Peak Demand and Energy Savings from Properly Sized and Matched Air Conditioners

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ABSTRACT

Air conditioner energy efficiency ratings generally decrease by 2 to 8% per ton as the cooling capacity increases, and most residential and commercial air conditioners in the United States are oversized by 25 to 50%. Published field studies from pilot programs in hot climates have reported peak demand savings of 0.4 to 1.6 kW per unit for properly sized air conditioners. Improperly matched evaporators and condensers (even systems listed in the Air-conditioning and Refrigeration Institute directory) can reduce efficiency by 4 to 27% and increase peak demand by 0.2 to 1.2 kW per unit. Residential and commercial air conditioning electricity consumption in the United States accounts for 45% of average summer peak-day loads and 13% of total electricity usage. Potential savings from properly sized and matched air conditioners are estimated to be 37.2 +/- 2.2 GW and 10.2 +/- 1.8 TWh per year, and 6.6 +/- 1.1 million metric tones of carbon dioxide per year. The economic savings in terms of avoided power plants and unnecessary air conditioning equipment are estimated to be $61 to $122 billion.

Introduction

Research studies have shown that 50 to 70 percent (%) of residential and commercial air conditioning systems are oversized by 120% or more (James, et al 1997; Sonne, et al 2006; Mowris, 2006; Nadel 1998; Parker 1993; Jacobs 2003; Felts 1998; ACCA 2006). Air conditioners are typically oversized to compensate for installation design flaws and defects, such as cooling equipment installed in hot attics, leaky ducts, improper refrigerant charge and airflow (RCA), improper maintenance, or mismatched evaporator and condenser coils (Mowris et al 2007). Most homes in California have cooling equipment and ducts installed in hot attics where temperatures can reach 140 degrees Fahrenheit (°F) in the late afternoon (Parker 1998). This can add approximately 6,000 British thermal units per hour (Btu/hr) to the cooling load (Parker 1993).[1] Most air conditioning contractors in the United States do not know how to use the Air Conditioner Contractors of America (ACCA) Manual J sizing guidelines to specify and install properly sized air conditioners (Vieira, et al 1996; Mowris 2006). The Seasonal Energy Efficiency Rating (SEER) and Energy Efficiency Rating (EER) of air conditioners generally decrease by about 2 to 8% per ton as the cooling capacity increases.[2] Published field studies in hot climates have reported peak demand savings of 0.4 to 1.6 kW per unit for properly sized air conditioners. Residential and commercial air conditioning electricity consumption in the United States accounts for 45% of average summer peak-day loads and 13% of total electricity usage

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[1] The British thermal unit (Btu) is the energy required to raise one pound of water one degree Fahrenheit.

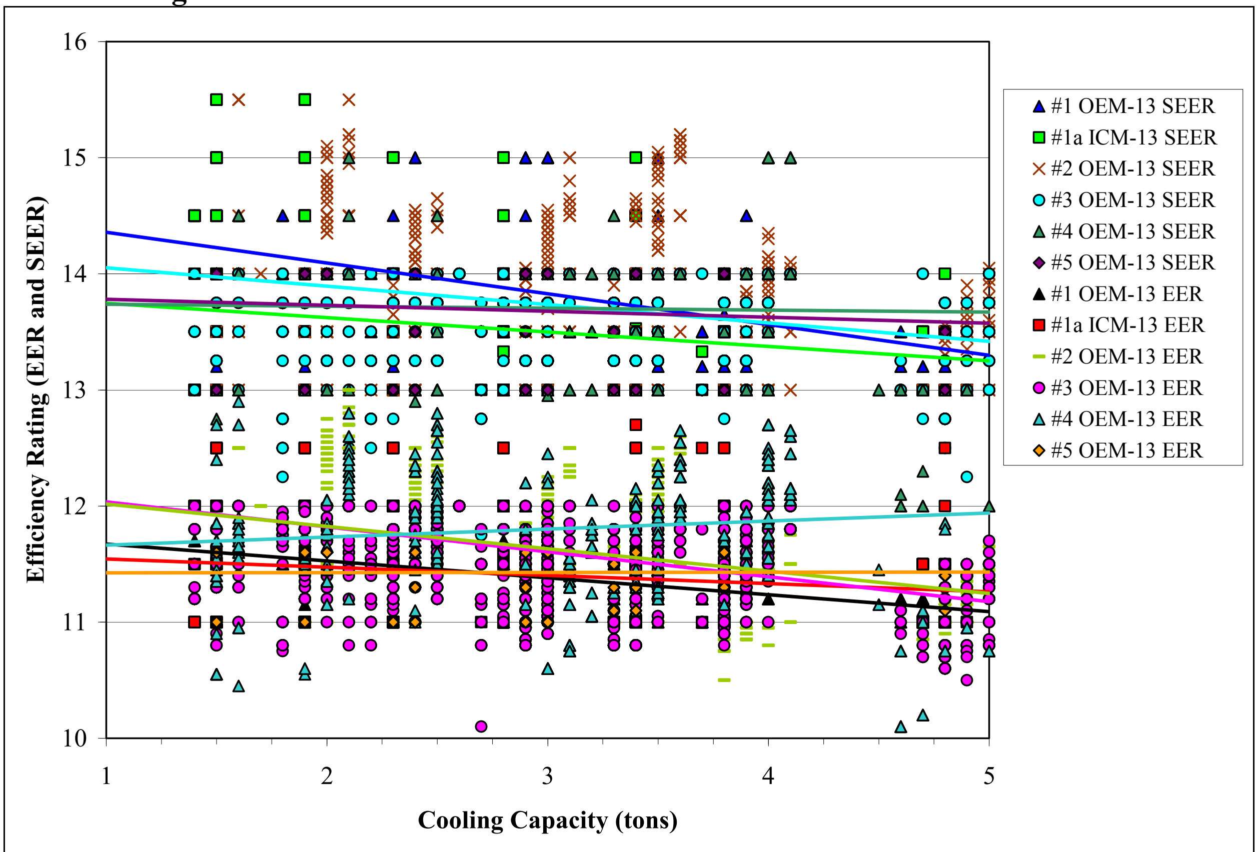
[2] SEER is an adjusted rating based on steady-state EER measured at 82°F outdoor and 80°F drybulb/67°F wetbulb indoor temperature multiplied by the Part Load Factor with a default of 0.875 (ARI 2003). The energy efficiency ratio or EER is the cooling capacity in thousand Btu per hour (MBtuh) divided by total air conditioner electric power (kW) including indoor fan, outdoor condensing fan, compressor, and controls. EER is typically measured under laboratory conditions at 95°F condenser entering air, 80°F drybulb, and 67°F wetbulb evaporator entering air.

(ERE 2007). Several studies have shown that oversizing air conditioners by 100 to 150% above Manual J specifications increased peak demand by 20 to 50% and increased energy use by 2 to 10% (Sonne et al 2006; James 1997; Mowris 2006).

ARI Efficiency Ratings of New Split-System Air Conditioners

All air conditioners and heat pumps (in cooling mode) with cooling capacities less than 65,000 British thermal units per hour (Btu/hour) are required by Federal Law (USDOE 2004) to meet the minimum Seasonal Energy Efficiency Rating of 13.0. The American Refrigeration Institute (ARI) provides efficiency ratings of air conditioners and heat pumps. **Figure 1** shows SEER and EER data from the ARI directory for nominal 13-SEER split-system air conditioners using R410A refrigerant ranging in size from 1.5 to 5 tons of cooling capacity.[3]

Figure 1. SEER and EER Data for Nominal 13-SEER Air Conditioners



Source: ARI 2008

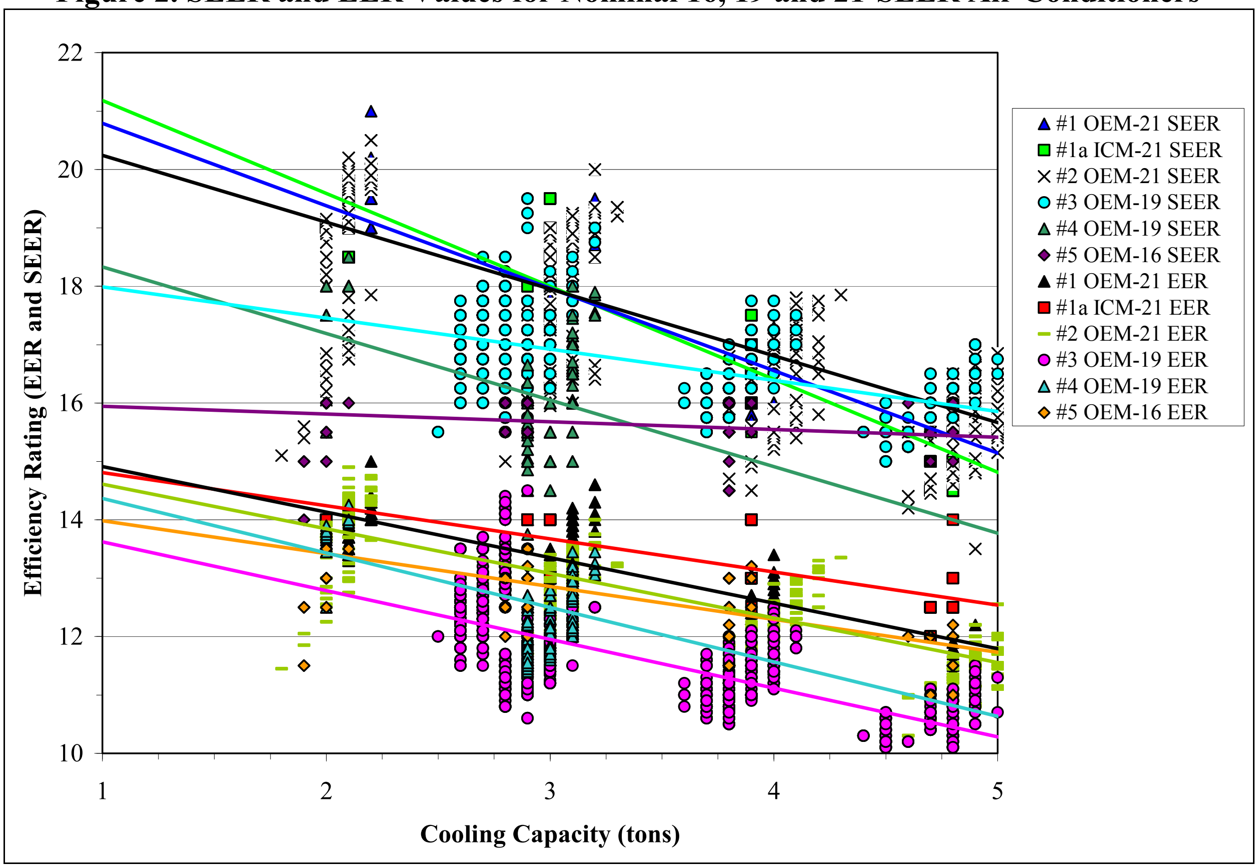
All units represented in **Figure 1** meet the minimum 13 SEER requirement. Some units in **Figure 1** have higher SEER values (i.e., up to 15.5 SEER), but all condensing units are nominally rated at 13 SEER. Data shown in **Figure 1** are labeled "OEM" for original equipment manufacturer (i.e., same manufacturer for condensing coil and evaporator coil) and "ICM" for independent coil manufacturer (i.e., OEM condensing coil and third-party evaporator coil). The

[3] The "ton" is defined as 12,000 Btu per hour of cooling capacity equal to the rate of extraction of latent heat when one short ton of ice (i.e., 144 Btu per pound) is produced from water at the same temperature.

data are representative of a cross section of manufacturers and residential split-system models accounting for approximately 82% of the US market. **Figure 1** shows some ICM air conditioners with 0.5 to 1 point higher efficiency ratings than OEM air conditioners with the same condensing unit (see #1a ICM - green and orange square symbols). The ICM ratings are based on computer simulations and the OEM ratings are based on laboratory measurements.[4] One study found cause for concern with actual SEER values being 59% and 84% of simulated values due to constant fan operation degrading seasonal efficiencies and reducing dehumidification (Proctor et al 2006). **Figure 1** shows that nominal 13-SEER air conditioners generally have consistent efficiency ratings decreasing by approximately 2% per ton for OEM units and 1% per ton for ICM units across all cooling capacities.

Figure 2 shows SEER and EER data from the ARI directory for nominal 16, 19 and 21-SEER residential split-system air conditioners using R410A refrigerant ranging in size from 1.5 to 5 tons of cooling capacity.

Figure 2. SEER and EER Values for Nominal 16, 19 and 21-SEER Air Conditioners



Source: ARI 2008

The data shown in **Figure 2** represent the highest efficiency units currently sold by the top five manufacturers. For the high-efficiency split systems shown in **Figure 2**, the EER and SEER values generally decrease by approximately 4 to 8% per ton respectively as the cooling capacity increases based on a simple best-fit linear regression. Only a few of the small 2-ton units meet the nominal 16, 19 or 21-SEER values. The 5-ton nominal 21-SEER units have an

[4] AHRI allows ICM ratings to be performed using simulations due to the wide number of coil combinations.

average rating of 14.5 SEER and 11.1 EER. This isn't much better than the nominal 13-SEER 5-ton units rated at 13.5 SEER and 11.1 EER. The nominal 16-SEER units are generally more efficient on peak than the nominal 19-SEER units, and the 16-SEER units provide comparable efficiency to 21-SEER units above 4 tons of cooling capacity. **Figures 1** and **2** also show that improperly matched evaporator coils can reduce the SEER or EER value by 0.5 to 3.5 points representing potential peak demand savings of 4 to 27% for efficient coil matching.

The potential efficiency improvement from properly matched evaporators is shown in **Table 1**. The OEM and ICM evaporators are paired with the same nominal 3-ton 13-SEER and 16-SEER OEM condensers. For these examples, properly matched evaporators improve efficiency by 1.6 EER points (14%) and 2 SEER points (15.4%) for the same 13-SEER condensers and 2 to 3.5 EER points (27.3%) and 3.6 to 3.8 SEER points (24.7%) for the same 16-SEER condensers (ARI 2008). The potential peak demand savings are 0.2 to 1.2 kW depending on cooling capacity and coil combinations. Contractors and customers often make decisions about efficiency based on the nominal SEER ratings of condensers rather than the ARI rating for properly matched evaporators. Many energy efficiency program incentive applications are either rejected or downgraded to lower incentive levels due to this problem (SCE 2008). The value to society for properly matched evaporators ranges from $280 to $1680 dollars per system (valued at $1400 per kW for coal power without carbon sequestration).

Table 1. Potential Efficiency Improvement from Properly Matched Evaporators

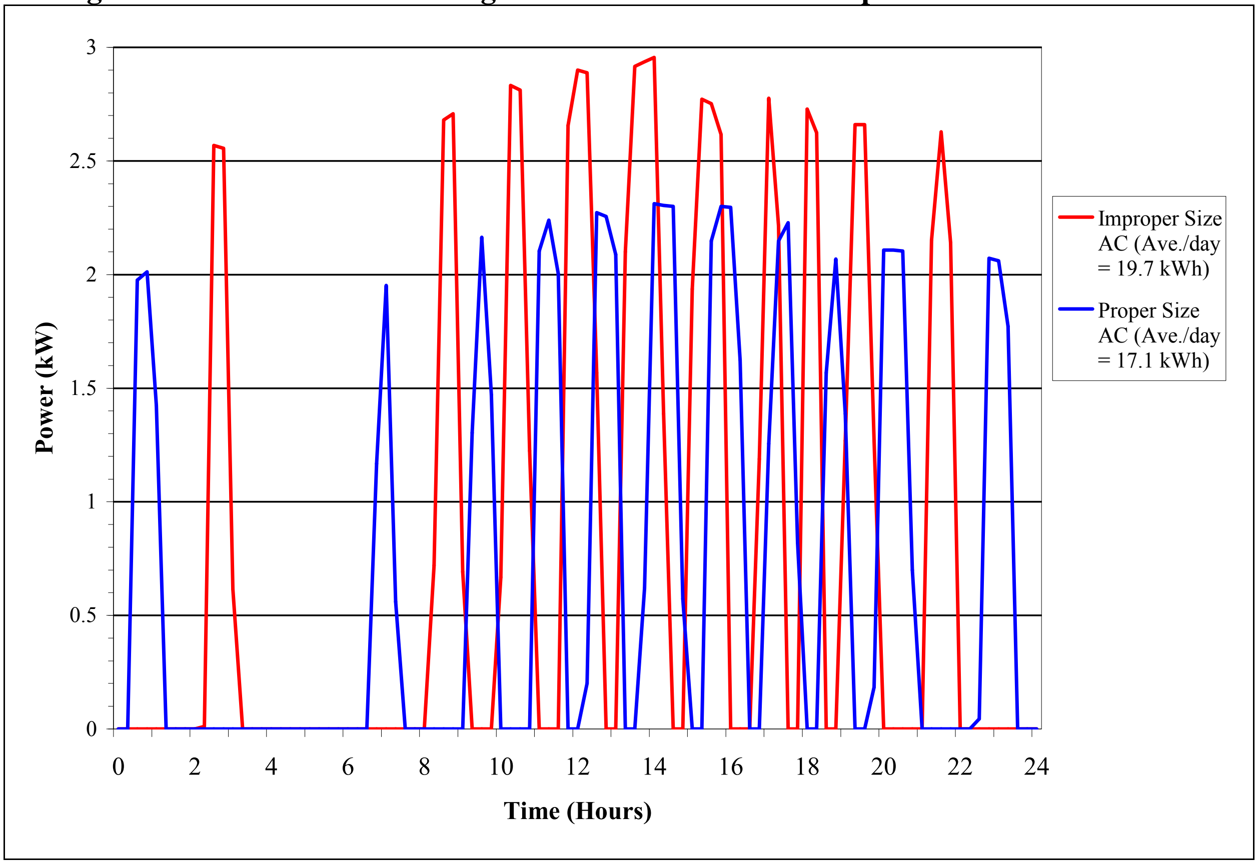
Nominal Condenser	Evaporator Make	Improperly Matched Evaporator EER/SEER	Properly Matched Evaporator EER/SEER	Efficiency Improvement ΔEER	Efficiency Improvement ΔSEER	Savings kW
13 SEER	OEM	11 EER/13 SEER	12.6 EER/15 SEER	1.6	2	0.39
13 SEER	ICM	11 EER/13 SEER	12.5 EER/15 SEER	1.5	2	0.49
16 SEER	OEM	10.6 EER/13 SEER	12.6 EER/16.6 SEER	2	3.6	0.54
16 SEER	ICM	9 EER/11.2 SEER	12.5 EER/15 SEER	3.5	3.8	1.12

Source: ARI 2008

Field Measurements of Properly Sized Systems

Properly sized systems (per ACCA Manual J or N) improve the efficiency of split-system and packaged air conditioners (ACCA 2006). **Figure 3** shows field measured maximum demand savings of 0.66 kW from proper sized coils (Sonne et al 2006). The original unit used 2.96 kW and the properly sized unit used 2.3 kW. Average peak demand savings are 5 to 27% and average energy savings are 2 to 5% for properly sized systems. These savings are based on field studies showing units are significantly oversized, resulting in inefficient operation, reduced reliability due to frequent compressor cycling, and poor humidity control (Jacobs 2003). Properly sized systems require less operational time and achieve 29% to 50% peak electricity demand savings (Ibid).

Figure 3. Measurements of Original Oversize and New Proper Size Air Conditioner



Source: Sonne et al 2006

The following example illustrates the potential peak demand savings from properly sized air conditioners. If a building has a peak cooling load of 3 tons and an over-sized 5-ton unit is installed, then the difference in peak demand will be approximately 2 kW, i.e., equivalent to the difference in tons. If both units are nominal 13 SEER and 11 EER, then the 5-ton unit will use approximately 2.2 kW more than the 3-ton unit. If both units are nominal 21 SEER then the 5-ton unit will use approximately 2.9 kW more than the 3-ton unit.[5] The difference could be even greater, i.e., 3.1 to 4.1 kW, if the evaporator is improperly matched. Installing improperly sized and improperly matched air conditioners is costly to end users and society. Government labeling programs (such as Energy Star) and utility incentive programs should provide information to customers and training to contractors, and distributors about these issues to save money on unnecessarily large systems and to realize large and reliable peak demand savings. The cost to install properly sized and matched air conditioners is often negative.

An evaluation study for the Environmental Protection Agency (EPA) Installation Pilot Commissioning Project in Northern California found new cooling equipment was over sized by 163 +/- 29% and heating equipment was over sized by 117 +/- 48% (Mowris 2006). Contractors in the program received training and incentives to work with third-party verification service providers (VSPs) to perform refrigerant charge, airflow, and duct leakage testing to comply with the Air Conditioning Contractors of America (ACCA) quality installation (QI) guidelines

[5] If the 5-ton nominal 21-SEER unit is rated at 14.5 SEER and 11.1 EER, then it will use 5.41 kW. If the 3-ton nominal 21-SEER unit is rated at 20 SEER and 14.6 EER, then it will use 2.47 kW. The difference is 2.94 kW.

(ACCA 2008). The ACCA QI guidelines include heating, ventilation, and air conditioning (HVAC) equipment sizing with adherence to ACCA Manual J (or N for small commercial). The cooling capacity must be within 105 +/- 10% of the calculated cooling load for air conditioners and heat pumps and the heating capacity must be between 120 +/- 15% of the calculated heating load. The contractors did not verify equipment sizing with the VSP. Without VSP involvement to check equipment sizing, the contractors used "rules of thumb" and installed oversized replacement equipment. The cooling equipment was oversized by an average of 0.95 +/- 0.4 tons adding unnecessary peak demand of 1.05 +/- 0.44 kW per site. The potential peak demand savings from proper sizing of air conditioning equipment are 3 to 10 times greater than savings from proper refrigerant charge, airflow or duct leakage. The participating homes were built before the California Energy Commission (CEC) adopted the residential energy conservation standards in 1978 (CEC 1978). If the homes were retrofitted with a cool roof or cool attic (i.e., attic insulation, radiant barriers, and efficient attic ventilation) and energy efficient low-emissivity windows, the air conditioners could have been downsized even more.

The ACCA Manual J and Manual N software sizing calculations are sensitive to cooling loads such as duct leakage and hot roofs or attics. It isn't possible with currently available software to enter duct leakage as a percentage of total system airflow without causing problems with the attic-to-duct heat-load model.[6] Manual J could be improved in several areas, particularly with respect to duct leakage and cool roofs or attics. The software is easy to use if data is entered with available visual drawing tools, but difficult to use if data is entered using a spreadsheet (i.e., the ACCA Manual J spreadsheet). This is one reason why few HVAC dealers and designers perform Manual J calculations properly.

Oversized systems waste capital invested in the HVAC unit and air-distribution system as well as the electricity supply system. Oversizing also affects the ability of the system to provide simultaneous economizer and compressor operation, and oversizing exacerbates problems with distribution system fan power, since larger units are supplied with larger fans. Each time an air conditioner starts, the input energy is approximately constant, while it takes several minutes to reach full cooling capacity. Oversized units operate for a shorter cycle, and the startup time is a greater fraction of the total runtime. The startup losses are also a greater fraction of the total cooling output, reducing overall efficiency. Systems that are properly sized will run longer during each cycle, and the startup losses are small relative to total cooling output. However, as shown by Sonne et al., longer runtimes will increase duct conduction and leakage losses such that potential energy savings can be negated unless these are effectively addressed. The same study did show, however, that peak demand impacts would remain. In a study of 250 rooftop units, conducted for Pacific Gas and Electric Company, the typical runtime under hot conditions was 6 minutes, with an off-time of 16 minutes based on measured data (Felts 1998). This represents a 27% run-time fraction (RTF) with a reduction in unit efficiency of 18% for packaged units. The system efficiency is reduced as the runtime decreases if there are no duct conduction or duct leakage losses. When the unit runs continuously (CLF = 1), the part-load factor is 1.0, indicating no degradation due to cycling. To obtain higher SEER and EER ratings, manufacturers of split-system air conditioners typically use timed indoor unit fan-off delay and control of post-cycle refrigerant migration to reduce cycling losses referred to as the "cooling coefficient of degradation" or "Cd" (Dougherty 2003). Modern efficient air conditioners have Cd values of 0.05, and standard units without these strategies have Cd values of 0.09. For split-system air conditioners, the potential cycling losses are theoretically limited to between 2 and

[6] Personal communication between Robert Mowris and Chip Barnaby, Wrightsoft™, November 3, 2006.

5% under typical conditions (Sonne et al 2006). Based on this theoretical limit, the average energy savings due to properly sized air conditioners are conservatively assumed to be 3.5%.

Efficient Coil Matching for Split-System Air Conditioners

Efficient evaporator and condenser coil matching provides optimal rated capacity and efficiency for split-system air conditioners. Even with correct refrigerant charge, many split-system air conditioners do not perform at their rated efficiency due to improperly matched evaporator and condenser coils. Condensing coil manufacturers cannot guarantee rated efficiency per ARI SEER/EER ratings with evaporator coils manufactured by independent coil manufacturers that are not listed in the ARI directory as a proper match for the condensing coil (ARI 2008). Field measurements of two new nominal 5-ton split-system air conditioners for two houses with the same floor plan are provided in **Table 2** (Mowris et al 2007). Pre-EER values were measured with improper RCA, and post-EER values were measured with proper RCA. The duct leakage shown in **Table 2** is the total leakage as a percent of the measured air flow. The efficiency degradation due to duct leakage was controlled by measuring evaporator coil entering and leaving air temperatures at the plenum. The rated in-situ EER values of 8.96 and 9.03 respectively, include the reduced efficiency due to high outdoor temperature and low airflow.[7] High outdoor air temperature of 105°F (compared to 95°F at standard conditions) reduces the in-situ EER by 10%. Low airflow of 1631 and 1734 cubic feet per minute (compared to 2000 CFM at standard conditions) reduces the EER by 5 to 6%. The post-EER is 6.5 and 6.55 respectively or 27% less than the in-situ EER values. The efficiency degradation due to mismatched coils is an important problem with split systems where evaporator coils are either incorrectly matched or not optimized for efficiency.

Table 2. Field Measurements for Two New 5-Ton Split-System Air Conditioners

Site	Rated In-situ EER 105°F	Rated In-situ Capacity MBtuh	Measured Cooling Capacity Post MBtuh	Average Outdoor, Indoor Dry/Wet Bulb °F	Airflow cfm	Duct Leak cfm @ 25 Pa	Infil. cfm @ 50 Pa	Pre-EER	Post-EER	Service Adjust Oz.	Percent Charge Adjust per Factory Charge
#1	8.96	50.9	38.5	105/81/65	1631	19%	1830	3.9	6.50	+98.2	+49.4%
#2	9.03	50.8	41.6	105/80/64	1734	12%	1537	5.5	6.55	+12.5	+6.3%

Source: Mowris et al 2007 (Note: Rated EER values are based on manufacturers' data.)

Potential Energy and Economic Savings in the United States

There are approximately 93 million air conditioners in the United States, and approximately 6 million new residential and commercial split-system, heat pump, and small packaged air conditioners are installed annually (ARI 2004).[8] Research shows 50 to 70% of air conditioners are oversized by 120% or more (James, et al 1997). Several studies have shown that oversizing air conditioners by 100 to 150% above Manual J increased peak demand by 20 to 50% and increased energy use by 3 to 10% (Sonne et al 2006; James 1997; Mowris 2006).

[7] The in-situ EER values are based on conditions provided in **Table 1**. The rated efficiency at standard conditions is 10.54 EER at 2,000 CFM, 95°F condenser entering air drybulb, 78°F return air drybulb and 67°F return air wetbulb.
[8] Total sales for split-system, heat pump and small packaged units in the 24,000 to 65,000 Btu per hour size categories based on monthly 2003 reports of US manufacturers shipments from *ARI Statistical Release* (ARI 2004).

Improperly matched evaporator and condensing coils (even combinations listed in the ARI directory) can reduce peak demand by 4 to 27% for the same condenser and increase peak demand by 0.2 to 1.2 kW per unit. Air conditioning uses the largest share of peak electricity in the United States with approximately 45% or 344 GW of total residential and commercial consumption (EIA 2001; EIA 2003). Annual air conditioning electricity consumption is approximately 246 TWh for residential and 171 TWh for commercial (EERE 2007). Assuming average savings of 15.5 +/- 1.2% for peak demand and 3.5 +/- 0.6% for energy applicable to 70% of residential and small commercial units, the total potential savings from properly sized and matched air conditioners are estimated to be 37.2 +/- 2.2 GW, 10.2 +/- 1.8 TWh per year and 6.6 +/- 1.1 million metric tones of carbon dioxide per year (based on the percentage savings and usage given above). The potential economic savings from properly sized and matched coils are estimated to be $2130 per system based on equipment savings of $800 per system plus peak demand savings of $1330 per system (assuming average savings of 0.95 kW per system and $1400/kW for avoided coal-fired power plants without carbon sequestration). The total potential economic savings in the US are worth $69.3 billion in avoided power plants, $52 billion in avoided air conditioning equipment, and $1.3 billion per year in energy savings ($0.13/kWh). The environmental benefits in terms of avoided air pollution are significant, but not calculated.

Market Barriers

There are many market barriers to proper sizing and coil matching (market barrier definitions are from Eto et al 1996). Performance uncertainty is an important barrier since consumers have difficulty evaluating claims about future benefits associated with unverified energy guide performance labels. Truth in advertising is important to consumers who assume new units will be properly sized, matched, and installed. Unfortunately, many new air conditioners do not perform as advertised due to improper sizing, coil matching, and installation, and this undermines the credibility of the US energy guide labels (USFTC 1996). At a minimum, the labels should include a caveat regarding SEER ratings only being valid for properly sized air conditioners with ARI matched coils, and quality installation according to ACCA specifications. Other important market barriers include lack of information or knowledge about the importance of proper sizing, matching coils, and quality installation in terms of delivering rated efficiency, reducing noise, and maintaining longer life of air conditioners. Organizational practices and rules of thumb discourage quality installation such as “size the air conditioner based on 500 feet per ton,” “the yellow label on the condensing unit specifies the SEER and EER,” “add or remove refrigerant until the suction line is six-pack cold” or “shows 70 psig on the suction side and less than 250 psig on the liquid line.” Service availability for proper sizing air conditioners is an important barrier for manufacturers, distributors, and dealers who are generally not specifying or installing properly sized air conditioners or verifying quality installation due to lack of awareness and availability of verification services.

Market Intervention Strategies and Recommendations

Market intervention strategies are required to encourage contractors to specify and install properly sized air conditioners with matched evaporators and condensers, including training on ACCA Manual J (residential) and Manual N (commercial), customer education, marketing, incentives, standards, labels, and third-party verification service providers (ACCA 2008). Third-party verification service providers are required to train and equip HVAC technicians to specify, install and verify properly sized and matched air conditioners. Customer education, standards, and labels are important to create demand. Incentives will help motivate interest, but are insufficient by themselves to transform the market. Consumers generally assume their air conditioners are properly installed. Current efficiency standards do not mention the importance of proper sizing and coil matching or quality installation and service, and California building standards do not provide any credit for proper sizing and matching air conditioner coils. Therefore, most consumers and builders do not understand the value of proper sizing and matching. Research studies show HVAC dealers lack interest, training, equipment, and methods to perform proper sizing and matching. Classroom training on proper sizing and matching will not be effective without field training and third-party verification.

One of the most important strategies for success is developing and supporting a verification service provider network to train and equip HVAC technicians to deliver and verify proper sizing/matching along with quality installation and service. Utilities and government agencies should consider implementing comprehensive and consistent HVAC programs targeting new and existing residential and commercial market segments. Programs should consider internet or database registration and permanent labels for identification and facilitation of evaluation, measurement, and verification inspections. Programs should work with manufacturers to incorporate proper sizing, matching and quality installation and service standards within warranty requirements, ASHRAE, and the International Standards Organization Technical Committee 86 (ISO, refrigeration and air conditioning: www.iso.org).

Example Strategies

The "COOL SMART" program throughout New England offers incentives for downsizing replacement air conditioning systems. In 2006, customers received an incentive of $50 per half ton of downsizing to the contractor and $50 per half ton of downsizing to the customer for replacement systems (NationalGrid, NSTAR 2006-08). In 2007, the incentive increased to $150 per half ton of downsizing. The COOL SMART program also required each qualifying system be sized to match ASHRAE Manual J sizing - or sized to match the measured system air flow of the existing ductwork. Pre-approval is required when the new installed system is 3 tons or greater. The California investor-owned utility HVAC incentive programs do not currently offer incentives for downsizing air conditioners (PG&E 2006, SCE 2006, SDG&E 2006). Instead, the programs offer incentives based on dollars per unit or per ton with more money paid for larger units. In California, uncontrolled air conditioner load growth is most important in new construction where many new homes receive multiple oversized air conditioners and virtually all new homes have air conditioning equipment installed in hot attics. The 2005 DEER Study inappropriately undersized air conditioners in the DOE-2 models and adjusted the results downward by 30% (Itron 2005). This problem is compounded by incorrect load profiles in the cost effectiveness calculators used to design and evaluate energy efficiency programs in California. HVAC peak demand in California is undervalued in DEER models, DEER studies, EM&V studies, programs, planning, and the E3 calculator (E3 2008). This creates barriers to market intervention strategies (i.e., programs cannot receive public goods charge funding) to address proper sizing and matching air conditioner coils to reduce peak electricity demand. HVAC energy efficiency is difficult to understand, as it is affected by many variables. Oversizing of air conditioners is a widespread problem in California and elsewhere, contributing to approximately 25% of summer peak demand. Most utilities are unwilling to offer programs and incentives to motivate HVAC contractors, builders, and customers to downsize air conditioners, move HVAC equipment out of hot attics, or motivate customers and builders to install cool roofs or cool attics. These program design issues need to be addressed in a comprehensive manner to avoid unnecessary societal investments in peak-load electric power plants which can cost more than $5000 per peak kW.

Conclusions

Energy efficiency programs have historically provided incentives to encourage customers to purchase high efficiency HVAC equipment to reduce energy use, but this only captured a small portion of the potential peak demand savings. Research shows 50 to 70% of HVAC systems are oversized and installed in hot attics with mismatched coils, improper refrigerant charge and airflow, leaky ducts, or improper maintenance causing them to be 10 to 50% less efficient than if they received quality design, specification, and installation. Most air conditioning contractors in the United States do not know how to use the ACCA sizing guidelines to specify and install properly sized air conditioners. Standard 13-SEER air conditioners generally have consistent efficiency ratings decreasing by only 1-2% per ton across all cooling capacities. Unfortunately, energy efficiency ratings for high efficiency split-system air conditioners vary widely, but appear to generally decrease by about 4 to 8% per ton as the cooling capacity increases. This means there is very little difference in the ARI efficiency rating between a 5-ton nominal 13-SEER unit and a 5-ton nominal 17 or 21-SEER unit.

Improperly matched evaporator coils and condensing units (even combinations listed in the ARI directory) can reduce efficiency by 4 to 27% for the same condenser and increase peak demand by 0.2 to 1.2 kW per unit. Several studies have shown that oversizing air conditioners by 100 to 150% above Manual J can increase peak demand by 20 to 50% and increase energy use by 2 to 5%. Other variables, such as duct leakage, may account for little or no observed energy savings, as longer runtimes mean more air loss, thereby decreasing delivered efficiency.

Residential and commercial air conditioning electricity consumption in the United States accounts for 45% of average summer peak-day loads and 13% of total electricity usage. With approximately 93 million air conditioners in the US and 6 million new air conditioners installed each year, the potential energy savings from proper sizing and matching of air conditioners are estimated to be 37.25 +/- 2.2 GW, 10.2 +/- 1.8 TWh per year and 6.6 +/- 1.1 million metric tones of carbon dioxide per year. The economic savings in terms of avoided power plants and unnecessary air conditioning equipment are estimated to be $61 to $122 billion. These savings can be achieved through a number of intervention strategies aimed at downstream, midstream, and upstream market actors including: education, marketing, training, incentives, standards, and labels.

One of the most important strategies for success is developing and supporting a verification service provider network to train and equip HVAC technicians to deliver and verify proper sizing/matching along with quality installation and service. At least two large utilities in New England are doing so by working with verification service providers to implement effective energy efficiency programs offering incentives to customers and contractors to promote proper sizing/matching and installation quality. More utilities and government agencies should encourage manufacturers, distributors, and HVAC dealers to work with verification service providers to improve HVAC efficiency with proper sizing/matching along with quality installation and service. Utilities and government agencies should also motivate consumers to demand proper sized air conditioners with ARI matched coils and quality installation through education, marketing, incentives, standards, and labels.

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