Energy Innovators Initiative

Technical Fact Sheet

# Choosing a High-Efficiency Chiller System

## Description

In many commercial facilities that require air conditioning, chillers are a major energy user. Thus, it is important to select a chiller that costs as little as possible to operate for the specific application.

Three basic designs of chillers provide cooling using a vapour compression cycle driven by electricity, while a fourth uses an absorption cycle driven by a heat source. Facility managers and maintenance planners should take care to select equipment with the lowest life cycle cost rather than simply the lowest purchase price, as the cost of energy for chillers over their life is usually many times the initial capital expense. Figure 1 shows a centrifugal chiller and controller.

**Figure 1** – Centrifugal Chiller and Controller

## Technical Specifications

Depending on the application, the type and size of a chiller will dramatically affect the plant's energy consumption. Care should be taken to select the most suitable chiller for the application. Some selection criteria are outlined in Table 1.

Many chiller manufacturers, including Trane, Carrier, McQuay, Dunham-Bush and York, are well-established companies that produce quality equipment. Before you select a new chiller, ensure that the equipment has the appropriate capacity to handle the desired load.

**Table 1** – Chiller Selection Criteria

| | Centrifugal | Reciprocating | Rotary | Absorption |
|---|---|---|---|---|
| **Description** | Variable-volume compression using centrifugal force | Piston-type compression, suitable for small and variable loads | Positive displacement compression using two machined rotors | Uses heat in the cycle instead of mechanical compression |
| **Initial cost** (per Ton[1] of cooling) | \$500–\$700 | \$450–\$600 | \$500–\$800 | \$1,000–\$1,400 |
| **Maintenance cost** | Medium | Higher | Lower | Lower |
| **Appropriate size** (Tons of cooling) | 90–1000 | 3–100 | 20–2000 | 100–5000 |
| **Space requirements, noise, vibration** | Small, high-pitched noise, no vibration | Large, high noise and vibration | Small, quiet, no vibration | Large, low noise and vibration |

[1] One Ton of cooling = 12 000 Btu/hr or 3.5 kW of cooling output.

## Energy Information

In recent years, chillers have generally become more energy efficient, even though at the same time most of them use low ozone-depleting refrigerants with lower heat-transfer capacities. Today's designs are 10–30 percent more efficient than previous generations of equipment. In most cases, chillers can be expected to become even more efficient over the next decade because of improved microprocessor control, superior flow and temperature measurement, and the introduction of larger heat exchangers. If a plant chooses to install only one large chiller, it should have a high part-load efficiency, as it will rarely operate at full load. Variable frequency drives can dramatically improve low-load efficiency for centrifugal and rotary chillers. Some of the newest centrifugal chillers have markedly improved part-load performance, which in many cases makes them more attractive than heat-source gas absorption chillers. However, absorption

Natural Resources Canada
Ressources naturelles Canada

Canada

chillers are regaining some market share – because they do not use electricity for cooling, they can help eliminate high electric demand charges. Where waste heat or inexpensive heat is available, absorption units may be a worthwhile choice. In regions with high peak demand costs, the most flexible scenario is to use both types of cooling systems.

## Comparison

Different chiller designs have different areas of strength, although some are inherently more efficient in terms of energy units consumed per unit of chilled water produced. Table 2 compares the energy efficiency of the different chiller types. Part-load efficiency is also improving gradually, and some recent design breakthroughs have yielded dramatic improvements. One manufacturer produces centrifugal chillers whose part-load efficiency is only slightly below full-load efficiency. Variable frequency drives can improve efficiency to this extent but can add $20,000 to $30,000 to the cost of any installation.

**Table 2** – Efficiency Comparison for Different Chiller Types

| | **Reciprocating** (kW/ton[2]) | **Centrifugal** (kW/ton) | **Rotary** (kW/ton) | **Absorption**[3] (kW/ton) |
|---|---|---|---|---|
| **Full load** | 0.84–1.00 | 0.48–0.65 | 0.70–0.80 | 3.2–5.6 |
| **Part load** | 0.84–1.00 | 0.55–1.00 | 0.75–0.90 | Slightly higher than full load |

[2] A lower number indicates a more efficient chiller.
[3] Because the input energy is not electricity, the units are converted to kW of heat energy demand.

## Case Study

**Figure 2** – Royal Bank Building in Halifax

At the 19-storey Royal Bank Building (Figure 2) in downtown Halifax, Nova Scotia, a single 600-ton Trane B5D General Assembly absorption chiller was replaced by two McQuay 215-ton PEH-063 centrifugal chillers with full-load performance of approximately 0.6 kW/ton (after accounting for the impact of ancillary equipment). The absorption chiller was suitable when inexpensive excess heat was available, but this became less practical as fuel costs rose. Energy efficiency improvements throughout the building had reduced the building's cooling loads enough to make an electrically driven chiller system feasible. The final selection of the two centrifugal chillers was based on low energy consumption, the ability to run one at full load for much of the time, the benefit of redundancy, and the availability of local maintenance technicians. In addition, the building owners will benefit from the lower operating costs for the life of the chillers – roughly 30 years or more.

Energy and cost savings have been significant – at 2000 rates, net overall savings are roughly $35,000 per year, which comprises a fuel oil cost reduction of $85,000 minus $35,000 for electricity and roughly $15,000 for electricity demand charges. Table 3 (below) was prepared based on an oil price of $0.35 per litre. In Nova Scotia, fuel costs are expected to increase, but with electricity generation fuelled by coal and natural gas, as well as oil, the utility may be able to maintain stable electricity pricing for many years, increasing the benefits of the centrifugal chiller choice.

**Table 3** – Energy and Carbon Dioxide ($CO_2$) Savings from Absorption Chiller Replacement

| | **Electricity Use** (kWh/yr) | **Fuel Oil Use** (L/yr) | **Electricity Cost** ($/yr) | **Fuel Oil Cost** ($/yr) | **$CO_2$ Production** (tonnes/yr)[4] |
|---|---|---|---|---|---|
| **Before Retrofit** (Absorption chillers installed) | 2 700 000 | 500 000 | $200,000 | $175,000 | 3523 |
| **After Retrofit** (Centrifugal chillers installed) | 3 000 000 | 255 000 | $250,000 | $90,000 | 3063 |
| **Annual Savings** | (300 000) | 245 000 | ($50,000) | $85,000 | 460 |

[4] Most electricity in Nova Scotia is generated by fossil fuels; an allowance of 0.78 tonnes of $CO_2$ per megawatt hour has been allowed.

## For more information, contact

Energy Innovators Initiative, Office of Energy Efficiency, Natural Resources Canada, 580 Booth Street, 18th Floor, Ottawa ON  K1A 0E4
**Tel.:** (613) 995-6950 • **Fax:** (613) 947-4121 • **Web site:** http://oee.nrcan.gc.ca/eii

*Leading Canadians to Energy Efficiency at Home, at Work and on the Road*

The Office of Energy Efficiency of Natural Resources Canada strengthens and expands Canada's commitment to energy efficiency in order to help address the challenges of climate change.


Cat. No. M92-242/2002-1E   ISBN 0-662-31578-2
***(Aussi disponible en français)***

Recycled paper