Counting kWs: How the Utilities in Texas Quantify the Demand Reduction Impacts of Air Conditioning Energy Efficiency Programs

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ABSTRACT

In Texas, air conditioning drives summer peaks. In 2006 the federal efficiency standard was increased to a 13 SEER (Seasonal Energy Efficiency Ratio) baseline for residential air conditioning equipment, and this has reduced the savings that can be obtained from energy efficiency programs targeting air conditioning. However, many cost-effective efficiency opportunities remain. Many of the current energy efficiency programs place greater emphasis on peak demand savings. However, quantification of the demand impacts of air conditioning efficiency measures can be complicated.

The energy efficiency programs administered by the investor-owned utilities in the state of Texas have adopted a unique method of accounting for the energy savings and peak savings from air conditioning programs. Performance data for residential heat pumps and air conditioners was collected from each of the four largest equipment manufacturers. From the performance data, Frontier Associates developed performance curves for air conditioning equipment in various size and SEER ranges. The availability of this data allowed us to directly assess the performance of similarly sized units in various SEER ranges. The kW demand and Btuh capacity of the units were calculated at each temperature point between 65 and 115 degrees ambient. Separate models were developed for single-speed and two-speed units. The average peak hour kW value corresponding to the 99% design temperature for representative cities in four Texas weather zones was calculated. This methodology was used to calculate kWh savings as well. While tedious, this approach yields more accurate energy and demand estimates than relying upon individual unit SEER values, EER values, and DOE's default air conditioner performance curves.

Introduction

The 13 SEER minimum efficiency standards for air conditioners and heat pumps less than 65,000 BTU/hr, implemented by the federal government in early 2006, resulted in a revision to the deemed savings values approved by the Public Utility Commission of Texas for energy efficient central air conditioners and heat pumps installed through utility energy efficiency programs. SEER, seasonal energy efficiency ratio, is a rating that is equal to the Btu of cooling output during a typical cooling season divided by the energy input in watt-hours. The higher the SEER value the more efficient the unit is. Since a new baseline efficiency was established, the deemed savings used in their programs to calculate savings had to be revised to reflect this change. Frontier developed an accurate way to evaluate and account for the effects of this change.

Review of Available Data

In reviewing data on the relationship between efficiency and outdoor air temperature, the research team concluded that actual unit performance data, if it could be obtained from the major manufacturers, should be used to develop performance curves for units in each of the following SEER ranges:

- 13.0 – 13.9

- 14.0 – 14.9
- 15.0 – 15.9
- 16.0 – 16.9
- 17.0 – 17.9
- 18 and above

Performance data for residential heat pumps and air conditioners was requested from each of the four largest manufacturers: Carrier, Goodman/Amana, Lennox, and American Standard/Trane. Collectively these manufacturers account for a 71% national market share. Each of these four manufacturers provided their performance data, which allowed the research team to develop performance curves for each unit size in each SEER range. In other words there were 42 possible performance curves for each manufacturer: 6 SEER ranges multiplied by the 7 standard tonnage sizes (1.5, 2, 2.5, 3, 3.5, 4, and 5 tons). However, for some units in certain higher SEER ranges, performance data had to be interpolated from other sizes in the same SEER range. This was necessary because all four manufacturers do not produce units in all size ranges and capacities. For example, some higher SEER units may not be available in 1.5, 2.5, 3.5, or 5 ton sizes.

The availability of this data allowed the research team to be able to directly assess the performance of typical units currently being installed in Texas residences. By using actual performance data in conjunction with hourly weather conditions in each of the four weather zones (Houston, Dallas, Amarillo and Corpus Christi) the research team avoided the need to weather-adjust SEER and EER values, and provided a potentially more accurate estimate of annual cooling energy use. This approach also allowed the research team to incorporate the cyclic degradation factor into the seasonal energy use calculation.

Compilation of Performance Data

For the air conditioner deemed savings, unit performance data was selected for units in each of the seven sizes and six SEER ranges. For each of the product types in the 13 and 14 SEER ranges, data was available from at least three manufacturers. One manufacturer supplied product data for selected condenser/coil combinations in each product line. The others provided data on all their residential products. In selecting an appropriate condenser/coil combination, the research team generally used the following criteria:

1. SEER value at or near low end of the SEER range, e.g., 14.00.
2. All units 14 SEER and above had to meet Energy Star standard
3. The specific condenser/coil combination that was tested by the manufacturer
4. Highest sales volume combination

In some cases, the research team selected a condenser/coil combination that didn't meet the above criteria, typically when required to find a sufficient number of units with a particular SEER value to produce a robust analysis. Selecting units with SEER values at or near the low end of the SEER range allowed for a more accurate analysis than the previous deemed savings, which used the midpoint instead of the median SEER value. Typically the units available on the market are closer to the bottom end of the range, for example 14.00 SEER, not 14.60 SEER.

The performance data is not reported in a consistent manner by all manufacturers. For example, some manufacturers don't report performance data for 65 degree ambient. In these cases, performance data was extrapolated.

The data from each manufacturer was weighted based on national market share information. Weighted average performance curves were thus developed for each of the product types. For the 13.0 – 13.9 SEER baseline unit, base model condenser/coil combinations were selected and adjusted for condenser-only changeouts by reducing the EER by 10%. The percentage of condenser-only changeouts (30%) was estimated from recent air conditioning contractor surveys conducted by Oncor.

Determination of Peak Demand and Annual Cooling Energy Consumption

Using the unit performance data compiled as outlined above, the kW demand and Btuh capacity of the units were calculated at each temperature point between 65 and 115 degrees ambient. An oversize factor of 115% was assumed, as was a cyclic degradation factor 0.25 (ASHRAE default value). Separate calculation models were developed for single-speed and two-speed units. For peak demand, the average peak hour kW value corresponding to the 99% design temperature for the representative cities in the four weather zones was calculated.

To determine annual cooling energy consumption, hourly weather data for each of the four weather zones was used. The performance of the unit at the midpoint of each temperature bin (e.g. 77.5 degrees for the 75-80 degree bin) was determined. Using manufacturer values for input kW and capacity, coupled with cooling load, and number of hours in each of the temperature bins, we produced the seasonal performance of each of the forty-two product types. Comparison with the performance of the baseline unit in each size range provided estimated off peak demand reduction and annual cooling energy savings.

Results

This method of calculating the deemed savings for air conditioning energy efficiency programs produced more accurate results than the previous deemed savings values. All of the factors were considered while designing the calculating tool; using real performance data from the four major manufacturers and hourly weather data for each region, and accounting for cyclic degradation as well as condenser-only changeouts, the team generated the most realistic deemed savings possible with the use of a tool. Below is a sample of the proposed deemed savings values for one of the climate zones analyzed - Amarillo. When interpreting these results it should be noted that the savings were calculated against a 13 SEER baseline. The tables depict the savings that can be associated with each higher SEER level that is implemented and the amount of savings the investor-owned utilities in Texas can claim that are a result of their air conditioning programs.

Central Air Conditioners

Table 1. Proposed Demand Savings (kW) – Amarillo

	SEER Range				
Size (tons)	**14.0-14.9**	**15.0-15.9**	**16.0-16.9**	**17.0-17.9**	**18+**
1.5	0.13	0.18	0.23	0.30	0.31
2.0	0.17	0.24	0.31	0.41	0.42
2.5	0.21	0.30	0.39	0.51	0.52
3.0	0.25	0.36	0.46	0.61	0.63
3.5	0.30	0.42	0.54	0.71	0.73
4.0	0.34	0.48	0.62	0.81	0.83
5.0	0.42	0.60	0.77	1.01	1.04

Central Air Conditioners

Table 2. Proposed Energy Savings (kWh) – Amarillo

	SEER Range				
Size (tons)	**14.0-14.9**	**15.0-15.9**	**16.0-16.9**	**17.0-17.9**	**18+**
1.5	219	384	457	615	657
2.0	292	512	609	821	876
2.5	365	640	761	1,026	1,095
3.0	438	769	914	1,231	1,314
3.5	511	897	1,066	1,436	1,533
4.0	584	1,025	1,218	1,641	1,752
5.0	730	1,281	1,523	2,051	2,191

Heat Pump (Cooling Savings)

Table 3. Proposed Demand Savings (kW) – Amarillo

	SEER Range				
Size (tons)	**14.0-14.9**	**15.0-15.9**	**16.0-16.9**	**17.0-17.9**	**18+**
1.5	0.12	0.20	0.21	0.22	0.24
2.0	0.16	0.27	0.27	0.29	0.32
2.5	0.21	0.33	0.34	0.37	0.40
3.0	0.25	0.40	0.41	0.44	0.48
3.5	0.29	0.47	0.48	0.51	0.56
4.0	0.33	0.53	0.55	0.59	0.64
5.0	0.41	0.66	0.68	0.73	0.80

Heat Pump (Cooling Savings)

Table 4. Proposed Energy Savings (kWh) – Amarillo

	SEER Range				
Size (tons)	**14.0-14.9**	**15.0-15.9**	**16.0-16.9**	**17.0-17.9**	**18+**
1.5	205	383	499	466	444
2.0	273	511	665	622	593
2.5	342	638	831	777	741
3.0	410	766	998	933	889
3.5	478	894	1,164	1,088	1,037
4.0	546	1,021	1,330	1,244	1,185
5.0	683	1,277	1,663	1,555	1,482