

# Application and Research of Refrigeration Energy

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**Abstract.** Refrigeration energy plays a crucial role in modern society, which is the key to realizing refrigeration technology. Widely used in multiple fields such as family, business, and industry. With the improvement of living standards and the advancement of technology, people's demand for refrigeration equipment is increasing, making the importance of refrigeration energy increasingly prominent. To improve energy utilization efficiency and decrease energy consumption, the refrigeration field continues to introduce new technologies and new types of refrigeration energy. At the same time, it also promotes the development of the refrigeration industry towards a more environmentally friendly and energy-saving direction. The article focuses on introducing and discussing refrigeration energy, which is divided into traditional refrigeration energy and new refrigeration energy, Emphasis was placed on analyzing its advantages and disadvantages, and comprehensive consideration was given to its application scenarios, energy conditions, environmental friendliness, and economic viability, Analyzed new refrigeration technologies such as magnetic refrigeration technology and radiation refrigeration technology, Summarized the application in air conditioning and the Beijing Winter Olympics, and future development trends of refrigeration energy.

**Keywords:** Refrigeration energy refrigeration technology refrigeration system.

## 1. Introduction

With the progress of society, people have invented various refrigeration technologies. From mechanical refrigeration technology in the 18th century to modern refrigeration systems today. Refrigeration energy plays an increasingly important role in food preservation and safety, medical health, industrial production, comfortable living, and other aspects. Its advantages of energy conservation, environmental protection, stability, reliability, intelligence, convenience, and diverse customization make refrigeration technology an indispensable part of modern society. Nonetheless, there are still many problems and challenges in the high energy consumption and energy pollution of refrigeration energy. According to statistics, the energy consumption of refrigeration is also increasing, currently accounting for about one-third of the global electricity consumption. Moreover, the problem of high energy consumption of refrigeration systems in large cold storage is prominent, and it is proposed to improve the operating efficiency of refrigeration systems to solve it [1]. Some traditional refrigerants, such as hydrofluorocarbons (HCFCS) and hydrofluorochlorides (HFCS), which threaten to the environment and human health. The natural low global warming coefficient (GWP) is being developed and applied to address this issue [2]. With the development of refrigeration technology, the development of new refrigeration technologies will continue to revolve around the three core goals of energy conservation and emission reduction, environmental protection, and user experience improvement, such as passive cooling technology [3]. This article aims to comprehensively review the current research status in the field of refrigeration energy, the Application of refrigeration energy in air conditioning, and the 2022 Beijing Winter Olympics. And provide a reference for the innovation and sustainable development of future refrigeration energy in terms of technological innovation, environmental protection, and intelligence.

## 2. Refrigeration Energy

Refrigeration energy refers to various energy sources required for the refrigeration process, which refers to the use of a certain method or device to transfer heat from a specific environment to the surrounding environment, thereby reducing the temperature of the medium in that area, Create a 'cold' environment with a lower temperature than the surrounding environment. This is an energy transfer process, in which the energy involved is refrigeration energy.

### 2.1. Traditional Refrigeration Energy

Traditional refrigeration energy is mainly divided into electric refrigeration and thermal refrigeration, each with its advantages and disadvantages as shown in Table 1.

**Table 1.** Advantages and disadvantages of traditional refrigeration energy

Classification	Advantage	Disadvantage
electric refrigeration	Simple operation, stable and reliable performance, mature technology with a wide range of applications, high refrigeration efficiency, and the ability to quickly reach the set temperature. Accurate control and easy implementation of automated management.	High energy consumption, especially in high-temperature environments. Strong dependence on the power grid, unable to work during power outages. Some traditional refrigerants have negative impacts on the environment
thermal refrigeration	Low-quality thermal energy such as waste heat and waste heat can be utilized. Good energy-saving effect, with lower operating costs compared to electric refrigeration. Environmentally friendly and reduces greenhouse gas emissions.	Requires stable heat source supply, limited by heat source conditions. The refrigeration efficiency is influenced by the choice of working fluid and system design. The system is relatively complex and the maintenance cost is relatively high.

Electric energy: One of the most common refrigeration energy. By consuming electrical energy, the compressor, condenser, evaporator, and other components in refrigeration equipment (such as air conditioners, refrigerators, etc.) are driven to operate, the structure is shown in Figure 1, achieving the cooling effect.



**Fig. 1** Internal parts of the refrigerator (Photo credit: pconline)

Thermal energy: In certain specific situations, thermal energy can also serve as a cooling energy source. For example, absorption refrigeration systems can use thermal energy (such as solar energy, industrial waste heat, etc.) to drive the refrigeration process.

### 2.2. New Refrigeration Energy Sources

New refrigeration energy mainly includes solar refrigeration, magnetic refrigeration, and new refrigeration technologies such as radiation refrigeration. They each have their advantages and

disadvantages as shown in Table 2. Compared with traditional refrigeration energy, new refrigeration energy places more emphasis on the utilization of renewable energy and the improvement of environmental performance. For example, renewable energy sources such as solar and wind power can achieve cooling effects by converting them into electrical energy or directly driving cooling equipment (such as solar cooling systems). Compared to traditional refrigeration energy, it is more environmentally friendly.

**Table 2.** Advantages and disadvantages of new refrigeration energy

Classification	Advantage	Disadvantage
Solar refrigeration	Utilizing renewable energy, environmentally friendly and pollution-free. Reduce dependence on traditional energy sources and achieve significant energy-saving effects. It has better application effects in areas with strong solar radiation.	Due to the influence of weather and geographical location, the utilization rate of solar energy is unstable. Requires a larger heat collection area and energy storage system. The initial investment cost is relatively high
Magnetic refrigeration	No need for compressors and refrigerants, reducing mechanical wear and environmental pollution. Efficient and energy-saving, the magnetic refrigeration efficiency can reach a high proportion of the Carnot cycle. Easy to miniaturize and suitable for various application scenarios.	The cost of magnetic materials and magnetic field sources is relatively high. The technology is not yet fully mature, and commercial applications need to be promoted. Require professional maintenance and operational knowledge
Radiation refrigeration	No energy consumption is required, achieving passive cooling. No vibration or electromagnetic interference, suitable for special environments. Long lifespan and low maintenance cost.	The cooling effect is influenced by environmental conditions and material properties.

**Solar refrigeration:** Solar cooling is mainly achieved through two ways: one is photothermal conversion, which uses solar collectors to convert solar energy into heat energy, and then uses the heat energy to drive the refrigeration mechanism for cooling [4]. The other one is photoelectric conversion, which converts solar energy into electrical energy through solar cells, and then uses the electrical energy to drive conventional compression refrigeration machines or other refrigeration equipment.

**Magnetic refrigeration:** Magnetic refrigeration technology is a solid-state refrigeration method based on material properties (magnetocaloric effect), which uses environmentally friendly media such as water as heat transfer fluid and has the characteristics of zero GWP (global warming potential) and zero ODP (ozone depletion potential)

**Radiation refrigeration:** Radiation refrigeration is a refrigeration technology that uses objects to radiate energy to the outside world to lower their temperature. Li and others are also working on researching its materials and have found that it does not consume energy and is also very environmentally friendly. And analyze its application and solve the problems it faces [5]. Different types of refrigeration energy have their advantages and disadvantages, and the selection should be comprehensively considered based on specific application scenarios, energy conditions, and economy. With the continuous advancement and innovation of technology, new types of refrigeration energy and technology are expected to play a greater role in the future.

### 3. Application of Refrigeration Energy

Refrigeration energy is widely used in various occasions and fields that require refrigeration, such as home air conditioning, commercial cold storage, cold chain logistics, industrial refrigeration, etc. With the advancement of technology and optimization of energy structure, the types and application methods of refrigeration energy are constantly enriching and developing.

#### 3.1. Application in Air Conditioning Refrigeration

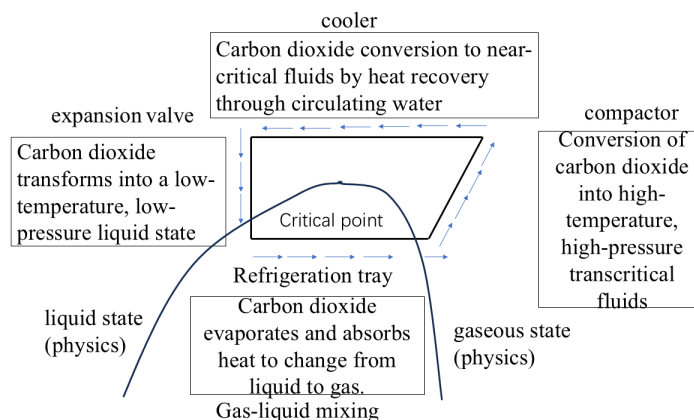
Air conditioning systems typically use refrigeration equipment consisting of a compressor, condenser, expansion valve, and evaporator. Among various energy sources, there is traditional energy such as electric energy and thermal energy. Electric energy drives compressors through electricity to achieve refrigerant circulation and compression, thereby achieving refrigeration effects. In addition to traditional energy sources, new energy solar energy is also particularly important in air conditioning applications. Solar energy is one of the cleanest and pollution-free new energy sources, its biggest characteristic is its permanence [6]. Solar refrigeration is mainly based on two conversion methods, as shown in Table 3.

**Table 3.** The conversion method and principle of solar refrigeration applied to refrigerators

Transformation	Refrigeration principle
Photoelectric Conversion	By converting solar energy into electrical energy through solar panels, the compressor and other components of the air conditioning system are driven. This method directly utilizes the electricity generated by solar energy, achieving efficient utilization of energy. However, the efficiency of photoelectric conversion is influenced by various factors, such as solar radiation intensity, solar panel performance, etc.
Photothermal conversion	By using a collector to convert solar energy into thermal energy, and then utilizing this thermal energy to drive a refrigeration mechanism for cooling. Common photothermal conversion refrigeration technologies include absorption, adsorption, jet, etc. These technologies utilize the heat generated by solar energy as a power source and achieve cooling effects through specific refrigeration cycles. The advantage of photothermal conversion refrigeration technology is that it can utilize low-quality thermal energy and, in some cases, has a higher energy efficiency ratio.

#### 3.2. Application of Refrigeration Energy in the 2022 Beijing Winter Olympics

The Carbon dioxide refrigeration system (CDRS) is a refrigeration technology that uses carbon dioxide as a refrigerant, utilizing the physical properties of carbon dioxide through a series of processes such as compression and condensation as shown in Figure 2.



**Fig. 2** The refrigeration system achieves a cooling effect by utilizing the state of carbon dioxide (Original)

To be specific, the low-temperature and low-pressure CO<sub>2</sub> gas is compressed into a high-temperature and high-pressure state by a compressor, and then releases heat in a gas cooler and is converted into a high-temperature and high-pressure liquid. Liquid CO<sub>2</sub> enters the evaporator through the throttle valve, absorbs heat evaporates into low-temperature and low-pressure gas inside the evaporator, and then enters the compressor cycle again.

The Beijing Winter Olympics has built or renovated 7 ice venues with a total of 9 ice surfaces, all of which use environmentally friendly refrigeration systems and refrigerants. Among them, 5 ice surfaces use a carbon dioxide transcritical direct refrigeration system, which has the advantages of green environmental protection, accurate temperature control, excellent ice surface quality, and high ice-making efficiency [7].

In summary, refrigeration energy refers to various types of energy used to achieve refrigeration effects, with a wide range of types and application fields

## **4. Innovation and Development of Refrigeration Energy**

### **4.1. Technological Innovation**

With the continuous advancement of technology, technological innovation in the field of refrigeration energy will continue to drive industry development. The breakthroughs in key technologies such as new refrigerants and efficient heat exchangers will provide strong support for the efficient utilization of refrigeration energy. Some better and new refrigeration technologies will drive the development of the refrigeration industry, making refrigeration technology more efficient and environmentally friendly. For example, thermal-driven thermoacoustic refrigeration technology will be studied in the future in terms of new thermoacoustic processes, making this technology more efficient, powerful, and reliable [8]. As mentioned earlier, magnetic refrigeration and radiation refrigeration are also directions for future research and development.

### **4.2. Energy Conservation and Environmental Protection**

The increasingly strict environmental regulations and the improvement of consumer environmental awareness will promote the development of refrigeration energy in a more energy-efficient and environmentally friendly direction. The application of new environmentally friendly refrigerants, waste heat recovery technologies, and other environmental and energy-saving technologies will become an important trend in the development of the industry. The new environmentally friendly refrigerant mainly refers to refrigerants that have a minimal environmental impact, high energy efficiency, and are harmless to human health. Some environmentally friendly new refrigerants, such as hydrofluoroalkenes (HFOs), hydrocarbon natural refrigerants (HCs), and the new generation of environmentally friendly refrigerants R290 (propane), and their mixtures, not only help reduce carbon emissions and environmental pollution but also improve the energy efficiency and performance of refrigeration equipment. In the future, with the emergence of more innovation and research and development achievements, it is expected to see more types, higher efficiency, and more environmentally friendly refrigeration refrigerants applied to various fields.

## **5. Intelligentization**

The application of technologies such as the Internet of Things, big data, and artificial intelligence will promote the intelligent development of refrigeration energy. Optimizing the operation and improving energy efficiency of refrigeration systems through intelligent control, remote monitoring, and other means will become an important direction for industry development. Gree and Haier Industrial Park just use intelligent technology. The whole process of energy and power production, distribution, and allocation is intuitively and dynamically monitored and digitally managed in combination with technologies such as source Internet, big data, cloud computing, and 5G network.

Efficient analysis and management of data have been achieved, and data security has been improved, greatly enhancing energy utilization efficiency [9].

## 6. Conclusion

As the core driving force of refrigeration technology, the efficient utilization and sustainable development of refrigeration energy are of great significance for promoting industry progress and socio-economic development. The full text discusses in detail the classification of refrigeration energy, including electrical energy, thermal energy, cold energy, renewable energy, and the application of refrigeration energy in daily life. This article provides examples of the application of refrigeration energy in air conditioning refrigeration and its use at the 2022 Beijing East Olympics, particularly the CDRS. It is particularly looking forward to the innovation and future development of refrigeration energy, which is moving towards diversification, efficiency, and intelligence, greatly improving the efficiency and reliability of refrigeration energy. In the future, with the continuous advancement of technological innovation, energy conservation, environmental protection, and intelligent development, the field of refrigeration energy will embrace broader development prospects. This article summarizes the application of refrigeration energy in air conditioning and the Beijing Winter Olympics, as well as the future development trends of refrigeration energy in technological innovation, energy conservation environmental protection, and intelligence.

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