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Zoe Zuo

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Efficient and effective use of solar panels

While walking around my neighbourhood, I have noticed that many households have solar panels on their roofs. Some are placed flat on the roof, while some are angled, which made me wonder how angles and other factors influence the efficiency of solar panels.

A solar cell panel, an assembly of PV solar cells mounted in a frame, captures sunlight and converts it into electric energy in the form of direct current electricity [1]. As a renewable source of power, solar energy plays a crucial role in reducing greenhouse gas emissions, mitigating climate change, protecting environment, and supporting sustainable human activities [2]. However, people may not know how to use it to its fullest potential. This paper will examine the factors influencing solar panel efficiency and identify a factor that we primary school students can explore through experiments.

Abundant experiments and research on solar panel efficiency have found various factors that influence the power output, including the coating and surface cleanliness of the solar panel, weather conditions, the materials of solar cells, and the angle and orientation of panel instalment.

Cleanliness

The solar power system's output can be reduced if the panels are covered in dust, dirt, grime, debris and other contaminants [3]. These block the sunlight from the solar panels and reduce its efficiency [4], losing 20–25% of energy output [5]. Solar panels should be cleaned every 6–12 months to maintain their productivity, efficiency and effectiveness. The necessity of cleaning may be more frequent with higher level of dirt and pollution [6].

Weather

Weather obviously influences the efficiency of solar panels. For example, Hailstorms or bad weather can damage the solar panels, compromising their functions [7]. On a cloudy day the amount of direct sunlight that can reach the solar panel is reduced, therefore, decreasing the efficiency [8].

Coatings

Coatings on solar panels not only influence energy efficiency but also determine the life of the solar cells and thus the overall power output [9]. The most common solar panel coatings include anti-reflective coating, solar glass, epoxy resin and ceramic coating. Anti-reflective coating boosts the efficiency by decreasing the light reflecting from the solar cell, increasing power output by 10–14% [10]. Solar glass is one most important barrier of traditional solar panels, protecting solar cells against harmful elements, such as water, vapour and dirt [11]. Solar glass must be of high quality, flat and transparent, allowing as much sunlight as possible to pass through to the solar panels [12]. Epoxy resin is durable, weatherproof and long-lasting, making it the ideal material to protect the solar panels from the outdoor elements [13]. Ceramic coating can protect panel glass from erosion and staining from salt spray or mineral deposits. It is able to endure harsh conditions from sub-zero to extremely hot environments [14]. Choosing the coating depends on the physical environment the solar panel is installed.

Solar cells

Solar cells use a variety of minor metals, such as silicon, indium, gallium, selenium, cadmium and tellurium [15]. The most efficient solar panels generally use either N-type (IBC) monocrystalline silicon cells or a N-type variation, heterojunction (HJT) cells [16]. Monocrystalline solar cells are made from a single crystal of silicon, which is more efficient than those with multiple fragments of silicon melted together [17]. Some other cells work well for solar panels. Crystalline silicon (c-Si) has been the material most used for photovoltaic conversion of solar photons to electric currents [18]. Perovskites solar cells have become an alternative material to silicon in traditional, inorganic solar cells. It has the ability to enable higher power conversion efficiencies [19].

Angle and orientation

The angle and orientation of the roof, as well as the location of the property, impact on how much solar power the panels can generate. Solar panels generate maximum power when positioned perpendicular to the sun, so the ray of sunlight hits the panels at a 90-degree angle [20]. The changes in the tilt angle can increase or decrease the power generated by solar panels [21].

While all of these factors are important, finding the best angle and orientation is probably the most important [22]. An unideal angle can significantly comprise the energy that the panel can

generate [23]. Angle can also determine how well the panel is washed in the rain. Appropriated angled solar panels can get a decent wash by allowing rain running across the panel [24].

After examining the important factors influencing solar panel efficiency, I found that the angle and orientation are a more feasible study area than coating and cells for primary students to conduct experiments on. Therefore, I collaborated with another student to conduct an experiment on the influence of angle and orientation on solar panel efficiency, which is submitted under the category of Scientific Inquiry.

(Word count: 799)

References

[1] Mr Solar.com (n.d.) What is a solar panel? https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwivp8rzuoj-AhVrjVYBHRvrC8wQFnoECAwQAQ&url=https%3A%2F%2Fwww.mrsolar.com%2Fwhat-is-a-solar-panel%2F&usg=AOvVaw3HAno_wigbFASf0sI9pZ1m

[2] Zen Energy (n.d.) 5 advantages of solar energy on the environment https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwikt76PvYj-AhWsslYBHVYDBmQQFnoECAoQAw&url=https%3A%2F%2Fwww.zenenergy.com.au%2Fknowledge-base%2Fpopular-topic%2F5-advantages-of-solar-energy-on-the-environment%2F&usg=AOvVaw0AdI2Cbqw6PjcrsnwWS2Uk

[3] Chint Global (n.d.) Benefits of cleaning solar panels https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi-07igwaX8AhVX8DgGHV-PALoQFnoECDAQAw&url=https%3A%2F%2Fchintglobal.com%2Fblog%2Fbenefits-of-cleaning-solar-panels%2F&usg=AOvVaw12Gg9FduKwZyxSGK6gd8fI

[4] Sun Run (n.d.) How much solar power can my roof generate? https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiKnYjhvqX8AhW1zTgGHTH6DcAQFnoECBUQAw&url=https%3A%2F%2Fwww.sunrun.com%2Fgo-solar-center%2Fsolar-articles%2Fhow-much-solar-power-can-my-roof-generate&usg=AOvVaw3zueW5JcCEIibAlhBl4Esj

[5] Clean Solar Solutions (n.d.) Why clean solar panels?

https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi-07igwaX8AhVX8DgGHV-PALoQFnoECC0QAw&url=https%3A%2F%2Fwww.solar-panel-cleaners.com%2Fwhy-clean-solar-panels%2F&usg=AOvVaw2H4_rGuaI-UOmEEvizClnM

[6] Sun Power and Green Convergence (November 15, 2016) Do solar panels need cleaning? https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjXttGQw6X8AhWK6jgGHaGtA9sQFnoECBwQAw&url=https%3A%2F%2Fwww.greenconvergence.com%2Fblog%2F2016%2Fnovember%2Fdo-solar-panels-need-cleaning-%2F&usg=AOvVaw39KpdkrXj_M-4qa8NPTsbp

[7] Sun Run (n.d.) Can solar panels break? https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjHh6P3xaX8AhVQ7TgGHQ11AcUQFnoECAYQAw&url=https%3A%2F%2Fwww.sunrun.com%2Fgo-solar-center%2Fsolar-articles%2Fcan-solar-panels-break&usg=AOvVaw303s2-FIKr7nCR8IlMtVQv

[8] Solar Bright (n.d.) How does the weather affect the efficiency of my solar panels? https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjH8Iqood3_AhWxwzgGHQgEDlQQFnoECBAQAw&url=https%3A%2F%2Fsolarbright.com.au%2Fhow-does-the-weather-affect-the-efficiency-of-my-solar-panels%2F%23%3A~%3Atext%3DClouds%2520generally%2520reduce%2520the%2520amount%2Cthe%2520clouds%2520vary%2520so%2520greatly.&usg=AOvVaw1pQhem3bhy-SLIXpLYOiy9&opi=8997844

[9] Green Match (April 13, 2023) New coating makes solar cells more powerful https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiurqD9w6X8AhUVwjgGHQNCDVIQFnoECDAQAw&url=https%3A%2F%2Fwww.greenmatch.co.uk%2Fblog%2F2014%2F07%2Fnew-coating-makes-solar-cells-more-powerful&usg=AOvVaw1iQ9ytsqdGQb6dbt38BGZs

[10] M. Rajvikram and S. Leoponraj (December, 2018) A method to attain power optimality and efficiency in solar panel https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiurqD9w6X8AhUVwjgGHQNCDVIQFnoECBAQAw&url=https%3A%2F%2Fwww.sciencedirect.com%2Fscience%2Farticle%2Fpii%2FS2314853518303639&usg=AOvVaw23trpFqcSLhaokW0BVnxtJ

[11] Dricus De Rooij (n.d.) Solar glass: applications and comparison to light-trapping

https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi-z6nOm6b8AhXWS2wGHRXmCPUQFnoECCYQAw&url=https%3A%2F%2Fsinovoltaics.com%2Flearning-center%2Fmaterials%2Fsolar-glass-applications-and-comparison-to-light-trapping%2F&usg=AOvVaw1oHVzg13dfPYj6-ZBvduuV

[12] Conserve Energy Future (n.d.) Do solar panels work through glass, windows or windshields?
https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwi-z6nOm6b8AhXWS2wGHRXmCPUQFnoECCIQAw&url=https%3A%2F%2Fwww.conserve-energy-future.com%2Fdo-solar-panels-work-through-glass.php&usg=AOvVaw0rIwqRBD3yX3WUMQb49tQJ

[13] Epic Resins (n.d.) Solar panel encapsulation
https://www.epicresins.com/ApplicationPhotoGallery/SolarPanelEncapsulation

[14] Element 199 (n.d.) Solar panel coatings
https://www.element119.com/solar-panel-coatings/

[15] Laura Rodríguez (September 23, 2021) Rare metal in the photovoltaic industry
https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjT-5X5nab8AhW4XWwGHUlmC_QQFnoECAYQAw&url=https%3A%2F%2Fratedpower.com%2Fblog%2Frare-metals-photovoltaic%2F&usg=AOvVaw1zj0eriCKN1imyHEOWxnCd

[16] Jason Svark (June 22, 2023) Most efficient solar panels 2023
https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiqh7-znab8AhX9XmwGHSAKD_UQFnoECA8QAw&url=https%3A%2F%2Fwww.cleanenergyreviews.info%2Fblog%2Fmost-efficient-solar-panels&usg=AOvVaw28NaQF9Bgnrk_VwN2ccRf9

[17] Emily Walker (May 18, 2023) What are the most efficient solar panels? Top brands in 2023
https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiqh7-znab8AhX9XmwGHSAKD_UQFnoECCUQAw&url=https%3A%2F%2Fnews.energysage.com%2Fwhat-are-the-most-efficient-solar-panels-on-the-market%2F&usg=AOvVaw0PgA6VzFUUEy2USk0C60aS

[18] Materion (n.d.) Solar cells need coatings from materion microelectronics and services https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwiurqD9w6X8AhUVwjgGHQNCDVIQFnoECDEQAw&url=https%3A%2F%2Fmaterion.com%2Fresource-center%2Fnewsletters%2Fnewsletter-archives%2Fcoating-materials-news-2000-to-2010%2Fsolar-cells-need-coatings-also&usg=AOvVaw0f510zZueL7UkY8Ptpnbmp

[19] Liam Critchley (November 15, 2022) Perovskite solar cells offer alternative to silicon https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwj9gZzxxaX8AhX18TgGHZ6TCNgQFnoECDAQAw&url=https%3A%2F%2Fwww.eetimes.com%2Fperovskite-solar-cells-offer-alternative-to-silicon%2F&usg=AOvVaw0LSbu4vb2awT3cJdrIoEIm

[20] Solar Calculator (n.d.) Solar panel angle affects performance https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjJqenpqNP8AhXt8DgGHc7DAgYQFnoECBAQAw&url=https%3A%2F%2Fsolarcalculator.com.au%2Fsolar-panel-angle%2F&usg=AOvVaw1mKx0a-GrTOJPLfTAAMMhA

[21] M.A.A. Mamun, M.M. Islam, M. Hasanuzzaman Jeyraj Selvaraj (July, 2022) Effect of tilt angle on the performance and electrical parameters of a PV module: Comparative indoor and outdoor experimental investigation https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjJqenpqNP8AhXt8DgGHc7DAgYQFnoECBsQAw&url=https%3A%2F%2Fwww.sciencedirect.com%2Fscience%2Farticle%2Fpii%2FS2666123321000179&usg=AOvVaw2sWnQHjswYOSrdA3d_p2Am

[22] Jason Svark (June 22, 2023) Most efficient solar panels 2023 https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwio66-XprD-AhXaaN4KHUg-CukQFnoECAwQAw&url=https%3A%2F%2Fwww.cleanenergyreviews.info%2Fblog%2Fmost-efficient-solar-panels&usg=AOvVaw28NaQF9Bgnrk_VwN2ccRf9

[23] Dual Sun (April 11, 2023) https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjvn6eGjLD-AhXFrVYBHV-5CawQFnoECAsQAw&url=https%3A%2F%2Fdualsun.com%2Fen%2Fblog%2Finstallation-maintenance%2Foptimal-orientation-tilt-angle-solar-panels%2F&usg=AOvVaw30DWF3utc4DL2kIQmc6c5O

[24] Solar Victoria (March 30, 2023) Spring cleaning: Looking after solar https://www.google.com.au/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&ved=2ahUKEwjJx7SqjLD-

AhUQyGEKHbahAO0QFnoECAkQAw&url=https%3A%2F%2Fwww.solar.vic.gov.au%2Fspring-cleaning-looking-after-solar-systems&usg=AOvVaw2IIRxO3ngwJ9-llHLaX28V

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