Using Renewable Energy with Solar Panels for Flying a Drone

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Abstract

This study addresses the critical challenge of limited operational endurance in Unmanned Aerial Vehicles (UAVs) by integrating renewable solar energy into the drone's power system. The main objective was to investigate and compare the efficiency of two distinct photovoltaic technologies—monocrystalline and polycrystalline solar panels—when permanently affixed to the wings of a fixed-wing drone prototype. The research aimed to determine the optimal panel type for maximizing supplemental power generation and extending mission time. The investigation involved designing and developing a modified drone platform and a specialized electronic data acquisition system. This system, built around a microcontroller, was essential for precisely measuring and recording the voltage and charging current delivered by the solar panels and the primary Lithium Polymer batteries under controlled laboratory conditions, simulating flight irradiance. The performance metrics gathered allowed for a direct, real-time comparative evaluation of the energy yield from both solar technologies within the constraints of an aerial platform. The results successfully demonstrated that solar energy harvesting provides a significant contribution to the drone's power budget, enabling a meaningful extension of operational capacity. Monocrystalline panels consistently outperformed the polycrystalline array, yielding a higher power output and superior energy conversion efficiency, which resulted in a substantial increase in overall flight endurance. These findings validate the technical feasibility of incorporating solar cells into UAV wings and confirm that monocrystalline technology offers the best return on investment for applications demanding maximum time aloft. This research provides a crucial framework for optimizing solar-powered UAV design, paving the way for autonomous, long-endurance missions in areas such as remote environmental monitoring, precision agriculture, and infrastructure inspection.

Keywords

Cells, Drone, Energy forecast, Photovoltaic panels, Solar radiation

1. Introduction

The prevailing opinion among the global community of computer scientists is that the future is oriented towards renewable energy. This perspective is informed by the understanding that renewable energy is an abundant and continually expanding resource, with the potential to become the predominant source of energy by the year 2025 [1]. Presently, the employment of this technology, which entails the generation of energy by radiation, is regarded as one of the most promising forms of renewable energy in existence. This assertion is made without the intention of superseding other renewable energy sources, such as hydroelectricity, wind power, and photovoltaics, which have also been identified as promising avenues for sustainable energy production. The objective of photovoltaics is to leverage the sun's energy in a manner that is analogous to the use of fossil fuels in contemporary society [2]. This phenomenon is illustrated in Figure 1, which demonstrates the present state of advancement in the field of renewable energies [3].

The objective of this research was to obtain photovoltaic energy. To this end, solar panels were manufactured using various materials, including silicon, gallium arsenide, and aluminum arsenide. The

IWSAI 2026: 1st International Workshop on Systems, Applications, Artificial Intelligence and Innovation, September 16–18, 2026, Piura, Peru
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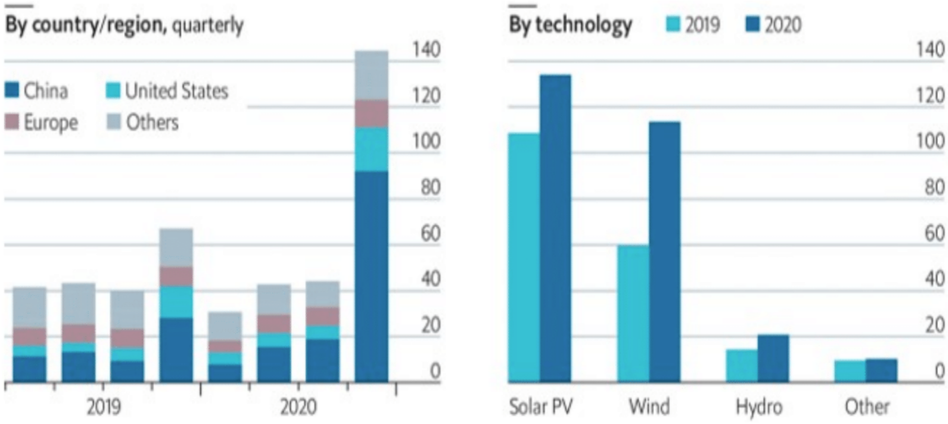

Figure 1: Use of solar energy by countries and technology (2019 and 2020). Source: (The economist, 2021) [3].

primary aim of this research was to generate a large electrical power output of electrical energy and to achieve conversion efficiency (reducing or optimizing energy consumption). In this field, theoretical studies and experiments with solar energy have been conducted in numerous locations worldwide. For instance, a stochastic analysis of company improvement in China and Taiwan was performed, revealing the potential for significant impact on solar energy companies in these regions. The study's findings suggest that the results will likely attract the attention of solar energy companies in China and Taiwan, leading to cost reductions and enhanced management strategies.

It has been demonstrated that most entities that utilize this category of renewable energy have experienced an enhancement in their investment returns and a reduction in their operational expenditures.

Despite numerous studies conducted about solar panels [4, 5, 6, 7], a paucity of research has been carried out in the field of drone-assisted comparison of solar panels. The present study aims to address this critical gap in the research landscape by conducting a comparative analysis of solar panels utilizing unmanned aerial vehicles (UAVs).

The paper is divided into four sections, the first of which is of particular importance. The introduction is the first section of the text. It presents the objective, justification, and importance of research. The methodology is the second section. In this section, the different photovoltaic panels used for the UAV are tested. The results are the third section. In this section, a comparative analysis of the different photovoltaic panels used for the UAV is presented. The conclusions are the last section. In this section, the final remarks and ideas are presented.

1.1. Precision Agriculture

Precision Agriculture constitutes a component of Agromatics, defined as a management strategy that collects, processes, and analyzes finite, temporal, spatial, and individual data. This data is then combined with other information obtained from histories to support decision-making in management with the estimated variability [8]. The result of this process is an improvement in the efficiency of resource use, productivity, quality, profitability, and sustainability of agricultural production [9]. This is the official definition promulgated by the International Society of Precision Agriculture (ISPA) [3].

This branch of Agromatics utilizes a range of technologies related to robotics and artificial intelligence to offer farmers numerous advantages, which will be outlined below [10, 11].

This approach enables the assessment of both temporal and spatial variability. The system under consideration enables the monitoring of growing areas in which production is suboptimal. It is imperative to obtain decision-making authority for the optimal utilization of soil in the context of cultivating extensive land areas.

This technology facilitates the registration of a real scheme of the land. The utilization of inputs is reduced, thereby decreasing pollution caused by their excessive use. This approach enhances the analysis and interpretation of the information provided in data collection, facilitating informed decision-making regarding the processes to be followed. It is imperative to meticulously monitor the harvesting process to ensure precision and accuracy.

The provided meteorological information is intended to assist in the understanding of the growing area. The optimization of decisions regarding crop harvest times is a crucial aspect of agricultural management. This tool enables precise monitoring of crop development.

1.2. Drones: Aerial Vehicles called VANTs

The drone is classified as an unmanned aerial vehicle (UAV), and in the Spanish acronym, it is designated as VANT (vehículo aéreo no tripulado). This vehicle is autonomous, meaning it is capable of flying without the need for a pilot. The United States military designated it as UAV.

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Unmanned aerial vehicles (UAVs) possess integrated information systems that facilitate the collection of data, incorporating positioning systems such as GPS, navigation systems like GIS, and servomechanisms, among others. The onboard central processing unit (CPU) is responsible for the autonomous operation of the vessel, thereby eliminating the necessity for human presence on board. Despite their initial development for military purposes, drones have found civilian applications due to their versatility. These unmanned aerial vehicles (UAVs) have been utilized for various purposes, including fire monitoring [13, 14] and disaster management [15]. In addition to these applications, drones have been employed in agriculture [16], security [17], and other fields [18].

The classification of drones can be approached from multiple perspectives; however, the most salient categorization is contingent upon the mission at hand, as evidenced by the following citation:

- For target: These systems are used for the purpose of simulating enemy aircraft, as well as attacks on ground-based or air defense systems.
- Recognition: The dissemination of military personnel information is contingent upon the specific requirements of the recipient.
- Combat: Participation in missions that are typically perilous from an aerial perspective and that would be unfeasible for a human to undertake.
- Logistics: The vehicle has been engineered to facilitate the transportation of various types of cargo, including but not limited to items related to Amazon or eBay transactions. Its multifaceted functionality encompasses the conveyance of both standard goods and specialized equipment, such as medical supplies or groceries.
- Research and development: In these facilities, the testing and investigation of systems under development for any scientific subject is conducted.
- Commercial and civil: These entities have been developed for utilization in both civil and commercial contexts.

1.3. Fixed-wing hybrid

The unmanned aerial vehicle (UAV) employed in this project is a hybrid fixed-wing model. This particular class of Unmanned Aerial Vehicle (UAV) possesses the capacity for vertical takeoff and landing, enabling it to ascend and descend in a vertical direction. Once airborne, its aerodynamic characteristics resemble those of a fixed-wing aircraft. The objective of this design is to integrate the advantages inherent to a multi-rotor system with the high-flying efficiency characteristic of a fixed wing unmanned aerial vehicle (UAV). It is imperative to acknowledge the necessity of a substantial wing for the installation of a considerable number of solar panels, which are essential for the connection of batteries and hardware. This fixed-wing UAV emerged as the optimal choice for this application. This intricate design is characterized by its reduced complexity during flight [19].

Table 1
Types of uses according to their power sources

Power source	Pros	Cons
Battery-powered drones	Lightweight	Short lifespan
	Ability to store decent amounts of energy	Mistreat them and they can start a fire
	High discharge rates	Use up energy fast
Gasoline-powered drones	Potentially dangerous as they carry highly combustible fuels	No need for expensive battery backup and charging stations
	More noise than a battery-operated drone	No need to wait for batteries to recharge
	Large size	Higher flight speed
		Easily carry heavier payloads
		Longer flight time
		Smooth and stable flight
Hydrogen fuel cell drones	Renewable and environmentally friendly	Generate a lot of heat
	Resourceful	Currently very poor in terms of efficiency
	Higher energy density than batteries	
	Longer flight time	
	Refuels in just minutes	
	Works at low temperatures	
Solar drones	Reduce operating costs	Limited flight time
	Increase operating hours	
	Lightweight	

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As previously mentioned, the decision was made to undertake this project with a fixed-wing UAV. In order to select a frame, it is necessary that the payload capacity be sufficiently large to accommodate all the hardware components, as well as an infrared thermal camera for mapping. However, the most critical aspect of this process is the attachment of photovoltaic (PV) cells to the frame. A plethora of frames are available on the market; however, the Skywalker X8 frame (Figure 2) was selected for this study. The frame in question was commercially available, straightforward to implement in simulations, and possessed a substantial wing area. Its use has been extended to other flying projects. A secondary rationale pertains to the economic affordability of the frame, which is a relatively inexpensive UAV.

Figure 2: Skywalker X8 that we use for this project

1.4. Solar panels

The panels will power the entire UAV, from the sensors to the battery charge, so that the impact on the environment is positive [21]. The connection that will be made is to place solar panels in parallel to optimize the milliamp capacity (mA).

As illustrated in Figure 3, the orange curve represents the output values of the photovoltaic generation system, specifically the 12-volt solar panels intended for use in isolated systems with batteries. These panels are capable of producing an output voltage of 18.4 volts. The panels are interconnected in a parallel configuration, and the total current of 33.48 amps is the sum of the individual branch currents, i.e., a, b, and c.

The objective of this study is to formulate a proposal for sets of photovoltaic cells that will ensure the reliability of the continuous operation of the UAV. This is necessary to meet the operational needs of all elements and to ensure optimal flight performance.

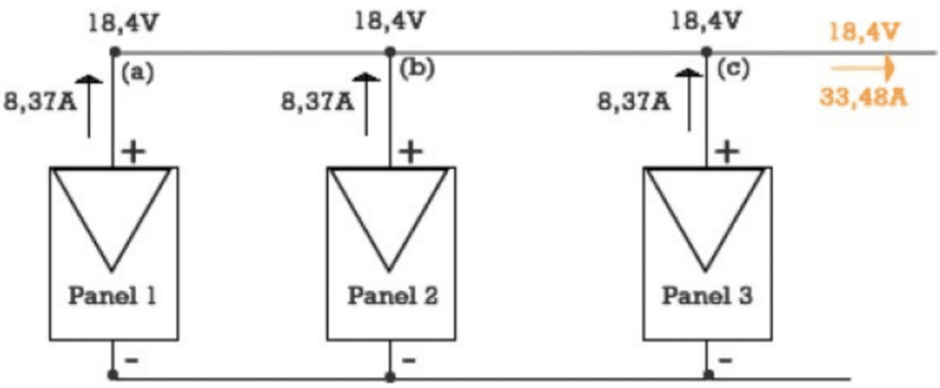


Figure 3: Parallel Solar Panel Circuit

2. Methodology

This section delineates the methodology for the utilization of solar panels in the present experiment. The data collection process for this scientific research proposal entails the implementation of interviews with the ranch administrator, the supervisor, and the field staff. This field technique is employed to ascertain the feasibility of reproducing the results obtained in the laboratory for a project entitled "Drone for the pitahaya."

This data is intended for use in a precision agriculture project that will observe a pitahaya ground. The scientific research was conducted in a series of farms situated in the coastal region of Guayas province. The information was obtained as part of the research proposal, and its analysis suggests significant and noteworthy insights for the development of this research project.

The population to be considered for participation in the interviews is as follows:

- The Administrator of the cultivation of pitahaya.
- The Crop Supervisor.
- The farmers.

This will facilitate the collection of the requisite information to support the scientific research. The study was conducted over a 15-day period, encompassing 21 samples collected from 8:00 a.m. to 3:00 p.m. The samples were meticulously separated into two distinct groups for a duration of 20 minutes to achieve voltages of 12 volts, currents of 2 amps, and a power output of 24 watts. This is a critical component for ensuring the prolonged operational endurance of UAVs.

The findings of this study suggest that the energy produced by the system accounts for approximately 40% of the energy necessary for an unmanned aerial vehicle (UAV) to maintain flight for a period of four hours and to successfully execute its daily tasks in a variety of environmental conditions. The objective of this research is to determine the energy requirements of UAVs (unmanned aerial vehicles) for the completion of their assigned daily tasks in various environmental conditions. The sample considered in this study is estimated to generate 40% of the energy necessary for UAVs to remain airborne for 10 hours, thereby ensuring the successful execution of their assigned tasks.

2.1. The process

For the processing and analysis of the data (the information obtained in the field tests), we used an Arduino R3 quipped with an electrical sensor that allowed to see the quantity of voltage, also we used a little lcd to show these values (Figure 4). We add little solar panel cells to obtain the exact quantity of power that the UAV need.

The Arduino R3 it is an open-source electronic prototyping platform, it is based on easy-to-use and very flexible hardware and software, automates anything, and treats it as autonomous agents (robots), this can be viewed in the light control, ignition of engines or devices, and much more.

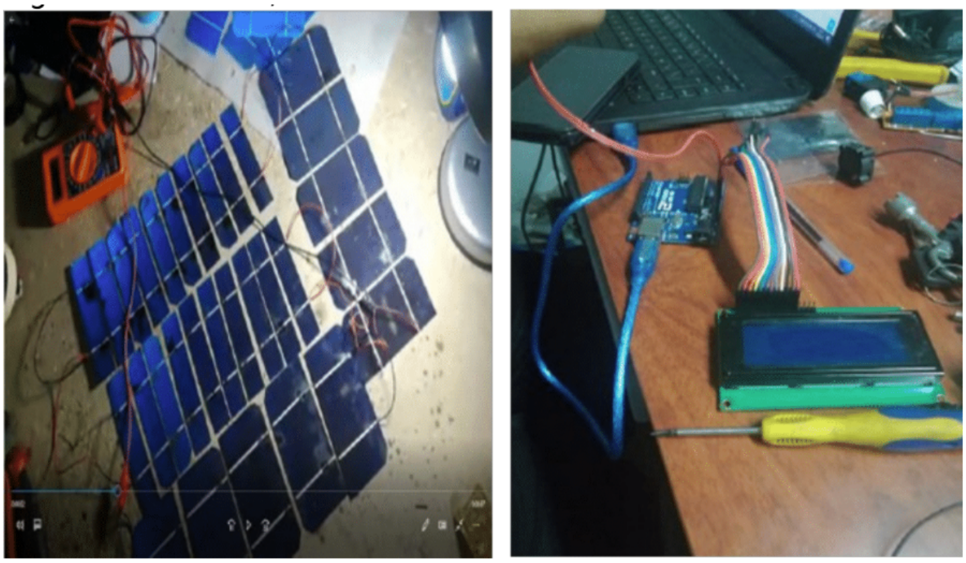


Figure 4: Arduino R3, lcd, sensors and the set of solar cells.

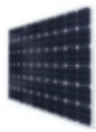
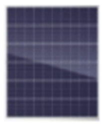
The objective of this research is to identify various types of solar panels (see Table 1). An attempt was made to procure these panels within our country; however, only two types were deemed suitable for our research: the monocrystalline photocell and the polycrystalline photocell.

Each of these panels possesses the capacity to generate energy, which is subsequently transmitted to the regulator. The regulator constitutes a pivotal element within the system. It fulfills the function of regulating the voltage delivered by the panel and charging the battery. The regulator is designed to monitor and control the charging and discharging processes of the batteries, thereby safeguarding them and prolonging their lifespan.

The battery's design aims to accumulate all the electrical energy delivered to it, thereby ensuring the seamless operation of equipment during both diurnal and nocturnal periods, when sunlight is unavailable. The inverter facilitates the conversion of direct current into alternating current. Accumulators, also known as electric batteries, are devices that facilitate the collection of energy produced during daylight hours. They are utilized during dusk or on overcast days, providing a reliable source of power when it is not available.

Photovoltaic cells that utilize crystalline semiconductors exhibit superior efficiency in comparison to those employing polycrystalline semiconductors. This discrepancy can be attributed to the presence of imperfections in the compound structure of the former.

Table 2
Types of Solar Panels

Company	Type	Features	Price	Pic
Alta Devices	UAV GaAS	31.6% efficiency, Made GaAs, thickness 45 um, cell mass 253 g/m2	50	
Jxsol	JXM200	Monocrystalline Silicon, max power of 200 Wp, TUVPRO certificate(IP65), white 6063-t5 aluminum alloy anodized frame. Efficiency 17.80	87	
Glory Solar	GSP-130W	Monocrystalline Silicon, size 125x125mm, max power 130Wp, efficiency 22%	300	
Sunket	SKT250M-24EC0	Monocrystalline Silicon, 1480x992,maximun power 250Wp, it is known a 250 W Mono solar panel, efficiency 17.03%	145	
Company	FS-F0-171000	Flexible, it comes charging adapter, maximum power 100w, 17.3 v output, weight 2.6 kg, efficiency >22%	169	
Anhui Cambag	Cbe CBE/SP	For industrial, output voltage 110v/220v, maximun power 260 Wp, time 24h, Monocrystalline silicon	220	

3. Results

In this study, two types of solar panels are utilized: The monocrystalline solar cell is characterized by dimensions of 3.5 centimeters in width and 12.5 centimeters in length. It possesses the capacity to generate a minimum of 0.49 volts and a maximum of 0.66 volts. Four blocks of (5, 6, 6, 6) are arranged in series, yielding 23 solar cells with a total weight of 30 grams. This configuration enables the generation of 12 volts and 2 amps, which are the requisite parameters for the UAV.

Secondly, the polycrystalline solar cell, measuring 6.3 centimeters in width and 12.5 centimeters in length, has been utilized. This cell possesses the capacity to generate an electrical potential of at least 0.55 volts and a maximum of 0.70 volts. A configuration of four blocks, each containing five solar cells, has been arranged in a series, resulting in a total of 20 solar cells with a combined weight of 70 grams. This configuration is capable of generating 12 volts of electricity, which is sufficient for the operation of a UAV. Additionally, the parallel arrangement of these cells allows for the attainment of 2 amps, a crucial requirement for the operation of UAVs.

Table 3
Results Of The Averages Of The Values Obtained By The Monocrystalline Panels

MONOCRISTALLYNE			
Time	**Mean VCC**	**Mean Amp**	**Mean Watts**
8:00	11.900000	1.954286	23.2560
8:20	11.900000	1.954286	23.2560
8:40	11.900000	1.954286	23.2560
9:00	11.902857	1.954286	23.2616
9:20	11.902857	1.954286	23.2616
9:40	11.902857	1.954286	23.2616
10:00	11.975714	1.954286	23.4040
10:20	11.981429	1.954286	23.4151
10:40	11.981429	1.970000	23.6034
11:00	11.981429	1.970000	23.6034
11:20	12.007143	2.001429	24.0314
11:40	12.028571	2.018571	24.2805
12:00	12.051429	2.027143	24.4300
12:20	12.037143	2.015714	24.2634
12:40	12.075714	2.032857	24.5482
13:00	12.147143	2.047143	24.8669
13:20	12.147143	2.047143	24.8669
13:40	12.325714	2.101429	25.9016
14:00	12.325714	2.101429	25.9016
14:20	12.385714	2.121429	26.2754
14:40	12.385714	2.121429	26.2754
15:00	12.385714	2.121429	26.2754

Following the acquisition of the results, it was demonstrated that monocrystalline photocells exhibit superior performance in comparison to their polycrystalline counterparts. This finding is supported by a graph that illustrates the power output of these two types of solar panels.

The employment of monocrystalline solar panels, configured with parallel connections, is advised to attain the present intensity demanded by UAV, amounting to 44,000 mha. It is recommended that when

Table 4
Results of the averages of the values obtained by the polycrystalline panels

POLYCRISTALLYNE			
Time	**Mean VCC**	**Mean Amp**	**Mean Watts**
8:00	11.664286	1.894286	22.0955
8:20	11.664286	1.894286	22.0955
8:40	11.664286	1.894286	22.0955
9:00	11.664286	1.894286	22.0955
9:20	11.664286	1.894286	22.0955
9:40	11.687143	1.894286	22.1388
10:00	11.690000	1.920000	22.4448
10:20	11.690000	1.920000	22.4448
10:40	11.690000	1.925714	22.5116
11:00	11.690000	1.925714	22.5116
11:20	11.715714	1.934286	22.6615
11:40	11.724857	1.938514	22.7288
12:00	11.798571	1.944286	22.9398
12:20	11.790000	1.941429	22.8894
12:40	11.910000	1.954286	23.2755
13:00	11.955714	1.965714	23.5015
13:20	11.955714	2.028571	24.2530
13:40	11.970000	2.028571	24.2820
14:00	11.970000	2.037143	24.3846
14:20	11.961429	2.037143	24.3671
14:40	11.961429	2.037143	24.3671
15:00	11.961429	2.037143	24.3671

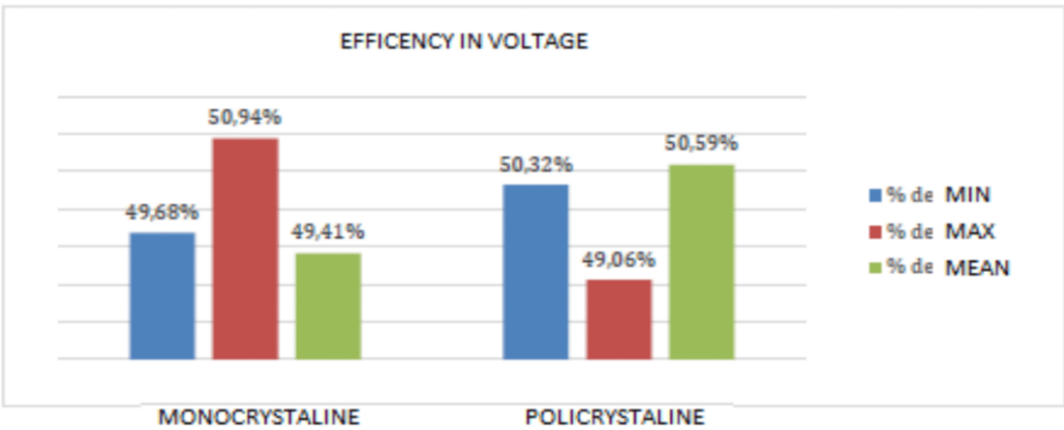


Figure 5: Comparision between the voltage of a Monocistallyne and Policristallyne values

planning UAV overflights, the optimal time period is considered to be between 10:00 a.m. and 2:00 p.m. According to the findings of the studies that have been conducted, the time of day when the sun falls perpendicularly and exerts its greatest force is of particular significance.

It is recommended that solar panels be cleaned three to four times per year. The most effective

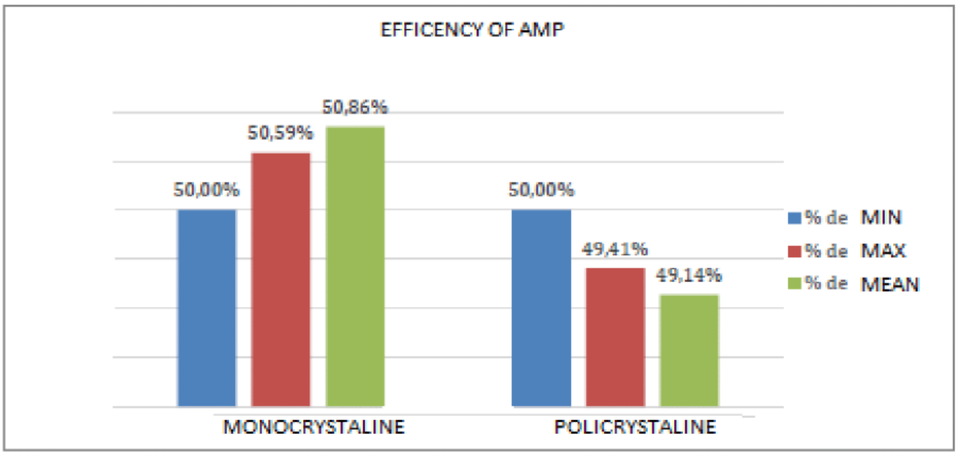


Figure 6: Comparision between the current of a Monocistallyne and Policristallyne values

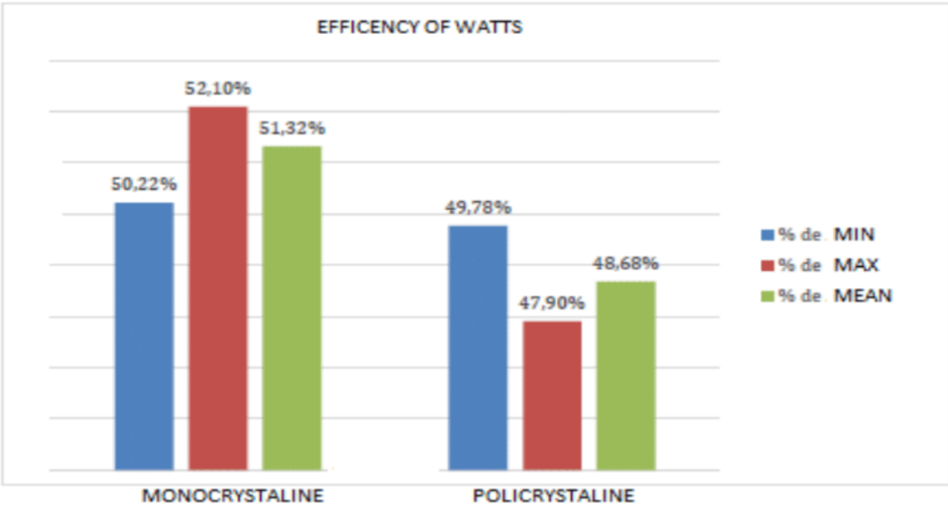


Figure 7: Comparision between the power of a Monocistallyne and Policristallyne values WATTS

method for cleaning solar panels is to employ a sponge or soft cloth in conjunction with a container of water that has been treated with a diluted solution of dishwashing soap. It is imperative to exercise restraint in the application of soap; an excess may impede the efficacy of rinsing, thereby increasing the likelihood of residue retention. Initially, the panel must be thoroughly moistened to ensure optimal dirt removal. This process also prevents the panel from being scratched during the subsequent wiping of the surface with a chamois or sponge. The object must be rinsed extensively with high-quality water, which is defined as water that is not hard water or water from wells.

4. Conclusion

The findings of this study indicate that for Unmanned Aerial Vehicles (UAVs) exhibiting low power consumption (24-20W), the utilization of monocrystalline photovoltaic cells remains a viable option. Additionally, the weight of the material is a pertinent factor to consider. Monocrystalline material has a lower weight compared to polycrystalline material. Through a series of experiments, it was determined that this set meets the energy consumption requirements of the UAV. Despite extensive research, an infinite charge has not been demonstrated. However, it has been determined that the charging time is limited depending on the existing batteries of the UAV. Therefore, it is necessary to recharge the batteries so that the team can carry out the planned tasks. A secondary conclusion of significance is that the power obtained and stored from solar cells is contingent upon several factors, including the composition of the solar panel materials, the intensity of solar radiation, the geographical location (rural or urban), the time of year, and the atmospheric conditions under which the UAV operates.

The implementation of solar energy as a type of renewable energy offers numerous advantages, including the reduction of energy transmission costs and the mitigation of global warming issues, which are of global concern. Consequently, numerous investigations are currently focused on acquiring the requisite operational parameters to enhance the system in various settings, including companies, residences, and governments. Numerous optimization methods for solar energy transformation have been employed to enhance energy efficiency. Nevertheless, the utilization of this natural phenomenon's potential has not yet been fully realized.

Declaration on Generative AI

During the preparation of this work, the author(s) used Perplexity, Claude, and ChatGPT in order to sentence polishing, paraphrasing, and rewording. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the publication's content.

References

[1] International Energy Agency, Renewables 2020: Analysis and forecast to 2025, 2020. URL: https://www.iea.org/reports/renewables-2020.
[2] F. J. Nijsse, J.-F. Mercure, N. Ameli, F. Larosa, S. Kothari, J. Rickman, P. Vercoulen, H. Pollitt, The momentum of the solar energy transition, Nature Communications 14 (2023) 6542.
[3] The Economist, The use of renewable energy is accelerating, 2026.
[4] J.-S. Wu, Applying stochastic frontier analysis to measure the operating efficiency of solar energy companies in china and taiwan, Polish Journal of Environmental Studies 29 (2020) 3385–3393.
[5] S. Sugianto, Comparative analysis of solar cell efficiency between monocrystalline and polycrystalline, INTEK: Jurnal Penelitian 7 (2020) 92–100.
[6] M. Benghanem, S. Haddad, A. Alzahrani, A. Mellit, H. Almohamadi, M. Khushaim, M. S. Aida, Evaluation of the performance of polycrystalline and monocrystalline pv technologies in a hot and arid region: An experimental analysis, Sustainability 15 (2023) 14831.
[7] S. Elsayed, et al., Performance study of monocrystalline, polycrystalline, and thin-film solar pv modules in the egyptian environment, Acse (2022).
[8] B. Petrović, R. Bumbálek, T. Zoubek, R. Kuneš, L. Smutnỳ, P. Bartoš, Application of precision agriculture technologies in central europe-review, Journal of Agriculture and Food Research 15 (2024) 101048.
[9] A. Monteiro, S. Santos, P. Gonçalves, Precision agriculture for crop and livestock farming—brief review, Animals 11 (2021) 2345.
[10] D. Khadka, Modern technology and scope of precision agriculture (pa), International Journal of Social Sciences and Management 10 (2023) 83–87.
[11] D. Maloku, P. Balogh, A. Bai, Z. Gabnai, P. Lengyel, Trends in scientific research on precision farming in agriculture using science mapping method, International Review of Applied Sciences and Engineering 11 (2020) 232–242.
[12] G. Lakshmi, Solar-powered drone for extended flight time, Tuijin Jishu/Journal of Propulsion Technology 44 (2023) 2874–2880.
[13] S. Li, Z. Fang, S. C. Verma, J. Wei, A. V. Savkin, Navigation and deployment of solar-powered unmanned aerial vehicles for civilian applications: A comprehensive review, Drones 8 (2024) 42.
[14] S. Duangsuwan, K. Klubsuwan, Accuracy assessment of drone real-time open burning imagery detection for early wildfire surveillance, Forests 14 (2023) 1852.
[15] X. Chen, B. Hopkins, H. Wang, L. O'Neill, F. Afghah, A. Razi, P. Fulé, J. Coen, E. Rowell, A. Watts,

Wildland fire detection and monitoring using a drone-collected rgb/ir image dataset, IEEE Access 10 (2022) 121301–121317.
[16] I. Chandran, K. Vipin, Multi-uav networks for disaster monitoring: challenges and opportunities from a network perspective, Drone Systems and Applications 12 (2024) 1–28.
[17] N. E. Mohd Sabri, M. K. Chainchel Singh, M. S. Mahmood, L. S. Khoo, M. Y. P. Mohd Yusof, C. C. Heo, M. D. Muhammad Nasir, H. Nawawi, A scoping review on drone technology applications in forensic science, SN Applied Sciences 5 (2023) 233.
[18] R. R. Hernández, La agricultura de precisión. una necesidad actual, Revista Ingeniería Agrícola 11 (2021) 67–74.
[19] Unnamed Aircraft System, Different types of drones and uses (2024 full guide), Online, 2024.
[20] S. Sonkar, P. Kumar, R. C. George, T. Yuvaraj, D. Philip, A. Ghosh, Low-cost development of a fully composite fixed-wing hybrid vtol uav, Journal of the Brazilian Society of Mechanical Sciences and Engineering 46 (2024) 252.
[21] M. V. Dambhare, B. Butey, S. Moharil, Solar photovoltaic technology: A review of different types of solar cells and its future trends, in: Journal of Physics: Conference Series, volume 1913, IOP Publishing, 2021, p. 012053.