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A Review on Solar Powered Air Conditioning System

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Abstract - *An air conditioning system utilizing solar energy would generally be more efficient cost wise, if it was used to provide cooling requirement in the commercial and domestic as well as industrial buildings. And in twenty first century is rapidly becoming the perfect energy storm and the greatest challenge facing mankind is energy. The demand for energy could double or triple as global population grows and developing countries expand their economies. And so the most abundant energy resource available to human society is solar energy. Among the various renewable energy resources, the least utilized energy is solar energy. To maintaining thermal comfort in indoor environments, air conditioning is essential for hot and humid climates. The demand for electricity is greatly increase in summer due to extensive use of air conditioning systems. The country's facing a source of major problem is electricity supply and contributes to an increase of carbon dioxide emissions causing environmental pollution and global warming and other hand, vapour compression air conditioning systems have effect on stratospheric ozone depletion due to use of chlorofluorocarbons (CFC) and the hydro fluorocarbon (HCFC) refrigerants. To cool with solar thermal energy one solution is to use an absorption chillier using water and lithium bromide solution. Solar air conditioning systems help in minimize fossil fuel energy use. Among the evolving energy efficient air conditioning technologies are liquid desiccant air conditioning systems(LDAC) and is environmental friendly. And liquid desiccant air conditioning can be driven by low grade heat sources such as solar energy and industrial waste heat.. And by use of Si solar cell covered with the hierarchically structured packaging glass exhibit enhanced conversion efficiency by 5.2% at normal incident angle of 60*. And the nano-structured surface effectively repels dust/particles. So the self-cleaning omnidirectional light-harvesting design using the hierarchical structured packaging glass is a potential universal scheme for practical solar applications.*

Key Words: *solar energy, LDAC , Si solar cell, abundant energy resource, carbon dioxide*

1. INTRODUCTION

As a kind renewable energy solar energy is paid more and more in the world. Solar system can be classified into two categories; those are thermal systems which convert solar energy to thermal energy and photovoltaic systems which convert solar energy to electrical energy. However more solar radiation which falling on photovoltaic cells is not converted to electricity, but either reflected or converted to thermal energy. This method leads to a drop of electricity conversion efficiency due to an increase in photovoltaic cells working temperature[1].

In the past century, scientific community has devoted much effort to procure energy sustainability of housing in two main direction; those are reducing external energy supply and using renewable energy for the remaining. In both ways, solar resources are gaining popularity because they increase energy independence and sustainability at the same time offering nearly zero impact to the environment [1].

The earth's surface receives a daily solar dose of 10E+8KW-hr, which is equivalent to 500,000 billion oil barrels that is one thousand times any oil reserve known to man. And the solar energy is collector area dependent, and is a diluted form of energy and is available for only a fraction of the day[6]. A lot of research is being conducted 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 of cooling is required. But the today's energy sources as shown in Fig. (1.1)

1.1 Renewable Energy

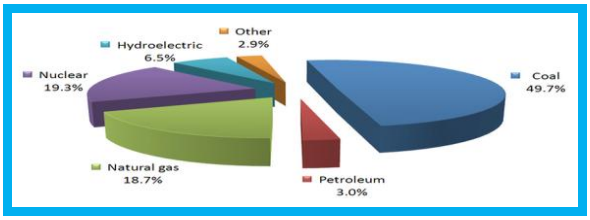


Fig.1.1 Today's Energy Sources

Renewable Energy considers the primary energy from recurring and non-depleting indigenous resources. The reference scenario is projecting the world primary energy demand expands by almost 60% from 2002 to 2030, and the average annual increase percentage is 1.7% per year. The demand will be reaching 16.5 billion tons of oil equivalents compared to 10.3 billion toes in 2002. There is the projected rate of growth, but it is slower than over the past three decades when it grew by 2% per year [3] .

On the other hand, the fossil fuels will keep monopolizing the global energy use. They will take up around 85% of the increase in world primary demand over 2002–2030. Furthermore, the share in total demand will increase slightly from 80% in 2002 to 82% in 2030. The share of renewable energy sources will remain the same which is at around 14% while the nuclear power will drop from 7% to 5%[3] .

Hence, the negative effects of fossil fuel combustion on the environment with limited stock can force many countries seeking environmentally friendly alternatives to sustain the increasing energy demand. In this condition, the improvement in the quality of life is raising with the indigenous energy resources. The growth of scarcity in fossil fuels has raised the global interest in the harnessing of solar energy[3].

Solar power is a renewable energy while currently covering and assisting in merely a small portion of global energy demands. However, Photovoltaic (PV) power generates less than 1% of total electricity supplies since solar power has been considered as one of the most expensive sources of renewable energies [3].

1.2 Renewable Energy & Industry

On the other hand, the need for cleaner alternative energy resources seeks various economy opportunities, especially the solar energy and biomass industry. Correspondingly, Malaysia introduced the solar (PV) and Feed-in Tariff (FiT) grid system on 1st December 2011 as represented in Fig. (1.2)[3].

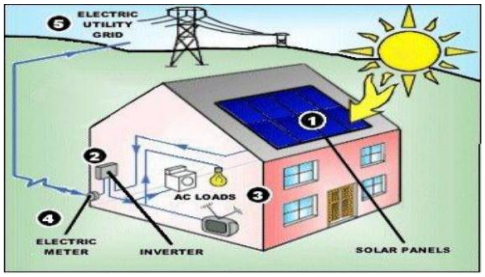


Fig.1.2 Solar (PV) Grid System And The Solar Panel Attach To Roof of Building [3]

1.3 Utilization of Air Conditioning

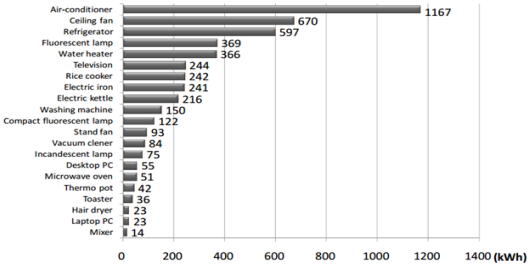


Fig.1.3 Yearly of the Consumption Electricity Adapted From [3]

At present, air conditioning is generally performed through a common electronic device applies into various buildings. And air conditioning plays an important role towards achieving a comfort level in terms of thermal sensations. And the above Fig.(3) shows the distribution of electricity consumption among general appliances while highlighting the air conditioners as the top ranked[3].

2. LITERATURE REVIEW

Ravi Gugulothu et. al., present that today the human society is facing problem is energy and they say that can be overcome by use of abundant energy sources available to us is solar energy and the demand for energy will be double or triple in coming year around 2050. The more use of electricity and CO_2 emission is major problem for the country's and due to this the global warming and environmental pollution take place. Due to the vapour compression air conditioning system also have impact on stratospheric ozone depletion because of the chlorofluorocarbon and hydro fluorocarbon refrigerants and the efficient technology to use is liquid desiccant air conditioning system and environmental friendly to cool indoor environment of building [1].

Khaled S. Al Qdah, purposed to study the design and performance of the system in AlMadinah AlMunawwarah to cool the indoor environment by solar air conditioning system because the temperature in summer is around 42°C , so the air conditioning system is almost every building of Saudi Arabia. And the coefficient of performance varies from

2.16 to 4.22 for the system and the result compare with conventional is better[2].

Edlas Khor Jiunn Hao et. al., they made the comparison between the solar and conventional air conditioning systems and say that the greatest use of electrical energy is contemporary energy crisis. They also focuses on Limkokwing University campus, and made a use of solar energy for running an air conditioning system in the campus, save the energy for sustainable promotions also calculation applied to estimate the save electricity, by the payback of investment is in accordance. And because of this saving of energy is done so reduction in the greenhouse gas is possible. The study represent the difference between the air conditioner and solar air conditioner regarding the energy saved, the final outcome is toward saving cost and environmental friendly [3].

A. vaidyanathan, present that India receives solar radiation to more than 5,000 Trillion KWh/year, which is more than its total annual energy requirement. Among solar photovoltaic technologies, there are some devices/system such as solar lanterns, solar home system, solar street lights, solar pumps, solar power packs, roof top solar photovoltaic systems etc. By using of solar energy we can reduce burden of conventional fuels. So this concept can use electrical equipment in both rural and urban area. The commercial building uses excess electricity for air conditioning system i.e. nearly 60% and 20% for lighting, 5% for ventilation fans and finally 20% for remaining equipment[5].

3. METHOD AND MATERIALS

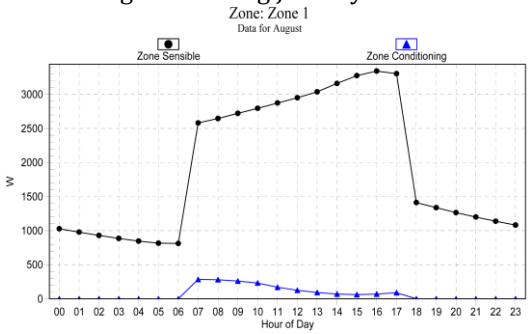
Many tools are available for sizing the PV system with battery storage. The steps below summarize the methodology for this investigation[2].

3.1. Collection of the required meteorological data

Such as design temperatures, humidity, tilt angle, daily and annual values of solar radiation for the site and the number of working hours. The space that has been chosen to be cooled in this work is the office room with 4 × 4× 3 m used by faculty member located inside AlMadinah and the first step to size the air conditioner is the cooling load estimation for this selected space[2].

3.2. Cooling load calculation

Cooling load includes what kind of cooling and how much of cooling needed. The space that will be cooled in this work for eight working hours a day located near AlMadinah city. Hourly analysis program (HAP) used, this program calculating the cooling load for any location. First of all the site must be specified as well design inside and outside design temperature and relative humidity, thickness and type of insulation materials used and the building structure. The design temperature used are 45˚C as a maximum temperature during summer and the comfort temperature or the inside temperature is 23˚C and the relative humidity of 50%. Finally the output of the program will be displayed for each month. Fig.(3.1) displays the maximum and minimum cooling load for this space. It was found that the maximum cooling load during August it is about 3.4 kW where as the minimum cooling load during January 2.4 kW [2].



Graph.3.1 Maximum cooling load during August[2]

3.3. Design of the air conditioning system

Based on cooling load calculations, the air conditioning unit has been selected with the following specification: unit capacity 3.52 KW or 1 ton refrigeration (1 TR) split unit, 220v, input power 1.250 - 1.374 KW to provide the suitable COP [2].

3.4. PV system sizing and material selection

Based on air conditioning unit capacity that has been selected under almadinah climatic conditions and the data collected, where the intensity of solar radiation about 7.5 kwh/m2, the PV solar-powered system specifications can be selected and design.

A photovoltaic system is an array of components designed to supply usable electric power for a variety of purposes. The sun delvers its energy to us in two main forms, heat and light. There are two main types of solar power systems, namely, solar thermal systems that convert heat to electricity, and solar PV systems that convert sunlight directly into usable direct current (DC) electricity. One or more DC to alternating current (AC) power converters which called inverters. PV cells are made from layers of semi-conducting material, usually silicon [2].

When light shines on the cell it creates an electric field across the layers. The stronger the sunshine, the more electricity is produced. Groups of cells are mounted together in panels or modules that can be mounted on your roof . The peak sun hour is essential in order to know the number of PV modules to be installed. Before doing so, the power that can be assumed generated by the PV modules must be determined based on solar irradiance of the location [2].

The function of charger is to regulate the voltage and current coming from the solar panel going to the battery. The battery is the key components in PV-SA systems as it act as energy back-up for the renewable energy systems. It also functions as storage devices for storing PV generated electricity during cloudy days and at night. In order to apply this system in AC load, the inverter is needed to convert the DC electricity generated by the PV panel into AC. The AC load is a common type of load and easily available with cheaper in price[2].

As we mentioned previously, the purpose of charge controller is to regulate the current from the PV module to prevent the batteries from overcharging. A charge controller is used to sense when the batteries are fully charged and to stop, or decrease, the amount of current flowing to the battery. The solar energy is received by the PV module and transform into electrical energy. The electrical energy is then being regulated by charge controller either by supplies it directly into the load or charges the batteries. As the electrical energy coming from the PV module is in DC, inverter will convert it into AC as the compressor needs AC to operate. The electricity provided by the panel array and battery is DC at a fixed voltage. The voltage provided might not match what is required by the load. A direct/alternating (DC/AC) converter, known as inverter, converts the DC current from batteries into AC[2].

Fig.3.1 Actual system cycle[2]

3.5. PV Installation and Tilt Angle Selection

In order to make the system work efficiently, the inclination angle for the panels (Tilt angle) should be carefully selected. The optimum tilt varied from month to another and the collected solar energy depends on the optimum panel tilt for each month. It was found that the average optimum tilt angle at Madinah for the winter months is37˚ and for the summer months is 12˚. So, the yearly average tilt panel is 23.5˚ which nearly corresponding to the latitude of Madinah site 24.5˚

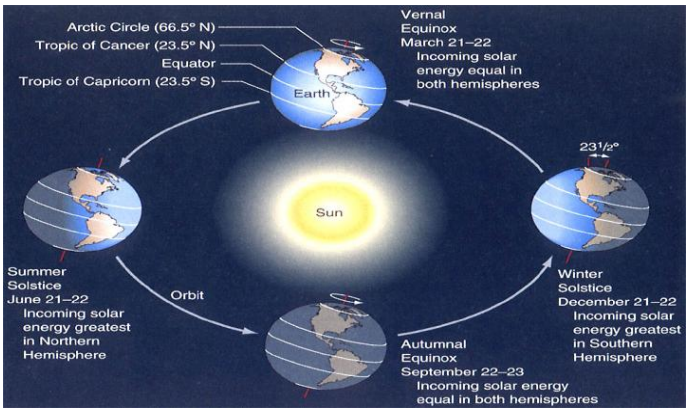


Fig.3.2 Position of earth and sun

3.6. PV System Installation and Connections

After the material selection for PV panels, batteries, charge controller and inverter then using suitable basement, cabinets to protect the system, the frame for the panels designed at an optimum tilt angle, the system installed with the help of technical as shown in fig. which explain the actual final cycle that includes the air conditioning unit and power supply system that can be used at any time; the system has been tested for 8 hours per day with a full capacity [2].

4. SOLAR CELLS

The heart of photovoltaic system is a solid state devices is called as solar cell.
And the photovoltaic (PV) is the field of technology and research related to the application of solar cell for energy by converting sunlight directly into electricity.

4.1. Type of solar cells

- **Silicon Solar Cells:**
  Single Crystal Si Cells: Commonly used. Usual efficiency of 20%.Long lifetime (>20 yrs). Approaching the theoretical limit of 29%. Cost of production $2.48/watt.
  Poly Crystal Si Cells: Less expensive. Efficiency is usually less than 15%.
  Amorphous thin film Si Cell: thin non-crystalline Si layers are printed on a substrate. Light weight and less expensive. Efficiency around 10%.
- **Cadmium Telluride Thin Film Cells**
  Inexpensive to produce; US$1/watt reported. Best efficiency reported is 16.5%.Popular for solar panel arrays.
- **Copper Indium Gallium Selenide Thin Film Cell:**
  Efficiency around 20% . Manufacturing costs are higher that amorphous Si thin film cells, but dropping fast.

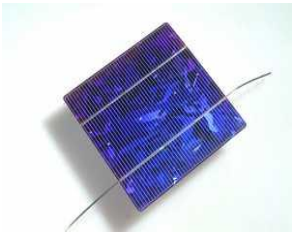


Fig.4.1 Polycrystalline Si Cell

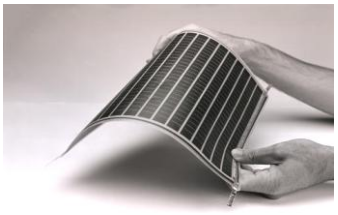


Fig.4.2 Thin Film Cell

- **Gallium Arsenide Multi junction Cells:**
  Maximum reported efficiency of 42.4%.Much more expensive to produce. Limited to scientific and high cost commercial usage.

4.2. Solar module

Fig.4.3 Solar Module

Group of PV cells are electrically configured into modules and arrays which can be use to charge batteries, operate motors, and to power any number of electrical loads.

5. ADVANTAGES

- Abundant, Constant and Perennial Supply
- Free, hence no fuel cost
- Clean and Green that is no emission of CO2,SO_x, NO_x, etc.
- 1 unit of solar energy saves 3.3 liters of fresh water and 1 kg of CO2.
- Can be generated at the point of consumption
- Low T&D losses

6. FACTORS AFFECTING SOLAR ENERGY

6.1. Factors Governing availability of solar energy on the earth

- Earth sun distance
- Tilt of the earth's axis
- Atmospheric Attenuation

6.2. Factors Affecting Solar Energy availability on a Collector Surface

- Geographic location
- Site location of collector
- Collector orientation and tilt
- Time of day
- Time of year
- Atmospheric conditions
- Type of collector

3. CONCLUSIONS

It is observed that today the human society facing problem is energy. And by using solar energy we will save our environment from greenhouse gases and keep our environment clean and green for coming generation. So using of the electrical equipment like air conditioner, fans, etc, for our comfort by using fossil fuel like coal, petrol and natural gas which form CO_2 after burning of this fuel. Many place were solar energy can be use and government also giving a good policy for solar energy user and it also have long life, investment cost can be recovered within 4-5 year of span .Today every modern I.T building using air conditioning system for comfort in indoor environment.

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