

The optimum tilt angle and orientation for Solar panels

Eman Mohammed

Directorate of Baghdad Education Karkh III, Ministry of Education, Baghdad, Iraq

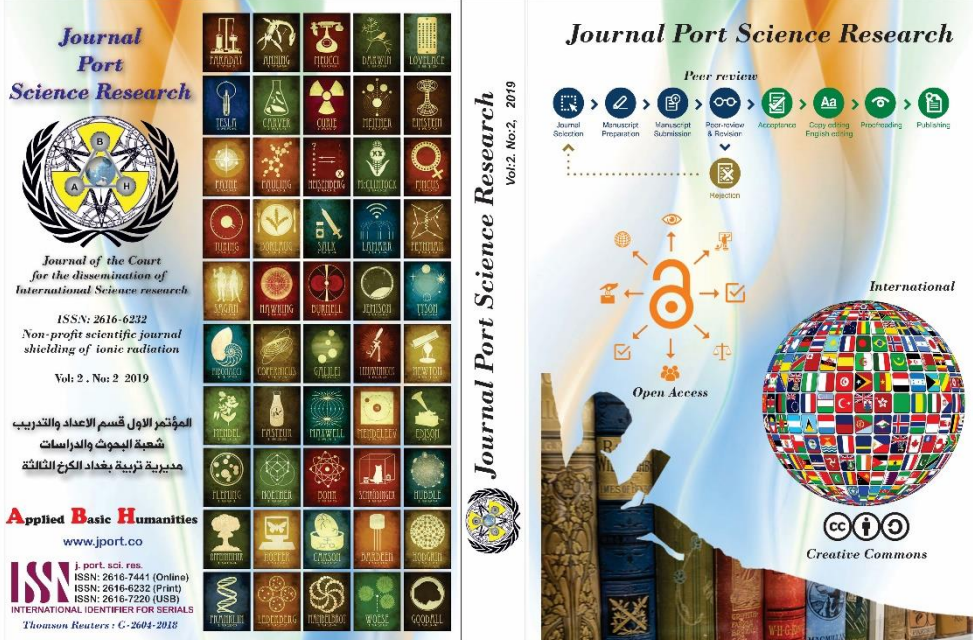
eman.mohammed2017@yahoo.com

زاوية الميل المثلى والاتجاه للألواح الشمسية

ايمان محمد

وزارة التربية، مديرية تربية بغداد الكرخ الثالثة، بغداد، العراق

eman.mohammed2017@yahoo.com



The image displays the cover and logo of the journal. The cover features a grid of 48 icons representing various scientific fields. The logo includes the journal's name, ISSN numbers, and contact information. The cover also highlights the journal's commitment to open access and international reach.

Journal Port Science Research
Vol:2, No:2, 2019

Journal Port Science Research
Journal of the Court
for the dissemination of
International Science research
ISSN: 2616-6232
Non-profit scientific journal
shielding of ionic radiation
Vol:2, No:2 2019

المؤتمر الأول قسم الإعداد والتدريب
شعبة البحوث والدراسات
مديرية تربية بغداد الكرخ الثالثة

Applied Basic Humanities
www.jpport.co

ISSN: 2616-7441 (Online)
ISSN: 2616-6232 (Print)
ISSN: 2616-7220 (USB)
INTERNATIONAL IDENTIFIER FOR SERIALS
Thomson Reuters • C-2604-2018

Journal Port Science Research
Peer review
Journal Selection Manuscript Preparation Manuscript Submission Peer-review & Reviewer Acceptance Copy editing English editing Pre-proofing Publishing
Selection
Open Access
International
Creative Commons

View for up <https://jpport.co>

To cite this article: Published 2019 • © 2019 Bryant University United States of America Publishing Ltd.



The optimum tilt angle and orientation for Solar panels

Eman Mohammed

Directorate of Baghdad Education Karkh III, Ministry of Education, Baghdad, Iraq

eman.mohammed2017@yahoo.com

Abstract In this paper we present evaluated the performance of four small PV modules at different tilt angle and analyze the relationship of solar radiation power Production with the angle by using actual measurement data for all months of the year and in August specially. And then study the relationship between the solar radiation and output power. We installed these panels in four angles at 0°, 15°, 30°, 45°, and fixed solar panel all the month of the year and fixed in august especially to study the daily solar radiation in summer. The results indicate that the highest output power of the PV is obtain in July at the 35° tilt surface for all day's year.

Keywords: Energy, Solar radiation, Solar Panels.

زاوية الميل المثلى والاتجاه للألواح الشمسية

ايمان محمد

وزارة التربية، مديرية تربية بغداد الكرخ الثالثة، بغداد، العراق

eman.mohammed2017@yahoo.com

المستخلص في هذه الورقة، قمنا بتقييم أداء أربع وحدات PV صغيرة في زاوية ميل مختلفة، وتحليل العلاقة بين طاقة الإشعاع الشمسي والإنتاج والزوايا باستخدام بيانات القياس الفعلية لجميع أشهر السنة وفي أغسطس بشكل خاص. ومن ثم دراسة العلاقة بين الإشعاع الشمسي والطاقة الناتجة. لقد قمنا بتركيب هذه الألواح بأربع زوايا عند درجة حرارة 0 درجة و15 درجة و30 درجة و45 درجة وطاقة شمسية ثابتة طوال شهر السنة وثابتة في أغسطس خاصة لدراسة الإشعاع الشمسي اليومي في الصيف، وتشير النتائج إلى أن أعلى يتم الحصول على الطاقة الإنتاجية PV في يوليو على سطح الميل 35 درجة طوال العام.

الكلمات الدالة: الطاقة، الإشعاع الشمسي، الألواح الشمسية.

Introduction

Photovoltaic (PV) Panels collect and absorbs solar radiation directly from the sun, and transforming it into electrical energy [1] by produce electron-hole pairs and generated the current and voltage During the photon's incident on semiconductor material of panel give their energy [2] to the electron to break the potential barriers of the p-n junction and exist the semiconductor surface to generating an electrical current [3] The output power of a PV module depends on two parameters :

- 1) Temperature of the cell, when the temperature increases, thus leading to a reduction in maximum power [4].
- 2) Solar radiation incident, the power output increase with the incident radiation for example when the sun's rays are perpendicular to the panel's surface the collected of solar radiation most efficiently therefore the PV panels must be orient horizontally to face the sky directly to allow the panels collect the large amount of solar radiation [5]

The optimal tilt angle for panel in the winter will differ from it in the summer because of the angle of the sun varies throughout the season of the year as shown in fig (1)[6]

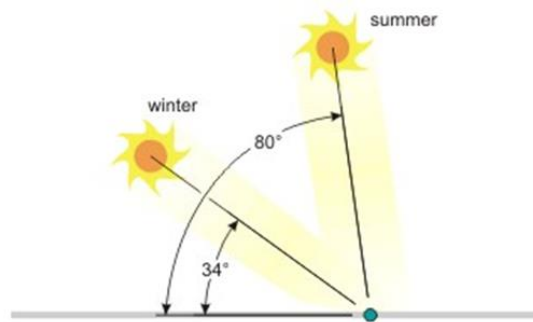


Fig (1) the angle of the sun in summer and winter

the important step to determine the optimal orientation is review the site of PV system between the trees, [7] high building which drop this shadow on the panel as well as the position of the panel from the equator for example in the north position [8] the panel must face south vice- versa if south of equator [9] The amount of incident radiation became the maximum value on equator line because of the incident angle equal to zero which lead [10] to the sunshine cut the minimum distance through air atmosphere, symbolizes for this distance L_0 if the radiation incident in another angle more than zero in this case it will cut a path longest , it is symbol L . [11] The effect of the air atmosphere on solar radiation (absorption, reflection, scattering) called air mass (AM) [12] is define in the equation.

$$AM = \sec Z \dots\dots\dots (1)$$

Which Z the incident angle

To achieve a maximum amount from solar energy incident on the earth must oriented the solar panel in direction which the incident angle of solar radiation has the minimum value [13] because of the value of solar incident on the panel approximated from maximum value $1000\text{W}/\text{m}^2$ [14] Experimentally cannot achieve the maximum amount of solar power ($1000\text{W}/\text{m}^2$) because of many factor such as the cloud, dust, smoke, [15] which lead to reduce the amount of the solar radiation incident to the panel, as well as the sun position in the sky which cause the variation of incident angle for the radiation [16].

Materials and Methods

Four PV modules facing towards the south in roof of the building to reach the maximum solar radiation without any shadow with various tilt angles of 0° , 15° , 35° and 45° have been installed.



The dimension of each module is 0.5 m×0.2 m, with an area of about 0.1 m², and consists of 33 solar cells, the brand used solar panel is (JS Solar) manufacturer in China.

Results and discussion

Solar radiation and power output data have been measured in each season for each PV module and their relationships with the tilt angle have been investigated. The monthly total solar radiations of different tilt angles are shown in fig 1, the tilt angle receive the largest radiation was 45 between February and march, 35 between Jun and July, 15 in July, 0 in Jun Fig (2) show the relationship between the solar radiations with time in (h) to long day for four tilt angles in July month from 6 a.m. to the 5p.m. this fig show the amount of solar radiation change for different time in the day because of the position of the sun is not standard. The maximum value of output radiation appeared in afternoon since the sun is perpendicular to the panel surface which leads the air mass (AM) equal to one. Fig 3 show the relationship between radiation intensity and power output the fig certain that the relation between them is linear, which can be put in the formula equation: $E = 0.1073 I - 0.357$ Where E is the power output MJ/m², I is the solar radiation MJ/m²

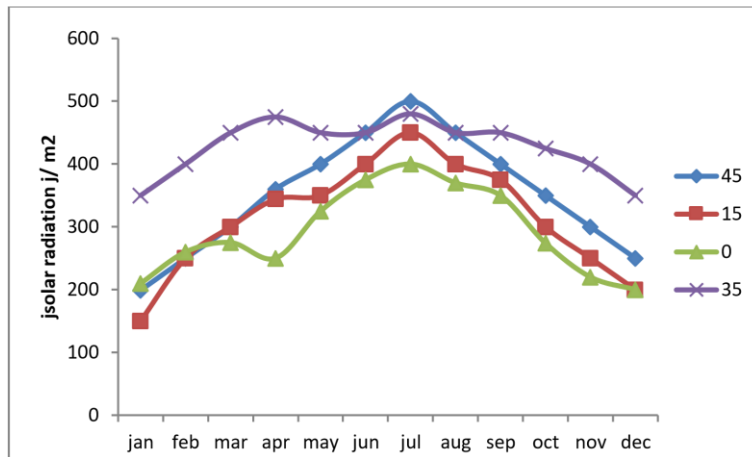


Fig (2) Monthly Solar Radiation for Various Tilt Angles (0,15 ,35 ,45)

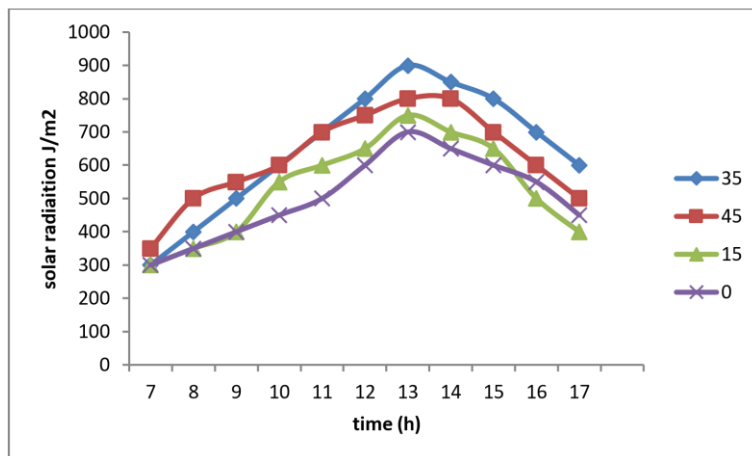


Fig (3) the solar radiation with the time for four tilt angles to day in July 2018

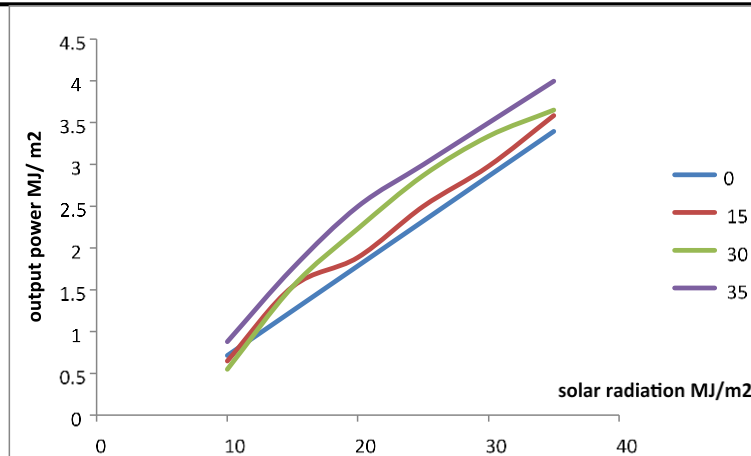


Fig (4) the output power versus solar radiation for various tilt angle

Conclusion

In this paper four solar panels with radiation meter orientation towards south for various tilt angle 00, 150, 350, 450 which installed in Baghdad .

From the relationship between the tilt angles, solar radiation and power output one can be found that :

- 1) The solar radiation in summer month in Iraq has the large amount comparative with the winter month and then the output of the panel becomes more efficiency .
- 2) The optimum tilt angle 35 0 for all the day in the year
- 3) The angles 45, it is good in winter to give to solar panel more solar radiation .
- 4) The favorite time to get the maximum value of solar radiation for the day in afternoon hours '
- 5) The relationship between solar radiation and output power is linear.

References

- [1] B.SRINIVAS, S.BALAJI, M. N. B. Y. S. R. (2015). REVIEW ON PRESENT AND ADVANCE MATERIALS FOR SOLAR CELLS. *International Journal of Engineering Research- Online*, 3, 178–182.
- [2] Islam, T. (2014). Household level innovation diffusion model of photo-voltaic (PV) solar cells from stated preference data. *Energy Policy*, 65, 340–350. <https://doi.org/10.1016/j.enpol.2013.10.004>
- [3] Castañer, L., Bermejo, S., Markvart, T., & Fragaki, K. (2012). Energy Production by a PV Array. In *Practical Handbook of Photovoltaics* (pp. 645–658). Elsevier Ltd. <https://doi.org/10.1016/B978-0-12-385934-1.00018-0>
- [4] Sugathan, V., John, E., & Sudhakar, K. (2015, August 12). Recent improvements in dye sensitized solar cells: A review. *Renewable and Sustainable Energy Reviews*. Elsevier Ltd. <https://doi.org/10.1016/j.rser.2015.07.076>



- [5] Shu, N., Kameda, N., Kishida, Y., & Sonoda, H. (2006). Experimental and Theoretical Study on the Optimal Tilt Angle of Photovoltaic Panels. *Journal of Asian Architecture and Building Engineering*, 5(2), 399–405. <https://doi.org/10.3130/jaabe.5.399>.
- [6] Zang, H., Guo, M., Wei, Z., & Sun, G. (2016). Determination of the optimal tilt angle of solar collectors for different climates of China. *Sustainability (Switzerland)*, 8(7), 1–16. <https://doi.org/10.3390/su8070654>
- [7] Kaldellis, J., Kavadias, K., & Zafirakis, D. (2012). Experimental validation of the optimum photovoltaic panels' tilt angle for remote consumers. *Renewable Energy*, 46, 179–191. <https://doi.org/10.1016/j.renene.2012.03.020>.
- [8] Shu, N., Kameda, N., Kishida, Y., & Sonoda, H. (2006). Experimental and Theoretical Study on the Optimal Tilt Angle of Photovoltaic Panels. *Journal of Asian Architecture and Building Engineering*, 5(2), 399–405. <https://doi.org/10.3130/jaabe.5.399>.
- [9] Razykov, T. M., Ferekides, C. S., Morel, D., Stefanakos, E., Ullal, H. S., & Upadhyaya, H. M. (2011). Solar photovoltaic electricity: Current status and future prospects. *Solar Energy*, 85(8), 1580–1608. <https://doi.org/10.1016/j.solener.2010.12.002>.
- [10] Kacira, M., Simsek, M., Babur, Y., & Demirkol, S. (2004). Determining optimum tilt angles and orientations of photovoltaic panels in Sanliurfa, Turkey. *Renewable Energy*, 29(8), 1265–1275. <https://doi.org/10.1016/j.renene.2003.12.014>
- [11] Al-Sarray, E., & Jabbar, A. (2018). Investigate the ability of the eggshell to attenuate the gamma and beta rays as compared with composite $\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$. *Nuclear Science*, 313(1), 16–22. <https://doi.org/10.11648/j.ns.20180301.13>.
- [12] Eltbaakh, Y. A., Ruslan, M. H., Alghoul, M. A., Othman, M. Y., Sopian, K., & Fadhel, M. I. (2011, April). Measurement of total and spectral solar irradiance: Overview of existing research. *Renewable and Sustainable Energy Reviews*. <https://doi.org/10.1016/j.rser.2010.10.018>.
- [13] Xu, R., Ni, K., Hu, Y., Si, J., Wen, H., & Yu, D. (2017). Analysis of the optimum tilt angle for a soiled PV panel. *Energy Conversion and Management*, 148, 100–109. <https://doi.org/10.1016/j.enconman.2017.05.058>.
- [14] Shnishil, A. H., Chid, S. S., Yaseen, M. J., & Alwana, T. J. (2011). Influence of air mass on the performance of many types of PV modulus in Baghdad. In *Energy Procedia* (Vol. 6, pp. 153–159). Elsevier Ltd. <https://doi.org/10.1016/j.egypro.2011.05.018>.
- [15] Ebrahiem, S. A., Falih, E. H., Mahdi, A. M., Shaban, A. H., & Majeed Mahdi, H. A. (1968). Indoor 222 Rn measurement and hazards indices in houses of Al-Najaf province – Iraq Rn Measurement and Hazards Indices in Houses of Al-Najaf Province – Iraq. *AIP Conference Proceedings*, 030003. <https://doi.org/10.1063/1.5039190>
- [16] Lee, C. Y., Chou, P. C., Chiang, C. M., & Lin, C. F. (2009, April 27). Sun tracking systems: A review. *Sensors*. <https://doi.org/10.3390/s90503875>.