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OVERVIEW OF THE HYBRID SOLAR SYSTEM

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ABSTRACT

This paper investigates the uses of solar energy systems in various applications to define the most appropriate system that has highly efficient and reliable. Most of the urban even rural areas that suffer from lack of continuous power supplies it prefers to depend on hybrid systems like solar/wind systems, solar/geothermal system, and solar/diesel-battery systems. Investigation indicates that hybrid systems could meet the required loads in different proportions depending on the operating conditions and components of the hybrid system compare with the separate system but has complexity regarding their components of the system with the high initial cost. Moreover, utilize hybrid solar/thermal system is more sufficient than had systems that mentioned as a result of the improvements at his parts to increase the overall efficiency by using phase change material (PCM), nanofluid or a mix of PCM - nanofluid as cooling the photovoltaic (PV) panel to keep the efficiency of the solar cells and increase thermal energy. Thus, hybrid solar/thermal systems had proven effective to meet the required loads of electric energy and good capacity to provide thermal energy simultaneously without toxic emissions with a negligible complexity of its components.

Keywords: Irradiation, Hybrid system, PCM, Nanofluid

1. INTRODUCTION

Growing of human population growth and the associated industrial revolution leads to increasing energy demand constantly where fossil fuels are the main source of energy which causes by a huge of carbon dioxide emissions due to electricity generation. Many feasibility studies have conducted to determine the systems that work as environmental friendly systems (renewable energy systems) that has a long life operation with high reliability and efficiency, these systems have selected as an alternative to fossil fuel systems [1], adopting alternative energy sources as non-conventional sources such as wind energy, hydropower, biogas, biomass energy and solar photovoltaic. As a reason for the increasing demand for electricity, other causes like increasing global warming and fluctuate of oil price and gas emission [2], In this context, utilize new environmental friendly systems that called hybrid system to be a viable alternative for a single system where the hybrid system has a suitable ability to fulfill the energy demands of consumers in isolated areas [3]. A hybrid system is a combination of two or more systems that depend on energy sources to generate efficient power that could supply stable power. Many scientists found that solar/geothermal system represents a suitable option for achieving a stable energy source because it has a good feature allows to operate without emissions and work with steady-state. Converting the excess heat energy gained from the sun during the day by units stored energy to use it during the night to meet the required energy demands [4]. Hybrid solar/wind system is preferred especially at the rural area, where there is no benefit could get from the grid supply due to rise the demand for electricity which lead to heading toward the renewable. Feature of solar and wind energies is intermittent for this reason adopting hybrid systems became a good feature to ensure the energy supply even with the absence of one of its sources like sun or wind and thus, achieve the maximum capacity to benefit from it [5]. Combine conventional with eco-friendly system represented by hybrid solar/diesel system that used as a solution for areas that have to lack a grid system where select hybrid solar/diesel- battery system has a reliable with suitable efficiency to supply the power without considerable interruption although it is a product of toxic emissions [6], adopting on solar radiation as clean energy sources that use with a different type of the

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system even hybrid or separate. Recently a hybrid photovoltaic/thermal collector is commonly used and this system will provide by electric and thermal energy simultaneously. The main aim of the combined PV/thermal system is achieving increasing in the overall efficiency of the PV system by cooling the solar cells by the pipes of solar collectors that including the (water, air) or another fluid medium. Thus, decrease the temperature of solar cells make the PV work with good efficiency adding to the thermal energy that increases due to the heat gain from solar radiation and solar cells [7]. In Hungary, nuclear power as well coal is dominated by producing electricity in addition to imported electricity. Recently, Hungary desires to support its capabilities in the field of energy permanence by adopting renewable energy sources that characterized as clean, secure and economic to meet its needs of electric power and heating, etc. [8]. Technical and economic studies have conducted the various design of the photovoltaic system according to Hungarian conditions with different capacities from 50 kW to 500 kW for local governments and industry sectors. The results show that the investment in the solar energy field was good economically and technically with low payback periods of less than 10 years. [9]. According to data of the Photovoltaic Geographical Information System of the University of Miskolc-Hungary from 2006-2016 as seen in Fig. 1, where shows the monthly solar irradiation estimates (Horizontal irradiation) with slope angle 37° which considered suitable to encourage the use of solar energy in various fields.

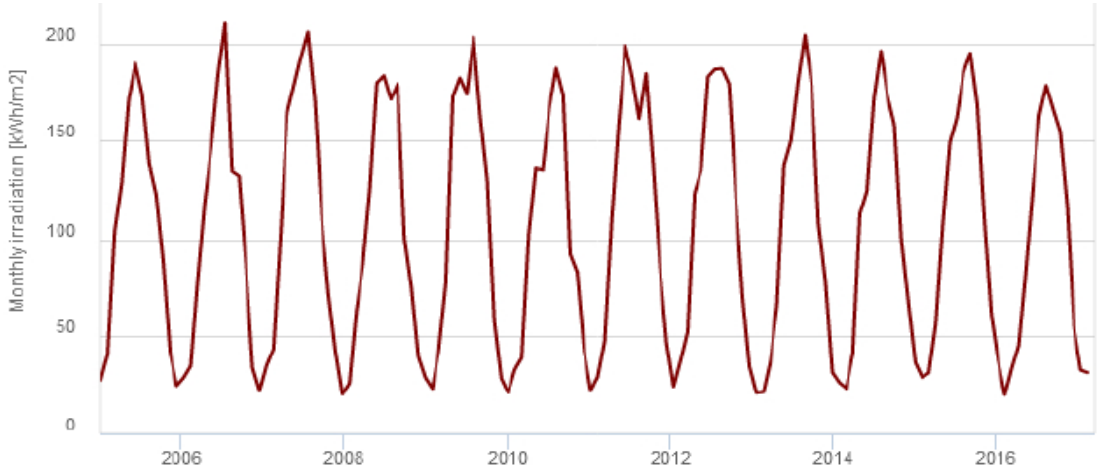

Figure 1. Global horizontal irradiation for University of Miskolc

2 HYBRIDS SOLAR/ WIND SYSTEM

Hybrid solar Photovoltaic/Wind system is a parallel hybrid system that combined the PV array that depends on the abundant solar radiation which is not the same intensity during the same day and wind turbine that depend on the abundant of wind source. Thus, generate power that could meet the load consumption when the solar radiation is available, the hand when the sun goes down the wind turbine could cover power shorting when the wind source is available and Fig. 2, show the schematic diagram of hybrid PV/wind system [10]. Adopted both of wind and solar energy resources as one system (hybrid) by using both wind energy and solar energy like a combined system to the resolved issue of variability and optimization the production of the system by converting wind and solar energy into electricity that directly storage by batteries to meet the required loads [11], Thus, to build a hybrid system it is very important to study the technical abilities of the local consumers for knowledge of the advances that include this sector. In 2012, a study had conducted to determine the performance and compatibility of the hybrid PV/wind system on the remote area power system (RAPS) around the year. Therefore, data analysis funded that for

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each hour around the year both wind and solar energy resources one of them completes the other with meet the specific loads without the need for additional batteries for charging compared with converting and storing for separate PV system [12]. Therefore, increasing utilizing hybrid systems like solar and wind systems that considered as promising energy resources that use for residential and industrial applications. Although lowering usable in the rural areas due to the reduction of technical capacity such as break-even distance and low population size [13]. In another hand, hybrid solar/wind systems are a little complicated regarding to their components (non-linear properties) and other variables parameters among both of configurations to reach optimization technique for hybrid solar/wind system with the assistance of computer software which plays an important role to design safe energy systems [14].

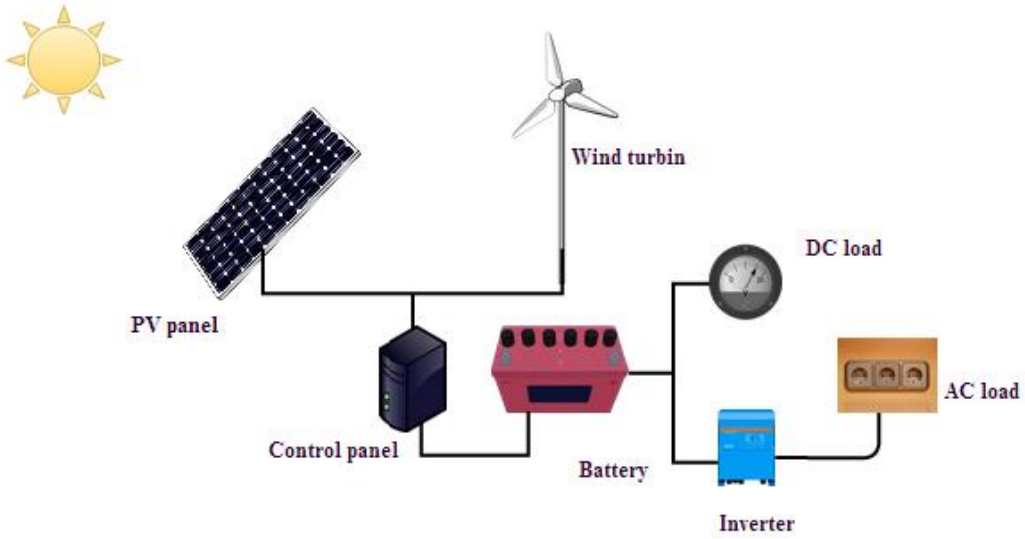

Figure 2. PV/ Wind Hybrid System

Both systems that combined use batteries as a back-up option for the stored energy generated in the case of one of the sources (solar radiation or wind) is not sufficiently available. However, in case of the solar hybrid PV/wind that connected by the grid, there is no effect on the stability of the system and in case of off-grid hybrid PV/wind system It is possible to reach stability in the system by increasing the number of batteries [15], it is necessary at design the hybrid system to specify equipment's with taking in consideration the capacity maintain the reliability of system when meeting the loads with reducing of system capital cost [16].

3. HYBRID SOLAR/GEOTHERMAL SYSTEM

Maximizing the benefit of renewable energy sources which has rapid growth in the recent period, several hybrid systems can be used in different applications areas like hybrid solar/geothermal systems to obtain thermal and electric energy. Hybrid PV/geothermal system has two configurations one of them is building-integrated PV/thermal, the other is earth-air heat exchanger both of them work as a heating and cooling modes adding to the electric energy production to achieve the efficient benefit of solar/geothermal energy as shown in Fig. 3. According to the thermodynamic performances of hybrid PV/geothermal, the results show improvement by performances of the hybrid system and achieve appropriate thermodynamic with improving the efficiency of the hybrid system [17]. Hybrid solar/geothermal systems have promising

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features and it is applicable spicily at the regions that have high heat flux with surface radiation which leads to combined solar energy with geothermal is possible.

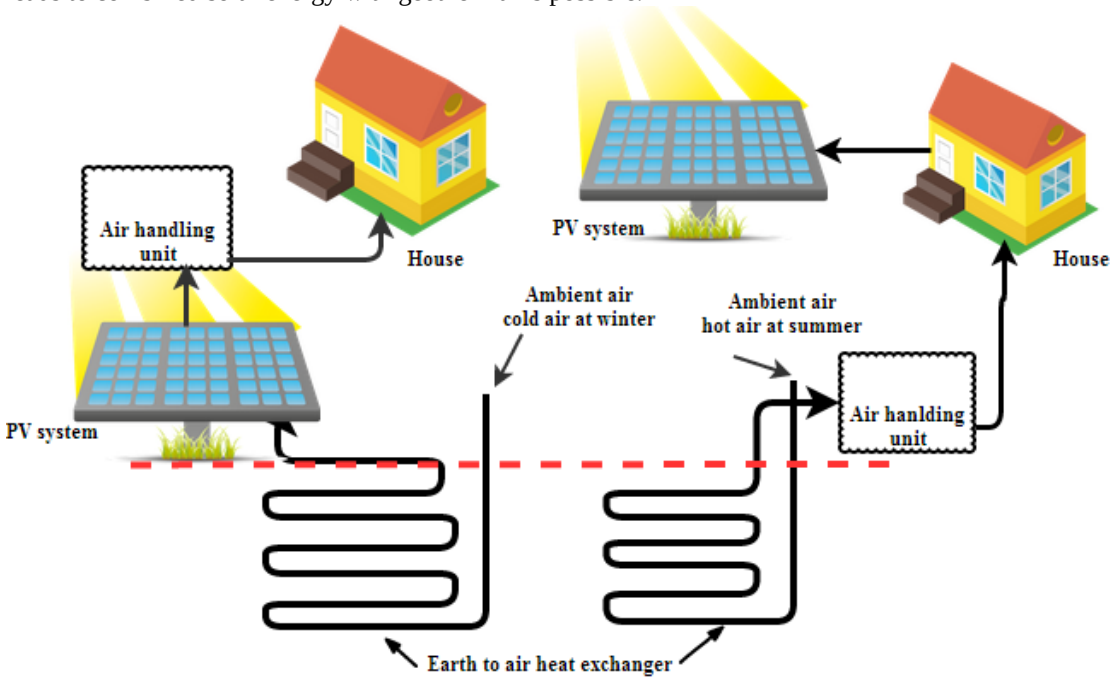

Figure 3. Hybrid solar/geothermal systems for heating and cooling mode

Hybrid solar/geothermal systems have proved it is a suited choice to processing the lowering of the capacity factor with the instability of the grid which leads to the fluctuated power supply. Combined solar with geothermal energy will contribute to compensation the lower capacity factor of solar energy by geothermal and improve the configurations of hybrid during heating geothermal fluid that has a low temperature of solar energy. Generally, geothermal energy has a temperature between moderate-low to raising the temperature of geothermal fluids it is important to make the efficiency of geothermal generation is better by combined with solar energy and to solve the instability of solar system by using geothermal fluids that gain high temperature as a storage system which leads to obtained mutually beneficial due to combined with promising renewable energy. The results of many studies show that hybrid solar/geothermal has a great performance comparing with separating systems and the efficiency of the system depended on the improvement of hybrid system components. However, as there are advantages of hybrid solar/geothermal systems there are disadvantages represented by high initial cost adding to the complexity in the components of hybrid systems [18]. One of the suggested solutions to meeting the shorting in energy supply is geothermal energy that represents by stored energy that proposed as a combined concentrated solar array with geothermal depending on stored energy under the earth (water or steam) which effected by high pressure and temperature. In this respect, the productive lifetime of hybrid concentrated solar arrays/geothermal energy will extension and by reheating the fluid during reinjection in the well which leads to increase the thermal energy of concentrated solar collectors thus could use this system as alone grid with providing energy security when the energy consumption be high [19].

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4. HYBRID SOLAR/ DIESEL SYSTEM

Most governments have a trend of covering the remote areas by electricity to reach 24 hours by day and the clean energy systems are a suitable alternative for conventional grid electricity [20]. Furthermore, some studies found out using a hybrid solar PV/diesel as stand-alone power generation is a good economically that can meet the load demands as well observed that there is a lowering in emissions when using hybrid system comparison with only generator system. According to previous studies that conducted to determine an appropriate system for rural areas where had analyzed and simulated for energy systems, which are generator system with, without battery and PV/Generator with, without battery system. Thus, it found that use a generator/battery system is the least suitable option while hybrid PV/Generator with battery more suitable option economically and the cost of electricity generated of a hybrid system is cheaper than a generator that uses or not use battery [21]. Planning for build renewable hybrid system it is necessary to study optimal sizing of the system such as the capital cost of equipment and size of the load that must be covered by the system with a suitable level of reliability by consideration the highest of flexibility and efficiency to meet the load [22], in another hand to achieve large savings in both of energy and cost where most of the studies have focused on reducing the cost of energy, fuel consumption to maximizing PV energy produce by using stored energy in the battery off-peak and adopting on the generator operation in the peak period [23], using hybrid PV/diesel system that grid connects can significantly reduce the cost of electric power at the demand peak at the daytime with the minimum of annual cost and makes dependence on the equipped national network of electricity power smaller [24]. Thus, several kinds of research that used different design models with different software prove that hybrid PV/diesel with battery It has better flexibility and efficiency than PV system only adding to that is economically suitable for remote areas where is no electricity available. The hybrid PV/diesel system has a lower cost of energy produced comparison with energy conventional production with noting the decrease both of operating costs and gaseous emissions in Fig. 4, shows the scheme of a hybrid PV/diesel -battery system [25].

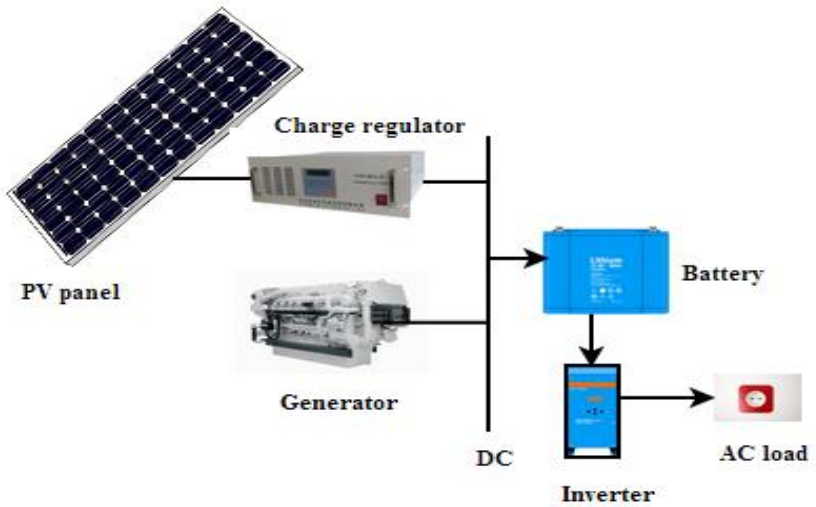

Figure 4. Scheme of hybrid PV/diesel -battery system

Subsequently utilizing a PV hybrid power system either for backup or complementary purposes will be very interesting to lower operational expenses as well as component replacements [26], adopted other studies to determine different strategies that can affect the cost of energy of PV/diesel with the battery as well as net present cost by select two types of battery (Lead Acid and Lithium-ion) and type of diesel

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generator that used with grid-connected hybrid PV/diesel. Results indicate that both of cost of energy with net present cost will be greatly affected by the capital cost beside of discount rate another hand there are negligible effects of the battery, PV module and fuel for both of (PV/Diesel/Lead Acid or PV/Diesel/Lithium-ion) hybrid systems [27].

5. HYBRID SOLAR PV/THERMAL SYSTEM

Accreditation on the photovoltaic system has grown rapidly increased in the last years with different capacities of clean electricity production and decrease dependence on traditional energy. The photovoltaic system has a disadvantage when the temperature goes up to where the solar cells will be affected which leads to lower the efficiency of the PV panel and sometimes lead to degradation in solar cells [28]. Utilizing different techniques that contribute to maintaining the efficiency of solar cells and one of these techniques is a cooling system that combined with the PV system by air as a heat transfer medium through channels placed behind the plate and in contact with the PV panels to lowering the high temperature of the solar cells. On the other hand, use water as a medium that has a high thermal capacity where the cooling system is attacked the PV panel from the back that consists of absorber plate with tubes embedded in absorbing the high temperature of the PV cells with keeping it in an acceptable range. Thus, obtain electric energy with high efficiency and thermal energy due to the heat gain from the PV system [29]. The overall efficiency of the PV/thermal system represents the intrinsic of the PV/thermal system and according to that many researchers have developed various techniques that would increase the efficiency of the system while maximizing the output power. Therefore, to improve the performance of the PV/thermal a new technique had used represented by adding PCM for the solar collectors that have a good advantage to absorbing and releasing heat as shown in Fig. 5, where It absorbs heat from the PV panel when temperatures rise and at the night the stored heat is thrown out by the fins, this advantage made it suitable for cooling of solar cells when the temperature is rising thence use PCM make the solar cells work at nearly constant temperature add the increasing by the efficiency of the PV panel. A fatty acid used as PCM to cool the PV after putting it in rectangular metal includes fins to dissipation the heat gain of the PV panel where the low thermal conductivity PCM (fatty acid) contributed to improve the PV efficiency [30].

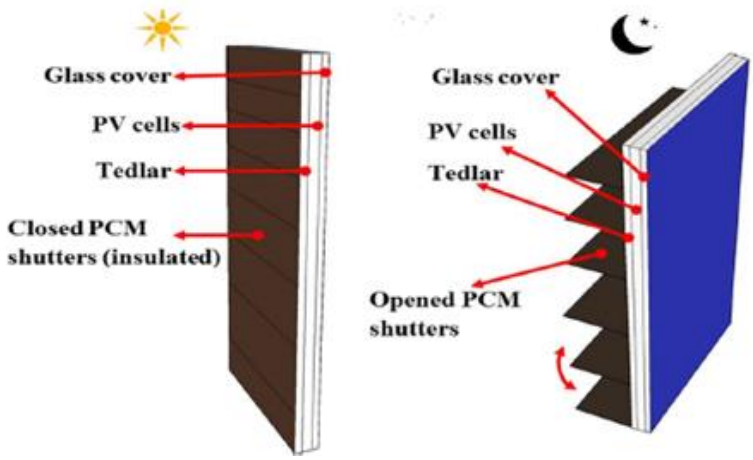

Figure 5. Hybrid PV/Thermal system with PCM

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Different percentages of nanofluids had mixed with the fluid as a new technique with the PV as a heat transfer agent that has a high thermal conductivity compare by base fluid and it is widely used in heat exchangers as well the PV/T system [31]. The ability to integrate more than one technique that contributes to increasing overall efficiency and improving system performance is meaningful. Mixing certain percentage of nanofluid with PCM that aims to increase thermal conductivity where the PV module will connection with heat storage tank in the backside of PV panel and the tank that include copper tubes that will be filled by PCM-nanofluid that works to the absorbed high temperature of the PV panel thus the tank will cool by recycling nanofluid by an external heat exchanger. Increase thermal efficiency of PV/thermal respectively with electric energy and economy of the system which made it promising in the future [32].

6. CONCLUSION

Accreditation on various resources of renewable energy that could ensure energy supply sustainability by meets the load demand continuously. Adoption of the solar energy systems that have efficiency with reliability as an alternative resource of conventional energy contributes to reducing emission and conventional energy. This paper seeks to identify the suited hybrid system t for general applications by studying a different type of hybrid system. Adopting hybrid solar/wind could meet the required loads but it has a little complicated regarding their components (non-linear properties) with the assistance of computer software that has an important role to design safe energy systems. Using a hybrid solar/geothermal system has great performance comparing with separation systems and efficiency depends on system components which is complexity with the high initial cost. However, hybrid solar PV/Generator with battery more suitable option economically that could meet the load demands for rural areas but it does not evacuate from a certain value of toxic emissions result by using it with little effects of the battery. While Hybrid solar PV/thermal system experiencing significant growth with improvements at his parts to increase the overall efficiency of the system by use PCM, nanofluid or a mix of PCM-nanofluid as cooling the PV panel to keep the efficiency of the solar cells and increase thermal energy. Utilizing a hybrid solar/thermal system has proven effective to meet the required loads of electric energy and good capacity to provide thermal energy simultaneously without toxic emissions with a little complicated component.

7. ACKNOWLEDGMENTS

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REFERENCES

[1] Makbul A. M. Ramli, Ayong Hiendro, Ssennoga Twah, Economic analysis of PV/diesel hybrid system with flywheel energy storage, Renewable Energy, 78 (2015) 398-405.
[2] Tripti Gupta and Swapnil Namekar, Harmonic Analysis and Suppression in Hybrid Wind & PVSolar System. International Conference on Electrical, Electronics, doi.org/10.1063/1.5031987.
[3] Yashwant Sawle, S.C. Gupta and Aashish Kumar Bohre, PV-wind hybrid system, A review with case study, Cogent Engineering, (2016) 3, 1189305. DOI: 10.1080/23311916.2016.1189305.
[4] K.H.M. Al-Hamed and I. Dincer, Investigation of a Concentrated Solar-Geothermal Integrated System with a Combined Ejector-Absorption Refrigeration Cycle for a Small Community, International Journal of Refrigeration, 106(2019)407–426.
[5] Rajesh Ka, D Kulkarnib, T.Ananthapadmanabha, Modeling and Simulation of Solar PV and DFIG Based Wind Hybrid System, Procedia Technology, 21 (2015) 667 – 675.

[6] Miriam Madziga ID, Abdulla Rahil, IDand Riyadh Mansoor, Comparison between Three Off-Grid Hybrid Systems (Solar Photovoltaic, Diesel Generator and BatteryStorage System) for Electrification for GwakwaniVillage. South Africa, Environments, 2018 5-57.
[7] Mostafa M. Abd El-Samie, Xing Ju, Zheyang Zhang, Saadelnour Abdueljabbar Adam, XinyuPan, Chao Xu: Three-dimensional numerical investigation of a hybrid low concentrated photovoltaic/thermal system. Energy, doi: https://doi.org/10.1016/j.energy.2019.116436.
[8] Viktor Miklos Kiss, Zsolt Hetesi, Tibor Kiss, Issues and solutions relating to Hungary's electricity system, Energy 116 (2016) 329-340.
[9] Henrik Zsiborács, Nóra Hegedűsné Baranyai, Szilvia Csányi, András Vincze and Gábor Pintér, Economic Analysis of Grid-Connected PV System Regulations, A Hungarian Case Study, Electronics, 2019 8 149; doi:10.3390/electronics 8020149.
[10] Ritesh Dash, Pratik Ranjan Behera, Dr. S.M Ali, HYBRID SYSTEM FOR MEETING GLOBAL ENERGY DEMAND WITH SOLAR PV AND WIND SYSTEM, 2014 International Conference on Control, Instrumentation, (ICCICCT).
[11] Zahnd Alexa, Angel Clark, Wendy Cheung, Linda Zou, Prof. Jan Kleissl, Minimizing the Lead-Acid Battery Bank Capacity through a Solar PV - Wind Turbine Hybrid System for a high-altitude village in the Nepal Himalayas. Energy Procedia, 57 (2014) 1516 – 1525, USA.
[12] RIDS-Nepal, [a] Nepali, not for profit local NGO, www.rids-nepal.org, 28th 2016.
[13] Bawah, Addoweesh, Eltamaly, Comparative study of economic viability of rural electrification using renewable energy resources versus diesel generator option in Saudi Arabia, J. Renew. Sustain. Energy 5 (4) 42701–427017, http://dx.doi.org/10.1063/1.4812646 2013.
[14] Connolly, Lund, Mathiesen, Leahy, 2010, A review of computer tools for analysing the integration of renewable energy intovarious energy systems. Appl Energy 87 (4)1059–1082. http://dx.doi.org/10.1016/j.apenergy.2009.09.026.
[15] Ritesh Dash, Pratik Ranjan Behera, Dr. S.M Ali, HYBRID SYSTEM FOR MEETING GLOBAL ENERGY DEMAND WITH SOLAR PV AND WIND SYSTEM, 2014 International Conference on Control ,Instrumentation (ICCICCT).
[16] Sasan Moghaddam, Mehdi Bigdeli, Majid Moradlou & Pierluigi Siano, Designing of stand-alone hybrid PV/wind/battery system using improved crow search algorithm considering reliability index, International Journal of Energy and Environmental Engineering, Springer, https://doi.org/10.1007/s40095-019-00319. 2019.
[17] Masoud Afrand, Amin Shahsavar, Pouyan Talebizadeh Sardari, Kamaruzzaman Sopian, Hamzeh Salehipour, Energy and exergy analysis of two novel hybrid solar photovoltaic geothermal energy systems incorporating a building integrated photovoltaic thermal system and an earth air heat exchanger system. Solar Energy 188 (2019) 83–95.
[18] SystemsKewen Li, Changwei Liu, Shanshan Jiang and Youguang Chen, Review on Hybrid Geothermal and Solar Power, Journal of Cleaner Production, (2019) Elsevier. doi.org/10.1016/j.jclepro.2019.119481.
[19] Bonyadi, N, Johnson. E, Baker. D, Technoeconomic and exergy analysis of a solar geothermal hybrid electric power plant using a novel combined cycle. Energy Convers. Manag, (2018.) 156 542–554. https://doi.org/10.1016/j.enconman.2017.11.052.
[20] Abdu Muhaimin Mahmud, Richard E. Blanchard, Assessing a system performance analysis on 11 solar PV-diesel hybrid systems, IEEE 2016 4th International Conference on the Development in the in Renewable Energy Technology, Dhaka, Bangladesh.
[21] Muyiwa S. Adaramola, Samuel S. Paul, OlanrewajuM, Oyewola, Assessment of decentralized hybrid PV solar-diesel power system for applications in Northern part of Nigeria, Energy for Sustainable Development, (2014).

[22] A. Yahiaouia, F. Fodhilb, K. Benmansoura, M. Tadjinec, N. Cheggagab, Grey wolf optimizer for optimal design of hybrid renewable energy system PV-Diesel Generator-Battery, Application to the case of Djanet city of Algeria, Solar Energy 158 (2017) 941–95.
[23] Sam M. Sichilalu, Xiaohua Xia, Optimal energy control of grid tied PV–diesel–battery hybrid system powering heat pump water heater, South Africa, Solar Energy 115 (2015) 243–254.
[24] Takahiro Kushida, Rikiya Abe, Optimal design of a grid connected PV-diesel hybrid system, IEEE 2016 IEEE, 16th International Conference on Environment and Electrical Engineering.
[25] A. Yahiaoui, K. Benmansour, M. Tadjine, Control analysis and optimization of hybrid PV-Diesel-Battery systems for isolated rural city in Algeria, Algeria, Solar Energy, 137 (2016) 1–10.
[26] Caroline Bastholm, Frank Fiedler, Techno-economic study of the impact of blackouts on the viability of connecting an off-grid PV-diesel hybrid system in Tanzania to the national power grid, Sweden, Energy Conversion and Management,171(2016) 647-658.
[27] Barun K. DAS, Forhad Zaman, Performance Analysis of a PV/Diesel Hybrid System for a Remote Area in Bangladesh: Effects of Dispatch Strategies, Batteries, and Generator Selection. Energy, (2018), doi: 10.1016/j, energy, 2018.12.014.
[28] Rasmus Luthander, Joakim Widén, Daniel Nilsson, Jenny Palm, Photovoltaic self-consumption in buildings, A review, Applied Energy, 142 (2015) 80–94.
[29] Taher Maatallah, Richu Zachariah, Fahad Galla, Al-Amria, Exergo-economic analysis of a serpentine flow type water based photovoltaic thermal system with phase change material (PVT-PCM/water), Solar Energy, 193 (2019) 195–204.
[30] Hongtao Xu, Chenyu Zhang, Ning Wang, Zhiguo Qu, Shuanyang Zhang a, Experimental study on the performance of a solar photovoltaic/thermal system combined with phase change material, china, Solar Energy, 198 (2020) 202–211.
[31] Ali H A Al-Waeli, Miqdam T Chaichan, Hussein A Kazem, K. Sopian, Evaluation and analysis of nanofluid and surfactant impact on photovoltaic-thermal systems, Case Studies in Thermal Engineering, https://doi.org/10.1016/j.csite.2019.100392.
[34] Ali H. A. Al-Waeli, Hussein A. Kazem, Miqdam T. Chaichan, K. Sopian, Experimental investigation of using nano-PCM/nanofluid on a photovoltaic thermal system (PVT). technical and economic study, Thermal Science and Engineering Progress, doi: https://doi.org/10.1016/j.tsep.2019.04.002.