REAL WORLD - REAL SOLUTIONS
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New Technology Track
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Achieving Energy Efficiency with Unitary HVAC Equipment

Many buildings are conditioned by single-package rooftop or split-system air conditioning units. These systems can be made more efficient by replacement or upgrading, and by implementing a detailed approach to preventative maintenance. Unitary HVAC (heating, ventilating, and air conditioning) units consist of pre-assembled systems. A typical packaged unit consists of a supply fan and filter, a return air fan, a heating coil, an outdoor air intake, and a mechanical refrigeration system. These can be provided in two configurations. *Packaged* equipment consists of one box containing all components, while a *split-system* consists of two boxes, one outside containing the condensing coil, fan, and compressor (the condensing unit), and one indoors with the rest of the components (the air handling unit).

Geothermal heat pumps (sometimes referred to as earth-coupled, ground-source, or water-source heat pumps) use the constant temperature of the earth as the exchange medium instead of the outside air temperature. This allows the system to reach higher efficiencies on hot days and cold nights. At least one manufacturer has combined an air-source heat pump with a geothermal heat pump, called a "Dual-Source" heat pump. Dual-source heat pumps have higher efficiency ratings than air-source units, but are not as efficient as geothermal units. The main advantage of dual-source systems is that they cost much less to install than a geothermal unit, and work almost as well.

Several manufacturers are making "high efficiency" units by incorporating improved fan design, higher compressor and condenser efficiency, improved cabinet designs, and other innovations. "High-efficiency" is not a strictly defined term. Even the best available units may not be sufficient to meet **EO13123 savings goals** at all buildings. In these cases, the efficiency upgrade options discussed in this fact sheet are considered necessary.

EFFICIENCY RATINGS

Jargon

A number of terms are used to describe the energy efficiency of air-conditioning equipment.

Energy Efficiency Ratio (EER)
Seasonal Energy Efficiency Ratio (SEER)
Integrated Part Load Value (IPLV)
Coefficient of Performance (COP)
Heating Season Performance Factor (HSPF)

What they mean

The common link between all energy efficiency ratings is they are a *ratio* of the cooling/heating they deliver versus the power they consume. Various conventions and standards dictate which rating is used for a particular class of equipment. EER is used for equipment greater than 5-tons in capacity, and is a single point rating at peak load conditions. SEER is used for

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equipment 5-tons and less, and is an average EER rating over a typical cooling season. Air conditioners run more efficiently when it is cooler out, so the SEER and IPLV were developed to take this into account. IPLV and *kW per Ton* are typically used for larger equipment. Heat pump performance in winter is rated using the COP, which is a single point rating, or the HSPF, which is a seasonal average.

Requirements versus Recommendations

CEE's Tier I level is the accepted minimum industry standard, representing a small improvement in energy efficiency over the current federal standard. CEE's Tier II is emerging as the new "high efficiency" requirement, promoted by ENERGY STAR® and FEMP. Significant improvement is not expected until 2006 as shown in the table below.

Minimum Allowable EER Ratings
MBH per kW

MBH	65-135	135-240
ASHRAE 90.1-1999 (Effective 10/29/2001)	10.3	9.7
CEE - Tier I	10.3	9.7
CEE - Tier II and EPA Energy Star	11.0	10.8
FEMP (as of 1/1/2002)	11.0	10.8
FEMP (after 1/3/2006)	**12.0**	**12.0**

MBH = kBtu/hr (1 ton = 12 MBH)
(65 = 5.4 tons, 135 = 11.3 tons, 240 = 20 tons)
CEE - Consortium for Energy Efficiency
EER - Energy Efficiency Rating
FEMP – Federal Energy Management Program

About half of all Federal energy use is for space conditioning. So, in order to meet 2005 savings goals, recommended efficiency levels for Federal buildings are higher than the minimum FEMP requirements. The recommended EER for FEDERAL buildings is minimum 12.0. If equipment is not available in the needed configuration or size, then get as close to 12.0 as is obtainable. If economically feasible, EER ratings of 14.0 for air-source and 16.0 for ground-source or dual-source should be considered. Operating EER can vary up or down by one point with the fan speed setting and proper matching of indoor and outdoor unit sections, so check these details to ensure the rated EER is realized.

FEMP Technology Procurement

DOE has developed a set of voluntary specifications for new high-efficiency air conditioners. FEMP anticipates that new air conditioners proposed by manufacturers will cut energy use by up to 20% compared to standard units now available. To be included in the program, the units must exceed CEE Tier II (11.0 EER; 11.4 IPLV) requirements; 13 EER or better is anticipated. They must also have lower energy consumption over temperatures encountered in typical applications, improved humidity control, and lower initial cost compared to other high-efficiency units. The procurement focus is on products that minimize life-cycle costs, taking into account electric energy consumption required to cool buildings under typical climate conditions. Vendors are selected based on price and operating costs estimated from manufacturers' performance data. Buyers can order units through a basic ordering agreement specifying prices, warranties, and other terms.

DESIRABLE FEATURES

Certain equipment features improve the long term operating efficiency of air conditioning equipment. The features listed below should be considered or specified/requested when installing new equipment.

Easy-open Access Panels

Hinged, tool-less filter access door with a tight sealing gasket allows for easy maintenance access and reduced air leakage. Panels requiring tools to open them make checking the coil and replacing air filters more difficult and less likely to be done regularly.

Scroll Compressors

Advances in technology are delivering significantly higher efficiency than traditional reciprocating compressors. Today's best compressors are more efficient, less expensive and very reliable. New technologies include two-speed motors, inverter-driven variable speed compressors, scroll, and twin-single® compressors

Two Stage Cooling

Dual refrigerant circuits, each with its independent compressor, can more closely provide the right amount of cooling needed. Unless conditions require the second circuit, only one compressor is used - consuming less energy than a single-compressor air conditioner would use.

Traditional units, particularly in the smaller sizes, employ one compressor and operate in an "on" or "off" mode. Equipment is selected to provide the needed capacity at full load conditions. Since those conditions occur infrequently, a single compressor is effectively oversized for all conditions less severe than maximum design. This over-capacity causes short-cycling and higher operating costs

TXV
Unlike a *fixed-orifice* or *capillary tube*, a *thermostatic expansion valve* (TXV) adjusts to changes in conditions and maintains high efficiency over a range of refrigerant charge. Over the life of a system, leaks and losses (from when service technicians check operating pressures) reduce the charge. The amount of liquid refrigerant flow through a TXV is automatically optimized by the temperature of the refrigerant leaving the evaporator in relation to the pressure differential across the valve.

Check Valve
Solenoid or check valves installed to minimize pressure equalization during the off-cycle increase seasonal efficiency. A solenoid valve in the liquid line as it leaves the condenser to retard equalization, and/or a check, or one-way, valve in the same location are recommended.

Filter Minder
A dedicated differential pressure switch senses a loaded filter and illuminates the "Service", "Check", or "Filter" LED on the thermostat, so the filter can be replaced before system efficiency is further reduced.

Fan Type
Fans with *airfoil* or *backward-incline* blades are more efficient and quieter than the traditional *forward-curved* fans.

Fan Drive
Premium high-efficiency fan motors should always be specified. The use of a one-step inverter can provide a second, lower speed airflow to match compressor stages at about one-third the cost of full variable speed capability. Multiple-speed direct-drive blowers preclude belt slippage but operate less efficiently than variable speed electrically-commutated motors (ECM). “Gear" or "cogged" drive belts with a belt tensioner are more efficient and last longer than smooth V-belts and pulleys.

Economizer
Economizers provide the correct amount of outside ventilation air and save energy. Sensors monitor indoor and outdoor air temperature and humidity, and whenever possible outside air is used to provide "free" cooling by opening a motorized adjustable damper.

EQUIPMENT UPGRADES

Dual Source and Hybrid Ground-Source
The main advantage of hybrid/dual-source systems is that they cost much less to install than a ground-source unit, and work almost as well. In a dual-source unit, the outside heat sink is both the ground and the air, in contrast to a conventional unit that uses either the ground (water-source) or the air (air-source). In a hybrid ground-source system, the outside heat sink is both the ground and a water source or cooling tower. Dual-source sizes range from 2½ -tons to 5-tons with a 16+ EER. Both hybrid and dual-source technology is available as a retrofit package for commercial units in the 5 to 100-tons range. In the retrofit application, the existing compressors can be replaced with downsized high-efficiency compressors. There is currently no standard efficiency rating procedure for dual-source units. At USPS Valrico MPO, three air-source heat pumps were retrofitted with the dual-source technology, reducing daily energy use by more than 20% and peak demand by 8 kW[1].

LPA
Liquid Pressure Amplification (LPA), also called Liquid Refrigerant Pumping (LRP) uses a pump to overcome head losses in the liquid line and dryer that would otherwise cause flashing (undesirable refrigerant boiling) ahead of the expansion valve. With the LRP suppressing flash gas, the condensing setpoint (temperature or pressure) can be changed to a lower value generating significant savings.

Little, if any, savings will be obtained by applying LRP to systems that already have floating-head control or that do not operate much during the cooler temperature conditions necessary to accrue floating-head savings. One of the main issues surrounding LRP technology is acceptance by air

[1] October 1998.Metering and Verification of Savings Report for CU-1,Valrico Main Post Office .

conditioner manufacturers. To endorse the patented and proprietary LRP is to acknowledge that their equipment is not as efficient as it could be.

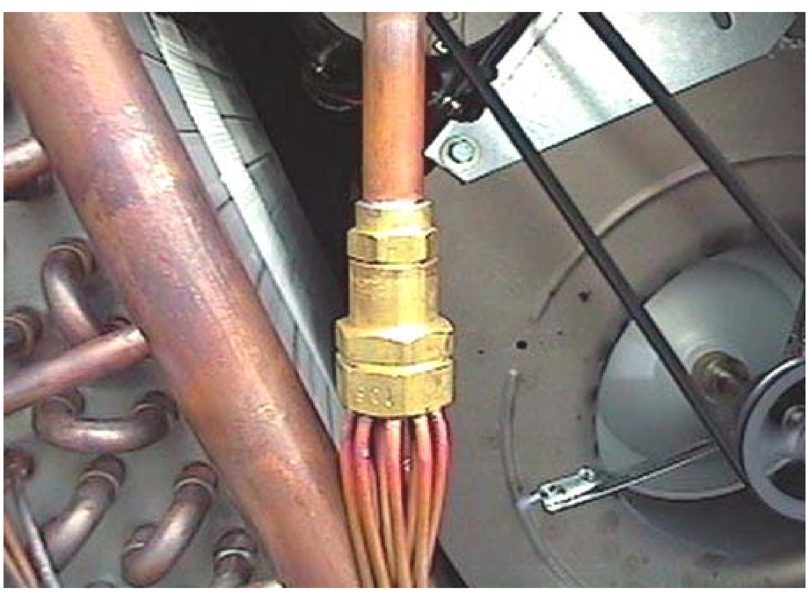
De-superheating and Subcooling

This technology modifies a standard direct-expansion air conditioning system with the addition of heat exchanger(s) in the liquid line and/or the hot-gas line of the system. It works best on hot days and in warm climates. Subcooling, which increases the refrigerant's cooling ability, is achieved with an external mini-cooling tower, evaporative cooling pad, or ground/well source water. De-superheating, which reduces the compressor discharge temperatures, results in less compressor power use.

Ice Storage

Although the low evaporator temperatures needed for ice making tend to reduce the efficiency of the compressor, the overall efficiency of an ice storage system may be higher than the efficiency of a packaged, conventional rooftop installation.

One version of this concept is the Roofberg® System. The unit can operate at night when it is cooler to meet a daytime cooling demand. This flexibility permits a smaller compressor to satisfy a larger peak cooling load. Further, the system can shift the cooling demand to off-peak hours when electricity from the utility is generated more efficiently and at lower cost.



SIZE DOES MATTER

Similar to an automobile in stop-and-go traffic, the overall efficiency of an air conditioner is reduced by excessive cycling. More starts and stops accelerate wear and tear on the equipment, which can lead to premature failure. Oversized systems use more fan power for the blower and often exhibit more duct leakage due to higher duct pressure. Oversized air conditioners greatly aggravate the peak kW demand on hot days. A Florida study found a 13 percent higher summer peak electric demand correlated to oversized units.

Insist that documented sizing calculations be performed using accepted ACCA/ASHRAE procedures. ACCA methods have sufficient built-in safety factors to accommodate most conditioning needs. Infiltration assumptions should be approached with caution. In lieu of other information, an infiltration rate of 0.25 ACH is recommended. Don't alter the suggested design temperatures. Using the annual extreme temperatures will lead to over-sizing. Be aware that exaggerating temperatures for indoor heating and cooling set points can have large impacts on required equipment size.

SYSTEM CONSIDERATIONS

Ducts

Air leakage and heat gains from ducts can rob air conditioning system efficiency. In most air conditioning systems, the duct system passes through the unconditioned space above the ceiling, which has thermally disadvantageous consequences. The insulation level of traditional duct systems tends to be only R-4 to R-6 and leakage rates are typically 10% to 15% of total system airflow.

Supply leaks can lose expensive conditioned air and depressurize the building, causing uncontrolled infiltration of warm humid air. Return leaks can add to the heat loads and draw air from unintended locations. Flimsy duct construction often allows duct connections and joints to open and large leaks to form. Cabinet access panels typically are not gasketed and leak considerable amounts of air. Sealing between the unit and the roof curb, and between the unit and the ducts is often overlooked during installation.

All these issues add up to a strong case for having the duct system well insulated and tightly sealed. The suggested leakage specification is a maximum of 3% to 5% leakage, which can be verified with a simple duct leakage test performed by a test & balance contractor. The suggested insulation thickness is 2.2-inches (R-6) to 3-inches (R-8). All joints should be thoroughly sealed and coated with duct mastic. Typical savings are 5% to 12%. Savings are much more when the duct system and/or unit cabinet has major leaks, which is surprisingly common and usually goes undetected.

Thermostats

Programmable electronic thermostats will automatically switch the system from occupied to unoccupied mode, every day, without anyone having to remember to change the thermostat. Recommended occupied/day settings for cooling are 74 degrees with the fan on continuous and the fresh air damper open. Recommended unoccupied/night settings for cooling are 80 degrees F with the fan on automatic cycle and the fresh air damper closed. Automatic setting changes can save 5% to 10% or more depending on the existing thermostats and how they are being used.

MAINTENANCE

Numerous energy surveys clearly show that ***lack of preventative maintenance is by far the major cause of air conditioning energy waste in FEDERAL buildings***. Common and costly problems include clogged, corroded, and/or fouled cooling and condenser coils, cabinet air leaks, low refrigerant, maladjusted air dampers, sizeable duct leaks, and un-calibrated or nonfunctioning thermostats. A suggested maintenance schedule that will pay for itself in energy savings is provided below:

Monthly

Filter inspection/replacement.

Quarterly

Check/tighten fan belts. Look for slippage or improper alignment.
Grease/lube fans and bearings.
Clean air intake screens.
Inspect/clean condensate pan and drain.
Review controls programming/operation

Semi-Annual

Clean condenser coils.
Inspect/test damper operation.
Adjust/calibrate thermostats.
Test/adjust economizer controls.
Grease/lube motors.

Annual

Clean evaporator coils.
Inspect/replace economizer gaskets.
Inspection/adjustment of ductwork system.
Inspect equipment cabinet seals.
Repair seals around access doors.
Check/adjust refrigerant charge.
Check amp draw of compressor and fans.
Clean blower.

SUGGESTED ACTION PLAN

1. Determine the operating efficiency of installed equipment, compared with the best available new equipment.
2. Identify units that are candidates for replacement when the existing EER is 4 or more points less than the best available new units.
3. Identify units that are candidates for upgrades when the existing EER is 2 to 4 points less than the best available units.
4. Identify units for a thorough preventative maintenance check when the existing EER is within 2 points of the best available units.

For More Information

Questions about this factsheet?

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