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Thermal Analysis and Cost Estimation Of Solar Glazing And Unglazing Roof Top System

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ABSTRACT:-*Photovoltaic-thermal collectors combine photovoltaic modules and solar thermal collectors, forming a single device that receives solar radiation and produces electricity and heat simultaneously. PV-Thermal collectors can produce more energy per unit surface area than side-by-side PV modules and solar thermal collectors. Depending on the existence of glass cover over PV module: glass-covered (glazed)PV-Thermal collectors, which produce relatively more thermal energy but have lower electrical yield, and uncovered (unglazed) PV-Thermal collectors, which have relatively lower thermal energy with somewhat higher electrical performance. Research is towards the analysis of such systems so as to deliver higher energy savings and to improve the cost effectiveness. Therefore the aim of the present project is go in the thermal analysis of PV-T glazed and unglazed Roof Top System.*

Key words: *Thermal networking, energy saving, finding the temperatures of each node of system, reduction of model*

I. INTRODUCTION

Generally Solar roof is the roof of house or any commercial building that is covered with an array of solar panels. Solar Photovoltaic- thermal is an solar system that combine both solar photovoltaic and solar thermal. Typically two forms of solar energy is collected through separate panels, but with solar PV-T only one panel is used, Sopian[1]. There are some reasons to use PV-T collectors instead of PV collectors in building envelope integrated application. Overheating of PV panel results in loss one is the protection- reduction and elimination of excessive thermal load of photovoltaic cells lamination and protection from accelerated degradation. Second one is the Increasing of electricity production by keeping the photovoltaic cell at considerably lower operation temperature during a whole year and third one is the higher specific energy gain from 1m2 of building envelope compared to separate installation of photovoltaic and PV-T collectors, if low potential heat is usable in technical system of the building,Ibrahim[2]. Solar PV-T is normally made with crystal silicon cells which generating electricity, but little heat. Stephan Harrison Joshua Pearce (Mechanical, Material Engineering) Designed and tested amorphous silicon cell in PV-T system. Their research shows increase heat generating because of higher operating temperature and 10% more solar electric output, amorphous silicon had several advantages over crystal silicon, Santberge[3]. One it requires less material. Cost is less to manufacture and offers higher return on investment. The amorphous silicon solar cell on be made into thickness cell as long as they are operated at higher temperature in PV-T system. For the air-based PV/T technology which is mostly diffused in the present market, the overall system efficiencies thermal and PV varies from 20 to 40% and sometimes more. The PV efficiency for the case of crystalline silicon cells has been seen as 10-12% and rest contributes to thermal efficiency. In a PV/T system, the heat drawn by the fluid also helps to reduce the temperature of the solar cells increasing their efficiency, Belusko[4]. The flowing air reduces the cell. Temperature up to 10 °C from the maximum achievable. It allows an increase of about the 5% of the PV efficiency. The long-term goal is to be realized that the PV/T systems that produces electrical as well as thermal energy at a sufficiently low cost.

Glazed collector has a glass covering, and it is made from copper tubing on an aluminium plates and has an iron tempered glass covers and its temperature ranges from 40 to 93°C compared to unglazed collector more expansive. Unglazed means don't have any glass covering, generally made of heavy duct rubber or plastic treated with an ultraviolet light inhibiter to extend the life of the system, the temperature ranges from 34 to 43°C. Glazed is cheap parts and easy to design, less expensive than glazed collector. Thus it is the objective of this project is to go for the simulation of glazed and unglazed solar roof top system.

II. OBJECTIVE OF THE WORK

The purpose of this present work is to compare the three types of roof 1) Conventional roof,2) roof with photovoltaic-thermal glazed (PV/T), 3)roof with photovoltaic thermal unglazed (PV/T) and to calculate the performance of each type of roof by using HAP Software. As we know the efficiency of the collector decreases with the increase in the temperature, therefore this heat is needed to removed from thecollector. This heat can be used for low temperature applications such as drying etc. The objective of this thesis is to estimate the electrical consumption in a office of 960 m^2 area for each system and conclude which system consumes less energy. Also the carbon-dioxide emissions are analyzed in this thesis.

III. METHODOLOGY

System considered:

Fig.1 & Fig.2 shows the cross-sectional view of the glazed and unglazed photovoltaic-thermal roof top system respectively. Glazed system has a glass covering whereas Unglazed do not have it. Solar radiation directly enters into the PV-T collector through glass and falls on photovoltaic cell. Generally the photovoltaic-thermal is made up of crystalline silicon. The photovoltaic pane absorbs the solar light intensity falling over it and converts into electricity. Normally, the temperature of the solar PV increases which degrades the cell and thereby efficiency of the solar PV decreases. To avoid this, atmospheric air is made to pass through natural convection in the air gap formed between the Solar PV pane and the conventional roof. The heated air is used for low thermal applications like drying applications and room heating during winter climates.

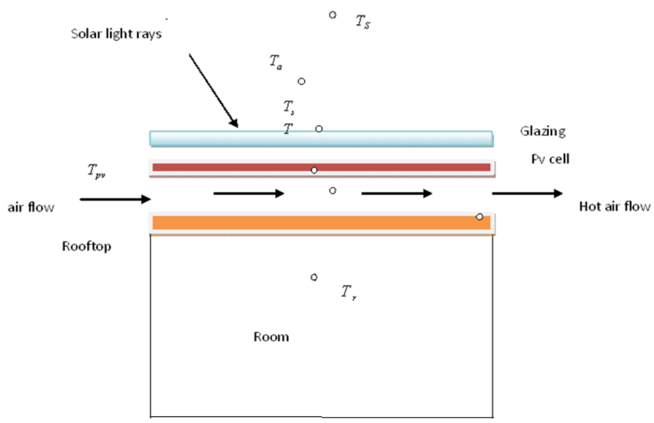

Fig.1. System I: Building Integrated Glazed PV-T Roof Top System

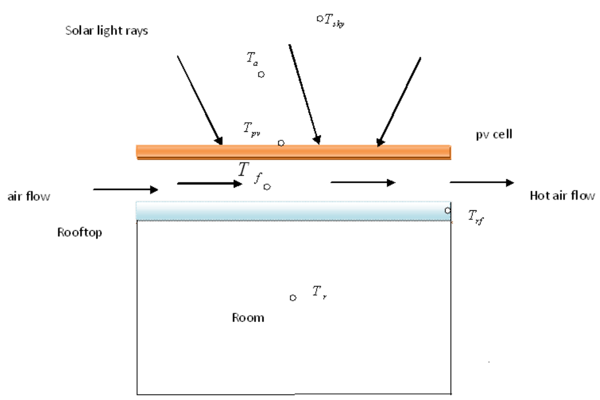

Fig 2. System II: Building Integrated Unglazed PV-T Roof Top System

IV. THERMAL NETWORKING

Fig. 3 & Fig. 4 shows the thermal network diagrams drawn for glazed and unglazed system respectively

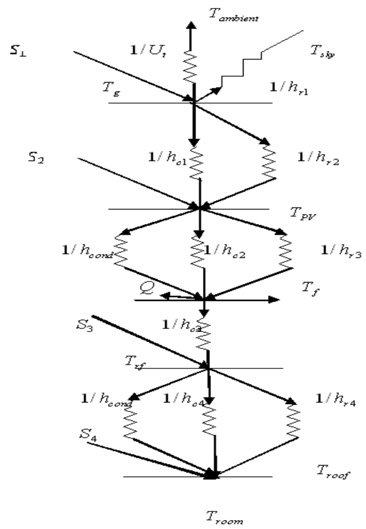

Fig 3 .Thermal Network diagram: System I

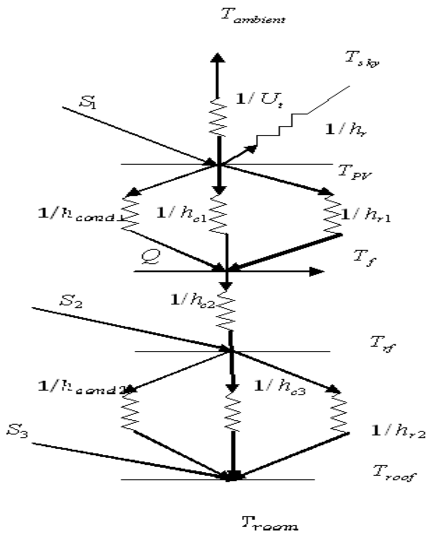

Fig.4. Thermal Network diagram: System II

V. ENERGY BALANCE EQUATIONS AT VARIOUS NODES

5.1 For Glazed

Node 1: At glazing

$$S_1 = U_t[T_g - T_a] + h_r[T_g - T_{sky}] + h_r[T_{pv} - T_g] + h_c[T_{pv} - T_g]$$

Node 2: At solar PV panel

$$S_2 = h_{cond}[T_f - T_{pv}] + h_{conv}[T_f - T_{pv}] - h_r[T_{pv} - T_g] + h_r[T_f - T_{pv}] - h_{conv}[T_{pv} - T_g] - E$$

Node 3: At fluid

$$Q = h_{conv}[T_{pv} - T_f] + h_r[T_{pv} - T_f] - h_{cond}[T_{pv} - T_f] + h_{conv}[T_f - T_{rf}]$$

Node 4: At roof

$$S_3 = h_r[T_{rf} - T_{room}] + h_{cond}[T_{rf} - T_{room}] + h_{conv}[T_{rf} - T_{room}] - h_{conv}[T_f - T_{rf}]$$

Node 5: At room

$$S_4 = h_{conv}[T_{rf} - T_{room}] + h_r[T_{rf} - T_{room}] + h_{cond}[T_{rf} - T_{room}]$$

5.2 For Unglazed

Node 1: At solar PV panel

$$S_1 = U_t[T_{pv} - T_a] + h_r[T_{pv} - T_{sky}] + h_r[T_f - T_{pv}] + h_{conv}[T_f - T_{pv}] + h_{cond}[T_{pv} - T_f] - E$$

Node 2: At Fluid

$$Q = h_{conv}[T_{pv} - T_f] + h_r[T_{pv} - T_f] + h_{cond}[T_{pv} - T_f] - h_{conv}[T_f - T_{rf}]$$

Node 3: At roof

$$S_2 = h_r[T_{rf} - T_{room}] + h_{cond}[T_{rf} - T_{room}] - h_{conv}[T_f - T_{rf}] + h_{conv}[T_{rf} - T_{room}]$$

Node 4: At room

$$S_3 = h_{conv}[T_{rf} - T_{room}] + h_r[T_{rf} - T_{room}] + h_{cond}[T_{rf} - T_{room}]$$

$$E = G_{pv}\eta_o \ [1 - 0.005(P_{pv} - 25)]$$

VI. PERFORMANCE ANALYSIS

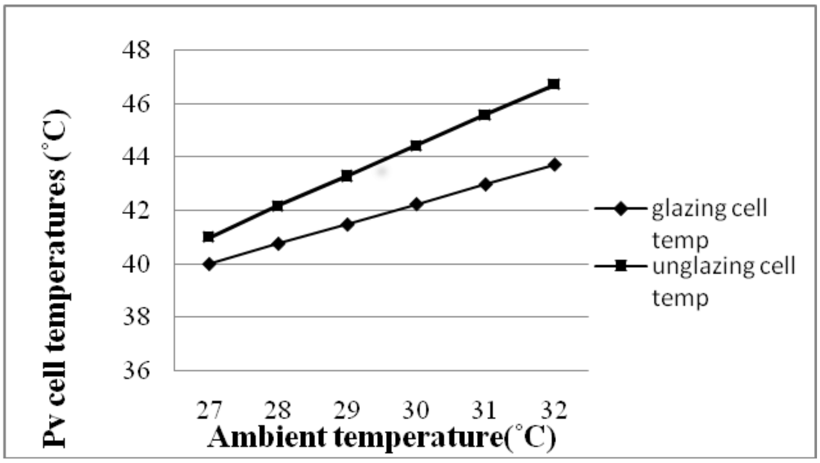

Fig.5. Solar radiation Vs pv cell temperatures

Fig 5. Shows The ambient temperature with respect to glzing and unglazing photovoltaic cell temperature. From the graph seen that the ambient temperature increases with respect to photovoltaic cell temperature, as well as time, due to radiations.

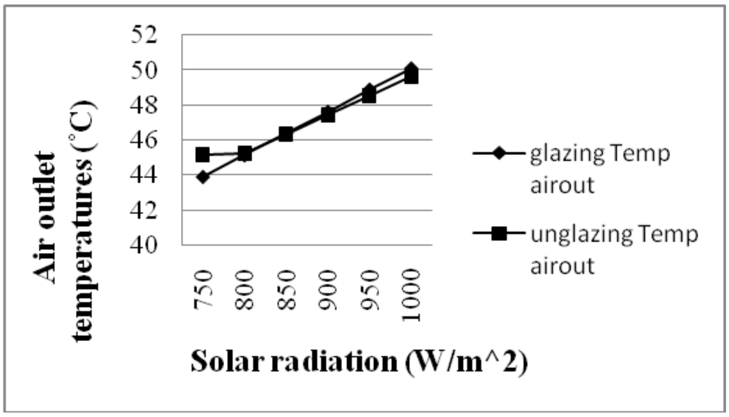

Fig.6. Solar radiation Vs outlet air temperature

Fig 6. Shows Solar radiation with respect to glazing and unglazing outlet air temperatures. From the graph Solar radiation increases out air temperatures increases, due to radiations. The air absorbs the heat when air passing underneath of photovoltaic cell.

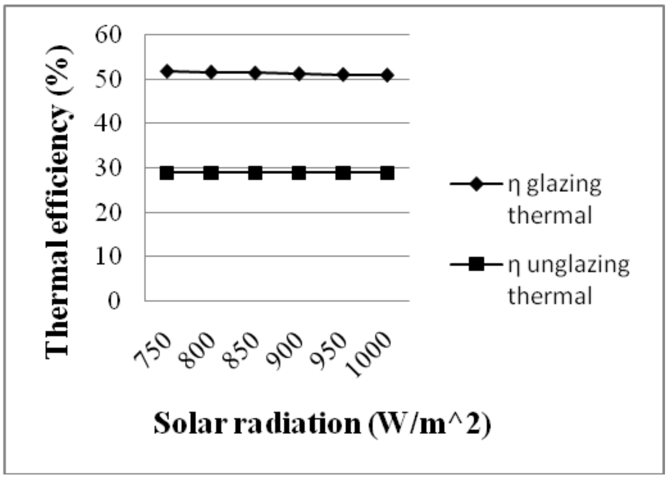

Fig.7. Solar radiation Vs thermal efficiency

Fig 7 Shows Solar radiation with respect to glazing and unglazing thermal efficiency. From the graph Solar radiation decrease thermal efficiency will decrease due low radiation; low radiation electrical efficiency will be increase.

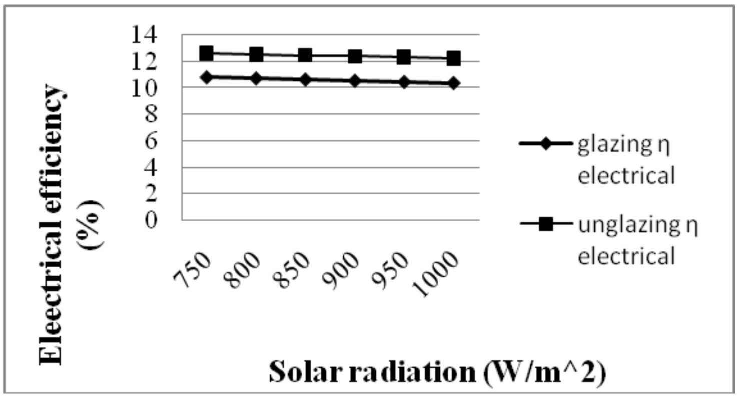

Fig.8. Solar radiation Vs electrical efficiency

Fig 8. Shows Solar radiation with respect to glazing and unglazing electrical efficiency. From the graph solar radiation decrease the electrical efficiency increase due to low radiation and air passing underneath of photovoltaic cell to reduce the photovoltaic cell temperature, to increase the electrical efficiency. Compared to glazing, unglazing electrical efficiency is high.

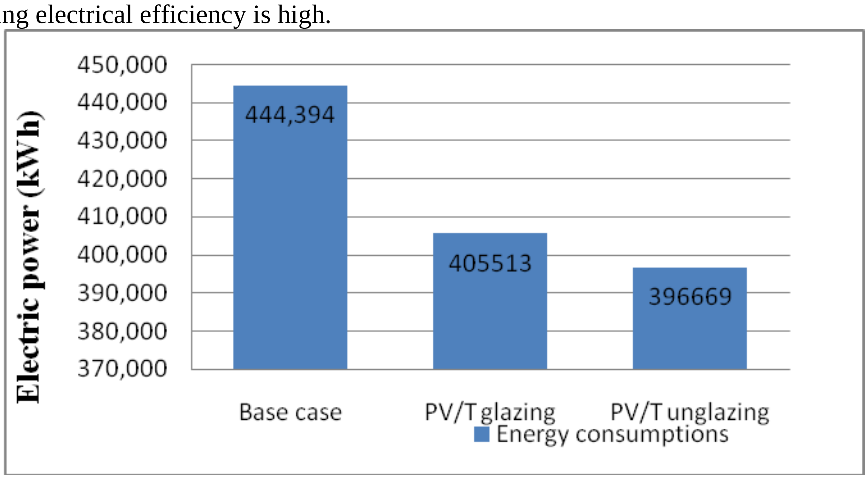

Fig 9. Energy consumption

As for the energy consumption graphs shown in Fig 5. PV/T unglazed is consuming less electric energy then PV/T glazing and base case (2.1% and 10.74% respectively)

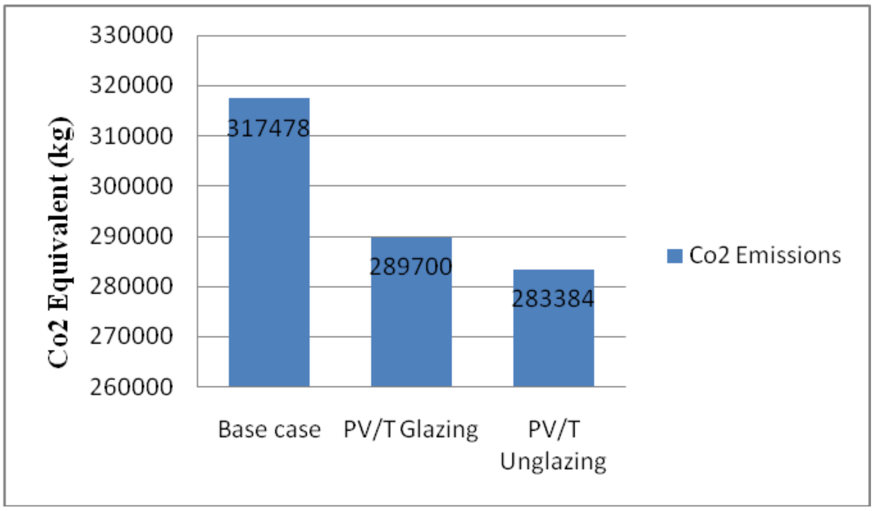

Figure 10. Annual CO_2 Emissions

As for the CO_2 emission graphs shown in fig 10., PV/T unglazed is consuming less Co2 equivalent (kg) then PV/T glazing and base case(2.1% and 10.74% 47 respectively)

$$P_{NPV} = P_i + R_m * \left(\frac{(1+i)^n - 1}{i * (i+1)^n}\right) + R_p * \left(\frac{1}{(1+i)^n}\right) - S * \left(\frac{1}{(1+i)^n}\right)$$

$$n_p = [\ln(\frac{CF}{CF - (i * P_{NPV})})]/\ln(1+i)$$

Initial investment

Cash Flow (CF)

Net present value(N_{PV})

Pay Back Period (n_p)

VII. CONCLUSION

From the analysis made it is seen that the thermal and electrical performance of the Glazed PVT roof top system is higher than that of the unglazed roof top system. This result in lowering the load of the electricity bill compared with base case resulting in reduction in CO_2 emission per annum.

On the basis of the present analysis, the following conclusions is common for both the systems

- While increasing the inlet air temperature, the overall energy efficiency and thermal efficiency of the system decreases.
- While increasing the air inlet velocity, it was found that the overall energy efficiency and thermal efficiency of the systems increase.

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