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ANALYSIS OF MALAYSIAN ECOTOURISM PERFORMANCE USING HYBRID PHOTOVOLTAIC THERMAL (PVT) SYSTEM

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Abstract

Malaysia is one of the top countries in the world for ecotourism. This type of tourism is broadly acknowledged for its positive impact on the environment. Ecotourism is a type of tourism that tourists travel to areas for the purposefulness of exploring their ecological beauty, and being harmonious with Mother Nature. Ecotourism had its establishments in the morals of preservation of pure nature, which can help keep up what is left of nature and encourages ecological instruction. Utilizing the economic vitality, giving careful consideration to the common assets and creating existing normal assets will have an immediate effect on the most advantageous manageable condition for the occupant. If not all, a large portion of the ecotourism locales is situated in the remote region in which to use electrical energy from the ordinary network is troublesome or expensive. On the incongruity, using the customary non-sustainable power source has a negative impact and demolishes the ecotourism destinations. Employing Photovoltaic Thermal (PVT) system is a fit energy source to serve the restricted energy required for the ecotourists. The measure of the energy created relies upon the solar radiation and the area of PV being used at the site. In this research, the manageability of nearby condition alongside the economical use of energy is considered. This paper also demonstrates the sustainable energy generated by PV in different locations in Malaysia and aims to address the impact of sustainable and non-sustainable on the rural area of ecotourism.

Keywords: Ecotourism, Environmental, Hybrid, Impacts sustainable, Sustainable energy.

1. Introduction

Tourism is a potential issue in ecological, temperate and social levels many government agendas. The government sees tourism as an apparatus of advancement offering need to ensure the situations and customs with minimum negative effects [1]. Malaysia being the real fascination for the tourist destination in this piece of the world appreciates a greater offer of the visitor for the whole year [2]. Among the tourism, ecotourism is one of the rapid developing developments in the overall tourism industry. Ecotourism is a strategy for eccentric tourism that expects to accomplish financial gain locally by improvement through common asset security. Nature has an intrinsic esteem, which wins its incentive as a tourism resource. Ecotourism transfers to the nature of the earth, which must be deliberately defended, from the impact of the movement and sort of energy usages in its region. The International Union for Conservation of Nature (IUCN) characterized ecotourism as "environmentally accountable travel and visitation to reasonably undisturbed natural areas in order to appreciate and enjoy nature (and any accompany in cultural features-both present and past) that encourages conservation, has low negative visitor impact and provides for beneficially active socioeconomic involvement of local populations" [3].

World Commission on Environment and Development defined sustainable as "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [4]. The definition portrayed above infers that the essential part of the definition is to acknowledge and ensure the nature in the meantime an instrument for preservation and manageable advancement. Keeping in mind the end goal to consent to the above definition and ensure the nature, the wellspring of vitality use must be deliberately considered and deny the use of any wellspring of vitality which delivers earth danger gasses, for example, carbon dioxide (CO_2), carbon monoxide (CO), nitrogen dioxide (NO_2) and phosgene (PO_4).

Sustainable power source asset, for example, the sun is a critical piece of creating vitality required in the normal country zone since sun is the most plenitude, reasonable and exist wherever with no cost. It intends to aid the decrease of the emanation of ozone-depleting substances, which are created by non-sustainable power sources, for example, non-renewable energy source. In any case, the recently outlined half breed PVT frameworks can create both electrical vitality and a similar time high warm vitality. Since the warmth aggregated on the PV lessens the PV effectiveness, the expulsion of the expansive measure of warm vitality from the PV not just keep up the PV electrical efficiency yet additionally to fill in as the helpful warm vitality required in the country region. The points of this paper are to examine ecological effects of vitality source utilization in connection to ecotourism and spotlights on the natural effect of the vitality source use on ecotourism in Malaysia.

This research paper is the continual and expansion of the previous paper which was published as conference paper.

1.1. Ecotourism in Malaysia

Malaysia is an outstanding nation regarding its vacation destinations and rich common assets. The most extreme essential qualities of the nation are its moral and social assorted variety, ecotourism attractions, and various regular assets. The

Belum Temengor Woodland Complex is presumed to be in excess of 130 million years of age. This is the most seasoned on the planet and even more established than the Amazon forest and Congo basin. The ten best attractions for Malaysian ecotourism, which have remarkable normal resources and present open doors for neighbourhood individuals to include in ecotourism improvement, appear in Table 1 in alphabetical order of priority [5].

Table 1. Top ten attractions for Malaysian ecotourism and their natural assets [5].

Place	Natural assets
Belum Temenggor, Perak	Wildlife, forest and lake
Gunung Stong, Kelantan	Mountain, waterfall, rockfaces
Hose Mountains, Sarawak	Forest, trekking, birdwatching
Kenong Forest Park, Pahang	Elephants, caves, streams
Lower Kinabatangan River, Sabah	Proboscis monkeys, river, wildlife
Pulau kukup Johor	Mangroves, wildlife, seafood
Tasik Bera, Pahang	Lake, culture, fish
Tasik Kenyir, Terengganu	Lake, boating, trekking, fishing
Ulu Muda, Kedah	Forest, lake and sandstone
Wang Kelian, Perlis	Limestone, caves and forest

1.2. Environmental impact of ecotourism

Ecotourism differs from conventional tourism because it primarily concerns the perceptions and values of individuals, which influenced mainly appreciation of the surroundings. In this way, it diminished the size of the misuse of these natural assets [6]. In contrast to another sort of tourism, recycling is one of the main concern. Ecotourism is particular in nature and it impacts the earth and also the adjustments in individuals' demeanours in a positive sense. Subsequently, it is recognized from other tourism owing to its natural zone surroundings [7]. In contrast, sustainable ecotourism objective is to address the needs of the local resident, sustain the visited environments, teach the local communities with respect to their surroundings and to preserve its untouched nature [8]. Nonetheless, the effect of the tourism on the destination could be negative. Among the negative effect is the creating Carbon dioxide (CO_2) which is delivered by utilizing a non-sustainable power source, for example, a petroleum product.

1.3. Carbon dioxide (CO_2) damage

Carbon outflows, specifically CO_2, hurtfully affect the air quality and raise the greenhouse impact. Activities such as energy consumption, waste disposal and transportation contribute towards carbon footprint. Environmental Impression is a typical gauge for Carbon Impression – release emission of gases adding to environmental change, related to the human creation or utilization exercises. In a rustic tourism setting, all specialist organizations to sightseers may add to the weakening of nature over the span of their tourism exercises. Whenever utilization (operational practices and exercises of visitors) supersedes carbon balance activities, moderation approaches are required [9].

1.4. Carbon counterbalance plan

In order to have an effective offset plan, the genuine measures are crucial to assess appropriate balanced techniques.

A carbon charge on avionics fuel would especially influence whole deal flights, in light of high discharges, and short-pull flights and the emanation amid take-off and landing [10]. Tax assessment ought to be as per the measure of contamination they create and utilize the store to invert the contamination by embedding trees, advance a more beneficial condition, advance practical vitality and different types of commitment to the Mother Nature on the location sites. The arrangement ought to have the capacity to compute the carbon emanation for every one of the exercises and offer balance value that is fixing to a picked venture before the instalment strategy is resolved. The said procedure appears in Fig. 1.

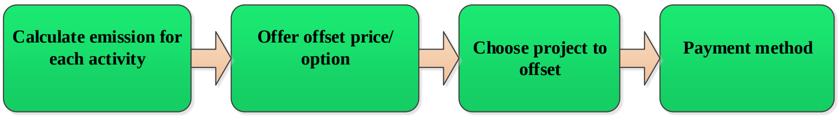


Fig. 1. Offset carbon mission plan [9].

It is suggested that the vehicle works on the site will be battery operated and the vitality for utilizing to revive battery originates from the PVT source. The use of sustainable power source without legitimate arrangement obstruct and cause restriction on the development of the region. The confinement in any viewpoint counteracts development in any shape and way, for example, the monetary effect on the nearby home and additionally on a national level and effect on the improvement of regular assets. The store produced from the sightseers can help the neighbourhood network's expectation for everyday comforts, physical, financial and social situations of goals, which exclusively rely upon the amount, and the nature of the ecotourists. There are a few different ways to limit the confinements for ecotourism. One approach is to get ready for the utilization of sustainable energy source in place of the polluting energy sources.

As an example, non-renewable energy sources such as fossil fuels, which are the non-renewable effect the earth's atmosphere such as Global warming. Most spotless, normal and sustainable power source comes either specifically or by implication from the sun. In this manner, the best answer that could be expressed out lies in the sun. The Sun remains as a dependable inexhaustible renewable wellspring of energy [11].

1.5. Demands for energy at the ecotourists site

As the quantity of ecotourists expands the energy request relatively will increment also. The PVT frameworks can be utilized to supply the requests and replaces the current petroleum product vitality. The eco locales typically situated in the provincial regions and are not happy to exchange the vitality from the ordinary customary source by means of the framework to these zones. In addition, the regular technique is not in accordance with the idea of ecotourism and in certainty is unsafe to the Earth, which will ruin the eco-framework. The fit elective strategy is the sun oriented energy source. The solar energy is available all over the place, sustainable, the most copious, free and naturally well-disposed [12]. Solar energy can cover a critical level of tourism infrastructures. The PVT frameworks can cover both thermal and electrical energy needed. The proposed system incorporates a PV cluster, solar charger for optimized energy harvesting, improved solar collectors and an inverter-converter module to supply ac and dc electrical power. The PVT system conveys both electrical energy to furnish the electrical energy requirements while the thermal system produces thermal energy, which can warm up the water to be utilized for a shower, pool or to be utilized in the radiator to warm the rooms and workplaces. The utilization of a PVT system in the business is recommended as a solid answer for a more extensive utilization of sun-based energy system [13]. Worldwide the use of renewable and sustainable energy source has been expanded. Figure 2 demonstrates the sustainable power source utilization by region in the word.

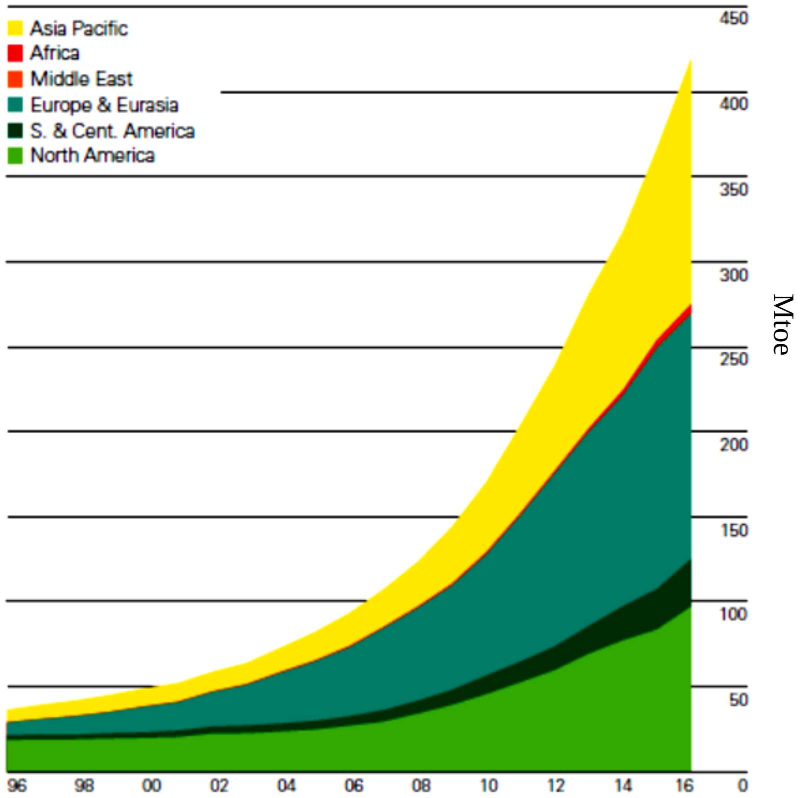


Fig. 2. Renewable energy consumption by region, the year 1996 – 2016 vs. Million tonnes oil equivalent (Mtoe) [14].

The chart demonstrates the exponential increment of sustainable power source utilization in the various mainland. This is supportive of the characteristic zone and better maintain the eco framework from the natural impact caused by CO_2, which is created by delivering energy from the non-sustainable and non-renewable energy source. Executing PVT frameworks in the country region will support the aggregate sustainable power source utilization of Malaysia, which thus help the natural and manage the ecotourists region. Creating 1kW electrical energy by PV modules delivering 150 kWh every month forestalls 75 kg of fossil fuel from being generated. It prevents from 150 kg of CO_2 from entering the environment and shields 473 L of water from being consumed [15]. Figure 3 demonstrates Malaysia energy utilization for as far back as 26 years. The chart demonstrates an enduring increment on the yearly energy utilization of Malaysia. This pattern is disturbing to the ecological and biological system, which put more strain to utilize elective technique to a non-sustainable power source to secure natural foundation.

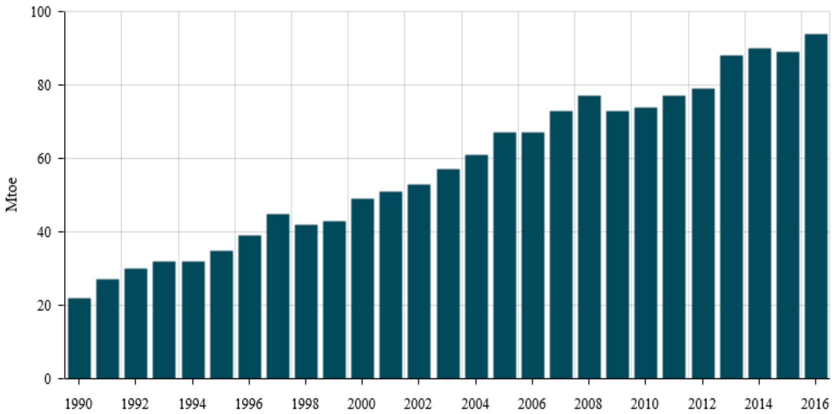


Fig. 3. Malaysian energy consumption, year 1996 – 2016 vs. million tonnes oil equivalent (Mtoe) [14].

2. Energy Requisite at the Ecotourists Location

It is very vital and basic to ascertain and break down the energy required for the ecotourism destinations.

Malaysia being a tropical nation normal sun insolation ranges around 4.8 $kWh/m^2/day$ – 5.8 $kWh/m^2/day$. Photovoltaic (PV) framework is very much perceived and generally used to convert the solar radiation into electric energy. The typical factor impacts the energy management is the active energy utilization (kWh), the reactive energy consumption (kVARh) and the peak request (kW). Traditionally the utility system put their exertion on the decrease of kWh utilization and on tending to the required reactive energy to improvise the power factor. Equations (1) and (2) shows the maximum demand (*PD*) and the power used in excess (*PE)* [16].

$$PE = PC - PD \tag{1}$$

$$PD = PDm \times KD \tag{2}$$

where *PC* is the maximum demand, *PD* is the power utilized in overabundance *PDm* is the actual peak demand value from the maximum demand meter and *KD* is the demand factor.

The penalty by the provider to the utility is figured as appeared in Eq. (3).

$$PP = (PC - PD) \times KP \tag{3}$$

where KP is the penalty factor. Along these lines the genuine KW value (PA) computed is given by Eq. (4).

$$PA = [(PC - PD) \times KP] + [PDm \times KD] \quad (4)$$

2.1. Energy creation by utilizing PV

The generation of electrical energy exclusively depends on the sunlight radiation, the aggregate surface zone of the PV being used and the effectiveness of the PV itself. Table 2 indicates average yearly sunlight radiation for various urban communities in Malaysia.

Table 2. Annual average sun radiation (kW/m^2) in Malaysia [17].

Regioin/Cities	Annual average value (kWh/m^2)
Bangi	1487
Bayan Lepas	1809
Georgetown	1785
Ipoh	1739
Johor Baru	1625
Kota Baru	1705
Kota Kinabalu	1900
Kuala Lumpur	1571
Kuantan	1601
Kuching	1470
Petaling Jaya	1571
Senai	1629
Seremban	1572
Taiping	1765

For instance, Kota Kinabalu with 1900 W/m^2 has the most average solar radiation, contrasted with Kuching with 1470 W/m^2 the least yearly average sun radiation. The normal electrical power (kWh) delivered by different PV surface zone for the various area can be calculated by utilizing Eqs. (5) and (6).

$$TkWh = G_{aa} \times \eta \times S \quad (5)$$

$$DkWh = TkWh / 365 \quad (6)$$

where $TkWh$ is the yearly average energy created by the PV, G_{aa} is the yearly normal sun radiation (kW/m^2), η is the efficiency of PV module, S is the aggregate surface of the PV and $DkWh$ is the daily average energy created by PV module.

With the given average yearly sun radiation in Table 2 and with the establishment of 10 m^2 area of PV modules with 15% efficiency can deliver 7.81 kWh in Kota Kinabalu and 6.46 kWh in Kuala Lumpur daily [17]. Table 3 demonstrates the assessed add up to electrical power age by various PV surface zone inclusion with the productivity of 15% for an entire day expecting 5 long periods of full sun oriented radiation without cloud. Table 3 was created in view of the information in Table 2 and Eqs. (5) and (6).

Table 3. Average daily total electrical power vs. PV surface area.

Locations in Malaysia	(10 m^2) kWh/day	(50 m^2) kWh/day	(200 m^2) kWh/day	(500 m^2) kWh/day	(5000 m^2) kWh/day
Kota Kinabalu	7.81	39.04	156.16	390.41	3904.11
Bayan Lepass	7.43	37.17	148.68	371.71	3717.12
Georgetown	7.34	36.68	146.71	366.78	3667.81
Ipoh	7.15	35.73	142.93	357.33	3573.29
Kota Baru	7.01	35.03	140.14	350.34	3503.42
Johor Baru	6.68	33.39	133.56	333.90	3339.04
Kuantan	6.58	32.90	131.59	328.97	3289.73
Seremban	6.46	32.30	129.21	323.01	3230.14
Bangi	6.11	30.55	122.22	305.55	3055.48
Kuching	6.04	30.21	120.82	302.05	3020.55
Kuala Lumpur	6.46	32.28	129.12	322.81	3228.08
Petaling Jaya	6.46	32.28	129.12	322.81	3228.08
Senai	6.69	33.47	133.89	334.73	3347.26
Taiping	7.27	36.33	145.32	363.29	3632.88

With the present Feed-In Tariff (FiT) RM1.37/kWh by the government for generating electrical power via PV, one can produce and transfer electrical power to Tenaga Nasional Berhad (TNB) from the top of the home or auto carport [17]. The estimated monthly fund generated by various surface area size of the PV establishment for Kota Kinabalu and Kuala Lumpur are demonstrated as follows.

Kota.Kinabalu: PV = 500 m^2;

Total RM=3904.11 × 30 × 1.37 = **RM160458.92**

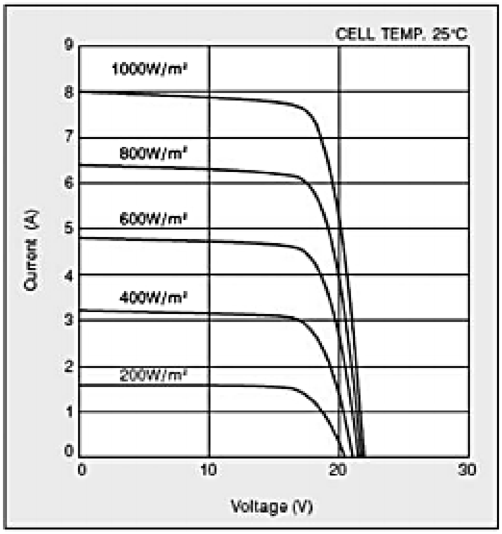
Kuala Lumpur: PV = 200 m^2

Total RM= 3228.08 × 30 × 1.37 = **RM 132674.18**

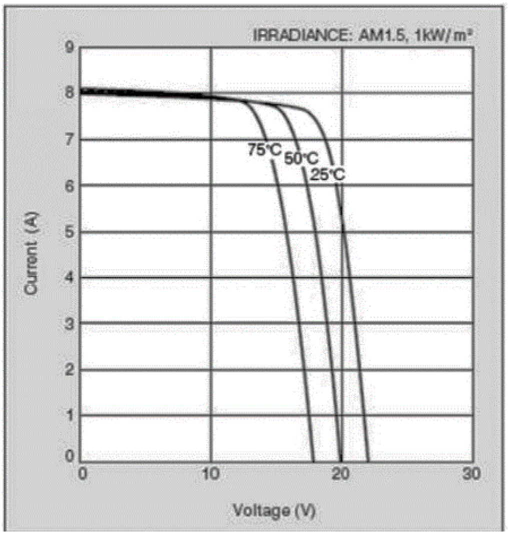
Despite the eminent innovative change in PV innovation, examination of outer components which may impact the generated energy by PVs, for example, climate conditions is still of significant consideration.

In such manner, one of the fundamental factors contrarily influencing PV's performance is the increase of cell temperature. For this reason, a notable effort has been made during recent years to examine the PV module temperature and its impact on the previous performance, mainly on the basis of detailed hypothetical analyse.

The electrical and thermal efficiencies of the PVT system are independent of location. Nonetheless, the sun based radiation and furthermore, to a lesser degree, surrounding conditions, for example, temperature and wind speed will unequivocally impact the aggregate vitality age. The electrical and hence thermal efficiencies are considered to shift in the reaches 18.0– 15.3% for temperatures between 25ºC and 85ºC [18]. Figure 4 indicates the current vs. voltage characteristic of a PV module at different cell temperatures and solar irradiance level.



(a) Voltage vs. current for different temperatures.



(b) Voltage vs. current for different solar radiations.

Fig. 4. Current-voltage characteristics of a PV module at various cell temperatures and irradiance levels. Datasheet obtained from [19].

With the thermal efficiency given above, the aggregate energy of the PVT frameworks can be higher than the given calculated value. For a PV module surface in air, the aggregate convective energy q_{conv} appeared in Eq. (6).

$$q_{conv} = h_c \,.\, A.\,(T_{module} - T_{ambient}) \qquad (6)$$

where *hc* is the convective heat transfer coefficient, A is the surface area of the PV module, T_{module} is the temperature of the module and $T_{ambient}$ is the surrounding temperature around the system [20].

2.2. PV module cooling

PV panels have efficiency better in cold condition than in hot condition. A valuable method of increasing efficiency and decreasing the rate of thermal degradation of a PV panel is via reducing the operating temperature of its surface. This can do by cooling the panel and decreasing the heat stored inside a PV module during operation. Crystalline silicon offers an efficiency of 15-16% and some studies consider that its limits would be reached about 25%. Heat decreases the performance of output power of the PV module by 0.4-0.5% per rising of 1ºC over its Standard Test Conditions (STC). It is because that the concept of "cooling of PV" has become very important [21]. Teo et al. [22] performed a cooling system for PV modules. In this method, to cool the PV modules a parallel set of ducts with inlet and outlet manifold designed for air flow distribution was attached to the back of the PV module.

Moharram et al. [23] carried out the test for increasing the performance of PV panels via water spraying. The temperature of the PV panel reached a maximum allowable temperature of 45ºC the sensor runs the pump resulting in water spraying on PV panel and cools the PV cell to a normal temperature of 35ºC.

Irwan et al. [24] carried out an indoor test performance of PV panel via water cooling test. In this test, water was made to flow on the front surface of the PV panel to increase the temperature of the PV panel. This test was carried out by halogen lamp bulbs, the lamps operate as a simulation of natural sunlight to produce radiation of 413, 620, 812, and 1016 W/m^2. The results of this test demonstrate the decline of operating temperature and increase of power output of the PV panel with water cooling mechanism based on different values of constant sun radiation.

Effect of temperature on PV performance

PV cells alter the changes in temperature. The changes in temperature effect on the power output from the panel. The voltage of the PV panel is extremely dependent on the temperature and an increase in temperature will decline the voltage. Figure 5 illustrates the effect of temperature on I-V characteristic of PV panel at fixed radiation. Decreasing temperature, the current of PV decline slightly. However, PV voltage increase clearly.

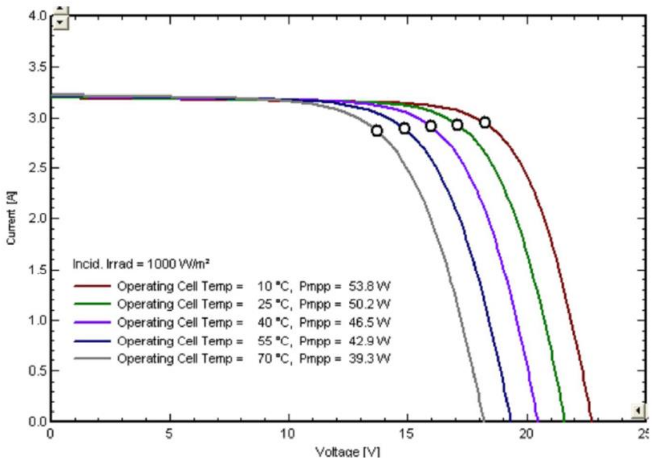


Fig. 5. Effect of temperature on I-V characteristic of PV panel at fixed radiation [19].

3. Framework Modelling and Methodology

3.1. PVT system design

PVT half-and-half frameworks comprised of two principal parts, electrical framework and warm framework. The PV module routinely creates electrical vitality while the warm unit produces warm vitality. The electrical framework comprised of PV module, charge controller, battery, converter and inverter for air conditioning and dc voltage use. The warm framework comprised of an aluminium plate, heatsinks, warm compartment, warm exchange liquid, warm exchanger, warm capacity tank and pump. The control unit manages the speed and activity of direct in light of the temperature distinction of warm liquid in the warm holder and the water in the warm stockpiling tank. The structure of the proposed half and half PVT frameworks appears in Fig. 6.

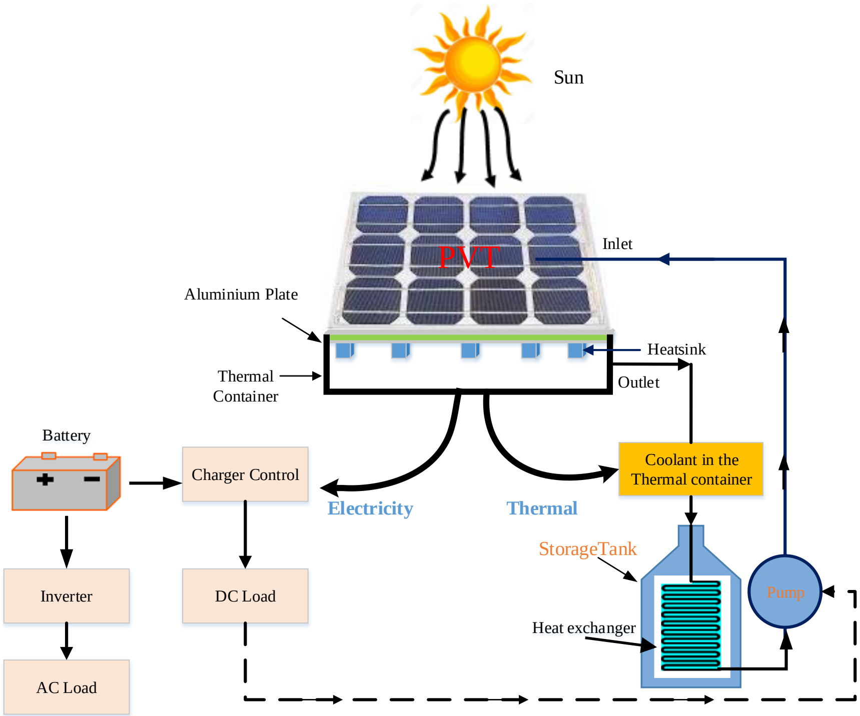
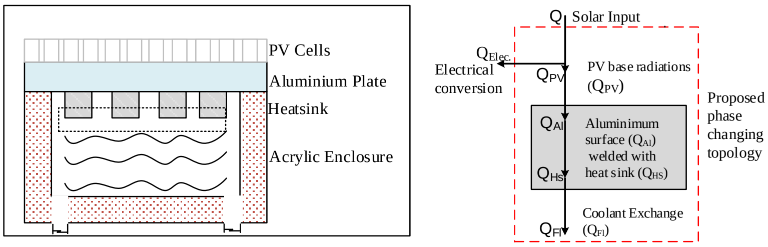


Fig. 6. PVT system set up [11].

3.2. System configurations

The outlined half and half PVT frameworks comprised PV module, aluminium plate, heatsinks and warm holder. The aluminium plate is specifically joined beneath the PV module through thermal paste to ingest the thermal energy from the PV module. The heatsinks are welded on the base layer of the aluminium plate to additionally expel the thermal from the aluminium plate. The thermal container is made of acrylic, which holds coolant. The coolant utilized as the exchange medium. The collecting unit is put inside a thermal container, which the unit sat on the highest point of the warm compartment. The heatsinks likewise fit inside the holder, which is drenched in the coolant. Each layer of the Hybrid PVT frameworks appears in Fig. 7.



(a) Phase layered system setup **(b) Stage changing topology**

Fig. 7. Hybrid PVT System with thermal container [25].

4. Conclusions

It is apparent that ecotourism impacts nature and the economy of the nearby and the nation as an entirety. The improvement of ecotourism can bolster in both safeguarding and preservation of nature at the destination site while the negative impact cannot be disregarded. The negative effect of ecotourism, for the most part, originates from making CO_2 by utilizing non-renewable energy source such as fossil fuel. However, there are trendsetting innovations and designs available for hybrid PVT system to meet the energy requirement of the tourism facilities. In order to tackle this issue and to further enhance the utilization of solar radiation, the PVT system is suggested. The suggested PVT system generates both electrical power by PV module and thermal energy via a thermal system, which removes the thermal energy from the PV module and transferred to a thermal tank to raise the temperature of the water in the tank.

Nomenclatures

A	Surface area of the PV module
G	Sun radiation, W/m^2
G_{aa}	Annual average sun radiation, kW/m^2
H	Total hours
hc	Convective heat transfer coefficient
q_{conv}	Convective energy
S	Surface area
$T_{ambient}$	Ambient temperature surrounding the system
T_{module}	Temperature of the PV module

Greek Symbols

η	Efficiency of PV module

Abbreviations

Fit	Feed-In Tariff
IUCN	International Union for Conservation of Nature
PDm	Actual Peak Demand
PVT	Photovoltaic Thermal
TNB	Tenaga Nasional Berhad

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