Journal of Solar Energy Research (JSER)

Journal homepage: www.jser.ut.ac.ir

PV/T Systems for Renewable Energy Storage: A Review

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ARTICLE INFO

Received: 05 Nov 2017
Received in revised form: 19 Nov 2017
Accepted: 22 Nov 2017
Available online: 26 Nov 2017

Keywords:
PVT System; Solar Power; Solar Heat Radiation; Thermal Energy System; HVAC

ABSTRACT

Sunlight is converted into electricity and heat simultaneously with the help of PV thermal panels. It is examined that the efficiency of the PVT panel is higher than the separate PV panels and solar thermal collectors' efficiency. The electricity conversion-efficiency for a PV system is about 6% to 15% and in moreover cases 85% of the incoming solar energy is either reflected or absorbed as heat energy. Now a day's Renewable energy has become a hot topic. The energy researchers day by day making advanced researches to make this type of system a useable one. Non-renewable sources will be approximately finished within next 100-150 years. So this type of energy is very important for everyone. Normally researches are made on producing electricity from renewable sources like sun-light, wind energy, tidal energy and etc. In this paper there is a compact review of solar photovoltaic thermal system. The performance of the solar cell decreases with the increasing of temperature. Both the electrical efficiency and the power output of PV module depend on the operating temperature. Photovoltaic thermal hybrid solar collectors, also known as hybrid PV/T systems are systems in which sunlight is converted into thermal and electrical energy both. This paper contains a combination of basic and advanced hybrid PV/T systems that are usable in Asian region.

1. Introduction

Solar energy is an inexhaustible form of energy which is eco-friendly along with being uninhibitedly accessible asset on earth. Proper utilization of this energy can protect the non-renewable sources and in the meantime executing the debasement of earth's normal ecology. Among all the inexhaustible energy sources, solar energy is by all accounts more meaningful, encouraging and economical form. The systems based on sunlight can meet the energy requests to some degree, keeping balance in natural processes. Sun radiation gives both heat and light, the PV/T systems are unique type of heat exchangers that change over solar radiation into heat through a vehicle medium and fluid movement (mainly water). This is a gadget which assimilates the approaching sun oriented radiation, changes over it into warm energy, and exchanges it through a liquid (typically air, water, or oil) for valuable reason/applications. For the most part, they are utilized as air dryer/warmer for drying the rural items or potentially heating/cooling applications in blend with the helper radiators for cooling of structures [1]. Photo-voltaic (PV) panel is the most valuable technique for collecting solar radiation straightforwardly changing it into power. Energy convertors, utilized to change over sunlight to power by means of photo-electric impacts are mainly known as solar cells. A photo-voltaic system comprises of solar cells with some other mountings. It directly converts sunlight into electrical energy. First PV-cell was invented in 1954 by some researchers of Bell Telephone Laboratory exhibiting the primary down to earth change of solar radiation into electricity by means of a p-n junction sort solar-cell having 6% efficiency. [2] Regular modern PV/T collectors have an effectiveness of 15-20%. [3] Various types of solar sorts of energies are shown in Fig. 1. In PV/T systems, heat and power are delivered at the same time, appearing as a legitimate planned device that is able to follow the request of power supply and green energy source.

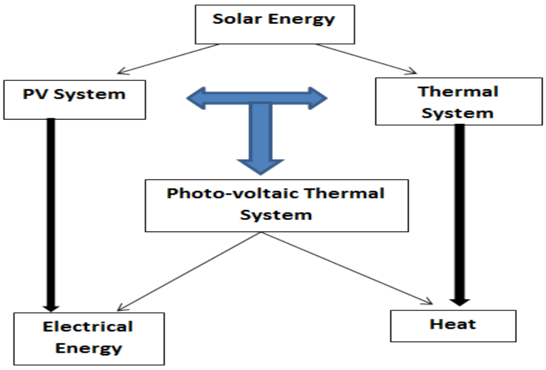


Figure-1 Schematic layout of various types of solar energies

2. Concept of PV/T System

A PV/Thermal (PV/T) gatherer is a module in which the PV isn't just delivering power yet in addition fills in as a thermal safeguard. Thus both heat and power are delivered all the while. The schematic of the PV/T advances is exhibited in Fig. 1. The double elements of the PV/T result in a higher general solar powered transformation rate than that of exclusively PV or sunlight based systems, and accordingly empowering more compelling utilization of sun oriented energy. Since the interest for sun oriented heat and sunlight based power are frequently supplementary, it is by all accounts a coherent plan to build up a gadget that can agree to the two requests.
A typical PV/T arrangement requires a PV module, Battery (Charge Storage), Inverter and a charge controller to set a con-current voltage. Fig.2 shows a schematic of conventional PV/T arrangement.

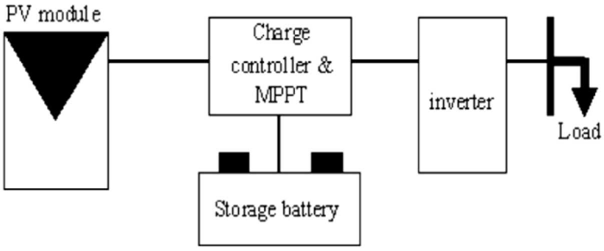


Figure-2 Schematic of Typical PV/T system.

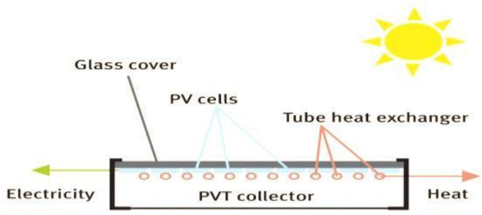
The concurrent cooling of the PV module keeps up electrical efficiency at acceptable level and along these lines the PV/T collector offers a superior method for using solar energy with higher productivity. There are selective methodologies in PV/T reconciliation. Among numerous others, there can be choices among air, evaporative gatherers, mono-crystalline/poly-crystalline/nebulous silicon (c-Si/pc-Si/a-Si) or thin-filmed solar cells, level plate or concentrator types, coated boards, characteristic or constrained liquid stream, independent or building-coordinated systems, and so on. A noteworthy innovative work take a shot at the PV/T innovation has been led in the previous couple of years with a slow increment in the level of experiments. The appealing highlights of the PV/T systems are: [4-6]

- It is double reason: a similar framework can be utilized to create power and thermal yield.
- It is productive and adaptable. The consolidated proficiency is constantly higher than utilizing two free systems and is particularly alluring in Building Incorporated PV (BIPV) when rooftop board separating is restricted.

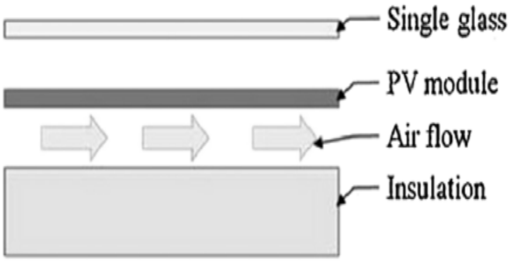
3. Varieties of PV/T Systems

3.1. PV/T_{air} Collector

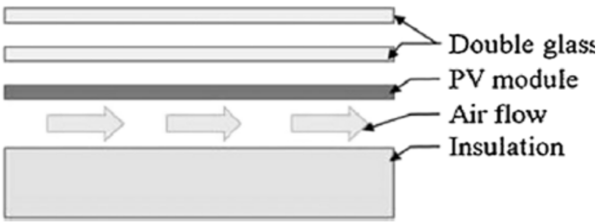
The fundamental air-cooled configuration uses an empty, conductive metal lodging to mount the photo-voltaic (PV) boards. Heat is emanated from the boards into the encased space, where the air is either circled into a building HVAC framework to recover energy, or rises and is vented from the highest point of the structure. Position of PV boards can be vertical or calculated. [7,8]
Air and water both have been utilized as heat move liquids in handy PV/T system, yielding PV/T_{air} and PV/T_{water} warming methods, individually. PV/T_{water} systems are more productive than those of PV/T_{air} because of the high thermo-physical properties of water when contrasted with air. However, PV/T_{air} is used in numerous common sense applications because of low development (negligible utilization of material) and working expense among others. Fig.3 outlines different kind of PV/T_{air} gatherers [7,9].



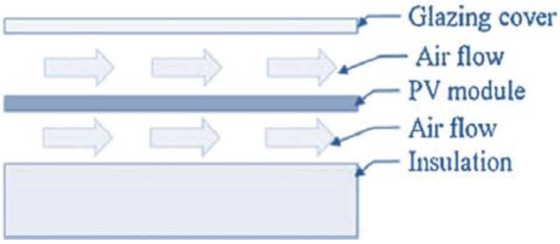
(a)Unglazed air PV/T



(b) Single Glazed air PV/T



(c)Double glazed air PV/T



(d) Glazed air PV/T

Fig.3: Schematic of different types of PV/T system: (a), (b), (c) and (d) [1,2,7,10]

3.1.2. Building-Integrated PV/T$_{air}$ (BIPV/T)

From a holistic viewpoint, the potential applications of PV/T system in the built environment are described below. The multi-functional rooftop was identified useful for PV/T installation that produces heat, light and electricity simultaneously. Other than the utilization of wind stream behind the PV modules, a PV/T system intended for light transmission requires no additional system cost except for ambient light sensors to optimize the pickup from day lighting as appeared in Fig. 3. Wei et al. have reviewed the applicability of domestic sun powered water heater (DSHW) and rooftop type building integrated photo-voltaic (BIPV) systems for China. [11,12] The photograph of the system is appeared in Fig. 4 and Fig.5. This DSWH however just 18% of the houses are suitable for the installing rooftop type BIPV.

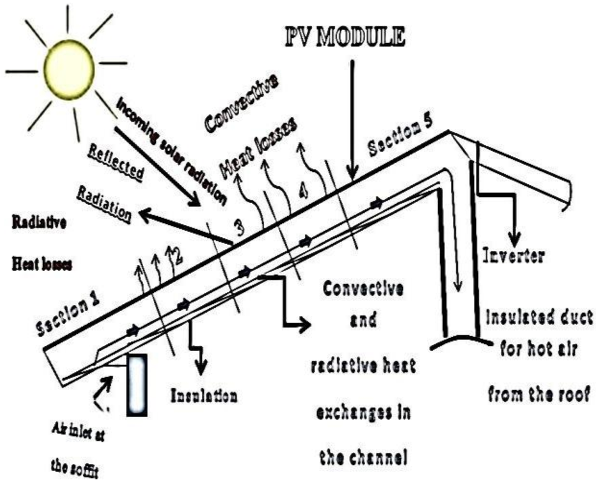


Figure-4 Schematic of BIPV/T system.

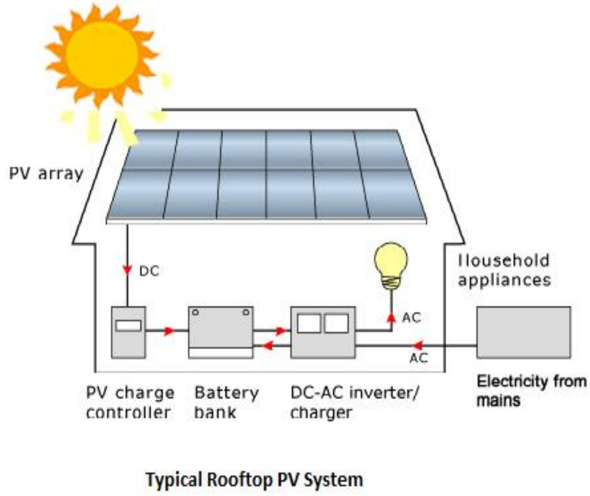


Figure-5 Photograph of DSWH roof type BIPV/T. [12,13]

3.1.3. Heat-pipe-based PV/T

Heat funnels are viewed as efficient heat transfer components that join the standards of both thermal conductivity and stage transition. A typical heat pipe, as indicated in Fig.6, consists of three sections to be specific, evaporated section (evaporator), adiabatic section and dense section (condenser), and gives a perfect solution to heat evacuation and transmission. [14,15]

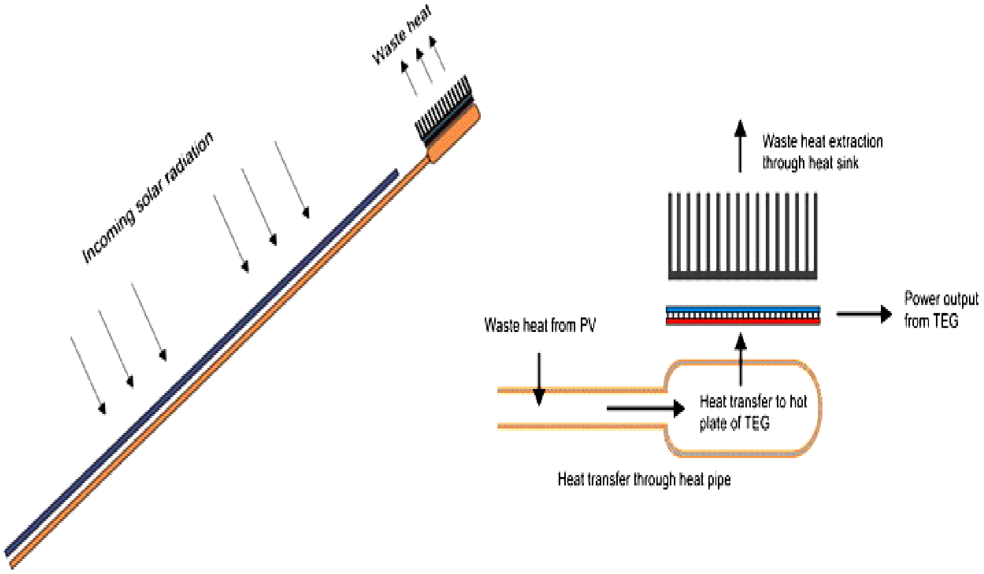


Figure-6 Schematic of a conventional Heat Pipe.

4. Comparative analysis on different PV/T systems studied

Table-1 represents the comparative analysis about different types of PV/T systems studied:

Sl. No.	Author(s)	Type	Analysis
01	Tyagi et al. [1]	Solar air heating PV/T	A study has been conducted on the solar air heater in the three different conditions namely without phase change material (PCM) - paraffin wax, with PCM and with hytherm oil. Study shows that efficiency in the paraffin wax condition is the highest as compared to other two conditions.
02	Touafek et al. [16]	||	A new improved design of hybrid solar collector for hot air supply have been fabricated and studied. Study shows better thermal and electrical performance as compared tradition solar air heater. It has thermal efficiency of 48%.
03	Amori et al. [17]	||	Different solar PV collectors of different configurations have been tested in the outdoor conditions. Mathematical model has been developed to predict the performance of these collectors.
04	Al-Alili et al. [18]	Concentrator PV/T	In this study concentrator photovoltaic system is applied to power the hybrid desiccant

			assisted air conditioner. Result shows that it provides better thermal comfort as compared to vapour compression system.
05	Ota et al. [19]	‖	In a concentrator photovoltaic system, the anti- soiling layer was coated on PMMA. This happens due to electrostatic charge. The system shows better performance than traditional parboiled PV/T concentrator.
06	Li et al. [20]	‖	A new static incorporated CPC-PV/T system have been designed and tested. Mathematic model to predict optical efficiency under outdoor conditions have been developed and was validated with experimental values. Results show good agreement with them
07	Yin et al. [21]	Building integrated air PV/T system	It is observed that airport structured received 90–95 % of global solar radiation.
			Hence PV Technologies can be used to generate power. BAPV shows lower peak power capacity and lower annual energy density.
08	Vats et al. [22]	‖	A study has been conduct with different photovoltaic material and different packing factors for BIPV system with air duct. The packing factor 0.62 shows superior thermal and electrical performance as compared to packing factor 0.83.

5. Recent trend on PV/T systems

Tripanagnostopoulos made some more improvements in the existing system by introducing an unglazed PV/T/double system with both water and air cooling modes and found that by attaching water tubes at the back surface of PV gives better thermal productivity. [23] By including a thin metal sheet (TMS), balances (FIN) and a combination of TMS with ribs (RIB) (TMS at the center of the air duct and RIB at the opposite side of the PV surface) he contrasted the three changed systems and the reference PV/T/double (water tube attached at back surface system and found a significant increment in thermal proficiency for the air heat extraction, which is respectively approximately 23, 33 and 36% higher for the systems depicted previously. This expansion in electrical execution percentage is more significant for higher (about 55 1C) operating temperatures, as it happens more often than not in PV/T collectors, thus the electrical execution can be higher by about 18% as electrical proficiency is 13 and 11%, respectively, for the PV also, the PV with booster diffuse reflector systems. Fig.7 below shows graphical relations of the systems studied from literature.

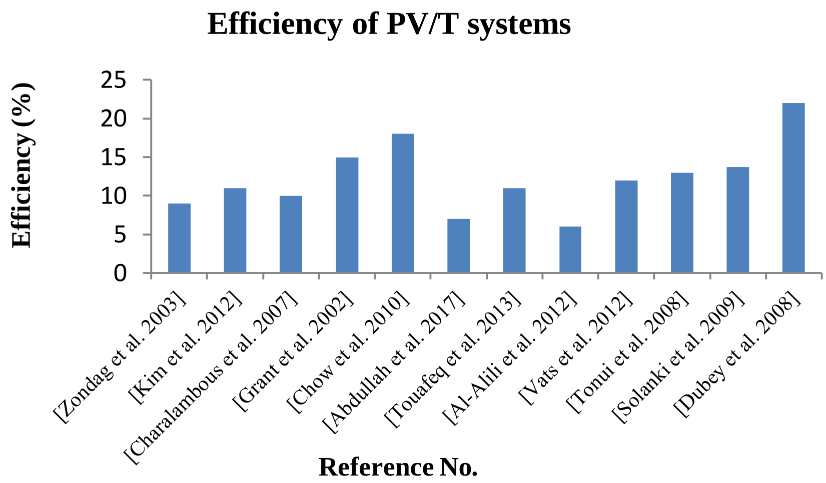


Figure-7 Efficiency (electrical) of PV/T systems from literature studied

Tonui et al. constructed an air-based PV/T sun powered collector which connected two ease ways to deal with upgrade heat transfer between the wind current and PV surface. [24,25] It is discovered that the initiated mass stream rate and thermal productivity diminish with expanding ambient temperature and increment with expanding tilt plot for a given insulation level. Solanki et al. [26] composed and constructed a PV/T sun based air heater, and studied its execution over different operational parameters under steady indoor conditions. They found that the thermal, electrical and general thermal proficiency of the sunlight based heater obtained at indoor condition was 42%, 8.4% and half, respectively. Dubey et al. [27] built up an analytical model with four different configurations. It was discovered that the glass to glass PV module with duct gives higher electrical effectiveness and the higher outlet air temperature among the each of the four cases. The yearly normal productivity of glass to glass type PV module with and without duct was reported 10.41% and 9.75%, respectively. In 2016, a group of researches leaded by Dr. Ka-Kui Tse carried out an experiment to make an energy convenient PV/T system and found greater effectiveness than conventional ones. Its efficiency was around 29.7% [28]. Fig.8 below shows the reprinted schematic below:

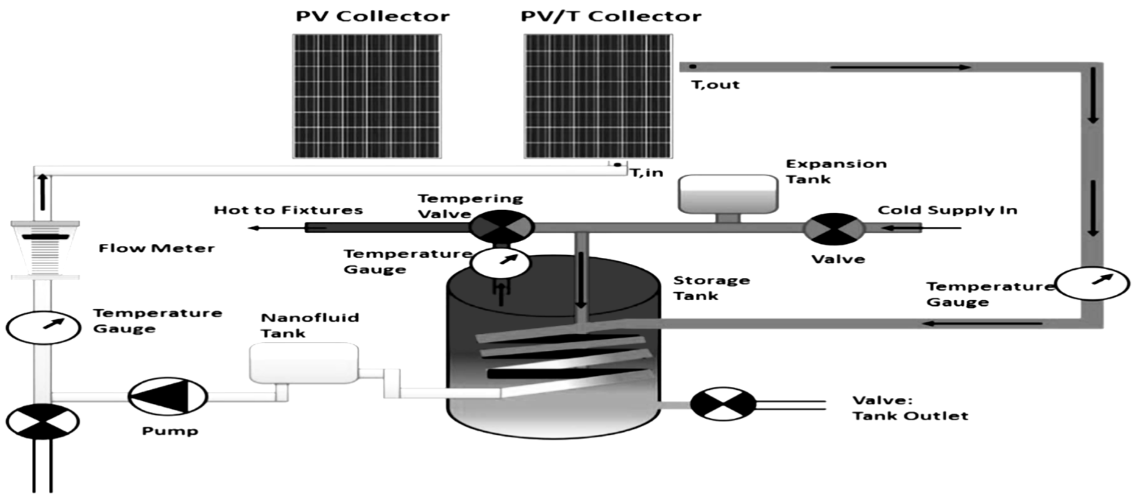


Figure-8 Schematic of the system found from Al-Waeli et al. [28] [Re-printed with permission]

6. Conclusion

Among all sustainable power sources, the sun oriented photo-voltaic technologies is observed to be a standout amongst the most encouraging. Because of this, intense research work is going on this field and this prompts significant enhancement of its execution. A detailed audits both historical and present trend of the sun powered photo-voltaic thermal technologies have been presented. The different application of the sunlight based photo-voltaic system, for example, building integrated air PV/T system, sunlight based air heating PV/T system and fluid PV/T collector, concentrator PV/T system, and heat-pipe-based PV/T are additionally presented.

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