SOLAR ENERGY POTENTIAL IN IRAQ
RECOMMENDED SOLAR TECHNOLOGIES FOR THE COUNTRY

Karrar-Al-Ahmedi

Warsaw University of Technology, Warsaw, Poland
Engkarrar0@gmail.com

ABSTRACT

The main purpose of this paper is to analyze the various cooling systems, using the readily available solar energy to cool down the buildings in Iraq during hot weather days. This paper presents the best solar cooling system which can be installed in Iraq for solar cooling. It also focuses on the type of thermally driven system which can be used for solar cooling. It is fact that many buildings in Iraq are designed far away from being energy efficient, hence this paper focuses on the standards which can be developed and can be used in the future on residential buildings from the energy point of view, with a suggestion to establish such solar cooling projects in Iraq.

Keywords: Cooling, Solar electric cooling system, solar thermal cooling system.

INTRODUCTION

Solar energy is considered as a renewable energy source due to the fact that a small part of the radiant energy that the sun emits into space ever reaches the Earth. The growth in the energy utilization sector has led to the interest in the utilization of renewable energies including cooling techniques which focus on solar energy. Solar energy is used in two forms i.e. thermal and photovoltaic for producing heat and electricity. Solar cooling systems are attractive because cooling is most needed, when solar energy is highly available. However, solar cooling systems by themselves are usually not economical at present fuel costs Basically, solar cooling is a technique which collects solar energy and converts it into the heat to provide space heating, cooling, pool heating for buildings. It's an advance technology, which eliminates the use of electricity and natural gas. This technology is safe and eco-friendly. In general, solar cooling depends on the things described below.

Cooling: It is a process of heat removal or transfer of thermal energy via thermal radiation, conduction, and convection. It can also be defined as a system that keeps something cool and dry.

Ventilation: It is a process by which ambient air is intentionally provided to give fresh environment in a building. It can be done by either naturally or mechanically. It provides high indoor quality air. It also controls the temperature, replenishes the oxygen, and removes moisture, odors, dust, smoke and other gasses. It also removes the unpleasant smell from the atmosphere and provides comfort. Ventilation plays a vital role in maintaining the indoor quality of buildings.

Air-Conditioning: Air-Conditioning is a combined process which performs many functions like conditioning of air, its transportation and introduces it to the conditioned space. It provides heating and cooling from its central plant to rooftop units. It also controls and maintains the temperature, humidity, air movement, air cleanliness and provides comfort. Air- Conditioning buildings often have their windows closed because the open windows can work against the air-conditioning process.

HVAC: It stands for heating ventilation and air-conditioning. Basically, it is a system which performs heating and cooling in buildings. This system is also responsible for providing quality air from volatile organic compounds (VOC) emitted from chemicals used for cleaning, interior furnishings. A properly designed HVAC system provides a comfortable indoor environment in buildings.

CLIMATE IN IRAQ

The climate of Iraq is hot and dry. In Iraq temperature is generally above 48 °C during summer months (June, July, and August). While lowest temperature can drop below freezing point during the coldest month January.

Iraq is strongly influenced in the summer by subtropical high pressure. This high-pressure zone influences desert regions across North Africa and the Arabian Peninsula. It migrates northward in the summer. Because of increased solar radiation associated with the summer solstice. By contrast, during the winter solstice, as the northern hemisphere is tilted away from the sun, the subtropical high pressure is replaced by periodic low- pressure systems, that travel from west to east across Iraq bringing winter rains and snow in the mountain regions of the north. The summertime is commonly marked by two types of wind phenomena. Southern and south-easterly wind called (***sharqi)*** is a dry, dusty wind which takes place from April to early June and again from late September until November with occasional gusts of 80 kilometers per hour. This wind can last for a whole day at the beginning and end of the season and for several days during the middle of the season. This wind is often

accompanied by violent dust storms. The wind may rise to heights of several thousand meters, that forces to close airports for short periods of time. From mid-June to mid-September the prevailing wind, called the ***(shamal)***,(North wind) is present throughout the country from the north and northwest. It is a steady wind, absent only occasionally during this period. The very dry air brought by this ***shamal*** permits extensive heating of the land surface, but the breeze has some cooling effect. The Ambient Air Temperature in Iraq during summer in the years,2014-16. Shown in Fig.1.

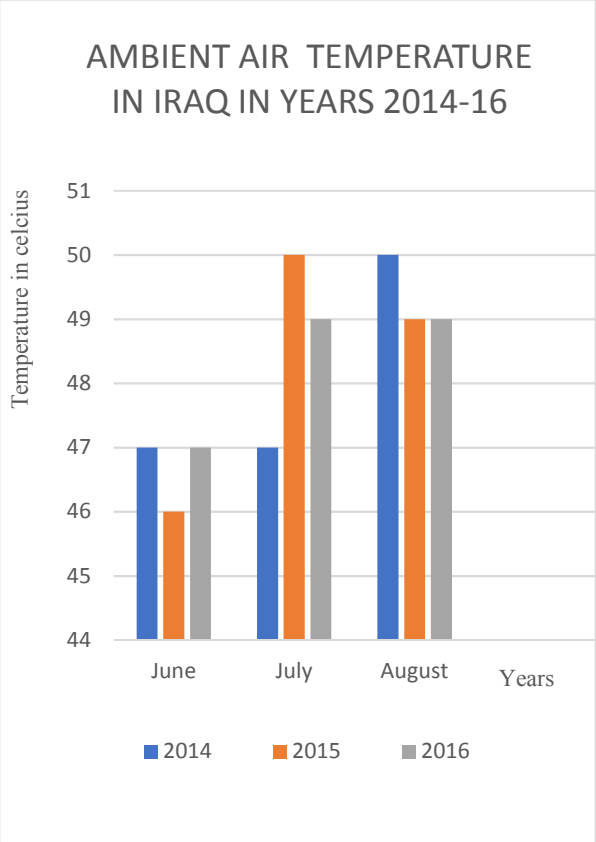


Figure 1. Ambient air Temperature in Iraq during summer in the years 2014-16

Average low temperature in Iraq during the winter months vary from near freezing point which is around 2°C or 3°C and 4°C to 5°C. While during the summer months the average low temperature ranges from 22°C to 29°C and commonly rise to a temperature above 48ºC. Temperatures throughout the country typically fall below freezing point and in previous years have fallen to as low as -14.5°C at AL Rutbah in the western desert area. However, temperatures are more likely to rise above 46°C in the summer months. The all-time record high temperature in Iraq of 52 °C (126 °F) was recorded near (***AL Nasiriyah***) city on 2 August 2011.(as the report in climate and average weather in Iraq,2017).

Iraq's climate is described as subtropical in terms of heat due to the presence of temperature rate more than 20 degrees for 4-11 months. According to Koeppen-Geiger classification, Iraqi climate is classified as BWh climate where B indicates Dry, W indicates dessert and h indicates hot climate. (as the report in The Iraqi Ministry of Environment's annual repo,2010.).

Some characteristics of Iraqi climate are as follows:

- It has a continental climate which brings a wide range of temperatures.
- Mountain region of the north has cold and less humid than in the south.
- Center of the Iraq is much hotter in summer and dust storms are the main feature of the central region.
- The southern area of Iraq i.e. around the Gulf has the highest temperature recorded anywhere in the world.
- In the northeast, heavy rainfall takes place.
- Desert area receive no rainfall at all.

SOLAR ENERGY POTENTIAL IN IRAQ

Iraq has an opportunity to become a solar king. It is well-known for long hours of sunshine. As it receives more than 3000 hours of solar irradiance per year in Baghdad alone. The hourly solar irradiance varied between 416 W/m^2 in January to 833W/m^2 in June. Iraq plans to invest in solar energy to generate electricity by panels (photovoltaic silicon) in the western desert.

There are possibilities of manufacturing solar cells in Iraq due to the presence of raw materials of silicates. Silicon is the most important element used in the solar cell, and it is easily available in Iraq, especially in the city of Ramadi and the Western Desert. Iraqi homes are more likely private homes, not big apartments, that is one of the reasons that electricity generation based on solar energy in Iraqi homes are more affordable than other countries (as the report in Sample research paper on renewable energy in Iraq,2013). Solar energy can provide a direct, rapid and sustainable source of power generation in Iraq, but high prices and rapidly evolving technologies, often impede investment in the development of solar power systems. (as the report.in ST Ahmed, 1988).

SOLAR COOLING TECHNOLOGIES

Solar cooling is a technology for converting heat gained from solar energy into useful cooling for refrigeration and air-conditioning applications. Solar thermal energy is collected and used by a thermally driven cooling process, which in turn is normally used to generate chilled water or conditioned air for use in the building. A typical solar cooling scheme essentially includes three components. They include the solar collector for harnessing the solar energy by converting it into heat or mechanical work, a refrigeration or air-conditioning plant for producing cooling and a heat sink for heat rejection. (as the report in GG Maidment, A Paurine, 2012) . Basically, there are two kinds of solar cooling system

- Electrically driven system (Photovoltaic).
- Thermally driven system.

Technology (Photovoltaic)

The transformation of solar energy into electrical energy is done through solar cells. It is a sophisticated technology and has a great impact on the preservation of

traditional energy sources. It is a free and clean source of energy and it doesn't produce any residue or danger to the environment. Figure 2 shows Basic working of a photovoltaic system.

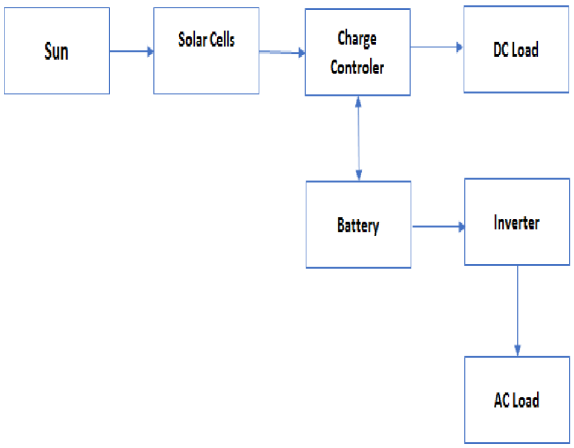


Figure 2. Basic working of a photovoltaic system

The solar cells are made up of silicon, which is a semiconductor. When the photons of sunlight hit the silicon atoms of the solar cell, they lose the electron and transfer the energy. It creates the electrical imbalance in the cell and electric current is generated. This is how solar energy is converted into electricity using solar cells.

Solar cells consist of a thin slice of pure silicon, which contains the traces of arsenic, called the Negative Silicon because they contain five electrons in the outer orbit. There is also a framework of silicon containing traces of boron element, called Positive Silicon because boron atom has three electrons in the outer shell and when sunlight falls onto these electrons, some electrons gain extra energy and begin to move, which would prejudice the situation of equilibrium between the two tranches of silicon and leads to the occurrence of an electric current.

Types of commercial solar cells

There are different types of commercial solar cells used:

- **Monocrystalline silicon solar cells**

These cells are made of monocrystalline silicon (mono-Si), they are also called as single-crystalline silicon (single crystal-Si). These are made out of silicon rods which are cylindrical in shape. To optimize performance and lower costs of a single monocrystalline solar cell, four sides are cut out the cylindrical rods to make silicon wafers, which gives monocrystalline solar panels their characteristic look.

Monocrystalline solar panels have the highest efficiency since they are made out of the highest-grade silicon. They are also space-efficient and live the longest. But they are the most expensive solar cells. (as the report in Energy Informative, 2017).

- **Polycrystalline silicon solar cells**

They are also called as polysilicon (poly-Si). They are made of high purity, polycrystalline form of silicon, used as a raw material by the solar photovoltaic and electronics industry. Polysilicon is produced from metallurgical grade silicon by a chemical purification process, called the Siemens process.

Polysilicon consists of small crystals, also known as crystallites, giving the material its typical metal flake effect. (as the report Wikipedia,2017).

The process used to make polycrystalline silicon is simpler and cost less. They have slightly lower heat tolerance than monocrystalline solar panels. But they have lower space-efficiency (as the report in Wikipedia,2017).

- **Thin-Film Solar cells**

These kinds of solar cells are also known as thin-film photovoltaic cells (TFPV). They are made by depositing one or more thin layers of photovoltaic material onto a substrate, such as glass, plastic or metal. The mass-production of these kind of cells is simple. They are cheaper but less efficient (as the report in Wikipedia,2017).

- **Amorphous silicon solar cells (cracked crystallization)**

Amorphous silicon is a non –crystalline form of the silicon which is made by vapor depositing on a thin layer of silicon material around one micrometer in thickness-on a glass or metal. For high stability, we use thinner layers which reduce light absorption and hence decrease in cell efficiency.

This system directly produces electricity, which can be used, stored or converted for long distance transmission. PV Panels can be manufactured by using a variety of materials and processes and are widely used for solar projects around the world (as the report in Solar Energy Industries Association,2012).

They generally have low efficiency, but are one of the most environmentally friendly photovoltaic technologies because they don't use any toxic heavy metals.

Thermally Driven Cooling Systems

A thermally driven system uses solar energy to generate thermal energy, which is environmentally friendly and low cost. It doesn't require any fossil fuels to produce heat. The thermal energy generated is used to heat water or other fluids and can also drive solar cooling systems. Basically, thermal driven system differs from an electrically driven system (Photovoltaic) which generates electricity rather than heat.

This system is classified as follows:

- Absorption Systems
- Adsorption System
- Desiccant Cooling System

Absorption Systems

The absorption cycle consists of four basic components operating at two pressure conditions and uses an absorbent-refrigerant solution such as water-lithium bromide (LiBr-H2O) as the working fluids. These components include the evaporator, absorber, generator, and condenser (as the report in Maidment, A Paurine, 2012). Figure 3 shows Basic Absorption system.

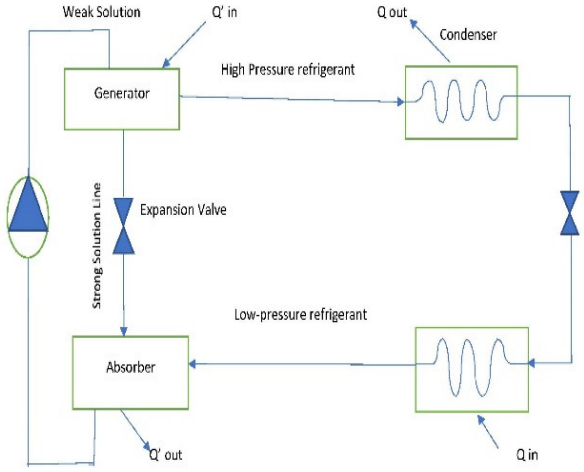


Figure 3. Basic Absorption system

Adsorption Systems

Both Adsorption, as well as absorption, is a very similar process, but they differ in one thing, basically, adsorption uses as solid sorbent while in absorption, the liquid is used. An adsorption process is caused by Vander Wall forces between adsorbate and atoms at the adsorbent surface. Adsorption is a surface based phenomenon while absorption is a volume based phenomenon. Adsorption process uses Zeolite and activated carbon to get the cooling effect. Zeolite is used to attract water vapor while activated carbon is used for adsorption of organic substances. Figure 4 shows (a) The adsorption (Refrigeration) process and (b) The desorption (Regeneration) process.

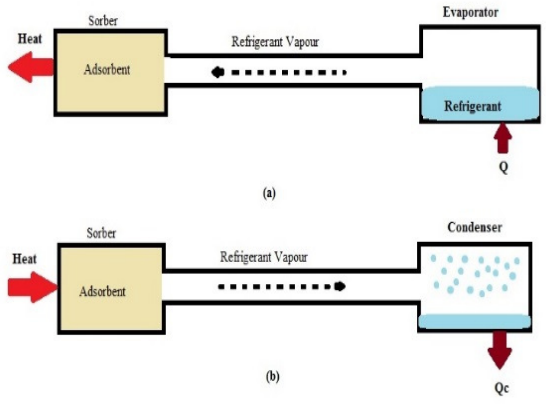
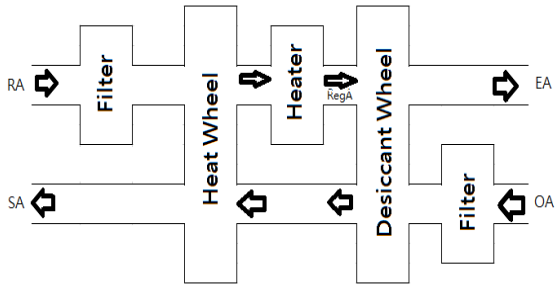


Figure 4. (a) The adsorption (Refrigeration) process and (b) The desorption (Regeneration) process

Desiccant Cooling System

In a desiccant cooling system, air can be passed over common solid desiccants such as zeolite or silica gel for dehumidification and to sensibly cool the air well below ambient temperature conditions in some form of evaporative cooling process. Also, liquid desiccants such as lithium or calcium chloride have been used for air dehumidification processes. In either case, the desiccant requires regeneration, and this can be achieved using solar thermal energy to dry it out, in a cost effective, low energy and continuously repeating the cycle. Basically, there are two kinds of desiccants (as the report in Maidment, A Paurine, 2012). Figure 5 shows Basic Concept of Desiccant cooling system.

- Solid Desiccant
- Liquid Desiccant



OA-Outside Air, SA-Supply Air, EA-Exhaust Air, RA-Return Air, RegA-Regeneartion Air

Figure 5. Basic Concept of Desiccant cooling system

SOLAR COOLING SYSTEM SUITABLE FOR IRAQ

The solar cooling system which is suitable for Iraq is the absorption system as it's more economical and reliable in comparison to the other solar cooling system. Other solar cooling systems are very sensitive to low temperatures and their thermal conductivity of the absorbent is quite poor as compared to the absorption system. Apart from this other system are quite heavy and complex and they require high maintenance while absorption system can be small and can operate at low temperature. It's a fact that most of the buildings in Iraq are designed to be more energy efficient and most of the solar energy produced within this hot climate regions are consumed by the buildings.

CONCLUSIONS

It can be concluded that due to a high ambient air temperature during most of months of a year in Iraq, the absorption system is the most suitable, it requires less maintenance, it's more economical and it has only one moving part i.e. pump. In Iraq, there is a shortage of electricity since the nineties and still, the people are facing it, absorption system does not require electricity, because it's totally based on the natural energy; hence it's the good option for the Iraq. During winters the temperature drops in between 2°C to 5°C, using such as absorption system it is possible to supply low-temperature heat. For Iraq, solar thermal collectors can be used which is cheaper than the photovoltaic cells. Because of the ambient air temperature in Iraq, there will be no effect on the performance of the absorption system due to temperature variations. Hence, absorption system is the fittest and reliable system to be used in Iraq.

REFERENCES

Climate and average weather in iraq,2017. https://weather-and-climate.com/average-monthly-Rainfall-Temperature-Sunshine-in-Iraq.

The Iraqi Ministry of Environment's annual report, 2010. http://www.moen.gov.iq/

Sample research paper on renewable energy in Iraq, 2013, (accessed 23 May) (http://www.customresearchcenter.com/samples/renewable-energy-in-iraq-sample-research-paper.html)

ST Ahmed, 1988, Study of Single-Effect Solar Still with an Internal Condenser,

GG Maidment, A Paurine, 2012, *Solar cooling and Refrigeration Systems*, London, UK,

Energy Informative, 2017, (accessed 30 May) http://energyinformative.org/best-solar-panel-monocrystalline-polycrystalline-thin-film/

Wikipedia,2017 (accessed 30 May) https://en.wikipedia.org/wiki/Monocrystalline_silicon

Wikipedia,2017 (accessed 30 May) https://en.wikipedia.org/wiki/Polycrystalline_silicon

Wikipedia, 2017(accessed 30 May) https://en.wikipedia.org/wiki/Thin-film_solar_cell

Solar Energy Industries Association,2012, http://www.seia.org/policy/solar-technology (accessed on 22 May)

GG Maidment, A Paurine, 2012, *Solar cooling and Refrigeration Systems*, London, UK,

GG Maidment, A Paurine, 2012, *Solar cooling and Refrigeration Systems*, London, UK,