Study of the Effect of the Energy Produced From a Grid-Connected Rooftop Solar PV System for Small Households

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Abstract—In recent years, a great popularization of the production of electricity from photovoltaic systems has been observed, which gives hope for reducing environmental pollution and tackling the shortage of natural resources used for electricity generation. This article will focus on studying the effect of energy produced by a grid-connected rooftop solar photovoltaic system for small households.

Keywords—computer simulations, computer simulation inverters, solar photovoltaic (PV) systems, energy simulation, PV*SOL

1 Introduction

At the base of the unprecedented increase in the use of conventional energy resources is the high rate of economic growth in developing countries. Globally, renewable energy sources are the fastest growing. Solar energy is a renewable energy source and is becoming increasingly popular and preferred by many households in order to save on electricity costs. By using a photovoltaic (PV) system, solar radiation can be directly converted into electricity. In Bulgaria in the months of May, June, July and August sunlight is plentiful and there are many people building different technologies to control this energy and convert it into electricity [1-8].

Many people who live at home install solar panels on the roofs, which absorb solar energy and convert it into electricity. It has now become very popular to install solar panels on the roofs of residential buildings, thus reducing the cost of common areas of residents [9-14].

The purpose of the current investigation is to study the effect of the energy produced from a grid-connected rooftop solar PV system for small households. The PV system with a power of 5kW is located on the roof of an existing residential building in the village of Cherniche, Blagoevgrad, Bulgaria [1].

2 Computer simulations

Computer simulations of the grid-connected rooftop solar PV system were performed in the software PV*SOL [15]. The results of the computer simulation of this system are presented in previous study [1] and shows that the maximum power that can generate the PV panels is 4,70 kW. The simulations show the operating range of the maximum power tracking system from 125V to 440V. The software calculates the total power of the PV system-4,6 kW [16].

The following Q-Cells SE Q, BASE-G2 235 Rev03 235 W panels were used to build the PV system which are characterized by higher performance than other modules due to the positive sorting technology [16-19].

In the installed PV system is used three-phase inverter Sunny Boy 5000TL which has a very high efficiency, up to 97% and the following characteristics: maximum input voltage of 750 volts, which expands the possibilities for installing a larger number of solar panels; maximum photovoltaic power 5250 W, maximum output power 240 - 5000W; frequency - 60Hz and maximum current -15A [1].

This SB5000TL inverter has all the latest internet connection technologies and it collects information and records on the manufacturer's cloud server, which we can monitor and analyze at any time.

In the current study we investigate the produced energy of the PV system for period from 2013 to 2020 year. The annual comparison of the PV system for this period is presented in Figure 1.

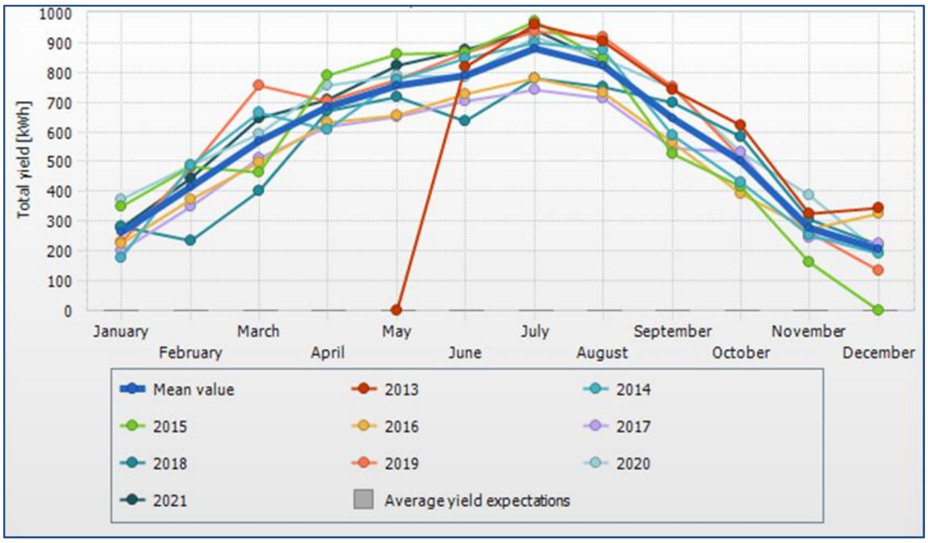


Fig. 1. The annual comparison of the PV system from 2013 to 2020

The results of the generated power of the 5kW built-in photovoltaic system by months for the studied period of 8 years are presented in Table 1. The amounts of energy generated by the PV system and the percentage distribution of energy for this period are presented in Figure 1 and Figure 2.

Table 1. Generated power produced by 8 years from the PV system

Year	January	February	March	April	May	June	July	August	September	October	November	December	Total
2013					0.46	817.58	961.42	905.64	743.00	620.91	325.01	344.36	4718.38
2014	177.22	490.14	666.29	609.96	773.29	848.83	898.51	873.63	587.67	432.02	255.55	190.98	6804.07
2015	351.14	482.22	464.71	788.78	859.81	864.58	969.64	845.29	525.04	417.73	165.03	0.00	6733.97
2016	222.82	373.67	497.22	630.06	654.50	728.41	779.47	729.98	563.51	394.18	273.23	323.47	6170.51
2017	199.13	348.38	511.65	617.71	652.43	703.02	741.12	711.13	545.04	529.75	241.83	225.71	6026.89
2018	283.18	234.37	402.32	669.49	719.09	634.60	778.75	751.75	700.90	582.03	308.54	220.77	6285.77
2019	228.41	477.54	756.91	702.00	776.62	866.31	937.91	920.12	750.26	511.53	260.84	134.36	7322.80
2020	372.46	488.77	595.61	754.28	787.40	786.25	920.89	845.27	744.34	533.00	388.94	194.62	7411.83
Mean value	262,05	413,58	556,39	681,75	746,16	776,00	860,90	811,02	630,97	485,75	270,57	184,27	6679,41
Year portion	3.88%	6.12%	8.33%	10.06%	11.09%	11.62%	12.93%	12.07%	9.46%	7.38%	4.07%	3.00%	100.00%

The maximum global irradiation of the PV system is found in July month in 2015: 969,64 kWh (Table 1, Figure 1). The total energy produced by investigated PV system for the period from 2013 to 2020 is 51474,22 kWh.

Figure 2 shows the solar energy produced from the investigated PV system by the installed inverter STP 5000TL-20034 in the period January – December 2019 and 2020. The diagrams show that the highest values are obtained in July and August 2019 and 2020, when the temperatures in Bulgaria are the hottest. November - February are months with low solar values radiation, which leads to lower energy production from PV system.

For the real-time monitoring of the investigated PV system, the Sunny Portal monitoring plat-form was used [20]. This software allows visualization and analysis of measured values. It can be used to make a comparative analysis of the power output during the study period 2013-2020 years and it is possible to detect deviations in the operation of the PV system [21-26].

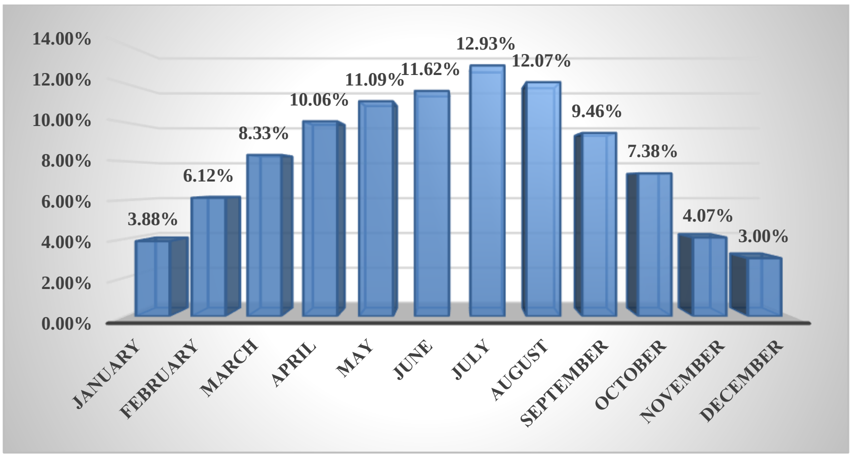


Fig. 2. Monthly percentage distribution of electricity produced by PV system for the investigated period 2013-2020

Through the Sunny Portal platform, the measured values are visualized and analyzed, a comparison of the extracted power over the years, which makes it possible to detect deviations in the operation of the PV system.

Figure 3 shows the typical nature of the solar radiation, the daily course of the measured voltage and the monthly distribution of the solar energy produced by PV system for 2019 year.

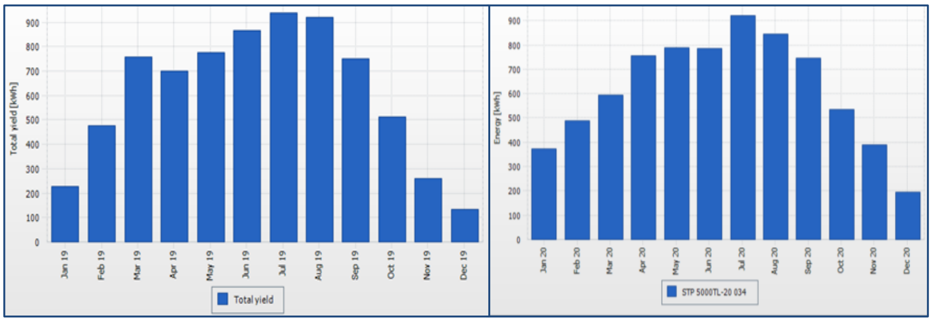
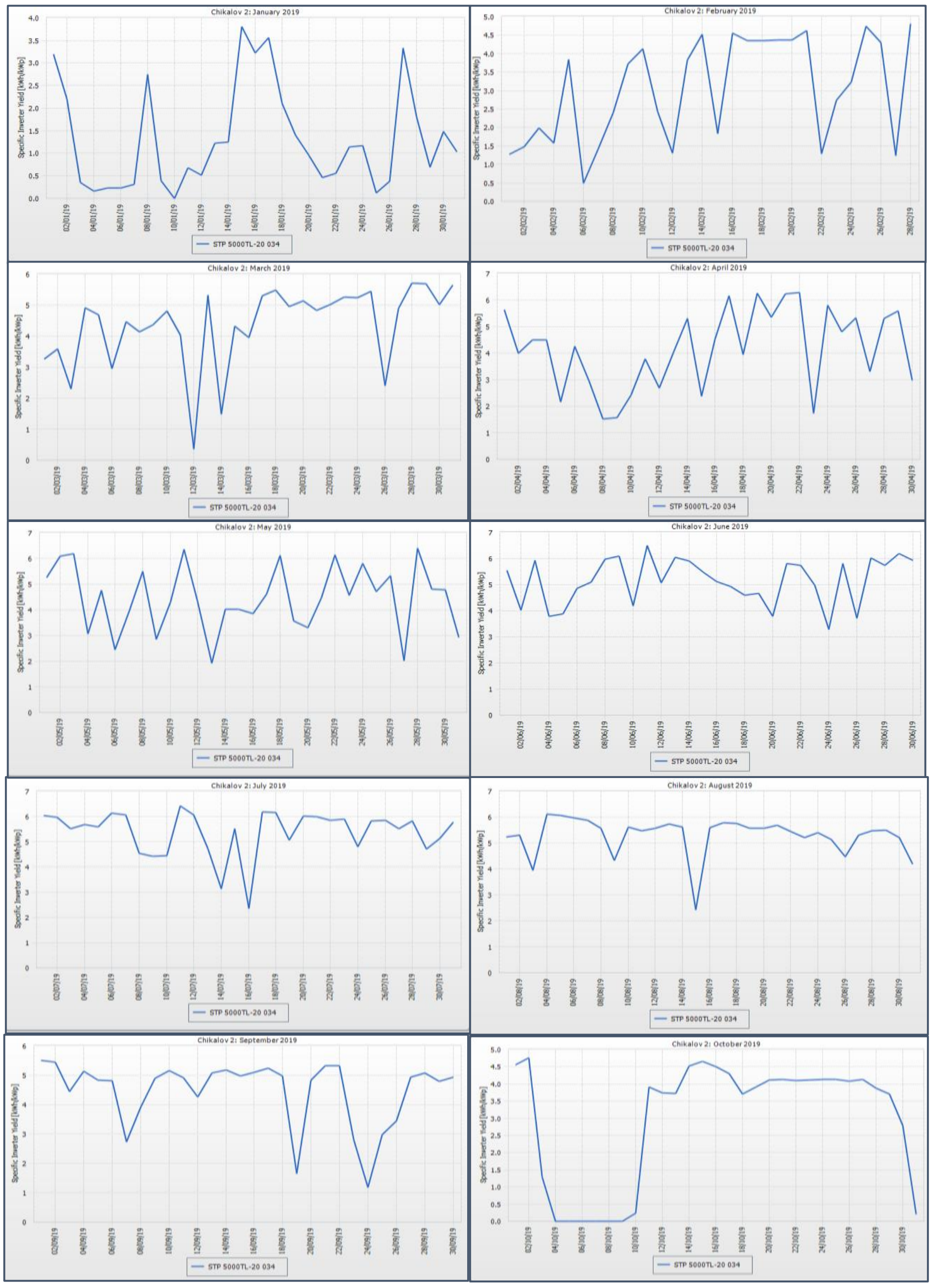


Fig. 3. Produced energy by invertor STP 5000TL-20034 of PV system for 2019 and 2020

Installing a solar PV system on a house roof is an environmentally friendly choice that is popular in society and industry. Nowadays, researchers are interested in improving the energy power of rooftop solar PV systems in small households [27-33]. This leads to the production of ecological energy and to saving households money.


Chikalov 2: January 2019
STP 5000TL-20 034
Chikalov 2: February 2019
STP 5000TL-20 034
Chikalov 2: March 2019
STP 5000TL-20 034
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STP 5000TL-20 034
Chikalov 2: May 2019
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STP 5000TL-20 034

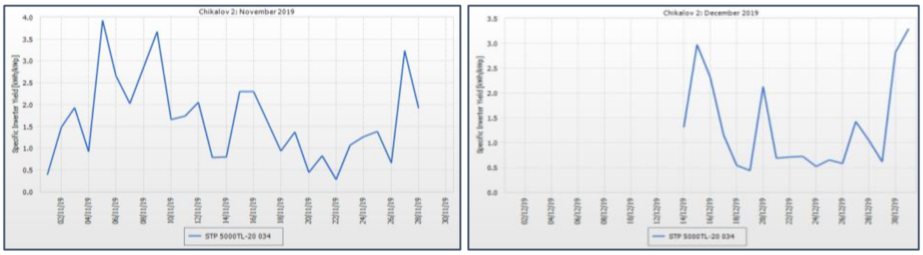

Fig. 4. Monthly distribution of the solar energy produced by PV system for 2019

3 Conclusions

Photovoltaic solar energy simulation of rooftops of house of Cherniche, Blagoevgrad, Bulgaria has been carried out. The studied photovoltaic system can help the electricity network in the Blagoevgrad region, Bulgaria by injecting additional photovoltaic electricity, especially during the hot and sunny periods in summer. Installing more PV systems on the roofs of people's houses will help reduce the climate and the impact on the environment.

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5 References

[1] Sapundzhi, F. (2019). Computer Simulation and Investigations of the Roof Mount Photovoltaic System: International Journal of Online and Biomedical Engineering, 15(12): 88-96. https://doi.org/10.3991/ijoe.v15i12.10869

[2] Obi, M., Bass, R. (2016). Trends and challenges of grid-connected photovoltaic systems – A review. 58: 1082-1094. https://doi.org/10.1016/j.rser.2015.12.289

[3] Nordin, A., Omar, A. (2011). Modeling and simulation of Photovoltaic (PV) array and maximum power point tracker (MPPT) for grid-connected PV system. 3rd International Symposium & Exhibition in Sustainable Energy & Environment (ISESEE), 114-119. https://doi.org/10.1109/ISESEE.2011.5977080

[4] Kesraoui, M., Lazizi, A., Chaib A. (2016). Grid Connected Solar PV System: Modeling, Simulation and Experimental Tests. Energy Procedia, 95: 181-188. https://doi.org/10.1016/j.egypro.2016.09.043

[5] https://www.iea.org/reports/world-energy-outlook-2020

[6] https://www.iea.org/reports/key-world-energy-statistics-2020

[7] Cuce, E., Riffat, S. (2016). A comprehensive assessment of sectoral energy consumption in the UK: past, present and future. International Journal of Low-Carbon Technologies. 11 (3): 424–430. https://doi.org/10.1093/ijlct/ctv013
[8] Milea, P., Zafiu, A., Drăgulinescu, M., Oltu, O. (2010). MPP tracking method for pv systems, based on a three points prediction algorithm: U.P.B.Sci. Bull. Series C.72(4): 149-160.
[9] http://www.terna-energy.com/company/The-Sector/Advantages-Of-RES
[10] Zarkov, Z. et al. (2016). Modeling of PV generators from different technologies - Case study: Proceedings - 2016 IEEE International Power Electronics and Motion Control Conference: 419-424. https://doi.org/10.1109/EPEPEMC.2016.7752034
[11] Mohan, N., Undeland, T., Robbins, W. (2003). Power Electronics-Converters Applications and Design: John Wiley & Sons.
[12] Rashid, M. (2007). Power Electronics handbook: devices circuits and applications: Academic Press.
[13] Nedyalkov, I., Arnaudov, D., Hinov, N., Kanchev, H. (2017). Modelling of an off-grid photovoltaic power supplying system for telecommunication equipment: 15th International Conference on Electrical, Machines, Drives and Power Systems (ELMA), 1-3 June 2017, Technical University of Sofia, Bulgaria. https://doi.org/10.1109/ELMA.2017.7955402
[14] Deambi, S. (2016). Photovoltaic System Design: Procedures, Tools and Applications: CRC Press. https://doi.org/10.1201/9781315372181
[15] http://www.sunsys.info
[16] http://solaritybg.com
[17] http://files.sma.de/dl/15330/SB5000TL-21-DEN1551-V20web.pdf
[18] https://multiwatt.de/wp-content/uploads/2012/07/Q-Cells_QPRO-G2_Datenblatt_DE.pdf
[19] http://files.sma.de/dl/15330/SB5000TL-21-DEN1551-V20web.pdf
[20] http://www.sunnyportal.com
[21] Köehler, M., Wiartalla, W., Feige R. (2007). Interaction between PV-systems and extensive green roofs:U.S.Department of Energy Office of Scientific and Technical Information:1-16.
[22] Dondariya, C., et al. (2018). Performance simulation of grid connected rooftop solar PV system for small households: A case study of Ujjain, India. Energy Reports. 4: 546-553. https://doi.org/10.1016/j.egyr.2018.08.002
[23] Zhang L., et.al. (2019). Energy Consumption Balanced Topology Variable Routing Algorithm for WWSN in Disaster Rescue Scenarios: International Journal of Online and Biomedical Engineering, 15(7): 52-65. https://doi.org/10.3991/ijoe.v15i07.10043
[24] Zheng W. et al. (2019). APP Design of Energy Monitoring in Smart Campus Based on Android System. International Journal of Online and Biomedical Engineering. 15 (7): 18-27. https://doi.org/10.3991/ijoe.v15i05.8225
[25] Sapundzhi, F. (2020). A survey of KNX implementation in building automation: TEM Journal, 9 (1): 144-148.
[26] Sapundzhi, F., Popstoilov, M. (2020). Maximum-flow problem in networking: Bulgarian Chemical Communications. 52: 192–196.
[27] Sapundzhi, F., Yordanov, K. (2020). Network monitoring of the MHT company using the DUDe: Bulgarian Chemical Communications, 52: 211–219. https://doi.org/10.37394/23204.2020.19.11
[28] Sapundzhi, F., Popstoilov, M. (2018). Optimization algorithms for finding the shortest paths: Bulgarian Chemical Communications, 50 (B): 115-120.
[29] Sapundzhi, F. (2019). Scoring functions and modeling of structure-activity relationships for cannabinoid receptors: International Journal of Online and Biomedical Engineering, 15(11): 139-145. https://doi.org/10.3991/ijoe.v15i11.10893

[30] Sapundzhi, F., Dzimbova, T. (2019). A study of QSAR based on polynomial modeling in Matlab: International Journal of Online and Biomedical Engineering, 15(15), 39–56. https://doi.org/10.3991/ijoe.v15i15.11566
[31] Kralev, V., Kraleva, R. (2020). Methods for software visualization of large graph data structures: International Journal on Advanced Science, Engineering and Information Technology, 1: 1–8. https://doi.org/10.18517/ijaseit.10.1.10739
[32] Sapundzhi, F, Popstoilov, M. (2019). C# implementation of the maximum flow problem. 27th National Conference with International Participation: The Ways to Connect the Future, TELECOM 2019 - Proceedings, 62-65, 8994883. https://doi.org/10.1109/TELECOM 48729 .2019.8994883
[33] Nedyalkov, I., Georgiev, G. (2021). Application of the methods for monitoring of IP networks for studying power electronic devices: IEEE EUROCON 2021-19th International Conference on Smart Technologies, Proceedings, 397 – 402. https://doi.org/10.1109/EUROCON52738.2021.9535626

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