



Chillers, Refrigerant Compressors, and Heating Systems

Course Number: ME-02-242

PDH: 6

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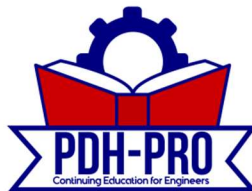
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1 EXECUTIVE SUMMARY

This course covers energy consumption in commercial building HVAC systems in the U.S. It focuses on energy use for generation of heating and cooling, i.e. in equipment such as boilers and furnaces for heating and chillers and packaged air-conditioning units for cooling.

A lot of information is provided on the equipment and equipment components used to generate heating and cooling. It does not include fans and pumps. This distinction is clear for most equipment types, such as unit heaters, boilers, and chillers. However, for packaged air-conditioning (AC) equipment the distinction can be subtle. Most packaged AC equipment is treated as a unit by performance rating procedures. Hence, separation of the fans is difficult. For this course, only the refrigerant compressors of packaged equipment are considered. In some cases, however, the fans of packaged equipment are included in order to allow comparison to other studies.

This is pointed out in the text where necessary. The total cooling energy use in commercial building HVAC systems, including the refrigerant compressors and chillers, accounts for about 1.4 quads of primary energy¹ use annually, while the total heating energy use in commercial building HVAC systems, including furnaces and boilers, accounts for about 1.7 quads of primary energy.

1.1 Objectives

The objectives of this course are:

- To provide an accurate estimate of the energy used by primary cooling and heating equipment in the US commercial building sector.
- To provide a physical understanding of the factors which contribute to energy use by the equipment.
- To provide a baseline estimate of current national energy use which can be used for calculation of the national energy savings impact of various options for reducing energy usage. The estimate is based on calendar year 1995.

1.2 Summary

The energy use estimates presented in this course were developed from a bottom-up approach. Distribution of the commercial building floorspace among building type, system type, and region is based largely on the 1995 Commercial Building Energy Consumption Survey (CBECS95, Reference 3). Models for cooling and heating loads were obtained from Lawrence Berkeley National Laboratory (LBNL) and were based on building models initially presented in Reference 7. Models of HVAC equipment design loads and operating characteristics were developed based on engineering calculations and product literature. Energy use estimates, for both heating and cooling, were developed representing the different building types, regions, system types, and equipment considered in the study. The results are considered to be conservative, because of insufficient available quantitative information regarding excess energy use associated with poor installation, operation, and/or maintenance of HVAC systems. Details regarding the calculation methodology are presented in Section 5.

Figure 1-1 below shows the breakdown of cooling and heating energy use by equipment type. About half of the cooling energy is associated with Packaged AC (mostly Rooftop units). Packaged AC units consume an estimated 0.74 quads for cooling. The heating systems of these units consume 0.44 quads for heating (they are referred to as "Packaged Units" in the heating chart). In addition, 0.46 quads is associated with the supply and condenser fans of these units (Reference 9). These units contribute so much to national HVAC energy use primarily because they are used in a majority of the building types comprising a significant amount of floorspace (about 48% of 36 billion sqft cooled commercial floorspace.) The efficiencies of this equipment type are lower on average than those of other equipment types, particularly water-cooled chiller systems.

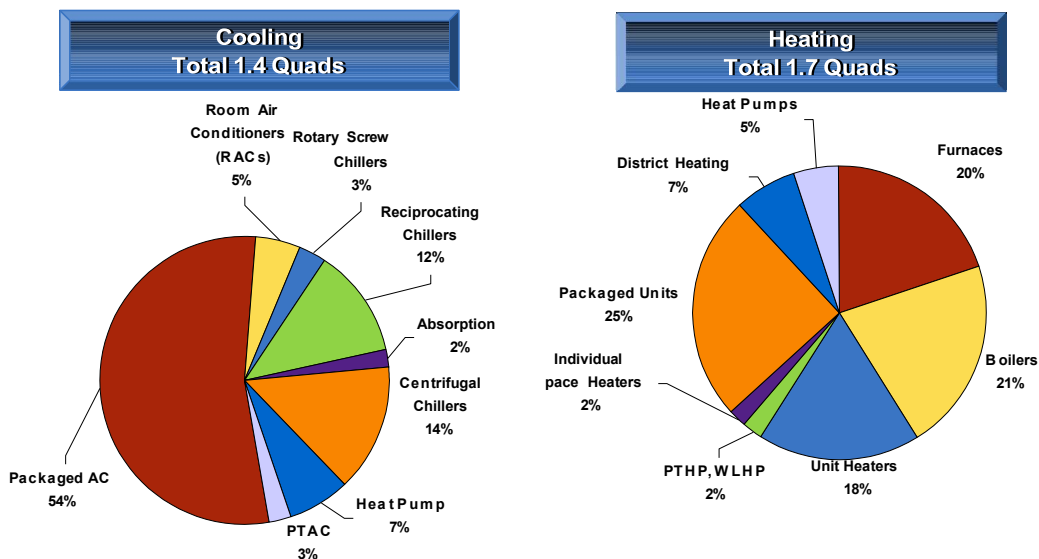


Figure 1-1: Primary Energy Use — Equipment Breakdown

The other cooling equipment types representing high energy use are centrifugal and reciprocating chillers. It is noteworthy that the energy use of centrifugal chillers, which have received much interest in recent years, is only about 14% of the total. Reciprocating chillers, which are typically smaller in size, are generally less efficient, in part because most of them are air-cooled (rather than water-cooled, which is typical for centrifugal chillers, and which allows condensing temperatures to approach ambient wet bulb temperatures). Floorspace for heating and cooling equipment is shown in Figure 1-2 below.

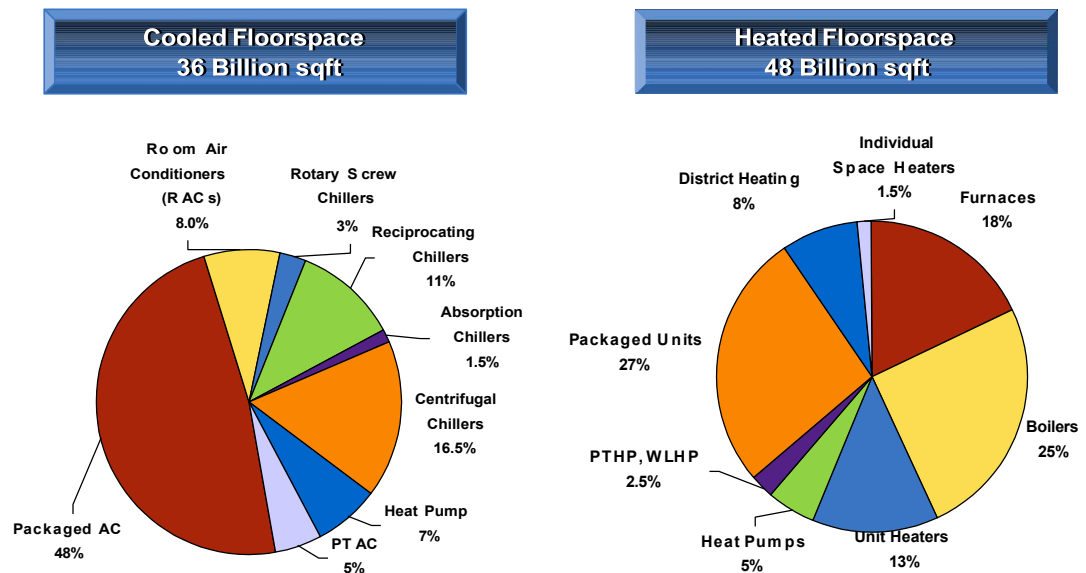


Figure 1-2: HVAC Equipment Distribution

The heating equipment types representing high energy use other than packaged units are furnaces, boilers, and unit heaters, representing 0.34, 0.36, and 0.31 quads respectively in commercial buildings.

The distribution of heating and cooling energy use by building type is shown in Figure 1-3 below. The building categories are identical to those used in the 1995 Commercial Building Energy Consumption Survey (CBECS95-Reference 3)². The most energy use is in the Office, Mercantile & Service, and Public Building categories. These categories are large energy users due to their large floorspace in the commercial sector (they each represent at least 7 billion sq. ft.), and they each account for roughly 0.6 quads of heating and cooling energy use. The education category is noteworthy in that it has large floorspace but relatively modest combined cooling and heating energy use. The high energy use intensity of the food service and health care categories make these building types very important, particularly for cooling. Commercial building floorspace distribution by building is shown in Figure 1-4 for reference.

² The Building Category "Public Buildings" includes CBECS95 categories "Public Assembly", "Public Order and Safety", and "Religious Worship".

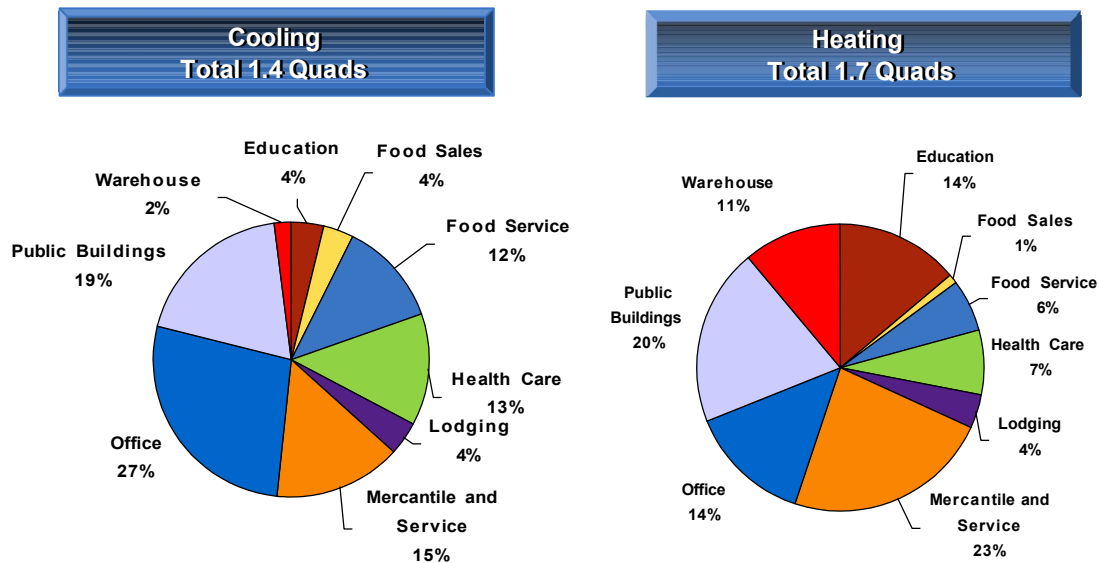


Figure 1-3: Primary Energy Use - Building Type Breakdown

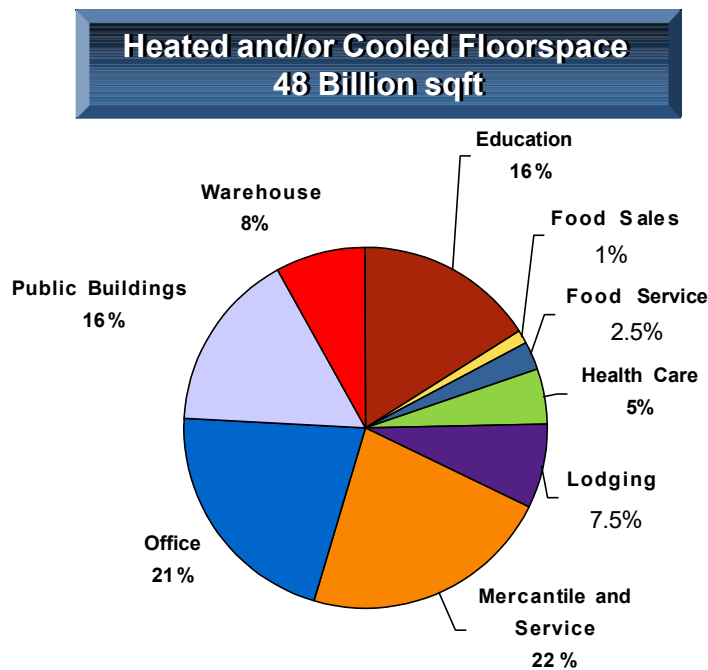


Figure 1-4: Heated and Cooled Commercial Building Floorspace



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