Application of solar refrigeration technology

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SAVONIA UNIVERSITY OF APPLIED SCIENCES **THESIS Abstract**

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Abstract

With the continuous progress and development, people's living standards increase. Air conditioners, refrigerators and other electrical products are more popular in average families. In summer, people enjoy the fresh air, while electricity costs are staggering. Can I create non-consumption of energy, but also can bring achieve cooling? The answer is yes, now researchers are developing a device using solar energy to refrigeration, to be put on the market, the device not only consumes energy but also has environmental features.

This paper introduces the development of solar refrigeration system process and the current situation of different forms through solar refrigeration system is operating principle and characteristics of different forms; it analyzes the advantages and disadvantages of solar refrigeration system. It can also show the improvement of the solar collection efficiency, reducing production cost of solar collecting system, optimizing the refrigeration system design. These topics are the solar energy application for large-scale commercial refrigeration, and they are discussed in the thesis.

Keywords
Solar cooling, energy, environment, refrigeration

CONTENTS

Symbols

COP: Refrigerator's efficiency

EER: Energy Efficiency Ratio

1 Introduction

Currently, in order to reduce the energy consumption of air conditioning, reducing energy shortage, researchers in the field of solar refrigeration pay unremitting efforts. So far, people in the field of solar refrigeration have done a lot of research and have made some progress. The study on solar cooling originates from the 1930s, but with the high cost, low efficiency and low commercial value, its research has stagnated. Since the 1970s, with the emergence of the world's energy crisis, solar collector technology and photovoltaic technology have made considerable progress. Solar refrigeration industry has also gained popularity and developed. In the meantime, the world's first solar-powered single-effect lithium bromide refrigerator in the US state of Indiana was put into commercial operation, and this caused widespread concern in the solar refrigeration industry.

2 Overview of Solar Cooling Technology

There are two basic types of solar cooling, and the text below will introduce these cooling technologies and how they work.

2.1 Basic types of solar refrigeration and how they work

Currently, solar cooling in principle includes two types. One is the use of photovoltaic technology. First translate solar energy is converted into electricity, and then electrical energy is used to drive energy for cooling and refrigeration, such as photovoltaic refrigeration and thermoelectric refrigeration. Another technique is the use of solar collectors. Solar energy is converted to heat first, and the heat is used to drive energy for cooling, such as absorption refrigeration, adsorption refrigeration, and jet refrigeration. Based on these three cooling methods and combination of some other refrigeration methods these are some new refrigeration methods. Solar cooling in the generalized sense can also include ground-source heat pump.

2.1.1 Solar light - electricity conversion refrigeration

After converting solar energy into electricity by photovoltaic conversion device, the driver will use ordinary vapour compression refrigeration system or semiconductor refrigeration system to refrigerating, namely photoelectric semiconductors refrigeration and photoelectric compression refrigeration, and the key is the photoelectric conversion technology.

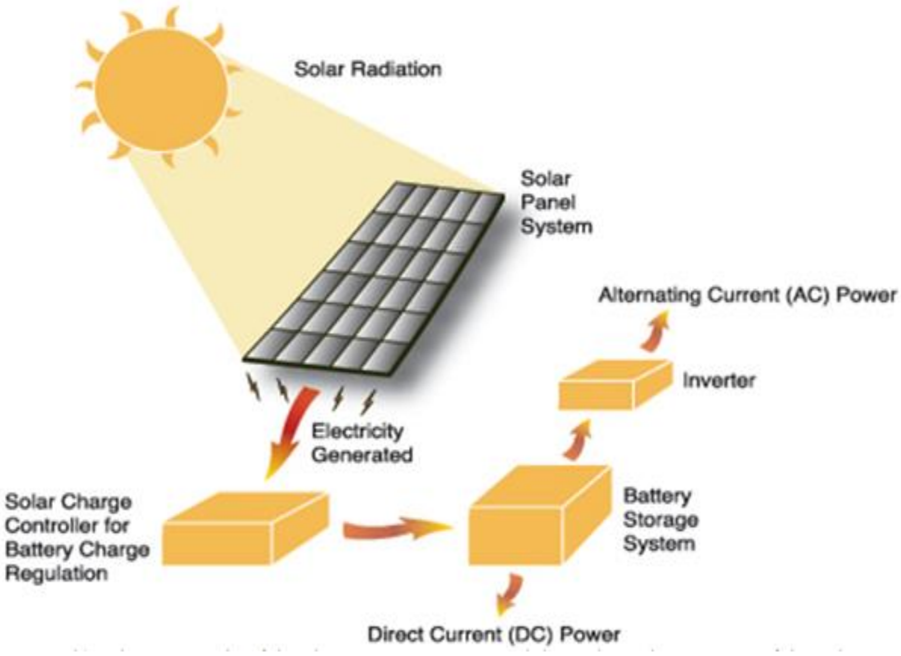
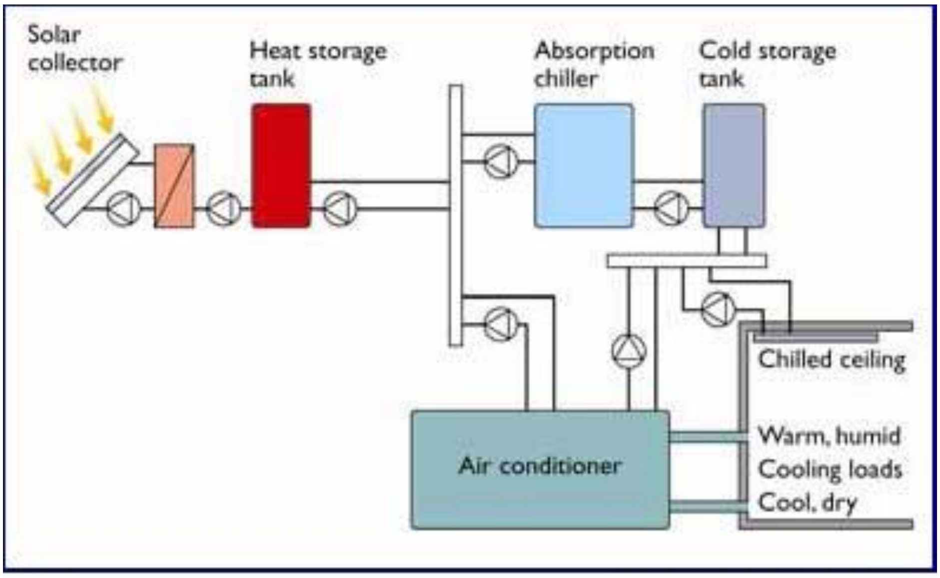


Figure1. Basic principles of solar light - electricity conversion refrigeration [1]

Currently, the efficiency of solar cells can only directly generate about 10% electricity, while the cost of photovoltaic panels, batteries and inverters of photovoltaic generation is very high. Currently photovoltaic solar refrigeration systems have been directly applied to conventional air conditioners and refrigerators, but generally they do not consider the characteristics of the photovoltaic system. The lower the efficiency of the whole system, the costs are about 3-4 times more with heat-driven refrigeration cycle. But with the improvement of the efficiency of photovoltaic energy conversion device and reduction of costs, photoelectric solar refrigeration products will still have broad prospects for development.

2.1.2 Solar absorption refrigeration

Absorption refrigeration is vaporization of the liquid refrigerant, and vapour-compression refrigeration which is the use of a liquid refrigerant at low temperature and pressure to achieve vaporization cooling. The difference of solar absorption refrigeration and conventional absorption refrigeration is that solar absorption refrigeration uses solar energy for the refrigeration of heat energy. Its working principle is to use solar collectors heating water, and then with hot water refrigerant heat the generator to produce a dilute solution of the refrigerant vapour. The refrigerant vapours after cooling down, the throttle pressure, and is vaporized in the evaporator suction heat to refrigeration. The refrigerant vapour is absorbed by the refrigerant after the absorption of the endothermic reactor, and then the refrigerant is pressurized by the pump into the generator for heating the dilute solution evaporates to complete a refrigeration cycle. As shown in Figure 2, absorption refrigeration refrigerants and its characteristics are related. Commonly used refrigerants are lithium bromide- water and ammonia- water actuating medium. The present study also includes alcohol-based refrigerants.



Schematic of an absorption solar cooling system.

Figure 2. Basic principles of solar absorption refrigeration [2]

Depending on the number of generators, different absorption refrigerators can be divided into single-effect, double-effect and multi-effect refrigerators. Studies have shown that single-effect absorption refrigerator type's optimum operating temperature is 80 ~ 100 ℃, its limits COP value of about 0.7. In the 30 ℃ cooling water, the case of the preparation of 9 ℃ chilled water, refrigerator in the heat when the temperature is 80 ℃, COP value can reach 0.7. After 85 ℃ the heat source temperature even further increases, COP value of the refrigerator will not increase significantly. At the same cooling water and chilled water temperature conditions, single effect refrigerator's COP value will decline sharply after the heat source temperature is below 60 ℃.At 50 ℃ it cannot cool when the refrigerator's COP value to 0. Compared with the single-effect absorption refrigerator, double-effect and triple-effect absorption refrigerator takes advantage of high-temperature heat source and the thermal efficiency is higher than that of the single-effect absorption refrigerator. Due to the use of high temperature heat source, the COP value of double-effect absorption refrigerator can reach 1.0 to 1.2, while the triple-effect can reach 1.7 COP value. It's significantly better than single-effect. Figure 3 clearly compares the same condition single-effect relationship between the double-effect, triple-effect refrigerator heat source temperature and COP values. As can be seen from the figure, in the heat source temperature of 80-100 ℃ single effect type is in the best condition, even if the temperature of the heat source increases, COP value of the refrigerator cannot be remarkably improved. Obviously when the heat source temperature exceeds 100 ℃, the use of double-effect refrigerators can significantly improve the COP value. So that when the heat source temperature reaches 160 ℃, triple-effect refrigerators meet the requirements. It is worth noting that, no matter what form of refrigerator, there is a minimum critical source temperature. When the heat source temperature is lower than this value, there will be a sharp decline in the value of COP. This is why we need to provide a reason for the heat in the solar absorption refrigeration system.

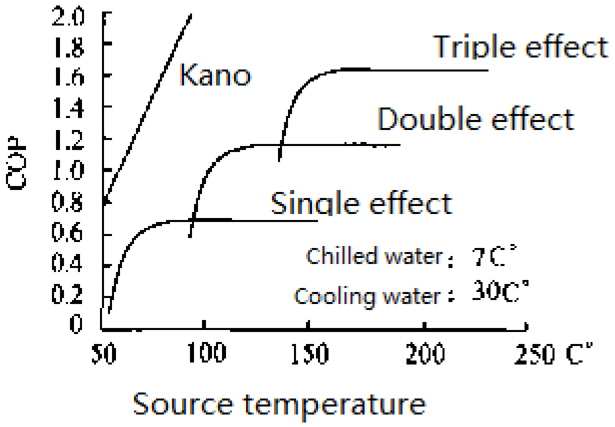


Figure 3. Kano, single effect, double effect, and triple effect temperature heat absorption chillers and COP graph

Gershon Grossman [3] made a comparison with single-effect, double-effect, and triple-effect lithium bromide absorption refrigerator. In comparison there were the following assumptions: (1) All refrigerators work 8h a day from May to September quarter, (2) the frozen water of preparation refrigerator is 7 ℃, the cooling water is 30 ℃, (3) solar cooling system includes collector, hot water storage tank and auxiliary equipment. Their calculated installation costs were in accordance 1.5 times higher than the cost of the collector. Comparative results are shown in Table 1. It's shown in Table 1, that single-effect refrigerator's COP is the lowest, and triple-effect refrigerator's COP is the highest. Therefore, the area of the refrigeration capacity of the single - effect refrigerator is the largest, triple-effect refrigerator's cooling capacity per kilowatt minimum required collector area, but the single effect refrigerator system in the form of relatively simple structure of the collector the type of requirements are relatively low. Overall, the total cost of the difference between double-effect refrigerators and single effect refrigerator system is different, but if we can reduce the price of high-temperature collectors, triple-effect absorption refrigerator will be more competitive on the market.

In addition to conventional absorption refrigeration system, researchers have proposed a new two-stage single-effect absorption refrigeration cycle, increasing the temperature difference between the heat sources which uses the idea of the cycle. Studies show that the heat source temperature of the system can drop to 55 ℃, its COP value can reach 0.42 to 0.62. Because the water temperature is low, it is more suitable for the use of solar energy. Also it helps to improve the efficiency of the solar system.

2.1.3 Solar adsorption refrigeration

Adsorption refrigeration depends on solid adsorbent to absorb solar energy. Adsorption refrigerator is constituted by adsorbent bed, condenser, throttle valve, evaporator, and accumulator. Adsorbent and adsorb together form chemisorption refrigeration working pair. Common adsorption working pairs are: activated carbon - methanol, zeolite - water, silica gel - water, metal hydrides - hydrogen (physical adsorption) and calcium chloride - ammonia, chloride, strontium - Ammonia (chemisorption), etc.. The current application is more of the first two. Depending on the role of the relationship between the adsorbent and adsorb ate, adsorption refrigeration can be divided into physical adsorption and chemisorption. [4]

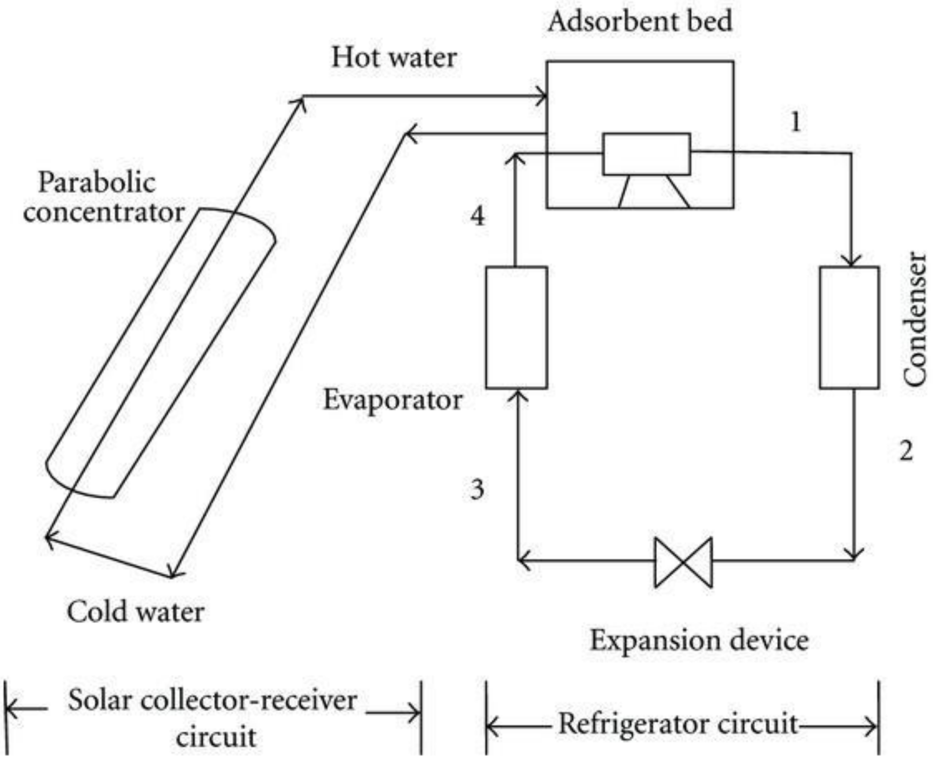


Figure 4. Basic principles of solar adsorption refrigeration

The basic cycle of adsorption refrigeration cycle is the use of solar or other heat sources. The adsorbent and adsorb ate formed mixture (or complex) desorption occurs in the adsorbed. With the release of high temperature and pressure refrigerant vapour into the condenser, the condensed refrigerant flow out and gets through the throttle valve into the evaporator. The evaporator absorbing-heat in the evaporator, followed by evaporation of the refrigerant vapour out of the generator into the adsorption, the formation of a new post-adsorbed mixture (or complex), to complete a adsorption refrigeration cycle.

In solar-powered adsorption refrigeration cycle, there are two basic types: one is the use of alternating day and night to achieve a natural cycle intermittent refrigeration cycle; the other is a plurality of adsorption beds alternating adsorption and desorption, and heat in the bed of the continuity between the occurrence of the recuperative heat exchange circulatory system [5]. Recently, people start to study on heat absorption and heat absorption refrigeration. In heat wave cycle [6], the bed can be viewed as a series of independent small heat exchange beds composed of two adsorption bed reverse operation, only a small portion of them get heat-exchange, and the other part to maintain the temperature, thus effectively reducing the heat loss and improving the COP value. Experiments show that its COP value can be 0.9 to 1.0.

2.1.4 Solar ejector refrigeration

The principle of solar ejector refrigeration system is shown in Figure 5. The entire refrigeration cycle is basically made up of three sub-cycles, namely the sub-cycle refrigeration, power sub-loops and sub-loops of solar energy conversion. Specific engineering work is described as follows: the refrigerant (typically water) in the heat accumulator absorbs high temperature heat transfer working fluid after the heat of vaporization, pressurized, In order to produce saturated steam, the steam enters the injector, and through the high speed nozzle, a near vacuum nozzle is formed. The low pressure evaporator steam gets through the injector into the condenser heat transfer, and then the condensate through the throttle valve. A portion of the refrigerant water enters the evaporator to absorb the heat and to complete a refrigeration cycle. A portion of the refrigerant water enters the evaporator to absorb the heat and to complete a refrigeration cycle. Another part of the working fluid through the circulation pump after the booster into the accumulator, re-absorbs heat of vaporization, and then get into the injectors, condensed into a liquid flows into the condenser, which is called the power sub-loop cycle. The solar collectors convert solar energy into thermal energy, so that the working fluid within the heat collector goes to absorb solar heat collector by the circulation pump, this sub-cycle calls solar energy conversion.

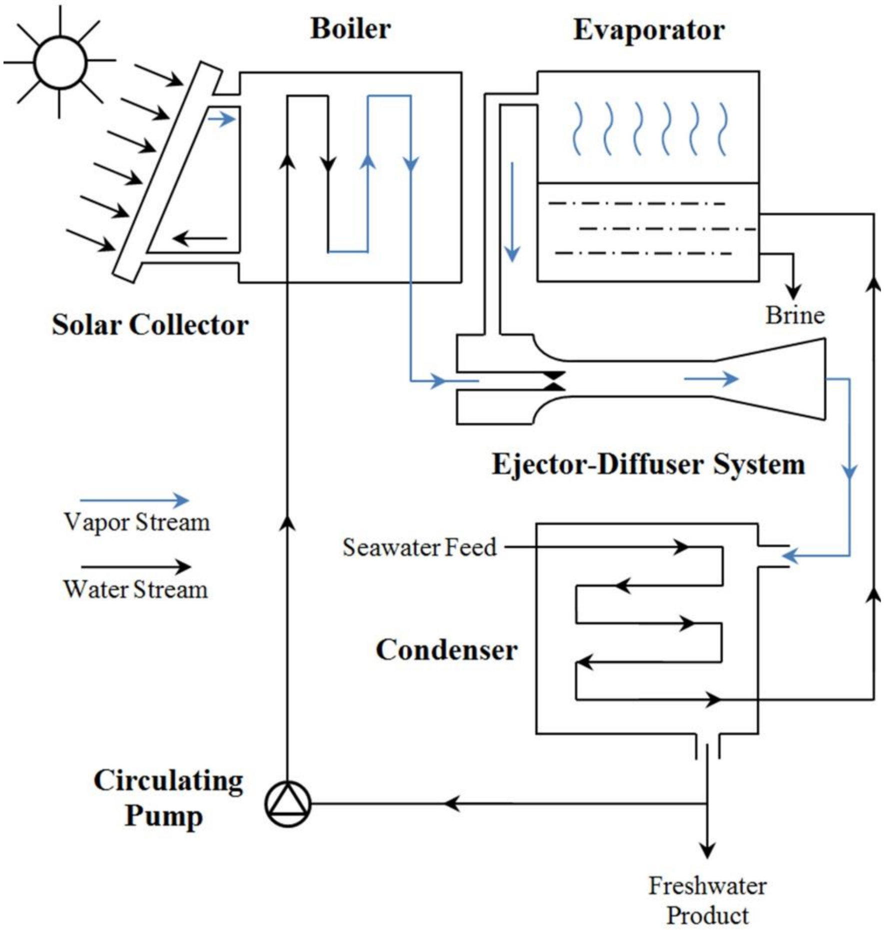


Figure 5. Basic principle of solar ejector refrigeration

Decided ejector refrigeration system's performance is the working fluid jet body and lead the state and the compressed fluid jet injector coefficient. In recent years, a lot of scholars have carried out a lot of research on the research of jet refrigeration. Sokolov, who designed the booster injection cycle and combined cycle thoroughbred injection compression solution, says that COP can be 50 percent higher than conventional jet refrigeration [7]. In addition, S.B.Riffat and A.Holt proposed a very innovative cooling system - jet heat pipe cooling system, basic heat pipe jet heat pipe cooling system, injectors, evaporator, capillary and other components [8].

In order to improve the efficiency of the cooling jet or full use of solar energy, often jet refrigeration and absorption refrigeration or absorption refrigeration combine to form a new kind of solar absorber - Spray or solar absorption refrigeration system - injection combined refrigeration system [9]. The new system can make full use of the advantages of both systems, improve the cooling efficiency.

3 Application of solar refrigeration technology in engineering

There are 2 main factors driving the solar refrigeration technology application, one is the solar refrigeration efficiency and the other is the high cost of solar energy.

3.1 Application of solar cooling technology

According to the second law of thermodynamics, heat can pass spontaneously from a hot object to a cold object, and if cannot pass spontaneously from a cold object to a hot object. The process of artificial refrigeration is to compensate at low temperature and heat transfer to the object at high temperature.

In theory, solar cooling can be converted by the solar photovoltaic and solar thermal cooling refrigeration in two ways to achieve conversion.

Solar photovoltaic refrigeration is to convert solar energy into electrical energy through solar cells, and then to drive the traditional compression type refrigeration machine. At present, solar photovoltaic refrigeration makes high cost of solar cells and solar photovoltaic power generation; also its cooling will take a lot of time. So the technology is difficult to promote the application.

Solar heat conduction refrigeration, which is introduced in this paper, a solar refrigeration, is the first to convert solar energy into heat (or mechanical energy), and then use the heat (or mechanical energy) as an external compensation system to achieve and maintain the ideal of a refrigeration.

3.1.1 Solar cooling efficiency

Solar cooling efficiency has two parts: one is the refrigerator itself efficiency (COP), and the other is the efficiency of solar collectors. Refrigerator’s efficiency (COP) with the increase of the driving temperature and the evaporation temperature rises. Solar collector efficiency with the increase of the intensity of solar radiation increases with the rising temperature of the medium decreases. The total efficiency of the solar air conditioning system can be obtained by multiplying the solar collector efficiency and chiller’s COP. Thus, in order to achieve the highest overall efficiency of the system there must be a reasonable choice of solar collectors and refrigerators, making it the highest volume of the product.

Solar energy is a heat source with low-grade, low-density, intermittent and instability. To ensure the continuity and stability of the refrigeration system operation in the refrigeration system there is the need to increase the auxiliary heat source heat reservoir and other auxiliary equipment. An auxiliary heat source and the heat storage device selection can meet the most adverse conditions terminus cooling demand, Therefore solar cooling system design must be determined by optimizing the auxiliary heat source and the heat storage unit and other auxiliary equipment calculations to improve the overall operation of the system performance and reduce system cost purposes.

3.1.2 Solar collectors

Another key factor in solar cooling technology is the solar collector. Grossman points out that in the use of lithium bromide - water solar air conditioning system, more than 50% absorption refrigeration in solar collector’s cost, accounting system costs, cost collectors and thermal storage devices accounted for the vast majority of system costs section. So the use of double-effect and single-effect cycle system costs less, but the double-effect cycle COP is higher. In the use of three- effect cycle, the cost will be doubled. Research and efficient solar collector materials help to reduce the collector area and reduce system cost, the development and application of solar refrigeration.

Common types of solar collectors have flat water heaters, vacuum-type water heaters, heat pipe water heaters and others. The most commonly used is the flat plate and vacuum tube. Due to the fact that flat-plate collector does not have the function of focusing on the sun, and its working temperature is generally limited to 100 ℃. The operating temperature of the vacuum tube collector or collector is usually at 100, so the single effect absorption chiller is generally a heat source for a single acting absorption chiller. Triple-effect and double-effect absorption chiller should use vacuum-type collector, not only to meet the needs of the refrigerator temperature heat source, but to reduce the cost of whole system.

Improving collector's absorbing material is also an effective way to improve the efficiency of solar collector. Selective absorbing coating materials are currently being developed by the multi-layer gradient direction, and have been discovered as a series of excellent coating materials, such as black cobalt selective absorbing coating and aluminum - N / Al - solar selective absorption spectrum coating. In addition, a German research showed that nanostructure treatment on the flat plate surface, in order to increase the transmittance of sunlight to reduce emission loss of solar energy, solar energy efficiency has been further improved. So the solar panels must have absorbing properties, service life must be long and the production cost must be low.

3.2 Application example of solar refrigeration technology

The example will take a new-efficient house to test feasibility and cost-effacing of solar cooling

3.2.1 Project Profile

The building is a new energy-efficient house, two floors with a construction area of 419 ㎡, the number of the rooms is 15, brick structure, hollow glass steel doors and windows, wall thickness of 370_{mm} of hollow brick, wall thickness of 70_{mm} with standard installation squeeze plastic board insulation, roof with 200_{mm} thick polystyrene board insulation, energy-efficient building envelope structure conforms to the standard 50%.

3.2.2 Design requirements

Press the 3-month summer cooling and winter heating four months throughout the year to provide 480 of hot water of 45 ℃. Design parameters refer to the table

Table 1. Air conditioning outdoor calculation parameters

	Dry bulb tempera-	Wet bulb tempera-	relative humidity, %

	ture, ℃	ture, ℃	
Summer	32	26.4	65
Winter	-9	----	45

And there are air conditioning indoor calculation parameters

Table 2. Air conditioning indoor calculation parameters

	Summer		Winter	
Room features	Temperature, ℃	Relative Humidity, %	Temperature, ℃	Relative Humidity, %
Living room	24	≦65	18	≦45
Bedroom	26	≦65	22	≦45
Kitchen	26	≦65	20	≦45

Below are solar calculation parameters

Table 3. Solar calculation parameters

Month	1	2	3	4	5	6
T	-4.6	-2.2	4.5	13.1	19.8	24.0
H	15.081	17.141	19.155	18.714	20.175	18.672
Month	7	8	9	10	11	12
T	25.8	24.4	19.4	12.4	4.1	-2.7
H	16.215	16.430	18.686	17.510	15.112	13.709

T= monthly average outdoor temperature, ℃

H= same latitude angle monthly average daily solar radiation, MJ / ㎡ d.

3.2.3 Load calculation basis

There are used following standards

- Standard for the design of energy saving family homes (ISO 13153)

- Building energy efficiency design standards (JGJ26-95)

- Technical Specification of low-temperature radiant floor heating (JGJ142-2004)

- All-glass vacuum tube of GB/T17049—199

Table 4. Total DHW daily load

Building area m^2	Cooling load	Heat load	DHW daily load
The total area $F=419m^2$	$Q=35W/m^2$ Q hour =q*F=14.67kw	$Q=20.6w/m^2$ Q hour =q*F=8.63kw	Q=CM∆T=1*480kg* （45-10）℃ /860kcal=19.5kwh

Annotation:

1. According to the building’s heat load index "hot summer and cold winter region residential building energy efficiency design standards", envelope achieves 50% energy saving for 20.6 W/m²; the total load of the building in winter is 24854 kWh. Cooling load index is 35 W/m², 419m² total building cooling loads in summer is 15844kWh (12 hours a day).

2. Winter heating water temperature: ⩾35 ℃, return water temperature: ⩽30 ℃

3. Winter heating design heat load ratio: Solar winter heating contribution rate of 40%, the remaining 60% is provided by the auxiliary low-temperature heat source heat pumps.

4. System components and working principle

Solar heating - cooling - Hot triple for the system (as shown below) consists of the following six subsystems: solar collector systems, low temperature hot water radiant floor heating systems, water supply systems, auxiliary power systems, air systems, automatic control system.

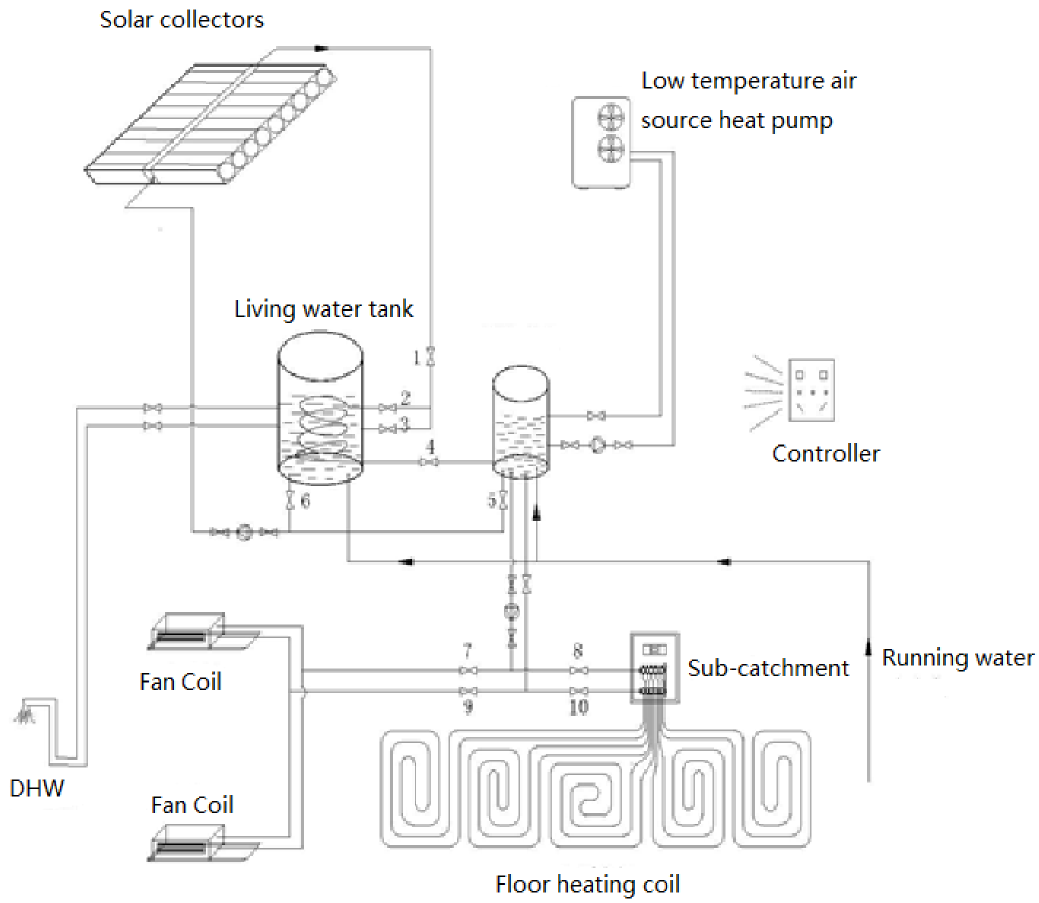


Figure 6. Solar heating - cooling - water supply triple systems [10]

(1) Solar collector system

Solar collector system consists of solar collectors, collector bracket, loop piping, circulation pumps, valves, filters, thermal storage tank and other components. The private collector is composed of a solar heating vacuum tube and a hot pot, which has the properties of pressure, ultra-low temperature difference, anti-freezing, anti-leakage, wind resistance and so on. The vacuum has been specially processed, even if the glass damage to the system is not leaking, it can run as usual. The design and installation of the collector and the bracket can realize the building appearance, and can play a role in the roof insulation layer.

Heat collector to collect water as the carrier, through the circulation line is stored in the thermal storage tank. There are two water tanks, hot water tank, is mainly used for domestic hot water and hot water bath, and the other is the expansion tank which is mainly used for heating and cooling. Water tanks and collector use high-low collector tank installation, forced circulation, stop emptying operation mode to achieve acquisition and antifreeze solar system, greatly improving the efficiency of solar energy collection and system security.

(2) Auxiliary energy system

When the solar heat cannot meet the system requirements, insufficient heat energy is provided by auxiliary energy. We can choose a new generation of low-temperature engineering air source heat pump as an auxiliary energy, with a cooling capacity of 31kW, heating capacity of 32kW, supply voltage of 380V. Cold air source heat pump has been successfully reached 15℃, its rated heating capacity than the traditional heat pump to reduce about 25%. In addition, the minimum operating temperature is 20℃. The outdoor temperature of the EER unit is 0 at 3.

(3) Low temperature hot water radiant floor heating system

This project uses low-temperature hot water radiant floor heating, two floors total of four components catchment. Thermostat controls were used in each group, the priority use of solar energy. According to the requirements of the heating zone temperature, the rational use of auxiliary heat source greatly reduces operating costs. In the winter heating, the system must be carried out in winter and summer line loop pipeline conversion. For the collector system and the auxiliary energy system, the production of hot water heating medium in the coil, and heating the floor. Low temperature hot water radiant floor heating requires water temperature of 35 ℃ -50 ℃, compared with ordinary radiator water temperature which is 85 ℃ -95 ℃ lower. From the heating tank to the heating terminal, there is cryogenic transfer, so the transfer heat loss is greatly reduced. Due to the heating pipe below ground, the heat emitted from the floor from the lowest to the high transmission, in less than 2 meters of human activities in the region is effectively utilized, heat loss is small.

(4) Water supply system

System produced by the hot water in addition to provide heating, but also through the hot water supply system to provide users with daily life with hot water. This system uses constant temperature water terminal device to ensure that the water temperature and pressure, does not appear insufficient water or water phenomenon. The system uses the automatic circulating heat preservation device to guarantee the water supply pipe and the water terminal time has the comfortable temperature of the hot water, even if people do not have the hot water for a long time.

(5) Air cooling system

The system uses the advantages of air-cooled heat pump, which can not only provide the heating of the solar energy to provide heat energy, but also can be completed independently of the summer cooling demand. This system can realize a machine to use, make full use of energy and reduce investment costs. To enter the summer cooling system must first be carried out in the winter and summer, the pipe line of water, the living water tank and the expansion tank independently, the solar collector to provide users with hot water. Produced by the heat pump unit to produce low temperature water and stored in the expansion tank, through the fan coil to absorb the indoor heat, to cool down, to achieve the purpose of refrigeration. Due to the use of cold water system, indoor moisture and moisture is not easy to lose, so far better than the direct use of fluoride system.

(6) Automatic control system

Microcomputer automatic control is used in this system, which automatically identifies the presence of the sun's light and weak, monitoring water temperature and indoor temperature, the realization of solar heating system and heating system temperature cycle, heating the implementation of time interval control room. Hot water system can achieve automatic cycle heat preservation, constant temperature and constant pressure water supply. The man-machine interface of the control system can display all kinds of parameters and operating conditions of the equipment, automatic detection system fault and display fault code, in order to facilitate the inquiry and maintenance. Through the full intelligent control function, that is, the full and effective use of renewable energy and the maximum energy savings, while ensuring the stability, reliability and security of the system.

3.3 Economic Analysis

Here is a practical example.

Table 5. Building, area 419m², heating, cooling, The initial investment and operation and maintenance costs of the domestic hot water supply are relatively high.

Appellation / Project	Solar + Low-temperature heat pump heating 、Refrigeration 、Hot water	Coal-fired boiler heating + Central air conditioning and refrigeration	Electrically heated hot water(0.48t/day)	Solar hot water (0.48t/day)
Initial investment(k euro)	30.32 (72.38euro/ m²)	(15 euro/m² +34 euro/m²)*419 ㎡ =20.5	64(6kw Electric boiler)	
Summer running costs 、euro/m ² (90 days)	419 ㎡ *2.5 euro/ ㎡ =1048 euro	419 ㎡*20 euro/ ㎡=1048 euro	245 days*0.5*2.5 =306 euro	

Winter running costs 、 euro/m ² (120 days)	419 ㎡ *1.56 euro/ ㎡ =654 euro	419 ㎡ *4 euro/ ㎡=1676 euro	120 days*0.5*2.5 =150 euro	152*30% =45.6 euro
The average annual maintenance costs (euro)	52	250	50	45
Annual domestic hot water (euro)			514	45
The total cost of the total annual operating maintenance (euro)	1790	3035	519	45

Carbon Emission Reductions

Solar hot water system of carbon dioxide emission reductions

Qco_2=ΔQsave*n/W*Eff*Fco_2*44/12

(Qco_2=Carbon dioxide emission reduction system lifetime)

ΔQ_{save}=62632MJ

Eff=95% (Conventional energy efficient water heating device)

Fco_2=0.866kg Carbon/kg Coal (Carbon dioxide emission factor, kg carbon / kg coal)

W=29308MJ/kg (Calorific value of coal)

n=20 (Economic Analysis duration years)

Calculate according to the table:

Qco_2=62632MJ* 20year/29.30MJ* 0.866kg carbon* 44/12=181205.94kg

Total 181 tons

Solar heating, cooling, domestic hot water system in the lifetime of carbon dioxide emission reductions for 181 tons

4 Research Development and Prospect of solar cooling technologies

Although many technologies have been used in the solar refrigeration technology, it is still in the initial stage of the experiment. Technical complexity and difficulty, economic performance, cost and other factors restrict its development. Although solar refrigeration system has been put into commercial operation in the world, there are still many problems. How to reduce the cost of solar refrigeration system, so that it is more widely used in commercial applications is the main research topics in the field of solar refrigeration. To solve this problem mainly from the following aspects:

(1) Developing a device for using solar energy.

(2) To improve the research of solar collector, improve the collection efficiency and reduce the cost.

(3) Solar cooling and solar hot water should be reasonably integrated; high-grade and low-grade really make the best use of each solar radiation, allowing the system to run throughout the year.

4.1 Research and development of solar absorption air conditioning technology

1983 the world's first large-scale solar energy absorption refrigeration system is installed in Arabia, Kuwait. The Ministry of Kuwait built a 530m2 building to provide cooling. 1995 M.HAMMAD of Jordan University developed the improved second generation solar-powered lithium bromide chiller. In May 1998 by Beijing Songda Company in Stuttgart, Germany Meissner & Wurst Company solar absorption air conditioning system was completed. Various foreign studies also focused on the search of new refrigerants right, aspects of the relationship between structure and performance of the solar collector loop, the system energy balance studies, refrigeration and heating the joint research work.

4.2 Problems and possible solutions

1. Due to the low efficiency of solar collector, the high price of solar energy air conditioning and other common problems. However, the application of solar air conditioning is built in solar hot water, solar air conditioning solar collector and general solar water heater combined, with the development of solar water heater, solar collector efficiency will be improved, for the original solar users can change the water heater, waste heat of cooling bath, and then have a better economy.

2. Cost allocation from the corresponding collector, refrigerator, etc., the collector temperature, the cold water temperature and the cooling water temperature should be for each number, in order to establish one of the most economical solar air conditioning systems, but also the unresolved issue. But I think that with the right collector and refrigerator; it can build economical solar air conditioning systems, only a matter of time.

3. Because there is a limitation to collect solar energy issues, storage technology must also be a good solution. Existing methods are mainly used to increase the hot water heat storage capacity, enhance the insulation effect, with the storage technology research and development and regenerative carrier, unreliability and intermittent solar air conditioning systems will be improved.

4. The collector installation is greatly limited for residential buildings are relatively concentrated. This is mainly due to the installation of solar air conditioning is not widespread, the building's design does not take into account the solar air conditioning, solar water heaters as the eighties, the installation is very complicated, and now think of building designers, solar water heater is carried.

5. Don’t have solar air conditioning system design computer software, control chip, technical standards and uniform equipment and spare parts. This is a combination of technology and market issues that require a certain scale solar air conditioning, occu-

pied a certain market, but also need the support of a certain time and the government, science and technology sector.

6. Energy system optimization. Solar semiconductor refrigeration system itself there is a loss of energy, how to reduce these losses, to ensure stable and reliable operation of the system is a very important issue. Photoelectric conversion efficiency and cooling efficiency is the primary measure of energy loss. The higher the photoelectric efficiency, at the same power output, the smaller the required area of solar cells, which facilitates miniaturization of semiconductor solar refrigeration system. At present widespread use of photovoltaic solar cell efficiency of up to 17%. For any refrigeration system, the cooling efficiency COP is the most important operating parameters. Currently, COP semiconductor cooling device is generally about 0.2 to 0.3, well below the compression refrigeration. After testing found that the cold and hot side temperature difference has a significant impact on the efficiency of semiconductor cooling, semiconductor cooling system performance is greatly improved by strengthening the hot side heat make the method.

7. Effective control and optimal matching of system operation. Different general refrigeration equipment, solar thermoelectric cooling system by solar radiation and environmental conditions, system conditions for a day tend to have changed a lot. Therefore, the solar thermal cooling system, in addition to the solar cell and semiconductor refrigeration devices are required to control the NC. Battery solar cooling systems are to ensure continuous operation of the important conditions.

CNC matching allows solar array output impedance and equivalent load impedance, the power output at its best, while the energy storage device overcharge and over-discharge control. To achieve the best part of the whole energy transfer conditions, ensuring system reliability, stability and efficiency, it is necessary for the operation of the entire system for effective control. Therefore, select the appropriate storage device, developed effective control of the entire solar cooling system is very important.

5 Economic benefits in the market

Solar powered refrigerators offer the potential benefits of lower running costs, greater reliability and a longer working lifespan than kerosene refrigerators or diesel generators, which have mainly been used for cooling in remote areas of developing countries. However, it should be noted that all types of solar refrigerator systems have far higher acquisition and installation costs than comparable kerosene and bottled gas fuelled refrigerators.

The costs for solar refrigerator vary widely, depending on the technology used. Costs can range from between US$ 1,200 (for a simple cabinet) to over US$ 7,000 for a complete system. 1, 13 A kerosene unit costs only about US$650 – US$1300, but uses 0.5 - 1.4 litres of fuel per day, making the life-cycle costs comparable to that of solar refrigerators – but solar refrigerators have no additional fuel costs.

The use of solar refrigerators also eliminates the risks of fuel supply problems and avoids fuel transportation costs in remote areas. Sorption refrigerators have, in addition, lower maintenance costs compared to kerosene and bottled gas fuelled refrigerators. The intended use of the solar refrigerator influences the acceptable price range for solar cooling. The price elasticity for medical applications where only limited capacity is needed can be much higher than for food preservation. As electricity and energy costs in general are predicted to rise in the future, the cost aspect could become a significant factor in the growth of solar cooling and refrigeration devices.

6 Future

Solar cooling technologies and vapour compression refrigeration, solar refrigeration technology is not very mature, but because of its eco-friendly features, a decision which has good prospects for development. Currently, the main reason for restricting its wide application is costly. To reduce the cost of solar cooling, the party vigorously develop efficient solar panels to improve the thermodynamic performance. On the other hand, take the industrial development of the road. To do this, you can combine with the water heater applications (such as solar refrigerator for hot sealing machine), solar cooling and solar water heaters combined heat and power implementation. Solar hot water heaters, solar energy can be seen in the broad prospects.

Huge solar absorption refrigeration system is complex. And adsorption refrigeration is to stay in the laboratory stage, and therefore the absorption refrigeration miniaturization and practical adsorption refrigeration is the research focus. Solar energy is an inexhaustible supply of green energy, improve the efficiency of the practical use of solar energy and solar cooling technology is the future direction of the focus of research. With the rise of green building, with its combination of solar adsorption refrigeration, adsorption of a jet refrigeration, such as a new type of heat pipe cooling jet ejector refrigeration technology is bound to have a rapid development.

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Appendix A

This appendix is willing to explain some of the specialized equipment and materials

Drying and Gas or Vapour Contact With Solids, appropriate subclasses. See Lines With Other Classes and Within This Class in the class definition of Class 34 for the line.

Refrigeration, appropriate subclasses, for processes limited to refrigeration and apparatus having features specialized to refrigeration. In general if the heat exchanging means is such that it is adapted for interchangeably or convertibly heating or cooling it is not specialized to refrigeration. For example, features such as ice supports, material phase changing means (refrigeration producers), atmospheric condensate handling or an article handler with means peculiar to refrigerating the article would be considered specialized to refrigeration. As to structure adapted to both heat and cool, see Subclass References to the Current Class in this class (165). See Subclass References to the Current Class for a subclass reference to the line between Classes 62 and 165.

Glass Manufacturing, subclasses 512+ for specialized cooling of newly formed glass fibers or filaments; subclasses 509+ for specialized heating of newly formed glass fibers or filaments; subclasses 348+ for means specialized to the cooling of manufactured glass products; subclasses 484+ for means specialized to exchange heat in a fiber or filament forming operation and appropriate subclasses for processes or means specialized to the application of or removal of heat in glass manufacturing.

Gas Separation: Processes, for processes of gas separation including heat exchange. Cold wall-hot wall thermal diffusion processes will be found in Class 95, subclass 289. Class 165 will take processes where only indirect heat exchange is involved, whether or not gas separation is said to occur. See Subclass References to the Current Class in this class (165) for a subclass reference for heating and cooling including addition or removal of water vapour from air.

Gas Separation: Apparatus, for apparatus for gas separation including a heat exchanger. Cold wall-hot wall thermal diffusion apparatus will be found in Class 96, subclass 221. Class 165 will take apparatus where only indirect heat exchange is involved, whether or not gas separation is said to occur. See Subclass References to the Current Class in this class (165) for a heating and cooling system with an ancillary separator.

Foods and Beverages: Apparatus, appropriate subclasses for food treating apparatus having heating or cooling means combined with additional apparatus specialized to food.

Presses, subclasses 92+ for presses means to heat, cool or dry the material.

Liquid Heaters and Vaporizers, subclasses 32+ for an indirectly heated closed liquid container with an internal vapour separator, and appropriate subclasses for a closed liquid heating vessel with a heat generator and for an accessory or element that of necessity must form a part of the liquid heating combination.

Stoves and Furnaces, subclass 33 for a stove with a steam table; subclasses 204+ for a body warmer: subclasses 226+ for a tool heater; subclass 247 for a frictional heater; subclasses 263.01+ for a chemical reaction type heater; subclasses 561+, 569+ and 714 for a solar heater; subclass 343.5 for a melting furnace; and appropriate subclasses, for open liquid heating structures not equally adapted for cooling, for heating stoves, for means for the application of heat for house warming and cooking purposes, and for specialized accessories and elements of such means.

Fluid Handling, subclasses 334+ particularly subclass 340 for fluid handling apparatus combined with means to heat or cool a part of the system or its contents by a heat exchange.

Pipes and Tubular Conduits, subclasses 37+ for general utility pipe having flow regulator or baffle.

Concentrating Evaporators, appropriate subclasses, for means for the generation and transfer of heat of the specific purpose of concentration by evaporation.

Mineral Oils: Apparatus, subclasses 104+ for a still designed for mineral oil distillation and subclasses 138+ for condensing peculiarly adapted and limited to the mineral oil art.

Distillation: Apparatus, subclasses 163+ and 232+ for apparatus for volatilizing a substance for the purpose of recovering material from the vapour by condensation or absorption.

Distillation: Processes, Separatory, subclasses 41 and 42, for a process of volatilizing a substance and recovering material from the vapour by some type of sorption.

Liquid Purification or Separation, subclasses 175+ , 612+, 664, 737, 742, 766, and 774 for processes and apparatus of that class with heat or heat exchange.

Electric Heating, appropriate subclasses for an electric heater or an electrically heated tool.

Article Dispensing, subclass 150 for subject matter of that class with cooling or heating.

Dispensing, subclass 146 for dispensers with heating or cooling means.

Automatic Temperature and Humidity Regulation, subclass 44 for automatic humidity controlling mechanism; subclass 46 for temperature or a humidity controlling mechanism including a timing means; and appropriate subclasses for a temperature or humidity control mechanism for a control of general utility. The line between Class 165 and 236 is: Class 165 takes: (a) Nominal recitation of a means for heating and cooling, and a means for automatically controlling the means for heating and cooling. (b) Specific heat exchanger structure in combination with a means for automatically controlling a heat exchanger. (c) Specific heat exchange structure in combination with a means for automatically controlling a heating and a cooling means. Class 236 takes: A patent with nominal recitation of a heat exchanger in combination with a means for automatically controlling a heating or cooling means.