Annual Energy Efficiency Ratio: A Better Measure of Refrigeration System Performance

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Climate Technologies

Overview

Purpose

The purpose of this paper is to review existing methods for measuring the efficiency of refrigeration and air conditioning systems, and to introduce a new method that more accurately measures how a refrigeration system actually operates.

Contents

This paper contains the following topics:

Summary

ARI test standards for compressors

The Air-Conditioning and Refrigeration Institute (ARI) Standard 540-2004 spells out the conditions at which commercial refrigeration and air conditioning (AC) compressors must be tested for measuring and reporting important compressor performance data, such as capacity and Energy Efficiency Ratio (EER).

Existing EER efficiency measure

The EER for AC and refrigeration compressors is calculated using the ARI standard. The EER has its benefits, since it is a standardized measure of compressor performance.

Problem with EER

EER is a single-point efficiency measurement for an AC or refrigeration compressor at a specific condition. EER is based on one rating point at one evaporating temperature and one condensing temperature; therefore, EER is not representative of how a system actually operates under other temperatures and conditions.

New AEER measure for refrigeration

The Annual Energy Efficiency Ratio (AEER) is an efficiency measure for refrigeration systems that takes the concept of Seasonal Energy Efficiency Ratio (SEER) in AC a step further. While SEER neglects the high load on hot summer days in AC, AEER does a better job of taking seasonality into account for a fixed-load refrigeration system.

Why AEER is more representative

AEER is a weighted average performance for a refrigeration system, using varying condensing temperatures tied to the actual weather data for a location. The AEER is a single number that represents an average performance for the whole year and lends itself easily to calculations of total annual power and energy cost.

Case-study results

A case study was done using EER and AEER to evaluate the efficiency of walk-in refrigeration compressors. The results of the study show that although one compressor received a higher EER than another compressor, the compressor with the lower EER could actually be more efficient when the performance of both compressors is evaluated through the entire operating range, using the AEER analysis.

Conclusion

The AEER measure is more representative of how a refrigeration system actually operates and gives a more accurate efficiency measure, as opposed to the EER measure, which is a single-point efficiency measure.

Air-Conditioning and Refrigeration Institute (ARI) standards

What is ARI

The Air-Conditioning and Refrigeration Institute (ARI) is the trade association representing manufacturers of more than 90 percent of the AC and commercial refrigeration equipment installed in North America. ARI is an internationally recognized leader in developing standards for and certifying the performance of these products.

Standard 540-2004

ARI Standard 540-2004 spells out the conditions at which commercial refrigeration and AC compressors need to be tested for publishing performance-rating data.

Test conditions

The ARI test conditions are different for medium- and low-temperature applications and are reproduced in Table 1 from ARI Standard 540-2004. The table also shows the appropriate pressure and temperature settings for different operating conditions.

Table 1

Standard Rating Conditions for Compressors and Compressor Units for Commercial Refrigeration Applications
(Based on 95°F [35°C] Ambient Temperature)

Suction dew-point temperature		Compressor type	Discharge dew-point temperature		Return-gas temperature		Subcooling	
°F	°C		°F	°C	°F	°C	°F	°C
45	7.2	All	130	54.4	65	18	15	8.3
20	-6.7	All*	120	48.9	40/65*	4.4/18*	0	0
-10	-23	Hermetic	120	48.9	40	4.4	0	0
-25	-32	All*	105	40.6	40/65*	4.4/18*	0	0
-40	-40	All*	105	40.6	40/65*	4.4/18*	0	0

Note: If airflow across the compressor is used to determine ratings, it shall be specified by the compressor manufacturer.
* 1) For hermetic compressors 40°F (4.4°C) return-gas temperature shall be used.
2) For external-drive and accessible hermetic compressors, 65°F (18°C) return-gas temperature shall be used.

How it is used

The ARI rating conditions are used for the purpose of measuring and reporting important compressor performance data, such as capacity and EER.

Bin analysis in refrigeration performance

Definition

Bin analysis is the analysis for the performance of a refrigeration system in a geographical location.

How it is calculated

Bin analysis is calculated by using the annual temperature profile of a geographical location to vary the condensing temperature of the system. Annual power consumption and average efficiency are calculated, to provide an estimate on the system performance.

The term “bin” comes from the fact that the weather data is used to summarize the variable ambient temperatures, by breaking them up into discrete and equal intervals and totaling the number of hours spent in each interval, or “bin,” throughout one year.

How it is used

Bin analysis is never exactly the same as the real performance of the system; however, this type of analysis is useful in comparing different system and compressor options, to select the optimum design.

Energy Efficiency Ratio (EER)

Definition

The **Energy Efficiency Ratio (EER)** is a single-point efficiency measurement for an AC or refrigeration compressor at a specific condition.

Equation

The equation for calculating EER is:

EER = (Cooling capacity in Btu/hr.) ÷ (Input power in watts)

How it is used

When EER is calculated using the ARI standard, it is a useful method of comparing different compressors and operating-condition choices. As a general rule, a compressor that has a higher EER at a given rating condition could be expected to perform better in a system than one that has a lower EER.

Assessment

The EER has its benefits, since it is a standardized measure of compressor performance; however, it is not representative of how a system actually operates.

Based on one rating point

EER is based on **one** rating point at one evaporating temperature and one condensing temperature. For low-temperature applications, -25 degrees Fahrenheit evaporating temperature and 105 degrees Fahrenheit condensing temperature are used to calculate the capacity, power and EER of the compressor. For medium-temperature applications, manufacturers use 20 degrees Fahrenheit evaporating temperature and 120 degrees Fahrenheit condensing temperature.

Limitation

EER's limitation is that in any given location, the ambient temperatures vary greatly from the single condensing-temperature rating point. In fact, in some regions temperatures never even reach the ambient temperature corresponding to the EER rating-point condition.

Ambient temperatures versus EER rating-point conditions

Introduction

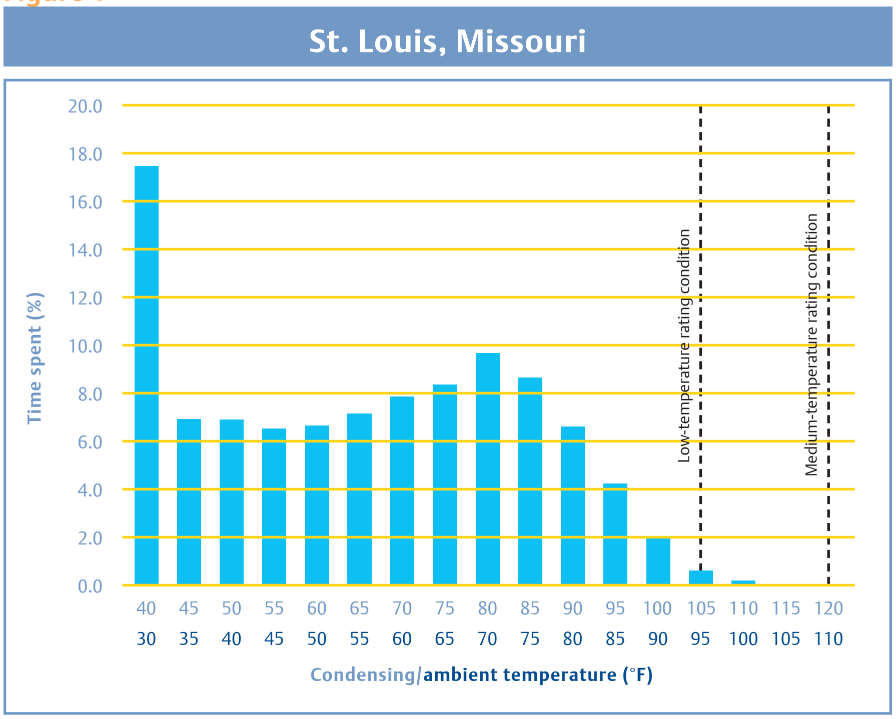
Figures 1 through 5 show graphs of the percentage of time spent at various ambient temperatures in different cities across the United States. The low- and medium-temperature EER rating-point conditions are also shown on the graphs (assuming a 10 degrees Fahrenheit temperature difference between the condensing and ambient temperatures).

Note that some cities never even reach the ambient temperature corresponding to the EER rating-point condition.

St. Louis, Missouri

Figure 1 shows the ambient temperatures of St. Louis, Missouri, versus EER rating-point conditions.

Figure 1

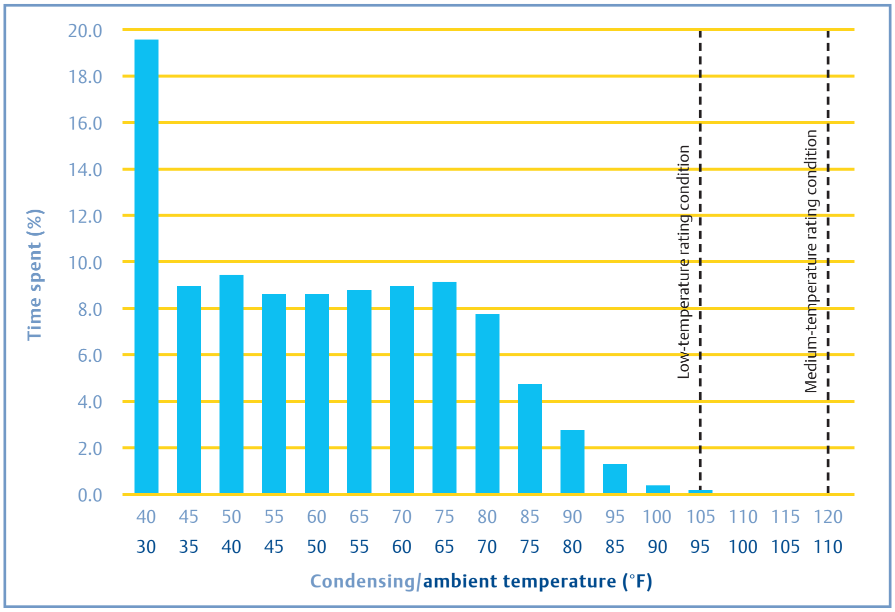


Boston, Massachusetts

Figure 2 shows the ambient temperatures of Boston, Massachusetts, versus EER rating-point conditions.

Figure 2

Boston, Massachusetts

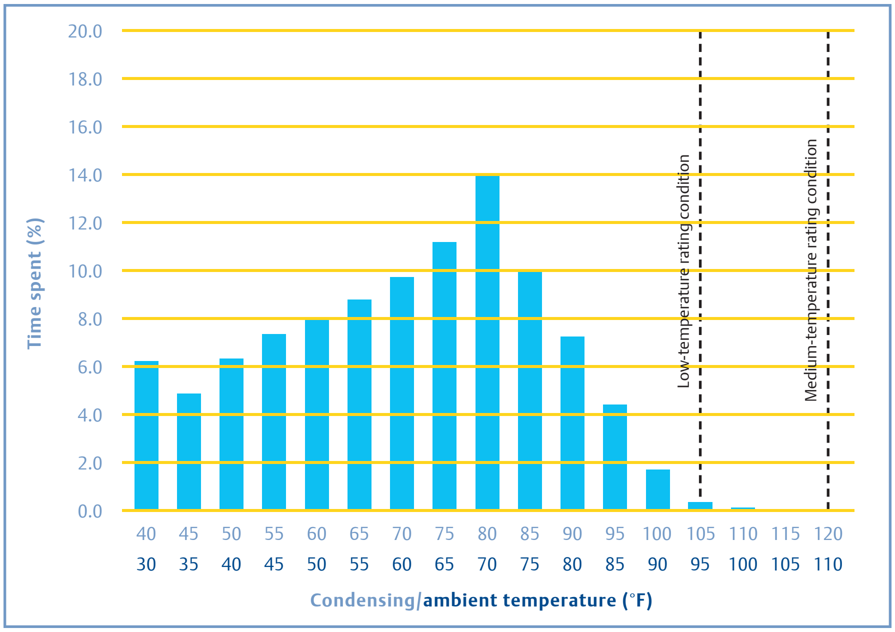


Atlanta, Georgia

Figure 3 shows the ambient temperatures of Atlanta, Georgia, versus EER rating-point conditions.

Figure 3

Atlanta, Georgia



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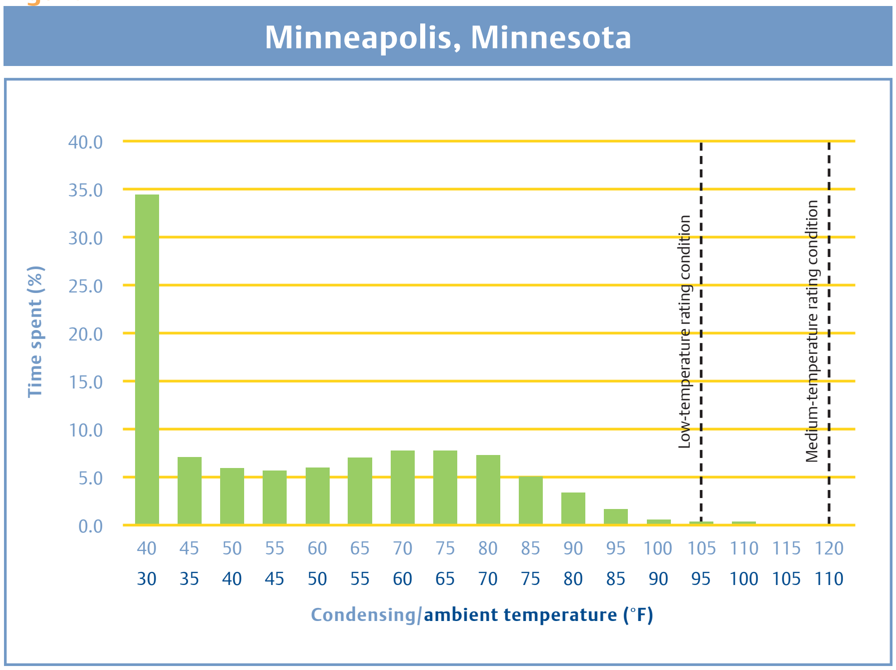
Ambient temperatures versus EER rating-point conditions (continued)

Minneapolis, Minnesota

Figure 4 shows the ambient temperatures of Minneapolis, Minnesota, versus EER rating-point conditions.

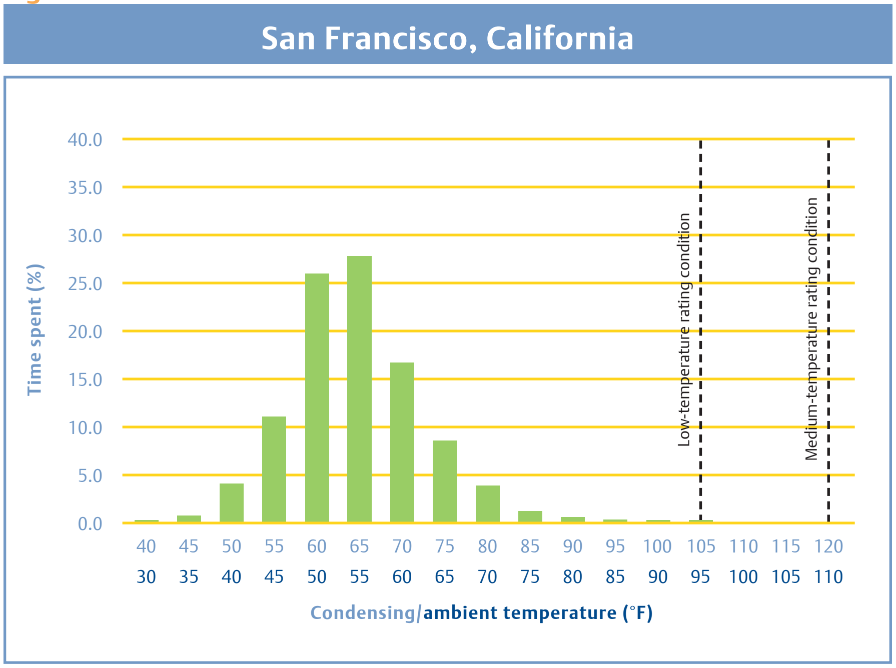
Figure 4



San Francisco, California

Figure 5 shows the ambient temperatures of San Francisco, California, versus EER rating-point conditions.

Figure 5



Seasonal Energy Efficiency Ratio (SEER)

Definition	The **Seasonal Energy Efficiency Ratio (SEER)** is an efficiency measure used to rate air conditioning equipment. The higher the SEER rating of a unit, the more energy efficient it is.
How it is calculated	The SEER rating is the Btu of cooling output during a typical cooling season divided by the total electric energy input in watt-hours (W-Hr) during the same period.
Relationship to EER	SEER is related to EER, the efficiency rating for equipment at a particular operating point. SEER is calculated over a range of expected external temperatures (i.e., the temperature distribution for the geographical location of the SEER test). The relationship between SEER and EER is relative, depending on location, because equipment performance is dependent on air temperature, humidity and atmospheric pressure.
Formulas for converting SEER to EER	The formula for the approximate conversion between SEER and EER in California is: SEER = EER ÷ 0.9 The relationship stated above is typical for the lower-elevation portions of California. In more humid locations, the relationship is better approximated by: SEER = EER ÷ 0.8
Limitations	SEER has its limitations. SEER is not an indicator for demand, since it is a seasonal value, and performance at severe conditions is not heavily weighted; thus, SEER might be a good way to compare equipment, but is not an ideal indicator of energy use. SEER neglects the high load on hot summer days.

Annual Energy Efficiency Ratio (AEER) – an improved efficiency measure

Definition

The **Annual Energy Efficiency Ratio (AEER)** is a weighted EER, based on the bin hours of different ambient temperatures.

A step beyond SEER

AEER takes the SEER concept a step further. While SEER in AC neglects the high load on hot summer days, AEER does a better job of taking seasonality into account for a fixed-load refrigeration system.

How it is calculated

AEER uses the concept of bin analysis to create a weighted Energy Efficiency Ratio that represents the whole year in a specific location. It is determined by taking the percentage of time spent at each condensing temperature and multiplying it by a weighted EER. (See Appendices for detailed AEER calculation.) Then the results are summed, to give an annual EER number for a compressor at a certain location with specific evaporating and return-gas temperatures.

Example

The data in Table 2 show the AEER calculation for a ZB45KCE, a medium-temperature scroll compressor running R-404A, in Phoenix, Arizona.

Table 2

AEER Calculation for ZB45KCE Compressor in Phoenix, Arizona

Phoenix, AZ, ambient temp. (°F)	% time spent @ temp.	Condensing temp. (°F)	Capacity (Btu)	Power (watts)	EER (Btu/W-Hr)	Bin efficiency
30	0.1	50	79,500	2,120	37.5	2.6667E-05
35	0.7	50	77,500	2,330	33.3	0.00021045
40	2.2	50	75,500	2,540	29.7	0.00074013
45	4.7	55	73,500	2,750	26.7	0.0017585
50	7.6	60	71,500	2,960	24.2	0.00314629
55	9.0	65	69,500	3,170	21.9	0.00410504
60	8.9	70	67,500	3,380	20.0	0.00445659
65	8.4	75	65,500	3,590	18.2	0.00460397
70	8.6	80	63,500	3,820	16.5	0.0052146
75	8.5	85	60,500	4,070	14.9	0.00571818
80	8.9	90	58,500	4,330	13.5	0.00658752
85	9.2	95	56,500	4,600	12.2	0.00755714
90	8.0	100	53,500	4,900	10.9	0.0073271
95	6.7	105	51,500	5,200	9.8	0.00683137
100	5.1	110	48,700	5,550	8.8	0.00581211
105	3.0	115	46,200	5,900	7.8	0.00383117
					Total AEER	14.72

Data description

The data in Table 2 show that only 6.7 percent of the year is spent at the low-temperature application condensing temperature of 105 degrees Fahrenheit. According to the U.S. National Weather Service, no significant hours are spent at 110 degrees Fahrenheit (120 degrees Fahrenheit condensing temperature), the medium-temperature application condensing temperature. Most of the year, the ambient temperature in Phoenix, Arizona, is between 55 degrees Fahrenheit and 85 degrees Fahrenheit.

Important note

In the example in Table 2, condensing temperatures had a lower limit of 50 degrees Fahrenheit. When performing any bin analysis, it is important to stay within the approved compressor or system operating envelope. Even though most compressors become more energy efficient at lower condensing temperatures, a certain head pressure must be maintained for the compressor to operate reliably.

Case study: EER versus AEER compressor evaluations

Introduction

Here are two examples demonstrating how EER and AEER evaluations of the same compressors will lead to different conclusions.

Situation one

A refrigeration system designer in Atlanta, Georgia, wants to select a compressor for a medium-temperature outdoor walk-in cooler. The system requirements are 17,500 Btu/hr. at 20 degrees Fahrenheit evaporating temperature (120 degrees Fahrenheit condensing temperature) with R-404A refrigerant at 60Hz.

EER evaluation

The EER evaluation yields these results:

Compressor model	Technology	20/120 EER
CS18K6E-PFV	Hermetic reciprocating	7.1
ZB19KCE-PFV	High-efficiency refrigeration scroll	6.6
Difference		**(7%)**

Misleading basis of EER evaluation

At first glance it looks like the CS18 hermetic reciprocating compressor is seven percent more efficient than the ZB19 high-efficiency scroll compressor. But even though Atlanta is hot, most of the time, the system will not be operating at 120 degrees Fahrenheit condensing temperature (see Figure 3). The compressor performance should be evaluated through its entire operating range.

AEER evaluation

The AEER evaluation yields different results than the one-point EER evaluation. Using the AEER analysis, the high-efficiency scroll compressor is eight percent more efficient than the hermetic reciprocating compressor.

Compressor model	Technology	AEER
CS18K6E-PFV	Hermetic reciprocating	14.7
ZB19KCE-PFV	High-efficiency refrigeration scroll	15.9
Difference		**8%**

Basis of AEER evaluation

The AEER evaluation was done for both compressors holding the minimum condensing temperature at 70 degrees Fahrenheit, the lowest allowable condensing temperature for the reciprocating compressor. Some scroll compressor models are actually approved for lower condensing-temperature operation. AEER can be improved further by allowing for the lowest approved condensing temperatures, but always check the approved compressor operating envelope for restrictions.

Situation two

A refrigeration system designer in Atlanta, Georgia, wants to select a compressor for a medium-temperature distributed refrigeration system in a supermarket. The system requirements are 44,000 Btu/hr. at 20 degrees Fahrenheit evaporating temperature (120 degrees Fahrenheit maximum condensing temperature) with R-404A refrigerant at 60Hz.

EER evaluation

The EER evaluation yields these results:

Compressor model	Technology	20/120 EER
ZS45K4E-TF5	Refrigeration scroll	7.2
ZB45KCE-TF5	High-efficiency refrigeration scroll	7.0
Difference		**(3%)**

Misleading basis of EER evaluation

The EER evaluation shows the ZS45 refrigeration scroll compressor as three percent more efficient; but the AEER analysis, which is more representative of the actual conditions that the compressor will see, clearly shows that the ZB45 high-efficiency refrigeration scroll compressor is 22 percent more efficient. In this example both compressors were held to a minimum of 70 degrees Fahrenheit condensing temperature.

AEER evaluation

The AEER evaluation yields different results than the one-point EER evaluation. Using the AEER analysis, the ZB45 high-efficiency refrigeration scroll compressor is 22 percent more efficient than the ZS45 refrigeration scroll compressor.

Compressor model	Technology	AEER
ZS45K4E-TF5	Refrigeration scroll	13.8
ZB45KCE-TF5	High-efficiency refrigeration scroll	16.9
Difference		**22%**

AEER – a more accurate evaluation of energy consumption

Evaluation equation

AEER can be used to make a more accurate evaluation of energy cost for the year, by using the following equation (valid only for constant refrigeration load):

$$\text{Annual energy cost (\$/yr.)} = \frac{\text{Load (Btu/hr.)}}{\text{AEER}} \times (8.76) \times \frac{(\$)}{\text{kWh}}$$

(See Table 5 for the average retail price of electricity to ultimate customers by end-use sector, by state.)

Basis of equation

There are 8,760 hours in a year. The equation uses the 8.76 multiplier, which also converts from hours to kWh (thousands correction).

Example

For example, using the CS18K6E reciprocating compressor and ZB19KCE scroll compressor previously described in the case study:

Reciprocating compressor annual energy cost = (17,500 Btu/hr. ÷ 14.7) x (8.76) x ($0.08/kWh) = **$834.29**

Scroll compressor annual energy cost = (17,500 Btu/hr. ÷ 15.9) x (8.76) x ($0.08/kWh) = **$771.32**

Typical energy costs

Typical energy costs are listed in the Appendices and are updated monthly at the Energy Information Administration (EIA) website, **eia.doe.gov**.

Future development

The AEER method described in this paper is intended to more accurately represent the power consumption of a refrigeration system with a constant load. It is meant to be an introduction to a weighted average energy-efficiency number. Future refinements of the AEER method might include provisions for handling variable-capacity compressors, variable loads and variable energy rates, as well as including more system parameters into the analysis. System configuration can significantly affect actual system performance.

About Emerson Climate Technologies

HVACR solutions leader

Emerson Climate Technologies, a business of Emerson, is the world's leading provider of heating, ventilation, air conditioning and refrigeration solutions for residential, industrial and commercial applications. The group combines best-in-class technology with proven engineering, design, distribution, educational and monitoring services to provide customized, integrated climate-control solutions for customers worldwide.

Emerson® brands

Emerson Climate Technologies' innovative solutions, which include industry-leading brands such as Copeland Scroll, improve human comfort, safeguard food and protect the environment.

More information

For more information, visit **EmersonClimate.com**.

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Appendices
Basic refrigeration cycle

Stages of cycle

The stages of a basic refrigeration cycle are described in Table 3.

Table 3

Stages of a Basic Refrigeration Cycle

Stage	Description
Stage 1 to Stage 2	A superheated refrigerant vapor leaving the evaporator enters the compressor and is compressed to a high-pressure and high-temperature vapor.
Point 2 to Point 3	The high-pressure vapor is then condensed and cooled, as it flows through the condenser coils from Point 2 to Point 3.
Point 3 to Point 4	An irreversible adiabatic situation is assumed from Point 3 to Point 4, as the expansion valve expands the condensed liquid refrigerant to the evaporator pressure.
Repeat	The cycle repeats once the liquid-vapor mixture flows through the evaporator, and the transfer of heat to the coils causes a change of state to superheated vapor.

Diagram: Basic refrigeration cycle

The basic refrigeration cycle diagram is shown in Figure 6.

Figure 6

Basic Refrigeration Cycle

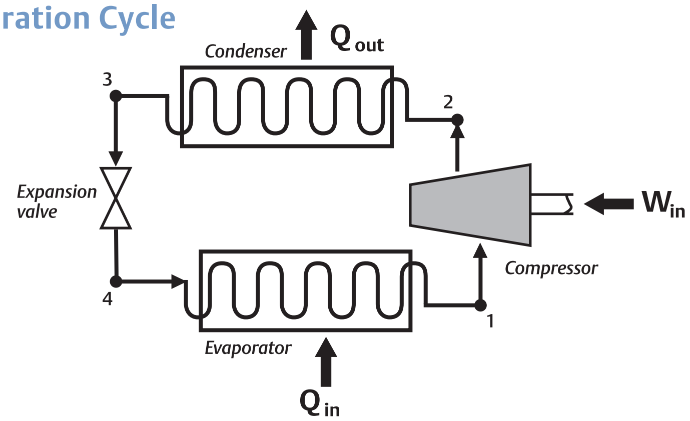
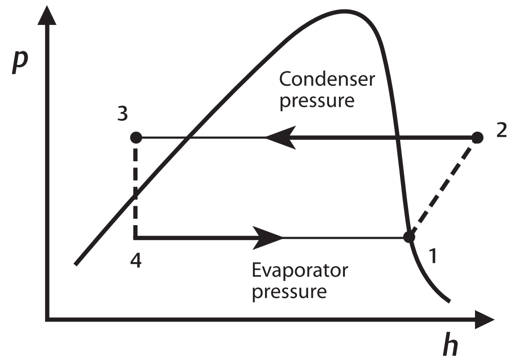


Diagram: Relevant pressure-enthalpy

The relevant pressure-enthalpy (p-h) diagram is shown in Figure 7.

Figure 7

Relevant Pressure-Enthalpy



Refrigeration terms and equations

Capacity

The cooling capacity of a refrigeration system is measured as the refrigerant mass flow through the evaporator and the difference in refrigerant enthalpy between the coil inlet and outlet.

Capacity = m (h1 – h4)

The units of system refrigerating capacity are Btu/hr., when the mass flow is in lbm/hr. and the enthalpies are in Btu/lbm.

Coefficient of performance

The coefficient of performance (COP) of a compressor is determined by taking the cooling capacity in British thermal units (Btu) in a refrigeration cycle and comparing it with the Btu equivalent of the energy put into the system. It is the ratio of the output (heat absorbed) divided by the input (energy required to produce the output).

COP = Qin ÷ Wout = Qin ÷ (Qout – Qin)

Energy Efficiency Ratio

The Energy Efficiency Ratio (EER) is similar to the coefficient of performance and is more commonly used in refrigeration. EER is a unit's rated cooling capacity in Btu/hr. divided by the electrical power in watts. This is the efficiency measure that is the subject of this paper.

EER = (Cooling capacity in Btu/hr.) ÷ (Input power in watts)

Isentropic efficiency

Isentropic efficiency is a compressor efficiency term. It is a comparison between actual and ideal performance of the compressor at the same inlet and exit states. The isentropic efficiency is defined as:

Isentropic efficiency = (h2 – h1) ÷ (h2s – h1)

where h2s is the enthalpy at isentropic State 2s, corresponding to State 1. Compressors commonly have isentropic efficiencies between 75 and 85 percent.

Volumetric efficiency

Volumetric efficiency is also a compressor efficiency term. It is a comparison between actual volume of gas compressed and the compressor's theoretical displacement volume. The volumetric efficiency is defined as:

Volumetric efficiency = (Volume of gas compressed per hour) ÷ (Displaced volume per hour)

AEER calculation

Equation

The AEER calculation is summarized as the following equation:

AEER = 1 ÷ sum (% time ÷ EER)

Note: The spreadsheets displayed earlier in this document show the calculation in tabular format. The AEER calculation is most easily done in a spreadsheet.

Calculation procedure

To calculate the AEER of a compressor, follow the procedure outlined in Table 4.

Table 4

Calculation of AEER

Step	Action
1	Find the ambient-temperature profile for the location, including the amount of time spent at each ambient-temperature "bin."
2	Assign a reasonable condensing temperature that is associated with each ambient-temperature bin. **Caution:** Ensure that the condensing temperature conforms to the approved operating envelope for the compressor.
3	Choose a constant evaporating temperature (20°F, for example) and list the capacity and power at each condensing temperature, using the compressor performance tables or curves.
4	Calculate EER at each point, by taking capacity and dividing by power.
5	Calculate "bin efficiency" as the percentage of time divided by EER.
6	Sum up all of the bin-efficiency numbers and take the inverse to yield an AEER figure. **Note:** In this way, the calculation takes into account that compressors typically have more capacity as condensing temperatures drop.

Average retail price of electricity

Table 5 lists the average retail price of electricity to ultimate customers by end-use sector, by state, for June 2007 and 2006, in reference to the energy calculation on page 14.

Table 5

Average Retail Price of Electricity to Ultimate Customers
by End-Use Sector, by State, June 2007 and 2006 (Cents per Kilowatt-Hour)

Census division and state	Residential		Commercial[1]		Industrial[1]		Transportation[1]		All Sectors	
	Jun. '07	Jun. '06	Jun. '07	Jun. '06	Jun. '07	Jun. '06	Jun. '07	Jun. '06	Jun. '07	Jun. '06
New England	**16.80**	**16.38**	**14.59**	**14.86**	**12.39**	**11.15**	**8.27**	**7.39**	**14.85**	**14.69**
Connecticut	19.43	16.73	15.21	13.87	12.45	12.03	12.89	12.35	16.22	14.68
Maine	15.10	16.72	12.12	12.75	11.05	8.39	--	--	12.84	12.97
Massachusetts	16.49	16.66	15.24	16.08	13.26	11.54	6.06	5.55	15.17	15.42
New Hampshire	14.96	15.40	13.09	14.44	11.95	11.99	--	--	13.53	14.34
Rhode Island	14.27	15.67	12.82	14.18	12.29	12.76	--	--	13.27	14.52
Vermont	14.56	13.76	12.29	11.86	8.79	8.33	--	--	12.07	11.50
Middle Atlantic	**15.12**	**14.05**	**14.01**	**12.53**	**8.04**	**7.66**	**11.49**	**11.03**	**13.19**	**11.98**
New Jersey	15.87	14.03	14.69	13.31	12.32	10.91	12.79	9.28	14.88	13.27
New York	18.12	17.12	16.34	14.00	9.26	8.77	12.32	11.96	16.06	14.20
Pennsylvania	11.69	11.06	9.50	9.31	6.82	6.54	7.73	7.84	9.33	8.92
East North Central	**10.33**	**9.60**	**8.47**	**8.42**	**6.00**	**5.47**	**6.51**	**5.82**	**8.26**	**7.72**
Illinois	11.05	8.96	8.28	8.54	6.68	4.87	6.05	5.26	8.86	7.47
Indiana	8.25	8.44	7.07	7.31	4.96	5.11	10.42	10.02	6.49	6.61
Michigan	10.76	10.26	9.10	8.78	6.73	6.49	10.50	13.07	8.90	8.59
Ohio	10.36	10.20	8.64	8.76	5.82	5.66	10.40	10.66	8.17	8.07
Wisconsin	11.07	10.25	9.03	7.97	6.59	5.58	--	--	8.82	7.79
West North Central	**9.20**	**8.83**	**7.56**	**7.30**	**5.60**	**5.40**	**7.97**	**7.75**	**7.55**	**7.30**
Iowa	9.95	9.89	7.40	7.46	5.16	5.04	--	--	7.20	7.18
Kansas	9.09	8.65	7.64	7.54	5.58	5.65	--	--	7.59	7.50
Minnesota	9.72	9.33	8.42	7.90	6.39	5.52	8.03	7.63	8.19	7.58
Missouri	8.90	8.47	7.42	7.12	5.70	6.12	7.91	7.90	7.67	7.46
Nebraska	8.64	8.24	6.72	6.62	4.93	4.61	--	--	6.72	6.53
North Dakota	8.37	7.93	6.74	6.33	4.65	4.31	--	--	6.53	6.15
South Dakota	8.70	8.48	6.62	6.55	5.16	5.06	--	--	7.05	6.96
South Atlantic	**10.28**	**9.98**	**8.61**	**8.48**	**5.71**	**5.72**	**9.47**	**7.43**	**8.77**	**8.58**
Delaware	13.73	13.68	11.27	13.75	8.76	4.47	--	--	11.43	11.04
District of Columbia	11.95	10.55	12.46	12.17	10.53	9.92	11.18	9.11	12.21	11.80
Florida	11.13	11.28	9.55	9.79	7.60	7.64	9.67	10.24	10.20	10.39
Georgia	9.63	9.32	8.25	7.79	6.00	5.80	7.41	6.81	8.30	7.94
Maryland	13.60	10.56	11.75	11.05	9.66	11.58	9.83	6.10	12.30	10.89

Census division and state	Residential		Commercial		Industrial		Transportation		All sectors	
	Jun. '07	Jun. '06	Jun. '07	Jun. '06	Jun. '07	Jun. '06	Jun. '07	Jun. '06	Jun. '07	Jun. '06
North Carolina	9.22	8.88	7.28	7.00	5.29	5.18	--	--	7.65	7.37
South Carolina	9.28	9.10	7.82	7.64	4.77	4.70	--	--	7.23	7.05
Virginia	9.28	8.97	6.38	6.23	4.93	4.73	6.77	6.81	7.26	7.02
West Virginia	6.64	6.41	5.61	5.54	3.85	3.61	5.60	5.57	5.14	4.91
East South Central	**8.51**	**8.61**	**8.06**	**8.25**	**5.55**	**5.54**	**11.22**	**11.11**	**7.31**	**7.36**
Alabama	9.49	9.22	8.74	8.69	5.64	5.62	--	--	7.85	7.70
Kentucky	7.45	7.43	6.86	6.86	5.32	5.04	--	--	6.36	6.17
Mississippi	9.61	10.13	8.87	9.64	5.89	6.41	--	--	8.19	8.87
Tennessee	7.85	8.00	7.96	8.15	5.53	5.64	11.22	11.11	7.17	7.27
West South Central	**11.47**	**11.91**	**9.43**	**9.32**	**7.18**	**7.18**	**8.59**	**8.63**	**9.53**	**9.79**
Arkansas	8.62	8.89	6.50	6.78	5.11	5.41	--	--	6.72	7.07
Louisiana	9.57	9.25	9.13	8.80	6.58	6.49	--	--	8.39	8.20
Oklahoma	8.71	8.69	7.71	7.85	5.67	5.52	--	--	7.58	7.67
Texas	12.74	13.38	10.10	9.90	7.98	7.98	8.38	8.40	10.52	10.84
Mountain	**9.74**	**9.42**	**8.06**	**7.84**	**5.83**	**5.69**	**8.20**	**6.51**	**8.01**	**7.81**
Arizona	9.93	9.99	8.35	8.35	6.21	6.22	--	--	8.79	8.85
Colorado	9.65	8.83	8.26	7.86	6.12	5.88	7.67	3.19	8.18	7.72
Idaho	6.96	6.40	5.52	5.10	4.17	3.98	--	--	5.16	4.88
Montana	9.39	8.56	8.55	7.29	5.18	4.50	--	--	7.60	6.59
Nevada	11.54	10.96	9.84	9.85	8.64	8.37	11.13	10.24	10.08	9.74
New Mexico	9.33	9.12	7.86	7.68	5.63	5.45	--	--	7.57	7.44
Utah	8.65	8.08	7.15	6.67	5.08	4.73	7.96	7.64	6.97	6.51
Wyoming	8.19	8.28	6.19	6.24	4.13	4.17	--	--	5.28	5.35
Pacific Contiguous	**12.28**	**12.57**	**12.14**	**12.53**	**8.35**	**7.78**	**7.12**	**5.90**	**11.37**	**11.46**
California	14.59	15.18	14.11	14.54	10.59	10.18	7.13	5.89	13.57	13.88
Oregon	8.33	7.41	7.03	6.90	4.95	4.31	6.67	6.40	6.93	6.29
Washington	7.34	6.72	6.35	6.35	4.71	4.14	5.44	5.00	6.28	5.84
Pacific Noncontiguous	**20.66**	**21.05**	**17.38**	**17.87**	**16.30**	**17.10**	**--**	**--**	**18.01**	**18.58**
Alaska	15.26	15.42	11.84	12.27	11.51	11.79	--	--	12.78	13.13
Hawaii	23.54	24.10	21.36	22.08	18.06	18.75	--	--	20.81	21.45
U.S. total	**11.07**	**10.85**	**9.92**	**9.74**	**6.61**	**6.35**	**10.06**	**9.24**	**9.47**	**9.24**

Source: Energy Information Administration, Form EIA-826, "Monthly Electric Sales and Revenue Report with State Distributions Report."

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