Heat Driven Cooling

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Introduction

Cooling and air-conditioning are some of the most energy intensive thermal process, solar driven cooling has the potential to lower the electricity (primary energy) used for residential air-conditioning since the production and the need for cooling is in phase. The purpose of this project is to investigate the possibility of constructing a heat driven cooling cycle, with evacuated tube solar collectors as the heat source in combination with an absorption cycle to convert the heat to cooling.

Purpose of project

Even though this project is carried out on a refrigerator the thought was that the technology should be used mainly for air-conditioning purposes. If the technology is implemented to drive an air-conditioning unit the user will experience no decline in the comfort level at all.

Performance of system

To illustrate the performance of the system the following is assumed:

- 1000 w/m2 direct solar radiation
- 150 w/m2 diffuse radiation
- 50 % efficiency of solar collector
- COP of 0.7 for the absorption cycle
- No pump

This means that there theoretically can be produced approximately 400 watts of cooling per square meter solar collector. A standard house in Bangkok (se figure 2) has an annual average cooling demand of 450 watts.

An equivalent modern air conditioning unit (assumed COP of 3) would use 130 watts in order to produce the same amount of cooling.

This means that it is possible to save 130 watts of electricity (primary energy) for every square meter of solar collector installed.

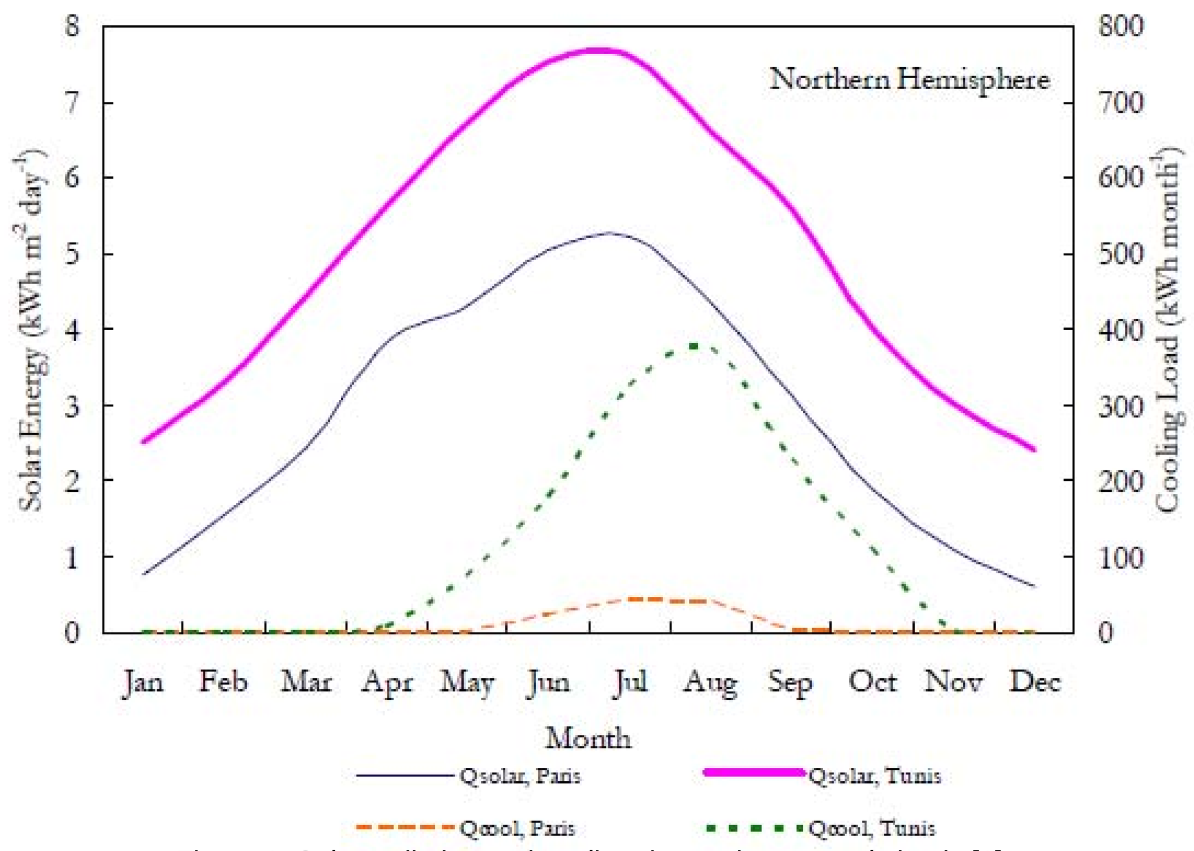

Figure 1: Solar radiation and cooling demand on a yearly basis [1]

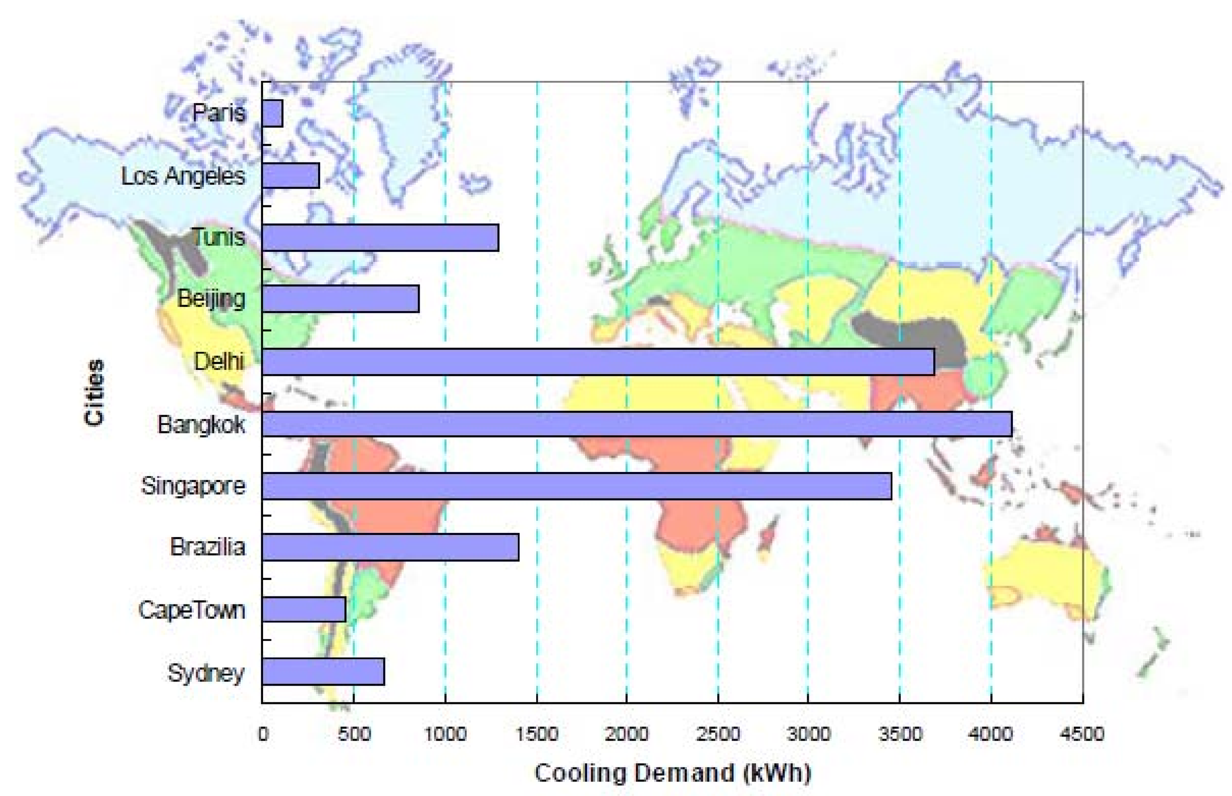

Figure 2: Cooling demand on a yearly basis, for a 60 square meter house [2]

Perspective

In Denmark the demand for air-conditioning is less than of heating, but this is not the case for many other parts of the world. In other parts of the world the need for air-conditioning is substantial larger than the heating demand (see figure 2). There is a large potential for using a solar driven cooling system to produce air-conditioning for offices as well as residential buildings.

By using solar driven air-conditioning systems the total electricity consumption will be lowered and thereby there will also be a reduction in CO_2 emissions and there will be an economic incentive to.

As an example the USA can be mentioned. About 14 % [6] of the total electricity consumption is used for air conditioning. This corresponds to an CO2-emission of approximately 30 million tons of CO2 per year. A large amount of this CO2 could be saved by switching from conventional air-conditioning to a solar driven system

A solar driven air-conditioning system will besides the emissions reduction also have some befits which are not related directly to the end user but much more to the produces and distributors of electricity. Since the need for cooling is in phase whit the amount of incoming solar radiation (see figure 1) some of the daily fluctuations will be eliminated since there only will be a minimal need for electricity to produce air-conditioning.

Conclusion

Solar driven cooling system can be used as one of the means to reduces the worlds energy consumption and thereby also the amount of green house gasses emitted.

All the needed technologies are on the market, and small demonstration plants have been made - which clearly indicated the potential of this technology.

Solar driven air-conditioning can help to reduce global emissions without any decline in the amount of comfort for the end user.

Technology

The key technologies in this project are the absorption cycle and specific types of solar collector know as evacuated tubes solar collectors (heat pipes). The absorption cycle has the capability of converting heat into cooling with a coefficient of performance (COP) of 1 (based on the heat input).

The evacuated tubes solar collector can approximately convert half of the solar radiation to warm water. The main advantage such a collector is that it is able to absorb both direct and indirect (diffuse) radiation, which increases the usage time of the combined system.

Absorption cycle

The absorption cycle used for this project is shown on figure 3. The process consists of a boiler, a condenser, an evaporator and the absorber.

In a regular cooling cycle the absorber and boiler would be displaced by the compressor and the rest of the process would remain the same.

This type of cycle has no pump instead it utilizes the partial pressure difference to circulate the refrigerant pair of water and ammonia. In this particular system hydrogen is used to circulate the medias.

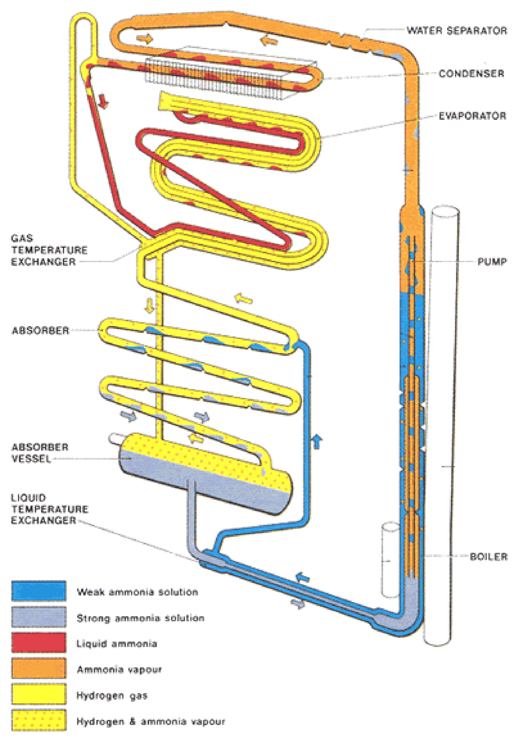

Figure 3: Overview of the absorption cycle [3]

Evaquated tubes solar collectors

This type of solar collectors is designed in a manor which makes it possible to achieve relative high temperatures (above 100 degrees Celsius).

The collector consist of a series of tubes, one tube can be considered as one individual solar collector. The tubes consist of two layers of glass with a vacuum in between.

As seen on figure 5 there is a heat pipe in the middle of the vacuum tube. The heat pipe is filled with water at low pressure which makes it boils below 100 degrees Celsius. This makes the water circulate in the heat pipe by natural convection. The heat absorbed by the heat pipe is transferred to the solar fluid, running through the top of the collector.

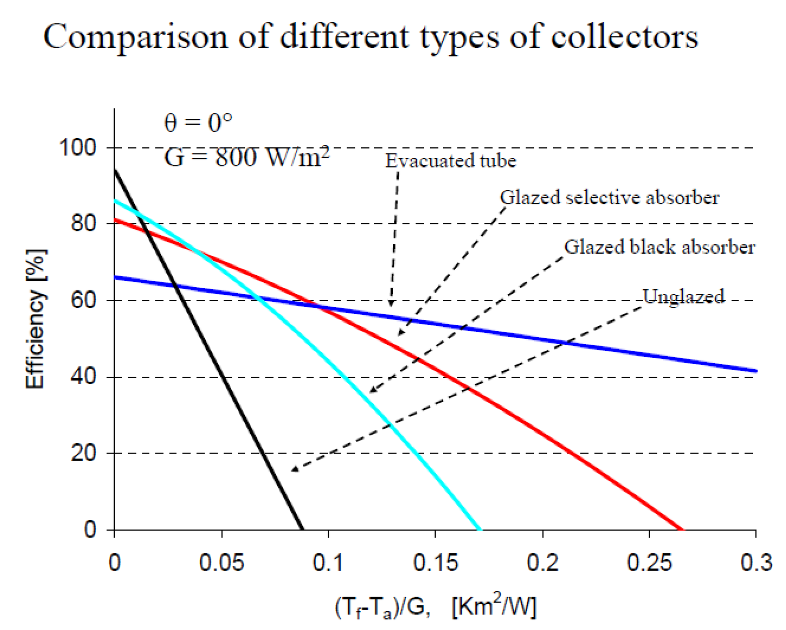

Figure 4: Performance of solar collectors as a function of fluid temperature [4]

Experimalt experience

This project has focused on the construction of a solar driven absorption refrigeration process. From the conducted experiments it is clear that it is possible to drive a absorption cycle purely with solar energy.

The experiments have also clearly show that there is a great potential for improvements. Most absorption refrigerators on today's market are designed to use either an open gas flame or an electrical heating element as the driving force. When switching to a water driven system one has to redesign the boiler of the absorption cycle.

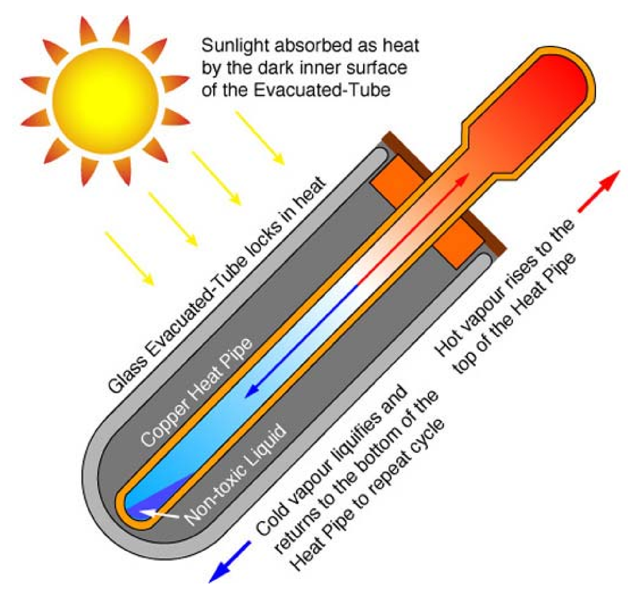

Figure 5: How a evaquated tube collector works [5]

References [1] Solar-Driven Refrigeration Systems with Focus on the Ejector Cycle, by Wimolsiri Pridasawas [2] Solar-Driven Refrigeration Systems with Focus on the Ejector Cycle, by Wimolsiri Pridasawas [3]www.gas-refrigiators.com [4]Solar heating system 11117 - Simon Furbo [5]www.rusticresurces.com [6] The US energy information administration

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