JOURNAL OF CRITICAL REVIEWS

ISSN- 2394-5125 VOL 7, ISSUE 15, 2020

Optimization of Solar Power Systems in Different Regions

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Received: 16 March 2020 Revised and Accepted: 17 June 2020

Abstract
In this article are considered possible schemes of functioning of a household photovoltaic system with autonomous and network connection of the load. For the first time, on the basis of a set of experimental and theoretical calculations, a comparative analysis of the energy and economic characteristics of the promising configurations of microelectric power generation has been carried out, and their economic attractiveness for individual consumers has been evaluated taking into account the climatic and tariff features of the electricity market in the regions considered. The daily operating modes of the system are determined taking into account the influencing factors. The analysis of the power part of the system for energy storage of a photovoltaic panel is carried out. Schemes for controlling the output currents of the Converter with the help of regulators are considered. The results of an experiment to determine the charging current of a photovoltaic system battery under natural weather conditions are presented.
Keywords:solar power, solar power plant, solar battery, photovoltaic systems, controller, inverter, battery.

1. Introduction

For electricity consumers who are far from traditional energy sources, there is no alternative but to use photovoltaic cells as an energy source. Increasing the efficiency of silicon photovoltaic cells, reducing their production costs, optimizing their design, and using new materials expands the market for photovoltaic cells. Currently, solar power plants based on photovoltaic cells are used by both individual consumers and electric companies. Depending on the destination, i.e. generated power, the composition of photovoltaic cells includes a different number of solar cells, the number and method of switching which determines the output power of the solar battery. The output power of photovoltaic batteries depends on the operating conditions, time of day, location (climate zone), the state of the ray-sensing surface of photovoltaic batteries, etc. [1, 2].Photovoltaic systems can be used to meet the electricity needs of a residential block or neighborhood. Photovoltaic systems are usually installed on the roofs of residential buildings. This reduces the space required for photovoltaic panels and components, which eliminates direct construction costs. One of the economic advantages of this system is that, according to the household's energy profile and the local electricity distribution tariff, network capacity can be realized or the excess part sold to the utility network[3,4].

2. The degradation of the marineandcoastalecosystems

Energy buffers or power storage devices, such as batteries, are required. When the available power from photovoltaic panels is greater than that consumed by consumers, the excess power can be used to charge batteries and Vice versa, batteries can be used when the users' power consumption is greater than the available power from solar panels. The system can also be connected to the network in order to get energy from the network or enter it into the network to eliminate the discrepancy between the generated, consumed and stored energy.To build an optimal and cost-effective energy management strategy, it is necessary to take into account the energy profile of the resident, the characteristics of electricity production based on photovoltaic cells, and the electricity tariff for utilities. Figures 1-4 show the block diagrams of the four main suggested operating modes for a household system.

A photovoltaic system consisting of photovoltaic panels, an inverter, and an energy storage battery is shown in Figure 2 with household load and network connection. A DC Converter is required to track the MPG point. A bidirectional electronic power interface that can work as a DC inverter or AC rectifier is required to charge the battery pack from the mains or a utility to discharge the battery into the load or network.

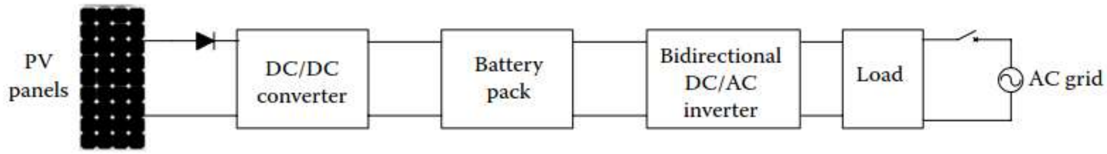

FIGURE 1. Power diagram of a household photovoltaic system.

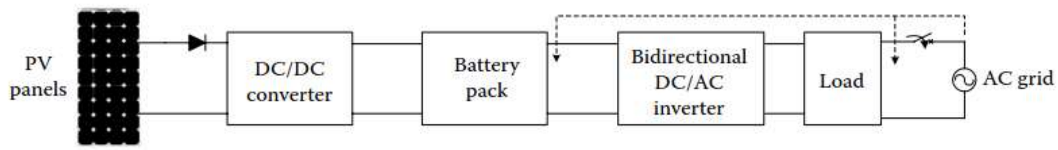

FIGURE 2. Operation mode 1 for the proposed household system.

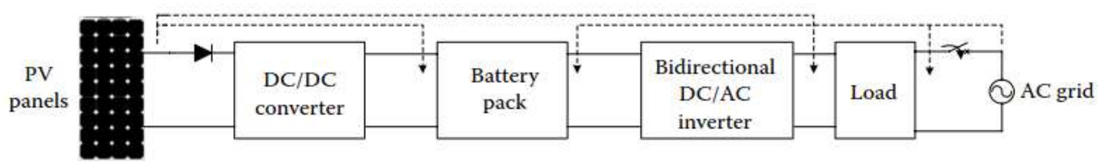

FIGURE 3. Operation mode 2 for the proposed household system.

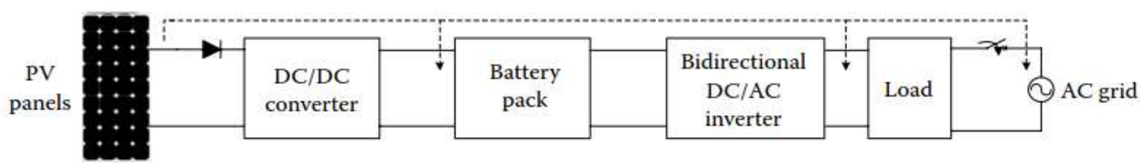

FIGURE 4. Operation mode 3 for the proposed household system.

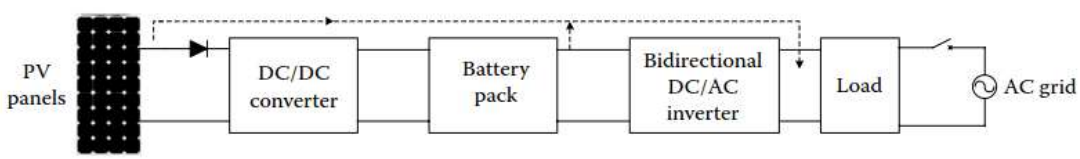

FIGURE 5. Operation mode 4 for the proposed household system.

The following factors are considered for the functioning of the proposed system [5,6]:

1. Power profile of the house: the power received from the network must be minimized, and excess power must be supplied to the network during the peak load of the network. The power profile can vary from region to region, in each case, and depends on the number of consumers in the household;
2. Characteristics of generation of photovoltaic panels: the level of insolation depends on the trajectory of the rays from the Sun t, e the angle of incidence changes with time. To achieve maximum efficiency, you can use solar tracking systems, but this will increase the cost of the system. The optimal power management of the proposed system should be taken into account in terms of power availability;
3. Peak network equalization: a typical power equalization policy for a network may be to sell electricity to a utility during peak load periods when the cost of kWh is relatively higher. During off-peak utility periods, certain energy can be brought in for recovery to change the power level.

3. Methodology

Mode 1 (Figure 2) non-peak load period: from midnight to sunrise, where there is no available power from a photovoltaic source. During this period, the network energy is used to load and recharge the batteries. In this mode of operation, there is no energy flow from the photovoltaic panels to the battery pack or to AC loads. Only mains power is supplied to the loads, and the batteries are charged if necessary.

Mode 2 (Figure 3) low power period: as soon as the sun starts to rise, the PV power starts to increase; however, this is not yet enough to meet the load requirements and to charge the battery. During this period, the power grid must be used to meet the missing electricity needs. In this mode of operation, both the photovoltaic panels and the power grid supply power to the load. At the same time, the battery pack is charged using power from photovoltaic panels and using the power grid, if necessary. However, power from photovoltaic panels takes priority for charging the battery pack as a more economical mode.

Mode 3 (Figure 4) high power period: the PV power is greater than the power consumed on the load from late morning to mid-evening. Solar panels are recharged and excess power can be injected into the utility network. The operating mode is shown in Fig. 4. In this mode of operation, the energy flow is supplied only from the photovoltaic panels to the load and the AC network. No power is consumed from the battery pack or AC power, since the power of the solar panels is sufficient for the load power requirements that can charge the battery, in addition, some power can be supplied to the network if there is excess power [7,8].

Mode 4 (Figure 5) discharge period: during this operating mode, from late evening to midnight, the load is powered by discharging the batteries, as well as the available PV power at the beginning. Subsequently, all the power consumed is satisfied by the batteries, and the power of the photovoltaic system is gradually reduced to zero. The operating mode is shown in Fig. 5. In this mode of operation, the direction of energy flow is from the photovoltaic panels and the battery towards the load.

A cost-effective solution is to operate the proposed system in accordance with the daily operating schedule shown in Fig. 6. The battery is charged during the off-peak period of the network and the cost of kWh from the network is saved, since the battery provides the peak load capacity of the residential block. Through bidirectional power meters, excess power can be sold to the network if the power mode allows it [9,10].

4. Finding

The configuration of the proposed PV energy storage system is shown in Figure 7, in which the DC Converter is responsible for tracking the maximum power, and the bi-directional battery Converter is a single-phase bridge Converter that is capable of working with both a DC inverter and AC Converter modules [11, 12].

The proposed system consists of the following main parts: a step-up Converter, a controller with an algorithm for tracking the maximum power of the MRRT, and a bidirectional DC/AC-AC/DC Converter [13, 14].

The boost Converter is installed between the photovoltaic panels and the battery pack and is responsible for controlling and adjusting the working point of the photovoltaic panels. The configuration of the photovoltaic panel amplifier Converter and batteries is shown in Figure 7.

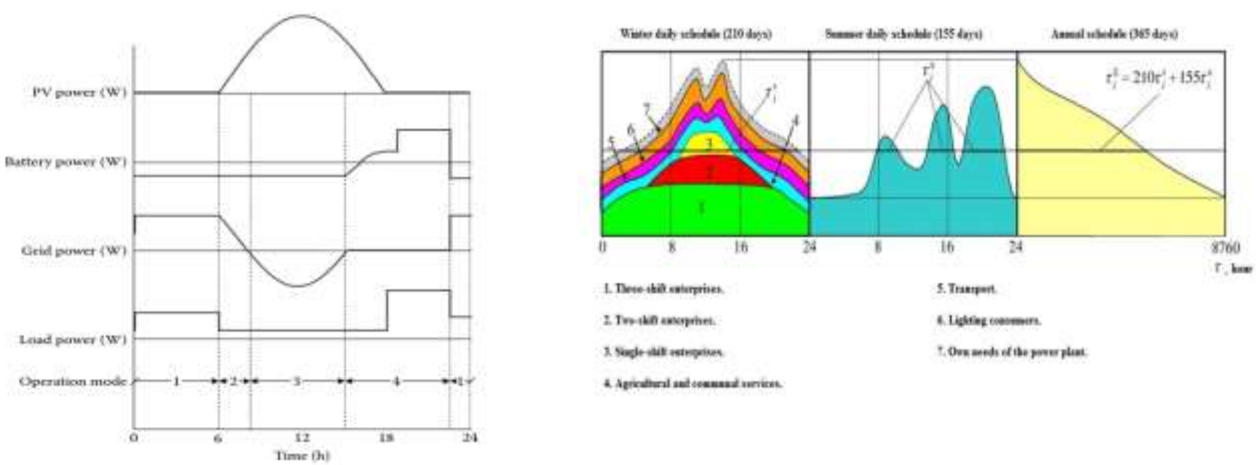

FIGURE 6. Scheme of daily operation of the proposed photovoltaic household system.

The output current of the PV panel (I_{PV}) can be controlled by controlling the current of the Converter (I_C). This is achieved using the current boost Converter control mode.

ISSN- 2394-5125 VOL 7, ISSUE 15, 2020

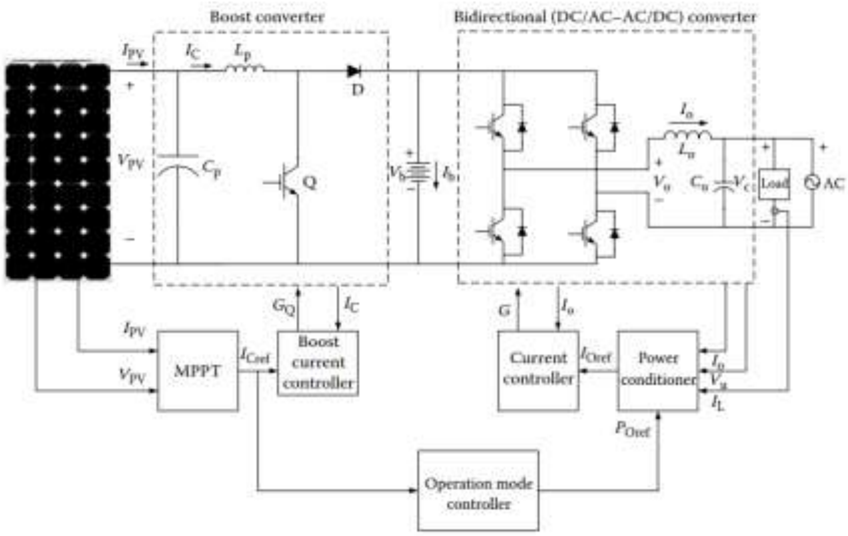

FIGURE 7. Configuration diagram for connecting a photovoltaic system to the network.

Under steady conditions, the voltage of the C_p capacitor reaches the output voltage of the photovoltaic panel.

$$I_{PV} = I_C \tag{1}$$

Using the averaging method, you can get and average two different circuits for turning the switch on and off. When the switch is in the "on" position, the circuit is a parallel CL circuit, and

$$L_P \frac{dI_C}{dt} = V_{PV} \tag{2}$$

When the switch is turned off, it is an open circuit; the current of the inductor charges the battery.

$$L_p \frac{dI_C}{dt} = V_{PV} - V_b \tag{3}$$

Equations 2 and 3 can be averaged on the basis of duty cycle, d, as

$$L_p \frac{dI_C}{dt} = V_{PV} - (1-d)V_b = V_{PV} - V_b + dV_b \tag{4}$$

The block diagram shown in Fig. 8, is an implementation of equation 4.

5. Conclusion

A proportional (P) or proportional-integral (PI) controller can be used to control the current of the boost Converter. The control scheme of the Converter with proportional control is shown in Figure 9.

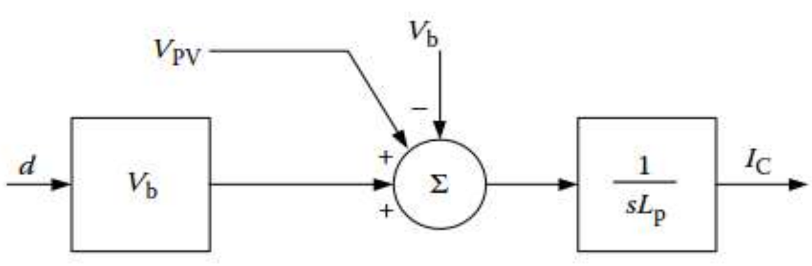

FIGURE 8. Block diagram of the implementation of equation 4.

The equivalent transfer function of the system Figure 9 can be written as

$$\frac{I_C}{I_{Cref}} = \frac{KV_b/L_p}{s+KV_b/L_p} \tag{5}$$

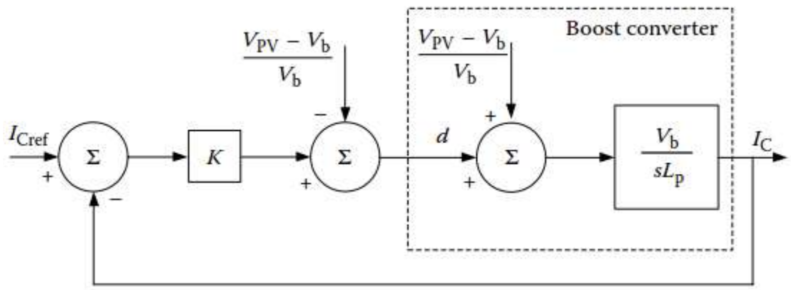

FIGURE 9. Current control scheme of the step-up Converter.

The transfer function can be written as a function of the bandwidth as:

$$\frac{I_C}{I_{Cref}} = \frac{\mu}{s+\mu} \tag{6}$$

where μ-is the bandwidth of the control loop. In order to reduce the system's build-up time, the throughput must be increased. Therefore, at higher values of proportional gain (K), the system will have a faster response. However, the system bandwidth must be limited to be less than the controller switching frequency. The rise time and throughput ratio can be approximated as follows:

$$t_{r\cong\frac{0.35}{\mu}} \tag{7}$$

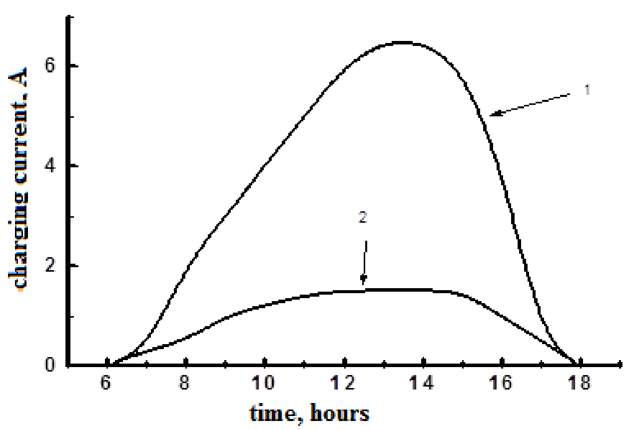

FIGURE10. The dependence of the charging current on the weather condition. 1 - in clear weather. 2 - with continuous clouds.

The short-circuit current, no-load voltage and power of the PV batteries consisting of 40 SE with an efficiency of 18.5% were measured. Measurements were carried out in the Autonomous Republic of Karakalpakstan in winter in clear and cloudy (solid cloud cover) weather.For rice. 10. the results of short-circuit current measurements depending on the time of day are presented. It can be seen that the charging current in clear weather (42.7 A×h, at 790 W/m^2) is 4 times greater than the charging current in cloudy weather (11.6 A×h, at 280 W/m^2). It is obvious that in cloudy

weather, photovoltaic batteries can not work effectively due to a decrease in the charging current, and their charging time depends on the daytime. To reduce battery charging time and ensure the profitability of photovoltaic batteries, you can use, for example, a traditional power grid on winter or cloudy days [15,16].
A number of assumptions are made in the calculation. The project life cycle is assumed to be 20 years, while the estimated lifetime of the PV and the is 20 years. Interest rate r = 5%. The cost of equipment was determined on the basis of retail prices, while it was assumed that the cost of PV a changes in direct proportion to the change in their size. The annual costs of operation and maintenance of the PV and electric and thermal energy storage devices make up 1.5% of the corresponding investment costs.
It is also accepted that the tariffs for the purchase of energy from the network and the sale of energy to the network are independent of the time of day. All of these assumptions, as well as cost parameters relevant for all the regions under consideration, are presented in Table 1.

Name	**Value**
Project life cycle n, years	20
Interest rate r,%	5
Specific investments in the generating part of the microelectric power station I_{pv}, $/kW peak	8300
Specific investments in I_{bat} PV, $/ kW×h	2500
Maintenance costs O_{pv}, O_{bat}, O_t (% of capital costs)	1,5
PV N_{pv} service life, years	20
Total annual electricity consumption E_l, kW×h	550
Electricity price growth rate per year	4 %

Characteristics of microelectric PV systems adopted in the calculations. TABLE 1.

Acknowledgement
As a result of the analysis of possible schemes of functioning of a household photovoltaic system, the optimal scheme of the daily operation of the system was determined. An effective configuration scheme for the power part of the system is proposed. It is possible to control the output current of the system using the current regulators of the converting amplifier. As a result of the experimental determination of the battery charging current in natural weather conditions, it is concluded that it is necessary to add a switching device to the system's operation scheme in the absence of the sun and in cloudy weather conditions.
The team of authors is grateful to professors N.F.Zikrillayev and I.A.Yuldoshev for his valuable advice and discussion of the experimental results.

6. References

[1] Davletshina M.R., Khabirov I.K. The use of GIS technology in soil research. In the collection: Agroecological role of soil fertility and modern agrotechnology materials of the International Scientific and Practical Conference. BashkirStateAgrarianUniversity 52-53 p. 2008.

[2] Khaligh, Alireza. Energy harvesting: solar, wind, and ocean energy conversion systems/ Alireza Khaligh, Omer C. Onar. p. cm. -- (Energy, power electronics, and machines) Includes bibliographical references and index, pp.9-15.

[3] JavoxirToshov, ElyorSaitov. Portable autonomous solar power plant for individual use// E3S Web of Conferences RSES 139, 01087 (2019) pp. 1-4, 2019.
[4] M.K.Bakhadyrkhanov., S.A.Valiev., N.F.Zikrillaev., S.V.Koveshnikov., E. B. Saitov., S. A. Tachilin. Silicon-based solar cells with clusters of nickel atoms // Geliotekhnika No. 4 pp. 28-32, 2016.
[5] ZikrillayevNurullo and SaitovElyor. Silicon materials -the future of photovoltaics// LAP LAMBERT Academic Publishing (2020-01-06) - ISBN-13: 978-620-0-50311-4. pp.94, 2020.
[6] ZikrillayevNurilla, SaitovElyor, BotirovBozorbek, NasirdinovBakhodir, KurbanovYunus, TurayevFarxodjon, ShodiyevaNozina. Study of the results of diffusion doping technique for producing heterostructures (Si-Ge) using microprobe analysis// Austrian Journal of Technical and Natural Sciences. «East West» Association for Advanced Studies and Higher Education GmbH. No.1-2. pp.56-61, 2019.
[7] B.A.Abdurakhmanov, M.K.Bakhadirkhanov, H.M.Iliyev, S.B.Isamov, E.B.Saitov, A.Mavlyanov, H.U.Kamalov, Z.Saparniyazova, O.Sattarov, U.Kh.Sodikov, N.F.Zikrillayev. Silicon with Clusters of Impurity Atoms as a Novel Material for Photovoltaics // Nanoscience and Nanotechnology 4(3): pp. 41-43, 2014.
[8] Saitov E. Study of Quantitative and Qualitative Characteristics of Nickel Clusters and Semiconductor Structures. Journal of Materials Science and Chemical Engineering. №4 pp. 30-35, 2016.
[9] M.N. Tursunov., I.A. Yuldoshev. Development of photovoltaic batteries, installations efficiently operating in Central Asia // Problems of energy and resource conservation. - Tashkent. - Special issue. 160-165 s, 2011.
[10] Avezova, N.R., Toshev, J.B., Dalmuradova, N.N., Farmonov, A.A., Mardonova, M.S. Renewable Energy: Scenario and Model of Development // Applied Solar Energy, 2019, Vol. 55, No. 6, pp. 438–445. DOI: 10.3103/S0003701X19060021.
[11] Abdurakhmanov B.A., Bakhadirkhanov M.K., Ayupov K.S., Iliyev H.M., Saitov E.B., Mavlyanov A., Kamalov H.U. Formation of Clusters of Impurity Atoms of Nickel in Silicon and Controlling Their Parameters// Nanoscience and Nanotechnology. V. 4. N 2. pp. 23–26, 2014.
[12] Saitov E. Study of Quantitative and Qualitative Characteristics of Nickel Clusters and Semiconductor Structures. International Journal of Advanced Research in Science, Engineering and Technology, Vol. 3, Issue 5, May 2016. pp. 1952-1956.
[13] Saitov E.B. Low-temperature diffusion of Ge, S, Ni, and Mn impurities in silicon to produce photocells. Conference proceedings. Energy: management, qualityandenergyefficiency. 532-536 s, 2015.
[14] M.K. Bakhadyrkhanov, S.B. Isamov, Z.T. Kenzhaev, S.V. Koveshnikov. Studying the effect of nickel doping of silicon solar cells with a deep p – n junction // Journal of Physics and Technology, vol. 45, no. 19, 2019.
[15] Bakhadyrhanov M.K., Sodikov U.X., Melibayev D., Wumaier T., Koveshnikov S.V., Khodjanepesov K.A., Zhan J. Silicon with Clusters of Impurity Atoms as a Novel Material for Optoelectronics and Photovoltaic Energetics// Journal of Materials Science and Chemical Engineering. V. 6. pp.180–190, 2018.
[16] M.K. Bakhadyrkhanov, B.A. Abdurakhmanov, E.B.Saitov. Study the current-voltage characteristics of the atoms cluster microstructure of nickel-silicon. Proceedings of international conference dedicated to the seventeenth anniversary of Physical-technical institute, SPA 'Physics-Sun' 'Fundamental and applied problems of physics. pp.107-108, 2013.