Enhancing the efficiency of photovoltaic power system by submerging it in the rivers

Majid Valizadeh[1], Ibtihal Razaq Niama ALRubeei[2], Haider TH. Salim ALRikabi[3], Faisal Theyab Abed[4]
[1,2]Department of Electrical Engineering, Faculty of Engineering, Ilam University, Ilam, Iran
[2,3,4]Department of Electrical Engineering, College of Engineering, Wasit University, Al Kut, Iraq

Article Info

Article history:

Received Aug 19, 2021
Revised Dec 17, 2021
Accepted Dec 28, 2021

Keywords:

Cell performance
Low cost
Renewable energy sources
Solar cell design

ABSTRACT

In light of the advanced technological development in the world, this study aims to use alternative energy for generating electric energy at the lowest cost. Solar cells are devices that have special operating conditions. The most important of these conditions are the temperature of cells and the intensity of solar radiation. Sometimes the climate condition does not match the ideal conditions used for operating solar cells in many regions around the world. Although the Middle East and Iraq in particular, is considered one of the sunniest areas in the world, solar energy cannot be relied upon to generate electric energy effectively because of the problem of high temperature in solar cells in the summer as well as the problem of dust. In this paper, a simple and economical method was designed to overcome the main problems in the operation of solar cells represented by high temperature in solar cells as well as the problem of dust accumulated on the surface of solar cells which impedes the entry of sunlight into those cells. The method is conducted by immersing the solar cells in running water at a distance that should be close to the surface of the water.

Corresponding Author:

Haider TH. Salim ALRikabi
Department of Electrical Engineering, College of Engineering, Wasit University
Al Kut, Wasit, Iraq
Email: hdhiyab@uowasit.edu.iq

1. INTRODUCTION

The demand for electrical energy in Iraq increases dramatically in the summer, especially in the hot daylight hours, when the main use of electric energy is to cool air inside homes and buildings. Iraq is currently suffering from a deficit in the provision of energy continuously due to increased demand. The increased demand for electrical energy makes solar energy an ideal source to fill the deficit. The problem of rising summer temperatures up to 47 degrees celsius leads to a rise in the temperature of the solar cells to high levels which leads to lowering the efficiency of cells. The use of solar cells to generate electricity is one of the modern and advanced technologies that can solve the problem of severe electricity shortage. Thus, using solar cells to generate electrical energy is one of the necessary devices that overcome the acute shortage of electric energy in Iraq. One of the most important problems that face the use of solar cells is the high temperature of the panels, thus reducing the efficiency and age of the cell. The high levels of panels thus affect the efficiency and age of the cell. Table 1 shows the temperatures in Iraq throughout the months of the year [1]. We can see clearly from the table that the summer temperatures are higher than the ideal limits for the operation of solar cells, so the temperature of solar cells will be higher than the weather temperature because they are dark bodies. For example, if the air temperature is 45 degrees celsius, the cell temperature will be about 70 degrees celsius. In addition, it shows the average maximum temperature in all months of the year. It is noted that the maximum temperature may reach 48.3 °C in August which must be taken into account in the design calculations.

A large amount of radiation falling on the solar cell panels is converted to heat. The efficiency of solar cell would be decreased by 0.5% because of the heat of solar panel for increasing one temperature degree, and it depends on the type of solar cell used and its specifications [2], [3]. The study aims to overcome the main problems in the operation of solar cells of the high temperature in solar cells and dust accumulated on the surface of solar cells which obstructs the entry of sunlight into those cells. One of the factors that help in achieving this project is that all Iraqi cities are located on rows of rivers. It makes the sources of power generation close to the consumption areas. To achieve this aim, we need to do the following: we need a solar cell that produces electrical energy as required by consumers. In addition, silicone material is required for protecting the electrical circuits. Moreover, fixed substrates are necessary to install the solar cell which allows immersing the surface of solar cells for about 10 cm. To keep 10 cm, it should be installed by a solid iron frame. Also, the run water is needed to prevent algae from gathering on the surface of the cell. The development in this paper is using an economical method which is the exploitation of available running water to cool the solar cell without any energy consumption with the lowest cost. Another development is getting high efficiency for producing electrical energy.

Table 1. The temperature of weather throughout the year in the south of Iraq

Element: mean max. temp. (°C)												
Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
2011	_	22.1	29.5	31.7	38.8	43.9	46.9	45.4	41.9	38.2	26.9	19.2
2012	18.0	19.9	26.3	33.9	39.8	43.7	46.6	46.0	42.0	36.2	24.9	22.7
2013	18.2	20.4	28.0	33.6	40.1	46.0	45.3	48.3	42.4	36.8	24.1	15.0
2014	15.7	21.8	25.7	31.6	41.1	44.4	45.7	46.2	43.2	38.0	27.9	19.5
2015	14.2	20.7	31.2	36.0	40.0	43.8	46.5	47.1	43.1	34.9	25.3	20.2
2016	18.2	23.0	26.9	31.5	40.0	43.2	44.7	45.9	41.4	36.9	25.9	21.9

2. LITERATURE REVIEW AND PROBLEM STATEMENT

At a United Nations Conference about the environment in 2013 held in Nairobi, Kenya, Martin Kobler the special representative of the United Nations Secretary-General for Iraq reported that Iraq faced more than one hundred and twenty sand-dust storms per year and it is expected that Iraq will face three hundred storms per year soon [4]. In [5], [6], the authors indicated a reduction of 30% in flat plate collectors after three working days without cleaning. In [6], [7], a 17% reduction was found in photovoltaic modules efficiency after six days without cleaning. In Saudi Arabia, the authors found a reduction of 7% in photovoltaic panel performance [8], [9]. In [10], [11], researchers reported a 40% reduction in photovoltaic panels efficiency in six months of the Saudi Arabian and Qatar weather. In Mozumder *et al.* [12], Alamoud adduced an efficiency decrement from 5.73% to 19.8%. The variation depended on the type of module exposed to the Saudi environment. Hasan and Sayigh examined the reduction in transmittance due to the tilt angle variation of panels [13]. The study was conducted during thirty-eight continuous days in the Kuwait region. Also, the authors suggested using an auto-cleaning robot to avoid the effects of accumulated dust on solar panel transmittance [14]. Chandela and Agarwal examined using inorganic phase change materials for photovoltaic cooling. A study suggested that inorganic phase change materials have a good potential for photovoltaic cooling [15], [2]. The market review suggests that materials-based photovoltaic cooling technology is not yet commercialized due to its inefficiency primarily because of technological challenges, high system costs, and non-availability of reliable operating designs [16]-[19]. It is noted in the below map that the regions of southern Iraq are located on the same latitude as the regions of North Africa, which are considered one of the best regions in the world for solar energy production, but the Iraq region is not suitable for energy production, due to the bad desert climate in southern Iraq. On the other hand, the Mediterranean climate affects positively the regions of North Africa [20]-[29]. The region of this study is located in Iraq, in the Middle East continent. Degrees minutes seconds (DMS) latitude longitude coordinates for Al- Basra are: 30°31'58.87"N, 47°47'50.89"E. Researchers have found many methods for solving the problem of high-temperature solar cells, and these methods can be classified according to the obstacles which make it difficult to implement these solutions. First, some researchers use expensive materials or complicated technologies as in [12]-[17]. The problem here is the high costs and economic incompatibility; usually these studies make cells very expensive, as is the case with the study by Chande. Second**,** the problem of energy consumption; in these studies, the researchers added devices to cool the solar panels like fans, but these devices are a burden on the solar cells because they consume part of their energy [20], [21]. Some researchers relied on natural ventilation, and these methods give a limited cooling effect, which may not even exist on some hot days. Third, the problem of high costs and economic incompatibility; usually these studies make cells very expensive, as is the case with the study by Chande. Table 2 shows the amount of weather temperature, as well as the temperature of the solar cell panel and, compares it with the standard temperature of the solar panel. In addition, Figure 1 shows the appropriate time for working solar cells. It is drawn by using an Excel sheet.

Table 2. Showing the temperature of weather and solar panel throughout the year

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean max. temp. (C°)	17	20	29	32	40	44	46	47	42	38	26	20
Temp. of solar panel (C°)	22	28	42	47	56	64	68	70	63	57	42	35
Standard temp. of solar panel (C°)	25	25	25	25	25	25	25	25	25	25	25	25

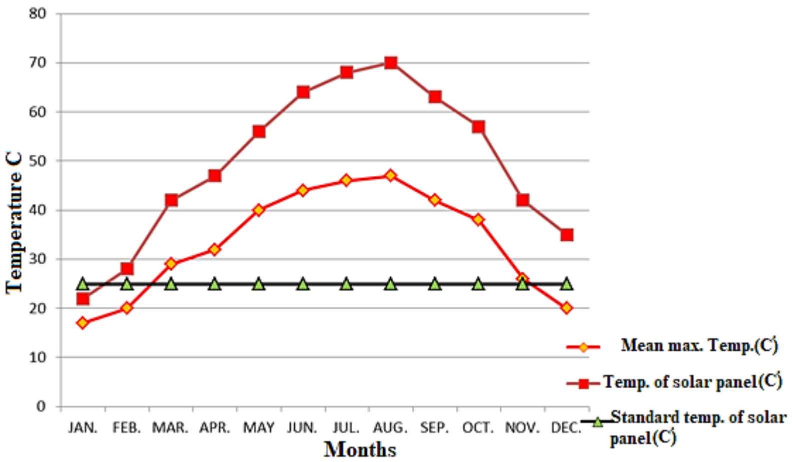

Figure 1. It is showing the appropriate time for working solar cells in the south of Iraq

Curve A represents the temperature of the solar panel throughout the months of the year; while curve B represents weather temperatures throughout the months of the year. In addition, straight-line C represents the standard solar cell temperatures over the year. The intersection points of curve A with C represent the appropriate time for the operation of the solar cells. When the distance between A and C increases, the efficiency of the solar cell will decrease. We can see from the graph that the efficiency of solar cells during July and August will be at the lowest levels. The two most important problems facing solar energy investment are high temperatures and dust.

3. THE PROBLEM OF OVERHEATING OF THE SOLAR CELL PANEL, AND WAY TO REDUCE IT (COOLING SOLAR CELL PANELS)

3.1. Air cooling

There are two main methods of air cooling natural ventilation and forced ventilation. Firstly, the natural ventilation method uses the water surrounding the solar cells to reduce temperature. The temperature can be reduced by designing the cell fins. One of the major disadvantages of this method is the fluctuation of the temperature of the solar cells [22]. In the second method, the temperature can be reduced by flowing water in the front and back of the cell. This method causes an increase in the output of electrical energy by 8%, but it causes a large consumption of fan energy [23].

3.2. Water-based cooling

Firstly, passive cooling mainly relies on water to cool the solar cells without using electric pumps. It is provided if the contact between the cell and the collector system is good. In addition, the excess heat should be removed from the water [24], [25]. Secondly, Active cooling mainly relies in cooling the solar cell panels will be good when the water flow increases. Also, this increased inflow leads to an increase in the efficiency of the plate to produce electrical energy up to 9% [26], [27]. Finally, liquid immersion cooling which make the solar cell panels will maintain their temperature at 30-45° C, the excess heat in the solar cell panels will be eliminated by immersing them in a dielectric liquid in an elongated tube [10], [11].

3.3. Thermoelectric cooling

In this method, the extra heat produced from the cell plate is converted to electrical energy. Using this technique leads to an increase in the cell efficiency for producing electrical energy by 8%-23% [28]. In addition, there is a lot of studies that used cooling methods to reduce the temperature cell. In [28], [29], a nano-liquid was used to cool the cell, and it was found to cause an increase in thermal efficiency by 12.8%. In [30], [31], the effect of the nanogram thickness of water/magnesium was studied by concentrating magnesium in water.

4. THE PROBLEM OF DUST AND SAND STORMS AND THE WAY TO REDUCE IT (CLEANING SOLAR CELL PANELS)

Sandstorms and dust are major challenges in investing solar energy by cells in the Middle East region generally and in Iraq particularly. Dust reduces the sunlight entering the cells, so a permanent cleaning process is required, hence increasing production costs. It makes the energy production process of solar cells costly and economically useless [32]-[34].

- The natural method (wind lift, wind-induced vibration).
- The electromechanical method (shaking by sound our mechanical actuators).
- The mechanical method (cleaning tools, cleaning robot systems).
- The electrical method (electrostatic and electrodynamics).
- The physical-chemical method (self-cleaning materials).

4.1. MATERIALS AND METHODS TO IMPROVE THE EFFICIENCY OF THE SOLAR CELL

4.1.1. Materials and equipment used in the experiment

The solar cell used in the practical experiment was produced by a company. Figure 2 shows the characteristics of the solar cell panel. The solar cell used in this study has a datasheet characteristic of the solar cell panel for standard conditions. It has model no: S/P-250W, Pmax 250 Wp, Tolerance ±3%, Vmp 30.8 V, Imp 8.12 A, Voc 37.6 V, Isc 8.94, maximum system voltage 100 V, size 1640 mm×992 mm×35 mm. This condition is for every solar panel to get tested with a temperature equal to 25 °C, 1000 watt/square meter light intensity, and sun angle directly perpendicular to the solar panel, and 1.5 atmospheric density.

4.1.2. The technique for solar cells efficiency improvement

The solar cell was submerged in the waters of the Tigris River under different condition. In addition, a simulation of river water conditions for different seasons of the year has been done in terms of temperature and water quality through the use of a water pool filled with water as shown in the Figure 2. In addition, protection has been made for the electrical circuits behind the photovoltaic panels by using a silicone material to prevent water from entering into the cell's electrical circuits during the operation process.

(a) (b)

Figure 2. It shows that the practical experience of submerging the solar cell in the waters: (a) at the Tigris River in southern Iraq and (b) at a water pool

5. RESULTS OF COMPARING THE INDICATORS OF THE SOLAR CELL IN TWO CASES

The data and efficiency of the solar cell were recorded and compared to the traditional method and the method used in this paper. The results obtained were shown in the Table 3. Table 3 shows that the efficiency of the solar panels when it is immersed under the water. From the table, we notice that the production efficiency is almost constant when using the second method, while production efficiency is fluctuating and unstable in the first method. In addition, Figure 3 shows a comparison of the efficiency of the solar cell in air and immersion. From the Table 3, we notice that the production efficiency is almost constant when using the second method, while production efficiency is fluctuating and unstable in the first method. The values are percentages of the panel's standard efficiency.

Table 3. The efficiency of the solar cell in air and immersion

Year	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean max. temp. (C°)	17	20	29	32	40	44	46	47	42	38	26	20
Temp. of solar cell (C°)	22	28	42	47	56	64	68	70	63	57	42	35
Efficiency of solar cell in air %	96	97	81	76	67	61	54	48	60	63	80	89
Efficiency of solar cell under water surface %	93	95	96	97	94	96	97	97	94	95	92	91

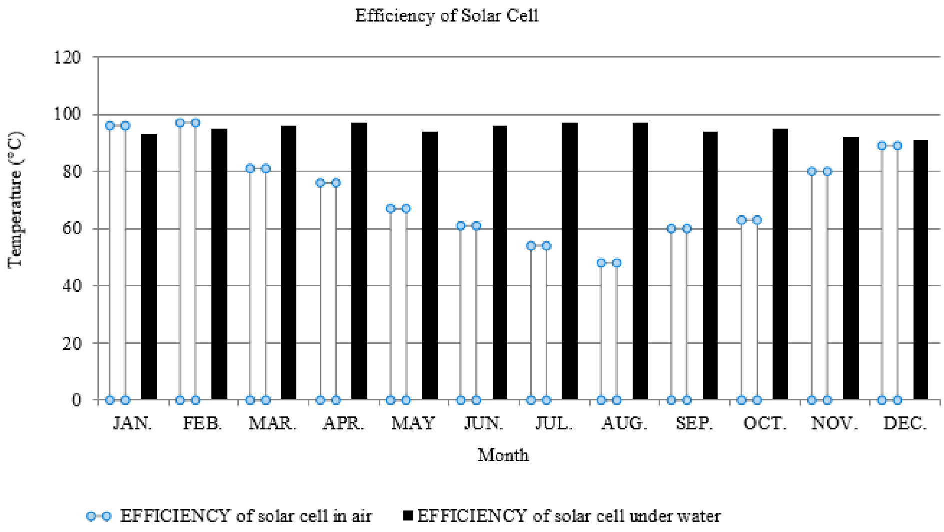

Figure 3. The efficiency of the solar cell in air and immersion

6. DISCUSSION OF EXPERIMENTAL RESULTS

In this implementation, the entry of sunlight into the solar cells will be smooth and the cell will maintain its ideal temperature, which is the same as the river water temperature (20-30) degrees celsius. In addition, the surface of solar cells does not need cleaning from dust because it is submerged underwater. Moreover, it leads to a reduction in the cost of production of electrical energy, and thus increases the efficiency of production. Obstacles that the researchers encountered during the implementation of the current project were in installing the substrates for the solar panels in the river. One of the obstacles of this method is the growth of algae in pools and leaks and this can be overcome by setting up the solar panels in running water.

7. CONCLUSION

The method used in this study is considered the best solution which is economical and eco-friendly to overcome the two problems of high temperatures, and dusty weather during the months of the year. Firstly, this method is characterized by effectiveness, simplicity, and ease of implementation due to the possibility of using commercial solar cells which are currently available at the national market without needing to change the designs of the cells or using new materials in their manufacture. In addition, the investment of solar energy in electricity generation is possible and economically feasible after it had been very difficult due to the problems of high temperatures, and the amount of dust that accumulates on the solar panel. Secondly, all solutions used in this study are sustainable solutions in terms of cooling the solar cell and cleaning it from the dust. Moreover, this method has high suitability with the increasing demand on the energy consumption in Iraq during the summer days. Therefore, the solar units can be connected directly to the National Electricity Network without the need for storage. Finally, this method is characterized by low costs of energy transferring because all Iraqi cities are located at the seaside of rivers.

REFERENCES

[1] H. F. Khazaal, H. T. Alrikabi, F. T. Abed, and S. I. Kadhm, "Water desalination and purification using desalination units powered by solar panels," *Periodicals of Engineering and Natural Sciences*, vol. 7, no. 3, pp. 1373-1382, 2019, doi: 10.21533/pen.v7i3.748.
[2] S. Chandel and T. J. Agarwal, "Review of cooling techniques using phase change materials for enhancing efficiency of photovoltaic power systems," *Renewable and Sustainable Energy Reviews*, vol. 73, pp. 1342-1351, 2017, doi: 10.1016/j.rser.2017.02.001.
[3] H. Tuama, H. Abbas, N. S. Alseelawi, and H. T. Salim, "Bordering a set of energy criteria for the contributing in the transition level to sustainable energy in electrical Iraqi Projects," *Periodicals of Engineering and Natural Sciences*, vol. 8, no. 1, pp. 516-525, 2020, doi: 10.21533/pen.v8i1.1183.g533.
[4] A. A. Kazem, M. T. Chaichan, and H. Kazem, "Dust effect on photovoltaic utilization in Iraq," *Renewable and Sustainable energy reviews*, vol. 37, pp. 734-749, 2014, doi: 10.1016/j.rser.2014.05.073.
[5] A. Sayigh, "Effect of dust on flat plate collectors," in *Sun: Mankind's Future Source of Energy: Elsevier*, 1978, pp. 960-964, doi: 10.1016/B978-1-4832-8407-1.50190-2.
[6] S. Karki, K. R. Haapala, and B. Fronk, "Technical and economic feasibility of solar flat-plate collector thermal energy systems for small and medium manufacturers," *Applied Energy*, vol. 254, pp. 113649, 2019, doi: 10.1016/j.apenergy.2019.113649.
[7] F. J. Wakim, "Introduction of PV power generation to Kuwait," *Kuwait Institute for Scientific Researchers*, 1981
[8] S. A. M. Said, "Effects of dust accumulation on performances of thermal and photovoltaic flat-plate collectors," *Applied Energy*, vol. 37, no. 1, pp. 73-84, 1990, doi: 10.1016/0306-2619(90)90019-A.
[9] Y. Firdaus, V. M. Corre, J. I. Khan, Z. Kan, F. Laquai, P. M. Beaujuge, and T. Anthopoulos, "Key Parameters Requirements for Non-Fullerene-Based Organic Solar Cells with Power Conversion Efficiency> 20%," *Advanced Science*, vol. 6, no. 9, pp. 1802028, 2019, doi: 10.1002/advs.201802028.
[10] S. Ghazi and A. Sayigh, "Dust effect on flat surfaces–A review paper," *Renewable and Sustainable Energy Reviews*, vol. 33, pp. 742-751, 2014, doi: 10.1016/j.rser.2014.02.016.
[11] A. A. Hachicha, I. Al-Sawafta, and Z. Said, "Impact of dust on the performance of solar photovoltaic (PV) systems under United Arab Emirates weather conditions," *Renewable Energy*, vol. 141, pp. 287-297, 2019, doi: 10.1016/j.renene.2019.04.004.
[12] M. S. Mozumder, A.-H. I. Mourad, H. Pervez, and R. Surkatti, "Recent developments in multifunctional coatings for solar panel applications: A review," *Solar Energy Materials and Solar Cells*, vol. 189, pp. 75-102, 2019, doi: 10.1016/j.solmat.2018.09.015.
[13] A. Hasan and A. Sayigh, "The effect of sand dust accumulation on the light transmittance, reflectance, and absorbance of the PV glazing," *Technology and the Environment*, *Pergamon Press, Oxford*, pp. 461-466, 1992.
[14] H. T. Salim. M. Farhan, and D. Hasan, "Impact of Temperature and Dust Deposition on PV Panel Performance," in *AIP conference proceedings*, 2021, vol. 2394, no. SICPS2021: AIP Publishing LLC.
[15] M. M. Islam, A. K. Pandey, M. Hasanuzzaman, and N.A Rahim, "Recent progresses and achievements in photovoltaic-phase change material technology: A review with special treatment on photovoltaic thermal-phase change material systems," *Energy Conversion and Management*, vol. 126, pp. 177-204, 2016, doi: 10.1016/j.enconman.2016.07.075.
[16] S. Manju and N. J. Sagar, "Progressing towards the development of sustainable energy: A critical review on the current status, applications, developmental barriers and prospects of solar photovoltaic systems in India," *Renewable and Sustainable Energy Reviews*, vol. 70, pp. 298-313, 2017, doi: 10.1016/j.rser.2016.11.226.
[17] S. H. Alawaji, "Evaluation of solar energy research and its applications in Saudi Arabia—20 years of experience," *Renewable and Sustainable Energy Reviews*, vol. 5, no. 1, pp. 59-77, 2001, doi: 10.1016/S1364-0321(00)00006-X.
[18] H. Alrikabi, M. Farhan, and T. N. Sultan, "Investigation The Factors Affecting on The Performance of PV System," in *AIP conference proceedings*, 2021, vol. 2394, no. SICPS2021: AIP Publishing LLC.
[19] F. T. Abed, H. T. S. ALRikabi, and I. A. Ibrahim, "Efficient Energy of Smart Grid Education Models for Modern Electric Power System Engineering in Iraq," in *IOP Conference Series: Materials Science and Engineering*, 2020, vol. 870, no. 1, pp. 012049: IOP Publishing, doi:10.1088/1757-899X/870/1/012049.
[20] K. Zweibel, *Harnessing solar power: The photovoltaics challenge*, Boston, MA, USA: Springer, 2013, doi: 10.1007/978-1-4899-6110-5.
[21] N. A. Hussien, A. A. D. Al-Magsoosi, H. T. S. AlRikabi, and F. T. Abed, "Monitoring the Consumption of Electrical Energy Based on the Internet of Things Applications," *International Journal of Interactive Mobile Technologies*, vol. 15, no. 7, pp. 17-29, 2021, doi: 10.3991/ijim.v15i07.20183.
[22] J. Arce, M. J. Jiménez, J. D. Guzmán, M. R. Heras, G. Alvarez, and J. Xamán, "Experimental study for natural ventilation on a solar chimney," *Renewable Energy*, vol. 34, no. 12, pp. 2928-2934, 2009, doi: 10.1016/j.renene.2009.04.026.
[23] K. Rishi, M. Balachandran, G. Raagul, A. Srinivasagopalan, B. Ramkiran and P. Neelamegam, "Solar Cooling Technologies - A Review," *2018 International Conference on Computation of Power, Energy, Information and Communication (ICCPEIC)*, 2018, pp. 174-178, doi: 10.1109/ICCPEIC.2018.8525162.
[24] M. A. Al Mohsen, S. Ismail, and I. S. Ismail, "Improving Thermal Comfort Through Natural Ventilation and Passive Solar Systems in Residential Buildings in Iraq," in *ICACE 2019*: Springer, 2020, pp. 207-216.
[25] A. E. Mohamed, "Comparative study of four supervised machine learning techniques for classification," *International Journal of Applied*, vol. 7, no. 2, 2017.
[26] D. Du, J. Darkwa, and G. J. Kokogiannakis, "Thermal management systems for photovoltaics (PV) installations: a critical review," *Solar Energy*, vol. 97, pp. 238-254, 2013, doi: 10.1016/j.solener.2013.08.018.
[27] S. Krauter, "Increased electrical yield via water flow over the front of photovoltaic panels," *Solar energy materials and solar cells*, vol. 82, no. 1-2, pp. 131-137, 2004, doi: 10.1016/j.solmat.2004.01.011.
[28] W. Van Sark, "Feasibility of photovoltaic–thermoelectric hybrid modules," *Applied Energy*, vol. 88, no. 8, pp. 2785-2790, 2011, doi: 10.1016/j.apenergy.2011.02.008.
[29] Q. Zhang and J. Liu, "Nano liquid metal as an emerging functional material in energy management, conversion and storage," *Nano Energy*, vol. 2, no. 5, pp. 863-872, 2013, doi: 10.1016/j.nanoen.2013.03.002.
[30] O. C. Olawole *et al.*, "Innovative methods of cooling solar panel: A concise review," in *Journal of Physics: Conference Series*, 2019, vol. 1299, no. 1, pp. 012020, doi: 10.1088/1742-6596/1299/1/012020.
[31] T. N. Sultan, M. S. Farhan, and H. T. ALRikabi, "Using Cooling System for Increasing the Efficiency of Solar Cell," in *Journal of Physics: Conference Series*, 2021, vol. 1973, no. 1, pp. 012129, doi: 10.1088/1742-6596/1973/1/012129.
[32] T. Sarver, A. Al-Qaraghuli, and L. Kazmerski, "A comprehensive review of the impact of dust on the use of solar energy: History, investigations, results, literature, and mitigation approaches," *Renewable and sustainable energy Reviews*, vol. 22, pp. 698-733, 2013, doi: 10.1016/j.rser.2012.12.065.

[33] H. Zuo *et al*., "Catastrophic analysis on the stability of a large dish solar thermal power generation system with wind-induced vibration," *Solar Energy*, vol. 183, pp. 40-49, 2019, doi: 10.1016/j.solener.2019.03.003.
[34] H. Khonkar *et al.*, "Importance of cleaning concentrated photovoltaic arrays in a desert environment," *Solar Energy*, vol. 110, pp. 268-275, 2014, doi: 10.1016/j.solener.2014.08.001.

BIOGRAPHIES OF AUTHORS

Majid Valizadeh received the B Eng. Degree in electrical engineering from the Kashan University, Kashan, Iran in 2003. He received the MSc and PhD from University of Tabriz, Tabriz, Iran in 2007 and 2013 respectively. He is currently an assistant professor of electrical engineering, Ilam University. He is author and coauthor of some technical journal and international conference papers. His current research interests include renewable energies, protection and power converters in electrical power system and drive. He can be contacted at email: m.valizadeh@ilam.ac.ir

Ibtihal Razaq Niama ALRubeei received the B.Sc Eng. Degree in Electrical Engineering from the University of Technology, Iraq in 2010. She is presently an Engineer in College of Engineering, Electrical Engineering Department, Wasit University in Al Kut, Wasit, Iraq, and master student in electrical engineering, Ilam University. Her current research interests include renewable energies, control system, and Smart Technologies. She can be contacted at email: ibtihalalrubeei82@gmail.com

Haider TH. Salim ALRikabi is presently Asst. Prof and one of the faculty College of Engineering, Electrical Engineering Department, Wasit University in Al Kut, Wasit, Iraq. He received his B.Sc. degree in Electrical Engineering in 2006 from the Al Mustansiriya University in Baghdad, Iraq. His M.Sc. degree in Electrical Engineering focusing on Communications Systems from California state university/Fullerton, USA in 2014. He is author, coauthor, and Editor of some international journals and international conference papers. His current research interests include Communications systems with the mobile generation, Control systems, intelligent technologies, smart cities, Renewable Energies, and the Internet of Things (IoT). Al Kut city – Hay ALRabee, Wasit, Iraq. The number of articles in national databases – 10, and the number of articles in international databases – 42. He can be contacted at email: hdhiyab@ uowasit.edu.iq

Faisal Theyab Abed is a lecturer in the Engineering College, at the Wasit University, Iraq. His area of research focuses on power systems and their applications. He received his B.Sc. degree in Electrical Engineering in 2006 from the Al Mustansiriya University in Baghdad, Iraq. His M.Sc. degree in Electrical Engineering focusing on power systems from Russia in 2017. Al Kut city – Hay ALRabee, Wasit, Iraq.The number of articles in national databases – 4, and the number of articles in international databases – 10. He can be contacted at email: ftheyab@ uowasit.edu.iq