# ECONOMIC AND EMISSION ANALYSIS OF PV SYSTEM,SOLAR THERMAL SYSTEM, HYBRID SYSTEMS FOR RURAL ROW HOUSES

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## *ABSTRACT*

The Emission and Economic analysis is undertaken to prove that Hybrid PV/Solar-Thermal (PVT) systems is optimized for distributing electricity and hot-water for rural row houses. For this study, Kallipatti village in Coimbatore District is chosen. The Rural Row Houses load capacity is 3KW and 700 liters of hot water is required daily. The emission and economic analysis was carried out for Conventional system, Photovoltaic (PV) system, Solar Thermal System and Hybrid PV and Solar-Thermal(PVT) system individually. From the Emission analysis, the PVT system has less carbon dioxide emission when compared to other systems. The Economic analysis shows that Photovoltaic(PV) System is less cost. But for generating both electricity and hot water, hybrid PV/solar-thermal (PVT) system is optimal when compared with installing Photovoltaic (PV) system for electricity and Solar-Thermal (PVT) system for hot water. The simulation is carried out by using MATLAB

*Keywords— Energy consumption in buildings,Distributed generation, Hybrid systems, MATLAB*

## I. INTRODUCTION

In Photovoltaic panel, the absorbed solar radiation that is converted into electricity increases the temperature of photovoltaic, leading to a reduction of their electrical efficiency. Therefore, PV cooling is needed to maximize electrical efficiency at a satisfactory level and it can be achieved by water or air heat extraction. Method to remove heat from PV modules are natural or forced air circulation is a low-cost method to get rid of heat from PV modules, but it is less effective at low latitudes where the ambient air temperature is over 20 $^{o}$C for many months during the year. Water heat extraction is more lavish than air heat extraction, but it can work adequately as the water temperature from mains is lower than 20 $^{o}$C almost all year. If the heat removal fluid is used not only for PV cooling, but also for other practical applications, hybrid photovoltaic/thermal (PVT) solar system will be obtained [1, 2].

To convert solar radiation to electricity and heat simultaneously, PV modules and thermal units are seated together in this system.PVT systems provide a fears an innovative approach when it comes to providing energy to buildings. It focuses on both the thermal and electrical elements unlike most studies in which the thermal part plays a secondary role, with little regard to its effects on the performance of the system [5, 6]. Many surveys have been developed on PV, solar thermal and wind technologies, but comparatively few on their integration with cogeneration systems: hybrid systems, where all these technologies are combined with the idea of improving energy efficiency [7]. In addition, analysis of the Life Cycle Costs and emissions are calculated for conventional, PV, Solar Thermal system and hybrid photovoltaic/thermal (PVT) solar system to prove that (PVT) system is optimal system. For analysis, Kallipatti village in Coimbatore District is chosen. Seven Row houses are chosen according to the survey in Kallipatti village and consumption readings obtained from TANGEDCO [8, 9].

## II. BLOCK DIAGRAM

### *A. BLOCK DIAGRAM FOR PV SYSTEM*

higher energy output than standard PV modules and can be cost effective if the additional cost of the thermal unit is low. In the recent years, the concept of energy efficiency has been receiving widespread attention due to the realization that fossil fuel resources required for energy generation are limited and that climate change is related to carbon emissions. These have encouraged a tremendous amount of studies with different approaches related to the implementation of technologies capable of generating energy in a more efficient way and abate its environmental impact. These studies include the use of technologies such as Hybrid PV and Solar-Thermal (PVT) system which are able to produce electricity and thermal energy from the same source [3].

The power production process is more efficient, polluting emissions are diminished; there are fewer losses in the distribution network. The safety and aspect of the supplied energy is increased [4]. This paper of

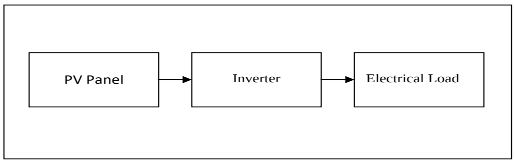


Fig.1. Block Diagram of PV System

### *B. BLOCK DIAGRAM FOR SOLAR THERMAL SYSTEM*

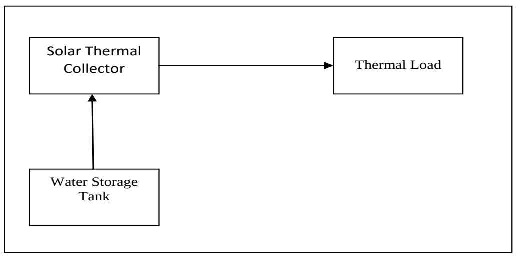


Fig.2. Block Diagram of Solar Thermal System

*C. BLOCK DIAGRAM FOR HYBRID PVT SYSTEM*

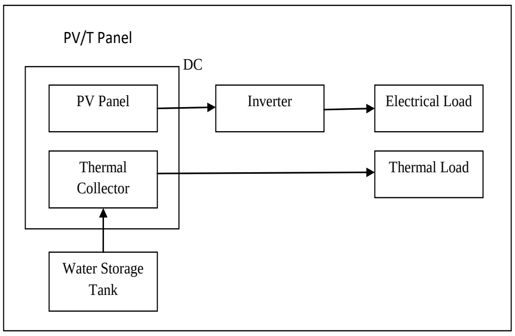


Fig.3. Block Diagram of Hybrid PVT System

## III. METHODOLOGY

*A. Building*

For this analysis, Kallipatti village in Coimbatore District are chosen. Seven Row houses is chose according to the survey in Kallipatti village and consumption readings obtained from TANGEDCO [10].

*B. Building energy needs*

Seven Row houses have following load capacity

House1 load L1 = 0.2KW,
House2 load L2 = 0.99KW,
House3 load L3 = 0.3KW,
House4 load L4 = 0.32KW,
House5 load L5 = 0.61KW,
House6 load L6 = 0.3KW,
House7 load L7 = 0.28KW.

Therefore, the total electrical load capacity for seven houses is 3KW.

Each house has 4 members. Each house needs 100 liters of water for 4 members daily and hence for seven houses totally 700 liters are needed daily. The following table shows that the power consumption of houses over a year [11, 12].

Table.1. Power Consumption of Houses

| Month | Load1 (kW) | Load2 (kW) | Load3 (kW) | Load4 (kW) | Load5 (kW) | Load6 (kW) | Load7 (kW) | Total Power (kW) |
|---|---|---|---|---|---|---|---|---|
| May-June | 80 | 140 | 110 | 150 | 170 | 180 | 30 | 860 |
| July-Aug | 70 | 60 | 70 | 90 | 120 | 140 | 20 | 570 |
| Sept-Oct | 60 | 110 | 70 | 110 | 100 | 140 | 20 | 610 |
| Nov-Dec | 70 | 90 | 90 | 100 | 100 | 210 | 30 | 690 |
| Jan-Feb | 80 | 40 | 190 | 130 | 130 | 200 | 20 | 790 |
| Mar-April | 80 | 20 | 100 | 130 | 130 | 190 | 30 | 680 |

*C. Analysis and Protocol*

For analysis, Emissions of $CO_2$ and Life Cycle cost are calculated. These parameters are individually calculated for PV system, Solar Thermal system, hybrid PV/Thermal systems (PVT) and conventional system. From results PVT is chosen best. The simulation for PVT is carried out using MATLAB.

## IV. ECONOMIC AND EMISSION ANALYSIS

*A. $CO_2$ Emission for conventional System*

For Conventional system, Grid connected electrical loads and thermal loads are used. The formula for grid connected load is Emission (g $CO_2$/kW)= Power consumed (kW)

*Emission (g $CO_2$/kW) (1)

For conventional system, power consumed is taken Table 1.

Emission for grid connected load if coal is used for generation of power, 975 g$CO_2$/kW. The formula for thermal load is

Emission=Energy in wood (kW)*Emission of wood (g$CO_2$/kWh) (g $CO_2$/kW) (2)

Energy in wood (J) = 4.18(J)*(Litres of water) (100℃-normal temperature of water) (3)

1 Joule of energy is 2.7 e^ (-7) kW

Where

Litres of water=700 litre
Normal temperature of water=25°C
Emission of wood = 390 g$CO_2$/kWh

The following table shows the emission of $CO_2$ for conventional system.

Table.2. $CO_2$ Emission for Conventional System

| Month | For electrical load (conventional) (g $CO_2$/kW) | Thermal load (g $CO_2$/kW) | Total $CO_2$ emission (g $CO_2$/kW) |
|---|---|---|---|
| May-June | 838500 | 1426.42 | 839926.4 |
| July-Aug | 555750 | 1426.42 | 557176.4 |
| Sept-Oct | 594750 | 1426.42 | 596176.4 |
| Nov-Dec | 672750 | 1426.42 | 674176.4 |
| Jan-Feb | 770250 | 1426.42 | 771676.4 |
| Mar-April | 663000 | 1426.42 | 664426.4 |

*B. $CO_2$ EMISSION FOR PV SYSTEM*

For $CO_2$ emission for PV system, power consumed is taken from the Table 1 and emission is calculated by using formula (1). The Emission of PV panel is 50g of $CO_2$ per kW

And for thermal load, $CO_2$ emission is 1426.42 g/kW [13].

Table.3. $CO_2$ emission of PV system

| Month | For electrical load (PV) (g/kW) | Thermal load (g/kW) | Total $CO_2$ emission (g/kW) |
|---|---|---|---|
| May-June | 43000 | 1426.42 | 44426.42 |
| July-Aug | 28500 | 1426.42 | 29926.42 |
| Sept-Oct | 30500 | 1426.42 | 31926.42 |
| Nov-Dec | 34500 | 1426.42 | 35926.42 |
| Jan-Feb | 39500 | 1426.42 | 40926.42 |
| Mar-April | 34000 | 1426.42 | 35426.42 |

*C. $CO_2$ EMISSION FOR SOLAR THERMAL SYSTEM*

For solar thermal system it consists of Solar Water heater for Hot water production. For Seven Houses, 700 liters of hot water is needed for daily. For Electrical Load, Grid connected $CO_2$ emission is taken. For Thermal system, there is no $CO_2$ emission.

### *D. $CO_2$ EMISSION FOR HYBRID SYSTEM*

Both electrical and thermal load are supplied from hybrid system. The following table shows the $CO_2$ emission for PVT system.

Table.4: $CO_2$ emission of PVT system

| Month | For PVT system (g $CO_2$/kW) |
|---|---|
| May-June | 43000 |
| July-Aug | 28500 |
| Sept-Oct | 30500 |
| Nov-Dec | 34500 |
| Jan-Feb | 39500 |
| Mar-April | 34000 |

### *E. $CO_2$ EMISSION FROM HOUSES BY USING DIFFERENT SYSTEM*

Table.5. $CO_2$ emission of different system

| Month | For PVT (g $CO_2$/kW) | For PV (g $CO_2$/kW) | For Conventional (g $CO_2$/kW) |
|---|---|---|---|
| May-June | 43000 | 44426.42 | 839926.4 |
| July-Aug | 28500 | 29926.42 | 557176.4 |
| Sept-Oct | 30500 | 31926.42 | 596176.4 |
| Nov-Dec | 34500 | 35926.42 | 674176.4 |
| Jan-Feb | 39500 | 40926.42 | 771676.4 |
| Mar-April | 34000 | 35426.42 | 664426.4 |

### *F. EMISSION GRAPH*

The carbon dioxide emission graph between conventional, PV and PV/T is shown below.

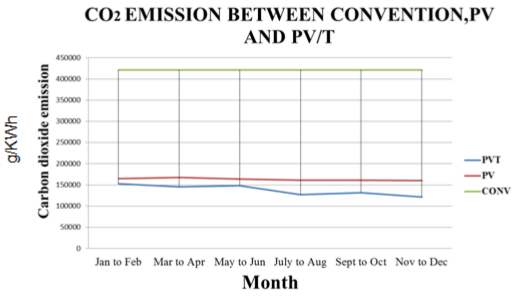


Fig.4. Emission Graph

### *G. RESULTS OF $CO_2$ EMISSION*

From graph, $CO_2$ emission of PVT is very less.

From these results, it is observed that PVT emission is less when compared to other systems[14].

## V. LIFE CYCLE COST (LCC) CALCULATION

The formula for the calculation of life cycle cost is given below

Life Cycle Cost = Initial investment + Costs replacement + (Cost operation + Cost maintenance) *

$$\sum_{t=1}^{10}(1/(1+r)^t) \qquad (4)$$

Where

t = 10 years, r = Inflation rate = 0.03

## V. LIFE CYCLE COST CALCULATION

### *A. LIFE CYCLE COST FOR CONVENTIONAL, PV, SOLAR THERMAL, PVT SYSTEMS*

For life cycle cost of conventional system thermal power station is taken. For PV system, PV panel, Inverter and battery are used. For Solar thermal system, Thermal collector and storage tank are used. For PVT system, PV panel, Inverter, Thermal collector, storage tank and battery are used [15].

The following Table shows the Life cycle cost of various systems.

Table -6" Life cycle cost of various system

| SYSTEM | Life Cycle Cost in Rupees |
|---|---|
| PVT | 1,75,008 |
| PV | 1,07,008 |
| Thermal | 1,91,008 |
| Conventional | 300,008 |

## VI. LIFE CYCLE COST GRAPH

The Graph for the Life cycle cost of Conventional, PV, Solar Thermal and Hybrid system is shown below.

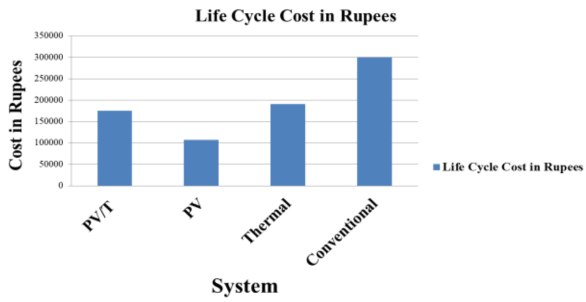


Fig. 5: Life Cycle Cost graph

From the graph, it shows that PV only seems to be better. But when lighting loads are supplied with PV and thermal Loads are supplied with solar thermal collector for row houses, the cost will be more when compared to hybrid PV/T system [16,17].

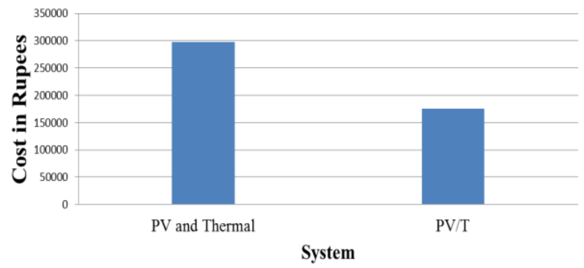


Fig. 6: LCC of PVT and PV+Thermal

## VII. SIMULATION RESULT

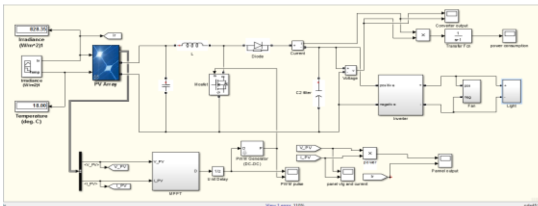

Fig.7: Simulation model of PV/T for houses

The irradiation and temperature given to the solar panel is shown below

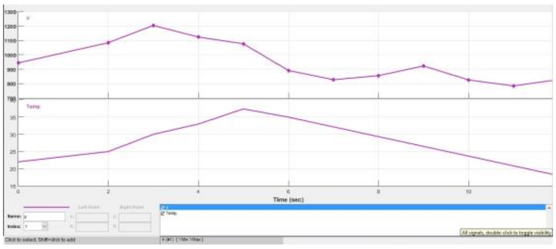

Fig.8. Irradiation and Temperature graph

The pulse from the PWM generator to the gate of the MOSFET is shown below.

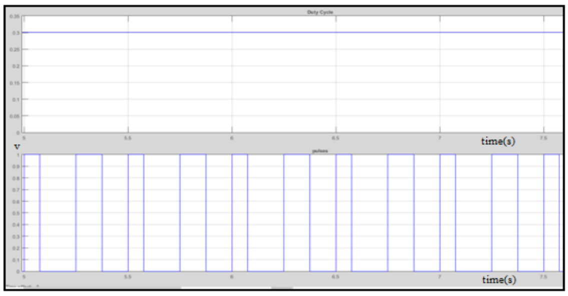


Fig.9. PWM generator to the gate of the MOSFET

The output from PV panel for a year is shown below.

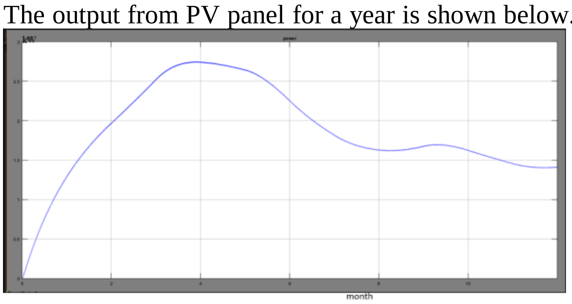


Fig.10. PV panel output

VIII. CONCLUSION

The present study has realized evidence on the long-term behavior of such systems. For the considered designs and climatic condition, calculations have been developed in order to obtain a comparison depending on the chosen criteria (Life Cycle Cost or emissions). According to the results obtained, as so for the LCC is concerned the conventional case. On the other hand, as has been seen, if properly designed hybrid systems suppose a decrease in energy consumption and emissions. PVT technology would have approximately the same payback as PV. It is concluded that, if primary energy (currently dominated by fossil fuels) and $CO_2$ emission minimization are important goals of national energy policy

IX. REFERENCE

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