PROCURING HIGH-EFFICIENCY AIR CONDITIONERS: HARNESSING COMPETITION TO ACHIEVE ADVANCES IN TECHNOLOGY

J. Bradford Hollomon
Kelly L. Gordon
Pacific Northwest National Laboratory[1]

ABSTRACT

This paper describes a program designed to develop the market for energy-efficient, packaged, unitary "rooftop" air conditioners through a competitive procurement process. The procurement encourages air conditioner manufacturers to produce equipment that exceeds federal energy efficiency standards by at least 25 percent. The program described here aggregates market demand by organizing groups of large-volume buyers of air conditioning equipment, and then it invites manufacturers to propose technologies meeting specific technical requirements and cost-effectiveness criteria. Basic market characteristics and opportunities for technical improvements contributing to energy efficiency in rooftop air conditioning units are described, as are the procurement strategy and process and the roles of the lead Government agencies.

INTRODUCTION

The Unitary Air Conditioner Technology Procurement is designed to pool demand from high-volume buyers of air conditioning equipment and by doing so, to encourage manufacturers to produce more high-efficiency products to meet this demand. Two offices of the U.S. Department of Energy (DOE) – the Federal Energy Management Program (FEMP) and Office of Building Technologies, State and Community Programs (BTS) – are sponsoring the procurement, which focuses on unitary "rooftop" air conditioners with 65,000 to 135,000 Btu/hour of cooling capacity. Air conditioners of this size are the most common cooling equipment used in low-rise, commercial-style buildings like offices, clinics, barracks, warehouses, stores and other facilities common in both the government and private sectors.

DOE has teamed with the Defense Logistics Agency (DLA) to issue a Request for Proposals (RFP) for specified equipment. DLA, an arm of the U.S. Department of Defense, procures and deploys equipment and services to U.S. military and federal civilian agencies nationwide. The federal government purchases thousands of rooftop air conditioning units annually. DLA plans to promote air conditioners selected under the solicitation through its Maintenance, Repair and Operations (MRO) program.

To support the team of federal agencies, Pacific Northwest National Laboratory (PNNL) has conducted market research, identified private-sector buyers, developed the technical specifications, and in coordination with DLA, prepared the RFP. The laboratory has also begun producing marketing and promotional materials to increase awareness and demand for high-efficiency air conditioning equipment. To evaluate the life cycle cost effectiveness of equipment proposed in response to the RFP, PNNL developed a cost simulation analysis tool. An interactive web-based version of this tool, with expanded capability, is available at www.pnl.gov/uac.

PNNL issued a request for proposals for high-efficiency unitary air conditioning equipment in early January of this year, with proposals due March 29. Products will be evaluated in terms of their life-cycle cost, taking into account energy consumption at full and partial load under representative climate conditions. The winning products resulting from the evaluation will be available to all federal agencies, both military and civilian, through DLA. Equipment will be available to non-federal customers, including private companies, institutional facilities, and state and local governments, through a basic ordering agreement (BOA) administered by PNNL.

[1] Pacific Northwest National Laboratory is a multiprogram national laboratory operated by Battelle for the U.S. Department of Energy.

The purpose of the acquisition is to accelerate the commercial introduction of advanced, highly efficient air conditioners and to make them available to buyers at an attractive cost. Air conditioners selected for inclusion in the program will reflect the lowest possible life-cycle cost, taking into account both initial price and electricity use, that can be achieved while meeting specifications for long-term performance and reliability.

The air conditioners selected for the procurement will also meet the needs of federal agency purchasers who must be responsive to the requirements of Executive Order 13123 and other Federal government-wide policies requiring acquisition of energy efficient products consistent with minimizing life-cycle cost.

MARKETS FOR ROOFTOP AIR CONDITIONERS

A study by the U.S. Department of Energy (DOE) in 1999 found that packaged cooling systems serve about 15 billion square feet of buildings, including education, food sales and service, health care, lodging, retail, office, public buildings, storage, and warehousing [1]. An earlier report by DOE (1995) found that packaged units cooled some 55 percent of air-conditioned commercial floor space, and 2 million out of 4.6 million air-conditioned buildings nationwide. [2] Total U.S. sales of air-cooled unitary air-conditioners of 65,000 to 135,000 Btu/hour capacity amounted to approximately 200,000 units in 2000. [3]

Because most individual facilities only replace a small number of units at a time, the procurement effort focuses on working with volume buyers, such as the federal government and national accounts that have facilities across the country. Aggregated large-volume purchases represent a large enough market to induce manufacturers to offer a product they might otherwise hesitate to offer due to concerns about market demand. Although purchases from smaller buyers are more difficult to aggregate and by themselves would be unlikely to provide adequate assurance of market demand to manufacturers, the program has engaged several energy service companies, which serve smaller customers.

The High Cost of Low Efficiency

Cooling and heating account for more than half of the total energy operation cost for commercial and government buildings. Unitary rooftop air conditioners dominate the market for small- and medium-sized low-rise buildings, accounting for 60 percent of cooling energy and nearly one-third of total heating and cooling energy—more than one quadrillion Btus per year.

The best commercially available energy efficiency ratio (EER) for air-source rooftop air conditioners in the 65,000 to 135,000 Btu/hour size range is 11.8 [4]. About 14 percent of commercially available rooftop air conditioner models are considered "high efficiency," i.e., having an energy efficiency rating (EER) of 11.0 or greater. Most buyers still opt for lower-efficiency models with their lower purchase price instead.

However, a building's owner or occupants must pay the operating costs of lower efficiency units, and higher operating costs typically will rapidly erode any first-cost savings. Table 1 below compares the energy operating costs of unitary commercial air conditioners operating in Philadelphia with three different levels of energy efficiency: 1) base model that just meets the current federal energy efficiency standard; 2) FEMP recommended minimum efficiency level; and 3) best currently available efficiency level.

TABLE 1. ENERGY OPERATING COST PHILADELPHIA)

	Base Model	FEMP Recommended	Best Available
EER	9	11	12
Annual Energy Use (kWh)*	6,710	5,263	5,216
Annual Energy Cost**	$403	$337	$313
10 Yr. Lifetime Energy Cost	$4,030	$3,370	$3,130
10 Yr. Energy Cost Savings	--	$660	$900

*Annual energy use is derived by applying the cost simulator at www.pnl.gov/uac to a 90,000 Btu/hour, 2-stage model operating Mon. - Fri., 7 am - 7 pm in Philadelphia, PA.
**Costs reflect a typical US average electricity price of $0.06/kWh, including demand charges.

In warmer climates, the savings can be significantly greater. The 10-year savings anticipated with 11 and 12 EER units over 9 EER in Ft. Worth, Texas, for example, are $1,130 and $1,560, respectively.

Market Barriers to Energy Efficiency

Barriers to wider adoption of high-efficiency rooftop air conditioners include

- lack of awareness on the part of contractors, installers, and buyers of the financial and performance benefits of energy efficiency;
- split incentives; building occupant pays energy bills but doesn't select or own cooling equipment;
- lack of availability of high-efficiency units in the market;
- longer lead/delivery times relative to standard efficiency equipment; and
- higher purchase price of high-efficiency units.

Examples of Technical Improvements

The performance and energy efficiency requirements specified in the unitary air conditioner solicitation can be met using currently available technology. Some of the technologies and measures available to improve the energy and non-energy performance of rooftop air conditioners include

- increasing effective heat transfer surface area through increased frontal area, added subcooler, added desuperheater, and micro-channel heat exchangers;
- increasing effective heat transfer coefficient through increased fin density, improved fin design, improved tube design, and parallel flow coils;
- improving compressor efficiency through inertial reciprocating compressors, scroll compressors, improved rotary compressors, and other advanced designs;
- improving fan efficiency through high-efficiency motors, airfoil fan blades, and variable air volume;
- improving capacity control through variable speed compressors, unloading cylinders, and multiple compressors;
- electronic expansion devices; and
- liquid overfeed technology.

Other measures and technologies that are not yet commercial for rooftop units may be readily adaptable from other applications of compressor-based refrigeration. Many of these options involve little or no technical risk. However, some will increase first cost, thus requiring effective communication and marketing of the life-cycle cost and performance benefits of the improved technology.

TECHNOLOGY PROCUREMENT

Technology procurement is an interactive method of pulling new energy-efficient technologies and products into the marketplace. By working closely with potential buyers, technology procurement increases the likelihood that products brought to market will be well-received by buyers. By organizing large-volume buyers for new products, technology procurement reduces the risks of new product introduction and thus allows the manufacturers to introduce products at more competitive prices.

DOE and PNNL have developed a successful technology procurement process that generally includes the following steps:

1. Organize selected large-volume buyers and market influencers (such as utilities, government agencies, and national accounts).
2. Develop technical specifications for new products in cooperation with buyers, then review the specifications with potential manufacturers.
3. Issue a solicitation to potential suppliers requesting competitive bids for new products meeting the specifications.
4. Select one or more winning products from among those offered.
5. Negotiate basic ordering agreements with the winning suppliers to stipulate prices and other terms under which buyers can purchase new products. Market and promote the new products through web sites, news releases, publications, and presentations featuring participating companies.

Role of Market Players in Procurement

Market players work with DOE in key parts of the solicitation process and take the following active roles:

- Market leading buyers and government agencies purchase the new products offered and establish purchasing requirements or guidelines that lead to future purchases of the new products.
- Manufacturers and suppliers design, manufacture, and market the next generation of energy-saving technology.
- Utilities, energy service companies (ESCOs), energy advocates, and market transformation organizations publicize the technology procurement opportunities to customers and offer technical and financial assistance

Successful Past Procurements

DOE and other organizations, often in partnership, have successfully employed the technology procurement approach to a variety of energy-consuming products. Other partner organizations have included

- New York Power Authority (NYPA),
- Consortium for Energy Efficiency (CEE),
- International Energy Agency (IEA),
- Environmental Protection Agency (EPA), and
- National Energy Administration of Sweden.

Examples of successful procurements include

- Apartment-Size Refrigerator Program sponsored by CEE, NYPA and DOE;
- CEE's Super Efficient Refrigerator Program (SERP);
- DOE's Subcompact Fluorescent Lamp (Sub-CFL) Technology Procurement;
- Energy-Efficient Window Procurement, Sweden; and
- EPA/DOE/IEA Copier Procurement.

EVALUATION CRITERIA

To be considered under the competitive procurement, equipment offered must be a single package air-to-air direct expansion (DX) mechanical cooling system with 65,000 to 135,000 Btu/hour of cooling capacity and must meet all of the minimum technical requirements set forth in

the RFP. (The RFP documents and specifications are available on the project website at http://www.pnl.gov/uac.) The energy efficiency of the proposed models must meet or exceed CEE Tier II levels with an EER of at least 11.0 and Integrated Part Load Value (IPLV) of at least 11.4. These levels represent minimum requirements and the Government is seeking equipment that substantially exceeds the minimum.

From among models that meet these requirements, winners will be selected based on their anticipated life-cycle cost. Life-cycle cost is calculated as the sum of the initial price offered and the present value of the operating costs over 15 years, discounted at 10 percent per year, as follows:

$$LCC = P+7.61\times E$$

Where LCC is life-cycle cost, P is the unit price offered, and E is annual electricity cost. E is derived from a simulated energy calculation form, by multiplying the total annual energy use in kWh by $0.06.

LCC will be scaled by the total capacity of the unit, yielding a normalized life-cycle cost in dollars per thousand Btu per hour. Products will be evaluated based on simulated performance under representative climate conditions using the Simulated Energy Calculation Forms mentioned above.

STANDARDS

Congress originally established federal efficiency standards for packaged rooftop air conditioners in the Energy Policy Act of 1992. CEE, a non-governmental organization set up to coordinate utility energy efficiency (market transformation) efforts, is promoting a voluntary two-tier efficiency criterion that exceeds the federal standards. (See Table 2 below.)

The American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) recently revised its voluntary efficiency standard (ASHRAE Standard 90.1-1999) to a level equivalent to CEE's Tier I level, with an effective date of October 29, 2001. Corresponding mandatory federal standards pursuant to the Energy Policy Act of 1992 must be at least as stringent and may be set at a higher energy efficiency level. DOE is currently evaluating whether a more stringent standard is justified.

Further, the ENERGY STAR® labeling program of DOE and EPA recently adopted a specification set at CEE Tier II levels for unitary commercial air conditioning equipment of 65,000 to 135,000 Btu/hour capacity. The new label became available January 1, 2002. FEMP's recommendations to federal agencies reflect the new ENERGY STAR® standard.[5]

The California Energy Commission has also adopted the CEE Tier II efficiency level as a state mandatory standard. Pending approval of a waiver from federal preemption, necessary because the standard will be more stringent than the federal standard, the California ruling would take effect in approximately 2004.

In summary, CEE's Tier I level has now become the industry standard, currently on a voluntary basis, but becoming mandatory by the end of 2003. This represents a 15.7 percent improvement in energy efficiency over the current federal mandatory standard. CEE's Tier II is now the "high efficiency" standard, promoted by ENERGY STAR® and FEMP.

TABLE 2: ENERGY EFFICIENCY CRITERIA

	65-135 kBtu/hr		135-240 kBtu/hr	
	Full-load (EER)	*Part-load (IPLV)*	*Full-load (EER)*	*Part-load (IPLV)*
ASHRAE 90.1-1989 *(1992 Fed. Standard)*	8.9	8.3	8.5	7.5
ASHRAE 90.1-1999 *(Effective 10/29/2001)*	10.3	10.6	9.7	9.9
CEE – Tier I	10.3	10.6	9.7	9.9
CEE – Tier II	11.0	11.4	10.8	11.2
ENERGY STAR	11.0		10.8	

EER—Energy Efficiency Rating, IPLV—Integrated Part-Load Value [6]

CONTACTS

For further information, please contact the authors:
Brad Hollomon, Program Manager, Pacific Northwest National Laboratory, Washington, DC.
Tel. 202-646-5043. Email: hollomon@pnl.gov.
Kelly Gordon, Program Manager, Pacific Northwest National Laboratory, Portland, OR. Tel. 503-417-7558. Email: kelly.gordon@pnl.gov.

REFERENCES

[1]Arthur D. Little, Inc. *Energy Consumption Characteristics of Commercial Building HVAC Systems, Volume II: Thermal Distribution, Auxiliary Equipment, and Ventilation,* Washington, DC: U.S. Department of Energy, Office of Building Technology, State and Community Programs, October 1999.
[2]*A Look at Commercial Buildings in 1995: Characteristics, Energy Consumption and Energy Expenditures.* DOE/EIA-0625(95). Washington, DC: U.S. DOE Energy Information Administration, October 1998.
[3] Air Conditioning and Refrigeration Institute 2000 Statistical Releases. http://www.ari.org/sr/2000/

[4] Energy efficiency ratio (EER): the ratio of net equipment cooling capacity in Btu/hour to total rate of electric input in watts under designated operating conditions.
[5] "Commercial Air Conditioning," *CEE Update*. Boston, MA: Consortium for Energy Efficiency. March 2001.
[6] Integrated part-load value (IPLV) is based on Air Conditioning and Refrigeration Institute (ARI) Standard 210/240 or 360. Units are rated at 80°F entering dry bulb and 67°F entering wet bulb at ARI-rated cfm.