4 Refrigerators & freezers

The efficiency of refrigerators and freezers has increased significantly in the past two decades, and considerable room for further improvement remains. New standards for average-sized refrigerators call for the use of less than 500 kWh per year—a decade ago, the average refrigerator used more than 1,160 kWh per year. Even without any technological breakthroughs, units of the same size that use only 300 kWh per year are feasible.

4.1 End-use and market data

Thanks to the lack of natural ice in the hot Australian climate, an expatriate Scotsman convinced a colleague in England named Seebee to help him design a refrigeration system that enabled artificial ice-making in warm climates. The design proved successful in the late 1800s in its first application—cooling lager at an Australian brewery—a breakthrough that eventually led to an almost universal ownership of refrigerators in homes in the industrialized world.[1] ("Refrigerator" as used in this chapter, refers to units that are combination refrigerator/freezers as well as those that do not have a freezer compartment.)

There are 117.5 million refrigerators and 36.9 million freezers in U.S. homes.[2] Refrigerators account for about 12 percent of the electricity consumed in U.S. households, and stand-alone freezers consume a little over 5 percent (see **CHAPTER 2**).[3]

Nearly every household in the U.S. has a refrigerator;[4] market penetration in Europe and Japan is similar.[5] Separate freezers are found in 42.4 percent of U.S. homes, a figure that has grown continuously from 28 percent in 1970.[6] Recent years have also seen growth in the use of small refrigerators (and even small refrigerated drawers) for use in rooms other than the kitchen and growth in the use of wine chillers. Among countries in the

Highlights

- Fine tuning of various refrigerator components could increase energy efficiency by as much as 30 percent compared to new U.S. standards.
- Although chlorofluorocarbons (CFCs) tend to be more energy efficient than alternative refrigerants and blowing agents, the appliance industry is meeting the challenge of phasing out CFCs while increasing energy efficiency. Models produced for sale in the U.S. after January 1, 1996, are required to use alternative refrigerants and blowing agents for insulating foam. Hydrochloro fluoro carbon (HCFC) blowing agents are being phased out in the U.S. by 2003.
- Advanced insulation based on low-conductivity gases or a vacuum is an emerging technology likely to improve the energy performance of refrigerators in the future.
- The development of very small high-performance compressors is one of the most important frontiers in refrigerator efficiency.
- The availability of high-efficiency refrigerator models should improve as the deadline for compliance with the July 2001, refrigerator standard nears and the corresponding increase in Energy Star compliance levels that took effect January 1, 2001 makes its mark.

European Union, overall freezer market penetration averages about 53 percent, with a range of 19 to 77 percent according to individual country.[7]

In the U.S. and other developed countries, because such a high percentage of homes have refrigerators, replacement of old units constitutes most sales. Refrigerators can last for two decades or more, and the average life expectancy of first ownership is 14 years,[8] meaning that there is still a large stock of inefficient refrigerators operating in U.S. homes. Based on equipment age and industry estimates, about 9.1 million refrigerators were sold in 1999, and similar sales are forecast for 2000.[9] And even in developing countries, refrigerator ownership is growing fast. For example, in Thailand, the penetration of refrigerators exceeds one per household in greater Bangkok. In China, market penetration in urban areas has grown from less than 7 percent in 1985 to 73 percent in 1997.[10]

For a comprehensive list of appliance manufacturers and brand names, see Appendix A.

4.1.1 Manufacturers

There is a wide array of refrigerator and freezer brands in the U.S., although one producer may manufacture several different brands. Several companies dominate the markets (**Figure 4-1** and **Figure 4-2**), which are very competitive.[11] The Canadian market is served by these same manufacturers, sometimes under different names: Inglis Ltd. is Whirlpool's Canadian division and Camco is General Electric's Canadian division.

In Europe, a large number of companies manufacture appliances. No one company dominates, although there have been a number of consolidations in recent years because of takeovers and mergers.

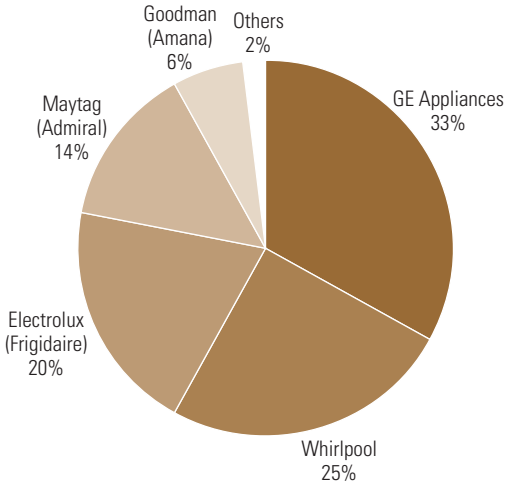
4.1.2 Types of refrigerators and freezers

A number of styles and configurations of refrigerators are available, ranging from countertop compact units of 6 cubic feet or less that are suited to dormitory rooms or offices, up to 30-cubic-foot models for large households. Volume is given in two ways for refrigerators: the net volume, which is a measure of the interior space in which food can be stored, and the adjusted volume (AV), a measure of the appliance volume in which a multiplier of freezer volume is used to account for the different operating temperatures of the fresh and frozen food compartments. The U.S. energy efficiency standards are calculated based on the adjusted volume

Figure 4-1

U.S. refrigerator market shares (1999)

Five companies accounted for 98 percent of the 9.1 million refrigerators shipped by U.S. manufacturers in 1999.

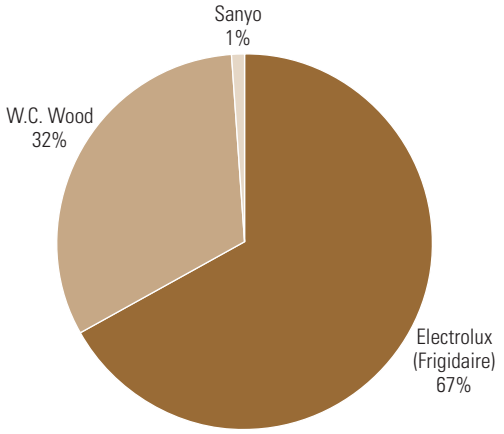


Source: *Appliance Manufacturer*

Figure 4-2

U.S. freezer market shares (1999)

Two companies accounted for virtually all of the 2.4 million freezers shipped by U.S. manufacturers.



Source: *Appliance Manufacturer*

of refrigerators, which is defined as refrigerator volume plus 1.63 times freezer volume. For example, an 18-cubic-foot refrigerator in which the fresh food storage compartment is 12.5 cubic feet and the freezer 5.5 cubic feet would have an adjusted volume of about 21.5 cubic feet.

One major variable in refrigerators is the placement of the freezer compartment. In North America, some models without freezers are available, but these are a tiny fraction of the market and consist mostly of compact models. In Europe, however, the refrigerator and freezer are often separate units. Market saturation of combination refrigerator/freezers in the European Community is only about 48 percent of households.[12]

In some units, frozen and fresh food storage sections are in a shared cabinet, accessible through a single door. In most U.S. models, however, the freezer compartment is accessed through a separate door and is located at the top, bottom, or side of the unit. Close to 70 percent of refrigerators sold in U.S. are top freezer models, about 25 percent are side-by-sides, and only three percent are bottom freezers.[13]

Freezers come in two basic types: upright, similar in appearance to a refrigerator, or chest style. The basic types of refrigerators and freezers are shown in **Figure 4-3**. Freezers can also be classified as automatic or manual defrost. Automatic defrost dominates in the U.S. market, although manual defrost freezers still maintain significant sales. Manual defrost models are still the norm in Europe, although sales of automatic defrost units are growing, particularly in Great Britain.[14]

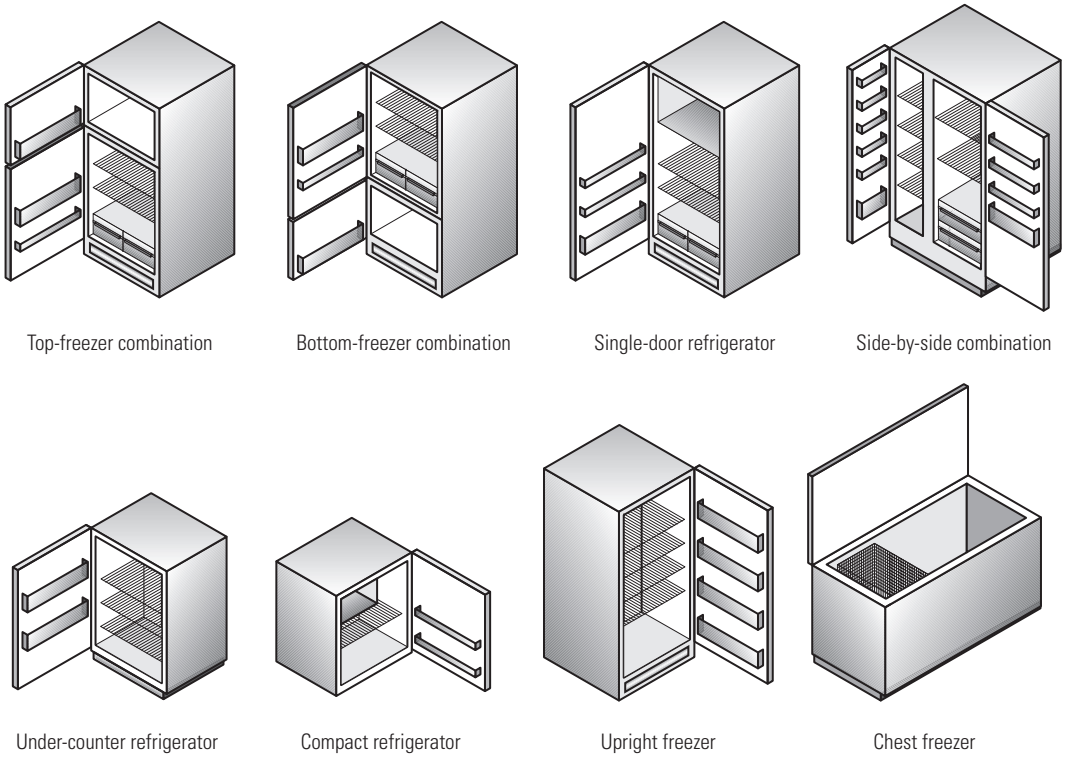
4.1.3 Product lists

The Association of Home Appliance Manufacturers (AHAM) has certified and list-

Figure 4-3

Basic types of refrigerators and freezers

Refrigerators and freezers are available in a variety of styles. In the United States, the most popular model is a refrigerator with a top freezer.



ed the volume and shelf size of some models. The AHAM list also includes rated energy consumption. The directory is published twice a year and includes all models from companies licensed to participate in the AHAM Refrigerator/Freezer Certification Program, including most of the major manufacturers listed in Figures 4-1 and 4-2. A regularly updated list of refrigerator and freezer models that are available in the U.S. is maintained by the California Energy Commission (CEC) as part of a larger appliance database. Information is sorted according to manufacturer, brand, model, volume, style, and energy efficiency. The American Council for an Energy Efficient Economy publishes lists of the most efficient appliances on its Web site (http://aceee.org) as a stand-alone pamphlet and as part of its periodically revised Consumer Guide to Home Energy Savings. The EPA/DOE Energy Star program maintains an updated list of all models qualifying for the Energy Star label on its Web site (www.energystar.gov/products/refrigerators/index.html).

In Canada, the government publishes consumer guides and product lists. Government agencies in some European countries also offer product lists so that the energy consumption of a number of machines can be compared.[15] Information on obtaining lists of models sold in the U.S. and Canada is provided in **Table 4-1**.

4.1.4 Availability of high-efficiency refrigerators and freezers

In the U.S., refrigerators that exceed energy efficiency standards are readily available at major appliance stores. The availability of the highest efficiency models, however, is much less consistent. Stores in areas where utility-sponsored rebates or state tax incentives are

Table 4-1

Where to obtain lists of refrigerator and freezer models

Contact	Title	Cost	Comments
In the United States			
Association of Home Appliance Manufacturers (AHAM) 20 Wacker Drive Chicago, IL 60606 tel 312-984-5800	Directory of Certified Refrigerators and Freezers	$7.50 Cost includes two editions published annually (usually in January and June) plus any necessary supplements. Remittance must accompany order.	AHAM sponsors a program to verify the total refrigerated volume and total shelf areas of household refrigerators and freezers. This directory lists models AHAM has certified. Participation by manufacturers is voluntary.
ACEEE Contact: Jennifer Thorne 1001 Connecticut Avenue NW, Suite 801 Washington, DC 20036 tel 202-429-8873 fax 202-429-2248 web www.aceee.org	List of Most Efficient Appliances in "Consumer Guide to Home Energy Savings."	$8.95	Lists are based on product directories and manufacturer's data. Only includes models that are widely distributed in the U.S.
U.S. Environmental Protection Agency U.S. Department of Energy Energy Star program www.energystar.com 1-888-782-7937	Appliance database	Free at www.energystar.gov/products/refrigerators	Lists refrigerators that qualify for an Energy Star.
In Canada			
Energy Efficiency Publications Line, Natural Resources Canada tel 800-387-2000 (calls within Canada) tel 613-995-2943 (calls from outside Canada) fax 819-994-1498	Energy Consumption Ratings of Major Household Appliances	Free in Canada US$15 elsewhere	In addition to refrigerators and freezers, this booklet includes clothes washers and dryers, ranges, and dishwashers.