How to Buy an Energy-Efficient Air-Cooled Electric Chiller

Energy Efficiency and Renewable Energy
Federal Energy Management Program

Why Agencies Should Buy Efficient Products

- *Executive Order 13123 and FAR section 23.704 direct agencies to purchase products in the upper 25% of energy efficiency, including all models that qualify for the EPA/DOE* ENERGY STAR® *product labeling program.*
- *Agencies that use these guidelines to buy efficient products can realize substantial operating cost savings and help prevent pollution.*
- *As the world's largest consumer, the federal government can help "pull" the entire U.S. market towards greater energy efficiency, while saving taxpayer dollars.*

For More Information:

- DOE's Federal Energy Management Program (FEMP) Help Desk and World Wide Web site have up-to-date information on energy-efficient federal procurement, including the latest versions of these recommendations.
  Phone: (800) 363-3732
  www.eere.energy.gov/femp/procurement
- American Council for an Energy-Efficient Economy (ACEEE) publishes the *Guide to Energy-Efficient Commercial Equipment*, which includes a chapter on HVAC systems, as well as a listing of chiller models that meet this Recommendation.
  Phone: (202) 429-0063
  www.aceee.org
- ASHRAE publishes the *Cooling and Heating Load Calculation Manual*.
  Phone: (800) 527-4723
  www.ashrae.org
- Air-Conditioning & Refrigeration Institute (ARI) publishes the *Applied Directory*, which lists manufacturers' catalogues and software with ARI-certified capacity and efficiency ratings. This information is also available through ARI's on-line directory, "Prime Net."
  Phone: (703) 524-8800
  www.ari.org
- E SOURCE publishes the *Electric Chillers Buyer's Guide*.
  Phone: (303) 440-8500
  www.esource.com
- Lawrence Berkeley National Laboratory's "Cool $ense" Web site has a variety of resources to help in combining building retrofits with chiller replacements.
  http://ateam.lbl.gov/coolsense/
- Lawrence Berkeley National Laboratory provided supporting analysis for this recommendation.
  Phone: (202) 646-7950

Efficiency Recommendation[a]

Compressor Type and Capacity	Part Load Optimized Chillers	
	Recommended IPLV[b] (kW/ton)	Best Available IPLV[b] (kW/ton)
Scroll (30 – 60 ton)	0.86 or less	0.83
Reciprocating (30–150 ton)	0.90 or less	0.80
Screw (70 – 200 ton)	0.98 or less	0.83
	Full Load Optimized Chillers	
	Recommended Full-Load (kW/ton)	Best Available Full-Load (kW/ton)
Scroll (30 – 60 ton)	1.23 or less	1.10
Reciprocating (30–150 ton)	1.23 or less	1.00
Screw (70 – 200 ton)	1.23 or less	0.94

a) Depending on the application, buyers should specify chiller efficiency using either full-load or integrated part-load values as shown (see text).

b) Values are based on standard rating conditions, as specified in ARI Standard 550/590-98. Only packaged chillers (i.e., none with remote condensers) are covered.

Definitions

Integrated Part-Load Value (IPLV) is a weighted average of efficiency measurements at various part-load conditions, as described in ARI Standard 550/590-98. These weightings have changed substantially from the previous standard, ARI 590-92, lowering IPLV ratings by 10-15% for the same equipment.

Full-load efficiency is measured at peak load conditions as described in ARI Standard 550/590-98.

How to Select an Energy-Efficient Air-Cooled Chiller

Buyers should decide whether to emphasize full-load or part-load efficiency for their application. IPLV is preferred for more variable loads and variable ambient temperature and humidity, a situation common for air-cooled chiller applications. However, buyers may wish to put more emphasis on full-load performance in installations with staged chillers, or in locations where peak demand and demand charges are a primary concern. When selecting an air-cooled chiller, specify an energy consumption rate (in kW/ton) that meets the recommended level for that compressor type. The Air Conditioning and Refrigeration Institute (ARI) lists manufacturers' catalogues and software with ARI-certified ratings in its *Applied Directory* (see "For More Information").

When to Choose an Air-Cooled Chiller

When deciding on a chilled water system, designers must choose either an air- or water-cooled chiller. Air-cooled systems eliminate the need for a cooling tower, reducing installation and maintenance costs. However, air-cooled chillers are substantially less efficient than water-cooled models (see "How to Buy an Energy-Efficient Water-Cooled Electric Chiller"). To compare air- and water-cooled options, a detailed life-cycle cost analysis can be performed using FEMP's "Building Life-Cycle Cost" (BLCC) software (see "For More Information"). Maintenance costs for air-cooled chillers vary by compressor type. Screw and scroll compressors cost more initially, but can operate longer before overhauling.

Sizing

When selecting a chiller, careful attention to appropriate sizing is critical. An oversized chiller not only costs more to purchase, but also wastes energy due to poor low-load performance and excessive cycling. Use the referenced ASHRAE calculation procedure (see "For More Information") to determine the cooling load. It is often cost-effective to combine a chiller replacement with other measures that reduce cooling load, permitting specification of smaller capacity chillers (see the "Cool $ense" Web site in "For More Information").

Environmental Tips

Refrigerants with ozone-destroying chlorofluorocarbons (CFCs) were common in older chillers but are not used today. The 1992 Montreal Protocol banned the production of CFCs in the U.S., beginning in 1996. Most air-cooled chillers sold today use hydrochlorofluorocarbon (HCFC) refrigerants, which have a much lower ozone-depleting effect. There are many energy-efficient chillers on the market that use hydrofluorocarbon (HFC) refrigerants, with no ozon-depleting effect. When retiring a chiller that contains CFCs or HCFCs, the Clean Air Act requires that the refrigerant be recovered on-site by a certified technician (for information call (800) 296-1996).

Chiller Cost-Effectiveness Example
100-ton Screw Chiller

Performance	Base Model[a]	Recommended Level	Best Available
IPLV Efficiency (kW/ton)	1.25	0.98	0.83
Annual Energy Use	250,000 kWh	196,000 kWh	166,000 kWh
Annual Energy Cost	$15,000	$11,800	$10,000
Lifetime Energy Cost	$219,000	$172,000	$145,000
Lifetime Energy Cost Savings	–	***$47,000***	***$74,000***

a) The efficiency of the base model is just sufficient to meet ASHRAE Standard 90.1-99.

Definition

Lifetime Energy Cost is the sum of the discounted value of annual energy costs, based on average usage and an assumed chiller life of 23 years. Future electricity price trends and a discount rate of 3.4% are based on federal guidelines (effective from April, 2000 to March, 2001).

Cost-Effectiveness Assumptions

Annual energy use is based on 2,000 equivalent full-load hours per year. IPLV efficiencies are compared, since air-cooled chillers are generally installed in applications with highly variable load conditions. The assumed electricity price is 6¢/kWh, the federal average electricity price (including demand charges) in the U.S. Since this average cost does not incorporate the disproportionately large portion of demand costs that chillers usually contribute, the cost savings shown in the table may be conservative.

Metric Conversion

1 ton (cooling capacity)
= 12,000 Btu/h
= 3.517 kW

Understanding the Cost-Effectiveness Table

In the example shown above, a 100-ton air-cooled screw chiller with an IPLV efficiency rating of 0.98 kW/ton is cost-effective if its purchase price is no more than $47,000 above the price of the Base Model. The Best Available screw model, with an efficiency of 0.83 kW/ton, is cost-effective if its price is no more than $74,000 above the price of the Base Model. FEMP provides a Web-based "cost calculator" screening tool that simplifies the energy cost comparison between different air-cooled chillers. Go to www.eere.energy.gov/femp/procurement/air_chiller.html, and click on the "Cost-Effectiveness Example."

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