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Editorial

R&D in Photovoltaic Thermal (PVT) Systems

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Editorial

A substantial change in global perceptions about renewable energy since 2004 has shown its potential. Renewable energies have been improving, and many technologies are at par with conventional energy generation technologies. Renewable energy has gained much research attention due to its reliability and potential in global production of electrical and thermal energies. With consideration of the aspects of photovoltaic thermal (PVT) system, many improvements have been implied theoretically and experimentally. The PVT system is a popular technology for harvesting solar energy. A PVT system can generate thermal and electrical energies simultaneously.

During the past years, several researches about advancements in solar energy technology have been conducted to establish reliable energy source. These studies focus into the improvements on the cooling system design and the working fluid used as coolant in the PVT system. With the recognition of the potentials and contributions of PV system, considerable research has been conducted to attain the most advancement which may produce reliable and sustainable PVT system. The cooling system's design refers to the absorber design which mostly focuses on water and air PVT solar systems. Initially, an air-based system has been developed through different absorber configurations, air flow modes and single- or double-pass design.

The introduction of water-based PVT started in the early 1970s. Wolf studied the efficiencies of combined heating and PV power systems for residences. This study used a flat-plate thermal collector where the heat is transferred to the load through a liquid channel. His study concluded that the value of the combined energy attained from the system used is higher than the system's output alone which is for single purpose. Combined PVT collectors were also evaluated by Hendrie; the performances of electrical and thermal energies show notable relation to theoretical results. Additionally, the PVT collector system presents potential thermal and electrical energy gains. He also concluded that analytical models can be used in predicting the energy production's performances because they yield accurate data. Erdil also conducted an experimental study that focused on energy generation using a PV-solar thermal hybrid system with water as coolant. Two experimental modules were used as hybrid system, and input/output diverse system was installed to ensure constant flow circulation of water across the cavity. A vent pipe was used at the passage so that trapped air can flow through, thereby preventing the glass plate from breaking due to the formation of high compression in the cavity. In accordance with a previous research by Bakker thick glass was used to resist water pressure in the channels. PVT water collectors under continuous variation in temperature mode with unlike constant flow rate mode were compared by Mishra and Tiwari for two panel configurations, namely, partially covered and completely covered PV modules. Partially covered PV is preferable for hot water or high thermal yield production; the one with complete cover results in the generation of high electrical gain which is beneficial in obtaining high electrical gain. Chow also studied dissimilar PVT water collector, in which the unglazed PVT generates higher thermal energy than that of glazed PVT. Moreover, Shyam investigated partially covered PV module of PVT water collector connected in series and concluded that temperature relies on module efficiency, tank and outlet water temperature. Boubekri presented a numerical model to examine the electrical performance of a collecting hybrid PVT water collector; they showed that the overall efficiency of the collector can also be influenced with the inclination angle, mass flow rate of water and conduction heat transfer coefficient in the adhesive layer. Kalogirou simulated industrial PVT systems with water heat extraction in three places at different latitudes; different types of solar cells were also used. Previous study verified that water efficiency during heat extraction and latitudes influence energy generation.

In air-based PVT, the air cools down the panel. Several studies on air hybrid collectors have been conducted recently. Early in 1996, a performance comparison on single- and double-pass PVT air collector was conducted by Sopian they concluded that the double pass-type PVT air collector performs well in solar cell cooling. Single- and double-pass PVT systems were optimised; the performances were analysed for both cases with varied air flow rate, as well as packing factor, collector length and duct depth. They concluded that the thermal efficiency generated by double-pass system is higher by 8% because it produces 32%-34% thermal efficiency compared with that of single-pass which produces 24%-28%. The combined efficiency of a double-pass system is also higher than

that of a single-pass system (30%-35% vs. 40%-45%). Hegazy evaluated such collectors through numerical modelling.

This study involved various designs of PVT air collectors: (i) air channel above PV collector (ii) air channel below PV collector (iii) single-pass PV collector and (iv) double-pass PV collector. In Sydney, a PVT air system designed by Bambrook included a PVT air collector connected to a short length duct with fan for air transfer. To minimise the energy output, the collector depth and the air mass flow rate were optimised. Yang and Athienitis presented a prototype of open-loop air-based building integrated PVT system with a single inlet. The study involved a series of experiments in a full-scale solar simulator. A numerical control volume model was also demonstrated and confirmed on the basis of experimental results. Kamthania improved the single- and double-pass designs of PVT for energy and exergy analyses.

This study also verified the excellent performance of double-pass PVT design. Tonui and Tripanagnostopoulos developed an economical modification technique that improves the heat transfer of PVT air collector. Experimental data were validated for glazed and unglazed PVT models based on the experimental procedure. Solanki assessed the performance of air-based PVT under variable insolation and air flow rate by constituting three monocrystalline silicon glasses to tedlar-type PV modules. They obtained 42%, 8.4% and 50% thermal, electrical and system efficiencies, respectively. An exergy analysis on flat plate air-based PVT system was conducted by Srimanickam. The system generates 9.78%, 24.22%, 44.84% and 11.23% electrical, thermal, overall energy and energy efficiencies, respectively.

The use of water and air in a single PVT solar collector increases the overall efficiency per unit area which is assumed higher than that of the conventional solar collector even with same collector area. To produce hot water, hot air and electricity simultaneously, PVT should use air and water as coolants. This integration of heat removal is known as bifluid-based PVT which can overcome the limitations of using air and water as single coolant. Assoa conducted studies on the use of bifluid in PVT solar collector. A quasi 2D analysis was carried out, and the position of the thermal component of the collector and PV sector was alternated. Consequently, the temperature of water production becomes high without increasing electricity production. A good agreement between the theoretical and experimental results was obtained. A PV module, serpentine-shaped copper tube and a single-pass air channel were also integrated by Abu Bakar and bi-fluid was utilised as the working fluid.

With consideration of a few design and environmental parameters, simulations were carried out, and efficiency curves were calculated using a numerical model. Simulations showed satisfactory overall performance when the fluids are operated independently; the performance becomes highly satisfactory when the fluids are operated instantaneously. The technical and commercial feasibilities were concluded to involve experimental fabrication. A design for improving bifluid PVT system was proposed by Abu Bakar in 2014. Satisfactory thermal, electrical and equivalent thermal efficiencies were obtained for independent and simultaneous fluids; about 76% of equivalent thermal efficiency was obtained at optimal mass flow rate. A hybrid PVT system with transparent PV panel was used and mounted on the top of a designed system by Othman. The electrical and total thermal efficiencies obtained are 17% and 76%, respectively, at an irradiance of 800W/m^2 with optimum air and water flow rates of 0.05 and 0.02kg/s, respectively. Su conducted a numerical study on the performance of double-channel PVT system. This research revealed that the designated PVT system performs well in generating electrical and thermal energies.