



Current situations and technical development of energy-savings in China refrigeration industries



Shangjie Wu^a, Hongqi Li^{b,*}, Jianhong Cheng^c, Chengcheng Tian^b

^a China Household Electric Appliance Research Institute, Beijing, PR China

^b Department of Refrigeration, Beijing University of Technology, Beijing, PR China

^c China National Institute of Standardization, Beijing, PR China

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ABSTRACT

The promotion of Energy Efficiency Standards and the implementation of Energy Labels have greatly improved energy efficiencies of Chinese refrigeration products in recent years. These products are now moving towards multiple heat sources and multiple functions, to obtain further energy-savings. Some typical products, such as solar energy refrigerators and air conditioning-water heater system are introduced. The current energy efficiencies of Chinese refrigeration products are also introduced in this paper. Some recommendations are given to make the standards accommodate these changes.

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1. Introduction

In the past 10 years, the production capacity of refrigeration products has rapidly increased in China. Now Chinese products take a large portion of the worldwide refrigeration market. Chinese energy conservation policies and technical development have led to greatly improved efficiencies of these refrigeration products. For example, China air conditioner manufacturers produced more than 10 million air conditioners in 2010, about 75% of the world market. The lowest EER (Energy Efficiency Ratio) of constant speed air conditioners with cooling capacities below 4500 W in the market has increased from 2.6 before 2010 to 3.2 after 2010.

There is then a limit to how high these energy efficiencies can be due to unavoidable losses and technical limits that make further energy efficiency improvements more and more difficult. Actually, the way to continuously increase the energy efficiency when its energy efficiency is already high may not be wise since energy efficiency improvements usually cause other costs, such as increased material consumption, energy consumption and pollutant emissions during manufacturing. The Chinese refrigeration industry is now facing a problem on how to further increase energy efficiencies when facing technical limits.

Solution to improve energy use is to use multiple energy sources, multiple heat sources and multiple functions. The multiple

energy sources refer to the use of other energy sources such as solar energy to replace or complement the electrical energy. Liam Paull [1] introduced a multi-objective demand side management program. It uses remote control of domestic electric hot water heaters to make the added power system efficiency and reliability. H. Gari et al. [2] designed and simulated a solar-powered/fuel-assisted Rankine engine for power generation. The system has two energy sources and an auxiliary oil heater and could provide about 70% of the total energy by solar energy in winter season. The multiple heat sources mean to use more than one heat source for the refrigeration cycle. Multiple functions means to add functions of the product while having approximate the same energy consumption. Some such products have appeared in the Chinese market in recent years, they are relatively few, they show a great potential in the future. Some relevant researches, such as heat exchange and thermal energy storage technologies, have been able to support the development of these new systems [3].

Other solutions may improve the energy efficiency evaluation methods, i.e. improved standards. Some products that have high efficiencies evaluated in standard laboratory tests may not have high energy efficiency during operation. Since test conditions stipulated in the standards do not represent the real operating conditions. There are two reasons for these differences. One is that operating product will experience different operating conditions from the test conditions. For example, the actual outside temperature may differ from the test temperature. Differences can also be caused by the difference in system containing the product. For

* Corresponding author. Tel./fax: +86 (10) 67391613.

E-mail address: atianchengcheng@gmail.com (H. Li).

Table 1
Existing energy efficiency standards for Chinese refrigeration products.

Standard No.	Standard Name
1 GB12021.2-2008	The maximum allowable values of the energy consumption and Energy efficiency grade for household refrigerators
2 GB12021.3-2010	The minimum allowable values of the energy efficiency and Energy efficiency grades for room air conditioners
3 GB21455-2008	The minimum allowable values of the energy efficiency and Energy efficiency grades for variable speed room air conditioners
4 GB19576-2004	The minimum allowable values of the energy efficiency and Energy efficiency grades for unitary air conditioners
5 GB19577-2004	The minimum allowable values of the energy efficiency and Energy efficiency grades for water chillers
6 GB21454-2008	The minimum allowable values of the energy efficiency and Energy efficiency grades for multi-connected air-condition (heat pump) unit

example, a water chiller in a central air conditioning system or a compression-condensing unit in a cold storage system. In this situation, the energy efficiencies are not only dependent on products themselves but also on the system factors, such as system design, operating conditions and system control, etc. Both of these problems and new products need improved test standards.

2. Current energy efficiencies of Chinese refrigeration products

In the past 10 years, the Chinese government has paid much attention to energy conservation in refrigeration of products. Many policies have been issued with Energy Efficiency Standards, Energy Labels, and financial subsidies for energy saving products including room air conditioner and household electric appliances especially to rural markets to increase use of high efficiency and inexpensive products in rural area. Energy Efficiency Standards stipulate the lowest allowable energy efficiencies of products as market thresholds to eliminate low energy efficiency products. The standards also divide products into different energy grades from 1 to 5 in most cases with grade 5 as the lowest efficiency according to their energy efficiencies to provide energy consumption information to buyers.

In general, energy efficiency standards and energy efficiency labels have been proved as a best way to reduce energy consumption [4]. Energy labels can: (i) Encourage consumers to select products that consume less energy, (ii) Educate consumers to know the operating energy costs of products and to reduce the total life cycle costs, (iii) Require importers and manufacturers to improve the energy efficiency of products that they supply to the market [5]. The energy label system requires all products covered by the Energy Efficiency Standards to have Energy Labels to indicate their energy grades. These policies have greatly increased the energy efficiencies of these products.

Table 2
Current energy efficiencies of some typical refrigeration products in China.

Product	Number of types	Energy Efficiency distribution				
		Grade 1	Grade 2	Grade 3	Grade 4	Grade 5
1 Refrigerator	4096	66.3%	27.6%	3.3%	1.3%	1.4%
2 Room Air conditioner	12359	21.9%	46.0%	32.1%	0%	0%
3 Water Chiller	5844	15.6%	30.8%	29.2%	19.1%	5.3%
4 Unitary Air conditioner	2764	15.5%	16.5%	27.2%	26.6%	14.3%
5 Multi-connected Air conditioning Unit	1224	66.9%	15.8%	5.2%	9.6%	2.5%
6 Variable speed room air conditioner	2973	14.5%	36.6%	35.7%	11.7%	1.5%

2.1. Current energy efficiency standards for Chinese refrigeration products

The Energy Efficiency Standards play a very important role in promoting energy efficiency improvements. China has an extensive Energy Efficiency Standard system for refrigeration product with six Energy Efficiency Standards issued in China as shown in Table 1 [6].

New Energy Efficiency Standards are now being developed for more refrigeration products, such as heat pump water heaters, commercial freezers and show cases/cabinets, heat pumps, absorption refrigeration units, and cold and hot water dispensers.

2.2. Current energy efficiencies of Chinese refrigeration products

The energy efficiencies of some typical refrigeration products at the end of 2010 are listed in Table 2 [7].

The energy efficiency distributions in Table 2 are not based on their sales but on their numbers of types. The distributions are also dependent on the levels of each grade. For example for room air conditioners, the allowable lowest energy efficiency (EER) was greatly increased in the 2010 Energy Efficiency Standard revision, from 2.6 before 2010 to 3.2 after 2010 as shown in Table 3 [8,9]. Thus the energy efficiency distribution for a product will change when the standard is revised to get better each time.

3. Development trends of Chinese refrigeration products

Because of the difficulties and technical limitations to improving the energy efficiencies of high efficiency products, Chinese refrigeration product manufacturers are now developing new products using multiple energy sources, multiple heat sources and multiple functions. These products aim to improve energy use in different ways.

3.1. Multiple function products

Multiple function products are developed with the same main function with other functions to meet other needs of the user. The additional function should not increase the overall energy consumption.

The typical multi-function product is the air conditioning-water heater system. A traditional air conditioner only absorbs the heat from the room to reduce the room temperature. The air conditioner then discharges energy, including the heat absorbed from the room and the energy input by the compressor, to the surroundings. The discharged heat energy is usually wasted as thermal pollution. The energy usage can be easily improved by using the discharged heat in a combined air conditioning-water heater system. The system has the basic air conditioning function to cool the room while using the discharged heat to provide hot water in a water heater. Since the system must discharge heat, the added water heating function will greatly enhance the product energy efficiency [10]. This can be

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