The Energy Nerd

Analysis and insight into the renewable energy sector.

Monday, May 9, 2011

The Fascinating World of Air Conditioner Efficiency

I was inspired to write about the oh-so-sexy topic of air conditioner efficiency and consumer behavior patterns after reading an innocuous article in Slate today. The author, Brian Palmer, did a thorough job of summarizing pros and cons, however (and here's where I think he opened up his article to vehement commentary) concluded that it's difficult to say which method of cooling is more energy efficient. In fact, window ACs use less energy than central ACs despite lower SEER ratings, but rather than narrowing our focus on trying to criticize a single article, let's open up the discussion a bit, because, surprisingly, we use a great deal of energy just to keep ourselves comfortable.

According to the DOE's Energy Information Administration (probably my favorite reference), Americans used 24.5% of their electricity to keep themselves cool at home [1]. Looking at the US, this accounts for 7% of ALL electricity usage [2]. And the major contributor to AC energy use is central AC systems at 3745 kWh/year vs. 1259 kWh/year for window AC systems. Now, these are just household-level numbers, which don't take into account any confounding variables. One study, by a David Rapson of UC Berkley's Department of Economics, points out that households with central ACs are larger and are in climates with more cooling degree days (see Table 2) [3]. Even factoring that in, window ACs use less energy on a per cooling degree day and per square footage basis by a factor of 1.75. So there you have it: window ACs are better at cooling a space efficiently than central ACs.

But why? Why should window ACs, which have a lower SEER rating, use less energy than central ACs? Murphy's law provides a bit of insight here. Central AC systems are more than just the air handler and compressor that comprises the window AC unit. There's dozens of linear feet of air ducting, an automatic control system, and the whole system has to be engineered and installed by some contractor. A quick survey of central AC units in Austin, TX by a few University of Texas, Austin engineering students revealed blowers to circulate cooled air were operating too high, unsealed ducts leaking cooled air to the environment, control systems extending operating times, and systems being oversized from specification [4]. The result is a high efficiency compressor but low efficiency ducting and control systems.

But that only covers energy efficiency. What about consumer behavior? After all, this is a blog about behavior change. Well, the brilliant minds at the EIA have that covered; a

section of their RECS questionnaire was about thermostats and usage. Of the 64 million central AC systems, 40 million consumers reported running them all summer, while 11 of the 27 million households that use window AC units report using them "only a few times when needed." And while fewer window AC units had programmable thermostats (only 15%), users simply turned them off or on when necessary. Conversely, 39% of central AC units had programmable thermostats, but 64% of users actually use the programmable thermostats as indicated.

The bottom line seems to be that households with window air conditioners use them more consciously (and conscientiously) to cool smaller areas within the home, while households with central AC allow their units to run continuously and cool the entire home, whether it's necessary or not. Hence the factor 1.75 lower energy consumption per household for homes that use window AC units vs. central AC units.

ACs represent an interesting home appliance where improvements in consumer usage behavior can be just as important as improvements in unit energy efficiency. Now it's just a matter of encouraging the right behavior...

---

[1] http://www.eia.gov/emeu/recs/recs2005/c&e/airconditioning/pdf/alltables1-11.pdf
[2] http://www.eia.doe.gov/cneaf/electricity/epm/table5_1.html
[3] http://www.econ.ucdavis.edu/faculty/dsrapson/Rapson_LR_electricity.pdf
[4] http://bit.ly/msvo1j (unfortunately, I don't have the full article on this one, just the abstract)

Posted by Tim Grejtak

Tim Grejtak
Mechanical Engineer at Lockheed Martin Advanced Energy Storage LLC
Greater Boston Area
Mechanical or Industrial Engineering

Current	1.	**Lockheed Martin**
Previous	1.	**Sun Catalytix**,
	2.	**Massachusetts Institute of Technology**,
	3.	MIT Dorm Electricity Competition
Education	1.	Massachusetts Institute of Technology