Proceedings of the
International Conference on Mechanical Engineering and Renewable Energy 2019
(ICMERE2019) 11 – 13 December, 2019, Chattogram, Bangladesh

ICMERE2019-PI-210

PERFORMANCE IMPROVEMENT OF SOLAR CELL BY SUBMERGING IN CHEMICALS: A CASE STUDY IN CUET

Mostafizur Rahman[1], Md. Iftekhar Arefin[2*], Faisal Ahmed[3] and Sadnan Mohosin Mondol[4]

[1-4] Department of Mechanical Engineering
Chittagong University of Engineering & Technology, Chattogram-4349, Bangladesh
Email: [1]rmostafiz31@gmail.com, [2*]iftekhararefin22@gmail.com, [3]faisal.cuet16@gmail.com,
[4]smsadnan15@gmail.com

Abstract*: The importance of renewable energy is beyond description as amount of natural resources of energy is decreasing drastically. Hence, it is a timely challenging issue to increase power sources that will meet the demand of power in near future. However, increasing source of power is not a simple task. Moreover, what we can do is to utilize the sources of renewable energy more efficiently and effectively. It is worthy to mention that solar energy is one of the most important sources of renewable energy. This paper focuses on the performance test of a photovoltaic cell submerged in glycerin, water and vinegar to make a comparative study of the results found from photovoltaic cell which is normally exposed to air. This is done as extra undesirable heat is expelled from both front and back surfaces of the cell by directly submerging in different chemicals such as glycerin, water, and vinegar. The immediate contact heat transfer and relatively bigger heat dispersal surface area might gain a satisfactorily low cell temperature which results in greater solar conversion efficiencies. It is noted that higher temperature getting from continuous exposal to air on the cell decrease energy conversion efficiency. Hence, research is carried out to increase performance of photovoltaic cell under several liquids and compare the efficiency with air. In this paper, four photovoltaic cells which are made of having dimension about 60 mm × 60 mm are used for performance test. Three of the cells are submerged in three different liquids (water, vinegar and glycerin) and other one is exposed in air The experimental investigation is performed in CUET student residential area for five days to take data. It is noted that performance of solar cell submerged in water is satisfactory than vinegar, glycerin, and air.*

Keywords: Solar cell, Submerged solar cell, Chemicals, Solar cell effectiveness.

1. INTRODUCTION

Solar photovoltaic systems are attracting lot of attention as electrical power sources that can complement or replace fossil and nuclear fuels power generation systems [1]. However, cost of PV systems is still not competitive with conventional power generation systems. In addition, concentrating photovoltaic (CPV) systems provide economic advantages by combining cheap concentrators with high efficiency solar cells [2]. It is known to all that solar energy is one of the most important sources of renewable energy. A photovoltaic cell or solar cell represents an appliance that transforms the direct solar energy to electrical energy through the procedure of photovoltaic. Photovoltaic solar cells act as a reliable source of electric power in presence of sunlight [3]. Nevertheless, researchers are trying to find out how solar cell power generation system can be improved by modifying solar cell design and submerging solar cell in different chemicals. A submerged photovoltaic cell or solar cell is a concept developed in order to increase efficiency of solar cell. As, energy of sunlight is incurred directly from sun, cost of producing this energy is very low. When the solar panel is exposed in sunlight for long period of time, it gets heated and this heating results in decreasing the rate of producing energy [4]. This is why it is taken as challenging issue to increase efficiency of solar panel by decreasing amount of heat produced in the panel. It is worthy to mention that different approaches are performed to increase effectiveness of solar energy conversion. Most importantly, one of the effective pathway of decreasing heat produced in solar panel and increasing cell performance is to submerge the photovoltaic cell in chemicals such water, vinegar, glycerin etc. [5]. Submerging the solar panel in various liquid which shows the most efficient result in water that is 17.8% than air [6]. The sea water shows increase in power that ranges from 10% to 15%. For experimental issue the De-ionized (DI) water, isopropyl alcohol (IPA), ethyl acetate, dimethyl silicon oil are used as liquid [6]. In this paper, the solar cell is submerged in normal water because of ease availability. In addition, also submerged in chemicals such as vinegar, glycerin as recommended by authors in [7] for making a comparative study.

2. MATERIALS AND METHODOLOGY

An important task of this study is to set up three solar panel board submerged in water, vinegar and glycerin and another board is normally exposed to air. Firstly, four solar panel boards are set up. Latterly, completing the wiring system, a multimeter, which is calibrated with multimeter available in fluid laboratory, CUET is used to take readings of voltage from all solar panel board at the same time. It is aforementioned that this study requires four solar panel boards used to submerge in water,

glycerin and vinegar respectively and another one exposed in air. In addition, dimension of solar panel board is 270 mm × 190 mm × 17 mm weighing 0.55 kg. It is noted that maximum system voltage is 715 volt DC and operating temperature is -40 ^{0}C to +80 ^{0}C. Furthermore, maximum power output of the solar panel is 5 Watt and power tolerance limit is ±3%. The commercial brand name of this solar panel board is RING SOLAR and module type: RL-6P005/18. Secondly, chemicals used to submerge solar panel are glycerin and vinegar. It is worthy to mention that glycerin is chemically tri glyceride alcohol. Pure glycerin is naturally so crystal clear that looks like water, impossible to identify only by eyesight without touching or testing it [8]. In addition, glycerin used in this study is nearly 100% pure purchased from chemical shop. On the other hand, vinegar is chemically solution of 6%-10% acetic acid [9]. There are many types of vinegar available in market such as apple cider vinegar, malt vinegar, rice vinegar, white vinegar etc. Hence, vinegar suitable for this study is white vinegar because of other type's vinegar conflict with the condition of this study for their opacity. Moreover, white vinegar is crystal clear like water and impossible to identify with eyesight and touch sense. It is noted that nearly about 3000 cm^3 to 3500 cm^3 water, vinegar and glycerin is needed to submerge solar panels at fixed depth. Three rectangular-shaped boxes (300mm × 250mm × 100mm) made of manually using cork sheet, are used to submerge the solar panel in different chemicals. After making the box, it has gone through a tough leak proof checking process. Besides, another important thing to complete this study is a multimeter. The multimeter is used to measure voltage produced in the solar panel boards. A Shanghai-zh model multimeter is used that ranges from 10 V DC to 1000 V DC. Shanghai-zh model MF15 multimeter is used where voltage of different ranges can be measured. The circuit diagram used in the solar panel is shown in Fig. 1

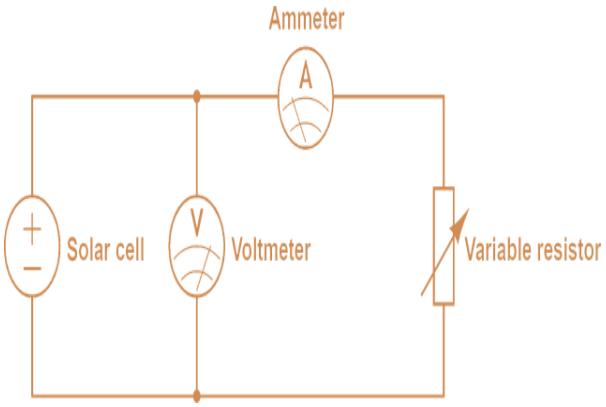


Fig. 1: Circuit Diagram of Solar Panel.

3. DATA COLLECTION & ANALYSIS

In this study, data was taken for six days at one hour interval to show the comparison. It is noticeable that voltage found for air, water, vinegar and glycerin is same at 1100 hrs. since the PV cells were kept in room temperature. Afterward, solar cells were exposed to sunlight together. Hence, the temperature difference was same initially. However, the temperature is increasing and performance of the PV cell is showing a variation as the time goes on. The variation is found with time because four different PV cells are at different fluid with different fluid properties. These different fluid properties create different medium. The specific heat of air is 1.005 kj/kg.K. On the other hand, specific heat of water, vinegar and glycerin is 4.22 kj/kg.K, 2.043 kj/kg.K and 2.32 kj/kg.K respectively [10]. Solar cell submerged in vinegar shows greater performance than glycerin though specific heat of glycerin is greater than vinegar. It is because of the viscosity of glycerin (950 cP) is higher than vinegar (12 cP). It is noted that convection heat transfer process is slower for glycerin than vinegar for higher viscosity [11]. However, water possesses highest specific heat (4.22 kj/kg.K) and lowest viscosity (0.89 cP). That's why PV cell submerged in water has shown highest performance than the other fluids. Furthermore, density of glycerin (1261kg/m^3) is higher than water (1000 kg/m^3) and vinegar (1050kg/m^3) and results in convection heat transfer is lowest compared to water and vinegar.

4. RESULTS AND DISCUSSIONS

Figure 2 shows that initial voltage found is same for all cases because of same initial temperature difference. Hence, time goes on and PV cell exposed to air is getting heated and the temperature difference is decreasing with time. Solar cell exposed to air decreases its voltage producing capacity 50 - 46 V within two hours from 1100 hrs. to 1300 hrs.

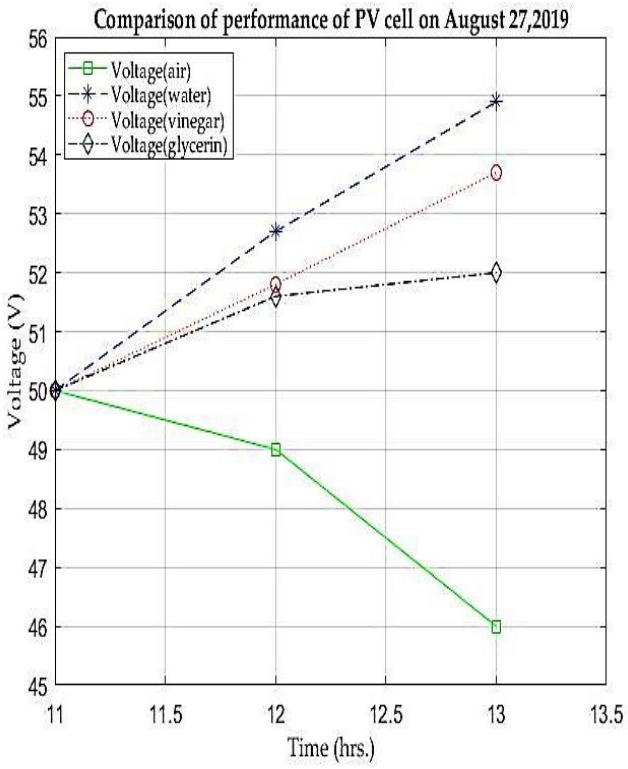
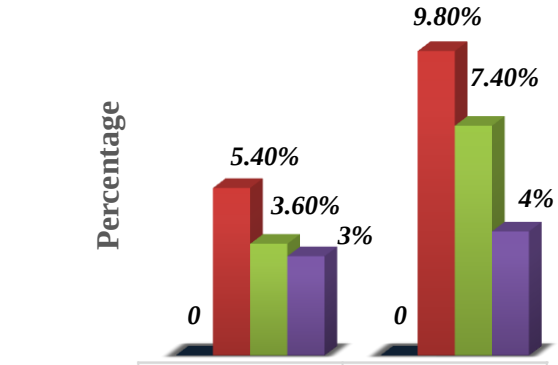


Fig. 2: Comparative performance of PV cell from data dated on August 27, 2019.

In contrast, PV cell submerged in different fluid is not getting heated faster as the PV cell heated exposed in air. Both energy of light and heat is coming from the sun but the heat energy is not necessary for us. It decreases performance of the solar cell [12]. Hence, submerging solar cell in fluid absorbs unnecessary heat produced and increases the performance [13]. Moreover, it depends on characteristics of the fluid and how much the performance is varied, is shown in Fig. 2 for data taken dated on as follows. Performance of PV cell submerged in water, vinegar, and glycerin is shown in Fig. 3. It is noted that performance is increased 3% for glycerin, 3.60% for vinegar, and 5.40% for water in compared with air at time 1200 hrs. On the other hand, performance is increased 4% for glycerin, 7.40% for vinegar, and 9.80% for water in compared with air at time 1300 hrs.



	12	13
Air	0	0
Water	5.40%	9.80%
Vinegar	3.60%	7.40%
Glycerin	3%	4%

Fig. 3: Performance increment of PV cell from data dated on August 27, 2019.

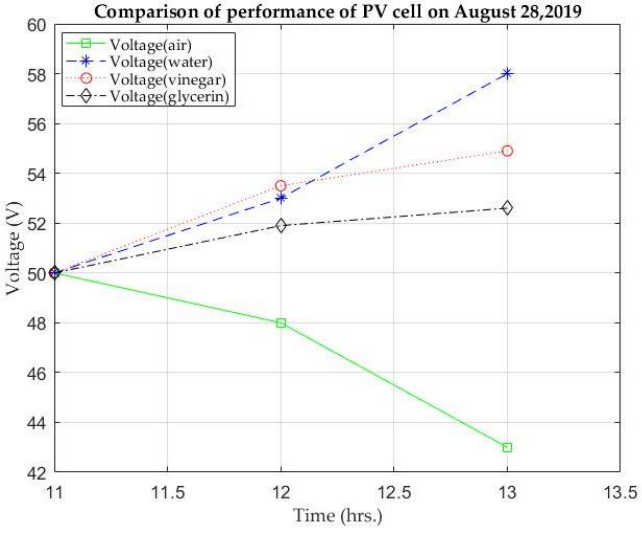
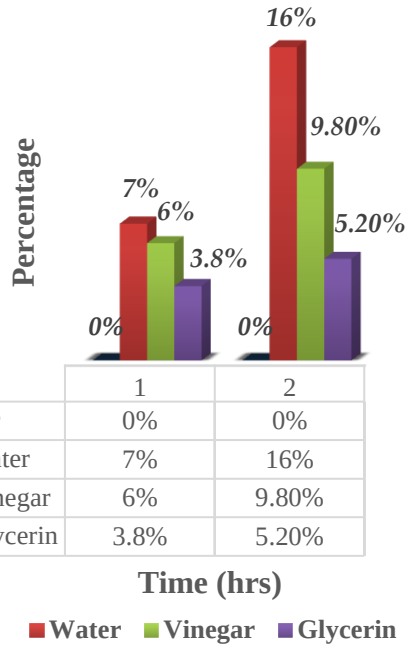


Fig. 4: Comparative performance of PV cell from data dated on August 28, 2019



	1	2
Air	0%	0%
Water	7%	16%
Vinegar	6%	9.80%
Glycerin	3.8%	5.20%

Fig. 5: Performance increment of PV cell from data dated on August 28, 2019

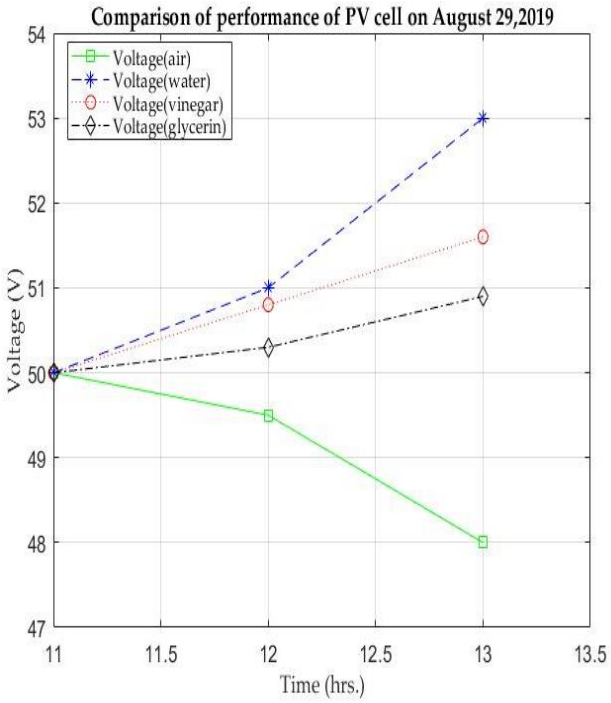


Fig. 6: Comparative performance of PV cell from data dated on August 29, 2019

It is noted that a little bit variation in output voltage and performance increment is observed from data taken dated on August 27, 28, and 29. Intensity of solar energy is not same as all the days. However, main purpose of this study is satisfied whatever the solar intensity is. It is worthy to mention that performance of solar cell submerged in water shows greater performance for each time whatever the output voltage is, depends on solar intensity.

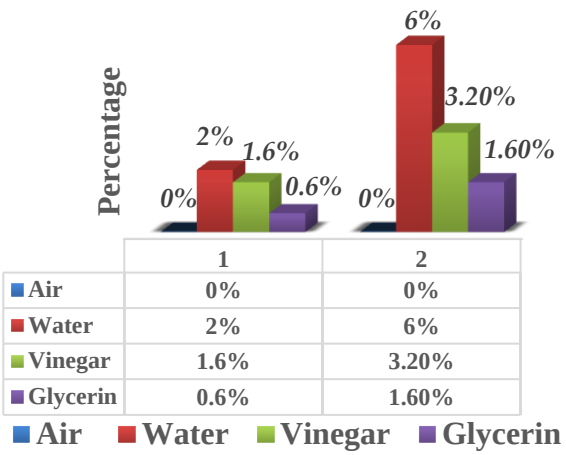


Fig. 7: Performance increment of PV cell from data dated on August 29, 2019

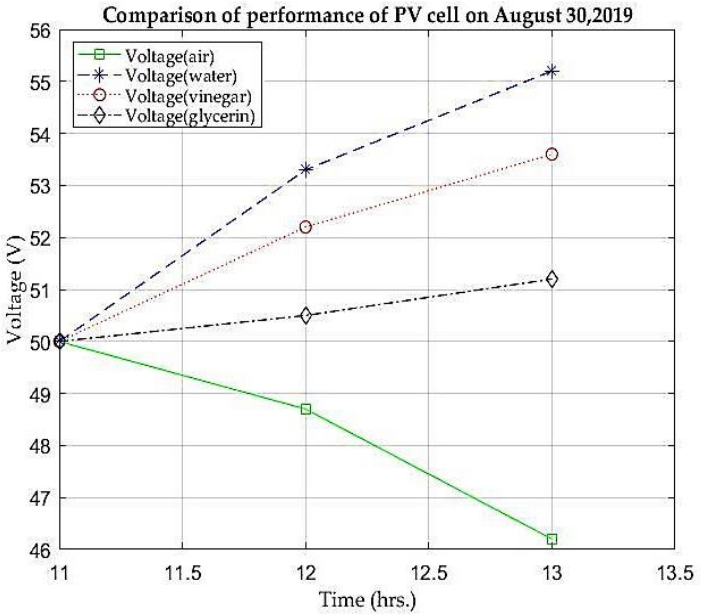


Fig. 8: Comparative performance of PV cell from data dated on August 30, 2019

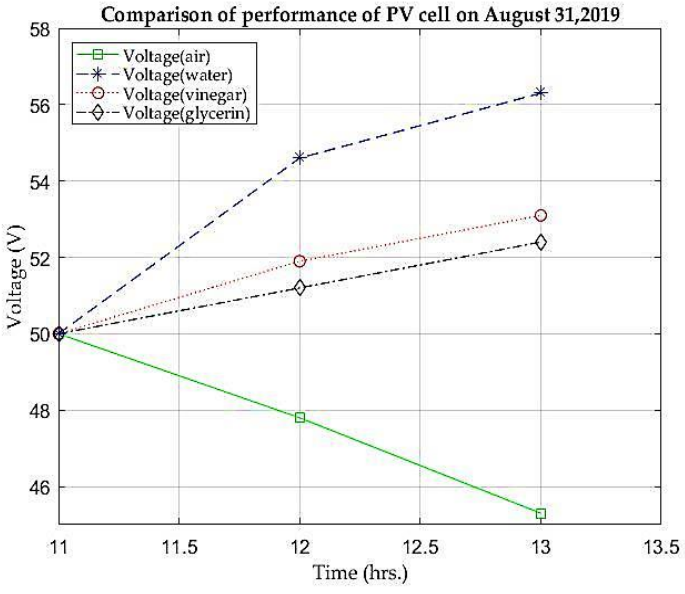


Fig. 9: Comparative performance of PV cell from data dated on August 31, 2019

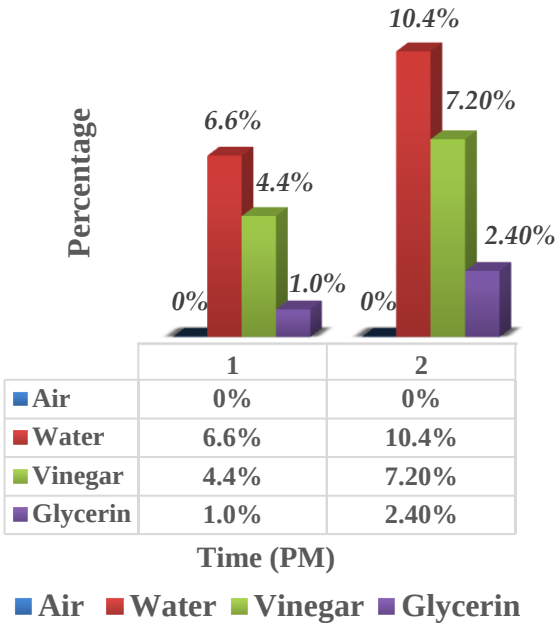


Fig.10: Performance increment of PV cell from data dated on August 30, 2019

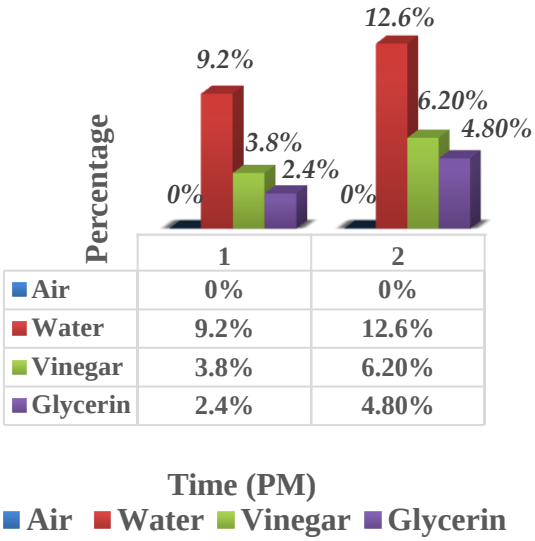


Fig.11: Performance increment of PV cell from data dated on August 31, 2019

Figure 10 shows that performance of solar cell is increased 1.0%, 4.4%, 6.6% when submerged in glycerin, vinegar, and water respectively at time 1 PM. In addition, 2.40%, 7.20%, and 10.4% increment at time 2 PM, as solar intensity increases. In contrast, 2.4%, 3.8%, and 9.2% is increased when submerged in glycerin, vinegar, and water respectively at time 1 PM in compared with air as shown in Fig. 11. Moreover, 4.80%, 6.20%, and 12.6% is increased at time 2 PM as shown in fig. 11. Figure 12 and figure 13 show a little bit increment depending on solar intensity. It can be concluded that performance submerged in water is more than glycerin, vinegar, and air for each time as shown all the figures. Hence, solar cell submerged in water into a definite depth is preferable as free of cost and ease availability that meets the main objective of this study.

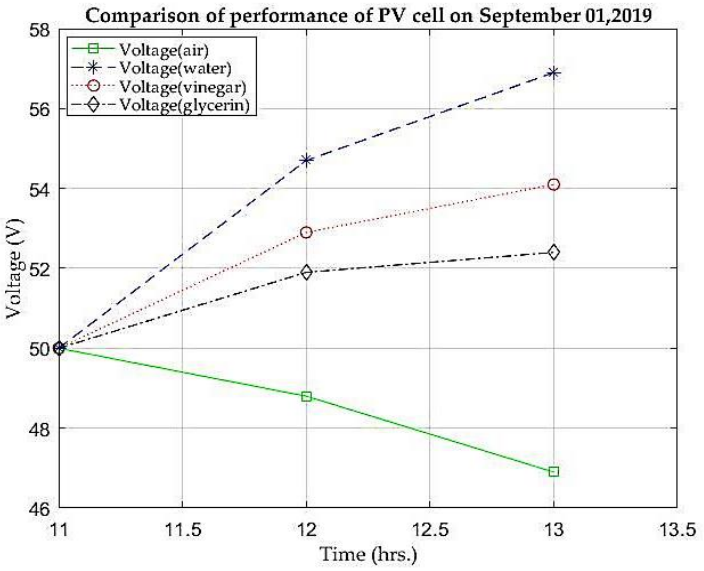
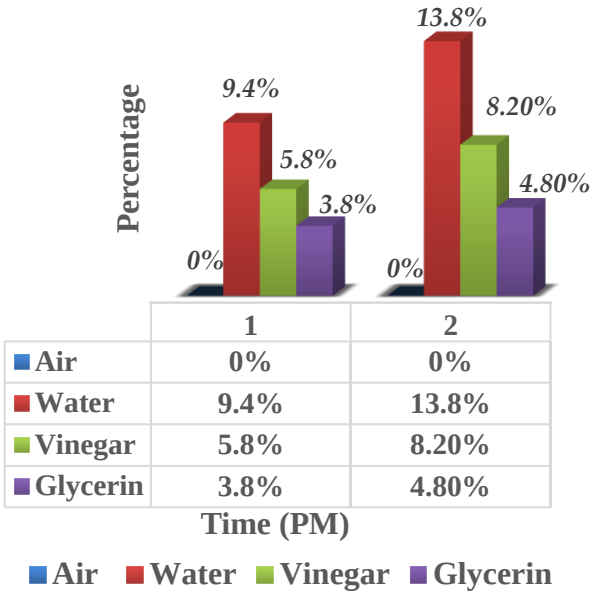


Fig. 12: Comparative performance of PV cell from data dated on September 01, 2019



	1	2
Air	0%	0%
Water	9.4%	13.8%
Vinegar	5.8%	8.20%
Glycerin	3.8%	4.80%

Fig.13: Performance increment of PV cell from data dated on, September 01, 2019

5. CONCLUSION

There are a lot of research is done and ongoing using different liquid as coolant in submerged cooling technique of solar panel. As glycerin is crystal clear, sunlight can easily transmit through this liquid. Hence, it can be chosen as a coolant liquid to submerge solar panel and test the performance as there are few research works done using glycerin for submerging solar panel. It is noted that combination of glycerin and water or other liquid might be used as coolant in the same type of cooling technique, as glycerin is natural antifreeze. In this paper, the comparative study is shown. Though the efficiency is found highest for the water, data compared to glycerin adds new dimension in this comparative study as the research is new. Glycerin is organic compound and other two water and vinegar are inorganic. The effect of organic and inorganic compound submerging solar panel is shown in this comparative study. If the cooling impact need to be compared, is must be identified universal value that defines the cooling with so many distinct cooling methods attempted. Since very few works have conducted full readings and calculations of the acquired energy, relative and total boost in effectiveness, and a full description of the cooling technique, the findings obtained are hard to compare. There are some limitation faced in this comparative study. As the liquid vaporize, the depth had to be checked as after specific period. Because depth effects the result.

REFERENCES

[1] M. Kazici.,"Solar Cells," *Comprison of Energy System.*, vol. 4–5, no. 7, pp. 637–658, 2018.

[2] X. Han, Q. Wang, J. Zheng, and J. Qu, "Thermal Analysis of Direct Liquid-Immersed Solar Receiver for High Concentrating Photovoltaic System," *Int. J. Photoenergy*, vol. 8, no. 2, pp. 1–9, 2015.

[3] D. Tanwar, D. Sharma, and Y. P. Mathur, "Ways of improving solar cell energy conversion using chemicals," *International Journal of Solar Engineering and Applications*, vol. 2, no. 5, pp. 1896–1903, 2013.

[4] S. S. Chandel and T. Agarwal, "Review of cooling techniques using phase change materials for enhancing efficiency of photovoltaic power systems," *Renew. Sustain. Energy Rev.*, vol. 73, no. December, pp. 1342–1351, 2017.

[5] S. Mehrotra, P. Rawat, M. Debbarma, K. Sudhakar, E. Centre, and M. Pradesh, "Performance of a Solar Panel With Water Immersion," *Int. J. Sci. Technol.*, vol. 3, no. 3, pp. 1161–1172, 2014.

[6] S. A. Abdulgafar, O. S. Omar, and K. M. Yousif, "Improving The Efficiency Of Polycrystalline Solar Panel Via Water Immersion Method," *Int. J. Innov. Res. Sci. Eng. Technol. (An ISO Certif. Organ.*, vol. 3297, no. 1, pp. 8127–8132, 2007.

[7] M. R. Clot, P. Rosa-Clot, and G. M. Tina, "Submerged PV Solar Panel for Swimming Pools: SP3," *Energy Procedia*, vol. 134, pp. 567–576, 2017.

[8] P. D. Wagh, and N. N. Shinde, "A Review on Floating Solar Photovoltaic Power Plants," *Int. J. Sci. Eng. Res.*, vol. 8, no. 6, pp. 789–794, 2017.

[9] A. Kosarev, A. J. Olivares-Vargas, S. Mansurova, A. Itzmoyotl Toxqui, and I. Cosme-Bolaños, “Effect of immerse an organic layer in isopropyl alcohol on characteristics of hybrid photovoltaic structures,” vol. 5, no. November, pp. 120-129, 2017.

[10] K. H. Mubanga and B. B. Umar, “Climate Variability and Change in Southern Zambia: 1910 to 2009 Kabwe: A case study on solar cell,” *2014 Int. Conf. Intell. Agric.*, vol. 63, no. 16, pp. 139–142, 2015.

[11] P. C. Choubey, A. Oudhia, and R. Dewangan, “Solar Cell Current Scenario and Future Trends: A Review” *Journal of Recent Research in Science and Technology*, vol. 4, pp. 99-101, 2013.

[12] A. M. Bagher, M. M. A. Vahid, and M. Mohsen, “Types of Solar Cells and Application”, *American Journal of Optics and Photonics*, vol. 3, pp. 94-113, 2015

[13] V. K. Sethi, M. Pandey, and P. Shukla, “Use of Nanotechnology in Solar PV Cell”, *International Journal of Chemical Engineering and Applications*, vol. 2, pp. 77-80, 2011

.