Can SEER Be Saved?

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ABSTRACT

Seasonal Energy Efficiency Ratio (SEER) is the only legal way to rate energy efficiency of central air conditioners in the U.S. SEER 13 replaced SEER 10 as the minimum in January, 2006. SEER is a national average rating. There is growing concern that the SEER's test conditions do not reflect installations in real houses (based on field data). There is also concern that SEER does not reflect regional performance concerns, including peak performance in hot regions or moisture control in humid climates. Achieving the next large national savings increase with today's metrics would require complex and expensive machinery. We support two changes. (1) Adjust test parameters, such as external static pressure levels and default fan power values, that materially affect the gap between laboratory ratings and field experience. Equipment optimized for real-world conditions will be more efficient in actual use. (2) Adopt rating methods that reflect regional needs.

Manufacturers already make regionally differentiated models (of furnaces), so regional products are feasible as well as desirable for comfort and efficiency. We discuss ways to modify and complement the current SEER test to address these issues.

Introduction

In the United States, the energy efficiency of single-phase, central air conditioners (and central heat pumps in the cooling cycle) up to 65,000 Btu/h is measured by the seasonal energy efficiency ratio test and rating procedure (DOE 1979), which was adopted in 1979.[1] On January 23, 2006, the minimum SEER value of 10 Btu/Wh in effect since 1992 rose to 13 Btu/Wh for residential, split and packaged central air conditioners, and heat pumps (DOE 2001). SEER is a single national standard, intended to provide a representative ranking or measure of seasonal performance for typical U.S. climate conditions (DOE 2005). Reviewing rating methods is important as needs have evolved since SEER was established, in at least three highly significant ways:

1. Since SEER was implemented, field tests of hundreds of houses in several regions have clearly shown that the test external static pressure (duct resistance to air flow) is less than half the average field measurement. Other test conditions also warrant review, such as default blower electricity consumption.

[1] Prior to 1979, the steady-state Energy Efficiency Ratio (EER), at "design" conditions, was the standard measure of central air conditioner efficiency in the United States. EER is the ratio of steady-state capacity at 95ºF to power at the same temperature, in units of Btu/Wh.

2. When the SEER approach was developed, the principal focus was on providing sensible cooling for temperature control. SEER has no explicit references to humidity control. Since then, construction methods have changed (tighter buildings with smaller sensible loads but similar or increased ventilation), so humidity control and moisture removal has become more important for consumers and for the building industry in much of the country.
3. SEER was designed as a metric for consumers to compare systems in terms of seasonal energy consumption. Today, utilities and consumers are also concerned about peak electric demand and performance at high temperature, since residential air conditioning is a significant contributor towards the need for new generation (and transmission-distribution) assets. Utility incentives (rebates) often focus now on demand reduction through high efficiency at high temperatures. As time-of-day pricing becomes important in the residential market, peak performance will also matter greatly to consumers.

Present Methods

SEER is required by federal law. In addition, Federal Trade Commission regulations discourage disclosure of any other measure of energy efficiency to consumers.[2]

About the Present Test and Rating Method

SEER was developed to provide an indication of seasonal energy efficiency in the cooling mode. The SEER test and rating procedure considers the following aspects of seasonal performance:

- Cooling capacity and efficiency of an air conditioner vary with outdoor temperature. The rating procedure tries to account for these seasonal variations by using outdoor temperature bin data (for variable speed systems) or the annual average temperature (for single-speed systems) to represent a typical U.S. climate.
- Air conditioners cycle off and on at part-load conditions to meet the load. Because of startup losses, capacity and efficiency are lower at part-load conditions. The SEER procedure accounts for part-load losses with a *cyclic degradation coefficient (Cd)*. Various equipment sizing and thermostat cycling assumptions are implicit in the procedures to determine Cd.

The SEER test and rating procedure apply to conventional constant-speed systems as well as variable-speed and two-speed systems. The SEER value is intended to provide accurate performance comparisons for these very different systems.

[2] Exceptions are made for information addressed to contractors and other professionals. For example, advertisements in the trade press can include EER (high temperature steady-state efficiency) as a guide for contractors (Newsome 2003).

Simplifying the Calculation Procedure

A key concept for SEER is the "bin" method. Temperature bins are just the frequency distribution of cooling hours for a season in a given location. For constant speed systems, the calculation procedures were simplified to eliminate the need to use temperature bin data. Instead the procedure simply uses performance data from the single outdoor temperature of 82ºF, which happens to be the load-weighted average of the temperature bin data (see the section below). The rating procedure still compensates for part-load degradation by assuming the air conditioner is sized to be 50% loaded at 82°F. The calculations for single-speed air conditioners become very simple:

$$\text{Equation 1.} \qquad SEER = (1 - Cd*0.5)*EER_{82}$$

Manufacturers can choose to forgo cyclic laboratory testing and use a default value of 0.25 for Cd. However, since most modern systems have a Cd of 0.10 to 0.15 (Dougherty 2003; CEC 2006), most manufacturers choose to determine Cd by testing their equipment.

This simple calculation procedure was adopted instead of a temperature bin method in 1979 because it yielded good results with fewer calculations. The bin method is required for equipment with multiple compressors or with compressors that can vary their output with load. Thus, the standard for two-stage equipment requires steady-state measurements at 82ºF and at 95ºF at each operating stage.[3] A potential problem with this simplification was that it caused manufacturers to focus design efforts on maximizing EER at 82°F, since the EER at 95°F is not included in the simplified calculations (only capacity matters at 95°F).

Are the Test Conditions Realistic?

The SEER metric was originally intended to provide a relative ranking of equipment in terms of seasonal efficiency. Thinking of the SEER value as a relative performance index is useful because it minimizes the need to accurately represent every aspect of field performance. However, for SEER to be a realistic measure of relative performance, the laboratory test conditions should at least be representative of field conditions. Some test conditions used to determine SEER values are not realistic.

The Air-Conditioning and Refrigeration Institute (ARI) test standards have historically used modest external static pressures (ESPs) as the nominal test conditions. Table 1 shows the current external static pressure values by size class, and our recommendations for more realistic values, which are based on field studies from Proctor and Parker (2000) as well as others. Field tests consistently show average values of 0.5 inches of water (IWP) for residential systems.[4] The low values of ESP in the test procedure mean that fan power is lower than actual values observed in the field and actual seasonal efficiency is lower than the SEER value would predict. Higher-than-expected ESP can be attributed to a combination of factors, particularly "upgraded" air filters with high pressure drops and constricted ductwork.

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[3] Continuously modulating equipment adds a third intermediate test measurement set at 87ºF dry bulb outdoors.

[4] We believe that a substantial majority of the houses that have been studied, both new and existing, have been slab-on-grade, which implies equipment and ductwork in the attic. In turn, we infer that these houses have substantial amounts of flex-duct. ACEEE is now collecting data on houses with equipment and ductwork in basements.

Table 1. External Static Pressure (Duct Resistance Levels) in Current Test Procedure

Capacity Range (Btu/h)	Current Minimum External Resistance (inches of water)
Up thru 28,800	0.10
29,000 to 42,500	0.15
43,000 and above	0.20

Source: Sachs (2004)

Test procedure entering temperatures to the indoor coil do not reflect field observations. The nominal conditions of 80°F dry bulb and 67°F wet bulb were originally selected to represent conditions in commercial buildings, where entering conditions are a mix of return air from the space and outdoor air. In residential applications, ventilation is usually not added in at the air handler, so a more representative operating condition would be 75°F dry bulb and 63°F wet bulb (52% RH). Kavanaugh (2002) also identified this as a concern. Both capacity and efficiency are directly proportional to the entering wet bulb (with very little impact of dry bulb temperature). Therefore, the actual seasonal efficiency in field applications (at 63°F wet bulb) would be lower than SEER by several percent. Therefore, the actual seasonal efficiency in field applications (at 63°F wet bulb) would be lower than SEER by several percent. The analysis by Henderson and Sachs (2006) showed that lowering the value of the wet bulb from 67°F to 63°F decreased the predicted seasonal efficiency (using today's rating method) by nearly 2%.

The bin calculations in the rating procedure—which currently apply only to multi-speed units—also make inherent assumptions about the characteristics of the load and the relative sizing of the unit, in order to calculate part-load losses. The balance point temperature for the cooling load is assumed to be 65°F (i.e., the cooling load goes to zero at this point). Also the cooling capacity at 95°F is assumed to be 10% greater than the cooling load at that temperature. Changing the balance point and sizing factor impacts the determination of seasonal efficiency (Henderson and Sachs 2006). Of course, the bin calculations inherently consider only total cooling and ignore the fact that the sensible and latent portion of the load and capacity can change with operating conditions and differ by region. More detailed calculations that consider the actual mix of sensible and latent capacity are likely to result in higher efficiency in humid climates (since the entering wet bulb is higher) and lower efficiency predictions in dry climates (Henderson and Sachs 2006).

SEER's Value for Market Differentiation

First, the goal of a seasonal measure is worthwhile. In the SEER 10 world, the SEER's greatest virtue may have been that it was a single number for comparing different types of equipment. When SEER 13 became the floor in 2006, the marketing environment changed: in much of the country, the savings from much higher efficiency (say, for example, SEER 16) are in the range of $50/yr at U.S. average energy prices (Michel 2005), which is not cost-effective in much of the country. One of our goals is to help rebuild market differentiation through improved efficiency metrics, so efficiency can continue to be useful for product differentiation.

A Key SEER Weakness: Regional Accuracy

SEER was developed as a single value for a typical U.S. climate with significant air conditioning loads. Using the temperature bin data from the procedure, the load-weighted average temperature is 82.4°F (Henderson and Sachs 2006). This bin data is representative of a broad range of U.S. cities, including Key West, Columbia, Reno, Kansas City, and San Antonio. However, several southwestern U.S. cities are not well represented by this typical weather profile, including Phoenix, Tucson, Fresno, Bakersfield, and Las Vegas. The equivalent load-weighted temperatures[5] in these cities are all over 85°F. In Phoenix, the load-weighted average temperature is nearly 91°F.

The SEER bin hour analysis inherently focuses on seasonal energy use and does not consider the economic impacts of demand charges or higher energy prices on hot summer days. California has included these impacts into all of its energy evaluations and utility planning through time dependent valuation (TDV) of energy (HMG 2002). TDV energy costs represent the long-term prices residential customers will face as "time-of-day" rates or demand surcharges become more common. The current SEER procedure does not address this newer concern.

The humid Southeast[6] offers a comparable regional challenge. Residential air conditioning equipment does both sensible (cooling) and latent (dehumidification) work. Latent cooling is critical in humid climates. Latent loads come from the introduction of humid outside air (both unintentional infiltration and ventilation) and from interior humidity sources (occupant respiration, plant transpiration, showers, and cooking). At rated conditions, residential air conditioners typically provide roughly 30% of their total capacity as latent heat removal and 70% sensible cooling, or have a sensible heat ratio (SHR) of 0.7. However, in recent years sensible loads in new houses have declined relative to latent loads because of better technologies (such as spectrally sensitive windows, more insulation, and tighter ducts). Particularly under part-load conditions when outdoor temperatures are mild but ambient humidity is high, the majority of the cooling load can be latent heat removal. Conventional residential air conditioners cannot meet this load (Gatley 2004, cited in Lstiburek 2002), suggesting that specialized equipment with lower SHR (higher latent heat removal capability) would be beneficial in humid regions. The SEER test procedure focuses on total cooling capacity and does not address the need to meet latent loads in humid climates. Unless the importance of controlling humidity levels is fully reflected in the performance metric for such a unit, it would have a SEER penalty.

The present SEER procedure does not address any issues related to humid climate performance. For instance, Kavanaugh (2002) provided an example of an SEER 18 two-speed unit that operates at high air flow with the compressor at low speed. The resulting SHR at low speed was much higher than the value for a comparable single-speed unit and would provide poor humidity control, even though the efficiency is higher. A detailed field test of a two-stage unit in Florida (Shirey, Henderson, and Raustad 2006) demonstrated that multi-stage units do not always provide the expected humidity control benefit. As a start, this issue could be addressed by requiring manufacturers to report the SHR data they already collect as part of the test procedure at 82°F and 95°F. For multiple-stage equipment, SHR is measured for each capacity level. The SHR at 82°F and at the lowest capacity stage is expected to be the most useful

[5] The load-weighted average temperature weights the bin temperature distribution by the load required to serve that bin, so the load-weighted temperature is the average of (temp * load) for each hour of the cooling season.

[6] The region includes Md., Del., D.C., Va., N.C., S.C., Ga., Ala., Miss., La., Ariz., and Tex. (east of San Antonio), about 76 million people (Sachs 2004).

measure of latent performance. Then, perhaps regulatory requirements for the maximum permissible SHR could be applied for regional ratings in humid climates.

Default fan power for furnaces. In many cases, the circulating fan for split system air conditioners is part of the furnace and is not sold as part of the central air conditioning system. To deal with this situation, the rating method prescribes a default fan energy level (365W/1,000 cfm) to use when calculating SEER values. The procedure also allows the manufacturer to use the actual fan power when the air conditioner is sold with specific furnaces (or other air handlers) that have better fan performance. The 365W/1,000 cfm value of default fan power is much lower than the average 500W/1,000 fan power observed in the field (Neme, Proctor & Nadel 1999).

Proposed Rating Methods

This section discusses test conditions and rating method changes that will improve national ratings and meet regional needs better, and also addresses emerging challenges, such as time-of-day pricing. We seek methods that will also simplify testing and improve product differentiation opportunities. This includes both the ability to effectively market regional models and credit for the energy savings potential with advanced technologies. In addition, rating methods must help consumers and utilities by both estimating energy and peak demand savings and providing reliable guidance on appropriate equipment for varying applications and climate conditions. We sequentially consider test conditions, seasonal methods for different regions, and steady-state metrics.

Test Conditions

We suggest that it is time to change the test temperatures and ESP, to align with what has been learned about field conditions since SEER was designed and adopted.

Entering temperatures. The indoor or entering conditions of 80°F dry bulb and 67°F wet bulb are historical operating conditions for commercial equipment and correspond to mixed air conditions when ventilation is provided. More appropriate residential conditions are in the range of 75°F dry bulb and 63°F wet bulb (around 50% RH). The recent analysis by Henderson and Sachs (2006) showed that the 67°F entering wet bulb is the single biggest systematic bias between bin-based SEER calculations and hourly simulations of seasonal performance.

Consider including higher ambient test conditions. 95ºF is the test temperature used for EER and capacity measurements. In Southwestern climates, peak demand on the utility grid can occur at much hotter temperatures. Rosenfeld, Rosenquist, and Rice (2005) have shown that products designed for high performance at hot conditions would be cost-effective in California and parts of the Southwest. Adding a test point at 115°F ambient to determine EER_{115} in such climates would assure better high-temperature performance. The ISO[7] standards for air conditioner and heat pump (ISO 1999) include a similar steady-state test condition, designated as "T3," for hot climates identified (46ºC/114.8ºF). UL certification in the U.S. already requires testing air

[7] http://www.iso.org

conditioner operation at 115°F for safety and survivability. Collecting performance data (and slightly modifying other test conditions) would impose only a modest additional testing burden.

Adjust external static pressure and default fan power upwards to more realistic levels. The ESP values used in the test procedure are less than half as high as the average value found in the field (Neme, Proctor, and Nadel 1999). This leads to reduced airflow, efficiency, and capacity. We recommend raising the default ESP values, as in Table 2. Increasing ESP under test conditions probably will require increasing the default of 365W/1,000cfm (DOE 2005) for condenser units applied with furnaces. Based on available field studies, a value around 500W/1,000 cfm would be appropriate.[8] In older U.S. houses, ductwork was generally sized for low flow since hot air furnaces provide supply air that is 50ºF warmer than the room air. Air conditioners run at a smaller temperature difference (typically 20ºF), so larger ducts should be specified. Neme, Proctor, and Nadel (1999) found that the average of field measurements is ~500W/1,000 cfm, consistent with higher ESP from undersized ducts.[9] Unfortunately, the ducts are rarely retrofitted when central air conditioning is installed.

Table 2. Current and Recommended External Static Pressure Values, by Equipment Size

Capacity Range (Btu/h)	Current Minimum External Resistance (inches of water)	Proposed Minimum External Resistance (inches of water)
Up thru 28,800	0.10	0.35
29,000 to 42,500	0.15	0.50
43,000 and above	0.20	0.65

Report SHR at the SEER test conditions. Manufacturers already capture the data necessary to determine SHR at each test condition. Latent capacity is important at design conditions as well as at low-load conditions. Manufacturers are now able to choose the airflow for SEER tests that maximizes the rating value.[10] This airflow can sometimes be much different than would be common practice in humid climates. To provide a valid comparison that considers both efficiency and latent removal, we propose that SHR be reported at DOE Test A conditions (95°F) at full load and full airflow. In addition, SHR should be reported at 82°F with the lowest capacity stage with the appropriate flow that would be specified by the unit controls (i.e., for units with a variable speed fan and a humidistat, this might be the lowest possible airflow). Determining efficiency and SHR under the same airflow conditions will encourage manufacturers to choose equipment operating conditions that are better aligned with practice in the field. The low capacity, low temperature SHR will provide a good indication of dehumidification performance in a modern home.

Air handling efficiency needs its own metric, W/cfm. As we have already seen, air flow across the evaporator is a critical ratings parameter. In addition, since the air handler motor is mounted in the air stream, the heat it throws off must be removed by the air conditioner,

[8] The concept of alternative test conditions might offer the possibility that manufacturers could offer machines rated at different ESP values to separately serve new construction with low ESP and thus low fan power (rated at current values of Table 1) vs. "standard" machinery rated at the proposed values in Table 1.
[9] To compensate for small diameter, higher velocities are used, which requires substantially more power.
[10] The test airflow is limited to below 450 cfm per ton.

decreasing efficiency.[11] Although the air handler is generally sold with the furnace (Sachs and Smith 2004), the furnace test procedure does not measure air handler efficiency.[12] Compounding this, air handler treatment in the *air conditioner* rating method is inadequate. It gives a default value (365W/1,000 cfm) that manufacturers can use in lieu of measurement (DOE 2005).

From the perspective of manufacturers, an air-flow efficiency rating poses some challenges. Should the rating be explicit in the furnace rating method, indicated as a note in the air conditioner rating (such as, "This air conditioner must be matched with an air handler that delivers a specified air handler efficiency [cfm/watt] at a specific external static pressure.") or by breaking out the air handler as a "virtual" appliance to be regulated separately from the furnace?

SEER Equivalents for Different Regions

The SEER value is a poor predictor of efficiency and performance in regions whose conditions differ significantly from the national norm. However, the rating method for SEER—as it was originally conceived—used a temperature bin analysis approach to calculate seasonal efficiency. This more complicated calculation procedure is currently used for multi-speed systems. We recommend the bin analysis approach for both single-speed and multi-speed air conditioners (Henderson and Sachs 2006). We recommend this approach for several reasons:

- Alternative temperature bin data for any weather location can be applied in the calculation procedure to calculate the local or regional SEER (e.g., $SEER_{Fresno}$). Henderson and Sachs (2006) showed that these local SEER values are much more in line with detailed energy simulations than the current generic SEER value.
- Constant and multi-speed systems are still compared on a fair basis in terms of energy efficiency. In contrast, switching to EER_{95} as the sole metric in hot-dry climates would ignore the part-load energy efficiency benefits of two-speed systems.
- Time (or temperature) dependent energy costs can be easily incorporated into the bin analysis to account for the fact that energy is more expensive when temperatures are higher. This would permit updating of the framework for considering energy costs when setting SEER standards.
- Compatibility with current federal and state regulations is maintained, since the current SEER (e.g., $SEER_{DOE}$) can be calculated by the original procedures to ensure compliance with current laws.

Thus, returning to the bin calculation procedure provides the means to move from a current single national metric to multiple efficiency metrics that can meet the needs of different regions. The paragraphs below discuss the different regional needs.

Hot-Dry climates. Energy consumption in hot, dry climates[13] correlates better with EER_{95} values than with the current SEER values (Horowitz 2004). A regional SEER value, determined with bin data for a Southwest climate, could solve this problem while also providing a fairer comparison of single and multi-speed systems than the steady state EER_{95}.

[11] This seems to be largely accommodated in the test method.
[12] Estimated total annual electricity use is disclosed, however, as the parameter Eae (GAMA 2005).
[13] Ariz., Calif., N.M., Nev., and Tex. from San Antonio west (Sachs 2004).

The regional SEER metric could also factor in temperature dependent costs such as the TDV costs that CEC now uses to evaluate energy efficiency programs in California (HMG 2002). An additional test point to determine EER_{115}, similar to the "T3" test condition in the draft ISO standard, would provide additional information about peak demand performance in this climate.

Hot-Humid climates. In the Southeast,[14] both efficiency and dehumidification performance are important. In many cases, conventional residential air conditioners may not allow SHRs low enough to meet design latent heat requirements for buildings with modest sensible loads. To address this, the most important step would be to provide an indication of moisture removal capability at moderate temperatures. The reported SHR should also correspond to the conditions used to determine the SEER value. A common rating point to determine efficiency and moisture removal will discourage manufacturers from selecting airflows and test conditions that maximize efficiency at the expense of latent performance.

Steady-State Rating Methods

One alternative to continued use of the seasonal approach (the SEER) would be to move to a system purely based on steady-state measurements (EER at one or more temperatures). In the simplest implementation, single-point EER-based methods are used for commercial unitary equipment >65,000 Btu/h. However, even in this case the rating is supplemented by (non-certified) application values, such as IPLV (integrated part-load value) that give designers necessary information. As another precedent, the U.S. has adopted International Organization for Standards standard ISO 13256-1 for water-to-air and brine-to-air heat pumps.[15] This gives ratings under three different conditions, so purchasers can select the equipment appropriate for their climate, whether Mediterranean or Nordic. ISO and ARI have also drafted a standard for ducted air-source equipment.

Standards could specify minimum values under each condition, or a national standard could be based on a simple or weighted average of steady-state EER at several temperatures. Steady-state EERS can also be used as the basis for regional standards by requiring equipment to meet a (normalized) EER appropriate for the region in which it is to be used. Normalization could take the form of the sum of three terms:

$$\text{Equation 2.} \qquad 13 \leq \alpha * (EER_{low}) + \beta * (EER_{medium}) + \gamma * (EER_{high})$$

where $EER_{low,}$ $EER_{medium,}$ and EER_{high} correspond to the respective ISO 13256-1 test points, and α, β, and γ would be empirical normalization coefficients, if this approach is feasible for broad classes of equipment.

In this approach, a hot climate rating might require rating with $\alpha = 0$, and $\beta < \gamma$ by some specified amount. Comparably, a humid climate rating might require minimum values of both α and γ, with a maximum SHR specified for $EER_{low.}$ Although the steady-state approach could be implemented, it has two major disadvantages. First, it will be hard for consumers and industry to make the transition to a completely new system. Second, it does not address cyclic loading

[14] MD, DE, DC, VA, NC, SC, GA, AL, MS, LA, AR, and TX—east of San Antonio (Sachs 2004).
[15] Generically, these are "water-source" and "ground-source" heat pumps. That method, ISO/PWD 13253R (ISO 1999), prescribes testing and reporting methods at three different outdoor conditions

issues. In effect, this obscures the advantages of two-speed or other modulating equipment, which will tend to run long periods at low capacity instead of cycling off and on.

Discussion: The Policy Implications

We have made a case for what is needed for ratings that are reliable indicators, reflect field conditions, can be easily used, and are relatively easy to carry out. This section takes a different perspective. The SEER method's present principal defects derive from its unrealistic test conditions (low static pressure, high entering wet bulb, etc.), and from the effort to have a single, national efficiency metric represent the disparate needs of different climate regions. The relevant parameters are different for hot-dry, hot-humid, and "normal" climates.

Our first recommendation is to change the test conditions. Then we consider whether to adopt optional regional rating methods that are scaled in SEER units. As we envision the outcome, manufacturers could continue using the improved national rating method and/or rate specific models by regional methods, but restrict their sales to the appropriate regions.

Test Conditions

We recommend the following test condition changes:

- Substantially raise the external static pressure under test conditions to more nearly reflect field conditions that are consistently found. High ESP is likely to be a continuing issue, as larger but better insulated houses and higher resistance air filters become more common.
- Change the test procedure entering temperatures to the indoor coil from 80°F dry bulb and 67°F wet bulb to 75°F dry bulb and 63°F wet bulb (52% RH). This will improve performance in humid conditions.
- To meet demands for high temperature performance in much of the country, we recommend adding an additional test point for determining capacity (and implicitly, EER) at 115°F, which is close to the upper test point for the proposed ISO ratings and already a test point for UL safety testing.
- Because air handling is a significant energy use, and because there is large variability among units sold, we recommend a minimum air handling efficiency requirement (W/cfm, or cfm/W).

These test point changes would allow implementation of alternative regional rating methods that reflect needs in hot-dry and hot-humid regions.

On the SEER Method

We recommend mandatory use of bin calculations to compute SEER values for all equipment classes. It is also worth considering abandoning the degradation coefficient Cd for rating central air conditioners (Equation 2). We believe this step is wiser than continuing to debate the appropriate values for Cd. This would decrease opportunities for "gaming" and simplify testing. This would somewhat improve average accuracy and make regional ratings feasible.

With changes in the method of test and agreement to implement regional alternative rating methods, the seasonal efficiency approach embodied in SEER could remain a useful way to help consumers select appropriate equipment for their needs. Its apparent uniformity across the country makes marketing easier and helps contractors explain the value of options. Even our call for regional SEER variants actually has a precedent today: the present federal method also includes an example of a mandatory regional rating variant. Section II.A.4 (p. 59125) of DOE (2005) requires some specific test conditions for "two-capacity, northern heat pumps."

Steady-State Rating Methods

We believe that moving from seasonal measures (SEER) to a system purely based on steady-state measurements (EER at one or more temperatures) is unlikely to offer benefits as great as those from new approaches to SEER. The steady-state approach has two major disadvantages. First, it does not address seasonal loading issues. Second, it would be hard for consumers and industry to make the transition to a completely new system.

Process

Changing the present rating methods effectively requires a consensus among utilities, consumers, manufacturers, and other stakeholders. We believe that this is the right time for exploring the issues to develop a consensus. The SEER 13 standard has just been implemented, so there is time before the next rulemaking round. Indeed, DOE has called for test method review for central air conditioners by September, 2007 (DOE 2006)[16] and has also expressed a preference for consensus recommendations. In order to develop consensus, the following issues and perspectives need to be addressed:

- Utilities and efficiency supporters will want a test procedure that better matches field performance. To get manufacturer acceptance, such a change cannot make it more difficult to meet the SEER 13 standard. This means either the new procedure should not go into effect until the next standard goes into effect or the SEER 13 standard would need to be adjusted, in accordance with existing law, so that a sample of products that just meet SEER 13 under the present test procedure would on average just meet the new standard under the new test procedure.[17]
- Manufacturers are interested in test procedures that are no more difficult to implement than the current procedure and preferably would like an easier procedure. They also are interested in better differentiating value-added equipment. Some of the changes we suggest address this second interest but it is unclear, on net, whether our proposed changes make testing simpler or more complicated.
- Many utilities and state officials, particularly in the West, want a standard that addresses peak demand, including peak demand at temperatures above 95^{o}F. Likewise, officials in the South are concerned about the health impacts of high indoor humidity. These considerations will need to be balanced against manufacturer concerns about keeping testing burdens manageable. Some manufacturers are also concerned about regional

[16] A revised test procedure can take effect concurrently with developing the next version of the standard, as happened with clothes washers.
[17] Energy Policy and Conservation Act as amended, section 323, subsection (e).

differentiation, worrying that regional test procedures could lead to regional standards, increasing compliance burdens.

Thus, we conclude that all stakeholders could benefit from changes in how the U.S. rates residential air conditioners, but there are also a variety of concerns that must be addressed. To achieve these benefits will require a careful balancing of interests and that all parties "suspend disbelief" and agree to explore mutually beneficial opportunities.

Conclusions

1. The Seasonal Energy Efficiency Rating (SEER) used to estimate the efficiency of central air conditioners in the U.S. reflects enormous work by industry and standards groups, and has been useful for two decades.
2. It is time to reconsider SEER. The Method of Test does not reflect field conditions, particularly the pressure drops from ductwork and high performance air filters, and the effect of pressure drops on fan power. A fan power metric (e.g., W/cfm or cfm/W) is needed, too. Equipment optimized for real-world conditions will be more efficient in actual use.
3. The single national standard does not serve well in hot-dry and hot-humid climates. Large efficiency and comfort improvements may be possible from optional regional standards that respectively give credit for very high temperature performance and improved humidity control. Regional standards could be implemented within SEER.

We believe that serious debate about changing our approach to rating air conditioners is a road worth taking.[18]

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[18] This discussion has been limited to mainstream split and packaged systems. Special considerations may be required for niche products and emerging technologies. These include small diameter, high velocity (SDHV) systems with very high intrinsic fan energy requirements. There are also challenges today to adapt rating methods for "ductless" or "mini-split" systems that use a single modulating compressor to support multiple evaporators.

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