evaluated savings estimates for the RSOP, HTR SOP, and LI programs. Results are shown first at the program level, and then at the program-measure level.

The tables below include savings estimates as they relate to the average TRM estimates as well as how they relate to pre-period weather-normalized annual consumption (PRENAC). These metrics give the savings estimates context.

One important note is that there are differences in the methods used to calculate savings in this analysis and the methods used to calculate savings in the TRM. The TRM is designed to estimate savings for a given measure in isolation of any others. The methods used here include instances in which measures were installed in combinations of two or more as well as in isolation of others. We examined the implications of this approach for our analysis and found that all but one of the measures from this analysis were installed in isolation for the majority of accounts; duct sealing was the exception. As shown in Table 42**Error! Reference source not found.**, the large number of measures installed in isolation of any others allows us to attribute savings to a certain measure confidently.

Table 42. Isolation of Modeled Measures by Program

Measure	RSOP			HTR SOP			LI		
	Total	Isolation	Percentage of Isolation	Total	Isolation	Percentage of Isolation	Total	Isolation	Percentage of Isolation
AC	3,579	3,555	99%	17	15	88%	10	4	40%
Air Infiltration	6,306	4,221	67%	4,445	2,867	64%	173	34	20%
Ceiling Insulation	1,778	1,421	80%	2,222	1,308	59%	300	119	40%
Duct Sealing	1,970	184	9%	775	59	8%	21	0	0%
Heat Pump	2,496	2,462	99%	659	653	99%	1,467	1,379	94%

There are also differences in the weather data used to estimate savings; however, these effects should be minimal as the TRM uses a subset of the weather stations used in this analysis. The TRM uses 5 TMY3 stations, whereas this analysis uses 61 TMY3 stations. A comparison of the TMY3 stations used by the TRM and a weighted average of the cooling degree days (CDD) and heating degree days (HDD) for the TMY3 stations used in this analysis are shown in Table 43. The climate zones that make up the bulk of the analysis (mainly climate zone 2, 3, and 4) show similar total CDD and HDD numbers between the one TMY3 station used by the TRM and the several TMY3 stations used in this analysis. To calculate the weighted average HDD and CDD, we weight the annual HDD and CDD of each station in a climate zone by the proportion of accounts that were assigned to that station.

Table 43. Comparison of TRM TMY3 Weather and Consumption Analysis TMY3 Weather

TRM Station	Station Name	Climate Zone	TRM CDD (70)	TRM HDD (56)	Stations Used in Climate Zone	Weighted Average CDD	Weighted Average HDD
723630	Amarillo International	1	993	2,773	1	1,464	2,065
722590	Dallas-Fort Worth International Airport	2	1,902	1,350	30	2,016	1,396
722430	Houston Bush Intercontinental	3	1,940	763	13	1,933	613
722510	Corpus Christi International Airport	4	2,158	415	9	2,498	309
722700	El Paso International Airport	5	1,609	1,313	0	N/A	N/A

Program-Level Findings:

Table 44, Table 45, and Table 46 show the program-level savings results. These savings are calculated by averaging savings over the *individual household weather-normalization* models within each program, for both the treatment and comparison group. The effect of the program can be seen in the line titled ‘Adjusted Gross,’ which shows the difference between the change in normalized annual consumption of the treatment and comparison group.

While the tables rely on the *individual household level* models, we also ran *program-level fixed-effects* models that resulted in similar savings estimates. See Appendix 1-C: Model Specifications, Details, and Results for model details and savings estimates generated by the *program-level fixed-effects* model.

As a guide to the RSOP table, participants saw an average reduction in weather-normalized consumption from the pre- to post-period of 1,401 kWh. Over a similar time period, the comparison group experienced an average reduction of 173 kWh. In the final line of the table, we adjust the treatment group savings to account for the comparison group savings and estimate that the overall impact of the RSOP was about 1,228 kWh for the average treatment group household, a 7.6 percent reduction in consumption on average. Precision can be interpreted as the amount to add or subtract to the model savings (kWh) estimate to form the 90 percent confidence interval. For example, savings from the RSOP were estimated at 1,228 kWh ±5.1 percent, making the lower and upper bounds of our estimate 1,165 kWh and 1,291 kWh. The final two columns of the table display the lower and upper bound of the estimate at 90 percent confidence.

Across the three programs, the HTR SOP resulted in the lowest savings for the average participant at around five percent, and the LI program had the highest average savings at about 16 percent.

Table 44. Program-Level Results, Residential Standard Offer Program

RSOP	n	PRENAC	Model Savings (kWh)	Precision at 90 percent	TRM Savings (kWh)	Savings as Percentage of TRM	Savings as Percentage of PRENAC	Savings Lower 90%	Savings Upper 90%
Treatment	13,988	16,067	1,401	5.6%	3,182	44.0%	8.7%	1,323	1,479
Comparison	10,986	17,185	173	27.2%	-	-	1.0%	126	220
Adjusted Gross	-	16,067	1,228	5.1%	3,182	38.6%	7.6%	1,165	1,291

Table 45. Program-Level Results, Hard-To-Reach Standard Offer Program

HTR SOP	n	PRENAC	Model Savings (kWh)	Precision at 90%	TRM Savings (kWh)	Savings as Percentage of TRM	Savings as Percentage of PRENAC	Savings Lower 90%	Savings Upper 90%
Treatment	6,501	13,771	797	11.0%	2,263	35.2%	5.8%	709	885
Comparison	7,430	14,167	117	42.6%	-	-	0.8%	67	166
Adjusted Gross	-	13,771	681	10.7%	2,263	30.1%	4.9%	608	753

Table 46. Program-Level Results, Low-Income

LI	n	PRENAC	Model Savings (kWh)	Precision at 90%	TRM Savings (kWh)	Savings As Percentage of TRM	Savings As Percentage of PRENAC	Savings Lower 90%	Savings Upper 90%
Treatment	1,808	11,255	2,079	9.4%	4,700	44.2%	18.5%	1,884	2,274
Comparison	1,274	13,260	285	41.6%	-	-	2.1%	166	403
Adjusted Gross	-	11,255	1,794	8.6%	4,700	38.2%	15.9%	1,639	1,949

Measure Level Findings:

Overall, the measure-level results suggest that, while each of the programs is generating considerable energy savings, the TRM may be overestimating the impact of the core measures of this analysis (AC, air infiltration, ceiling insulation, duct sealing, and heat pumps).

Table 47, Table 48, and Table 49 below exhibit measure savings for the core measures of the analysis as well as other measures where the precision of the savings estimate is less than 50 percent. When considering the results, it is important to observe the number of accounts that received the measure as well as the precision of the estimate. The model estimates are less reliable when there are few accounts or the estimate is less precise (i.e., the ± value for relative precision is a large number). Appendix 1-C: Model Specifications, Details, and Results provides a complete set of measure-level results.

Table 47. Measure-Level Results, Residential Standard Offer Program

RSOP	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings Compared to Pre-Program	TRM Compared to Pre-Program
AC	3,579	19,654	2,229	2,961	4.0%	75.3%	11.3%	15.1%
Air Infiltration	6,306	12,961	-62	1,363	127.1%	-4.6%	-0.5%	10.5%
Ceiling Insulation	1,778	15,977	615	3,552	19.0%	17.3%	3.9%	22.2%
Duct Sealing	1,970	15,466	383	668	31.9%	57.3%	2.5%	4.3%
Heat Pump	2,496	19,145	3,160	7,078	3.3%	44.6%	16.5%	37.0%

Table 48. Measure-Level Results, Hard-To-Reach Standard Offer Program

HTR SOP	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings Compared to Pre-Program	TRM Compared to Pre-Program
AC	17	13,427	2,070	1,345	49.3%	153.9%	15.4%	10.0%
Air Infiltration	4,445	13,474	179	1,328	45.7%	13.4%	1.3%	9.9%
Ceiling Insulation	2,222	14,830	617	1,889	16.0%	32.7%	4.2%	12.7%
Duct Sealing	775	16,146	471	695	34.9%	67.7%	2.9%	4.3%
Heat Pump	659	12,763	2,653	6,134	6.4%	43.2%	20.8%	48.1%

Table 49. Measure-Level Results, Low-Income

LI	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings Compared to Pre-Program	TRM Compared to Pre-Program
AC	10	11,595	1,872	2,211	75.3%	84.7%	16.1%	19.1%
Air Infiltration	173	14,130	113	613	336.7%	18.3%	0.8%	4.3%
Ceiling Insulation	300	13,231	950	1,083	30.1%	87.7%	7.2%	8.2%
Duct Sealing	21	17,578	621	460	151.1%	135.1%	3.5%	2.6%
Heat Pump	1,467	10,681	1,868	5,386	8.4%	34.7%	17.5%	50.4%
Wall Insulation	97	13,776	1,218	1,182	38.5%	103.1%	8.8%	8.6%

Overall, measure-level results are considerably lower than the TRM across all measures. The top-performing measure with a sufficiently large number of installations is *AC*, with savings estimated at about 75 percent of the TRM estimate in the RSOP.

While HVAC measure savings were lower than the TRM estimates, all *HVAC* measures showed considerably large savings. *AC* savings were closest to TRM estimates, while *heat pump* savings estimates ranged from approximately 1,900 kWh for the LI program to about 3,200 kWh for the RSOP. While this is a large amount of kWh savings, *heat pump* savings were still less than half of the TRM estimate in every program. *Duct sealing* measures produce fewer savings than other *HVAC* measures from a kWh standpoint, but the savings estimates for *duct sealing* measures in the RSOP and HTR SOP were the closest to the TRM estimates of any measure besides *AC*.

Shell measures showed the largest differences between modeled savings and TRM savings estimates. *Ceiling insulation* measure savings estimates were just 17 percent and 33 percent of the TRM estimates in RSOP and HTR SOP, respectively. The measure with the largest deviation from the TRM was *air infiltration*. In the RSOP and LI program, the air infiltration measure savings estimates were not significantly different than zero kWh, and the HTR SOP showed minimal savings at 13 percent of the TRM estimate. This low savings estimate for *air infiltration* is not the result of instability because there are few cases with *air infiltration* measures or because there are outliers skewing results. In fact, there were more *air infiltration* measures in the RSOP than any other measure (6,306). Additionally, about 65 percent of installed *air infiltration* measures were installed in isolation.

Wall insulation was not a focus of our analysis due to having a small number of installations; however, it showed strong savings in the LI program relative to the TRM at a statistically significant level of precision. We did not have a large number of *wall insulation* measures in the RSOP and HTR SOP.

Detailed Measure-Level Findings:

To disaggregate the results further, we divided the core measures of this analysis by their attributes. Table 50, Table 51, Table 52, and Table 53 show the measure categories and results by category for RSOP and HTR SOP. The LI program did not have a sufficient number of observations with measure details to be included in this part of the analysis. Many of the following findings are qualitative, based on a small number of observations with wide precision bands. We conducted these additional analyses to provide context to the overall results and to guide action plans for how to respond to the findings of this analysis.

Where ceiling insulation had a sufficient number of accounts in RSOP (R0, R0-R4, R5-R8), results were somewhat counterintuitive because higher starting R-values were associated with slightly higher savings. The difference in savings between R0-R4 and R5-R8 was relatively small at about 10 percent. In contrast, the difference in TRM estimates between the two groups was quite large, with the R0-R4 TRM estimate (4,001 kWh) being more than double the R5-R8 estimate (1,741 kWh).

Where *ceiling insulation* had a sufficient number of accounts in HTR SOP (all but R-15 to R-22), results were somewhat more intuitive, with the exception being R0 starting R-values, which were associated with lower savings estimates than similar starting R-values. Starting with R0-R4, savings decreased as starting R-value rose. Unlike the RSOP program, the trend between the R0-R4 group and the R5-R8 group mirrored the TRM trend. Model savings estimates for R0-R4 were approximately 50 percent higher than R5-R8 estimates, while TRM savings estimates for R0-R4 were approximately 59 percent higher than R5-R8 estimates.

For both the RSOP and the HTR SOP, all *ceiling insulation* segments continued to come in well below TRM estimates with the exception of HTR SOP R-15 to R-22 starting R-value projects. However, this savings estimate is based on relatively few projects (33).

Table 50. Detailed Measure-Level Results, Ceiling Insulation

Ceiling Insulation	Quartile/ Distribution	n	PRENAC	Model Savings	TRM Savings	Precision at 90%	Model as percentage of TRM	Model as percentage of PRENAC	TRM as percentage of PRENAC
RSOP	R0	420	14,594	397	3,906	58.3%	10.2%	2.7%	26.8%
	R0-R4	1,028	16,177	669	4,001	22.5%	16.7%	4.1%	24.7%
	R5-R8	286	16,894	733	1,741	38.0%	42.1%	4.3%	10.3%
	R9-R14	31	19,847	865	1,720	97.1%	50.3%	4.4%	8.7%
	R-15-R22	13	15,408	195	758	671.8%	25.8%	1.3%	4.9%
	Total	**1,778**	**15,977**	**615**	**3,552**	**19.0%**	**17.3%**	**3.9%**	**22.2%**
HTR SOP	R0	160	15,861	283	3,894	119.2%	7.3%	1.8%	24.5%
	R0-R4	798	14,583	791	2,318	19.6%	34.1%	5.4%	15.9%
	R5-R8	1,055	14,952	527	1,459	26.1%	36.1%	3.5%	9.8%
	R9-R14	176	13,430	160	828	201.1%	19.3%	1.2%	6.2%
	R-15-R22	33	19,358	1,240	1,175	59.6%	105.6%	6.4%	6.1%
	Total	**2,222**	**14,830**	**617**	**1,889**	**16.0%**	**32.7%**	**4.2%**	**12.7%**

RSOP *air infiltration* measures showed results that were not significantly different than 0 when broken down by the recorded CFM reduction percentage. HTR SOP *air infiltration* savings were lower for the lowest quartile of CFM reduction; however, they were relatively consistent across other quartiles.

Table 51. Detailed Measure Level Results, Air Infiltration

Air Infiltration	Quartile/ Distribution	n	PRENAC	Model Savings	TRM Savings	Precision at 90%	Model as percentage of TRM	Model as percentage of PRENAC	TRM as percentage of PRENAC
RSOP	Q1: 3-29% CFM	1,580	13,715	22	764	610.4%	2.9%	0.2%	5.6%
	Q2: 29-39% CFM	1,570	12,080	-5	1,054	2724.4%	-0.4%	0.0%	8.7%
	Q3: 39-61% CFM	1,575	14,032	-44	1,530	299.4%	-2.9%	-0.3%	10.9%
	Q4: 61-96% CFM	1,576	12,015	-183	2,108	68.8%	-8.7%	-1.5%	17.5%
	Total	**6,306**	**12,961**	**-62**	**1,363**	**127.1%**	**-4.6%**	**-0.5%**	**10.5%**
HTR SOP	Q1: 0-29% CFM	1,113	13,077	43	753	329.2%	5.7%	0.3%	5.8%
	Q2: 20-38% CFM	1,106	12,556	288	1,010	47.2%	28.5%	2.3%	8.0%
	Q3: 39-51% CFM	1,109	14,018	185	1,393	74.5%	13.3%	1.3%	9.9%
	Q4: 52-87% CFM	1,110	14,264	194	2,163	69.8%	9.0%	1.4%	15.2%
	Total	**4,445**	**13,474**	**179**	**1,328**	**45.7%**	**13.4%**	**1.3%**	**9.9%**

*Note: Total *n* may not match the sum of measures due to not having measure attributes for certain projects.

Duct sealing was segmented by the same metric as *air infiltration* and showed lower savings at the extremes of CFM reduction and higher savings for reductions in the 75-87 percent segments.

HTR SOP *duct sealing* performed somewhat similarly across quartiles, with the lower savings being the middle two quartiles of percent CFM reduction and the highest and lowest quartiles of CFM reduction being associated with higher savings, the opposite of the pattern shown by RSOP.

Table 52. Detailed Measure-Level Results, Duct Sealing

Duct Sealing	Quartile/ Distribution	n	PRENAC	Model Savings	TRM Savings	Precision at 90%	Model as percentage of TRM	Model as percentage of PRENAC	TRM as percentage of PRENAC
RSOP	Q1: 17-75% CFM	492	18,237	307	667	71.9%	46.0%	1.7%	3.7%
	Q2: 75-79% CFM	493	17,285	599	733	36.8%	81.7%	3.5%	4.2%
	Q3: 79-87% CFM	492	14,933	471	668	46.9%	70.5%	3.2%	4.5%
	Q4: 87-98% CFM	493	11,413	172	604	125.7%	28.5%	1.5%	5.3%
	Total	**1,970**	**15,466**	**383**	**668**	**31.9%**	**57.3%**	**2.5%**	**4.3%**
HTR SOP	Q1: 35-75% CFM	193	17,675	608	672	50.9%	90.5%	3.4%	3.8%
	Q2: 75-80% CFM	194	16,037	253	718	121.9%	35.3%	1.6%	4.5%
	Q3: 80-86% CFM	194	15,472	433	653	71.4%	66.3%	2.8%	4.2%
	Q4: 87-98% CFM	194	15,407	589	739	52.5%	79.7%	3.8%	4.8%
	Total	**775**	**16,146**	**471**	**695**	**34.9%**	**67.7%**	**2.9%**	**4.3%**

AC and *heat pumps* were segmented by seasonal energy efficiency ratio (SEER) value, with the highest savings for the segment that received SEER values of 18 or higher. *AC* results follow a more linear increase in savings with increases in SEER value, while *heat pump* savings for SEER values below 18 are relatively similar in the RSOP.

Similar segmenting was done to the HTR SOP; however, there were not enough AC units to include them as a measure group. *Heat pumps* only had sufficient data for projects where SEER value was less than 16 or exactly 15, and SEER values that were less than 16 were associated with higher savings. Still, the few accounts with a SEER value over 18 were associated with the highest savings.

Table 53. Detailed Measure-Level Results, AC and Heat Pump

AC/Heat Pump	Quartile/ Distribution	n	PRENAC	Model Savings	TRM Savings	Precision at 90%	Model as percentage of TRM	Model as percentage of PRENAC	TRM as percentage of PRENAC
AC RSOP	SEER <16	44	16,399	1,190	1,092	59.2%	109.0%	7.3%	6.7%
	SEER 16	2,169	18,907	2,038	2,413	5.4%	84.5%	10.8%	12.8%
	SEER 17	397	19,778	1,884	3,217	12.6%	58.6%	9.5%	16.3%
	SEER 18+	969	21,424	2,845	4,166	5.5%	68.3%	13.3%	19.4%
	Total	**3,579**	**19,654**	**2,229**	**2,961**	**4.0%**	**75.3%**	**11.3%**	**15.1%**
	SEER <16	436	18,275	3,318	7,618	6.9%	43.6%	18.2%	41.7%
	SEER 16	1,506	17,398	2,907	6,588	4.4%	44.1%	16.7%	37.9%

AC/Heat Pump	Quartile/ Distribution	n	PRENAC	Model Savings	TRM Savings	Precision at 90%	Model as percentage of TRM	Model as percentage of PRENAC	TRM as percentage of PRENAC
Heat Pump RSOP	SEER 17	121	23,164	3,374	6,885	12.6%	49.0%	14.6%	29.7%
	SEER 18+	421	25,222	3,936	8,388	5.9%	46.9%	15.6%	33.3%
	Total	**2,496**	**19,145**	**3,160**	**7,078**	**3.3%**	**44.6%**	**16.5%**	**37.0%**
Heat Pump HTR SOP	SEER <16	391	13,811	2,912	6,104	7.5%	47.7%	21.1%	44.2%
	SEER 16	263	11,082	2,229	6,229	11.9%	35.8%	20.1%	56.2%
	SEER 18+	5	19,285	4,257	3,446	44.2%	123.5%	22.1%	17.9%
	Total	**659**	**12,763**	**2,653**	**6,134**	**6.4%**	**43.2%**	**20.8%**	**48.1%**

*Note: Total *n* may not match the sum of measures due to not having measure attributes for certain projects.

Other Segmented Results:

Multifamily Findings:

An area of interest that arose following the initial analysis was the savings experienced by multifamily participants versus single-family participants. We modeled the measure-level analysis after segmenting the data into multifamily accounts and single-family home accounts. An account was assigned to the multifamily dataset or the single-family data set based on their address. String values indicating multifamily or apartment locations, such as apartment numbers, were identified in an automated fashion and subsequently reviewed for accuracy. Data was not separated by program for this portion of the analysis in order to maximize the number of each measure. Table 54 and Table 55show the measure level results for multifamily and single-family accounts.

Table 54. Measure-Level Results, Multifamily

Multifamily	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
AC	11	11,452	-122	2,195	988.7%	-5.6%	-1.1%	19.2%
Air Infiltration	7,203	10,962	-49	1,384	132.4%	-3.5%	-0.4%	12.6%
Ceiling Insulation	999	10,997	501	1,826	26.2%	27.5%	4.6%	16.6%
Duct Sealing	674	9,785	113	497	141.5%	22.6%	1.2%	5.1%
Heat Pump	2,782	10,794	2,004	5,701	4.4%	35.2%	18.6%	52.8%

Table 55. Measure Level Results, Single-Family

Single-Family	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
AC	3,594	19,627	2,284	2,953	4.0%	77.3%	11.6%	15.0%
Air Infiltration	3,695	17,475	112	1,239	107.1%	9.0%	0.6%	7.1%
Ceiling Insulation	3,268	16,437	728	2,724	13.2%	26.7%	4.4%	16.6%
Duct Sealing	2,085	17,573	441	731	34.5%	60.4%	2.5%	4.2%
Heat Pump	1,829	22,820	3,773	7,492	3.2%	50.4%	16.5%	32.8%

The tables above indicate that the single-family savings estimates were greater for every core measure category. It is important to note that measures with precision greater than 100 percent are not exhibiting savings significantly different than zero kWh.

While the point estimate for *air infiltration* is higher for single-family participants, it is not significantly different than zero kWh. *Duct sealing* and *heat pumps* performed more strongly for single-family homes, both on an absolute savings level as well as when compared to the TRM. *Ceiling insulation* was the only measure that produced similar results across the two segments. *AC* is the only measure where we cannot compare single-family and multifamily results because of the low number of cases in the multifamily segment.

<u>Heating Type Findings:</u>

We examined the heating type of accounts that received *air infiltration*, *ceiling insulation*, and *duct sealing* measures. The heating type was available for most treatment group accounts; however, it was not available for many comparison group accounts. In order to keep comparisons consistent, only comparison group accounts where the heating type was known were used. This approach may have led to slightly higher savings estimates, as the comparison group savings in these models were not significantly different than zero kWh for any segment. By contrast, comparison group savings for the RSOP, HTR SOP, and LI programs were about 160, 120, and 300 kWh on average, respectively. Table 56, Table 57, and Table 58 show the results by heating type.

Table 56. Measure Level Results, Electric Resistance Heat in Pre- and Post-Period

Electric Resistance	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
Air Infiltration	9,988	12,967	204	1,386	49.4%	14.7%	1.6%	10.7%
Ceiling Insulation	2,611	15,646	830	3,233	13.0%	25.7%	5.3%	20.7%
Duct Sealing	2,492	15,841	431	700	22.4%	61.6%	2.7%	4.4%

Table 57. Measure Level Results, Gas Heat in Pre- and Post-Period

Gas	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
AC	5	14,415	2,595	2,355	67.4%	110.2%	18.0%	16.3%
Air Infiltration	432	13,354	124	462	228.9%	26.8%	0.9%	3.5%
Ceiling Insulation	1,052	13,081	526	1,074	49.7%	48.9%	4.0%	8.2%
Duct Sealing	196	13,837	404	436	102.6%	92.8%	2.9%	3.1%
Wall Insulation	55	12,709	1,349	927	41.3%	145.6%	10.6%	7.3%

Table 58. Measure-Level Results, Heat Pump in Pre- and Post-Period

Heat Pump	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
Air Infiltration	426	17,533	240	1,105	155.7%	21.7%	1.4%	6.3%
Ceiling Insulation	416	18,195	1,012	2,225	37.6%	45.5%	5.6%	12.2%
Duct Sealing	70	15,228	183	489	366.4%	37.4%	1.2%	3.2%

In the above tables, *ceiling insulation* savings show variation between heating types, while other measures of interest are relatively constant in terms of absolute kWh savings. In relation to the TRM, of the measures of interest, *duct sealing* measures for accounts with gas heat are closest to the TRM estimate at 93 percent.

<u>Replacement of Heat Pump Findings:</u>

We examined how savings are affected by the type of heating system that the heat pump is replacing. In Table 59, we present data on heat pumps replacing electric resistance heat, followed by data on heat pumps replacing heat pumps.

Heat pumps replacing heat pumps make up less of the measures and have a similar level of savings to heat pumps replacing electric resistance heat in terms of kWh; however, they are far closer to the TRM savings estimate.

Table 59. Heat Pump Results by Existing Heating Type

Existing Heating Type	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
Electric Resistance	3,151	15,598	3,275	7,773	5.6%	42.1%	21.0%	49.8%
Heat Pump	831	23,129	3,599	3,755	14.0%	95.8%	15.6%	16.2%

We also ran models comparing the type of replacement for the heat pump (early retirement or burnout). Across all programs, savings were similar between the two replacement options. Savings for each program are shown in Table 60, Table 61, and Table 62.

Table 60. Heat Pump Replacement Type Results, Residential Standard Offer Program

RSOP	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
Early Retirement	2,293	18,931	3,176	7,257	3.4%	43.8%	16.8%	38.3%
Burnout	189	21,715	3,168	5,094	10.8%	62.2%	14.6%	23.5%

Table 61. Heat Pump Replacement Type Results, Hard-To-Reach Standard Offer Program

HTR SOP	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
Early Retirement	651	12,690	2,655	6,175	6.5%	43.0%	20.9%	48.7%
Burnout	8	18,722	2,500	2,781	59.5%	89.9%	13.4%	14.9%

Table 62. Heat Pump Replacement Type Results, Low-Income

Low Income	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
Early Retirement	594	11,309	1,932	5,943	11.0%	32.5%	17.1%	52.5%
Burnout	96	11,844	1,774	5,607	25.6%	31.6%	15.0%	47.3%

Replacement of AC Findings:

We compared the savings of AC units based on the type of replacement, which is shown in Table 63. Early retirement was associated with higher absolute savings, but the estimated savings for early retirement replacements was further from the TRM savings estimate. Only the RSOP had a sufficient number of accounts to warrant further analysis of AC replacement.

Table 63. Air Conditioning Replacement Type Results, Residential Standard Offer Program

RSOP	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
Early Retirement	3,116	19,897	2,303	3,122	4.1%	73.8%	11.6%	15.7%
Burnout	463	18,019	1,732	1,878	12.8%	92.2%	9.6%	10.4%

Peak Demand Findings:

Peak demand savings were estimated using our *individual household weather-normalizing* models for the top 20 hours for the summer and winter periods in the pre- and post-period. The TRM defines the top 20 hours. We then look at the mean difference between the pre- and post-period demand for both the summer and winter periods. For more details on the calculation, see

Appendix D. Results are shown below, first at the program level (Table 64and Table 65) and then at the measure level (Table 66, Table 67, and Table 68).

Table 64. Program-Level Peak Demand Results

Program	Group	n	Summer				
			Peak Pre	Model Savings (kW)	TRM Savings	Model as percentage of TRM	Savings as percentage of Pre
RSOP	Treatment	13,988	4.05	0.47	1.92	24.3%	11.5%
	Comparison	10,986	4.51	0.15	-	-	3.2%
	Adjusted Gross		4.05	0.32	1.92	16.7%	7.9%
HTR SOP	Treatment	6,501	3.00	0.16	1.62	9.8%	5.3%
	Comparison	7,430	3.03	0.04	-	-	1.2%
	Adjusted Gross		3.00	0.12	1.62	7.5%	4.1%
LI	Treatment	1,808	2.62	0.49	2.77	17.7%	18.7%
	Comparison	1,274	2.81	0.16	-	-	5.8%
	Adjusted Gross		2.62	0.33	2.77	11.8%	12.5%
Program	**Group**	**n**	**Winter**				
			Peak Pre	**Model Savings (kW)**	**TRM Savings**	**Model as percentage of TRM**	**Savings as percentage of Pre**
RSOP	Treatment	13,988	3.98	0.83	1.92	43.2%	20.9%
	Comparison	10,986	4.00	0.39	-	-	9.9%
	Adjusted Gross		3.98	0.44	1.92	22.7%	11.0%
HTR SOP	Treatment	6,501	3.85	0.72	1.62	44.3%	18.6%
	Comparison	7,430	4.08	0.37	-	-	9.1%
	Adjusted Gross		3.85	0.34	1.62	21.3%	9.0%
LI	Treatment	1,808	3.12	0.94	2.77	33.8%	30.0%
	Comparison	1,274	3.63	0.29	-	-	7.9%
	Adjusted Gross		3.12	0.65	2.77	23.5%	20.8%

At the program level, the winter peak savings are higher than summer for each program; however, the average savings provided come in far lower than the TRM estimates. The savings as a percentage of pre-program are fairly consistent with the program-level consumption analysis results but are a bit higher for each program. These are at 11, 9, and 21 percent for the RSOP, HTR SOP, and LI programs for winter peak reduction, respectively.

Compared to the 2014 consumption analysis, the savings for the RSOP were very similar, as that analysis found summer and winter peak reductions of 8 and 10 percent for the RSOP, and here we see 8 and 11 percent. The HTR SOP demand reduction estimates are lower than the previous analysis. The 2014 analysis noted 8 and 12 percent for summer and winter peak reductions while our models estimate a reduction of 4 and 9 percent.

As a supplement to the above analysis, we segmented participants by whether their winter or summer peak savings were higher rather than including all participants in both summer and winter results, as was done above. Savings estimates increased, as shown by the table below. This increase is to be expected since the higher savings are kept within each group, and the lower savings are effectively removed. By breaking out the data in this way, we can see how those accounts that benefit more from either the summer peak or winter peak compare to the comparison group. With this separation in place, winter peak savings were still larger than summer peak savings. While there was some improvement in the alignment of TRM and modeled savings, the TRM still overestimates kW reductions.

Table 65. Program-Level Peak Demand Results, Participants Segmented by Summer and Winter

Program	Group	n	Summer				
			Peak Pre	Model Savings (kW)	TRM Savings	Model as percentage of TRM	Savings as percentage of Pre
RSOP	Treatment	5,772	4.83	1.00	1.72	58.3%	20.7%
	Comparison	10,986	4.51	0.15	-	-	3.2%
	Adjusted Gross		4.83	0.86	1.72	49.8%	17.7%
HTR SOP	Treatment	2,229	3.19	0.55	1.50	36.7%	17.2%
	Comparison	7,430	3.03	0.04	-	-	1.2%
	Adjusted Gross		3.19	0.51	1.50	34.3%	16.1%
LI	Treatment	690	3.01	0.87	2.54	34.4%	29.1%
	Comparison	1,274	2.81	0.16	-	-	5.8%
	Adjusted Gross		3.01	0.71	2.54	28.0%	23.6%
Program	Group	n	Winter				
			Peak Pre	Model Savings (kW)	TRM Savings	Model as percentage of TRM	Savings as percentage of Pre
RSOP	Treatment	8,216	4.83	1.53	2.07	74.2%	31.8%
	Comparison	10,986	4.00	0.39	-	-	9.9%
	Adjusted Gross		4.83	1.14	2.07	55.1%	23.6%
HTR SOP	Treatment	4,272	4.38	1.25	1.68	74.5%	28.7%
	Comparison	7,430	4.08	0.37	-	-	9.1%
	Adjusted Gross		4.38	0.88	1.68	52.4%	20.2%
LI	Treatment	1,118	3.66	1.52	2.91	52.4%	41.6%
	Comparison	1,274	3.63	0.29	-	-	7.9%
	Adjusted Gross		3.66	1.24	2.91	42.5%	33.8%

The peak demand reduction at the measure level follows a similar pattern in that the winter peak savings were higher for all measures except for *AC*. Focusing on the savings as a percentage of the TRM estimate column, we see that the peak demand reductions were quite similar to the measure-level consumption analysis estimates in relation to how they compare to the TRM estimate. The exception is *duct sealing*, which was higher than the TRM estimate. Similar to the analysis discussed thus far, all peak demand savings estimates are considerably lower than the TRM estimate, with the exception of *duct sealing*.

Table 66. Measure-Level Peak Demand Results, Residential Standard Offer Program

RSOP	Group	n	Summer				
			Peak Pre	Model Savings (kW)	TRM Savings	Model as percentage of TRM	Savings as percentage of Pre
AC	Treatment	3,579	6.60	1.22	1.57	77.5%	18.4%
	Comparison	10,986	4.51	0.14	-	-	3.1%
	Adjusted Gross		6.60	1.08	1.57	68.7%	16.3%

RSOP	Group	n	Summer Peak Pre	Model Savings (kW)	TRM Savings	Model as percentage of TRM	Savings as percentage of Pre
Air Infiltration	Treatment	6,306	2.70	0.02	1.22	1.9%	0.9%
	Comparison	10,986	4.51	0.14	-	-	3.1%
	Adjusted Gross		2.70	-0.11	1.22	-9.4%	-4.3%
Ceiling Insulation	Treatment	1,778	3.80	0.30	2.43	12.2%	7.8%
	Comparison	10,986	4.51	0.14	-	-	3.1%
	Adjusted Gross		3.80	0.16	2.43	6.5%	4.2%
Duct Sealing	Treatment	1,970	3.40	0.18	0.23	79.2%	5.3%
	Comparison	10,986	4.51	0.14	-	-	3.1%
	Adjusted Gross		3.40	0.04	0.23	18.3%	1.2%
Heat Pump	Treatment	2,496	4.07	0.62	3.54	17.6%	15.3%
	Comparison	10,986	4.51	0.14	-	-	3.1%
	Adjusted Gross		4.07	0.49	3.54	13.7%	11.9%

RSOP	Group	n	Winter Peak Pre	Model Savings (kW)	TRM Savings	Model as percentage of TRM	Savings as percentage of Pre
AC	Treatment	3,579	2.25	0.40	1.57	25.4%	17.7%
	Comparison	10,986	4.00	0.39	-	-	9.7%
	Adjusted Gross		2.25	0.01	1.57	0.6%	0.5%
Air Infiltration	Treatment	6,306	3.92	0.38	1.22	31.3%	9.7%
	Comparison	10,986	4.00	0.39	-	-	9.7%
	Adjusted Gross		3.92	-0.01	1.22	-0.6%	-0.2%
Ceiling Insulation	Treatment	1,778	4.49	0.83	2.43	34.1%	18.4%
	Comparison	10,986	4.00	0.39	-	-	9.7%
	Adjusted Gross		4.49	0.44	2.43	18.1%	9.8%
Duct Sealing	Treatment	1,970	3.89	0.78	0.23	343.9%	20.0%
	Comparison	10,986	4.00	0.39	-	-	9.7%
	Adjusted Gross		3.89	0.39	0.23	172.6%	10.0%
Heat Pump	Treatment	2,496	6.51	2.29	3.54	64.8%	35.2%
	Comparison	10,986	4.00	0.39	-	-	9.7%
	Adjusted Gross		6.51	1.91	3.54	53.8%	29.3%

Savings estimates for the HTR SOP were quite similar to the RSOP estimates among measures, with slightly higher savings estimates in relation to the TRM for *air infiltration* and *ceiling insulation*. *Duct sealing* again had a model savings estimate that was far greater than the TRM estimate. *Heat pump* savings estimates were slightly lower for the HTR SOP program than they were for RSOP.

Table 67. Measure-Level Peak Demand Results, Hard-To-Reach Standard Offer Program

HTR SOP	Group	n	Summer: Peak Pre	Summer: Model Savings (kW)	Summer: TRM Savings	Summer: Model as percentage of TRM	Summer: Savings as percentage of Pre
AC	Treatment	17	4.11	0.60	0.75	79.7%	14.6%
	Comparison	7,430	3.03	0.04	-	-	1.4%
	Adjusted Gross		4.11	0.56	0.75	74.2%	13.6%
Air Infiltration	Treatment	4,445	2.71	0.04	1.20	3.3%	1.5%
	Comparison	7,430	3.03	0.04	-	-	1.4%
	Adjusted Gross		2.71	0.00	1.20	-0.1%	0.0%
Ceiling Insulation	Treatment	2,222	3.83	0.25	1.25	20.1%	6.6%
	Comparison	7,430	3.03	0.04	-	-	1.4%
	Adjusted Gross		3.83	0.21	1.25	16.8%	5.5%
Duct Sealing	Treatment	775	3.50	0.10	0.24	39.9%	2.8%
	Comparison	7,430	3.03	0.04	-	-	1.4%
	Adjusted Gross		3.50	0.06	0.24	22.9%	1.6%
Heat Pump	Treatment	659	2.44	0.36	3.37	10.7%	14.8%
	Comparison	7,430	3.03	0.04	-	-	1.4%
	Adjusted Gross		2.44	0.32	3.37	9.5%	13.1%

HTR SOP	Group	n	Winter: Peak Pre	Winter: Model Savings (kW)	Winter: TRM Savings	Winter: Model as percentage of TRM	Winter: Savings as percentage of Pre
AC	Treatment	17	1.30	0.14	0.75	18.3%	10.6%
	Comparison	7,430	4.08	0.37	-	-	9.0%
	Adjusted Gross		1.30	-0.23	0.75	-30.5%	-17.6%
Air Infiltration	Treatment	4,445	3.88	0.43	1.20	35.9%	11.1%
	Comparison	7,430	4.08	0.37	-	-	9.0%
	Adjusted Gross		3.88	0.06	1.20	5.3%	1.6%
Ceiling Insulation	Treatment	2,222	3.99	0.71	1.25	57.0%	17.8%
	Comparison	7,430	4.08	0.37	-	-	9.0%
	Adjusted Gross		3.99	0.35	1.25	27.7%	8.7%
Duct Sealing	Treatment	775	4.29	0.97	0.24	401.4%	22.7%
	Comparison	7,430	4.08	0.37	-	-	9.0%
	Adjusted Gross		4.29	0.61	0.24	250.4%	14.1%
Heat Pump	Treatment	659	4.08	1.58	3.37	46.9%	38.8%
	Comparison	7,430	4.08	0.37	-	-	9.0%
	Adjusted Gross		4.08	1.22	3.37	36.1%	29.8%

In the LI program, savings estimates were slightly higher than savings estimates from the RSOP and HTR SOP for *air infiltration* and *ceiling insulation* but were lower for heat pumps. *AC* and *duct sealing* had a low number of observations in this program.

Table 68. Measure-Level Peak Demand Results, Low-Income

LI	Group	n	Summer Peak Pre	Model Savings (kW)	TRM Savings	Model as percentage of TRM	Savings as percentage of Pre
AC	Treatment	10	3.66	0.81	1.36	59.8%	22.2%
	Comparison	1,274	2.81	0.17	-	-	6.2%
	Adjusted Gross		3.66	0.64	1.36	47.1%	17.5%
Air Infiltration	Treatment	173	3.83	0.20	0.52	37.8%	5.1%
	Comparison	1,274	2.81	0.17	-	-	6.2%
	Adjusted Gross		3.83	0.02	0.52	4.5%	0.6%
Ceiling Insulation	Treatment	300	3.51	0.37	0.79	47.0%	10.6%
	Comparison	1,274	2.81	0.17	-	-	6.2%
	Adjusted Gross		3.51	0.20	0.79	25.0%	5.6%
Duct Sealing	Treatment	21	4.45	0.53	0.27	199.0%	11.9%
	Comparison	1,274	2.81	0.17	-	-	6.2%
	Adjusted Gross		4.45	0.36	0.27	133.7%	8.0%
Heat Pump	Treatment	1,467	2.35	0.50	3.11	16.0%	21.2%
	Comparison	1,274	2.81	0.17	-	-	6.2%
	Adjusted Gross		2.35	0.32	3.11	10.4%	13.8%
LI	**Group**	**n**	**Winter Peak Pre**	**Model Savings (kW)**	**TRM Savings**	**Model as percentage of TRM**	**Savings as percentage of Pre**
AC	Treatment	10	1.58	0.22	1.36	16.0%	13.8%
	Comparison	1,274	3.63	0.26	-	-	7.1%
	Adjusted Gross		1.58	-0.04	1.36	-3.0%	-2.6%
Air Infiltration	Treatment	173	3.22	0.42	0.52	81.0%	13.2%
	Comparison	1,274	3.63	0.26	-	-	7.1%
	Adjusted Gross		3.22	0.17	0.52	31.7%	5.1%
Ceiling Insulation	Treatment	300	3.01	0.55	0.79	70.2%	18.4%
	Comparison	1,274	3.63	0.26	-	-	7.1%
	Adjusted Gross		3.01	0.30	0.79	37.5%	9.8%
Duct Sealing	Treatment	21	4.68	0.92	0.27	344.7%	19.6%
	Comparison	1,274	3.63	0.26	-	-	7.1%
	Adjusted Gross		4.68	0.66	0.27	247.8%	14.1%
Heat Pump	Treatment	1,467	3.20	1.00	3.11	32.1%	31.1%
	Comparison	1,274	3.63	0.26	-	-	7.1%
	Adjusted Gross		3.20	0.74	3.11	23.8%	23.1%

Similar to the analysis that was conducted at the program level, we segmented accounts into summer or winter peak groups based on which time period resulted in a larger demand reduction. The only exception to this method of segmentation was *AC* measures, which were only included in summer peak results. Additionally, rather than comparing the treatment group reduction to the entire comparison group for that program, only accounts in the same program that were scheduled to receive the same measure were used. Table 69, Table 70, and Table 71 display the results for each program.

In the RSOP, winter peak continued to see larger savings than summer peak savings estimates. Savings estimates relative to the TRM were slightly higher than they were in the consumption analysis as well as the above analysis. While *air infiltration* and *ceiling insulation* savings estimates were closer to TRM estimates, even with just the winter peak accounts, they each reached only about 40 percent of the TRM estimate.

Table 69. Segmented Measure-Level Peak Demand Results, Residential Standard Offer Program

RSOP	Group	n	Summer				
			Peak Pre	Model Savings (kW)	TRM Savings	Model as percentage of TRM	Savings as percentage of Pre
AC	Treatment	3,579	6.61	1.22	1.57	77.5%	18.4%
	Comparison	3,288	6.82	0.25	-	-	3.6%
	Adjusted Gross		6.61	0.97	1.57	61.8%	14.7%
Air Infiltration	Treatment	2,127	2.72	0.34	1.25	27.3%	12.6%
	Comparison	3,451	3.10	0.05	-	-	1.7%
	Adjusted Gross		2.72	0.29	1.25	23.2%	10.7%
Ceiling Insulation	Treatment	608	4.10	0.57	2.39	23.8%	13.9%
	Comparison	1,514	3.62	0.01	-	-	0.3%
	Adjusted Gross		4.10	0.56	2.39	23.4%	13.7%
Duct Sealing	Treatment	527	3.52	0.06	0.22	29.3%	1.8%
	Comparison	2,246	3.42	0.04	-	-	1.1%
	Adjusted Gross		3.52	0.03	0.22	12.1%	0.7%
Heat Pump	Treatment	491	4.24	0.94	2.92	32.2%	22.2%
	Comparison	2,811	4.02	0.17	-	-	4.3%
	Adjusted Gross		4.24	0.77	2.92	26.3%	18.1%
RSOP	**Group**	**n**	**Winter**				
			Peak Pre	**Model Savings (kW)**	**TRM Savings**	**Model as percentage of TRM**	**Savings as percentage of Pre**
Air Infiltration	Treatment	4,179	4.27	1.05	1.20	87.4%	24.6%
	Comparison	3,451	3.90	0.57	-	-	14.6%
	Adjusted Gross		4.27	0.48	1.20	40.0%	11.3%
Ceiling Insulation	Treatment	1,170	5.13	1.36	2.45	55.6%	26.5%
	Comparison	1,514	3.79	0.40	-	-	10.6%
	Adjusted Gross		5.13	0.96	2.45	39.2%	18.7%
Duct Sealing	Treatment	1,443	4.15	1.09	0.23	472.7%	26.2%
	Comparison	2,246	3.98	0.68	-	-	17.1%
	Adjusted Gross		4.15	0.41	0.23	177.2%	9.8%
Heat Pump	Treatment	2,005	6.95	2.89	3.69	78.2%	41.5%
	Comparison	2,811	6.31	0.46	-	-	7.4%
	Adjusted Gross		6.95	2.42	3.69	65.6%	34.9%

HTR SOP savings estimates were again similar to the RSOP estimates among measures. Winter peak continued to reflect higher savings estimates within each measure.

Table 70. Segmented Measure-Level Peak Demand Results, Hard-To-Reach Standard Offer Program

HTR SOP	Group	n	Summer Peak Pre	Summer Model Savings (kW)	Summer TRM Savings	Summer Model as percentage of TRM	Summer Savings as percentage of Pre
AC	Treatment	17	4.11	0.61	0.75	81.0%	14.8%
	Comparison	16	3.74	0.12	-	-	3.2%
	Adjusted Gross		4.11	0.49	0.75	65.2%	11.9%
Air Infiltration	Treatment	1,474	2.82	0.37	1.17	31.5%	13.1%
	Comparison	4,810	2.75	0.06	-	-	2.0%
	Adjusted Gross		2.82	0.31	1.17	26.8%	11.2%
Ceiling Insulation	Treatment	828	4.21	0.58	1.21	47.5%	13.7%
	Comparison	2,506	3.80	0.09	-	-	2.3%
	Adjusted Gross		4.21	0.49	1.21	40.2%	11.6%
Duct Sealing	Treatment	160	3.49	0.13	0.25	53.7%	3.9%
	Comparison	697	3.75	0.19	-	-	5.1%
	Adjusted Gross		3.49	-0.06	0.25	-22.2%	-1.6%
Heat Pump	Treatment	194	2.20	0.68	2.86	23.8%	30.9%
	Comparison	1,076	2.28	0.11	-	-	4.7%
	Adjusted Gross		2.20	0.57	2.86	20.0%	26.1%

HTR SOP	Group	n	Winter Peak Pre	Winter Model Savings (kW)	Winter TRM Savings	Winter Model as percentage of TRM	Winter Savings as percentage of Pre
Air Infiltration	Treatment	2,971	4.24	0.85	1.21	70.2%	20.0%
	Comparison	4,810	3.99	0.44	-	-	10.9%
	Adjusted Gross		4.24	0.41	1.21	34.1%	9.7%
Ceiling Insulation	Treatment	1,394	4.85	1.09	1.27	85.7%	22.5%
	Comparison	2,506	4.50	0.36	-	-	7.9%
	Adjusted Gross		4.85	0.73	1.27	57.6%	15.1%
Duct Sealing	Treatment	615	4.51	1.24	0.24	515.0%	27.4%
	Comparison	697	4.55	0.74	-	-	16.4%
	Adjusted Gross		4.51	0.49	0.24	205.2%	10.9%
Heat Pump	Treatment	465	4.89	2.27	3.59	63.2%	46.4%
	Comparison	1,076	3.51	0.42	-	-	12.0%
	Adjusted Gross		4.89	1.85	3.59	51.5%	37.8%

The LI program had some interesting results in this portion of the analysis as *air infiltration* exceeded the TRM savings estimate for winter peak, along with *duct sealing*. *Ceiling insulation* had savings that were higher than they were in the other two programs at 70 percent of the TRM estimate. *Heat pump* savings were lower than in the RSOP and HTR SOP at 37 percent.

Table 71. Segmented Measure-Level Peak Demand Results, Low-Income

LI	Group	n	Summer Peak Pre	Summer Model Savings (kW)	Summer TRM Savings	Summer Model as percentage of TRM	Summer Savings as percentage of Pre
AC	Treatment	10	3.66	0.88	1.36	65.0%	24.2%
	Comparison	7	5.29	0.36	-	-	6.8%
	Adjusted Gross		3.66	0.52	1.36	38.5%	14.3%
Air Infiltration	Treatment	81	3.96	0.18	0.52	34.0%	4.4%
	Comparison	338	2.46	0.12	-	-	5.1%
	Adjusted Gross		3.96	0.05	0.52	10.0%	1.3%
Ceiling Insulation	Treatment	130	3.99	0.71	0.77	92.5%	17.9%
	Comparison	282	4.09	0.21	-	-	5.0%
	Adjusted Gross		3.99	0.51	0.77	65.8%	12.7%
Duct Sealing	Treatment	8	4.98	0.88	0.19	455.5%	17.6%
	Comparison	31	5.01	0.35	-	-	7.0%
	Adjusted Gross		4.98	0.52	0.19	271.9%	10.5%
Heat Pump	Treatment	518	2.65	0.88	3.00	29.4%	33.3%
	Comparison	976	2.44	0.16	-	-	6.5%
	Adjusted Gross		2.65	0.72	3.00	24.1%	27.4%

LI	Group	n	Winter Peak Pre	Winter Model Savings (kW)	Winter TRM Savings	Winter Model as percentage of TRM	Winter Savings as percentage of Pre
Air Infiltration	Treatment	92	4.47	0.79	0.53	150.1%	17.7%
	Comparison	338	3.21	0.18	-	-	5.7%
	Adjusted Gross		4.47	0.61	0.53	115.4%	13.6%
Ceiling Insulation	Treatment	170	3.84	0.80	0.80	99.8%	20.8%
	Comparison	282	3.01	0.24	-	-	7.9%
	Adjusted Gross		3.84	0.56	0.80	70.0%	14.6%
Duct Sealing	Treatment	13	5.28	0.98	0.31	313.4%	18.5%
	Comparison	31	2.72	0.30	-	-	10.9%
	Adjusted Gross		5.28	0.68	0.31	218.4%	12.9%
Heat Pump	Treatment	949	3.64	1.53	3.17	48.2%	41.9%
	Comparison	976	3.89	0.34	-	-	8.8%
	Adjusted Gross		3.64	1.18	3.17	37.4%	32.6%

APPENDIX 1-A: SUPPLEMENTAL INFORMATION ON WEATHER DATA

Introduction:

In order to weather-normalize the electricity consumption of all households involved in the consumption analysis, we needed observed weather data for the time period of 2017 through 2019 to generate model coefficients. Below we give details about the data, describe the weather stations that were used, and how missing data were handled.

Collection:

Weather data for all ASOS stations were downloaded from Iowa State University's Mesonet[25] and added to our database. The ASOS network is a collection of automated airport weather observations from around the world with 208 stations in Texas. The data contains hourly temperature readings, and we downloaded data for the time period of January 1, 2017, to January 1, 2020. In some cases, there is more than one temperature reading per hour. In these situations, we average the temperature during that hour to come to one single temperature for that hour.

Station Selection:

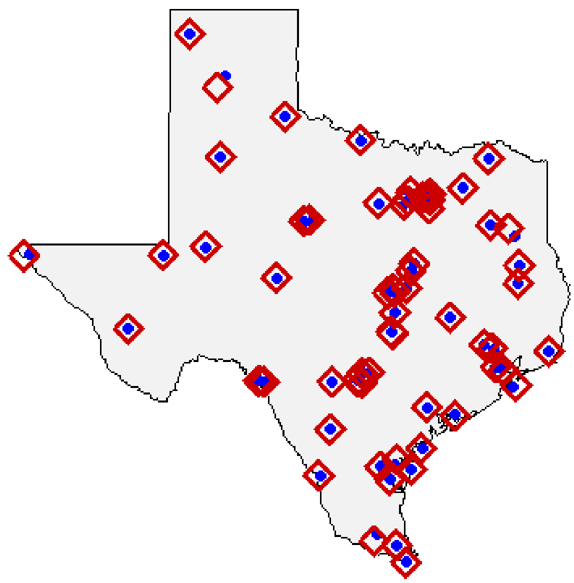
While there are 208 ASOS stations, only 59 were used. The reason for this is that each account (there are 61) would also need to be matched with a TMY3 weather station to complete the weather normalization. A majority of TMY3 and ASOS stations are co-located, and all TMY3 stations are within 20 miles of their matched ASOS stations, with 59 of the 61 within 10 miles. This analysis increased the number of available observed weather stations to 59, up from 13 in the 2014 consumption analysis, to increase the accuracy of models for each household. Additionally, while there are 208 ASOS stations, many stations' data are unsuitable for this analysis, as many have large amounts of missing data.

As mentioned above, we used the closest ASOS station to each TMY3 station. Distance between stations is measured in a straight line, often referred to as "*as the crow flies*." There are two fewer ASOS stations because station ATT (Austin) is the closest ASOS station to two different TMY3 stations (Austin Mueller Airport and Camp Mabry), and one ASOS station could not be used due to missing data. This station was VCT (Victoria Regional), and it appears to be missing several observations due to Hurricane Harvey.

[25] https://mesonet.agron.iastate.edu/.

Figure 38 displays a map of the stations, with the ASOS stations represented by the blue dots and the TMY3 stations represented by the red squares.

Figure 38. Map of Texas ASOS Weather Stations and TMY3 Weather Stations



Filling Gaps:

All of the 59 ASOS stations used for the analysis were missing some data. In order to complete the hourly weather observations needed to run hourly regression models, when data were missing, they were imputed from the nearest (in miles) weather station. Distance between stations was again measured in a straight line. When imputing data, we open our search to all 208 ASOS stations to get weather data from the closest available station. The final observed weather dataset has contributions from 107 stations.

When filling missing observations with the closest station proves insufficient to complete data for a given station, we use the second closest station to fill the missing data, and so on until as much missing data as possible are eliminated through data of nearby stations. For some stations, we go as far as a fourth station, provided that the distance is reasonable, which we generally consider being distances less than 50 miles. The stations used in the analysis are summarized below, showing the amount of data original to that station and the amount borrowed from other stations. We also show the distance between stations in miles. In the end, only 51 of the 59 stations were used in the final consumption analysis as eight of the stations were not the closest station to a single account. Overall, the distance between a borrowing and lending station was infrequently in excess of 30 miles, with only 10 of the 51 stations imputing data from a station that was beyond 30 miles. All information on the amount of data that is original to each weather station and the amount borrowed from another station can be seen in **Error! Reference source not found.**. As a guide through the table, station ABI had 99.4% complete data to start with, borrowed about 0.6% from station DYS, and had approximately 0.1% of observations approximated. When our method of borrowing data cannot fill in all missing data, we turn to approximate the missing weather data through the use of linear interpolation. The approximation is detailed following the table.

Table 72. Summary of Weather Station Data and Imputation Rates

Station	Percentage of Original	Secondary Station	Percentage	Distance from Station	Third Station	Percentage	Distance from Station	Fourth Station	Distance from Station	Percentage	Approximated Percentage
ABI	99.4%	DYS	0.6%	10	-	-	-	-	-	-	0.1%
ACT	99.0%	CNW	0.5%	9	PWG	0.3%	11	-	-	-	0.3%
ADS	95.4%	DAL	4.5%	8	-	-	-	-	-	-	0.1%
AFW	99.7%	FTW	0.1%	11	-	-	-	-	-	-	0.1%
ALI	97.5%	NOG	2.1%	11	IKG	0.3%	13	-	-	-	0.0%
ATT	97.5%	AUS	2.5%	10	-	-	-	-	-	-	0.0%
BRO	99.3%	PIL	0.2%	18	SPL	0.0%	20	HRL	26	0.2%	0.3%
CDS	99.4%	F05	0.5%	59	PVW	0.1%	84	-	-	-	0.0%
CLL	99.6%	CFD	0.4%	9	-	-	-	-	-	-	0.1%
COT	98.5%	CZT	0.9%	37	FTN	0.6%	52	-	-	-	0.0%
DAL	99.8%	ADS	0.1%	8	-	-	-	-	-	-	0.1%
DFW	99.8%	DAL	0.0%	11	-	-	-	-	-	-	0.1%
DLF	94.1%	DRT	5.5%	9	T70	0.2%	24	-	-	-	0.2%
DRT	98.0%	DLF	1.7%	9	T70	0.2%	32	-	-	-	0.2%
DWH	99.2%	IAH	0.7%	14	-	-	-	-	-	-	0.1%
DYS	95.6%	ABI	4.3%	10	-	-	-	-	-	-	0.1%
EBG	99.2%	MFE	0.7%	20	-	-	-	-	-	-	0.1%
EFD	88.3%	HOU	11.6%	8	-	-	-	-	-	-	0.1%
FTW	99.2%	NFW	0.8%	5	-	-	-	-	-	-	0.0%
GLS	99.2%	LVJ	0.6%	29	EFD	0.2%	30	-	-	-	0.1%
GRK	97.9%	HLR	0.7%	8	ILE	1.3%	9	-	-	-	0.2%
GTU	87.9%	T74	0.0%	16	EDC	11.8 %	21	RYW	21	0.3%	0.0%
GVT	99.5%	F46	0.4%	23	-	-	-	-	-	-	0.1%
HDO	97.2%	CVB	2.7%	20	SKF	0.1%	36	-	-	-	0.0%
HLR	90.9%	ILE	7.7%	4	GRK	1.2%	8	-	-	-	0.2%
HOU	99.8%	EFD	0.2%	8	-	-	-	-	-	-	0.1%
HRL	98.6%	T65	0.3%	20	TXW	0.9%	20	PIL	20	0.1%	0.1%
IAH	99.8%	DWH	0.0%	14	-	-	-	-	-	-	0.1%
ILE	92.0%	HLR	6.6%	4	GRK	1.2%	9	-	-	-	0.2%
INK	95.8%	PEQ	4.1%	33	-	-	-	-	-	-	0.1%
LFK	99.2%	OCH	0.7%	24	-	-	-	-	-	-	0.1%
LRD	98.7%	APY	1.2%	42	HBV	0.1%	46	-	-	-	0.1%
MAF	99.7%	MDD	0.3%	8	-	-	-	-	-	-	0.1%
MRF	89.1%	E38	10.7%	20	PRS	0.1%	55	-	-	-	0.1%
MWL	99.7%	GDJ	0.2%	27	-	-	-	-	-	-	0.1%
NFW	95.4%	FTW	4.5%	5	-	-	-	-	-	-	0.0%
NGP	95.6%	CRP	4.3%	15	RAS	0.0%	15	TFP	16	0.0%	0.1%
NQI	98.0%	IKG	1.9%	14	RBO	0.1%	20	-	-	-	0.0%

Station	Percentage of Original	Secondary Station	Percentage	Distance from Station	Third Station	Percentage	Distance from Station	Fourth Station	Distance from Station	Percentage	Approximated Percentage
OCH	92.6%	LFK	7.3%	24	-	-	-	-	-	-	0.1%
PRX	90.3%	LBR	0.0%	23	SLR	9.6%	34	-	-	-	0.1%
PSX	97.2%	PKV	2.0%	27	BYY	0.6%	29	-	-	-	0.2%
PWG	91.1%	ACT	8.4%	11	CNW	0.3%	18	-	-	-	0.3%
RBD	98.4%	GPM	1.5%	10	-	-	-	-	-	-	0.1%
RBO	86.6%	CRP	13.3%	11	-	-	-	-	-	-	0.1%
RFI	91.3%	GGG	8.6%	19	JSO	0.1%	29	-	-	-	0.0%
RKP	97.8%	TFP	1.6%	16	RAS	0.0%	19	CRP	31	0.5%	0.1%
SJT	99.5%	SOA	0.4%	54	OZA	0.0%	60	-	-	-	0.1%
SPS	99.5%	CWC	0.4%	8	-	-	-	-	-	-	0.1%
SSF	99.4%	SKF	0.5%	7	-	-	-	-	-	-	0.0%
TPL	97.1%	ILE	2.5%	17	HLR	0.4%	18	-	-	-	0.1%
TYR	98.9%	JDD	1.0%	27	-	-	-	-	-	-	0.1%

We fill missing observations with nearby stations until there are no more nearby stations from which to impute weather data. After borrowing from up to three stations, the longest consecutive streak of missing hourly temperature readings is 14. The vast majority of missing data streaks are far less than 14 hours, with only four stations having a consecutive streak of missing hourly temperature readings greater than 7 hours. At this point, the distance to borrow from the next station becomes further than we feel accurate. To fill in the remaining gaps, we create a linear interpolation using the observations immediately prior and following the stretch of missing hourly data to estimate the temperature during each hour with missing data. Doing this for short streaks of 14 hours or less keeps the estimations reasonable, and some visual inspection of the data has shown periods of approximation to work well. To provide an example, if June 20 had a reading of 74 degrees at 3:00 p.m. and 78 degrees at 6:00 p.m. with missing data in between, our data imputation procedures would impute those hours as 75.3 and 76.6 for the missing observations at 4:00 p.m. and 5:00 p.m. The data are always filled in a linear manner, representing a gradual increase or decrease in temperature throughout the missing observations. Approximated temperature readings make up less than 0.3 percent of all observations for every station and, on average, represent under 0.1 percent of a station’s hourly weather observations.

Stations CDS, COT, and SJT, were the only stations with borrowed observations that were more than 50 miles away from the actual station. Each of these stations was not used heavily in the analysis, having 1, 21, and 448 accounts involved in the treatment or comparison group, respectively. A visual inspection of the data showed a smooth transition between temperature data from the actual station and the borrowed stations.

When comparing with the tables below in the next section, we also see that our most common weather stations are complete with either their data or the data of a nearby station.

Station Details:

Table 73 shows the percentage of accounts assigned to each station in the treatment and comparison groups. The top stations are pretty similar across the treatment and comparison group, with the bulk of the observations coming from the Dallas metro area.

Table 73. Number and Percentage of Accounts Per ASOS Weather Station

Station	Treatment	Treatment Percentage	Comparison	Comparison Percentage	Overall	Overall Percentage
ADS	3,450	15.5%	3,449	17.8%	6,899	16.6%
RBD	3,275	14.7%	2,591	13.4%	5,866	14.1%
DFW	3,257	14.6%	1,496	7.7%	4,753	11.4%
DAL	2,009	9.0%	2,584	13.3%	4,593	11.0%
EBG	1,791	8.0%	1,192	6.1%	2,983	7.2%
NFW	548	2.5%	1,214	6.3%	1,762	4.2%
FTW	1,172	5.3%	506	2.6%	1,678	4.0%
NGP	512	2.3%	1,018	5.2%	1,530	3.7%
GVT	712	3.2%	745	3.8%	1,457	3.5%
ACT	632	2.8%	367	1.9%	999	2.4%
HRL	330	1.5%	532	2.7%	862	2.1%
IAH	663	3.0%	24	0.1%	687	1.6%
AFW	359	1.6%	243	1.3%	602	1.4%
HOU	463	2.1%	119	0.6%	582	1.4%
EFD	178	0.8%	326	1.7%	504	1.2%
SJT	257	1.2%	191	1.0%	448	1.1%
INK	174	0.8%	241	1.2%	415	1.0%
LRD	291	1.3%	101	0.5%	392	0.9%
ABI	255	1.1%	96	0.5%	351	0.8%
SPS	137	0.6%	210	1.1%	347	0.8%
GTU	171	0.8%	134	0.7%	305	0.7%
PSX	157	0.7%	140	0.7%	297	0.7%
BRO	83	0.4%	212	1.1%	295	0.7%
GLS	222	1.0%	47	0.2%	269	0.6%
TYR	84	0.4%	152	0.8%	236	0.6%
PWG	97	0.4%	127	0.7%	224	0.5%
MAF	81	0.4%	137	0.7%	218	0.5%
HLR	100	0.4%	104	0.5%	204	0.5%
PRX	6	0.0%	193	1.0%	199	0.5%
RBO	53	0.2%	136	0.7%	189	0.5%
TPL	64	0.3%	113	0.6%	177	0.4%
ILE	95	0.4%	76	0.4%	171	0.4%
NQI	101	0.5%	52	0.3%	153	0.4%
GRK	35	0.2%	113	0.6%	148	0.4%
ATT	72	0.3%	69	0.4%	141	0.3%
ALI	74	0.3%	30	0.2%	104	0.2%

Station	Treatment	Treatment Percentage	Comparison	Comparison Percentage	Overall	Overall Percentage
MRF	71	0.3%	23	0.1%	94	0.2%
DYS	57	0.3%	35	0.2%	92	0.2%
LFK	46	0.2%	45	0.2%	91	0.2%
MWL	23	0.1%	68	0.4%	91	0.2%
DWH	51	0.2%	5	0.0%	56	0.1%
OCH	10	0.0%	45	0.2%	55	0.1%
SSF	0	0.0%	36	0.2%	36	0.1%
RKP	7	0.0%	25	0.1%	32	0.1%
COT	18	0.1%	3	0.0%	21	0.1%
RFI	2	0.0%	16	0.1%	18	0.0%
DLF	5	0.0%	7	0.0%	12	0.0%
DRT	3	0.0%	6	0.0%	9	0.0%
CLL	3	0.0%	1	0.0%	4	0.0%
HDO	2	0.0%	1	0.0%	3	0.0%
CDS	1	0.0%	0	0.0%	1	0.0%
Total	**22,259**	**100.0%**	**19,396**	**100.0%**	**41,655**	**100.0%**

*Note: Totals may not sum to 100 percent due to rounding.

Lastly, Table 74 shows a reference of what specific station each station abbreviation represents.

Table 74. ASOS Abbreviation Definition

Station Abbreviation	ASOS Name	Station Abbreviation	ASOS Name	Station Abbreviation	ASOS Name
ABI	Abilene Municipal	EFD	Houston/Ellington	NFW	Fort Worth Nas
ACT	Waco	ELP	El Paso Intl Arpt	NGP	Corpus Christi Nas
ADS	Dallas/Addison Arpt	FTW	Fort Worth/Meacham	NQI	Kingsville Nas
AFW	Fort Worth - Alliance	GLS	Galveston/Scholes	OCH	Nacogdoches (Awos)
ALI	Alice Intl Airport	GRK	Fort Hood/Gray Aaf	PRX	Paris/Cox Field
AMA	Amarillo Arpt(Awos)	GTU	Georgetown (Awos)	PSX	Palacios Municipal
ATT	Austin	GVT	Greenville/Majors	PWG	Mc Gregor (Awos)
BPT	Beaumont/Port Arthu	HDO	Hondo Municipal	RBD	Dallas/Redbird Arpt
BRO	Brownsville Intl	HLR	Ft Hood Aaf/Killeen	RBO	Robstown
CDS	Childress Municipal	HOU	Houston/Will Hobby	RFI	Henderson
CLL	College Station	HRL	Harlingen Intl Arpt	RKP	Rockport/Aransas Co
COT	Cotulla Municipal	IAH	Houston/Intercontin	RND	Randolph Afb
DAL	Dallas/Love Field	ILE	Killeen Muni (Awos)	SAT	San Antonio Intl
DFW	Dallas/Ft Worth	INK	Wink/Winkler Co.	SJT	San Angelo/Mathis
DHT	Dalhart Municipal	LBB	Lubbock Intl Arpt	SKF	Kelly Afb
DLF	Laughlin Afb	LFK	Lufkin/Angelina Co.	SPS	Wichita Falls/Shep
DRT	Del Rio Intl (Aut)	LRD	Laredo Intl Airport	SSF	San Antonio/Stinson
DWH	Houston/D.W. Hooks	MAF	Midland Regional	TPL	Temple/Miller(Awos)
DYS	Dyess Afb/Abilene	MRF	Marfa Muni (Amos)	TYR	Tyler/Pounds Fld
EBG	Edinburg	MWL	Mineral Wells Muni	VCT	Victoria Regional

APPENDIX 1-B: SCREENING CRITERIA DETAILS

This appendix describes the screening criteria that were employed for the retrofit consumption analysis. We review the rules that were applied to exclude accounts from the analysis, step by step, stating the exclusionary condition, the reasoning, and analysis that informed the decision.

For each screening step, we present two tables summarizing the number of accounts affected. The first table shows the number of accounts remaining *after that step*, and the second table shows the number of accounts that were removed from the analysis *as a result of* that step. We also present tables at the end of this appendix that summarize the screening steps and the number of accounts affected at each step. Summary tables also show how screening affects accounts by TRM climate zone.

Defining the Pre- and Post-Periods:

Before enumerating the screening steps, we clarify the pre- and post-periods for measurement because these are different for the treatment and comparison groups. Some screening criteria deal with the dates of meter readings, which may differ for the two groups.

For the treatment group, the pre-period is 365 days *before* the participation date, and the post-period is 365 days *after* the participation date, including the participation date itself.

The comparison group is defined as future participants (PY2019 participants), and their pre- and post-periods are defined to construct a timeframe comparable to the treatment group during which energy consumption will be compared. Their PY2019 participation date is the reference point from which the pre- and post-periods are established. The pre-period is two years (730 days) before the 2019 participation date to 365 days before the participation date. The post-period is 365 days prior to the 2019 participation date. For example, if an account participated on January 1, 2019, its pre-period would be January 1, 2017 through December 31, 2017, while its post-period would be January 1, 2018 through December 31, 2018.

Four hundred thirty-eight accounts participated in the program in both 2018 and 2019. We include these as treatment group members only, focusing only on any measures received in 2018, provided that their 2019 participation date does not overlap with their post-period.

The Starting Number of Accounts:

As a starting point before any accounts are excluded, the tracking data include 33,567 treatment accounts and 29,785 comparison accounts. Table 75 presents the number of accounts by treatment or comparison status and utility. The 438 accounts mentioned above that are in both the treatment and comparison groups are included only in the treatment group frequencies.

Table 75. Number of Accounts by Treatment or Comparison Status and Utility

Starting	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	8,336	1,271	2,474	19,689	1,797	33,567
Comparison	7,420	928	2,092	17,539	1,806	29,785

Step 1: Accounts that Participated in Both 2018 and 2019. As mentioned in the introductory notes, 438 accounts participated in the program during both 2018 and 2019. These accounts are being included as part of the 2018 treatment group. We only include them if their 2019 participation date does not overlap with their post-period. For our first screening step, we check

that the 2019 treatment date is more than 365 days after the 2018 treatment date. Of the 438 accounts that were in both 2018 and 2019, 90 accounts qualified. The remaining 348 accounts were removed from the analysis. Table 76 and Table 77 present the results of this screening step.

Table 76. Accounts Remaining After Screening Step 1

Both Treatment and Comparison	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	8,188	1,268	2,330	19,636	1,797	33,219
Comparison	7,420	928	2,092	17,539	1,806	29,785

Table 77. Accounts Removed Due to Screening Step 1

Difference	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	-148	-3	-144	-53	0	-348
Comparison	0	0	0	0	0	0

Step 2: Solar Interconnect Agreement. We exclude accounts that have a solar interconnect agreement. These accounts are removed from the analysis because their consumption may be misleading since they generate some or all of their own power. All utilities provide data on accounts with solar interconnect agreements. Table 78 and Table 79 present the results of this screening step.

Table 78. Accounts Remaining After Screening Step 2

Solar	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	8,085	1,265	2,329	19,501	1,795	32,975
Comparison	7,341	925	2,092	17,539	1,803	29,700

Table 79. Accounts Removed Due to Screening Step 2

Difference	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	-103	-3	-1	-135	-2	-244
Comparison	-79	-3	0	0	-3	-85

Step 3: Account in Tracking Data but not in Meter Data. For each utility, some accounts were in the tracking data but were not in the meter data. As can be seen by the number of accounts that were removed for each utility, not many accounts were removed from consideration for this reason, with the CenterPoint comparison group being the exception. There was a missing file for LI program participants from 2019 that was never received. Despite this missing data, the LI program still had over 1,000 comparison group accounts. Table 80 and Table 81 present the results of this screening step.

Table 80. Accounts Remaining After Screening Step 3

No Meter	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	8,079	1,265	2,329	19,495	1,795	32,963
Comparison	7,326	924	652	17,532	1,803	28,237

Table 81. Accounts Removed Due to Screening Step 3

Difference	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	-6	0	0	-6	0	-12
Comparison	-15	-1	-1,440	-7	0	-1,463

Step 4: Inadequate Minimum and Maximum Date Ranges. We examine the minimum and maximum date that meter data was recorded for an account. If the minimum or maximum meter reading date would result in the pre- or post-period for an account not being a full year, the account is screened out. To provide an example, if an account's pre-period should start on January 1, 2017, but the first recorded meter reading comes after that date, the account is screened out due to the pre-period being too short. As shown below, AEP TCC loses 641 treatment group accounts; however, other utilities all lose less than 100 accounts. Table 82 and Table 83 present the results of this screening step.

Table 82. Accounts Remaining After Screening Step 4

Date Range	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	7,438	1,252	2,318	19,445	1,747	32,200
Comparison	7,178	888	651	17,531	1,764	28,012

Table 83. Accounts Removed Due to Screening Step 4

Difference	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	-641	-13	-11	-50	-48	-763
Comparison	-148	-36	-1	-1	-39	-225

Some accounts have multiple measures with different installation dates—506 (1.5 percent) treatment accounts and 849 (3 percent) comparison accounts. We require these accounts to have a year on each side of each measure for the treatment group. For the treatment group, the dates between are not used in the analysis and are effectively *blacked out*.[26] In other words, the pre-period is defined as the 365 days before the *first* installation, and the post-period is defined as the 365 days after the *last* installation. Because of how the comparison group pre- and post-period is structured, this does not affect the comparison group. The comparison group periods continue to be the two years preceding the *first* installation.

Step 5: Gaps in Meter Data During the Pre- or Post-Period. We exclude accounts that are missing more than one day of meter reads across the entire period (i.e., 96 15-minute intervals).[27] We retain cases with up to one day of missing meter reads to preserve the number of cases available for analysis, and this rule kept the amount of missing data in the pre- and post-periods consistent.

Among the accounts missing up to one day of data overall, 80 percent of treatment group accounts and 76 percent of comparison group accounts did not have a consecutive period greater than one hour (four 15-minute meter reads) of missing data. Ninety-nine percent (treatment group) and 97 percent (comparison group) did not have a consecutive run of missing data greater than 4 hours (sixteen 15-minute meter reads). While there are streaks of missing data as short as one 15-minute interval, every account that is missing data has a max consecutive missing streak of at least an hour.

Our analysis showed that allowing a greater amount of missing data did not appreciably increase the number of cases in the analysis group and would require imputing many observations. We gain only 2,120 accounts (from 52,700 to 54,820) if accounts with up to one

[26] The mean number of days between two measures for accounts that ended up qualifying for our analysis was about 34 days with a max of 165. Ultimately, since we do have a full year of data on each side of the measure dates, we do not remove any accounts for this reason.

[27] We do not know how the 2014 consumption analysis handled missing data other than the fact that some accounts were removed due to missing data

week (672 15-minute meter reads) of missing meter reads are retained. Table 84 and Table 85 present the results of this screening step.

Table 84. Accounts Remaining After Screening Step 5

Missing	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	4,518	813	2,308	19,445	1,699	28,783
Comparison	4,121	528	230	17,530	1,508	23,917

Table 85. Accounts Removed Due to Screening Step 5

Difference	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	-2,920	-439	-10	0	-48	-3,417
Comparison	-3,057	-360	-421	-1	-256	-4,095

Step 6: Meter Readings of Zero kWh in the Pre- or Post-Period. We exclude cases with more than one month (total across the period, 2,880 total meter reads) of zero kWh readings or more than one consecutive week (672 consecutive 15-minute meter reads) of zero kWh readings. As described below, this rule retains accounts between the 80th and 90th percentiles and below when examining the distribution of cases based on the total number of zero kWh readings and the longest consecutive run of zero kWh readings.

Zero kWh readings are quite common in the data, and this step removed 5,741 accounts from the treatment group and 4,101 accounts from the comparison group. This is a significant amount of removed accounts (about 17 percent for the treatment group and 14 percent for the comparison group) but is quite similar to the amount removed from this step last time this analysis was completed (about 15 percent).

As can be seen in Table 86 and Table 87, the distribution of meter readings of zero kWh is quite similar for the treatment and comparison group. While it is not included below, after we exclude the accounts that meet the rule for exclusion, the distribution of zero kWh readings from treatment to comparison remains very similar.

Table 86. Total Meter Readings of Zero kWh by Percentile (Numbers in Days)

Total Zeros (In Days)											
Percentile	**0%**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Treatment	0.01	0.08	0.14	0.21	0.32	0.53	1.17	3.8	11.16	36.41	729.91
Comparison	0.01	0.09	0.15	0.21	0.32	0.49	0.96	3.13	7.75	29.75	729.91

Table 87. Longest Streak of Meter Readings of Zero kWh by Percentile (Numbers in Days)

Maximum Streak of Zeros (In Days)											
Percentile	**0%**	**10%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**	**90%**	**100%**
Treatment	0.01	0.04	0.04	0.07	0.11	0.2	0.35	1.11	5.48	18.59	363.96
Comparison	0.01	0.04	0.05	0.07	0.11	0.19	0.35	1.01	4.21	14	401.3

There can be multiple reasons for meter readings of zero kWh. They include using no power for a 15-minute period, complete vacancy (extended streaks of zero kWh), brief power outages, shutting down power for work on a home, and meter reading failure. Meter readings of zero kWh are quite common in the data; few accounts have no zero kWh meter readings across the period of analysis.

Overall, there does not appear to be anything systematic about the timing of zero kWh readings.[28] The dates that are the most commonly associated with zero kWh readings are not related to Hurricane Harvey, which is something that we considered. Table 88 and Table 89 present the results of this screening step.

Table 88. Accounts Remaining After Screening Step 6

Zeros	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	3,460	621	1,358	16,376	1,227	23,042
Comparison	3,598	420	83	14,310	1,405	19,816

Table 89. Accounts Removed Due to Screening Step 6

Difference	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	-1058	-192	-950	-3069	-472	-5741
Comparison	-523	-108	-147	-3220	-103	-4101

Step 7: Drastic Changes in total Pre- and Post-Consumption. We exclude accounts with a change in consumption that was in excess of 70 percent in magnitude. This approach follows the same rule applied in the 2014 consumption analysis.

The histograms below show the distribution of changes in consumption from the pre- to post-period. There were 159 treatment accounts and 194 comparison accounts that had changes in excess of 100 percent that are not displayed in the histograms. Table 90 and Table 91 present the results of this screening step.

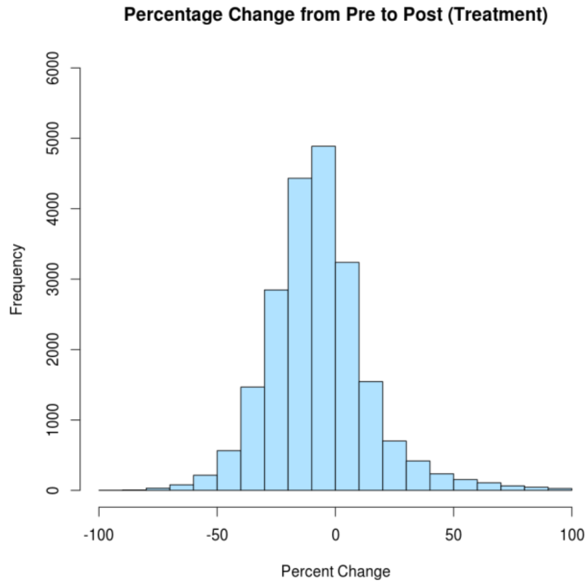
Table 90. Accounts Remaining After Screening Step 7

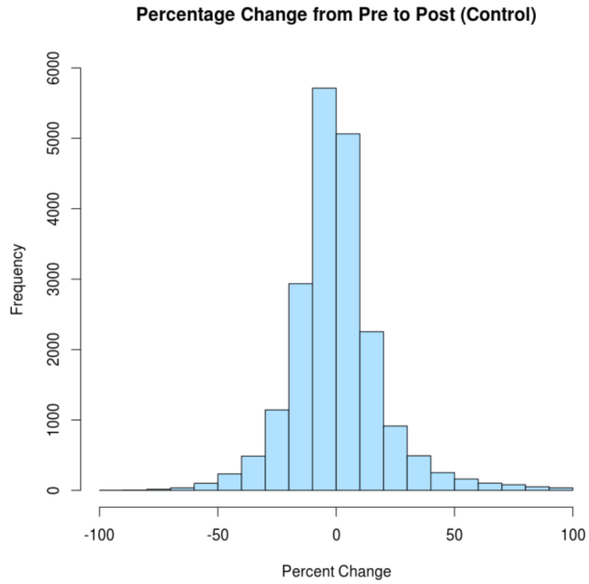
Percentage of Change	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	3,423	609	1,345	16,115	1,198	22,690
Comparison	3,476	400	83	14,108	1,362	19,429

Table 91. Accounts Removed Due to Screening Step 7

Difference	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	-37	-12	-13	-261	-29	-352
Comparison	-122	-20	0	-202	-43	-387

[28] Other than zeros associated with Daylight Savings Time, there are not any dates that have a markedly higher frequency of zero readings for either the treatment or comparison group.





Step 8: Projected Project Savings are Greater than 100 Percent or Less Than 1 Percent of Pre-Period Usage:

We exclude minor accounts (those with projected savings less than one percent of pre-period consumption). We also exclude projects where the projected savings could not possibly happen, or the pre-period consumption is low enough that savings may not be representative of typical savings (projected savings are greater than 100 percent of pre-period consumption). This approach follows the same rule applied to the 2014 consumption analysis.

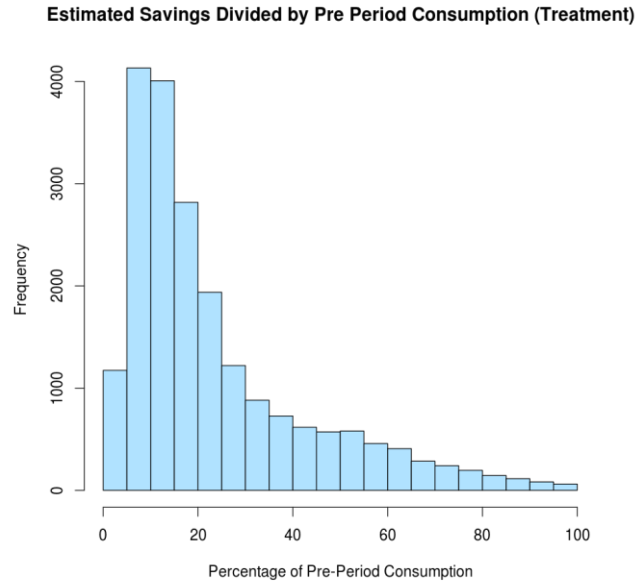
This screening step applies to the treatment group only. The histogram below shows the project size as a percentage of the pre-period consumption for each treatment group household. Table 92 and Table 93 present the results of this screening step.

Table 92. Accounts Remaining After Screening Step 8

Project Size	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	3,416	606	1,308	15,791	1,174	22,295
Comparison	3,476	400	83	14,108	1,362	19,429

Table 93. Accounts Removed Due to Screening Step 8

Difference	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	-7	-3	-37	-324	-24	-395
Comparison	0	0	0	0	0	0



Step 9: Total Usage in the Pre- or Post-Period is Drastically Below or Above the Average Consumption. We exclude accounts that consumed less than 1,000 kWh in the pre- or post-period or more than 70,000 kWh in the pre- or post-period. Consumption beyond these levels occurs rarely, and we do not feel it is representative of typical residential consumption as it is either less than seven percent of, or nearly five times the mean level.

The average pre-period consumption for accounts remaining in the analysis set after applying the previous screening steps is 15,383 kWh for the treatment group and 16,241 kWh for the comparison group. The post period is 13,652 kWh for the treatment group and 15,983 kWh for the comparison group.

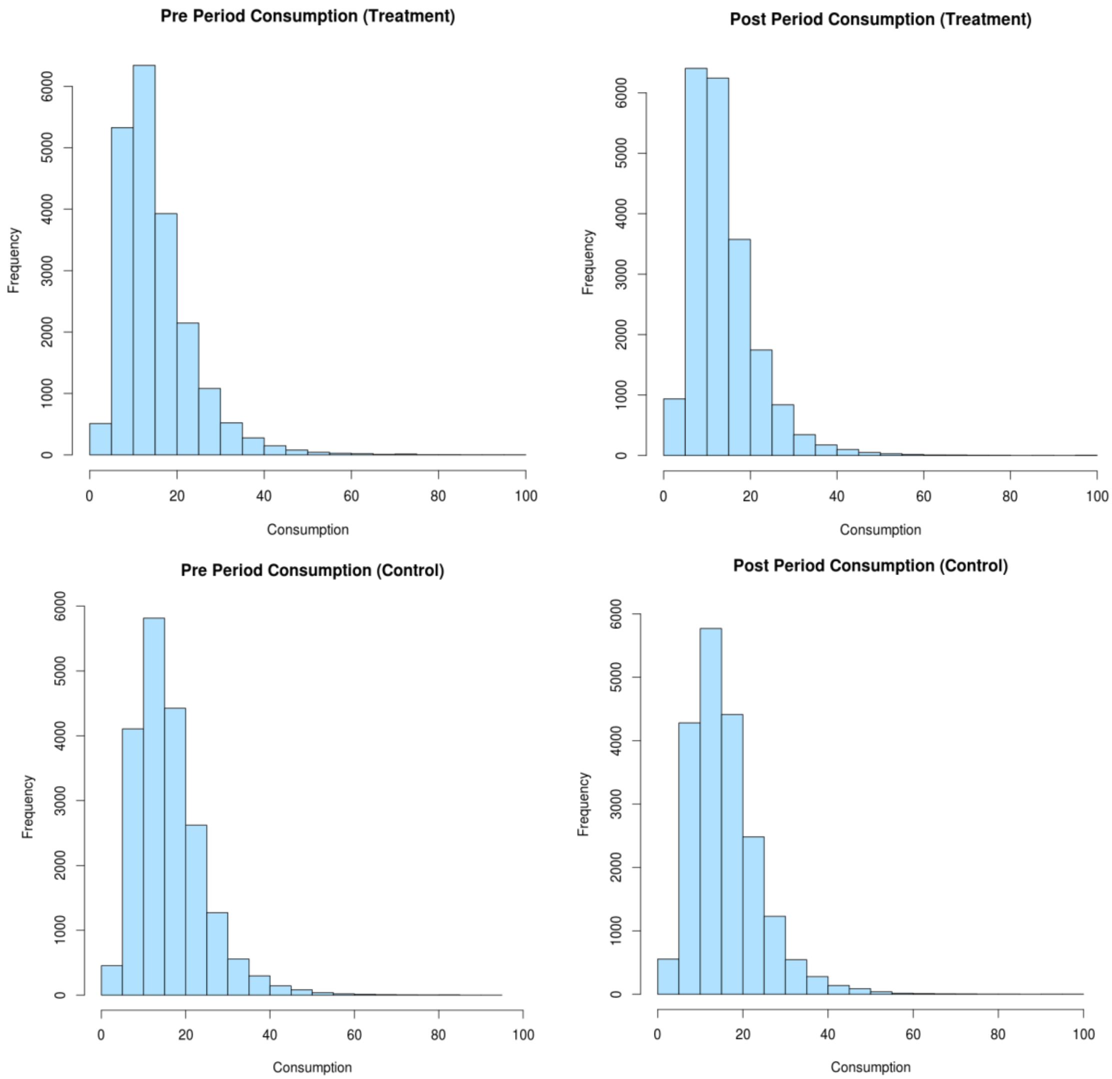
A histogram showing what the distribution looked like before these accounts were removed is shown below for both the pre- and post-period for treatment and comparison groups. To make them readable, a few accounts over 100,000 kWh were removed before plotting the histogram. Table 94 and Table 95 present the results of this screening step.

Table 94. Accounts Remaining After Screening Step 9

Total kWh	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	3,415	606	1,308	15,756	1,174	22,259
Comparison	3,475	399	83	14,077	1,362	19,396

Table 95. Accounts Removed Due to Screening Step 9

Difference	AEP TCC	AEP TNC	CenterPoint	Oncor	TNMP	Total
Treatment	-1	0	0	-35	0	-36
Comparison	-1	-1	0	-31	0	-33



Final Number of Accounts:

Table 96 and Table 97 present the final number of accounts for each screening step described above, first for the treatment group and then the comparison group. Overall, our total remaining percentage of about 66 percent of treatment group accounts and 65 percent of comparison group accounts is quite similar to the 2014 consumption analysis, where they had about 63 percent of treatment accounts and nearly 70 percent of comparison group accounts. We also include the screening results by TRM climate zone in Table 98 and Table 99.

Table 96. Model Screening Steps By Utility, Treatment

Treatment	AEP TCC	AEP TNC	CP	Oncor	TNMP	Total	Percentage Remaining
Starting	8,336	1,271	2,474	19,689	1,797	33,567	100.0%
Both Treatment and Comparison	8,188	1,268	2,330	19,636	1,797	33,219	99.0%
Solar	8,085	1,265	2,329	19,501	1,795	32,975	98.2%
No Meter	8,079	1,265	2,329	19,495	1,795	32,963	98.2%

Treatment	AEP TCC	AEP TNC	CP	Oncor	TNMP	Total	Percentage Remaining
Date Range	7,438	1,252	2,318	19,445	1,747	32,200	95.9%
Missing	4,518	813	2,308	19,445	1,699	28,783	85.7%
Zeros	3,460	621	1,358	16,376	1,227	23,042	68.6%
Percentage Change	3,423	609	1,345	16,115	1,198	22,690	67.6%
Project Size	3,416	606	1,308	15,791	1,174	22,295	66.4%
Total kWh	3,415	606	1,308	15,756	1,174	22,259	**66.3%**
Percentage by Utility	**41.0%**	**47.7%**	**52.9%**	**80.0%**	**65.3%**	-	-

Table 97. Model Screening Steps by Utility, Comparison

Comparison	AEP TCC	AEP TNC	CP	Oncor	TNMP	Total	Percentage Remaining
Starting	7,420	928	2,092	17,539	1,806	29,785	100.0%
Both Treatment and Comparison	7,420	928	2,092	17,539	1,806	29,785	100.0%
Solar	7,341	925	2,092	17,539	1,803	29,700	99.7%
No Meter	7,326	924	652	17,532	1,803	28,237	94.8%
Date Range	7,178	888	651	17,531	1,764	28,012	94.0%
Missing	4,121	528	230	17,530	1,508	23,917	80.3%
Zeros	3,598	420	83	14,310	1,405	19,816	66.5%
Percentage Change	3,476	400	83	14,108	1,362	19,429	65.2%
Project Size	3,476	400	83	14,108	1,362	19,429	65.2%
Total kWh	3,475	399	83	14,077	1,362	19,396	**65.1%**
Percentage by Utility	**46.8%**	**43.0%**	**4.0%**	**80.3%**	**75.4%**	-	-

Figure 39. Map of Technical Reference Manual Climate Zones

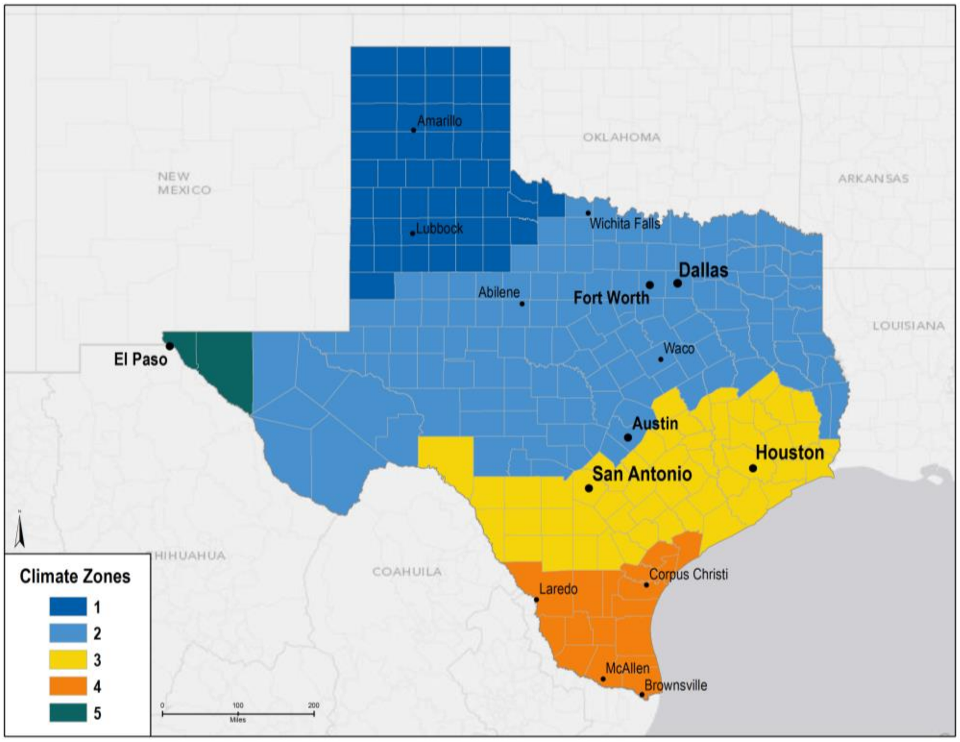


Table 98. Model Screening Steps by Climate Zone, Treatment

Treatment	1	2	3	4	5	Total	Percentage Remaining
Starting	21	22,182	3,305	8,051	8	33,567	100.0%
Both Treatment and Comparison	21	22,126	3,118	7,946	8	33,219	99.0%
Solar	21	21,987	3,116	7,843	8	32,975	98.2%
No Meter	21	21,981	3,114	7,839	8	32,963	98.2%
Date Range	21	21,870	3,099	7,202	8	32,200	95.9%
Missing	9	21,411	3,010	4,348	5	28,783	85.7%
Zeros	6	17,926	1,786	3,319	5	23,042	68.6%
Percentage Change	6	17,629	1,766	3,284	5	22,690	67.6%
Project Size	6	17,279	1,726	3,279	5	22,295	66.4%
Total kWh	6	17,244	1,726	3,278	5	22,259	**66.3%**
Percentage By Utility	**28.6%**	**77.7%**	**52.2%**	**40.7%**	**62.5%**	-	-

Table 99. Model Screening Steps by Climate Zone, Comparison

Comparison	1	2	3	4	5	Total	Percentage Remaining
Starting	155	19,510	3,106	7,014	0	29,785	100.0%
Both Treatment and Comparison	155	19,510	3,106	7,014	0	29,785	100.0%
Solar	155	19,504	3,104	6,937	0	29,700	99.7%
No Meter	154	19,497	1,661	6,925	0	28,237	94.8%
Date Range	141	19,435	1,652	6,784	0	28,012	94.0%
Missing	100	18,939	968	3,910	0	23,917	80.3%
Zeros	79	15,588	722	3,427	0	19,816	66.5%
Percentage Change	72	15,338	699	3,320	0	19,429	65.2%
Project Size	72	15,338	699	3,320	0	19,429	65.2%
Total kWh	72	15,306	699	3,319	0	19,396	**65.1%**
Percentage by Utility	**46.5%**	**78.5%**	**22.5%**	**47.3%**	**0.0%**	-	-

APPENDIX 1-C: MODEL SPECIFICATIONS, DETAILS, AND RESULTS

Individual Household Weather Normalization Models:

The following model was used to estimate weather-normalized consumption in the pre- and post-period for each account. This model was run for each treatment group and comparison group account, with a separate model performed for the pre- and post-period as well. For each household, the model was run with every possible combination of cooling degree hour (65-85 degrees) and heating degree hour setpoints (45-65 degrees), for a total of 441 regressions run for each account in both the pre- and post-period. Once all 441 models were complete, model coefficients were saved for the model with the most explanatory power (highest R^2).

Equation 1. Individual Household Weather Normalization Model

$$Hourly\ Consumption_{it} = \alpha_i + \beta_1 HDH_{it} + \beta_2 CDH_{it} + \beta_3 Hour\_1_{it} + \cdots + \beta_{25} Hour\_23_{it}$$

Where for each customer 'I' and hour of the year 't':

$Hourly\ Consumption_{it}$ = Actual hourly consumption in the pre- or post-program period

α_i = The participant intercept, representing the kWh baseload at hour 0 of the day

β_1 = The model heating slope, representing the average change in hourly usage resulting from an increase of one HDH

HDH_{it} = The base 45-65 HDH for the nearest weather station calculated as:

$$HDH_{it} = Base_{45-65} - Temperature_{it}$$

Where HDH_{it} is greater than 0, else HDH_{it} = 0

β_2 = The model cooling slope, representing the average change in hourly usage resulting from an increase of one CDH

CDH_{it} = The base 65-85 CDH for the nearest weather station calculated as:

$$CDH_{it} = Temperature_{it} - Base_{65-85}$$

Where CDH_{it} is greater than 0, else CDH_{it} = 0

β_{3-25} = Additional intercepts for each hour of the day, representing the kWh baseload at hour 1-23 of the day

$Hour\_1_{it}$ = Dummy variable indicating the hour of the day. There are variables for Hour_1 through Hour_23

Additional steps to get savings estimates:

Upon completion of the above models, we had *CDH*, *HDH*, and *hour_1-23* coefficients for each account in the pre- and post-period. The account was then matched with its nearest TMY3 station. Distance between stations was calculated using latitude and longitude, finding the closest station *as the crow flies*. CDH and HDH were then calculated for that TMY3 station based on the optimal setpoints of the specific account's models.

Once CDH and HDH were calculated for the TMY3 station, the TMY3 data was then fit to the model, yielding a weather-normalized consumption estimate for every hour of the pre- and post-period for each account. The hourly estimates of the pre- and post-period were then summed within their period, resulting in the normalized annual consumption for the pre- and post-period. At this point, we can take the difference between the pre- and post-period normalized annual consumption to get our savings estimates for each household.

Now that we have a savings estimate for every account, we average the savings over the treatment and comparison groups to come to overall savings at the program level. We do this by subtracting the average comparison group savings from the average treatment group savings. We also segment our data by program and perform this same calculation to arrive at savings estimates for each program.

The methods described above also allow us to look at savings on the measure level through the techniques presented below. To do this, we match the savings for each account up with binary variables representing the measures that the account received. We then use the following regression model to estimate the measure level savings. This model was chosen based on section 4.3.2.2 of the Uniform Methods Project. This model and our *measure-level fixed-effects* model provide similar estimates; however, this modeling technique offers more flexibility in weather modeling.

Equation 2. Measure Savings Regression Model

$$Change\ in\ NAC_i = \alpha_i + \beta_1 AC_i + \beta_2 Air\_Inf_i + \beta_3 Ceiling\_Ins_i + \beta_4 Duct\_Eff_i + \beta_5 Floor\_Ins_i + \beta_6 Heat\_Pump_i + \beta_7 Solar\_Screen_i + \beta_8 Wall\_Ins_i + \beta_9 Window_i + \beta_{10} Window\_AC_i$$

$Change\ in\ NAC_i$ = The change in weather-normalized consumption as calculated from the model and methods described above

α_i = The model intercept, representing the average $Change\ in\ NAC$ for the comparison group

β_1 =The deviation from α_i for accounts that received an *AC* measure, representing the average kWh savings among accounts that received an *AC* measure, holding constant all other measure installations

AC_i =A binary variable equal to 1 if an account received an *AC* measure and 0 if they did not

These definitions remain the same for all other coefficients and independent variables; however, each independent variable represents a different measure. This model gives us the change associated with each measure as well as the change associated with the comparison group. This way, we can separate program effects from non-program effects associated with the change in the comparison group. Measure results calculated based on this model are seen in the report where findings are significant. The complete results are shown below in Table 100, Table 101, Table 102, and Table 103. Following that, there is a section on model goodness of fit.

Table 100. Individual Household Weather-Normalization Model Measure-Level Results, Overall

Overall	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings Compared to Pre	TRM Compared to Pre
AC	3,605	19,602	2,235	2,951	3.6%	75.7%	11.4%	15.1%
Air Infiltration	10,898	13,171	31	1,334	184.9%	2.3%	0.2%	10.1%
Ceiling Insulation	4,267	15,164	651	2,514	11.4%	25.9%	4.3%	16.6%
Duct Sealing	2,759	15,671	387	674	25.0%	57.4%	2.5%	4.3%
Heat Pump	4,611	15,564	2,728	6,412	2.7%	42.5%	17.5%	41.2%
Other Recorded Measures								
Solar Screen	19	11,604	-686	309	-150.9%	-221.7%	-5.9%	2.7%
Wall Insulation	107	13,637	1,319	1,153	33.4%	114.4%	9.7%	8.5%
Window	47	14,023	-8	591	-8,592.2%	-1.3%	-0.1%	4.2%
Window AC	1	14,157	2,790	613	162.3%	454.9%	19.7%	4.3%
Floor Insulation	2	11,967	-1,340	195	-237.8%	-687.6%	-11.2%	1.6%

Table 101. Individual Household Weather-Normalization Model Measure-Level Results, Residential Standard Offer Program

RSOP	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings Compared to Pre	TRM Compared to Pre
AC	3,579	19,654	2,229	2,961	4.0%	75.3%	11.3%	15.1%
Air Infiltration	6,306	12,961	-62	1,363	127.1%	-4.6%	-0.5%	10.5%
Ceiling Insulation	1,778	15,977	615	3,552	19.0%	17.3%	3.9%	22.2%
Duct Sealing	1,970	15,466	383	668	31.9%	57.3%	2.5%	4.3%
Heat Pump	2,496	19,145	3,160	7,078	3.3%	44.6%	16.5%	37.0%
Other Recorded Measures								
Solar Screen	2	13,033	3,306	136	99.9%	2426.4%	25.4%	1.0%
Wall Insulation	3	14,697	-3,133	689	-86.1%	-455.0%	-21.3%	4.7%
Window	19	15,037	-1,411	813	-76.0%	-173.5%	-9.4%	5.4%

Table 102. Individual Household Weather-Normalization Model Measure-Level Results, Hard-To-Reach Standard Offer Program

HTR SOP	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings Compared to Pre	TRM Compared to Pre
AC	17	13,427	2,070	1,345	49.3%	153.9%	15.4%	10.0%
Air Infiltration	4,445	13,474	179	1,328	45.7%	13.4%	1.3%	9.9%
Ceiling Insulation	2,222	14,830	617	1,889	16.0%	32.7%	4.2%	12.7%
Duct Sealing	775	16,146	471	695	34.9%	67.7%	2.9%	4.3%
Heat Pump	659	12,763	2,653	6,134	6.4%	43.2%	20.8%	48.1%
Other Recorded Measures								
Solar Screen	2	12,002	565	166	526.1%	340.4%	4.7%	1.4%
Wall Insulation	7	11,256	419	954	379.6%	44.0%	3.7%	8.5%
Window	5	5,322	-1,554	383	-121.5%	-406.0%	-29.2%	7.2%
Floor Insulation	1	7,512	-3,336	195	-126.1%	-1711.6%	-44.4%	2.6%

Table 103. Individual Household Weather-Normalization Model Measure-Level Results, Low-Income

LI	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings Compared to Pre	TRM Compared to Pre
AC	10	11,595	1,872	2,211	75.3%	84.7%	16.1%	19.1%
Air Infiltration	173	14,130	113	613	336.7%	18.3%	0.8%	4.3%
Ceiling Insulation	300	13,231	950	1,083	30.1%	87.7%	7.2%	8.2%
Duct Sealing	21	17,578	621	460	151.1%	135.1%	3.5%	2.6%
Heat Pump	1,467	10,681	1,868	5,386	8.4%	34.7%	17.5%	50.4%
Other Recorded Measures								
Solar Screen	15	11,360	-1,542	352	-76.3%	-438.7%	-13.6%	3.1%
Wall Insulation	97	13,776	1,218	1,182	38.5%	103.1%	8.8%	8.6%
Window	28	13,336	702	440	115.9%	159.5%	5.3%	3.3%
Window AC	1	14,157	2,371	613	178.3%	386.6%	16.7%	4.3%
Floor Insulation	1	16,421	1,147	237	366.8%	484.4%	7.0%	1.4%

Table 104 and Table 105 show the distribution of R^2 for first the pre- and then the post-period. The average R^2 for both the treatment and comparison group was about 0.4 in both the pre- and post-period. There are histograms as well, with the treatment group in blue and the comparison group in red.

Table 104. Individual Household Weather-Normalization Model R^2 Distribution, Pre-Period

R^2	Treatment		Comparison	
	Number of Accounts	% of Accounts	Number of Accounts	% of Accounts
0-0.1	554	2.5%	326	1.7%
0.1-0.2	2,426	10.9%	1,859	9.6%
0.2-0.3	3,541	15.9%	3,196	16.5%
0.3-0.4	4,266	19.2%	3,776	19.5%
0.4-0.5	4,209	18.9%	3,646	18.8%
0.5-0.6	3,425	15.4%	3,031	15.6%
0.6-0.7	2,401	10.8%	2,006	10.3%
0.7-0.8	1,208	5.4%	1,274	6.6%
0.8-0.9	229	1.0%	281	1.4%
0.9-1	0	0.0%	1	0.0%
Total	**22,259**	**100.0%**	**19,396**	**100.0%**

Table 105. Individual Household Weather-Normalization Model R^2 Distribution, Post-Period

R^2	Treatment		Comparison	
	Number of Accounts	% of Accounts	Number of Accounts	% of Accounts
0-0.1	800	3.6%	544	2.8%
0.1-0.2	3,013	13.5%	2,351	12.1%
0.2-0.3	3,934	17.7%	3,453	17.8%
0.3-0.4	4,393	19.7%	3,693	19.0%
0.4-0.5	3,740	16.8%	3,371	17.4%
0.5-0.6	2,859	12.8%	2,467	12.7%
0.6-0.7	2,033	9.1%	1,905	9.8%
0.7-0.8	1,204	5.4%	1,254	6.5%
0.8-0.9	283	1.3%	357	1.8%
0.9-1	0	0.0%	1	0.0%
Total	**22,259**	**100.0%**	**19,396**	**100.0%**

Figure 40. Treatment Group R^2 Distributions, Pre-Period

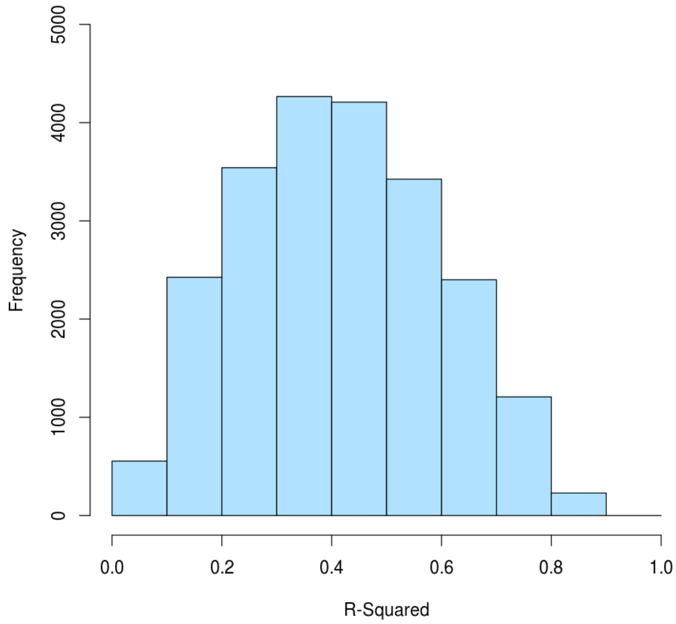


Figure 41. Treatment Group R^2 Distributions, Post-Period

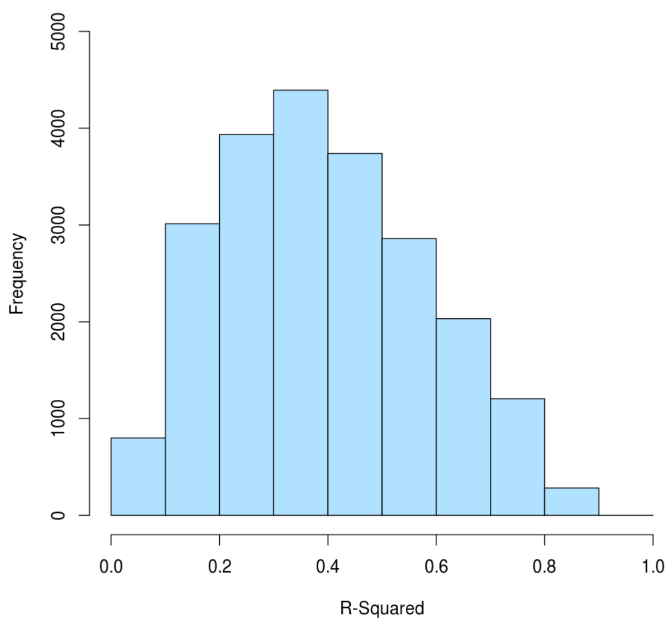


Figure 42. Comparison Group R^2 Distributions, Pre-Period

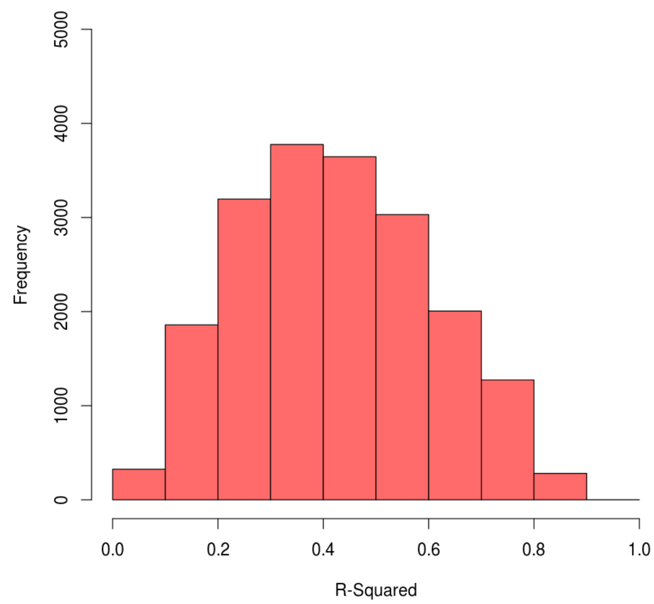
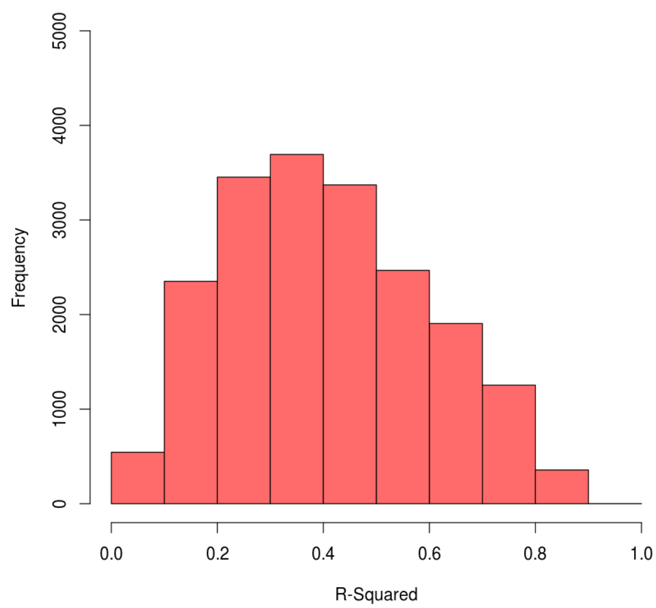


Figure 43. Comparison Group R^2 Distributions, Post-Period



Program-Level Fixed-Effect Models:

The following model was used to estimate the change in weather-normalized consumption from the pre- to post-period at the program level. It provides a result that is similar to our individual household models and acts as a backup model to validate the results of our individual household models. This model was run with the data in a daily format and with the average heating and cooling setpoints from the individual household models, 70 and 56. This model was inspired by the 2014 consumption analysis, where the average setpoints were 69 and 54.

Equation 3. Program-Level Fixed-Effect Model

$$Daily\ Consumption_{it} = \beta_1 HDD_{it} + \beta_2 CDD_{it} + \beta_3 post_{it} + \beta_4 HDD_{it} * post_{it} + \beta_5 CDD_{it} * post_{it} + esiid_{it}$$

Where for each customer 'i' and day of the year 't':

$Daily\ Consumption_{it}$	=	Actual daily consumption in the pre- or post-program period
$esiid_i$	=	The participant account number, representing the daily kWh baseload for each account; effectively, this is the intercept of account 'i'
β_1	=	The average change in daily usage resulting from an increase of one HDD in the pre-period
HDD_{it}	=	The base 56 HDDs for the nearest weather station
β_2	=	The average change in daily usage resulting from an increase of one CDD in the pre-period
CDD_{it}	=	The base 70 CDDs for the nearest weather station
β_3	=	The average baseload savings in the post-period
$post_{it}$	=	An indicator variable that equals 1 in the post-period (after the final measure installation for that account) and 0 in the pre-period (prior to any measure installation for that account)
β_4	=	The average savings in daily usage per HDD in the post-period
$HDD_{it} * post_{it}$	=	An interaction term between HDD and the post-indicator variable
β_5	=	The average savings in daily usage per CDD in the post-period
$CDD_{it} * post_{it}$	=	An interaction term between CDD and the post-indicator variable

Once the model has been run for a program, we fit the average annual TMY3 CDD and HDD for that segment to our model coefficients that contain the *post*-term and then multiply the *post*-term by 365 since this coefficient is at the daily level. Summing those results yields our annual savings estimate. We do this for both the treatment and comparison group and difference the *Savings as a Percentage of PRENAC* column to come to our final adjusted model savings. This differencing approach and this model were used mainly as a confirmation of our individual household models and to replicate the previous consumption analysis. The complete results are shown below in Table 106, Table 107, Table 108, and Table 109.

Table 106. Program-Level Fixed-Effect Model Results, Overall

Overall	n	PRENAC	Model Savings (kWh)	TRM Savings (kWh)	Savings as Percentage of TRM	Savings as Percentage of PRENAC	Precision at 90%	Savings Lower 90%	Savings Upper 90%
Treatment	22,259	15,004	1,214	3,032	40.0%	8.1%	±3.34%	1,174	1,255
Comparison	19,396	15,891	86	-	-	0.5%	±49.88%	43	129
Adjusted Gross	22,259	15,004	1,133	3,032	37.4%	7.6%	±7.36%	1,050	1,217

Table 107. Program-Level Fixed-Effect Model Results, Residential Standard Offer Program

RSOP	n	PRENAC	Model Savings (kWh)	TRM Savings (kWh)	Savings as Percentage of TRM	Savings as Percentage of PRENAC	Precision at 90%	Savings Lower 90%	Savings Upper 90%
Treatment	13,988	16,067	1,338	3,182	42.1%	8.3%	±4.4%	1,280	1,397
Comparison	10,986	17,185	131	-	-	0.8%	±45.6%	71	191
Adjusted Gross	13,988	16,067	1,216	3,182	38.2%	7.6%	±9.3%	1,103	1,329

Table 108. Program-Level Fixed-Effect Model Results, Hard-To-Reach Standard Offer Program

HTR SOP	n	PRENAC	Model Savings (kWh)	TRM Savings (kWh)	Savings as Percentage of TRM	Savings as Percentage of PRENAC	Precision at 90%	Savings Lower 90%	Savings Upper 90%
Treatment	6,501	13,771	716	2,263	31.6%	5.2%	± 1.2%	708	724
Comparison	7,430	14,167	45	-	-	0.3%	±137.3%	17	108
Adjusted Gross	6,501	13,771	716	2,263	31.6%	5.2%	±1.2%	708	724

Table 109. Program-Level Fixed-Effect Model Results, Low-Income

LI	n	PRENAC	Model Savings (kWh)	TRM Savings (kWh)	Savings as Percentage of TRM	Savings as Percentage of PRENAC	Precision at 90%	Savings Lower 90%	Savings Upper 90%
Treatment	1,808	11,255	2,038	4,700	43.4%	18.1%	±5.8%	1,921	2,156
Comparison	1,274	13,260	226	-	-	1.7%	±68.7%	71	381
Adjusted Gross	1,808	11,255	1,846	4,700	43.4%	16.4%	±14.8%	1,574	2,119

Measure-Level Fixed-Effects Models:

The following model was used to estimate the change in weather-normalized consumption from the pre- to post-period at the measure level. It provides a result that is similar to our individual household models and acts as a backup model to validate the results of our individual household models. This model was run with the data in a daily format and with the average heating and cooling setpoints from the individual household models, 70 and 56. To keep the specification shorter, the model specification below shows just one measure; however, all interaction variables shown below are repeated for each measure in the actual model specification.

Equation 4. Measure Level Fixed-Effect Model

$$Daily\ Consumption_{it} = \beta_1 AC_{it} * HDD_{it} + \beta_2 AC_{it} * CDD_{it} + \beta_3 AC_{it} * post_{it} + \beta_4 AC_{it} * HDD_{it} * post_{it} + \beta_5 AC_{it} * CDD_{it} * post_{it} + esiid_{it}$$

Where for each customer 'i' and day of the year 't':

$Daily\ Consumption_{it}$	=	Actual daily consumption in the pre- or post-program period
$esiid_i$	=	The participant account number, representing the daily kWh baseload for each account; effectively, this is the intercept of account 'i'
β_1	=	The average change in daily usage resulting from an increase of one HDD in the pre-period for accounts that received an AC unit
$AC_{it} * HDD_{it}$	=	The base 56 HDDs for the nearest weather station multiplied by the AC indicator variable (1 if the account received an AC measure, 0 if not)
β_2	=	The average change in daily usage resulting from an increase of one CDD in the pre-period for accounts that received an AC unit
$\beta_2 AC_{it} * CDD_{it}$	=	The base 70 CDD for the nearest weather station multiplied by the AC indicator variable
β_3	=	The average baseload savings in the post-period for accounts that received an AC measure
$\beta_3 AC_{it} * post_{it}$	=	An indicator variable that equals 1 in the post-period (after the final measure installation for that account) and 0 in the pre-period (prior to any measure installation for that account) multiplied by the AC indicator variable
β_4	=	The average savings in daily usage per HDD in the post-period for accounts that received an AC measure
$AC_{it} * HDD_{it} * post_{it}$	=	An interaction term between HDD and the post-indicator variable multiplied by the AC indicator variable
β_5	=	The average savings in daily usage per CDD in the post-period for accounts that received an AC measure
$AC_{it} * CDD_{it} * post_{it}$	=	An interaction term between CDD and the post-indicator variable multiplied by the AC indicator variable

Once the model has been run for a program, we fit the average annual TMY3 CDD and HDD for that segment and measure group to our model coefficients that contain the *post*-term and multiply the *post*-term by 365 since this coefficient is at the daily level. Summing those results yields our annual savings estimate for that measure. We do this for the treatment group and difference out the comparison group savings estimate that was calculated by the program-level fixed-effects model, which brings us to our final adjusted model savings for each measure. We look at changes in consumption at the program level rather than the measure level for the comparison group because the comparison group accounts have not actually received a measure during the time period of this analysis. This model was used mainly as a confirmation of our individual household models and to replicate the previous consumption analysis. Where we have a large enough sample size, model results are quite consistent. Complete results are below (Table 110, Table 111, Table 112, and Table 113), as well as comparisons to our reported measure-level results from the *individual household weather-normalization* models (Table 114, Table 115, Table 116, and Table 117). While the results of these models differ by up to approximately 52 percent for the core measures of this analysis in the RSOP and HTR SOP, the overall result of the analysis compared to TRM averages remains consistent.

Table 110. Measure-Level Fixed-Effect Model Results, Overall

Overall	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
AC	3,605	19,602	2,237	2,951	5.0%	75.8%	11.4%	15.1%
Air Infiltration	10,898	13,171	22	1,334	326.9%	1.7%	0.2%	10.1%
Ceiling Insulation	4,267	15,164	621	2,514	16.1%	24.7%	4.1%	16.6%
Duct Sealing	2,759	15,671	344	674	37.8%	51.1%	2.2%	4.3%
Heat Pump	4,611	15,564	2,730	6,412	3.6%	42.6%	17.5%	41.2%
Other Recorded Measures								
Floor Insulation	2	11,967	-2,177	195	-174.8%	-1116.8%	-18.2%	1.6%
Solar Screen	19	11,604	-639	309	-168.3%	-206.5%	-5.5%	2.7%
Wall Insulation	107	13,637	1,232	1,153	48.0%	106.8%	9.0%	8.5%
Window	47	14,023	-171	591	-553.4%	-28.9%	-1.2%	4.2%
Window AC	1	14,157	3,322	613	15.8%	541.8%	23.5%	4.3%

Table 111. Measure-Level Fixed-Effect Model Results, Residential Standard Offer Program

RSOP	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
AC	3,579	19,654	2,194	2,961	5.5%	74.1%	11.2%	15.1%
Air Infiltration	6,306	12,961	-94	1,363	99.9%	-6.9%	-0.7%	10.5%
Ceiling Insulation	1,778	15,977	622	3,552	24.1%	17.5%	3.9%	22.2%
Duct Sealing	1,970	15,466	243	668	65.5%	36.4%	1.6%	4.3%
Heat Pump	2,496	19,145	3,193	7,078	4.7%	45.1%	16.7%	37.0%
Other Recorded Measures								
Solar Screen	2	13,033	3,180	136	125.4%	2,333.9%	24.4%	1.0%
Wall Insulation	3	14,697	-3,228	689	196.0%	-468.8%	-22.0%	4.7%
Window	19	15,037	-1,245	813	101.2%	-153.1%	-8.3%	5.4%

Table 112. Measure-Level Fixed-Effect Model Results, Hard-To-Reach Standard Offer Program

HTR SOP	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
AC	17	13,427	2,191	1,345	57.6%	162.9%	16.3%	10.0%
Air Infiltration	4,445	13,474	236	1,328	41.9%	17.8%	1.8%	9.9%
Ceiling Insulation	2,222	14,830	582	1,889	22.1%	30.8%	3.9%	12.7%
Duct Sealing	775	16,146	578	695	37.6%	83.1%	3.6%	4.3%
Heat Pump	659	12,763	2,589	6,134	7.5%	42.2%	20.3%	48.1%
Other Recorded Measures								
Floor Insulation	1	7,512	-3,245	195	4.1%	-1,664.9%	-43.2%	2.6%
Solar Screen	2	12,002	600	166	194.9%	361.0%	5.0%	1.4%
Wall Insulation	7	11,256	555	954	456.6%	58.2%	4.9%	8.5%
Window	5	5,322	-707	383	79.1%	-184.7%	-13.3%	7.2%

Table 113. Measure-Level Fixed-Effect Model Results, Low-Income

LI	n	PRENAC	Model Savings	TRM	Precision	Savings Compared to TRM	Savings as a Percentage of Pre	TRM as a Percentage of Pre
AC	10	11,595	1,779	2,211	51.0%	80.5%	15.3%	19.1%
Air Infiltration	173	14,130	-24	613	-2,196.9%	-3.9%	-0.2%	4.3%
Ceiling Insulation	300	13,231	845	1,083	48.0%	78.0%	6.4%	8.2%
Duct Sealing	21	17,578	418	460	305.1%	90.8%	2.4%	2.6%
Heat Pump	1,467	10,681	1,895	5,386	10.5%	35.2%	17.7%	50.4%
Other Recorded Measures								
Floor Insulation	1	16,421	157	237	285.9%	66.2%	1.0%	1.4%
Solar Screen	15	11,360	-1,533	352	-94.4%	-435.9%	-13.5%	3.1%
Wall Insulation	97	13,776	1,014	1,182	62.7%	85.8%	7.4%	8.6%
Window	28	13,336	411	440	322.9%	93.4%	3.1%	3.3%
Window AC	1	14,157	2,701	613	20.5%	440.4%	19.1%	4.3%

Table 114. Comparison of Individual Household Weather-Normalized Model with Measure-Level Fixed-Effect Model, Overall

Overall	n	Individual Household Model Savings	Measure-Level Fixed-Effect Model Savings	Difference	Percentage Difference
AC	3,605	2,235	2,237	2	0.1%
Air Infiltration	10,898	31	22	8	26.9%
Ceiling Insulation	4,267	651	621	30	4.6%
Duct Sealing	2,759	387	344	42	11.0%
Heat Pump	4,611	2,728	2,730	2	0.1%
Other Recorded Measures					
Floor Insulation	2	-1,340	-2,177	837	-62.4%
Solar Screen	19	-686	-639	47	-6.9%
Wall Insulation	107	1,319	1,232	88	6.7%
Window	47	-8	-171	163	-2124.3%
Window AC	1	2,790	3,322	533	19.1%

Table 115. Comparison of Individual Household Weather-Normalized Model with Measure-Level Fixed-Effect Model, Residential Standard Offer Program

RSOP	n	Individual Household Model Savings	Measure Level Fixed-Effect Model Savings	Difference	Percentage Difference
AC	3,579	2,229	2,194	35	1.6%
Air Infiltration	6,306	-62	-94	32	-51.6%
Ceiling Insulation	1,778	615	622	6	1.0%
Duct Sealing	1,970	383	243	140	36.5%
Heat Pump	2,496	3,160	3,193	34	1.1%
Other Recorded Measures					
Solar Screen	2	3,306	3,180	126	3.8%
Wall Insulation	3	-3,133	-3,228	95	-3.0%
Window	19	-1,411	-1,245	166	-11.8%

Table 116. Comparison of Individual Household Weather-Normalized Model with Measure-Level Fixed-Effect Model, Hard-To-Reach Standard Offer Program

HTR SOP	n	Individual Household Model Savings	Measure Level Fixed-Effect Model Savings	Difference	Percentage Difference
AC	17	2,070	2,191	121	5.8%
Air Infiltration	4,445	179	236	58	32.2%
Ceiling Insulation	2,222	617	582	35	5.7%
Duct Sealing	775	471	578	107	22.7%
Heat Pump	659	2,653	2,589	64	2.4%
Other Recorded Measures					
Floor Insulation	1	-3,336	-3,245	91	-2.7%
Solar Screen	2	565	600	34	6.1%
Wall Insulation	7	419	555	136	32.4%
Window	5	-1,554	-707	847	-54.5%

Table 117. Comparison of Individual Household Weather-Normalized Model with Measure-Level Fixed-Effect Model, Low-Income

LI	n	Individual Household Model Savings	Measure Level Fixed-Effect Model Savings	Difference	Percentage Difference
AC	10	1,872	1,779	93	5.0%
Air Infiltration	173	113	-24	136	121.2%
Ceiling Insulation	300	950	845	106	11.1%
Duct Sealing	21	621	418	204	32.8%
Heat Pump	1,467	1,868	1,895	27	1.5%
Other Recorded Measures					
Floor Insulation	1	1,147	157	991	86.3%
Solar Screen	15	-1,542	-1,533	10	-0.6%
Wall Insulation	97	1,218	1,014	205	16.8%
Window	28	702	411	291	41.5%
Window AC	1	2,371	2,701	330	13.9%

Individual Household Weather-Normalization Demand Models:

To estimate demand impacts, the same model and coefficients from our *individual household weather-normalization* models are used. The key difference between this model and the *individual household weather-normalization* models is that rather than fitting the whole year of TMY3 data to the model coefficients in the pre- and post-period, only the top 20 hours, as defined by the TRM, are fit to the model coefficients, which results in an hourly demand estimate for the top 20 hours in winter and summer for the pre- and post-periods.

Once we have the hourly demand estimates for the pre- and post-period for the top 20 hours for that account's climate zone, we multiply the peak demand probability factor (PDPF) provided by the TRM for each hour by the demand estimate produced by our model coefficients. Next, we sum the term we just calculated and divide by the sum of the PDPF. This process is repeated for both the pre- and post-period, providing an estimate of peak demand in the pre-period and the post-period. We finally subtract the post-estimate from the pre-estimate, with the difference being our reduction in peak demand for that account.

Finally, to come to the reported numbers, we take the mean of the difference between the pre- and post-estimates for accounts in different programs. We do this for the treatment and comparison group, and subtract out the change in the comparison group, just as we have done in calculating our other results. When looking at the measure level, we re-use the regression noted towards the bottom of the Individual Household Weather Normalization Models section (**Equation 2**) but replace the change in normalized annual consumption with the change in peak demand. Both of these methods result in an adjusted peak demand reduction for the segment of interest. Complete peak demand results are available in the report.

TECHNICAL APPENDIX 2 NEW HOMES CONSUMPTION ANALYSIS

Methodology

The EM&V team performed a consumption analysis of the new homes programs to evaluate energy and demand impacts. The results are based on usage data that was weather normalized using an iterative method to optimize heating and cooling setpoints for each account.

The primary goal was to evaluate how well the TRM-based savings estimates characterized reductions in electric consumption in participating homes. We compared average annual energy usage estimated using the TRM methodology with the average weather-normalized usage observed in participating meters' data.

In addition to the energy model analysis, a secondary analysis compared the program homes with non-participating homes to provide broader context about real-world energy consumption in the markets in which the programs operate. Using this comparison group, we also estimated peak demand savings using a modified version of the approach presented in the TRM. Ultimately, because the comparison group sample had data limitations regarding household characteristics, the EM&V team provided numeric results, but emphasizes the broader suggested market transformation trends.

Data Sources

The EM&V team used the following data sources to perform the consumption analysis:

- **Program tracking data** for the new homes programs, provided by the Texas utilities for all electric participants from January 2017 through December 2018. These data included unique account numbers, participation dates, addresses, participant identifiers, and total reported TRM savings estimates per participant. These data also included detailed measure information such as measure names, reported Texas TRM savings estimates for each measure received, household characteristics, and the utility associated with the account.
- **Consumption data** for new homes, provided by the Texas utilities, for all electric use measured in 15-minute-intervals through advanced metering infrastructure meters. These data included time signatures for each interval reading and all kWh consumption, by participant account, from January 2017 (or when the meter entered service after that date) through December 2019.
- **Texas weather data**, retrieved from the ASOS network.[29] These data contained the hourly temperature readings for January 1, 2017, to January 1, 2020. We used data from the station closest to each TMY3 station, for a total of 59 weather stations. For more information on the Texas weather data, see Appendix 1-A: Supplemental Information on Weather Data.
- **County property tax data** containing square footage by address for relevant counties. We obtained property tax data for counties that had more than 50 participating new homes with the primary goal of adding square footage data to the non-participant group. These were available as downloads from various county tax and county appraiser

[29] https://mesonet.agron.iastate.edu/request/download.phtml?network=TX_ASOS

offices' websites and included Brazoria, Chambers, Fort Bend, Galveston, Harris, Montgomery, Nueces, San Patricio, Waller, and Webb counties.[30]

- **City and town population data** from the US Census Bureau.[31] These data were used to classify new homes by census division and stratify the data into segments representing urbanized areas, urban clusters, and rural areas.

Participant Group

The EM&V team defined the participant group as homes that participated in ERCOT utilities' new homes programs in PY2018. These accounts came from three utility companies: American Electric Power-Texas Central Company (AEP), CenterPoint Energy (CenterPoint), and Texas-New Mexico Power Company (TNMP).

Comparison Group

To analyze the efficiency of homes that did not participate in the program, we used a group of non-program customers with meters that came online in 2017 to late 2018 as the comparison group. These non-participants were selected from the three utility companies with new homes programs to control for differences in code enforcement or building practice across counties. All non-program customers were selected from counties that had at least 50 program participants. Furthermore, only counties with publicly downloadable tax data that contained square footage were used as this data point was an important factor used during the analysis.

Analysis Sample

Data Screening

Using the initial treatment and comparison groups, the EM&V team cleaned the data and screened for several criteria to identify the final analysis samples. The consumption analysis was conducted using participants with 12 full months of consumption data in calendar year 2019. Account-level reviews were performed on all individual households' monthly consumption to identify anomalies (e.g., periods of unoccupied units or missed readings) that could potentially bias results.

The EM&V team used the following screening criteria to remove anomalies, incomplete records, and outlier accounts that could potentially bias savings estimates:

- Accounts that could not be matched between participant program tracking data and consumption data (e.g., missing meter data or tracking data).

- Comparison accounts located in counties without sufficient participant accounts or in counties with inaccessible tax data. The EM&V team determined that non-participant accounts located in counties without sizeable participant populations would not provide appropriate comparisons because of different climate and code-enforcement conditions.

- Accounts that have solar interconnect agreements. Since these accounts produce some or all of their own electricity, we would not have complete consumption data.

- Accounts that recorded their first meter-reading after January 1, 2019, or recorded their last meter reading before December 31, 2019. In other words, accounts that had less

[30] See Appendix E

[31] US Census City and Town Population Total (2010-2019), https://www2.census.gov/programs-surveys/popest/tables/2010-2019/cities/totals/SUB-IP-EST2019-ANNRES-48.xlsx

than one full year of meter readings. Industry-standard practice in consumption analyses is to use one full year of usage data pre- and post-treatment; however, since these are new measures, no pre-treatment data exists.

- Accounts that recorded their first full day of non-zero kWh meter usage after January 1, 2019, which controlled for homes that were unoccupied at the start of the year. Given that the accounts in this analysis are new construction, it is important to consider that they may not be occupied at the start of the measured period, even if meters are installed. Accounts with extended periods of zero meter-usage indicated that base-load appliances were not yet installed. While it is a proxy for occupancy, the EM&V team felt that using the first date with a full day of meter-readings indicated that major appliances had been installed and thus occupancy was plausible.

- Accounts that were missing more than the equivalent of 12 hours total of consumption data (i.e., missing more than 48 15-minute meter data readings across the entire 365 days, not necessarily 48 consecutive 15-minute readings). This rule allows us to retain accounts with relatively small amounts of missing data, thus preserving the size and heterogeneity of the analysis group, while excluding those where large amounts of missing data could bias model coefficients. These levels were set at half of the values used in the retrofit analysis because the new homes analysis only uses one year of meter readings.

- Accounts with 15 days (1,440 15-minute meter data readings) of meter readings of zero kWh, in aggregate. Large amounts of meter readings of zero kWh indicate periods of vacancy, meter reading failure, or other issues that could bias model results. Meter readings of zero kWh are somewhat common; therefore, retaining accounts with some zero kWh readings was essential to preserve the size of the analysis group. As with the missing data metric, the threshold here was indexed at half the limit of the retrofit analysis.

- Accounts with total usage that was excessively high or low during the program year (less than 1,000 kWh or greater than 70,000 kWh). These accounts are outliers. The average consumption in the pre-period is about 15,000 kWh, and these accounts represent uncommon situations of drastically high or low consumption, which could influence model results.

- Comparison accounts with square footage below the participant minimum or greater than the participant maximum (under 784 or over 7,522 square feet). Comparison accounts that were outliers due to household size were deemed unlikely to prove useful for this analysis as they likely had characteristics that differentiated them from the participant population.

- Comparison accounts that were identified as cellular network towers, cable or phone relays, or other types of commercial accounts by the utility companies.

Model Attrition

Following these data screening steps, we retained a matched analytic sample consisting of 13,760 treatment and 17,288 comparison group accounts. Table 118 provides details of the screening process for accounts in the new homes program, and Table 119 provides utility-specific attrition. The data for the program participants tended to have fewer missing data than those found in the comparison group. Most of the participant accounts that were removed were due to excessive numbers of zero kWh readings, indicating potential irregularities in the smart meter function; however, this issue was still more pronounced in the comparison group.

Table 118. New Homes Program Screening - Statewide

Screen	Participant Group		Comparison Group	
	Accounts Remaining	Percentage Remaining	Accounts Remaining	Percentage Remaining
Original electric accounts	14,123	100%	56,150	100%
Did not match to billing data	14,120	100%	56,089	100%
Accounts from irrelevant comparison counties or counties with insufficient data	14,031	99%	46,941	84%
Accounts with solar interconnects	14,000	99%	46,884	83%
Accounts with insufficient start or end dates	13,958	99%	24,154	43%
Accounts that were not occupied at the start of 2019	13,958	99%	23,827	42%
Accounts with excessive missing meter reads	13,912	99%	22,687	40%
Accounts with excessive zero-kWh meter reads	13,763	97%	20,747	37%
Accounts that were usage or square-footage outliers	13,760	97%	18,264	33%
Accounts that were identified as commercial	13,760	97%	17,288	31%
Final Analysis Group	**13,760**	**97%**	**17,288**	**31%**

Table 119. New Homes Program Screening - Utility

Participant Group	AEP	CenterPoint	TNMP
Original Accounts	743	12,769	611
Final Accounts	592	12,569	599
Percentage Retained	**80%**	**98%**	**98%**
Comparison Group			
Original Accounts	10,436	43,169	2,545
Final Accounts	1,342	15,150	796
Percentage Retained	**13%**	**35%**	**31%**

Comparison meters had many reasons that contributed to a retention rate of approximately 33 percent. Most of the account loss stemmed from the original comparison account population having less selective criteria than the participants and can be attributed to specific data cleaning steps.

AEP and TNMP both provided many accounts that were in counties scattered throughout the state of Texas that did not correspond with where participant accounts were located. These accounts were in different counties and the code enforcement, market conditions, and building practices would likely differ and thus would not provide a relevant comparison. As a result, they are unlikely to make useful comparisons for the participant accounts. Additionally, some of the counties that had sizeable populations did not have any publicly downloadable databases that included square footage, so these were dropped from the comparison group. CenterPoint had many accounts that started after January 1, 2019, and thus were missing a full twelve months of data, which lead to a loss of almost half of their comparison accounts. While we attempted to screen ineligible accounts prior to requesting meter data, CenterPoint identified a group of approximately 1,000 comparison accounts that were commercial customers, and thus were removed from this analysis. CenterPoint also identified a group of accounts that were potentially multi-unit households, however due to the difficulty differentiating between true multi-unit buildings and single-family homes built close together, these were ultimately kept in the analysis. All the utilities suffered from issues with missing and zero kWh readings, which lead to further attrition that ultimately resulted in the relatively low retention rate.

Modeling Approach

Household-level weather normalization models

The team ran account-level regression models with weather-normalized hourly consumption to estimate the effect of weather on each household's energy consumption[32]. Results were then averaged across the sample to determine utility, census division, heating type, and statewide program findings. We originally calculated normalization models using both hourly and daily electricity usage aggregation; however, ultimately decided to use hourly normalization models as they fit the data more accurately.

- For the energy model analysis, treatment accounts were weather-normalized, and their usage was compared to the TRM usage estimates.

[32] For further details, see Appendix C.

- For the comparison analysis, both treatment accounts and comparison accounts were weather-normalized, and the two groups were compared.

Savings Calculation

The EM&V team derived gross energy consumption for the new homes programs using the following equation to compare the evaluated participant savings with those projected by the energy models defined in the TRM. The *plug load* variable used in the formula below represents the percentage of electrical consumption attributable to discretionary electrical consumption. The TRM estimates only include major appliances and heating and cooling; to compare meter data with the TRM estimates, we must include a correction for plug load.

$$Adj.Gross\ Consumption = \left(Normalized\ Usage_{Participant}\right)(1 - plug\ load)$$

$$Consumption\ Difference = (Adj.Gross\ Consumption) - (TRM\ Modeled\ Consumption)$$

For the comparison analysis, the EM&V team derived adjusted gross energy savings for the new homes programs compared to the comparison group using the formula below. This analysis represents the effect the new homes programs have on household consumption independent of standard building practices in their respective markets. These calculations do not include adjustments for plug load under the assumption that participant and comparison households use similar amounts of energy as plug load.

$$Adj.Gross\ Savings = Normalized\ Annual\ Usage_{Comparison} - Normalized\ Annual\ Usage_{Participant}$$

Similarly, we calculated peak energy reductions between the participant and comparison groups. We identified the normalized peak energy usage based on the *top 20 hours* methodology defined in the TRM.

$$Adj.Gross\ Peak\ Reduction = Normalized\ Peak\ Usage_{Comparison} - Normalized\ Peak\ Usage_{Participant}$$

Findings: Energy Models

Overall Results

This section presents evaluated savings estimates for the new homes programs at the statewide level, as well as by census division and heating type.

The EM&V team included weather-normalized annual consumption in these results to characterize the average energy consumption of the participant group; this helps control for variation in the temperatures during the program year that may have differed from conditions in a typical year in the same location.

After calculating weather-normalized consumption, usage was compared to the planning estimates reported in the utility tracking databases that are required to be consistent with the statewide TRM (which values are referred to as *TRM* in the tables below). It is important to note that there are differences in the methods used to calculate the evaluated estimates here and those methods used to estimate savings through the TRM. Specifically:

- ***Baseload Consumption*** – Billing analysis includes all electrical consumption during the program period, including the associated discretionary plug load. The TRMs are typically designed to estimate usage based on heating and cooling projections and consumption associated with major installed appliances that such as refrigerators, laundry machines, etc. Because plug load is not included in the TRM estimate, we must account for it before we can compare the two values and estimate it as 15 percent of overall consumption based on existing research[33].

- ***Weather*** – There may be some slight distinctions in weather data that may result in minor differences. As noted, this study uses data from 59 ASOS stations, specifically located nearest to each household in the analysis. However, the TRM primarily uses seven to nine regional stations to more broadly cover the state.

Statewide Findings

Table 120 provides model savings compared to TRM values by census classification and statewide.[34] The TRM is only meant to be accurate at a statewide level. However, we acknowledge there are differences in utilities' service areas that might affect the performance of homes, and one of these differences is the jurisdictions where the homes are built. Local jurisdictions are responsible for code enforcement, and the size of jurisdiction might affect that enforcement.

The US Census Bureau delineates geographic areas based on their population. It classifies areas with more than 50,000 people as *urbanized areas*, areas with between 2,500 and 50,000 as *urban clusters*, and all other areas as *rural*. While we present these additional findings by census division groups here, our focus will continue to be on the overall statewide results.

Statewide, the consumption model average savings converged closely with the TRM estimated savings. The EM&V team feels that the differences in average participant savings between the consumption model and the TRM could very plausibly be attributed to the limitations of estimating discretionary plug load.

Table 120. Census Division and Statewide Savings Summary

Census Division	n	Average Participant Annual Consumption			Average Participant Savings		Percentage of Savings Compared to TRM	Savings as a Percentage of Reference	
		Reference	Model	TRM	Model	TRM		Model	TRM
Urbanized Area	3,970	11,843	9,833	10,262	2,010	1,581	127%	17%	13%
Urban Cluster	9,014	12,177	10,468	10,461	1,709	1,716	100%	14%	14%
Rural Area	776	11,730	11,105	10,097	625	1,633	36%	5%	14%
All	**13,760**	**12,055**	**10,321**	**10,383**	**1,735**	**1,672**	**104%**	**14%**	**14%**

At the census division level, the models performed differently across the stratifications. Overall, results were in line with TRM estimates; however, in urbanized areas, the results indicated that the TRM might be underestimating savings compared to modeled usage (13 percent compared

[33] https://www.esource.com/es-wp-14/mind-gap-taking-comprehensive-look-plug-load-energy-use
[34] See Appendix F for similar results tables with confidence intervals.

to 17 percent). In rural areas, the TRM appears to be overestimating savings (14 percent compared to 5 percent).

Utility Findings

Table 121 provides model savings compared to TRM values by participating utility. Three utility programs participated in the new homes programs and used smart meters to measure usage: AEP, CenterPoint, and TNMP.

At the utility level, results varied widely. CenterPoint had, by far, the largest number of accounts and yielded the most similar results to the TRM estimate. The high number of accounts would suggest that the results are robust, and the models are performing well with a large population. Table 5 summarizes the results of utility savings.

Table 121. Utility Savings Summary

Utility	n	Average Participant Annual Consumption			Average Participant Savings		Percentage of Savings Compared to TRM	Savings as a Percentage of Reference	
		Reference	Model	TRM	Model	TRM		Model	TRM
AEP TCC	592	13,325	11,196	11,803	2,129	1,522	140%	16%	11%
Center Point	12,569	12,009	10,244	10,344	1,765	1,666	106%	15%	14%
TNMP	599	11,770	11,056	9,804	714	1,966	36%	6%	17%

AEP and TNMP both had results that were significantly different from the TRM estimates. The consumption model yielded higher savings for AEP than the TRM predicted (140 percent of TRM savings), while TNMP yielded lower savings (36 percent of TRM savings). The variation in these two utilities' results could potentially be the result of much smaller population sizes compared to CenterPoint, and it is possible that with additional participants, their results would converge on a point closer to the TRM estimates.

Heating Type Findings

Table 122 provides savings compared to TRM values by household space heating technology. Most of the accounts in this sample used natural gas (92 percent), while electric heat pumps (5 percent) and electric resistance (2 percent) made up the remainder.

As with the results overall, we expect to see some natural variation in this comparison due to plug load assumptions. For natural gas accounts, the differences between the calculated savings and TRM estimates were minuscule, echoing the previous finding that the TRM is performing well for homes using natural gas, which constitute the majority of homes in the program.

Table 122. Heating Type Savings Summary

Heating Type	n	Average Participant Annual Consumption			Average Participant Savings		Percentage of Savings Compared to TRM	Savings as a Percentage of Reference	
		Reference	Model	TRM	Model	TRM		Model	TRM
Electric Resistance	329	13,760	12,053	12,769	1,707	991	199%	12%	7%
Heat Pump	706	15,720	11,748	13,534	3,972	2,186	182%	25%	14%
Natural Gas	12,725	11,808	10,197	10,146	1,611	1,662	97%	14%	14%

The TRM estimates performed less well with the electric heating types, whose modeled usage both varied from the TRM estimates. In both cases, the model estimated average savings much higher than the TRM estimates. Accounts with electric resistance heating yielded average savings similar to households with natural gas, but nearly double what the TRM had predicted. For accounts with heat pumps, average savings were both substantially higher than the TRM estimates and far higher than other accounts overall.

Findings: Comparison Models

Overall Results

This section presents evaluated savings estimates for the new homes programs at the statewide level and census division, as well as by utility and heating type.

The EM&V team included the same weather-normalized annual consumption in these results to characterize the average energy consumption of the participant group, but also followed a similar procedure to normalize the average energy consumption for the comparison group. This weather-normalization helps control for variation in the temperatures during the program year that may have differed from conditions in a typical year in the same location.

Overall, the results of the comparison analysis indicate that the participant accounts are not using less energy than the comparison group. The EM&V team hypothesizes that this is likely due to market transformation stemming from a combination of market forces, including the new homes programs and outside influences.

The EM&V team took steps to ensure that the comparison group shared similar characteristics with the participant group; however, ultimately, it is difficult to be confident that the group provides an accurate analog. Additional information about the comparison group, including additional building or household characteristics, might allow for more accurate analyses in the future.

Statewide Findings

Table 123 provides modeled consumption both for the participant and comparison groups by census division and statewide.[35] At a statewide level, participating homes used slightly less energy than comparison homes on an annual basis.

When considering the weather-normalized energy consumption between the participant and comparison groups, we identified that the comparison households tended to be systematically smaller than the participant households. Since household square footage is related to electricity

[35] See Appendix F for similar results tables with confidence intervals.

associated with heating and cooling, this discrepancy causes the participants to use more electricity overall. To account for these differences, we also calculated the energy intensity of square footage by dividing household annual consumption by square footage for both the participant and comparison groups and then multiplied that by the category average square footage. Table 124 shows the results of this square footage adjusted consumption.

Table 123. Census Division and Statewide Consumption Summary

Census Division	Group	n	Model Average Consumption (kWh)	Participant Savings Versus Comparison	Participant Savings as a Percentage of Comparison Group
Urbanized Area	Participant	3,970	9,928	643	6%
	Comparison	8,023	10,572		
Urban Cluster	Participant	9,014	10,486	-410	-4%
	Comparison	8,151	10,075		
Rural Area	Participant	776	11,101	-38	0%
	Comparison	1,144	11,064		
All	**Participant**	**13,760**	**10,348**	**21**	**0%**
	Comparison	**17,288**	**10,369**		

Table 124. Census Division and Statewide Consumption Summary (Square Footage Adjusted)

Census Division	Group	n	Group Average Sq. Ft.	Model Average Energy Intensity (kWh/Sq. Ft.)	Census Division Average Sq. Ft.	Sq. Ft. Adjusted Average Consumption	Participant Savings versus Comparison	Participant Savings as a Percentage of Comparison Group
Urbanized Area	Participant	3,970	2,506	4.8	2,444	10,050	596	6%
	Comparison	8,023	2,397	5.1		10,646		
Urban Cluster	Participant	9,014	2,757	4.5	2,622	10,138	540	5%
	Comparison	8,151	2,421	4.8		10,678		
Rural Area	Participant	776	2,725	4.8	2,571	10,493	763	7%
	Comparison	1,144	2,369	5.2		11,255		
All	**Participant**	**13,760**	**2,680**	**4.6**	**2,553**	**10,091**	**673**	**6%**
	Comparison	**17,288**	**2,408**	**5.0**		**10,764**		

When we account for the differences in square footage between groups, the models yield energy savings for participants. However, compared with the Energy Models analysis results (14 percent savings over reference), the comparison group analysis suggests that savings above-market practices are less than 50 percent of the gross savings estimated by the TRM.

As indicated previously, market transformation is one possible explanation for this reduction in savings. If the industry standard has changed to build more energy-efficient housing, the TRM is not designed to represent this phenomenon when estimating energy consumption. If that is the case, it would explain why the energy model analyses appear to be performing well (the TRM is accurately estimating consumption in the participant group), but the comparison models show diminished savings.

Utility Findings

Table 125 and Table 126 provide modeled consumption for both participants and the comparison group, which are broken down by utility using the same methodology as in the previous section. Notably, TNMP shows savings higher than the TRM estimated savings when accounting for square footage.

As with the state and region level, initially, the results here indicated little to no savings across the utilities. When we account for square footage, we see considerable savings associated only with TNMP. One likely explanation for this discrepancy is that TNMP had a much larger difference in average square footage between its participants (2,725 square feet) and its comparison group (2,000 square feet) compared with AEP (1,977 square feet and 1,996 square feet, respectively) and CenterPoint (2,721 square feet and 2,450 square feet, respectively).

Table 125. Utility Consumption Summary

Utility	Group	n	Model Average Consumption (kWh)	Participant Savings Versus Comparison	Participant Savings as a Percentage of Comparison Group
AEP TCC	Participant	592	11,097	219	2%
	Comparison	1,342	11,316		
CenterPoint	Participant	12,569	10,244	33	0%
	Comparison	15,150	10,278		
TNMP	Participant	599	11,053	-534	-5%
	Comparison	796	10,520		

Table 126. Utility Consumption Summary (Square Footage Adjusted)

Utility	Group	n	Group Average Sq. Ft.	Model Average Energy Intensity (kWh/Sq. Ft.)	Utility Average Sq. Ft	Sq. Ft. Adjusted Average Consumption	Participant Savings versus Comparison	Participant Savings as a Percentage of Comparison Group
AEP TCC	Participant	592	1,977	6.8	1,985	11,428	301	3%
	Comparison	1,342	1,996	7.0		11,728		
Center Point	Participant	12,569	2,721	4.5	2,594	9,917	627	6%
	Comparison	15,150	2,450	4.8		10,543		
TNMP	Participant	599	2,725	5.0	2,411	10,211	2,936	22%
	Comparison	796	2,000	6.4		13,147		

As mentioned above, the results for TNMP show savings higher than the TRM estimates. These higher savings results might be a limitation of the square footage adjustment methodology. However, this might also reflect market practices within TNMP's service area, such as a lag in code adoption or enforcement or at least building practices closer to the code baseline. These results are based on the smallest number of observations for any of the utilities.

Heating Type Findings

The last stratification technique that the EM&V team was interested in was examining the results by heating technology. This stratification presented a unique challenge because, unlike the participant group, there was no heating information provided for the comparison accounts. To overcome this problem, we utilized a train-test split and cross-validation using the participant accounts to develop a model that would predict the heating type in the comparison group based on usage patterns[36].

While this model proved effective in testing and correctly identifying gas accounts, it could not reliably and consistently differentiate between accounts with electric resistance and heat pumps. Because of these limitations, for the comparison analysis, we ultimately decided to group electric heating types and compare them to gas heating.

Table 127 and Table 128 provide modeled consumption for participants and the comparison group stratified by heating fuel (or predicted heating fuel) using the same methodology as in the previous section.

The initial results by heating type yielded similar findings to the other analyses described previously. Without accounting for square footage, the models indicate higher usage for participant homes than comparison homes. Once we adjust for average square footage, we see savings that are larger than in previous stratifications, but still considerably less than the energy models predicted.

Table 127. Heating Type Consumption Summary

Heating Type	Group	n	Model Average Consumption (kWh)	Participant Savings Versus Comparison	Participant Savings as a Percentage of Comparison Group
Electric Heat	Participant	1,035	11,595	-278	-2%
	Comparison	1,342	11,316		
Natural Gas Heat	Participant	12,725	10,208	82	1%
	Comparison	15,946	10,290		

[36] See Appendix D for further details.

Table 128. Heating Type Consumption Summary (Square Footage Adjusted)

Heating Type	Group	n	Group Average Sq. Ft.	Model Average Energy Intensity (kWh/ Sq. Ft.)	Heating Type Average Sq. Ft	Sq. Ft. Adjusted Average Consumption	Participant Savings versus Comparison	Participant Savings as a Percentage of Comparison Group
Electric Heat	Participant	1,035	2,292	6.8	2,199	11,682	1,310	10%
	Comparison	1,342	1,996	7.0		12,992		
Natural Gas Heat	Participant	12,725	2,717	4.5	2,579	9,861	802	8%
	Comparison	15,946	2,427	4.9		10,663		

Peak Demand Results

As a part of the comparison analysis, the EM&V team also developed a method for calculating peak demand by adapting the method in the TRM, as was laid out in the savings calculation section. The peak demand savings estimates for the new homes programs overall are presented below in Table 129.

It is important to note that winter peak demand is typically only calculated for homes that use electric heating. Based on the tracking data, the EM&V team already knew that most of the participants' accounts use natural gas for heating. However, because the heating fuel is unknown for the comparison group, we again used predicted heat type to present results stratified by heating fuel. The results of this second calculation for the winter peak season are shown in Table 130.

Overall, the results of the peak demand calculation were consistent with the energy portion of the comparison group analysis in that it does not appear that participants reduced demand versus the comparison group. While there initially appeared to be a reduction in winter peak consumption, once heating type was disaggregated, these apparent savings could be attributed to natural gas heated accounts. Winter peak is only calculated for homes with electric heat, and those accounts did not yield savings.

Table 129. Peak Demand Summary

Season	Participant Peak Demand	Comparison Peak Demand	Demand Reduction	Demand Reduction as a Percentage of Comparison Peak
Summer	3.93	3.75	-0.17	-5%
Winter	1.05	1.76	0.71	40%

Table 130. Winter Peak Demand Summary by Heating Type

Season	Heating Type	Participant Peak Demand	Comparison Peak Demand	Demand Reduction	Demand Reduction as a Percentage of Comparison Peak
Winter	Electric Heat	3.23	3.20	-0.02	-1%
	Natural Gas Heat	0.87	1.64	0.77	47%

While the TRM does not provide a method for calculating peak demand reductions in natural gas heated homes, the observed savings are a potentially intriguing finding. Hypothetically, electrical consumption in these homes would not be affected by heating in winter, except for the electrical components associated with ventilation. It is possible that when heating and cooling are not factored into consumption, there are features of participant homes that set them apart from the comparison group in terms of energy efficiency.

Since the comparison group homes are smaller on average than participant homes, we also ran an analysis that adjusted peak demand based on average square footage within each group. The results of this calculation for the entire population are shown in Table 131, and results stratified by heating type are in Table 132.

Table 131. Peak Demand Summary (Square Footage Adjusted)

Season	Participant Peak Demand Intensity (kW/sq. ft.)	Comparison Peak Demand Intensity (kW/sq. ft.)	Sq. ft. Adjusted Participant Peak Demand	Sq. ft. Adjusted Comparison Peak Demand	Sq. ft. Adjusted Demand Reduction	Sq. ft. Adjusted Demand Reduction Percentage
Summer	0.0015	0.0016	3.74	3.98	0.23	6%
Winter	0.0004	0.0007	1.00	1.87	0.87	46%

Table 132. Winter Peak Demand Summary by Heating Type (Square Footage Adjusted)

Season	Heating Type	Participant Peak Demand Intensity (kW/sq. ft.)	Comparison Peak Demand Intensity (kW/sq. ft.)	Sq. ft. Adjusted Participant Peak Demand	Sq. ft. Adjusted Comparison Peak Demand	Sq. ft. Adjusted Demand Reduction	Sq. ft. Adjusted Demand Reduction Percentage
Winter	Electric Heat	0.0014	0.0016	3.10	3.53	0.43	12%
	Natural Gas Heat	0.0003	0.0007	0.83	1.74	0.92	52%

As Table 131 illustrates, once we included the adjustment for the different average square footage between groups, the analysis produced very modest demand savings for all accounts during summer peak (6 percent reduction) and slightly more pronounced demand reduction in winter (46 percent reduction).

When heating type is considered, all-electric homes yielded peak demand savings of 12 percent for the winter season. Accounts with natural gas heating showed substantial savings during the winter peak (52 percent). The results overall, as well as by heating type, indicate that peak demand reductions were much higher in the winter compared to summer, both in terms of relative percent of peak demand as well as absolute peak kW.

APPENDIX 2-D: HEAT TYPE PREDICTION DETAILS

The EM&V team utilized a model training and testing approach to predict the heating type in the comparison group. This method entailed randomly splitting the complete participant data set into a training subset (70 percent of the data) and a testing subset (30 percent of the data). Using the consumption and demographic details, we trained a model on the characteristics specific to different heating types. We then used this model to predict the heating type in the test portion of the participant population. Because we knew the heating type of all the participant accounts, we could compare whether the model accurately predicted the heating type in the test group (whose heating type we also knew) to evaluate its accuracy.

This testing process was repeated six times with different random samples of the population to further refine the training model to reduce bias and cross-validate results. After each round, the predictions were compared to actual heating types so that model accuracy could be tested. The accuracy was averaged over the six periods to arrive at approximately 94 percent. Upon examination of the misidentified accounts, nearly all appeared to be either heat pumps or electric resistance. This finding indicated that, while the model appeared capable of distinguishing natural gas versus electric heat, it was not sensitive enough to differentiate different types of electric heat. Due to this limitation, the EM&V team ultimately decided that we were not confident we could separate heat pumps and electric resistance and grouped the electric heating types to minimize identification errors.

Finally, once the model was trained and tested, it was applied to the comparison group to predict the heating type of these accounts based on their consumption and demographic details. The predicted results showed that the sample contained 1,342 electric heating accounts (7.3 percent) and 16,922 natural gas heating accounts (92.7 percent). The predicted results matched the participant group closely, which had 1,035 combined electric heating accounts (7.5 percent) and 12,725 natural gas heating accounts (92.5 percent).

APPENDIX 2-E: COUNTY DATA DETAILS

This appendix describes counties and county tax data relevant to the new homes programs analyses in greater detail. We used county tax data downloads to obtain household square footage for accounts in the comparison group.

One of the characteristics of the raw comparison group data was a much wider dispersal of accounts throughout the state than in the participant group. In order to make the sample distribution as similar as possible to the participant accounts, the decision was made to only include comparison accounts from counties with at least 50 participants. Ten counties met this initial requirement: Brazoria, Chambers, Fort Bend, Galveston, Harris, Montgomery, Nueces, San Patricio, Waller, and Webb.

Seven of these counties (all except Chambers, Waller, and Webb) had publicly available tax record data that could be downloaded and contained household square footage. Chambers county had publicly downloadable data; however, it did not contain square footage. Waller and Webb counties both had searchable databases that allowed individual address searches, but not downloadable data.

Due to the posed limitations, we took an alternative approach to get square footage for homes in these counties. Rather than individually query households one at a time, we instead looked for overlapping records from other neighboring counties; this allowed us to get the square footage data for a small subset of homes in these counties. However, this subset was enough to serve as a comparison in those areas. Table 133 illustrates the final numbers of participant and comparison accounts retained in each of the counties used in this analysis.

Table 133. County Distribution Summary

County Name	Group	n
Brazoria County	Participant	1,070
	Comparison	1,631
Chambers County	Participant	101
	Comparison	293
Fort Bend County	Participant	3,642
	Comparison	3,001
Galveston County	Participant	742
	Comparison	1,138
Harris County	Participant	6,296
	Comparison	10,131
Montgomery County	Participant	1,050
	Comparison	545
Nueces County	Participant	271
	Comparison	676
San Patricio County	Participant	75
	Comparison	154
Waller County	Participant	267
	Comparison	183
Webb County	Participant	246
	Comparison	512

APPENDIX 2-F: RESULTS TABLES WITH CONFIDENCE INTERVALS

This appendix contains similar tables to the results sections, but they have been expanded to include precision levels at the 90 percent confidence interval. These precision values were added and subtracted from the mean to provide the lower and upper bounds of the estimate at 90 percent confidence. The purpose of these tables is to provide additional information about the precision with which we calculated the means used in the primary results section. number of accounts that received the measure as well as the precision of the estimate.

Table 134 through Table 136 provide precision levels for the energy models, while

Table 137 through Table 139 provide precision levels for the comparison analysis. One important note is that as the sample is stratified into groups with fewer accounts, the precision level tends to fall, indicating that the results are less reliable. In these results, it is generally the case that strata with fewer than 1,000 accounts tended to suffer diminished precision.

Table 134. Census Division and Statewide Savings Summary with 90% Confidence Interval

Census Division	n	Average Participant Annual Consumption			Average Participant Savings		Percentage of Savings Compared to TRM	Savings as a Percentage of Reference		Average Model Savings Confidence Interval at 90%		
		Reference	Model	TRM	Model	TRM		Model	TRM	Precision	Lower Bound	Upper Bound
Urbanized Area	3,970	11,843	9,833	10,262	2,010	1,581	127%	17%	13%	4.6%	1,918	2,102
Urban Cluster	9,014	12,177	10,468	10,461	1,709	1,716	100%	14%	14%	3.8%	1,644	1,775
Rural Area	776	11,730	11,105	10,097	625	1,633	36%	5%	14%	39.7%	377	874
All	**13,760**	**12,055**	**10,321**	**10,383**	**1,735**	**1,672**	**104%**	**14%**	**14%**	**3.0%**	**1,682**	**1,787**

Table 135. Utility Savings Summary with 90% Confidence Interval

Utility	n	Average Participant Annual Consumption			Average Participant Savings		Percentage of Savings Compared to TRM	Savings as a Percentage of Reference		Average Model Savings Confidence Interval at 90%		
		Reference	Model	TRM	Model	TRM		Model	TRM	Precision	Lower Bound	Upper Bound
AEP TCC	592	13,325	11,196	11,803	2,129	1,522	140%	16%	11%	10.5%	1,906	2,352
Center Point	12,569	12,009	10,244	10,344	1,765	1,666	106%	15%	14%	3.1%	1,710	1,820
TNMP	599	11,770	11,056	9,804	714	1,966	36%	6%	17%	36.6%	452	975

Table 136. Heating Type Savings Summary with 90% Confidence Interval

Heating Type	n	Average Participant Annual Consumption			Average Participant Savings		Percentage of Savings Compared to TRM	Savings as a Percentage of Reference		Average Model Savings Confidence Interval at 90%		
		Reference	Model	TRM	Model	TRM		Model	TRM	Precision	Lower Bound	Upper Bound
Electric Resistance	329	13,760	12,053	12,769	1,707	991	199%	12%	7%	18.4%	1,393	2,021
Heat Pump	706	15,720	11,748	13,534	3,972	2,186	182%	25%	14%	3.4%	1,557	1,665
Natural Gas	12,725	11,808	10,197	10,146	1,611	1,662	97%	14%	14%	6.0%	3,732	4,212

Table 137. Census Division and Statewide Consumption Summary with 90% Confidence Interval

Census Division	Group	n	Model Average Consumption (kWh)	Participant Savings Versus Comparison	Participant Savings as a Percentage of Comparison Group	Precision	Lower Bound	Upper Bound
Urbanized Area	Participant	3,970	9,928	644	6%	1.1%	9,822	10,035
	Comparison	8,023	10,572			1.2%	10,443	10,700
Urban Cluster	Participant	9,014	10,486	-441	-4%	0.7%	10,409	10,562
	Comparison	8,151	10,075			1.1%	9,966	10,184
Rural Area	Participant	776	11,101	-37	0%	2.9%	10,782	11,420
	Comparison	1,114	11,064			2.8%	10,753	11,374
All	**Participant**	**13,760**	**10,348**	**21**	**0%**	**0.6%**	**10,286**	**10,410**
	Comparison	**17,288**	**10,369**			**0.8%**	**10,288**	**10,451**

Table 138. Utility Consumption Summary with 90% Confidence Interval

Utility	Group	n	Model Average Consumption (kWh)	Participant Savings Versus Comparison	Participant Savings as a Percentage of Comparison Group	Precision	Lower Bound	Upper Bound
AEP TCC	Participant	592	11,097	219	2%	2.3%	10,839	11,355
	Comparison	1,342	11,316			2.0%	11,095	11,537
CenterPoint	Participant	12,569	10,244	37	0%	0.6%	10,180	10,309
	Comparison	15,150	10,278			0.9%	10,188	10,367
TNMP	Participant	599	11,053	-534	-5%	2.8%	10,748	11,359
	Comparison	796	10,520			2.5%	10,259	10,780

Table 139. Heating Type Consumption Summary with 90% Confidence Interval

Heating Type	Group	n	Model Average Consumption (kWh)	Participant Savings Versus Comparison	Participant Savings as a Percentage of Comparison Group	Precision	Lower Bound	Upper Bound
Electric Heat	Participant	1,035	11,595	-278	-2%	1.8%	11,388	11,801
	Comparison	1,342	11,316			2.0%	11,095	11,537
Natural Gas Heat	Participant	12,725	10,208	82	1%	0.6%	10,144	10,272
	Comparison	15,946	10,290			0.8%	10,203	10,376

TECHNICAL APPENDIX 3: CONSUMPTION ANALYSIS RECOMMENDATIONS

This appendix provides recommendations for program year (PY) 2021 residential standard offer, hard-to-reach and low-income programs in response to the PY2019 EM&V residential consumption analysis results. The goal of these recommendations is to most effectively address differences in the technical reference manual (TRM) deemed savings and actual savings for the primary measures investigated in the consumption analysis. These recommendations were discussed with the TRM Working Group and each utility individually as part of the PY2019 EM&V results meeting.

Introduction

A residential consumption analysis of the standard offer, hard-to-reach and low-income programs was conducted as part of the PY2019 EM&V effort. The residential consumption analysis demonstrated that these programs are delivering significant savings to participants, measured by how much less energy they use annually. At the same time, it also demonstrated that the TRM deemed savings are overestimating claimed savings for the following measures: central AC, heat pumps, duct sealing, ceiling insulation, and air infiltration. Central A/C is the measure performing most closely to the deemed savings estimates in delivering savings. Air infiltration has the poorest performance in delivering savings comparable to TRM deemed savings. The reader is referred to the Residential Consumption Analysis Technical Appendix A that details consumption analysis results compared to TRM deemed savings by measure across the three programs as well as the supporting data and analysis methodology.

This section includes both PY2021 TRM updates and PY2021 implementation recommendations. The recommendations are based on various analyses of the consumption results and discussions with the TRM Working Group held on July 7 and July 14. A draft memo provided the basis for continued collaboration between the utilities, EM&V team, and PUCT staff in July and August. The goal of the collaboration was to agree on recommendations and incorporate these recommendations prior to launching the 2021 residential programs. This appendix presents the final version of this memo. While the recommendations include further considerations for future program years, we strove to keep recommendations feasible for 2021 implementation while addressing the critical need for more accurate claimed savings.

Next, we summarize observations based on EM&V analysis of what we believe are the primary causes of differences between actual and deemed savings for measures as follows: HVAC, duct sealing, ceiling insulation and air infiltration. We then list the actions to address these causes both in the PY2021 TRM and program implementation.

HVAC

<u>Baselines</u>

Observation: Claiming electric resistance heat as a baseline is a potential driver of differences between TRM deemed savings and consumption analysis results for heat pumps. Other issues may include TRM calculation methodology, or service provider data entry. This issue and proposed solutions also apply to the all envelope measures.

Objective: Ensure accurate selection of baseline equipment and evaluate other potential causes of the savings difference.

Next, we discuss how this objective will be achieved through TRM updates and utility implementation recommendations.

TRM 2021 Updates:

- Update measure requirements to clearly define and track both existing and baseline heating and cooling types, including defining the difference between central electric resistance furnace and electric resistance space heating
- Electric resistance heat baselines may not be claimed in multifamily properties when changing heating types from chiller to heat pump, except when the utility obtains advance review and approval by the EM&V team of project documentation that the planned heating type was electric resistance.
- Update measure requirements to include a tracking system indicator for projects that change heating types so that they can be easily identified in future consumption analyses

2021 Implementation Recommendations for Utilities:

- Track both existing and baseline heating and cooling types
- Track when heating types change so projects can be easily identified in future consumption analyses
- Conduct 100% utility QA/QC of electric resistance heat baselines for the first six months of the program year. After the first six months of PY2021, utilities may choose to decrease to 50% QA/QC of projects for service providers who have achieved a 100% passing rate for a minimum of 30 projects at different locations. Utilities may determine their preferred process to conduct QA/QC (videos, photos, interval meter data, etc.) of electric resistance heat baselines.

Future Considerations:

Utilities can further decrease QA/QC of electric resistance heating baselines based on service provider performance in future program years

<u>Customer Behavior</u>

Observation: Improper use of programmable thermostats designed to optimize HVAC equipment can decrease savings from new equipment (e.g., manual adjustments of thermostats can make heat pumps less efficient by triggering the electric resistance component)

Objective: Promote proper participant use of HVAC equipment and programmable thermostats as part of the program

TRM 2021 Updates:

- None

2021 Implementation Recommendations for Utilities:

- Consider developing and distributing customer education materials on correct HVAC set points and proper use of programmable thermostats

Future Considerations:

- Future EM&V participant surveys should assess the effectiveness of program education on customer use of HVAC equipment and controls
- Adjust TRM heat pump energy use to include backup and auxiliary electric resistance heat

Duct Sealing

Multi-family versus single-family

Observation: Multi-family consumption results for this measure are substantially less than single-family

Objective: Deliver duct sealing consistent with where actual savings occur based on the consumption analysis.

Next, we discuss how this objective will be achieved through TRM updates and utility implementation recommendations.

TRM 2021 Updates:

- Limit eligibility to single-family homes
- Modify documentation requirements to increase confidence in inside-to-outside testing only
- Apply an energy use multiplier for electric resistance heat that does not use duct systems (e.g., space heating)

2021 Implementation Recommendations for Utilities:

- Conduct 100% utility QA/QC of electric resistance heat for the first six months of the program year. After the first six months of PY2021, utilities may choose to decrease to 50% QA/QC of projects for service providers who have achieved a 100% passing rate for a minimum of 30 projects at different locations. Utilities may determine their preferred process to conduct QA/QC (videos, photos, interval meter data, etc.) of electric resistance heat.

Future Considerations:

- Consider tracking primary and secondary heating and cooling systems
- Utilities can further decrease QA/QC of electric resistance heating based on service provider performance in future program years
- Assess the TRM alternative streamlined approach and results of this approach
- Consider if a multi-family option should be developed and offered in future program years
- Review best practices across other utility programs and identify opportunities for Texas

Ceiling Insulation

Baselines

Observation: The majority of projects claim baseline insulation levels less than R-5 and electric resistance heat; these are also the projects most overestimating savings when comparing actual and deemed savings.

Objective: Set a minimum insulation baseline and requirements when claiming electric resistance heat

Next, we discuss how this objective will be achieved through TRM updates and utility implementation recommendations.

TRM 2021 Updates:

- Set the minimum baseline R-value to 5
- Define when existing (and baseline) resistance heat can be claimed
- Apply an energy use multiplier for electric resistance space heat (similar to existing room air conditioner measure)

2021 Implementation Recommendations:

- Conduct 100% utility QA/QC of electric resistance heat baselines for the first six months of the program year. After the first six months of PY2021, utilities may choose to decrease to 50% QA/QC of projects for service providers who have achieved a 100% passing rate for a minimum of 30 projects at different locations. Utilities may determine their preferred process to conduct QA/QC (videos, photos, interval meter data, etc.) of electric resistance heat.

Future Considerations:

- Consider tracking primary and secondary heating and cooling systems
- Consider if the energy use multiplier needs to be used if the baseline insulation is less than R5
- Consider if a R5 baseline (instead of the median point of the R5-R9 deemed savings) can be used for non-electric heating sources in 2021
- Adjust savings calculations to include primary and secondary heating and cooling system types, when applicable
- Determine if the energy models include approximately R-2 for non-insulation ceiling materials
- Review best practices across other utility programs and identify opportunities for Texas
- If future analysis shows the TRM deemed savings are no longer overestimating savings, re-visit the possibility of a conservative baseline approach for projects that may have less than R5
- Utilities can further decrease QA/QC of electric resistance heating based on service provider performance in future program years

Air Infiltration

Residential vs. Hard-to-Reach results

Observation: The residential standard offer program results showed no savings for air infiltration, whereas savings were found in the hard-to-reach program (though still considerably less than the TRM deemed savings). Some of the EM&V on-site inspections of sampled projects resulted in savings adjustments based on major leaks found by the EM&V team. While this was a small number, it suggests improper implementation of the measure could be part of why this measure is seeing small savings in the consumption analysis.

Objective: Address proper implementation of this measure coupled with a focused effort on those who are most likely to benefit

Next, we discuss how this objective will be achieved through TRM updates and utility implementation recommendations.

TRM 2021 Updates:

- Limit eligibility to low-income/hard-to-reach participants
- Reduce leakage caps for maximum pre-leakage and leakage reduction (analysis in progress to determined recommended cap)
- Apply cap to all sectors
- Require documentation similar to above-cap projects as outlined in the current TRM
- Apply an energy use multiplier for electric resistance space heat (similar to existing room air conditioner measure)

2021 Implementation Recommendations:

- Train contractors on the proper implementation of this measure
- Consider if a contractor certification requirement (i.e., HERS rater or BPI certified) could help improve results based on Texas' and other utilities' experience across the country, utilities may or may not decide this is a practical or helpful solution for them
- Conduct 100% utility QA/QC of electric resistance heat baselines (via virtual or remote inspections or other viable alternative for the utility; this does not have to be on-site inspections)

Future Considerations:

- If strategies show success, this measure may be expanded beyond hard-to-reach programs, beginning with residential single-family homes
- Investigate a streamlined approach to claim actual CFM reduced per house (and/or other metrics) coupled with an incentive structure that effectively addresses potential for gaming
- Review energy models to determine if smaller increments of leakage improvements should be modeled

- Review best practices across other utility programs and identify opportunities for Texas

Conclusion

For the residential measures covered in this memo, the EM&V team and PUCT staff would like to focus future discussions and collaboration on the above listed recommendations for 2021, welcoming additional questions or input from the utilities.