



## The Investigation of New Age Solar Absorption Air-Conditioner Systems

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**Abstract:** Many researchers have studied the solar absorption air conditioning system in order to make it economically and technically viable. An Air-Conditioner system utilizing solar energy would generally be more efficient, cost wise, if it was used to provide both heating and cooling requirements in the building it serves. But still, much more research in this area is needed. This paper will help many researchers working in this area and provide them with fundamental science on absorption systems, and a detailed review on the past efforts in the field of solar absorption cooling systems with the absorption pair of lithium-bromide and water. Various solar powered heating systems have been tested extensively, but solar powered air conditioning systems have received very little attention. Solar powered absorption cooling systems can serve both heating and cooling requirements in the building it serves. This science will help them to start the parametric study in order to investigate the effect of key parameters on the overall system performance.

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### 1. Introduction

The first form is the most familiar and that is using it for supplying domestic hot water for residences which is the most worldwide spread form of solar energy use. Another form is the photovoltaic, and these are special cells that transfer solar energy to electric ones. Also, some power plants are now present that produce electricity from solar energy (e.g. US Pilot Power Plant of 516 degree Celsius average temperature (Friefeld & Coleman 1986) and the Japanese experiment stations of 1MW power output (Tanaska 1989).

Solar energy is one of the most available forms of energy on the Planet's surface, besides; it is very promising and generous. The planet's surface receives a daily solar dose of  $10E+8$  KW-hr, which is equivalent to 500 000 billion oil barrels that is one thousand times any oil reserve known to man. The solar energy is collector area dependent, and is a diluted form of energy and is available for only a fraction of the day. Also, its availability depends on several factors such as latitude and sky clearness (Duffie & Beckman 1980. At the same time, its system requires high initial cost. But on the other hand, it has some attractive features such as its system requiring minimum maintenance and operation cost, and it does not have negative effects on the environment. Another important feature of solar energy is its ability to satisfy rural areas where

conventional energy systems might be not suitable or uneconomical.

Solar energy is being invested in many forms.

Some other applications of solar energy being investigated are its establish for cooling and heating of buildings. A lot of research is being conducted for this purpose especially in countries where there is high availability of solar energy just like in India. Solar energy is abundant in summer months where there is no heating load, but instead cooling is required. Solar Air-Conditioner has the advantage of both the supply of the sunshine and the need for refrigeration reaching maximum levels in the same season. As a result, solar Air-Conditioner is the particularly attractive application for solar energy.

In order to evaluate the potential of solar energy for the several solar cooling systems, a classification has been made by the scientists Best and Orgeta (1998). It is based on the two main concepts – solar thermal technologies for the conversion of solar heat into hot water, and the solar cooling technologies for the cold production. The solar thermal technologies are:

- Flat plate collectors
- Evacuated tube collectors
- Stationary, non imaging concentrating collectors
- Dish type concentrating collectors
- Linear focusing concentrators
- Solar pond

- Photovoltaic

The solar cooling technologies are mainly classified into two main groups depending on the energy supply: a thermal/work driven system and electricity (Photovoltaic) driven system. Each group can be classified as the following:

- Electricity (Photovoltaic) driven system
  - Thermo-electric refrigeration cycle
  - Stirling refrigeration cycle
  - Vapor compression refrigeration cycle
- Thermal/work driven system

- Chemical reaction refrigeration cycle
- Adsorption refrigeration cycle
- Desiccant cooling cycle
- Ejector refrigeration cycle
- Absorption refrigeration cycle

The solar-powered cooling system generally comprises three main parts: the solar energy conversion equipment, the refrigeration system, and the cooled object (e.g. a cooling box). A number of possible “paths” from solar energy to the “cooling services” are shown in Figure 1 (Pridasawas & Lundqvist 2003).

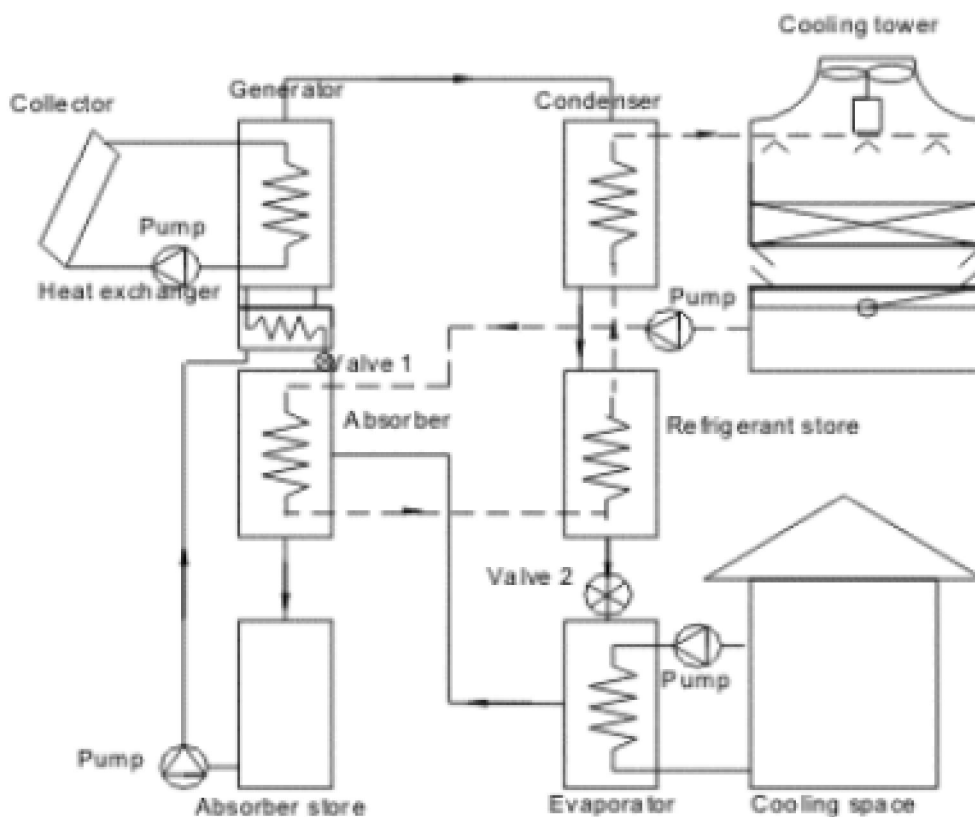


Figure 1: Schematic diagram of single effect solar absorption Air-Conditioner system with refrigerant storage

## 2. Solar absorption air conditioning system

Embodied in the absorption process is the conversion of vapor into liquid, and since the process is akin to condensation, heat must be rejected during the process. The next step is to elevate the pressure of the liquid with a pump, and the final step releases the vapor from the absorbing liquid by adding heat. Both cycles can be shown in the same figure. Figure 2 shows the methods of transforming low-pressure vapor into high-pressure vapor in a refrigeration system. The absorption cycle is similar in certain respects to the electrically driven vapor compression machines. A refrigeration cycle is operated with the condenser, expansion valve, and evaporator if low-pressure vapor from the evaporator can be transformed into high pressure vapor and delivered to the condenser.

The vapor compression system uses a compressor for this task. The absorption system first absorbs the low pressure vapor in an appropriate absorbing liquid.

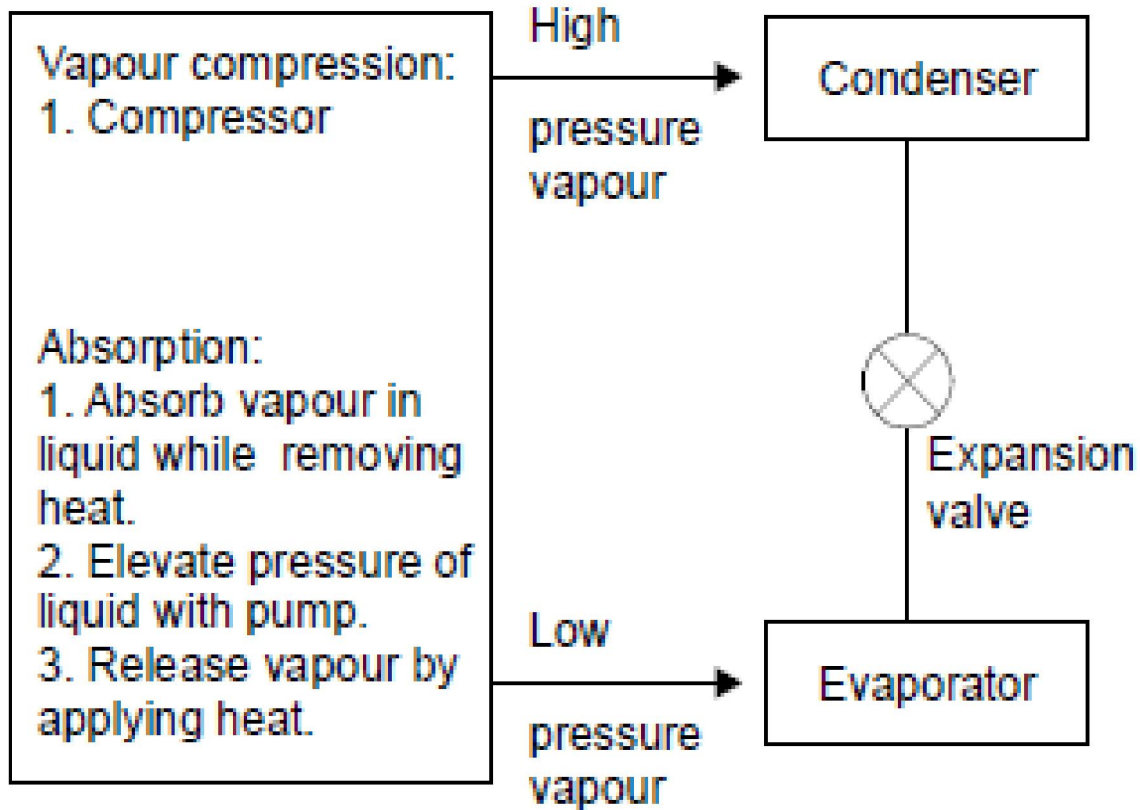


Figure 2: Methods of transforming lowpressure vapor into high-pressure vapor in a refrigeration system

The absorption cycle (see Figure 2), on the other hand, is referred to as a heat operated cycle because most of the operating cost is associated with providing heat that drives off the vapor from the high pressure liquid. For a solar absorption cooling system, this heat is taken from sun energy. The vapor compression cycle (as shown in Figure 2) is a Work operated cycle because the elevation of pressure of the refrigerant is accomplished by a compressor that requires work.

### 3. Single effect solar absorption Air-Conditioner system

The water vapor is cooled down in the condenser and then passed to the evaporator where it again is evaporated at low pressure, thereby providing cooling to the required space. Meanwhile, the strong solution leaving the generator to the absorber passes through a heat exchanger in order to preheat the weak solution entering the generator. In the absorber, the strong solution absorbs the water vapor leaving the evaporator.

Figure 3 shows the schematic diagram of a single effect solar absorption Air-Conditioner system. This system has been the basis of most of the experience to date with solar air- conditioning. Here, the solar energy is gained through the collector, and is accumulated in the storage tank. Then, the hot water in the storage tank is supplied to the generator to boil off water vapor from a solution of Lithium Bromide and water.

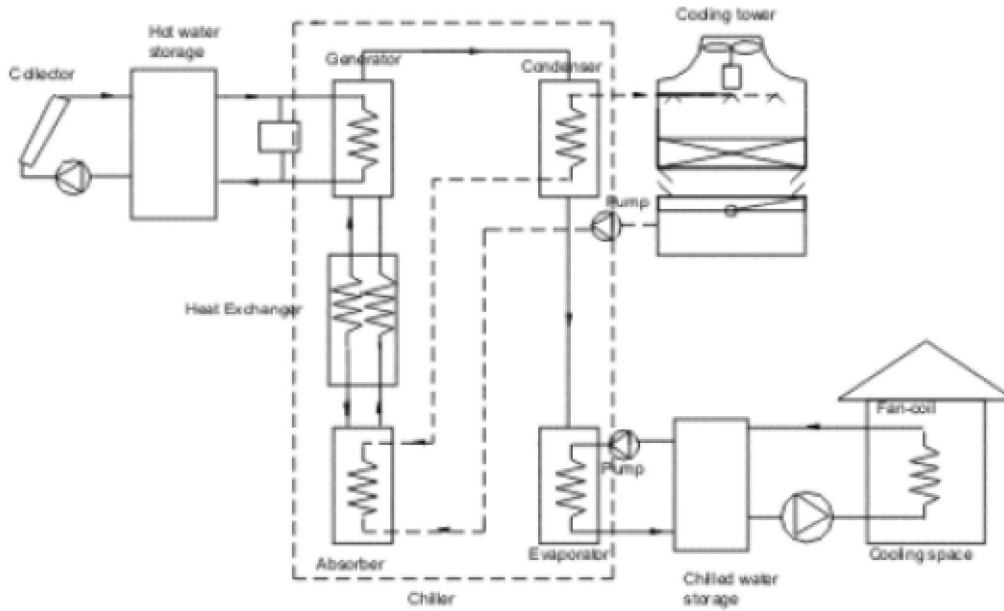


Figure 3: Schematic diagram of single effect solar absorption Air-Conditioner system

An auxiliary energy source is provided, so that hot water is supplied to the generator when solar energy is not sufficient to heat the water to the required temperature level needed by the generator. The main process taking place in the chiller is as follows (as shown in Figure 4). Cooling water from the cooling tower removes the heat by mixing and condensation. Since the temperature of the absorber has a higher effect on the efficiency of the system than the condensing temperature, the heat rejection (cooling water) fluid, is allowed to flow through the absorber first, and then to the condenser (Li & Sumathy 2000).

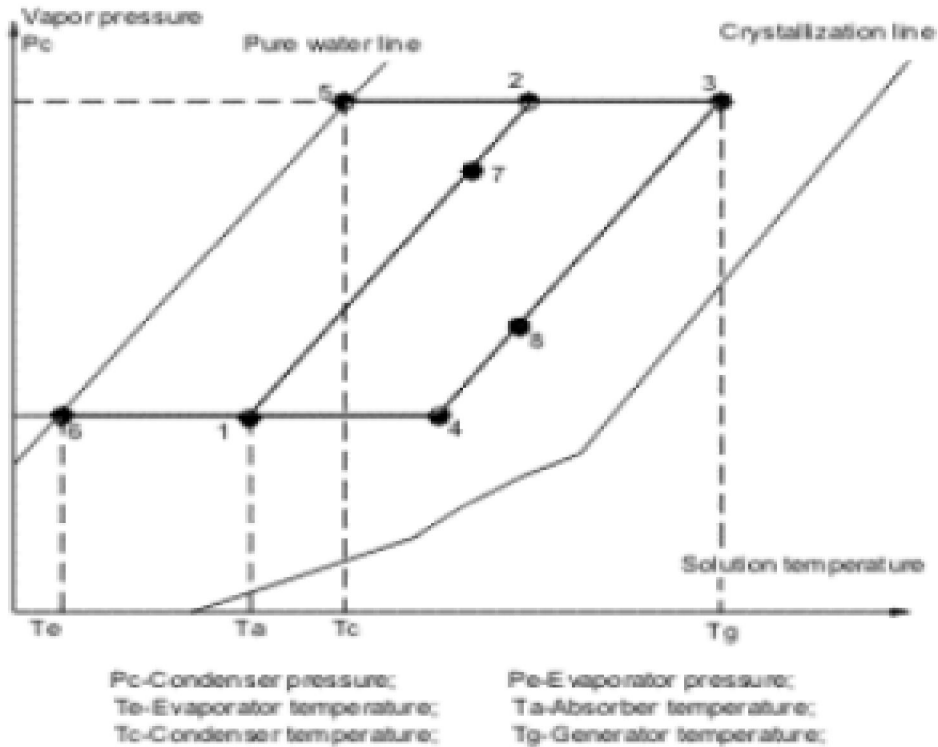


Figure 4: Process diagram of a Single-effect solar absorption Air-Conditioner system cycle

Then, this stored liquid refrigerant can be expanded at other times to meet the required loads. Storage is also needed in the absorber to accommodate, not only the refrigerant, but also sufficient absorbent to keep the concentration within allowable limits.

One of the improvements that would make the absorption machine more suitable for solar operation is refrigerant storage. Basically, the idea is to provide, in association with the condenser, a storage volume where the refrigerant can be accumulated during the hours of high solar insolation.

The advantages of the refrigerant storage over other methods include:

- The energy storage per unit volume is high as the latent heat of evaporation, which is larger, compared to available sensible heat changes, is involved;
- Losses are low as the storage occurs at or near room temperature;
- Further advantages arise when the storage is applied to the lithium bromide-water cycle;
- Water has one of the highest enthalpies of evaporation among known liquids;

A solar powered absorption Air-Conditioner system is a complex, dynamic system and it is difficult to predict with any certainty the annual saving of energy, and therefore, the return on investment. This uncertainty in system evaluation is a further obstacle to the wider application of solar cooling. In order to improve the system design of a solar powered absorption Air-Conditioner system, a parametric study must be carried out to investigate the effect of key parameters on the overall system performance. If experiments were used to perform the parametric study, effects of one key parameter on the overall system performance would normally require several cooling seasons and hence, years to establish a conclusion. Also, it is extremely difficult to keep the performance of the system components to be constant over entire experimental period as the components deteriorate with time. Therefore, in order to avoid extremely difficult and expensive experimentation, researchers can develop and validate a robust dynamic model of the solar powered absorption air-conditioning system and simulation can be done to study the system.

#### 4. Conclusion

Solar absorption Air-Conditioner has the advantage of both the supply of sunshine and the need for refrigeration to reach maximum levels in the same season. Of the two main technologies of solar cooling systems namely, solar thermal technology

and solar cooling technology, the emphasis in this paper is placed on solar cooling technology. Some of the findings of this paper are as follows:

- A Two-stage system has the advantage of lowering the generator temperature, which provides the establish of conventional flat plate collectors, thereby bringing down the cost of the system.
- Among the major working pairs available, LiBr-H<sub>2</sub>O is considered to be better suited for solar absorption Air-Conditioner applications.
- A Single effect system with refrigerant storage has the advantage of accumulating refrigerant during the hours of high solar insolation but the double effect convertible system has a higher overall COP.
- Generator inlet temperature of the chiller is the most important parameter in the design and fabrication of a solar powered Air-Conditioner system.

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