Survey of SEER Ratings for Independent Coil Manufacturer Mixed Systems Relative to Original Equipment Manufacturer Mixed Systems and Highest Sales Volume Tested Combinations

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BACKGROUND

This investigation compares the Seasonal Energy Efficiency Ratio (SEER) ratings of independent coil manufacturers (ICMs) and original equipment manufacturers (OEMs) to determine the distribution of mixed system SEER ratings provided by ICMs and OEMs. ICMs match their indoor evaporator/air handlers with condensing units from several OEMs. If not laboratory tested as a complete system, these "mixed" combinations must be rated using a procedure based upon sound engineering concepts and approved by the United States Department of Energy (CFR 2006). This investigation takes the SEER rating published by the ICMs for their mixed systems and compares them to the SEER of the OEM condensing unit / indoor unit highest sales volume tested combinations (HSVTC) or matched systems. The SEER ratings are compared by looking at the percentage of units with SEERs that are higher, equal, and lower than the HSVTC.

This survey examines the existing Air Conditioning and Refrigeration Institute's directory of unitary equipment (ARI 2006b). Only mixed systems with an active status and systems with the same ARI-type of indoor unit are compared; therefore, coil-only mixed systems are compared to coil-only HSVTCs and coil-blower mixed systems are only compared to coil-blower HSVTCs.

ICMs SURVEYED

Table 1 below lists all of the ICMs currently with information in the ARI Unitary Directory of Certified Performance for air conditioners and air conditioner coils (ARI 2006b) along with the number of active listings as of July 2006. Of the sixteen ICMs listed, four manufacturers were not included in the survey because they manufactured high velocity indoor airflow systems which use indoor air-handler types not tested by the OEMs. Two other ICMs were not included because they were only tradenames and produce no ratings. One entry is more closely related to OEMs than ICMs.

Table 1: Indoor coil manufacturers surveyed

Indoor Coil Manufacturer	# of Active Listings	Indoor Coil Manufacturer	# of Active Listings
Advanced Distributor Products	25 718	Freedom Air	227
Superior Coils, Inc.	21 878	Eubank Manufacturing Enterprises, Inc.	146
Aspen Manufacturing	8 643	Unico, Inc.	85
Summit Manufacturing, Inc.	3 926	Heat Controller, Inc.	42
Space Pak	1 445	Haier America	20
Allstyle Coil Co., Inc.	1 391	Firm Group Co., LTD	18
Benchmark Manufacturing, Inc.	843	Energy Savings Products, LTD	3
Apex Coil, LLC	744	U. S. A/C Products	0
Total # of Active Listings: 65129 Number of Manufacturer Listings Surveyed: 63599 Highlighted manufacturers are included in the survey.			

SUMMARY STATISTICS

Table 2 shows the list of ICMs surveyed along with the total number of active mixed systems rated as being higher, equal, or lower than the OEM HSVTC. Figure 1 shows the distribution of mixed system SEER ratings for all of the ICMs listed in Table 2. The totals in Table 1 and 2 are not equal due to the fact that some mixed systems are rated with a HSVTC that does not have an active listing, or the mixed and matched systems were not the same ARI type. Thus, the investigation considered 32 729 of the possible 63 599 active listings associated with the highlighted ICMs in Table 1. For this large sample population, Table 2 shows the average percentages of mixed systems rated higher, equal, and lower than the HSVTC.

Table 2: Summary statistics for ICM SEER ratings*

Indoor Coil Manufacturer					% Higher	% Equal	% Lower
ICM A					41.6	42.3	16.1
ICM B					22.0	67.4	10.6
ICM C					47.5	43.3	9.2
ICM D					64.5	23.8	11.7
ICM E					34.1	49.8	16.2
ICM F					9.7	83.9	6.5
ICM G					29.4	35.3	35.3
ICM H					25.5	61.8	12.7
ICM I					26.8	39.8	33.3
	Higher	Equal	Lower	Total	AVG	AVG	AVG
Totals	13204	13565	5960	32729	40.3	41.4	18.2

* Note: only includes cases where the ICM mixed system and the corresponding OEM HSVTC are the same ARI-type of indoor unit.

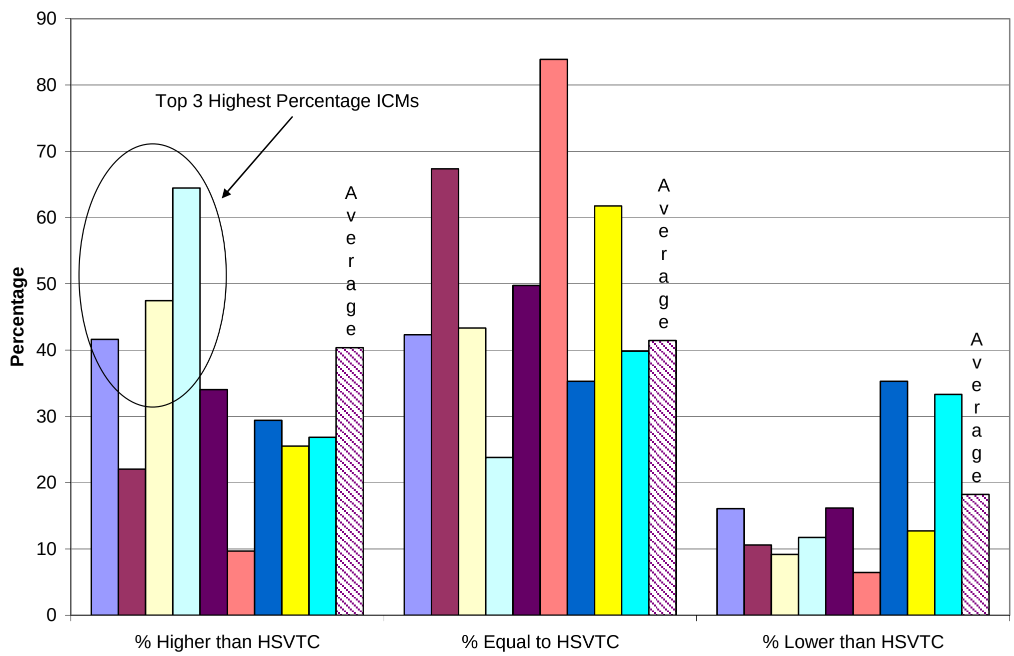

Figure 1: ICM SEER ratings % Higher, % Equal, and % Lower than the HSVTC (each bar within the corresponding category represents one ICM; the average for all ICMs in that category is also provided)

ICMs WITH THE LARGEST PERCENTAGE OF HIGH SEER RATINGS

The circled bars in Figure 1 show the three ICMs with the greatest percentage of mixed system SEER ratings that exceeded the comparable HSVTC. From highest to lowest percentage, these three ICMs are D (64.5 %), C (47.5 %), and A (41.6 %). These three ICMs are examined more closely below.

To gain insight into the effects of the indoor unit on SEER, a well-used cooling mode mixed system rating procedure (Domanski 1989) was examined. This procedure suggests that the maximum gains in SEER associated with coil capacity and improved expansion device are approximately 10 % and 2.5 %, respectively. Therefore, maximum to minimum SEER ratios greater than 1.13 are not expected for coil-only systems.

For the mixed system listings of the three ICMs that had the largest percentage of mixed systems rated higher than the comparable HSVTC, ten condensing units were chosen based upon their mixed systems having the highest departure from the HSVTC SEER. The SEER ratings reported by the OEM for each particular condensing unit, relative to the HSVTC SEER, were then plotted on a histogram. The SEER ratio of the selected ICM combination is then overlaid on this plot as a vertical line. Comparisons using the SEER ratios relative to the OEM's lowest SEER rating were also considered. In both cases the sets of SEER ratios are differentiated by coil-only versus coil-blower systems.

ICM D

Table 2 and Figure 2 show the percentage of ICM D indoor sections rated higher, equal, or lower than the OEM HSVTC. ICM D rates 64.5 % of their mixed systems higher than the OEM HSVTC. For each of the three categories shown in Figure 2, a separate bar equates to a unique OEM condensing unit supplier. Figure 3 shows a histogram of the ratios of the ICM SEER rating ($SEER_x$) to the OEM condensing unit HSVTC SEER ratings ($SEER_m$). The individual columns above the three categories in represent OEM manufacturers with some manufacturers having a column in every category. In any case, the percentages, represented by a column in each category, sum to 100 %.

Three coil-only mixed systems with SEER ratios higher than or near 1.13 were selected and, for each selected condensing unit, the OEM SEER distributions were examined.

Figures 4 (OEM coil-only and coil-blower systems) and 5 (OEM coil-only systems) show condensing unit #1 where the HSVTC condensing unit was re-rated, but the OEM and ICM mixed systems were not yet re-rated to reflect the change in the HSVTC SEER. This case was included to show that comparisons may still be made between the OEM mixed systems and the ICM mixed systems that use the same condensing unit. The original rating for the HSVTC was 13, but the system was re-rated to a 10.9 SEER. This re-rating caused the high SEER ratios in Figure 4 and 5. The SEER ratio of 1.24 corresponds to the highest SEER ratio seen in Figure 3 and was calculated from the ICM SEER of 13.5 divided by the matched system SEER of 10.9. In Figure 4 the 1.24 ratio for the ICM mixed system is not outside of the range of OEM SEER ratios for coil and coil-blower units combined. When coil-only OEM systems are examined relative to the minimum OEM mixed system SEER in Figure 5 however, the ICM coil-only system falls outside of the coil-only OEM SEER ratio distribution. For this condensing unit the HSVTC SEER corresponds to the minimum OEM SEER rating. Thus, the same SEER ratio histogram results whether expressing the ratio in terms of HSVTC SEER or the OEM minimum SEER.

The chosen ICM indoor section using condensing units #2 is a coil-only unit. The ratio of the ICM mixed system SEER to the HSVTC SEER is 1.15. Figures 6 shows that the ICM SEER rating is outside of the OEM SEER distribution for coil-only and coil-blower OEM mixed systems. In Figure 6 $SEER_m$ equals $SEER_{min}$.

For condensing unit #3, the ratio of the ICM mixed system SEER to the HSVTC SEER is 1.12. Figure 7 shows the OEM mixed system SEER ratios relative to the HSVTC for coil-only and coil-blower systems. The 1.12 ICM mixed system ratio is outside of the OEM mixed systems ratios for these combinations. Figure 8 shows the histogram of the OEM SEER ratings relative to the minimum OEM SEER rating for condensing unit #3, with Figure 8 limited to coil-only units. When overlayed on this plot, the ICM SEER ratio of 1.21 is well beyond the OEM distribution while also being higher than the earlier described expected upper limit of 13 % (i.e. a SEER ratio of 1.13). For condensing unit #2, the HSVTC SEER rating ($SEER_m$) is equal to the minimum SEER rating ($SEER_{min}$) thus a plot similar to Figure 8 would only marginally improve on Figure 6 by eliminating the OEM entries for coil-blower units.

Table 2: ICM D mixed system SEER ratings summary

	%high	%equal	%low
Average	64.5	23.8	11.7

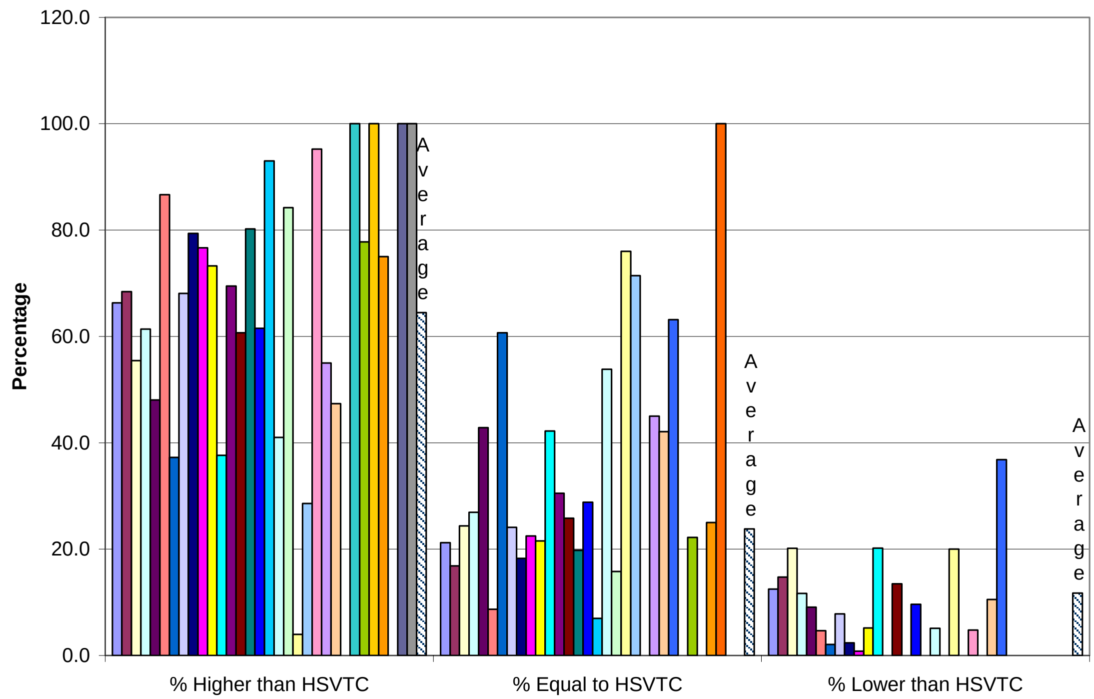

Figure 2: ICM D mixed system SEERs compared to HSVTC SEER ratings of various OEMs (each category has a column for each OEM and the average value for that category)

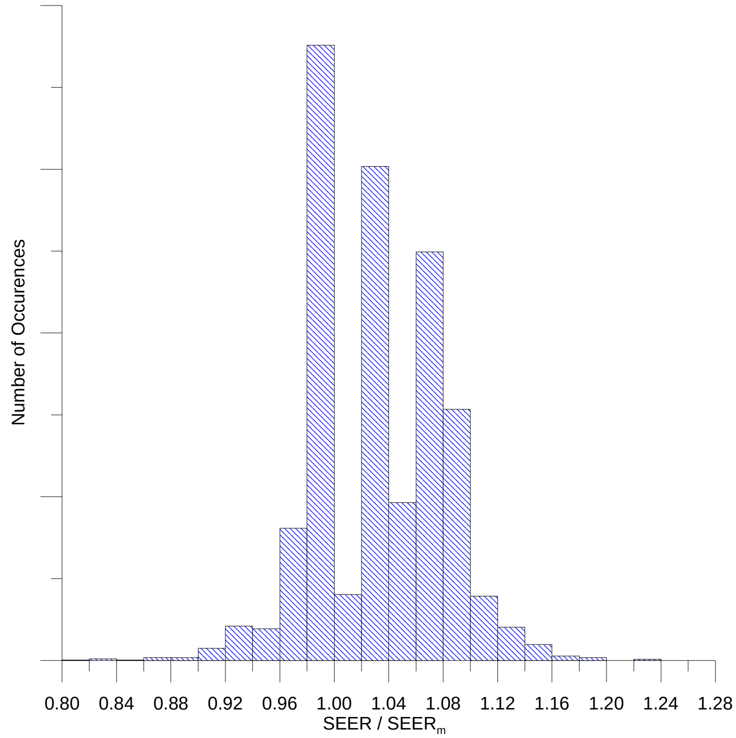

Figure 3: Histogram of the SEER ratio ($SEER_x$ / $SEER_m$) for all ICM D mixed systems (this chart compares only same ARI-type mixed and matched systems)

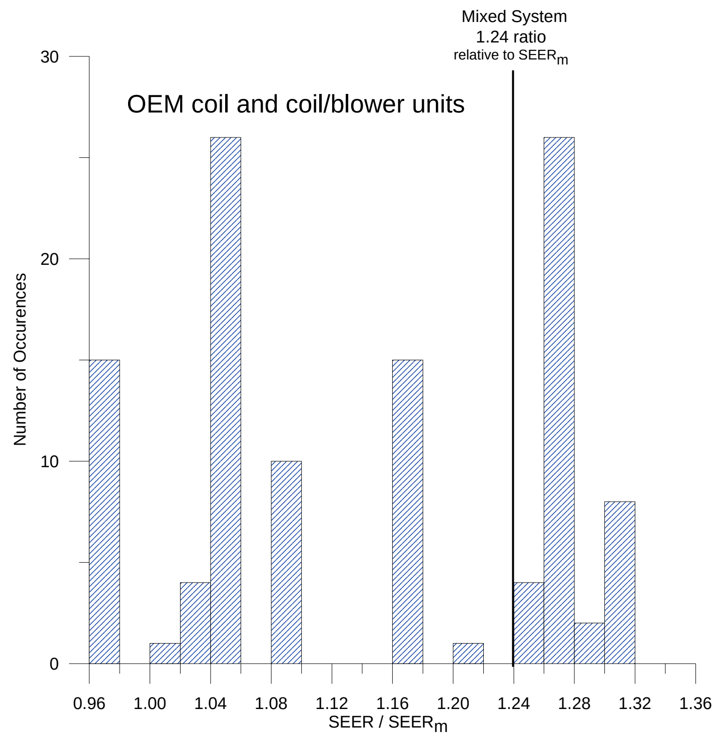

Figure 4: SEER ratios for condensing unit #1 relative to the HSVTC for OEM coil-only and coil-blower systems with the ICM D coil-only mixed system represented as a vertical line

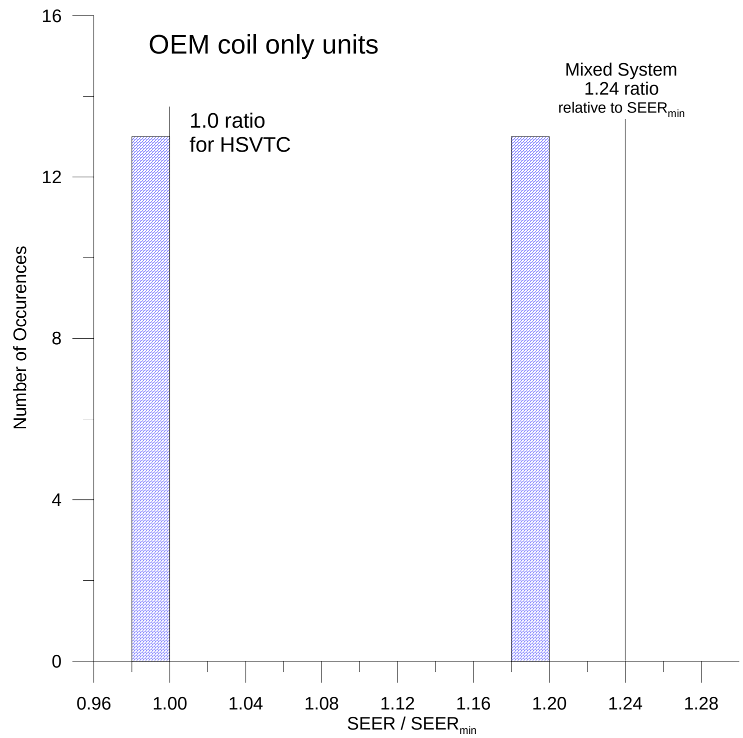

Figure 5: SEER ratios for condensing unit #1 relative to the minimum OEM SEER for OEM coil-only systems with the ICM D coil-only mixed system represented as a vertical line

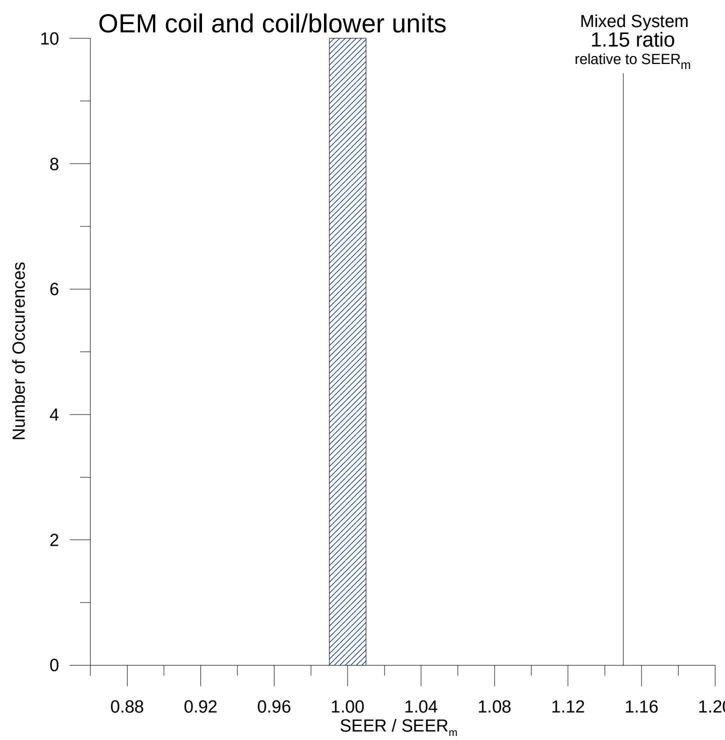

Figure 6: SEER ratios for condensing unit #2 relative to the HSVTC for OEM coil-only and coil-blower systems with the ICM D coil-only mixed system represented as a vertical line ($SEER_m$ = $SEER_{min}$ for this coil)

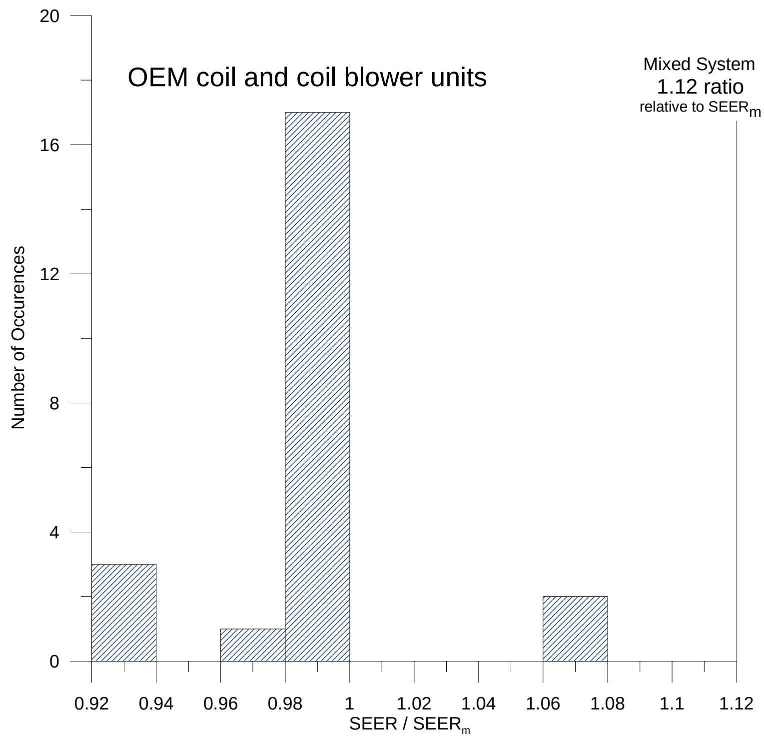

Figure 7: SEER ratios for condensing unit #3 relative to the HSVTC for OEM coil-only and coil-blower systems with the ICM D coil-only mixed system represented as a vertical line

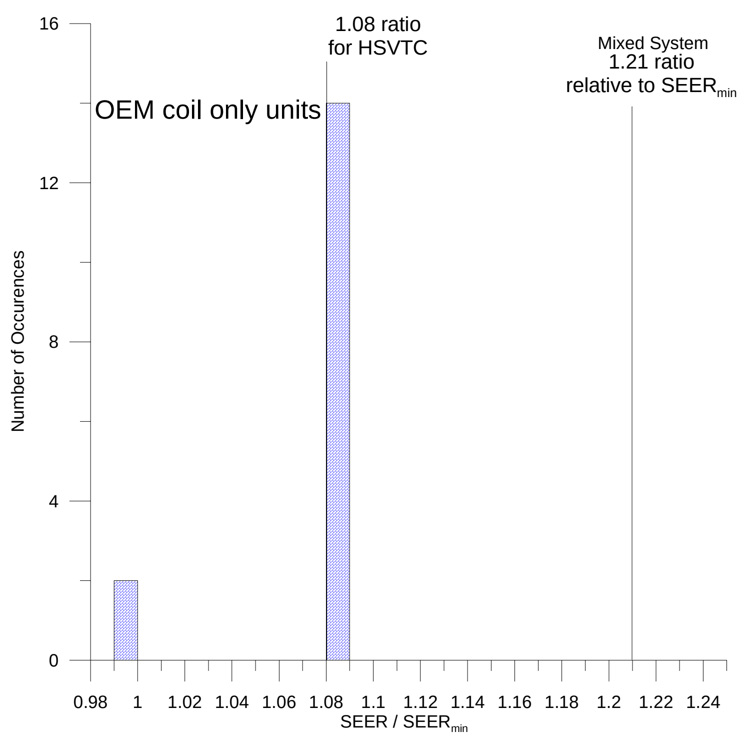

Figure 8: SEER ratios for condensing unit #3 relative to the OEM minimum SEER with the ICM D coil-only mixed system represented as a vertical line

ICM C

Table 3 and Figure 9 show the percentages of ICM C mixed systems rated higher, equal, or lower than the OEM HSVTC. ICM C rates 47.5 % of their mixed systems higher than the OEM HSVTC. The individual columns above the three categories in Figure 9 represent OEM manufacturers with some manufacturers having a column in every category. In any case the percentages, represented by a column in each category, sum to 100 %.

Figure 10 shows a histogram of the ratios of the ICM SEER ratings ($SEER_x$) to the OEM condensing unit HSVTC SEER ratings ($SEER_m$) for all the mixed systems rated by ICM C. From these mixed systems, three coil-only mixed systems with the highest SEER ratios were selected and compared to the OEM SEER ratings.

For condensing unit #4, Figure 11 shows that the mixed system SEER ratio relative to the HSVTC SEER, 1.12, is on the upper edge of the OEM SEER distribution for coil and coil-blower units. When the SEER ratio is recalculated with respect to the OEM minimum SEER for the selected condensing unit and the coil-blower entries are removed, the results are different. Figure 12 shows that the ICM coil-only mixed system has a SEER ratio of 1.16, which places it beyond the OEM distribution upper limit of 1.10 and above the previously suggested maximum limit of 1.13.

Figure 13 shows that the ICM coil-only mixed system using condensing unit #5 has a SEER ratio outside of the range of the OEM SEER ratios for both coil-only and coil-blower units. Figure 14 shows that the recalculated ICM mixed system SEER ratio relative to the OEM minimum SEER, 1.10, is outside of the OEM SEER ratio for coil-only units, although it is not beyond the suggested maximum of 1.13.

Figure 15 compares an ICM coil-only mixed system with a SEER ratio of 1.083 to the OEM SEER ratio distribution for condensing unit #6. This ICM coil-only mixed system has a SEER ratio within the range of OEM SEER ratios, at least when considering both coil-only and coil-blower OEM combinations. However, when the OEM SEER ratio distribution and the ICM SEER ratio are recalculated based upon the minimum OEM SEER value for coil-only units (Figure 16), the ICM coil-only mixed system falls outside of the OEM coil-only SEER ratio distribution, and it is greater than the 1.13 maximum suggested value.

Table 3: ICM C mixed system SEER ratings summary

	%higher	%equal	%lower
Average	47.5	43.3	9.2

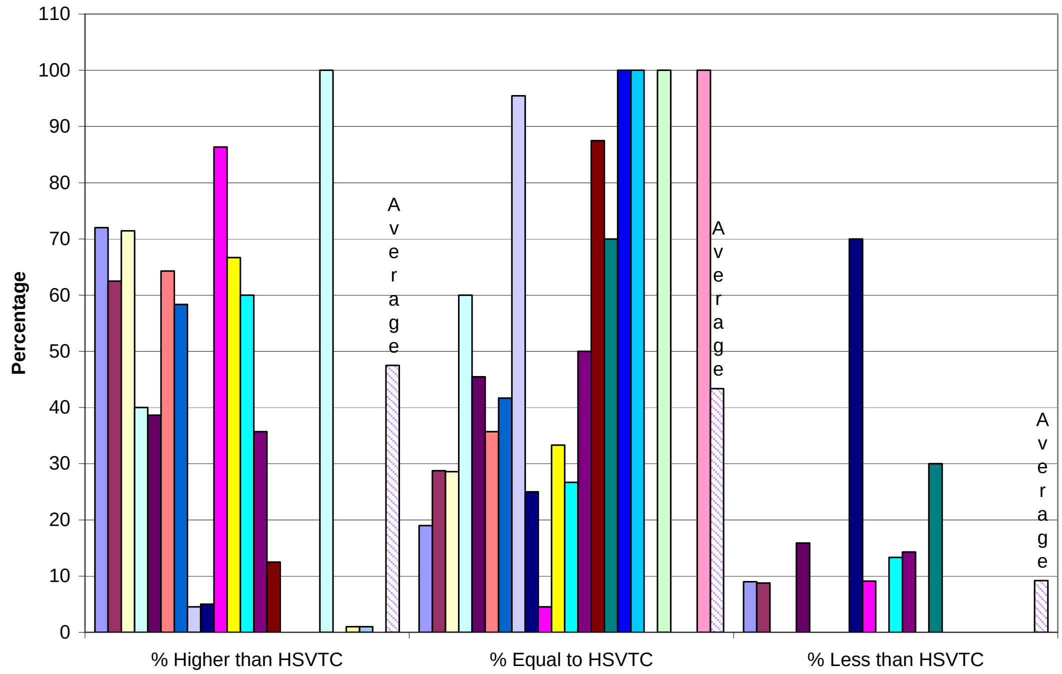

Figure 9: ICM C mixed systems compared to HSVTC SEER ratings of various OEMs (each category has a column for each OEM and the average value for that category)

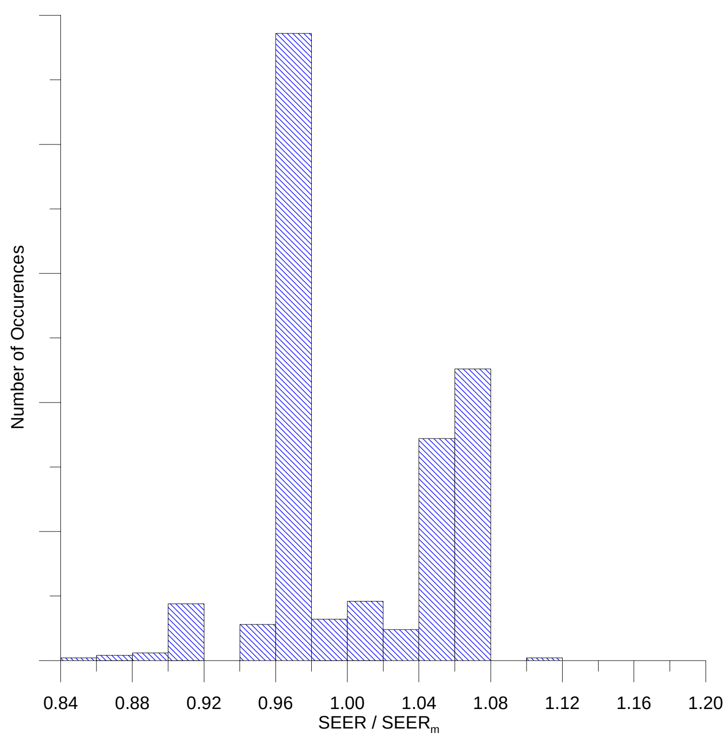

Figure 10: Histogram of the SEER ratios for all ICM C mixed systems ($SEER_x$ / $SEER_m$) (this chart compares only same ARI-type mixed and matched systems)

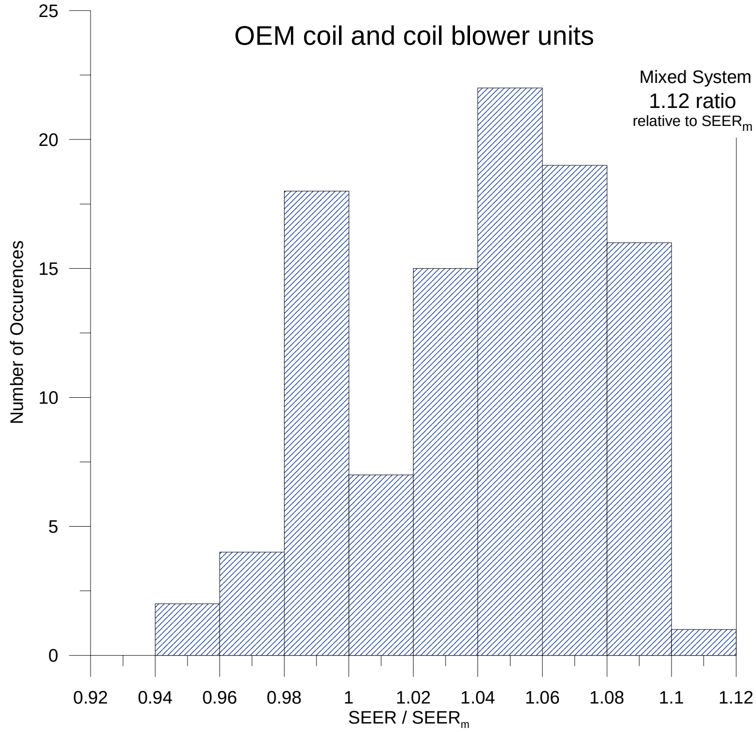

Figure 11: SEER ratios for condensing unit #4 relative to the HSVTC for OEM coil-only and coil-blower units with ICM C coil-only mixed system represented as a vertical line

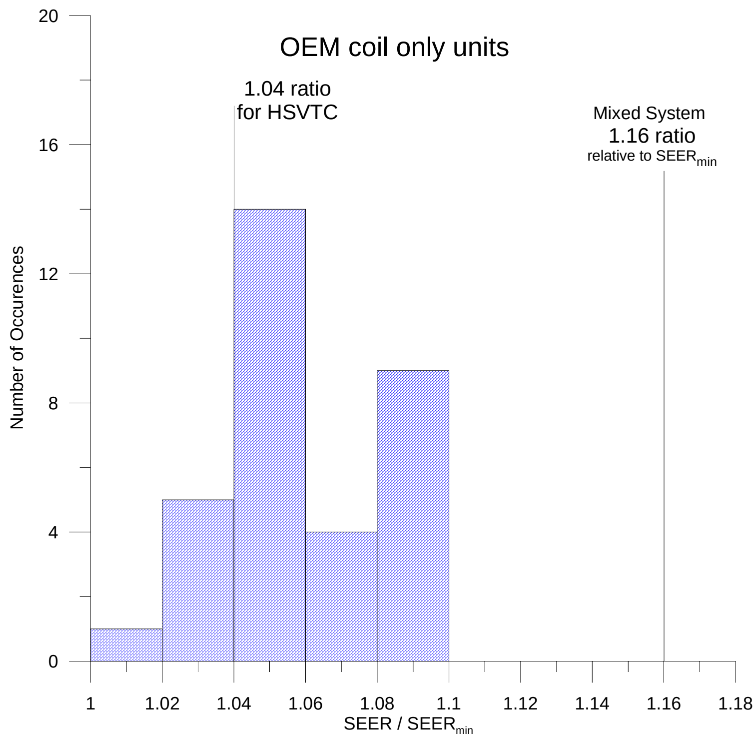

Figure 12: SEER ratios for condensing unit #4 relative to the OEM minimum SEER for OEM coil-only units with ICM C mixed system represented as a vertical line

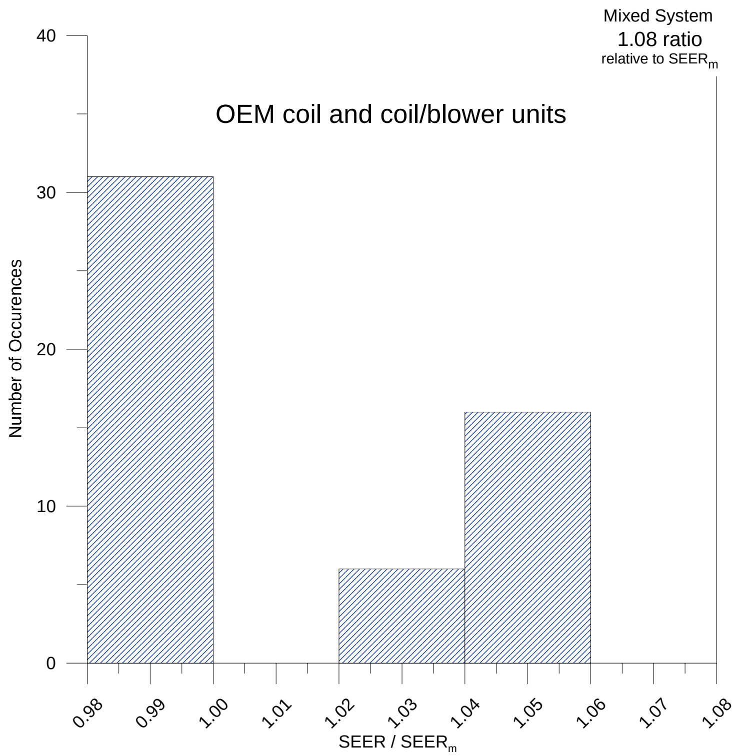

Figure 13: SEER ratios for condensing unit #5 relative to the HSVTC for OEM coil-only and coil-blower units with ICM C coil-only mixed system represented as a vertical line

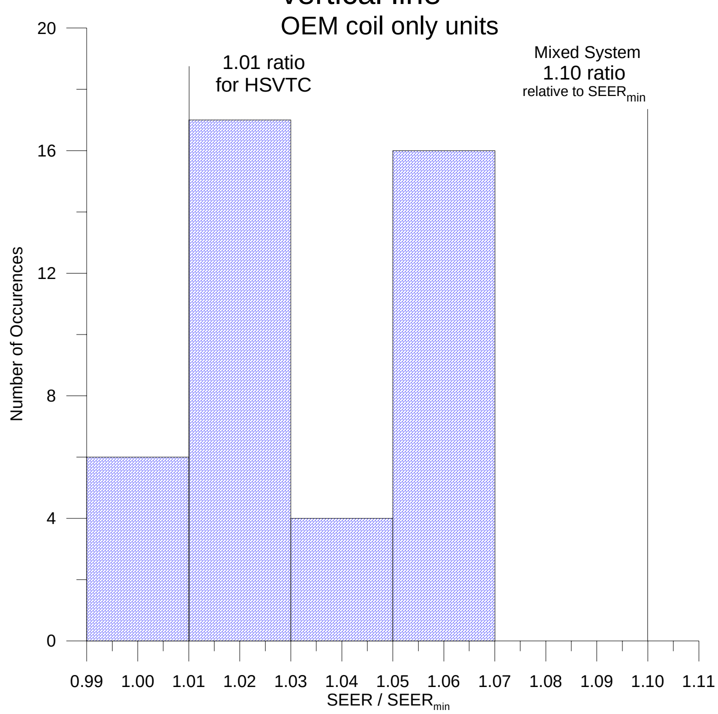

Figure 14: SEER ratios for condensing unit #5 relative to the OEM minimum SEER for OEM coil-only units with ICM C coil-only mixed system represented as a vertical line

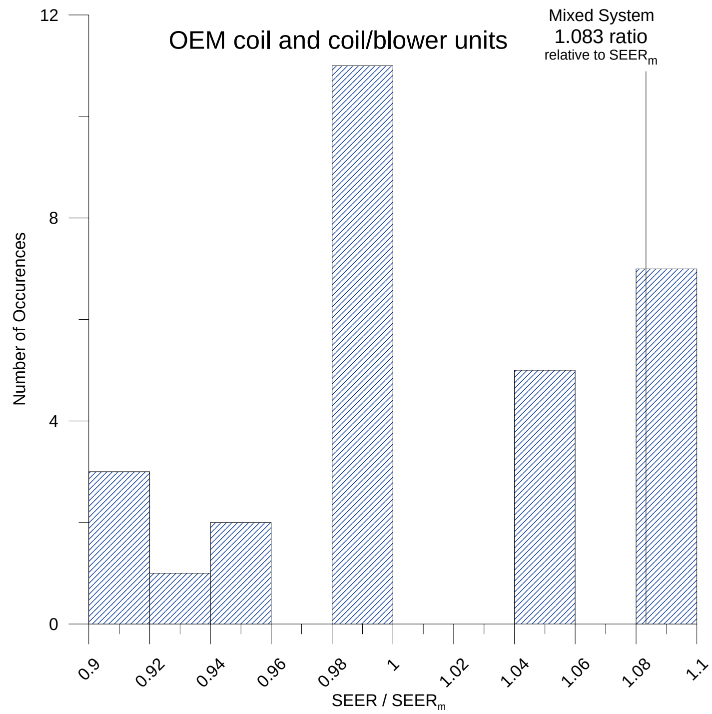

Figure 15: SEER ratios for condensing unit #6 relative to the HSVTC for OEM coil-only and coil-blower units with ICM C coil-only mixed system represented as a vertical line

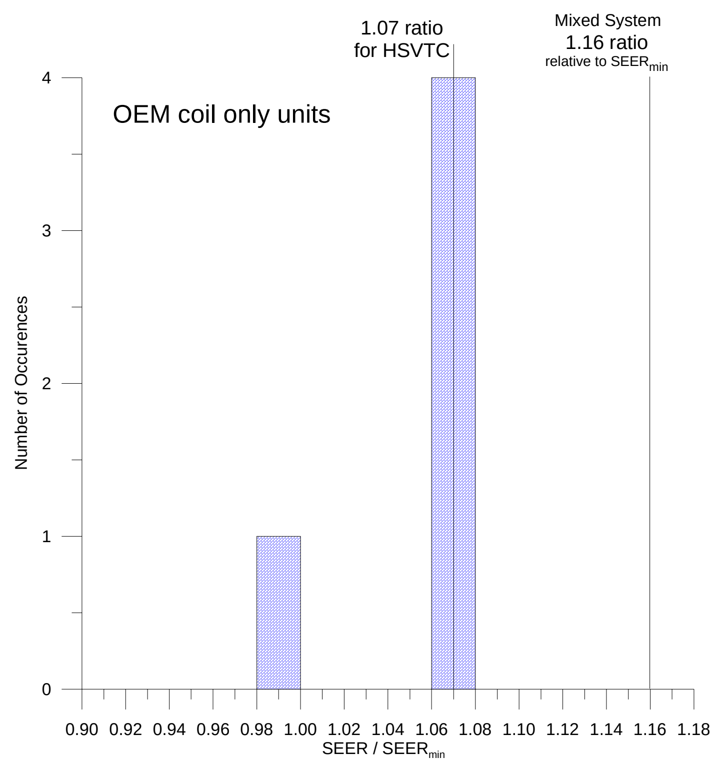

Figure 16: SEER ratios for condensing unit #6 relative to the OEM minimum SEER for OEM coil-only units with ICM C coil-only mixed system represented as a vertical line

ICM A

Table 4 and Figure 17 show the percentages of indoor sections rated higher, equal, or lower than the OEM HSVTC. ICM A rated 41.6 % of their mixed systems higher than the OEM HSVTC. The individual columns above the three categories in Figure 17 represent OEM manufacturers with some manufacturers having a column in every category. In any case the percentages, represented by a column in each category, sum to 100 %.

Figure 18 shows a histogram of the ratio of the ICM SEER rating ($SEER_x$) to the OEM condensing unit HSVTC SEER rating ($SEER_m$) for all mixed systems that are rated by ICM A. From these mixed systems, four coil-only mixed systems with high SEER ratios were selected for further examination.

Figures 19 and 20 compare a selected ICM coil-only mixed system to the OEM SEER ratio distribution for condensing unit #7. In Figure 19, the ICM mixed system SEER ratio of 1.125 falls within the distribution of the OEM SEER ratios for this condensing unit when all coil-only and coil-blower systems are included. Figure 20 shows the recalculated SEER ratios with respect to the minimum OEM SEER for this condensing unit ($SEER_{min}$) while only including coil-only OEM combinations. The ICM mixed system SEER ratio of 1.15 exceeds the 1.04 maximum OEM SEER ratio and surpasses the maximum suggested value of 1.13.

For condensing unit #8, Figure 21 shows the OEM SEER distribution and the ICM mixed system SEER ratio relative to the HSVTC SEER rating. The ICM mixed system is a coil-only system, and its 1.125 SEER ratio falls within the OEM SEER ratio distribution for coil-only and coil-blower units. Figure 22 shows the recalculated SEER ratio with respect to the minimum OEM SEER for this condensing unit. This figure shows that the ICM coil-only mixed system SEER ratio is much greater than the coil-only OEM maximum SEER ratio for this condensing unit and is much greater than the suggested maximum value of 1.13.

For condensing unit #9, Figure 23 shows that the ICM coil-only mixed system with a SEER ratio of 1.125 falls outside the SEER distribution of the OEM combinations for coil-only and coil-blower units. When this coil-only ICM mixed system is compared to coil-only OEM systems relative to the minimum SEER for the OEM combinations in Figure 24, the mixed system SEER ratio of 1.125 is higher than the OEM coil-only systems.

For condensing unit #10, Figure 25 shows that the coil-only ICM mixed system SEER ratio of 1.12 falls outside of the OEM SEER distribution that includes coil-only and coil-blower units. Recalculating SEER ratio based upon the minimum SEER value of the OEM coil-only combinations (Figure 26) shows that the ICM coil-only mixed system SEER ratio of 1.16 falls outside of the coil-only OEM SEER distribution and is greater than the suggested maximum of 1.13.

Table 4: ICM A mixed system SEER ratings summary

	%higher	%equal	%lower
Average	41.6	42.3	16.1

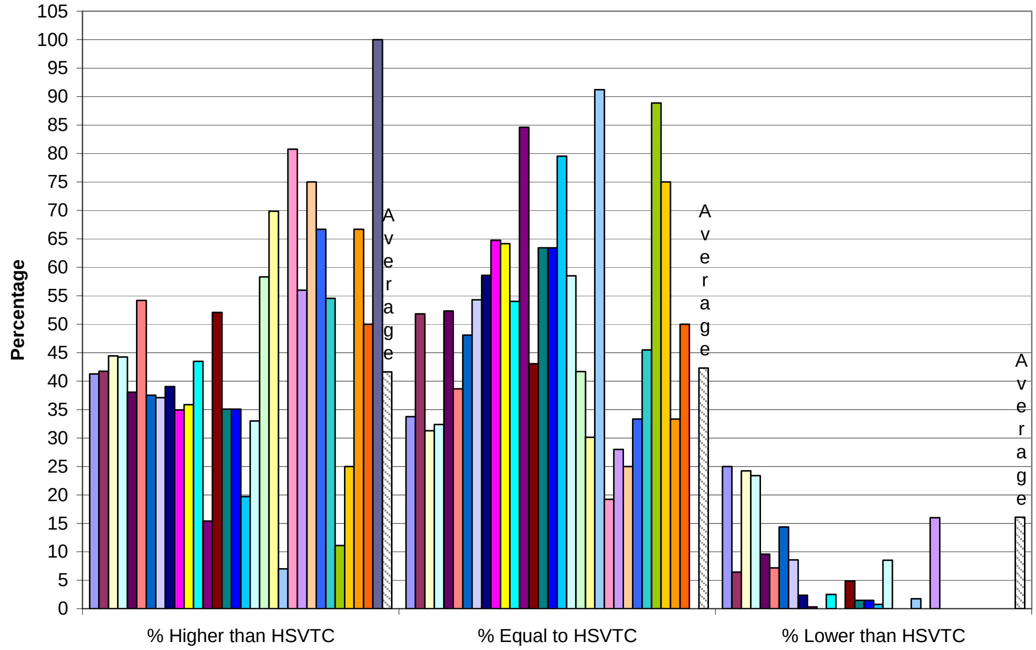

Figure 17: ICM A compared to HSVTC SEER ratings of various OEMs (each category has a column for each OEM and the average value for that category)

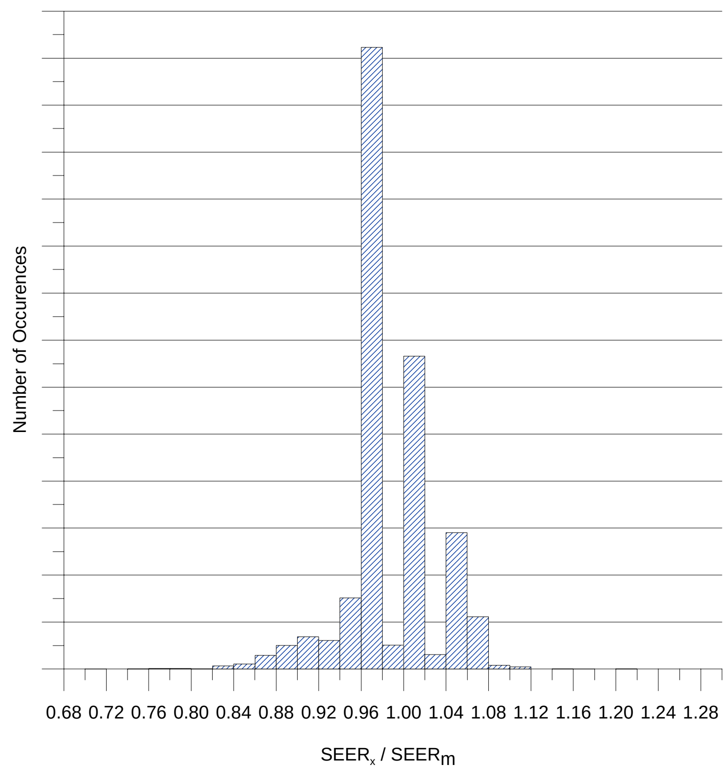

Figure 18: Histogram of the ratio $SEER_x$ / $SEER_m$ for all ICM A mixed systems

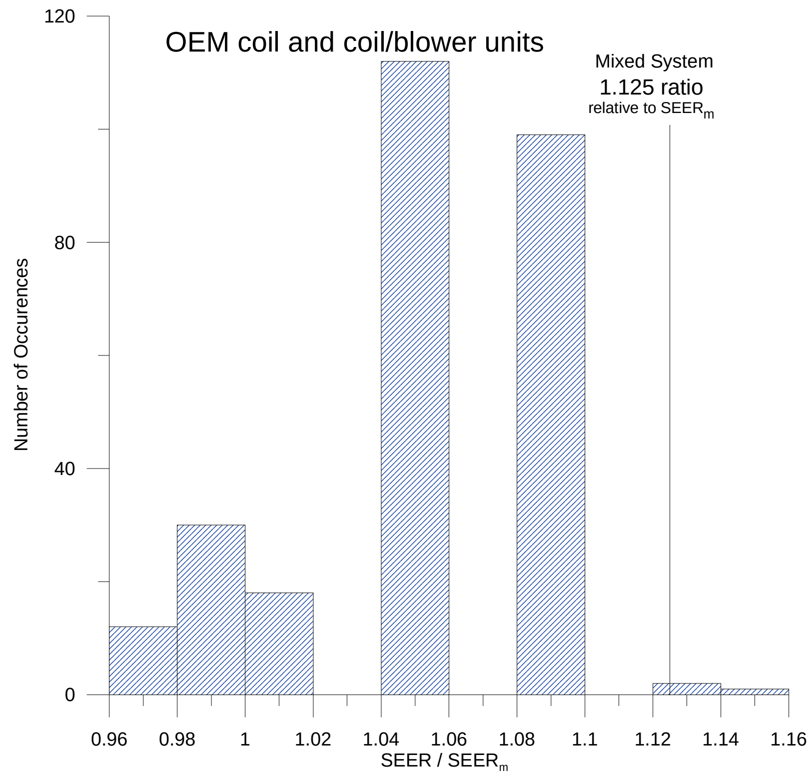

Figure 19: SEER ratios for condensing unit #7 relative to the HSVTC for OEM coil-only and coil-blower units with ICM A coil-only mixed system represented by a vertical line

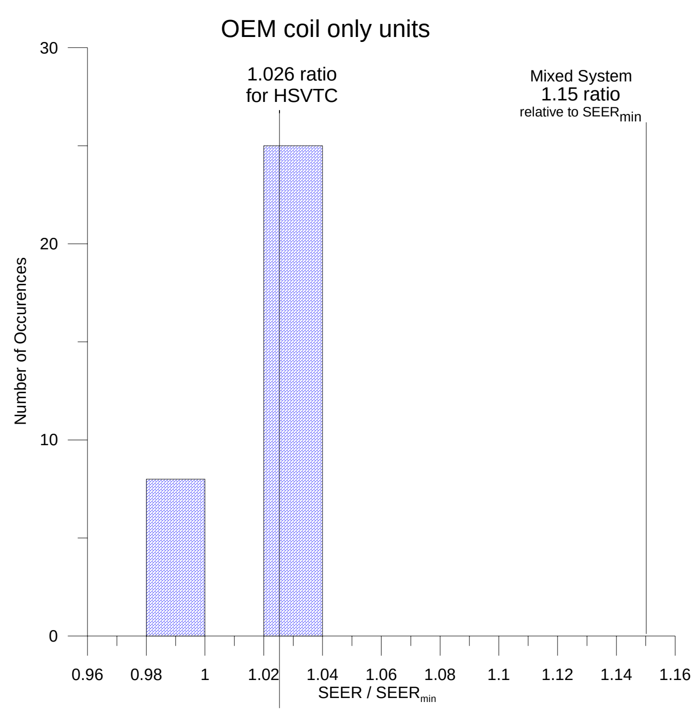

Figure 20: SEER ratios for condensing unit #7 relative to the OEM minimum SEER for OEM coil-only units with ICM A coil-only mixed system represented by a vertical line

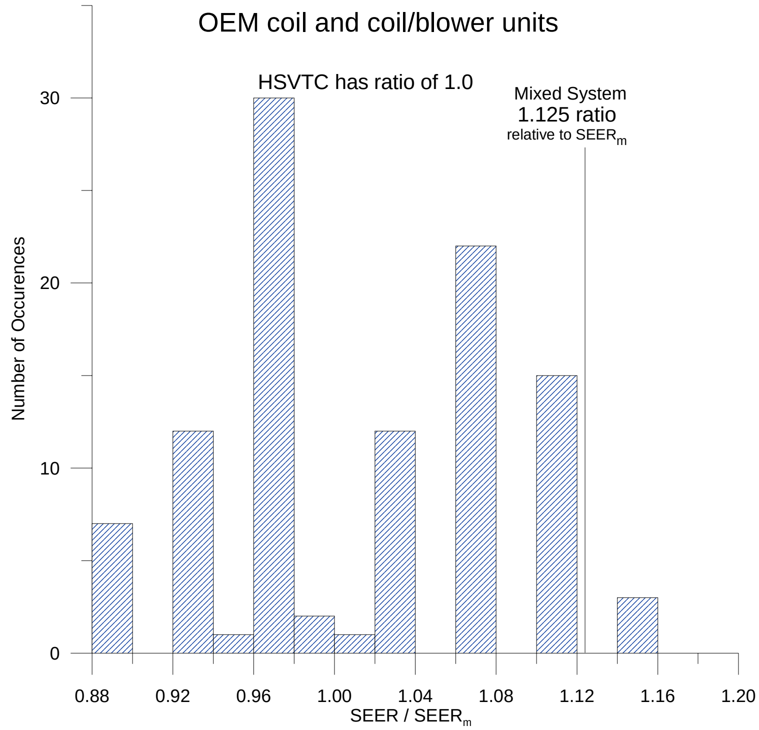

Figure 21: SEER ratios for condensing unit #8 relative to the HSVTC for OEM coil-only and coil-blower units with ICM A coil-only mixed system represented by a vertical line

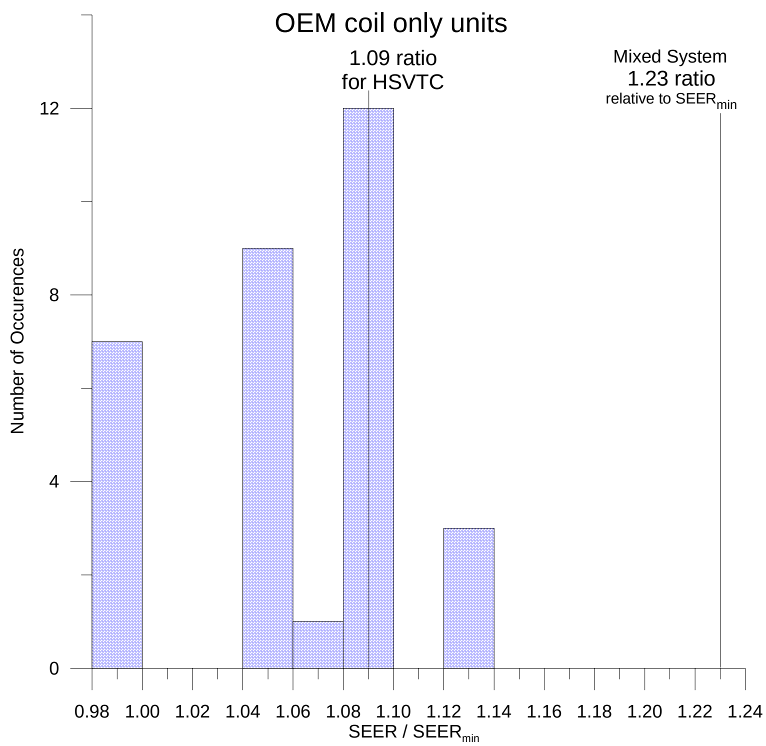

Figure 22: SEER ratios for condensing unit #8 relative to the OEM minimum SEER for OEM coil-only units with ICM A coil-only mixed system represented by a vertical line

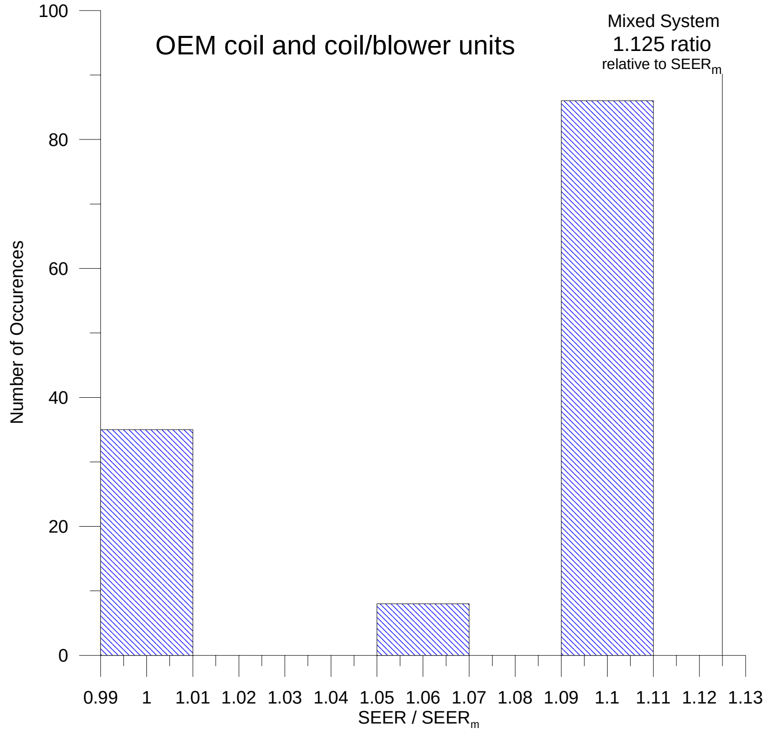

Figure 23: SEER ratios for condensing unit #9 relative to the HSVTC for OEM coil-only and coil-blower units with ICM A coil-only mixed system represented as a vertical line

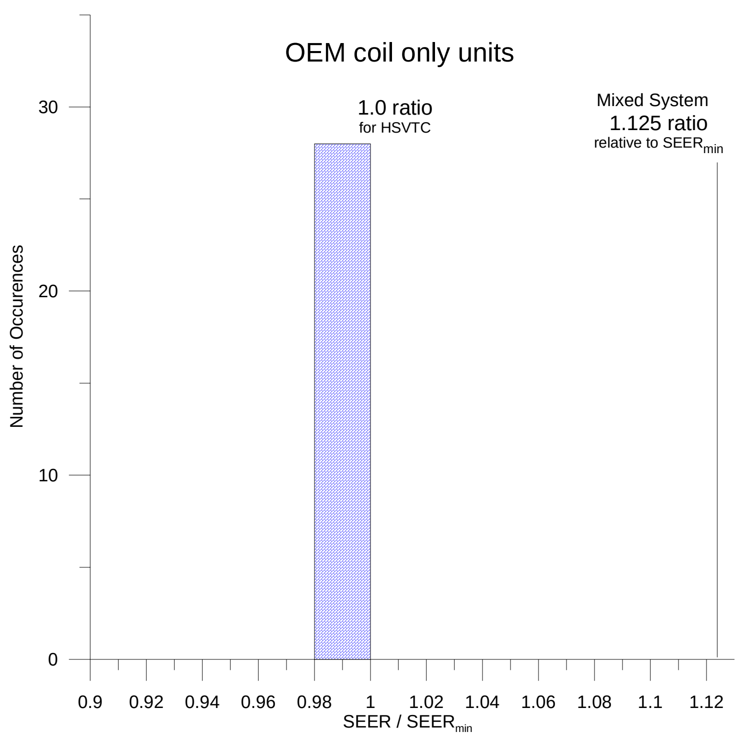

Figure 24: SEER ratios for condensing unit #9 relative to the OEM minimum SEER for OEM coil-only units with ICM A coil-only mixed system represented by a vertical line

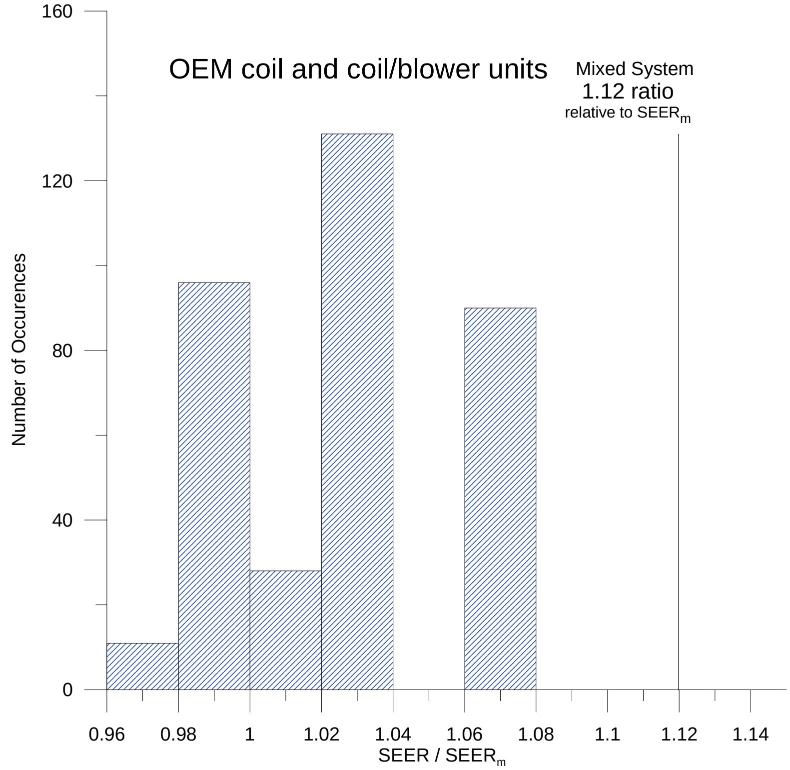

Figure 25: SEER ratios for condensing unit #10 relative to the HSVTC for OEM coil-only and coil-blower units with ICM A coil-only mixed system represented by a vertical line

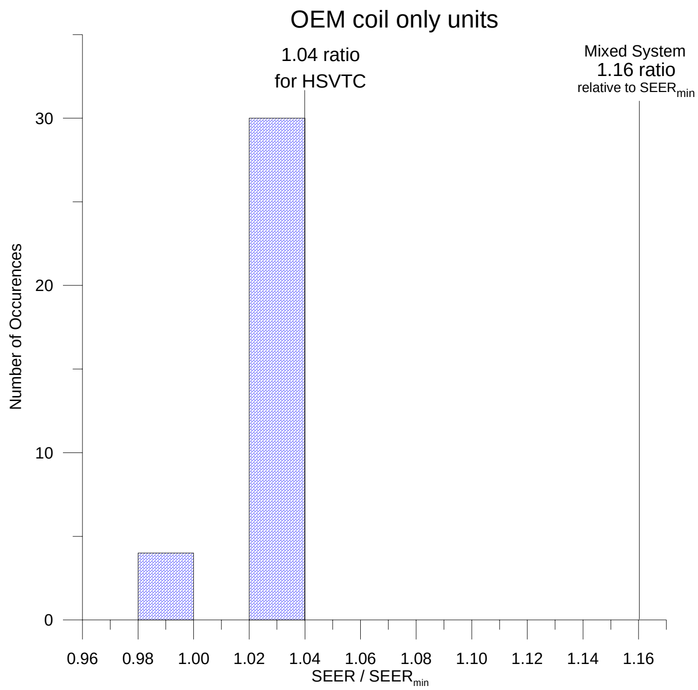

Figure 26: SEER ratios for condensing unit #10 relative to the OEM minimum SEER for OEM coil-only units with ICM A coil-only mixed system represented as a vertical line

SIMULATION OF EER IMPROVEMENT USING ACSIM

A National Institute of Standards and Technology (NIST) in-house air-conditioning system simulation software package, ACSIM, was used to determine the increase in Energy Efficiency Ratio (EER) due to enhancing the performance of the indoor coil, i.e. increasing indoor coil area, increasing heat transfer coefficients, and decreasing refrigerant pressure drop. This software package combines EVAP-COND (NIST 2003), an evaporator and condenser modeling software package, with an expansion device and compressor model. A baseline simulation was performed using an R410A example system. Indoor air flow was varied from 2039 m^3/h (1200 scfm) to 2633 m^3/h (1550 scfm) (values corresponding to 193 m^3/kWh (400 scfm/ton)). The system was simulated at ARI B-Test conditions. The indoor fan power was set at 365 W per 1699 m^3/h (1000 scfm). Table 5 includes the cooling capacity, sensible heat ratio (SHR), and refrigerant condensing temperature results. Table 5 also illustrates the changes in evaporator exit saturation temperature and the accompanying increase in EER.

Figure 27 shows the ratios of EER, compressor suction refrigerant density and mass flow rate relative to the initial condition at an evaporator saturation temperature near 7.2 °C (45.0 °F). A second degree polynomial was used to fit a smooth curve to the values shown in Figure 27. As the figure shows, EER change with respect to a change in evaporator saturation temperature (the slope) becomes smaller as the evaporator saturation temperature increases. From 6.9 °C (44.5 °F) to 11.6 °C (52.8 °F), EER increases by 11.6 %. Extrapolation of the EER curve from 11.6 °C (52.5 °F) to 12.8 °C (55.0 °F) would increase EER by only 2.0 % relative to its value at 11.6 °C (52.8 °F). The figure also shows that the increase in refrigerant mass flow rate is due to the increase in the suction refrigerant density. The results for the R410A system in Figure 27 are very similar to the results that were attained for an R22 system (not shown).

Figure 27 shows that the limit on EER increase for the ICM mixed system (or anyone’s mixed system) depends on the evaporator saturation temperature of the OEM matched system. If the OEM matched system operates at an evaporation temperature near 7.2 °C (45.0 °F) then an increase of EER in the range of 10 % is possible. If the OEM matched system operates closer to 11.1 °C (52 °F) then the possible EER increase is small. All inferences as to the maximum increase in EER between the OEM matched system and the ICM mixed system depend on the evaporator saturation temperature of the HSVTC OEM matched system. If the OEM HSVTC evaporation temperature were known, limits on the EER of the mixed system could be implemented.

Table 5: R410A system simulation and EER values from ACSIM

Indoor Airflow m^3/h (scfm)	Indoor HX Tube Length mm (in)	Total Capacity W (Btu/h)	SHR	m^3/ kWh (Scfm / ton)	T_{sat} Evap °C (°F)	Refrig. mass flow kg/h (lbm/h)	T_{sat} Cond °C (°F)	EER (Btu/(W h)	EER ratio wrt baseline
2294 (1350)	457 (18)	11752 (40098)	0.74	195 (403)	6.9 (44.5)	251.1 (553.6)	38.7 (101.7)	11.58	1.000
2379 (1400)	610 (24)	12506 (42673)	0.74	190 (393)	8.8 (47.9)	267.1 (588.8)	39.3 (102.7)	12.19	1.053
2591 (1525)	914 (36)	13264 (45260)	0.75	195 (404)	10.8 (51.5)	284.4 (627.1)	39.8 (103.7)	12.70	1.097
2633 (1550)	1016 (40)	13582 (46343)	0.75	194 (401)	11.6 (52.8)	291.3 (642.1)	40.1 (104.1)	12.92	1.116

Where: T_{sat} Evap = evaporator exit refrigerant saturation temperature
T_{sat} Cond = condenser inlet refrigerant saturation temperature
SHR = sensible heat ratio (sensible capacity divided by total capacity)
Scfm = air flow rate relative to standard air with a density of 1.2 kg/m^3 (0.075 lbm/ft^3)
Evaporator exit superheat set at 4.4 °C (8.0 °F) and condenser exit subcooling of 4.4 °C (8.0 °F)

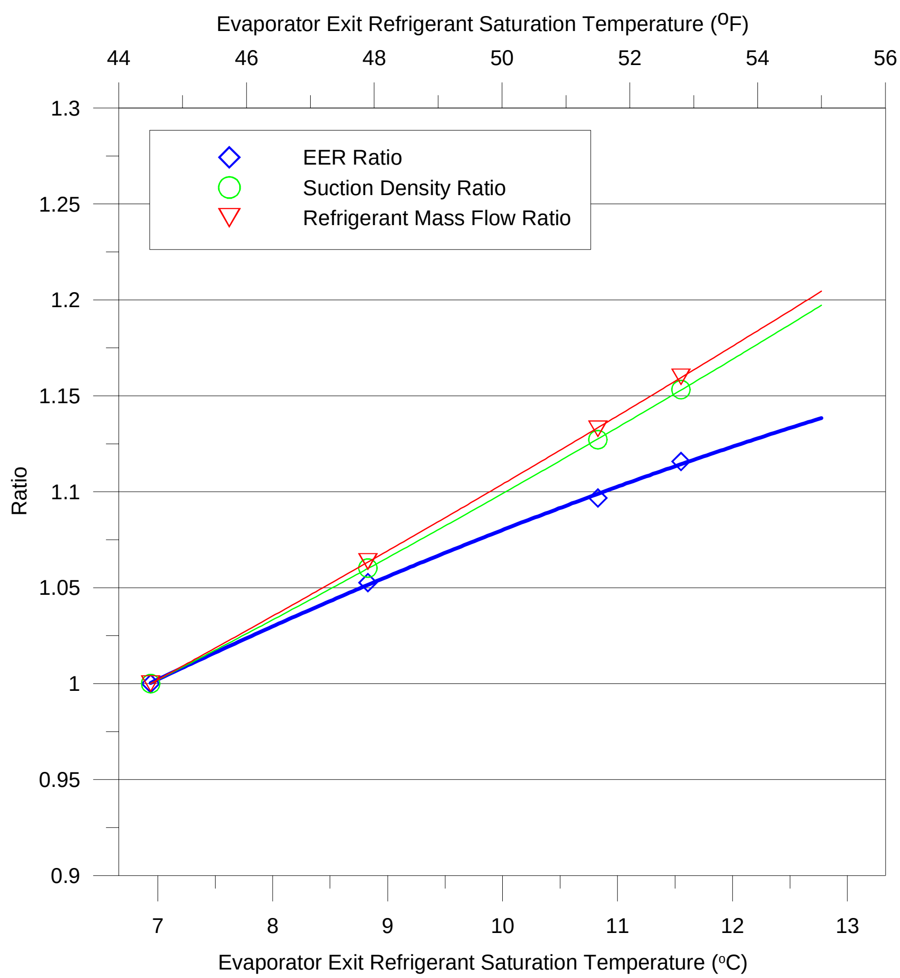

Figure 27: EER, suction density, and refrigerant mass flow ratios with respect to the values at an evaporator exit refrigerant saturation temperature of 6.9 °C (44.5°F) for the simulated R410A system

SUMMARY

All of the ICMs listed in the ARI directory of certified unitary air conditioners and air conditioner coils were included in this survey of SEER ratings. Only active status mixed systems with the same ARI-type indoor unit were compared. All mixed systems used in the comparison had an ARI Status of “Active” as of July 2006.

All of the similar mixed and matched systems were compared by sorting mixed systems into three categories; mixed systems with SEER ratings 1) higher, 2) equal, and 3) lower than the OEM’s HSVTC. All of the categories were tabulated and an average percentage value was calculated for each category. These averages showed that 40.3 % of mixed systems are rated higher, 41.4 % are rated equal, and 18.2 % are rated lower than the OEM HSVTC for all of the ICMs listed in Table 1.

From the three ICMs with the largest percentage of mixed systems rated higher than the HSVTC, ten condensing units were selected. The OEM SEER ratio distribution for each condensing unit was compared to the SEER ratio given by the ICM for their mixed system. For these ten ICM coil-only mixed systems, the ICM SEER rating relative to the HSVTC varied from a minimum of 8 % to a maximum of 24 % greater than the HSVTC. The OEM HSVTC condensing unit SEER ratio distribution was determined using all of the OEM’s SEER ratings for that particular condensing unit when paired with all of the coil-only and coil-blower indoor units manufactured by that OEM. When the ten ICM coil-only mixed systems were compared directly to coil-only OEM systems and the SEER ratio was recalculated based upon the minimum OEM coil-only SEER value, the mixed system SEER ratio ranged from a minimum of 10 % to a maximum of 24 % greater than the minimum OEM SEER ratio. When compared on this basis, all ten ICM mixed systems exceeded the maximum OEM SEER ratio.

Knowledge of the OEM matched system evaporator saturation temperature is the most important factor in determining the limit on possible EER improvements due to enhancing the capacity and performance of the evaporator alone. A system simulation was used to investigate the maximum EER increase possible as the evaporator exit refrigerant saturation temperature was increased. The example R410A system had its evaporation temperature increased from 6.9 °C (44.5 °F) to 11.6 °C (52.8 °F) with an accompanying increase of 11.6 % in EER. These simulations showed the gains in EER due to increase of the evaporation temperature. If the OEM matched system evaporation temperature is know, then real limits on EER may be put in place for the mixed system.

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