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A Review on Solar PV Interfaced With Thermal Collector: The Hybrid System

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ABSTRACT

With a perspective of climate change universally, numerous technologies are under development in the field of renewable energy resources from last two to three dacades. Amongst them, the more emphasis is given to huge and free source of solar radiation. Number of advanced techniques namely automatic PV tracker, solar thermal hybrid collector, concentrated solar technology (CST), Fresnel lens are in lined in a such renewable energy sources. The main objective of doing this is to improve the performance of PV panel and to generate maximum possible energy. This is due to the reason that, photovoltaic panel exhibits certain limitations under high temperature. Its performance may degrade under such circumstances. Steps are required to be taken to reduce this high temperature of PV panel. This can be full filed by reconstructing the solar photovoltaic panels with thermal collector system. A sound design of PV/T system can extract as much as possible heat from PV laminate with heating fluid (either water or air) to reduce the operating temperature of PV and keep electrical efficiency at sufficient level. As an effect, solar radiation conversion can be obtained higher than a PV module alone. This paper includes various aspects of hybridize solar PV/T collector system such as constraints of PV module, various possible designs of hybrid systems and its benefits.

KEYWORDS: Hybrid, Concentrated, Fresnel, Laminate

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INTRODUCTION

An Energy plays most important role in the persistence of living organs. The living quality and opulence of a nation vary directly with variation in the consumption of energy. The global energy demand is increasing rapidly due to industrial growth, population growth as well as increased and extensive use of electrical gadgets. In addition, the requirement of human being does not know no confines, at present most of the nation worldwide is experiencing the problem of energy shortages. The limited availability and depleting source of traditional fosil fuels have directed towards the use of non-conventional energy sources. About 25 % of India's energy use is in form of heat for processes up to 400 °C. Different thermal processes have different temperature and pressure requirements and they may use various heat conducting media such as steam, hot water, air, and thermal oil. India is active in the sector of utilizing solar thermal energy for both domestic use and industrial process heat for over two decades and is considered to be a global leader. It has worked on unique concepts and has first-hand experience in the design, installation, and operation of the first indigenous concentrating solar power plant in MW range. Today, the world is mainly concentrating on solar PV and wind energy technologies when it comes to electrical power generation, but these cannot easily be integrated with storage, thus limiting their penetration in the power grids. Solar thermal technologies will have significant role to play in this respect. Solar irradiance is one of the most promising sources of alternative energy available at free of cost worldwide. The increasing environmental apprehensions and the swelling conventional energy supply costs are creating a resurgence of curiosity in renewable energy resources. However, with the technological development one or more of these resources could be interfaced or coupled to extract maximum efficiency and obtain power output with a single usage. One of such technology is described here called as a solar photovoltaic thermal hybrid collector. This photovoltaic thermal solar collectors, which is hybridize PV/T device that converts solar radiation into electrical energy as well as provides a thermal energy. These system combines a photovoltaic cell, which converts electromagnetic radiation (photons) into electricity, with a solar thermal collector, which captures the remaining and incident excess energy and removes waste heat from the PV module.

The capture of both electricity and heat allow this mechanism to give overall energy higher than either solar photovoltaic (PV) or solar thermal collector itself. The maximum electrical conversion efficiency of the solar photovoltaic panel is 8-18% at the standard test condition (STC) temperature of 25˚C. However, the atmospheric temperature of Indian climatic condition is mostly above 30˚C - 45˚C, it incites 30˚C-80˚C heat over the panel since black body of the PV panel observe more heat and this temperature majorly affect the electrical efficiency of the panel. This limitation can be overcame by hybridized concept. In order to increase the efficiency of the PV panel, the energy payback time (EPBT) gets reduced.[1, 2]

HYBRID PV/T: CONCEPT

Solar cell consisting of its brink photon energy with respect to the particular energy band gap. Below this range electricity conversion is not possible. Photons with higher wavelength range do not generate electron–hole pairs however it only dissipate their energy in the form of heat in their cell. Normal PV module converts 4–17% of the incoming solar radiation into electricity, depending on the type of solar cells in use and the working conditions. This concludes that, more than 50% of Solar PV panel which is made from silicon cells, exhibit few drawbacks over high solar radiation temperature. As the hour of the day is rising, higher will be the solar radiation. Ultimately it will tend to increase the surface temperature of the PV Cells. Based on research it is observed that, for monocrystalline (C-Si) and polycrystalline (Pc-Si) silicon solar cells, the efficiency decreases by about 0.45 % for every degree rise in temperature and for amorphous silicon (a-Si) cells, the effect is less, with a decrease of about 0.25% per degree rise in temperature depending on module design. This undesirable effect can be partially avoided by a proper heat extraction with a fluid (either liquid or air) circulation. Here with a hybrid photovoltaic/thermal (PV/T) solar system, the reduction of PV module temperature can be combined with useful fluid heating. Therefore, hybrid PV/T systems can simultaneously provide electrical and thermal energy achieving a higher energy conversion rate of the absorbed solar radiation. PV/T systems provide a higher energy output that standard PV modules and could be cost effective if the additional cost of the thermal unit is low. Natural or forced air circulation are simple and low cost methods to remove heat from PV modules. However for air temperature being higher than 20 ºC, it is not as much effective. Therefore to overcome this effect, the heat may be extracted by circulating low temperature fluid through a heat exchanger that is mounted at the rear surface of PV laminate.[3, 11]

THE CONSPICUOUS FEATURES OF THE PV/T SYSTEM ARE AS BELOW:

- Simple and multipurpose usage: with a single unit of system two purpose can be fulfilled i.e. electricity generation and domestic heat output.
- When coupled, PV/T system every time constitute higher efficiency as compared to single unit.
- Hybrid PV/T system provides multiple applications of heat available either for heating or cooling purpose also.
- Designing or fabrication of the overall assembly is feasible and cost of development is also not much higher.[6]

SYSTEM CONFIGURATION

A PV/T system consist of a thermal unit for extraction of heat by fluid, which is circulated through pipes or tank in contact with the flat sheet placed in a thermal contact with the rear surface of the PV laminate. Material of PV module includes c-Si, pc-Si or a-Si. Whenever a-Si modules are used, ratio of additional cost for thermal unit per PV module cost is most of doubled than any others material selection. In addition, a-Si PV module provides lower electrical efficiency irrelevant of total energy output. The fact is that, the cost of the thermal unit remains same for whatever the cost of PV module may be or whatever the material of PV module may be. Larger active system for heat extraction. Either with the use of air or water. Fig (1) gives a brief idea about hybrid system. While, fig. (2) Exhibits proper line diagram of the unit with most of the parts.

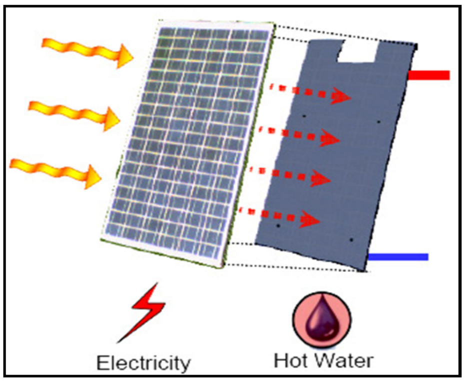

Figure1. Hybrid System Layout

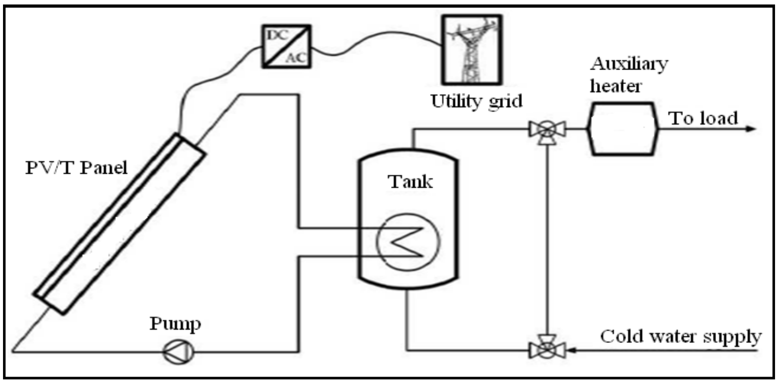

Figure2. Line Diagram of PVT System

DIFFERENT CONFIGURATION OF PV/T

The heat from PV modules can be removed in order to enhance the electrical performance of the PV module; this heat can be converted into useful thermal energy. As a result, PVT collectors can generate more solar energy per unit surface area than side by side photovoltaic modules and solar thermal collectors can.

In general, regarding water-type PVT collectors, two types can be distinguished. The first is the glazed PV/T collector, which has the advantage of heat production, and the second is the unglazed PVT collector, which produces relatively less thermal energy but shows better electrical performance than the former type (Fig. 3).Glazed PVT collectors are very similar in appearance to flat-plate solar thermal collectors, consisting of a PV-covered absorber in an insulated collector box with a glass cover. This glass-covered insulation provides high thermal efficiency with some reduction of electrical efficiency due to solar radiation reflection and the increase in the PV module temperature caused by the glass cover. Unglazed PVT collectors are more similar to regular PV panels. They consist of a PV-covered absorber with no additional glass cover. The configuration without a glass cover results in lower thermal efficiency compared to the glazed PVT collector. On the other hand, the electrical efficiency of an unglazed PVT collector is higher than that of a glazed PVT collector and is even higher than that of regular PV panels due to the PV cooling effect.[4]

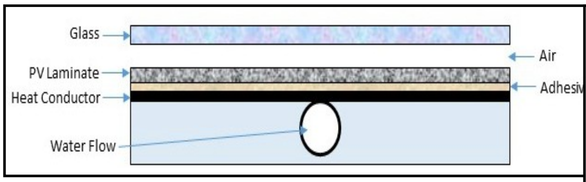

Figure3. Glazed Type Collector

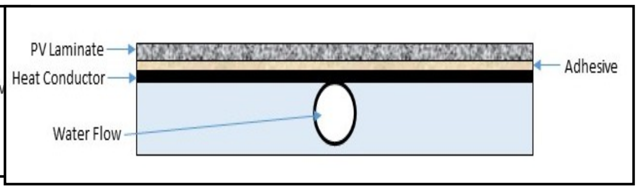

Figure4. Unglazed Type Collector

IMPACT OF HYBRIDIZED MECHANISM

The aim of the present model is to produce electricity and thermal heat by the hybrid solar collector system which is known as Solar Photovoltaic-Thermal (PV/T) hybrid system. It provides up to 300% more energy (in the form of solar electricity + solar heat) than a conventional solar Photovoltaic (PV) system. The heat energy captured from the PV modules can be used for various domestic application other that water heating, i.e. water desalination, room heating, drying etc., where it is used to displace the conventional heating load. The secondary benefit is to provide PV cooling by reducing the operating temperature of the PV modules, which improves the electrical performance. The hybrid PV/T system is ready to fit for all house-hold applications.

SPECIFIC OUTCOMES

Wider adaptation of proposed solar combined technology as it provides both electricity and thermal heat. Solar Energy helps reduce our carbon footprint as it is a clean energy alternative. For countries with very high usage of solar water heater i.e. Cyprus – 93% and Greece – 25%, where people are habitat to produce hot water with solar energy, they will not initially agree to install a PV system, where as a hybrid system producing both energy has better chances of success.

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