Options for a New ENERGY STAR® Specification for Residential Air-Source Heat Pumps and Central Air Conditioners

In January 2006, the Federal standard for central air conditioners (CAC) and air source heat pumps (ASHP) will increase to 13 SEER. As a result, the ENERGY STAR specification should be updated to capture energy savings beyond the standard in a way that is cost effective for consumers and maintains product performance. However, because of the new standard, the marginal benefit to consumers of selecting higher SEER equipment will be less than the past. In contrast, the potential benefits from improving the installation of HVAC systems are large, on the order of 10 to 20 percent savings in heating and cooling costs. Numerous field studies[1] have shown that more than half of CAC/ASHP systems are installed with incorrect refrigerant charge and/or airflow. Therefore, EPA is considering the development of an ENERGY STAR specification that addresses both equipment-related and installation-related criteria.

The following document outlines a range of potential elements for this new type of specification. In addition, a series of options that are being evaluated are listed for some elements. EPA plans to conduct a thorough and inclusive process to revise this specification and is open to additional ideas than the ones presented here. However, if it becomes apparent that developing an effective equipment specification is not feasible, EPA may decide to suspend the ENERGY STAR label for CAC/ASHP equipment.

I. Equipment Criteria

Equipment could be required to meet efficiency levels such as those specified in Table 1. In addition, Options A – C could be included as additional criteria to further enhance performance.

Table 1: Energy-Efficiency Criteria for ENERGY STAR Eligible Residential ASHPs and Central Air Conditioners

Product Type	SEER	EER	HSPF (for heat pumps only)
Split Systems	≥14	≥ 12	≥ 8.5
Single Package Equipment (including gas/electric package units)	≥ 14	≥ 11	≥ 8.0

A. Evaporator Access/Maintainability: To be considered eligible, evaporators would need to include one of the following two features:

i. Housings that include both the fan and evaporator coil would include an airtight means of allowing a service technician access to the air-inlet side of the evaporator for proper inspection and cleaning. For add-on coil systems, an air-tight inspection/cleaning door/panel would be included in the housing, or instructions for the field manufacturing and installation of such access would be provided in the manufacturer's installation instructions along with its requirement for ENERGY STAR labeling, or

ii. On-board diagnostic indicator that provides the installing or service technician with an indication of improper airflow or temperature change across the evaporator coil.

[1] All studies mentioned throughout this document are listed in Appendix B.

B. <u>Evaporator Measurement Access:</u> To be considered eligible, all evaporator housings would include one of the following two features:

i. An airtight access port on the inlet side of the evaporator to allow for the measurement of temperatures (wet and dry) and pressures. This test port may be included/installed in the service access panel described in section A above, or

ii. An indicator mark on the evaporator housing would be provided to direct a technician where he/she may drill up to a 3/8" hole to provide for the measurement of temperatures and pressures immediately before the evaporator.

C. <u>Automated Refrigerant Flow Metering Devices</u>: Eligible equipment would be required to have factory-installed, automatic-metering devices (TXV, EXV or equivalent), located within the evaporator housing, and protected by a full jacket of insulation. Heat pumps would require an automatic-metering device on both the indoor and outdoor units.

> The split system values in Table 1 correspond to the Consortium for Energy Efficiency (CEE) Tier 2 spec, while the packaged system values correspond to the CEE advanced tier. The advantage to choosing efficiency values that correspond to tiers offered by CEE is that the existing CEE/ARI database can be used to identify qualified models and more importantly, qualified coil combinations.
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> The CEE Tier 2 levels for packaged equipment are 13 SEER, 11 EER, and 8.0 HSPF. EPA chose to use the higher values because the SEER value in Tier 2 is identical to the new federal standard.
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> The efficiency values for split systems are a reasonable target, because many products meet the SEER specification prior to the change in the minimum requirement. The portion of 14 SEER units that currently meet the 12 EER spec is substantial (one third to one half). EPA anticipates that the number of models meeting these criteria will increase once the federal requirement changes.
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> The packaged system efficiency level is more difficult to meet, because packaged systems normally have lower SEER and EER levels than split systems. Currently only 24 packaged products listed in the CEE directory meet both 14 SEER and 12 EER.
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> The HSPF specs for both split and packaged heat pumps should also be reasonable, as many products would qualify. Appendix A includes graphs from the California Energy Commission website that show the number of products registered for sale in California that meet various SEER, EER, and HSPF levels.
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> Preliminary analysis reveals that an ENERGY STAR specification of 14 SEER is cost effective for few U.S. consumers, even in southern locales, when compared with 13 SEER units. This is based on inputs used in the life-cycle cost analysis of the DOE rulemaking completed in 2001. Any additional, more recent data for this analysis would be welcomed.

Options A-C address two key issues regarding the installation of split systems (1) adequate airflow over evaporator (indoor) coils and (2) the maintainability of those coils. Thermostatic expansion valves (TXVs) are devices that improve refrigerant flow control relative to fixed orifice tubes. Though a TXV has little benefit in systems with proper refrigerant charge and airflow, most systems will experience efficiency degradation overtime because of refrigerant leaks and debris buildup in the fan and coil systems. Over the lifetime of a system, a TXV will alleviate these problems, thus enhancing efficiency in the field. An electronic expansion valve, which is an electronic version of a TXV is another option which has the same advantages as a TXV, but is rarely used today in residential systems. As shown in Appendix A, based on a sample of products reviewed for the DOE rulemaking several years ago, most (~60%) of SEER 13 and 14 systems already use a TXV, and nearly all systems with a SEER >14 probably use them.

Product Testing Criteria: Manufacturers would be required to perform tests and certify models that meet the ENERGY STAR guidelines. Partners would agree to perform energy-efficiency tests for residential ASHPs, central air conditioners, and gas/electric package units under rating conditions in accordance with ARI 210/240. For EER, manufacturers would perform energy-efficiency tests based on ARI Standard 210/240-94, Operating Condition A: 95°F outdoor air temperature, 80°F dry bulb/67°F wet bulb indoor coil air entering conditions. For split systems, the energy-efficiency ratings of a particular model would be solely based on the following: the actual condenser-evaporator coil combination of the split system model. Product certification would be submitted for listing in the American Refrigeration Institutes (ARI) Certification Directories or to EPA for review and posting in ENERGY STAR product lists. To be listed, products would need to meet the testing criteria listed above. The HSPF and SEER ratings should be identical to the levels reported on the Federal Trade Commission (FTC) Energy Guide Label.

II. Installation Criteria

One of the key drivers of the actual efficiency of HVAC systems is proper installation of the equipment. The potential criteria outlined below cover information collection, proper installation based on that information, and the reporting of system information to homeowners and/or local program sponsors.

1) <u>Design and Installation:</u> Equipment would be required to be installed by contractors familiar and competent in the use of methods prescribed by the manufacturer, or in accordance with design and installation standards set forth by the Air Conditioning Contractors of America (ACCA) Residential Design Manuals, J, T, S and D, or equivalent.

> Properly designing systems is the first step in making an HVAC system efficient. Studies show that oversized equipment short cycles, reducing the ability to dehumidify the conditioned space, degrading efficiency and leading to a shortened equipment life. When aggregated, studies show that in newer homes, systems are oversized by an average of 47%, or by almost 1-full ton. Larger systems also require larger duct systems, which result in higher installation costs. Studies suggest that annual savings range from 2% to 10%.

2) <u>Refrigerant Charge and Airflow:</u> Refrigerant charge would be adjusted in the field in accordance with manufacturer's instructions, and the contractor would verify that the system is flowing a nominal 400 CFM/ton of capacity, or CFM specified by the manufacturer during full speed testing. Systems incapable of flowing 350 CFM/ton or greater at high speed (full capacity) must either be corrected by improving ducts (reducing static pressure) or would not qualify. Systems with more than ±3º deviation in sub cooling from manufacturer's specification would not qualify.

> Proper refrigerant charge is essential to maintaining the capacity of refrigeration equipment. Undercharged equipment has to run longer to produce the same amount of cooling. Too much refrigerant can also be detrimental. Both conditions can lead to premature compressor failure. As many as 41% of all systems may be undercharged, and 33% may be overcharged. Properly charging systems may save as much as 12% in annual heating and cooling energy.
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> Proper airflow is essential for the system to deliver the cooling or heating energy to the conditioned living space. Studies have shown that 70% of systems tested are operating at less than 350 CFM/ton. The ideal or nominal CFM required to optimize efficiency is 400 CFM/ton. By improving airflow, it is estimated that an additional 8% in annual savings can be realized.

3) <u>Duct Systems</u>: In new construction, or when new ducts are installed in existing homes, ducts would be installed to minimize or eliminate duct leakage by sealing all joints with a UL-181B-M approved and labeled mastic, mastic with fiberglass mesh tape (9x9 mesh weave), UL-181B-FX foil-faced, butyl-backed tape, or through an internally applied pressure induced sealant. The taping of externally-applied duct insulation would not satisfy the intent of this specification. The use of other tapes and sealants, unless specified by part number or integral to a specialty product and called out by a duct system manufacturer, is not recommended (i.e.: products with internal/integrated gaskets would meet requirements).

Studies have shown that unintentional duct leakage results in dramatic reductions in capacity, efficiency and comfort. Duct leakage may also cause unsafe depressurization of the building leading to excess infiltration, back-drafting of combustion appliances and radon infiltration. Sealing ducts properly when they are first installed is the least expensive way to ensure system capacity, efficiency and comfort for the life of the duct system.

When ducts are not properly designed, or oversized equipment is installed, they may operate at higher pressures, resulting in even more duct leakage than if properly sized equipment is attached. It is good practice to design ducts using proper industry standards such as ACCA's Manual D, and sealing all joints with approved sealants.

4) Analyze Performance: The installation contractor(s) would collect and analyze the following data to ensure that the installation meets manufacturer's installation specifications (at steady state operation):
   a. Factory charge,
   b. Sub-cooling required,
   c. Line set diameters,
   d. Line set length,
   e. Amount refrigerant charge adjusted (plus or minus - in ounces), or
      i. If system evacuated, total amount of charge added
   f. Airflow across evaporator (in CFM)
   g. Measured Amperage and Voltage for entire system,
   h. Liquid and suction pressures,
   i. Liquid and suction temperatures,
   j. Outdoor ambient air temperature at the condensing unit,
   k. Indoor conditioned space temperatures (dry and wet)
   l. Temperatures entering evaporator coil (dry and wet), and
   m. Temperatures leaving evaporator coil (dry and wet).

5) Commissioning Report: The installation contractor(s) would provide a commissioning data report, an ENERGY STAR Maintenance Checklist, and the manufacturer's product manuals and warranty information to the owner/operator of installed equipment. The report would list the minimum information:
   a. Installing Contractor name and contact information,
   b. Commissioning Date,
   c. Location of installation (street address, town, and state),
   d. Model and Serial Numbers of installed equipment,
   e. ACCA Manual J Heat Loss and Heat Gain load calculations,
   f. Square footage of conditioned space (as used for Manual J load calculations),
   g. Predominant type of glass (single pane clear, double pane low-e, etc.),
   h. Factory charge,
   i. Sub-cooling required,
   j. Line set diameters,
   k. Line set length,
   l. Amount refrigerant charge adjusted (plus or minus - in ounces), or
   m. If system evacuated, total amount of charge added,
   n. Airflow across evaporator (in CFM),
   o. Measured Amperage and Voltage for entire system,
   p. Liquid and suction pressures,
   q. Liquid and suction temperatures,
   r. Outdoor ambient air temperature at the condensing unit,
   s. Indoor conditioned space temperatures (dry and wet)
   t. Temperatures entering evaporator coil (dry and wet), and
   u. Temperatures leaving evaporator coil (dry and wet).

III. Options for Field Verification of Proper Installation

According to many stakeholders, the best and perhaps only way to truly ensure proper installation is to verify at least a portion of the installed systems. This is supported by several utility-sponsored field studies. The following are several options for addressing verification. A key challenge associated with including verification in the new ENERGY STAR specification is balancing the tradeoffs between costs and reliability.

Proper commissioning is essential to attaining the maximum comfort and efficiency of newly installed systems. There are several options for verifying an installation for ENERGY STAR qualification:

1) Energy Efficiency Program Sponsors (EEPS). A local utility offering a rebate could verify the installation or a sample of installations. Based on an agreement with EPA, the review by EEPS would be sufficient for qualifying the new system as ENERGY STAR.

This option would require an agreement between EPA and selected EEPS. To support this agreement EPA would need to design the agreement and to provide some sort of technical guidance on running a proper verification program.

2) Manufacturers. A manufacturer could choose to verify the installation of its equipment. Because correctly installed systems will perform better and likely last longer, manufacturers may want to offer additional warranty periods for verified systems. EPA encourages manufacturers to use an electronic data collection method to facilitate this process. Alternatively, EPA could initially screen data submitted under another option and forward data to the manufacturer for verification.

This option might appeal to manufacturers with their own installation or distributor networks. Manufacturers could self verify or could outsource this task to existing verification companies.

3) Third-party Verification Services. A manufacturer or contractor could use a provider of verification services to verify their installation. This verification would be sufficient to qualify the new system as ENERGY STAR.

This option is similar to how some EEPs programs are run. Installations are verified by a third party such as the *CheckMe* phone system. The crux to this option is the prevention gaming of an automated system through data review or field studies.

4) Home Energy Rating System (HERS). For HVAC installations in new construction eligible for the ENERGY STAR homes label, a local HERS rater (trained on HVAC verification) could inspect the HVAC installation.

A key issue associated with this option is the logistics of qualifying HERS raters to perform HVAC installation verification. EPA is beginning to review how this option could fit into the existing HERS infrastructure.

5) EPA Verification. The contractor would electronically submit a copy of the installation commissioning report to EPA. A random sample of reports from contractors would be selected and analyzed. If more than 10% of analyzed installations for a particular contractor do not meet installation specifications, then EPA could restrict that contractor's ability to use the label.

Under this option, a simple EPA database would capture basic data. This is different than the typical specification approach, but might be considered in addressing how to start off a specification focused on installation. In the long term, data verification may become the responsibility of EEPS and other interested parties.

Basic data checking in the database would prevent obvious gaming. Incorrect or duplicate data would flag an installation and a contractor. After the cost of setting up the database, nearly all error checking would be automated. A portion (~10%) could be verified in a more detailed manner either by EPA or by EEPS interested in installations in their territory. If performed by EPA, the review would be performed by one or more current vendors of automated checking services.

Based on estimates of anticipated market share of ENERGY STAR qualified installations, roughly 5,000 would be reviewed in detail. Actual field verification would not be performed; however interested parties such as local EEPS might choose to do this if rebates were applicable.

6) Self Certification. Allow NATE certified contractors (or equivalent) to perform their own post-installation inspection using an ENERGY STAR checklist, and then self certify the installation as ENERGY STAR qualified.

This option requires the least involvement of EPA, manufacturers, or local EEPS but provides the least probability of increased efficiency. Preliminary results from ongoing studies have shown anecdotal evidence that NATE certification, although beneficial, does not necessarily prevent poorly installed systems.

Once an installation is verified through any of the options above, the installation would be ENERGY STAR qualified and could be labeled by the installer, EEPS, or other party. The manufacturer, EEPS, or contractor would maintain a copy of the commissioning report for the life of applicable product warranties.

In the event the installation does not meet the manufacturer's installation specifications, the manufacturer, EEPS, or contractor may facilitate modifications to installation and re-test for ENERGY STAR qualification.

IV. Options for Labeling Qualified Systems

If the new specification contains only criteria for the efficiency of the system as manufactured and for required parts, and if no portion of the specification contains installation-related elements, then most of the current labeling procedures would remain in place.

If the new specification includes installation-related elements, then systems including condenser units could no longer be shipped with an ENERGY STAR label. Instead, some option for labeling the system after correct installation would be needed. In this case, the manufacturer could use a provisional label on sales literature, web sites, and other forms of communication that communicates that the equipment meets ENERGY STAR criteria if it is installed correctly.

There are several options for field labeling of HVAC systems:

1) Manufacturer ships label with equipment. Contractor would affix the label after completing and verifying installation.

This option offers little control over the use of the label but requires little resources and commitment from EPA. EEPS may oppose this option and not recognize it for these incentive programs.

2) Labels are supplied to eligible contractors that have agreed to follow the specified installation practices. These contractors would affix the label after completing and verifying installation.

This arrangement would operate similarly to how ACCA members that install ENERGY STAR equipment are identified. The contractor would be identified by ENERGY STAR after completing minimum requirements. The difficulty of this option is how EPA would identify pre-qualified contractors without certifying them.

3) Labels are supplied to EEPS for use in their programs and to third party verifiers for use in their verification efforts. Contractors are provided labels only through these channels.

This option provides the best control over labels and would not require a large effort from EPA. The limitation with this option is that it would only serve areas with robust EEPS programs. Outside of these geographic areas, only customers and contractors that use and pay for third-party verification services would receive the label.

V. Phase in of New Specification

The current ENERGY STAR specification for CAC and ASHP equipment will change by January 23, 2006. If an installation component is added, it could take effect at this time as well, or be phased in over an appropriate period of time. In either case, previous agreements and specifications regarding ENERGY STAR labeled residential CAC and ASHP would be terminated effective January 22, 2006.

VI Other Criteria to Consider

In addition to the criteria presented above, EPA anticipates that some additional issues will need to be evaluated carefully, with input from all stakeholders, for potential inclusion in a new ENERGY STAR specification for CAC/ASHPs:

- Should we require improved CFM/watt ratios across the evaporator coils? This could be accomplished by use of higher efficiency fan motors, improved fan blades, improved fan housing aerodynamics or some combinations thereof.

- Should we require built-in pressure and temperature sensors to allow for advanced diagnostics while minimizing or eliminating venting of refrigerant to the atmosphere?

- Should we require on-board diagnostics? Built-in technologies that announce to the building occupant, or report automatically to an HVAC service provider, the need to change filters (not based on time), clean the evaporator coil, and/or evaluate refrigerant charge.

- Should we require installation of ENERGY STAR systems by NATE certified technicians only? Should we require installation by accredited contractors only (e.g. BPI)?

- Should we require that contractors analyze airflow capabilities of retrofit applications prior to equipment selection?

- Should we specifically address duct leakage? The current ENERGY STAR recommendation is that duct leakage be less than 10% of rated system flow (based on 400 CFM/ton).

- Should we require that all system components (i.e., condenser, evaporator, thermostat and other controls) come from a single manufacturer?

Appendix A

(see separate appendix file)

Appendix B

List of Studies

(see separate appendix file)