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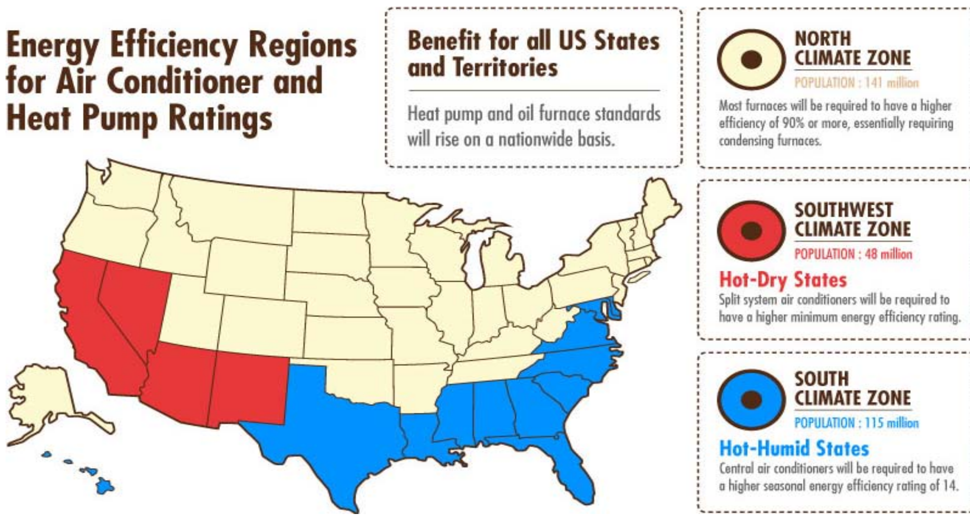
The Phoenix Factor versus the Atlanta Aspect: Regionalizing Central Air Conditioner Performance Ratings Promises Big Savings

by Jim Arwood & Leo Wiegman

Sonia lives in Phoenix, Arizona. Her twin sister, Caroline, lives in Atlanta, Georgia. They both moved into older homes last year and needed to buy new central air-conditioning systems. Sonia and Caroline are careful shoppers and compared notes as they did their research. To curb their monthly utility bills, they both needed to find the most energy-efficient air conditioner possible.

Sonia and Caroline discovered that air conditioners have efficiency ratings. The higher a unit's Seasonal Energy Efficiency Rating (SEER), the more cooling output the system delivers for the same electricity consumed. SEER is to central air-conditioning what MPG is to vehicle fuel mileage. Sonia and Caroline found identical systems for a very good price and bought them.



One year later, Sonia and Caroline compared notes on their new systems and their electric bills. They were both unpleasantly surprised to discover that their new efficient systems actually cost much more to operate than predicted. On top of that, Caroline discovered that her Atlanta home has a mold problem. And Sonia finds that her system runs constantly during the hours that her utility's electric rates are highest. Sonia and Caroline may be fictional, but this story shows how one-size-fits-all national air conditioner ratings can give perverse results.

Our national cooling load represents a huge conservation and efficiency opportunity. Air conditioners consume about 5 percent of the electricity used in American homes and cost homeowners about $15 billion annually, according to the American Council for an Energy-Efficient Economy (ACEEE). The household savings from much higher efficiency have been in the range of $50 per year for average U.S. energy prices. For example, when an old air conditioner with the minimum SEER 13 rating is replaced with a new unit with a SEER 16 rating.

The SEER rating only purports to measure the relative efficiency across different models of air conditioners. However, the original equipment manufacturers often suggest that SEER can be a predictor of electricity consumption for a particular home. Our twins, Sonia and Caroline, discovered one of the major weaknesses of the rating system: central air conditioners often use 10 to 30 percent more electricity than laboratory-based efficiency ratings predict.

In addition, the efficiency standards that manufacturers and consumers must use as guidelines make no allowance for the strong regional differences in seasonal climates throughout the United States. What if consumers in the Southwest could determine which air-conditioning systems provide the lowest cost of operation tailored to their hot-dry climate, thereby helping utilities to avoid investments in generators only used under peak demand conditions? What if residents of the Southeast could determine which heating and cooling equipment would be most cost-effective in combating spring and fall humidity?

Revising efficiency standards involves many stakeholders, from industry groups and national energy organizations to state and federal agencies as well as Congress. The State Technologies Advancement Collaborative (STAC) —a joint program of the National Association of State Energy Officials (NASEO), Association of State Energy Research & Technology Transfer Institutions (ASERTTI), and the U.S. Department of Energy (DOE)—acted as the catalyst for an important review of the strengths and weaknesses of SEER ratings for air conditioners and heat pumps. Using funds from NASEO and ASERTTI members, including the New York State Energy Research and Development Authority (NYSERDA), Florida Solar Energy Center, California Energy Commission, Energy Center of Wisconsin, as well as the DOE and others, STAC gathered $1.5 million to underwrite the cost of the multiyear research process.

In 2004, the two-year project (integrating research, development, initial deployment, and dissemination) began evaluating the efficiency of residential central air conditioners, with NYSERDA as the lead contractor and state-chartered organizations as partners. By 2006, the research results pointed strongly to the value of different standards for different climate zones. These findings, in turn, helped shape key provisions in the Energy Independence and Security Act of 2007 that requires the DOE to give deference to consensus agreements by stakeholders for regional standards.

“I regard the STAC work as catalytic,” notes the project’s technical director, Harvey Sachs of ACEEE. “The STAC project showed a clear rationale for regional air conditioner standards. This work complemented the obvious rationale for more expensive condensing furnaces in cold climates, a position that ACEEE had advocated for quite a while.”

Changing the system of measuring air conditioner performance is serious business, with large potential impacts on manufacturers and U.S. energy use. Findings from the multiyear STAC study, “Closing the Gap: Getting Full Performance from Air Conditioners,” are part of the foundation of an agreement that could yield $13 billion in net savings for the nation’s residential homeowners between 2013 and 2030, including the cost of new, more efficient equipment.

In short, the modest state and federal investment in this STAC project will lead to savings for American households of $700 million a year for the next two decades. The research funded by STAC created a widely accepted foundation for regional standards. That justification prompted a second legislative step: the Energy Independence and Security Act provision of 2007 that told the DOE to look at regional standards. This shift motivated the stakeholders to reach a consensus agreement about revised standards that would be accepted by both industry and consumer advocates.

In October 2009, the nation’s leading manufacturers of residential central air conditioners, furnaces, and heat pumps signed a groundbreaking, voluntary agreement with the nation’s leading energy efficiency advocacy organizations representing the states in support of new federal standards for their products. Taking effect in 2013, the consensus agreement calls for replacing current “one size fits all” standards with the adoption of new efficiency standards in each of three specific U.S. regions: the North, South, and Southwest. The agreement also calls for more stringent building code requirements in new construction, which will require legislative action that all the stakeholder groups support. The agreement has been submitted to the DOE for adoption as consensus among the key stakeholders. This consensus allows both industry and advocates to avoid a lengthy, contested rule-making process at the DOE, a positive outcome for all parties concerned. The manufacturers, state agencies, utilities, and advocacy groups that signed the consensus agreement say it represents the maximum levels that are technologically and economically justified, as the law requires. The agreement also calls for congressional action to update some building code provisions to achieve higher energy efficiency in new or significantly upsized buildings.

The combined impact is impressive: increased efficiency of central air conditioners, furnaces, and heat pumps called for in the agreement will reduce energy consumption by 3.7 quadrillion Btu. The new standards would raise the minimum efficiency of residential central air-conditioning systems by about 8 percent and of furnaces by about 13 percent, and would result in a 5 percent reduction of the total heating energy load and a 6 percent reduction of the total cooling energy load in 2030.

The agreement sets two new regional furnace standards and three new levels for air conditioners, so investments in heating and cooling efficiency will be more appropriate for the climate in each region. In the North, most furnaces will be required to have an efficiency of 90 percent or more, essentially requiring condensing furnaces. This is a change from the current national standard of 78 percent. In the South, central air conditioners will be required to have a SEER 14 rating, up from the present national requirement of SEER 13. Heat pump and oil furnace standards will rise on a nationwide basis. In addition, under the agreement, the DOE would be required to publish a final rule by the middle of 2011 that determines whether standards for through-the-wall and small-duct, high-velocity air conditioners and heat pumps should be amended as well.

“All of this work started by STAC culminated in a historic agreement between manufacturers and government. Furnaces and AC units that don’t perform well in certain climates will not be installed in regions with those climates,” notes NYSERDA’s Peter Douglas, the program’s manager and lead sponsor and ASERTTI member. “This outcome has a huge potential impact on the energy efficiency of the nation and will result in significant energy savings.”

The DOE has not yet conducted its rule-making session on how to enforce the regional standards. This task is likely to be handed down to building code officials at the state level. If so, state codes will be able to require somewhat higher performance for new construction baselines than the minimum standards in the consensus agreement. Such flexibility for the states has big implications for fine-tuning local building codes to maximize energy savings. In addition, under the consensus agreement, the equipment manufacturers will release important performance information that should allow for better design of weatherization and incentive programs than we have had in the past.

Air-conditioning labeling needs have evolved since the SEER was first developed and then implemented in 1982, when energy efficiency and consumption was the original focus. Today, electric utilities across the United States face grave challenges over their ability to meet peak demands during the hot summer periods. With the value of avoiding new investments in the electric grid estimated at $1,000 per kilowatt in California, shaving peak demand is a strong fiscal motivator for utilities. If time-of-day pricing becomes important in the residential market as it already is in California, peak performance will also become a pocketbook issue to consumers.

For residents of the hot-dry regions of California, Arizona, Nevada, and New Mexico, SEER underestimates actual energy use at peak times. For the hot-humid regions of the South, the average SEER label doesn't even consider dehumidification capacity. For many homes that use one duct system for both heating and cooling, the current SEER system assumes very low flow resistance to the air distribution system, which underestimates the fan power needed to push cool air through the ducts. The current SEER labels are not required to report the efficiency of the fan, and the default rating method underestimates the benefits of better fans and more efficient fan motors.

About 30 percent of energy use in some California cities occurs at 95°F or above. For the 48 million residents of the Southwest, this "Phoenix factor" pattern is typical. But the SEER testing process assumes that only an average of 2 percent of the cooling hours occur at or above an outdoor temperature of 95°F. This mismatch between the hot-dry conditions of the Southwest and the cooler and more humid average test conditions of the SEER laboratory leads to ratings that overestimate the efficiency of central air systems in the Southwest. This is why California compelled manufacturers to list the Energy Efficiency Ratio (EER), a steady-state measure of performance at 95°F, and an interim measure that is a better predictor of seasonal energy use than SEER. The DOE data show that the nation's six hottest cities are Phoenix, Bakersfield, Tucson, Dagget, Las Vegas, and Phoenix.

In cities from Phoenix to Fresno, heat reduction, also known as sensible cooling, is critical. In addition, the air-conditioning unit must operate efficiently at temperatures that often exceed 100°F. In California and the arid Southwest, an optimized air conditioner could have a relatively warm evaporator and do less latent dehumidification work. All other things being equal, this mechanical change could increase measured energy efficiency during the hotter and drier hours of the day. As a response, the consensus agreement specifies new higher minimum energy efficiency rating values for split air-conditioning systems sold in Arizona, California, Nevada, and New Mexico, to project a more realistic energy demand on a very hot day.

"Our analysis used weather data for several Southwestern cities in the SEER calculation procedures and showed that bin-calculated SEERs in hot, dry climates are 4 to 7 percent lower than the nominal SEER," notes Harvey Sachs of ACEEE. "That means a new hot-dry metric could help manufacturers sell systems tailored to the Southwest. And that those consumers could lower their operating costs 5 percent or more with those conditioners."

In contrast to the Southwest, 115 million residents in the South encounter higher humidity than the national average at lower temperatures than in the Southwest. Units in most of the South rarely see temperatures exceeding 95°F and operate hundreds of hours at milder temperatures. To combat humidity, an optimized air conditioner might have a colder coil to increase dehumidification, especially in part-load, lower temperature conditions. The initial focus for SEER during its development was on the ability to control temperature as the whole of thermal comfort. While efficiency for the South is reasonably well represented by SEER, the rating system has no explicit references to humidity control.

Over the past twenty-five years, new residences have seen improved performance due to increased insulation requirements, better windows, and some infiltration control. Ironically, however, a newer, more airtight home makes controlling humidity a more significant issue for consumers and the building industry, especially in the South.

In spring and fall in Atlanta or Houston, while outdoor temperatures hover in the low 70s, more than half the cooling load is latent from dehumidification. The consensus agreement requires that manufacturers disclose the sensible heat ratio at 82°F more prominently on equipment labels. A sensible heat ratio at 82°F at the lowest capacity cooling will help gauge the effectiveness of the system's dehumidification performance and will provide customers and contractors with a better way to understand the tradeoffs between capacity and efficiency.

"Manufacturers will provide a lot more information on performance in a humid climate," Harvey Sachs explains. "That in turn will help contractors write better proposals for equipment with realistic good-better-best measures that more closely meet the needs of specific houses."

Roughly 2 to 6 percent of annual electricity use is needed for the air-handler fans associated with central air-conditioning. Many homes have a combined heating and cooling system in which a fan forces air heated by a furnace or cooled by a central air conditioner through ducts to outlets in the rooms. The furnace, often fired by natural gas, has high operating temperatures relative to the desired indoor temperature of around 70°F. Therefore, manufacturers optimize hot air handlers to produce a low flow of air that is much hotter than the desired room temperature. Yet, the air-conditioning system condenser operates at a temperature much closer to the desired indoor temperature. A fan optimized for a low flow of hot air in winter may not deliver an adequate flow of cool air in summer at the same level of power. It must work harder to deliver a higher volume of cool air in the summer. In short, if fan tests used a higher power per unit airflow, typically of watts per cubic feet per minute, efficiency and capacity ratings would more closely match actual year-round home conditions.

The "Closing the Gap" report recommended several implementations of new test conditions for fan power, efficiency, and pressure levels within ducts to reflect actual field conditions. The consensus agreement did not include these measures, such as adding the power per unit airflow information to the rating label. That information would allow consumers to gauge the impact of fan efficiency on energy use.

Finally, no data is currently provided on the efficiency and capacity of air conditioners at extreme conditions. Yet, extreme temperatures are common and may become more frequent as climate disruption continues to unfold. In Sacramento, almost 40 percent of cooling energy is consumed at outdoor temperatures above 90°F and 10 percent is consumed at or above 95°F. Stress on the utility transmission grid to deliver electricity is highest when outdoor temperatures and power demand soar. Knowing how efficiently an air conditioner operates at an extreme temperature can help consumers make better choices as well. The consensus agreement will require manufacturers to disclose performance measures across an expanded temperature range. This publication of the higher temperature performance data may provide the means to rate the impact of air conditioners on generation, transmission, and distribution requirements, when demand load peaks during especially hot weather.

Soon Sonia will be able to see from the rating label on an air-conditioning system whether it performs efficiently for long periods in 95° F weather. Caroline will be able to find an air conditioner that is very good at dehumidifying her home in the spring and fall when moisture content is high, but the outside temperature is only 75° F.

As these new regional efficiency ratings become standard practice, all contractors and consumers will have more realistic performance predictions to help them specify and buy air-conditioning, furnace, and heat pump systems that cost less to operate in their region's specific climate.
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