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A New Approach to Air Conditioning System Using the Photovoltaic System in Combination With Electricity – Driven Heat Pump and Vapor Compression Chiller

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Abstract
Solar cooling systems have the benefit of the correlation between hours of cooling demand and the availability of solar radiation which can help to minimize electricity usage in buildings. Cooling and/or heating are the major requirements in houses, depending on local climatic conditions and construction style. As well as the impacts of global warming and climate change, air conditioning and refrigeration demands have risen. The development of cooling by using green energies, such as solar panels, is also a crucial solution for electricity and environmental problems. In this research, a solar air conditioning system using pv- vapor compression chiller is proposed. The objectives of this research is to design a system structure to reduce the energy consumption and electricity bill, investigate the performance of the proposed structure through simulation software, implement a hardware prototype based on the proposed design, and to evaluate the simulation and implementation data to validate the experimental results. Finally the data will be validating by the results from other works and simulation as well.
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Introduction

Pachauri, R. K., & Reisinger, A. (2007), the need for air conditioning is growing due to the impact of climate change and global warming. If we would rely on traditional electrical air conditioning because energy is produced in the form of fossil fuels, greenhouse gas emissions will begin to deteriorate global warming and the need for air conditioning will rise further. Fong, K. F., Lee, C. K., Chow, T. T., Lin, Z., & Chan, L. S. (2010), it is therefore urgent to reduce fossil fuel consumption and encourage wider use of solar energy, especially in refrigeration and air-conditioning.

Ochi, M., & Ohsumi, K. (1989), Air conditioning is characterized as the simultaneous processing of air current temperature, humidity, purification and distribution, in accordance with the requirements of air conditioning.. Bvumbe, J., & Inambao, F. L. (2011), Air conditioning which can also be called refrigeration is generally defined as any heat removal process. It requires energy to produce the process, where the source is usually gas and electricity Jiang, Y. (2007). & Wang, R. G., & Shen, T. X. (2004), Building energy demand consumes a very significant proportion of the world's electricity usage. Construction energy usage accounted for 42 – 45 per cent of overall energy use in more developed country in industry. Li, Z. J., & Jiang, Y. (2009), with economic and social growth, the proportion of energy use in building will increase year by year. The utilization of air-conditioning energy use in building energy use accounted for more than half of the overall energy use, and reducing energy use is one of the main ways of tackling energy use in buildings. Li, Y., Zhang, G., Lv, G. Z., Zhang, A. N., & Wang, R. Z. (2015), After 1990s, accelerated advancement of solar photovoltaic technology has begun. With the rapid increase of photovoltaic performance and the steady decline in the price of solar panels, solar photovoltaic technology is becoming increasingly widespread. Chandel, M., Agrawal, G. D., Mathur, S., & Mathur, A. (2014).There are two forms of solar cooling, solar photoelectric conversion and photo thermal heat conversion. Solar photoelectric cooling technology will be used in this work where PV cells are used to transform solar energy into electricity and when traditional vapor compression chillers are powered by electrical energy. The main objective of this research is to design and construct an air conditioning system using PV which electrically driven vapor

Compression chiller to reduce energy consumption as well as reduce an electricity bill.

1.1 Previous studies:

Several researchers have studied the economic excellence of the solar cooling system, as it a key factor in the implementation of solar cooling technology, in reducing energy consumption and electricity bills, and in reducing the determined environmental effect of greenhouse gas emission, we name a few:
Kim et al. compared the equipment costs of many kinds of solar photoelectric cooling systems and many kinds of solar photo thermal cooling systems in 2008. The results indicated that the equipment cost of the solar PV cooling system was higher than that of solar photo thermal cooling systems. Otanicar et al. predicted that the equipment cost of the solar PV cooling system would drop a lot by the year 2030 and the equipment cost of the

solar absorption cooling system would drop just a little. Mokhtar et al compared 25 kinds of solar cooling systems which were different in structure. This study was based on the conditions of Abu Dhabi. And the results indicated that the economic performance of the solar PV cooling system consisting of the vapor compression chiller and polysilicon PV cells was better than that of the solar absorption cooling system consisting of the single-effect absorption chiller and flat plate collectors or evacuated tube collectors. Infante Ferreira et al compared the economic performance of the solar PV cooling system and solar photo thermal cooling systems in the conditions of Spain and Dutch. The results indicated that the cooling system consisting of PV cells and the vapor compression chiller had the best economic performance .Noro et al. compared the economic performance of many kinds of solar PV cooling systems and many kinds of solar photo thermal cooling systems in the conditions of Milan and Trapani. The results indicated that the cooling system consisting of A-Si PV cells and the water-cooling compression chiller had the lowest cost, and the cost of every kind of PV cooling system was lower than that of solar photo thermal cooling systems. Chen, Yingya, et al proposed a design and adaptability of photovoltaic air conditioning system based on office buildings The results show that the PV AC system quickly decreases or increases the room temperature by ~9.5% and 17% in 1 h of cooling and heating periods, respectively, thus maintaining the room temperature within the set temperature range of ±0.9 °C. The data also show that by proper design of parameters, a PV AC system can satisfy the electricity demand of AC. In the cooling period, heating period, and annual operation conditions, the PV system provided 114%, 73%, and 188% of the energy for the AC system, respectively. Next, economic calculations show that PV AC is suitable for office buildings. The local payback period is only 7.5 years; both the energy saving and emission reduction are significant. Chen, Yingya, et al. predicated a design method of photovoltaic direct-drive air conditioning system, and arranges the photovoltaic direct-drive air conditioning system in an office building in hot-humid regions, the system mainly includes photovoltaic array, storage battery, confluence unit, PWM controller, and air conditioner. Through the test, we found that photovoltaic direct cur-rent air conditioning system is still able to better meet the indoor thermal environment needs even in hot weather. Besides, in the test day, the amount of photovoltaic power generation apart from meeting the demand for air conditioning and there are remaining. The excessively power generation is stored in the battery, it can be self-sufficient for the system, no municipal power grid supplement and energy efficiency is more significant. Mittelman , et al. proposed a solar cooling with a concentrating photovoltaic/thermal (CPVT) system,. CPVT collectors may operate at temperatures above 100 °C, and the thermal energy can drive processes such as refrigeration, desalination and steam production. The results show that under a wide range of economic conditions, the combined solar cooling and power generation plant can be comparable to, and sometimes even significantly better than, the conventional alternative. Hartmann, N, et al. performed a comparison of solar thermal and photovoltaic options for two different European climates, the comparison is based on load series for heating and cooling obtained previously from annual building simulations in TRNSYS. The simulated solar electric system consists of the reference system, equipped with a grid connected photovoltaic module, which can be varied in size. For cost comparison of the two systems, the electric grid is assumed to function as a cost-free storage. Within the system parameters and assumptions used here, the grid coupled PV system leads to lower costs of primary energy savings than the solar thermal system at both locations. The presumed macroeconomic advantages of the solar thermal system. Gao, Yuhe, et al. performed a comparison study between air conditioning system using solar PV and other cooling system based on the energy consumption and economic performance located in three region of China , from the result they observed that the energy consumption and economic performance of the PV cooling system is better that other solar cooling system (solar absorption cooling system and conventional vapor compression cooling system). Ma, Qimin, et alperformed a performance study for hybrid air conditioning systems , from the result, they observed that the performance of hybrid air conditioning systemis 44.5% higher than the CVCRS (conventional vapor compression refrigeration system at latent load of 30%, also, the improvement can be achieved by 73.8% at 42% latent load. Daut, I., et alproposed a design and construction of direct current air conditioning system coupled with PV system , they achieved that both PV system and air conditioner need to be consider in the system design. For both air conditioner and PV system, several characteristics are needed to know. For PV system, important characteristics are Electrical equivalent, IV characteristic curve and factors affect the output of PV cell, while the cooling capacity is important to give an idea on how to design and construct the system with enough electrical energy supplied to air conditioning. To improve the stability and efficiency of the system, all factors must be taken in consideration. Ammari, et al. performed a comparison study between solar PV driven vapor compression refrigeration system and solar thermal unit driven vapor absorption refrigeration system .This comparison is based on energy efficiency, cost, and payback period. They observed that the total cost of the absorption refrigeration system including the solar evacuated tubes unit is $9142 with a payback period of 1.36 years, whereas that of the vapor compression refrigeration system including the photovoltaic array is $7176 with a payback period of 1.88. Also, VCRC system would prefer after examination all of the parameters involves noisy compressor, since its low price, easily available in the market, simple structure and required low maintenance, and wider applications in commercial buildings and industry.

1.2. Problem statement:

High power demand of conventional air-conditioning system about 3-5 horsepower (HP) . The high demand for energy for cooling purposes raises the bill s for power which would result in an rise in the cost of living. The need to design an alternative cooling system is inevitable in order to utilize the electricity efficiently. Evaporative solar cooler system is a reasonable development.

1.1.2 Objectives:

The objectives of this research are:

- To design a system structure to reduce the energy consumption and electricity bill.
- To investigate the performance of the proposed structure through simulation software.
- To implement a hardware prototype based on the proposed design.

To evaluate the simulation and implementation data to validate the experimental results.

1.3. Methods

Schematic diagram of the air conditioning system using PV –vapor compression chiller is shown in Figure 1.

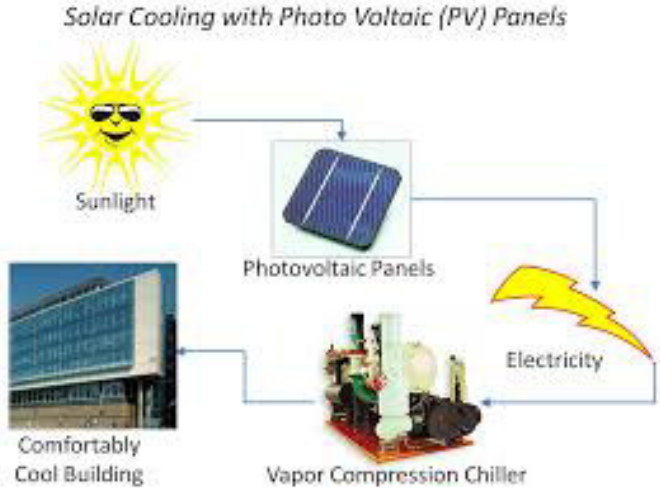

Fig .1 schematic of PV solar cooling schematic

The solar – mechanical system consist primarily of photovoltaic panel and an electrical cooling mechanism working according to the process of vapor compression. The greatest advantage of using solar electric panels for cooling would be their simple structure, combined with traditional vapor compression system, and high overall performance.

The approaches used in this research are divided into two subsections:

- The design and simulation of the air conditioning system using the photovoltaic and model the system in Matlab/Simulink and to reduce the energy consumption and consequently optimize the electricity bill and check the feasibility of the system.
- Hardware implementation and validating the results: hardware prototype will be designed in two parts:
- Photovoltaic based electricity driven heat pump.
- Vapor compression chiller.
- The implemented device will a tested for a three – month interval in case of checking the efficiency and solve the possible errors. In the end, the data will be validated by the results from other works and simulations as well. The methodology approach is shown in Figure. 2.

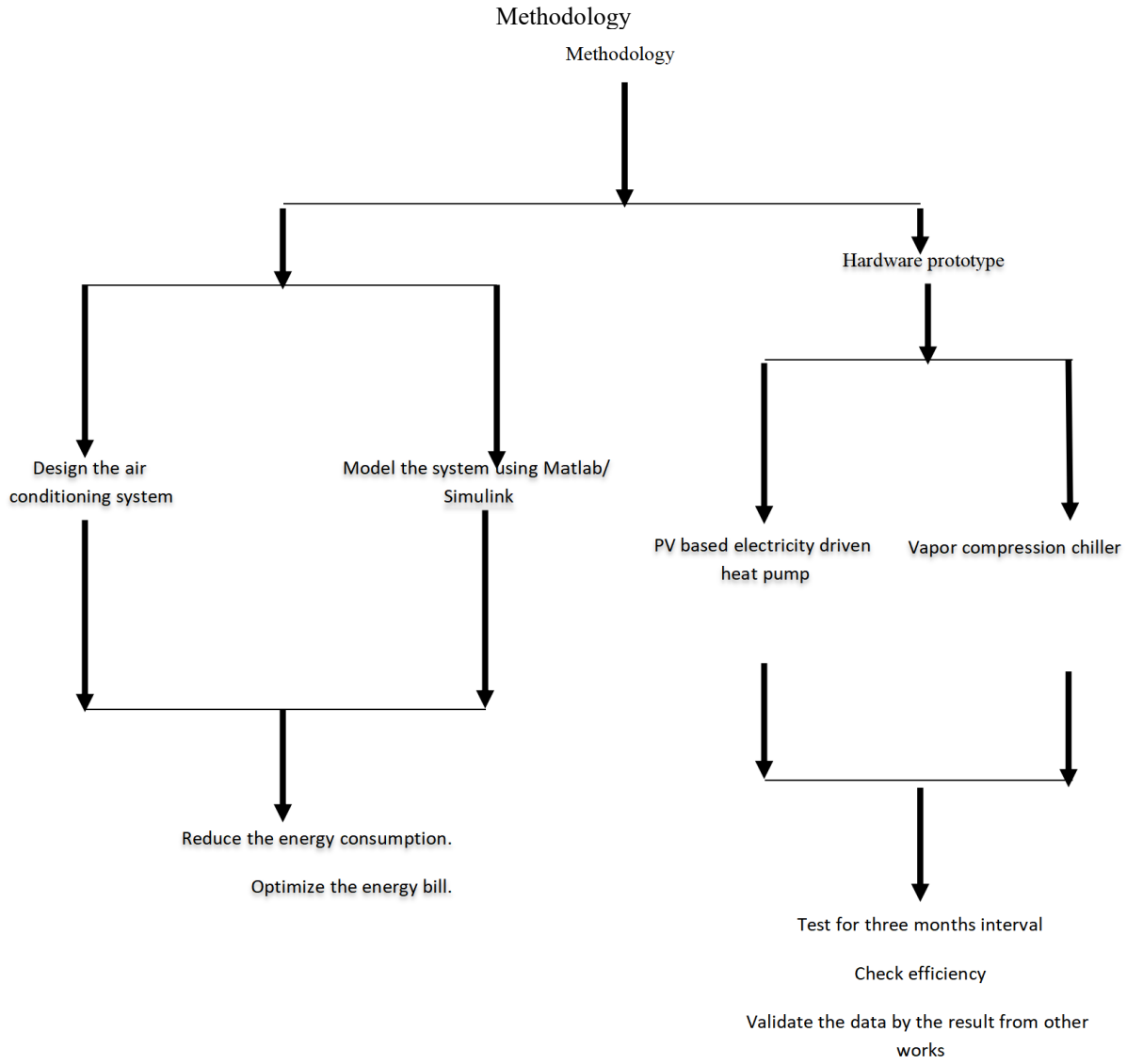

Figure .2 Methods Approach

Conclusion:

The air conditioning is consumed a half of building energy consumption. In this research , A solar air conditioning system which is driven by solar energy (photovoltaic) using the vapor compression technique is proposed. The main objective of the present research has been to design a system structure to reduce the energy consumption and electricity bill. The analysis is based on the design and simulation of the air conditioning system using the photovoltaic and model the system in Matlab/Simulink to check the feasibility of the system. The implementation of the prototype will be designed in two parts, PV based on electricity driven heat pump and vapor compression chiller. In case of checking the efficiency of the proposed system, the device will test for Three month. Finally, the data will be validated by the results from other works and simulations as well.

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