Economic efficiency in the use of solar energy: A case study of Agriculture in Uzbekistan

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Abstract. This article explores the cost-effectiveness of using a solar panel in a household. It also analyzes households' demand for electricity and their use. Daily household consumption of electricity was calculated based on monograph observations and its average daily consumption was 1513 kW/day. The solar panels' technical characteristics (current, voltage, battery capacity, inverter, and other) are based on the solar panels to fully meet their electricity demand. It was found that the lowest electricity generation potential could be accumulated in December, the highest in June and July, and the law was based on the opposite. Proposals and recommendations on efficient use of solar energy have been scientifically justified.

1. Introduction

Population Because of radical reforms in the fuel and energy sector in recent years in our country, comprehensive measures are being taken to fully meet the growing demand for energy resources and consistent work is being done to diversify energy sources.

The need for electricity and heat, which is a global problem, is growing day by day. This can be attributed to the depletion of traditional energy resources (oil, coal, and natural gas reserves), their rising cost, environmental degradation and various other factors [1-12]. Today, the developed countries of the world have also developed programs for the use of renewable energy sources (RES) [13, 14]. In particular, it is taking measures to increase the share of EU countries to 29% and China to 15% and to support the use of RES [14].

A number of scientists have conducted research in the field of efficient use of energy resources [1-21]. In addition, research on energy conservation in agriculture was conducted by Tursunov et al., Mamatov et al.,, Mirzaev et al., Mirsaidov et al., and others [1-7, 11, 12, 22, 23].

The usage of solar and wind energy is paid a great attention in our country. Solar energy serves as an additional source of energy that they are traditionally generated. In this regard, the President of the Republic of Uzbekistan dated November 8, 2017 "On measures to ensure the rational use of energy resources" and July 9, 2019 "On measures to ensure sustainable energy supply of the population and economy, financial rehabilitation of the oil and gas sector and its management system" An example of this is the decision of [24, 25].

One of the urgent issues is to study the problems associated with the implementation of some of the tasks set out in these decisions and ways to overcome them, and to develop science-based proposals. In particular, it is possible to analyze the possibilities of uninterrupted power supply to homes using solar panels, the demand of consumers (users) and the advantages and disadvantages of existing payments, and the development of acceptable proposals and recommendations.

The research was conducted in Zangiota, Kibray, Parkent districts of Tashkent region, and the data collected because of observations and research were calculated empirically. Dynamic changes in electricity payments were analyzed based on the established tariff and compared with the base period.

2. Methodology

Study was conducted on the views on the use of non-conventional energy sources and the age-related issues related to their use based on market principles. Based on the study of these energy sources using analysis and synthesis methods and the development of science-based proposals, the benefits and opportunities for solar energy users will be analyzed. It also requires a systematic analysis based on different scenarios, taking into account the social and economic significance of the use of solar energy.

The most essential directions of effective methods of using solar panels based on the results of scientific research or based on empirical analysis are proposed for residential areas.

3. Results and Analysis

3.1. Solar Housing Project

There are requirements for solar energy supply to residential areas. These include the organization of an independent power supply, the allocation of space for the installation of solar panels, the achievement of maximum light output and the ability to manage energy resources, and so on. It is also required to have a complete knowledge of the daily consumption and use of energy in the design of housing.

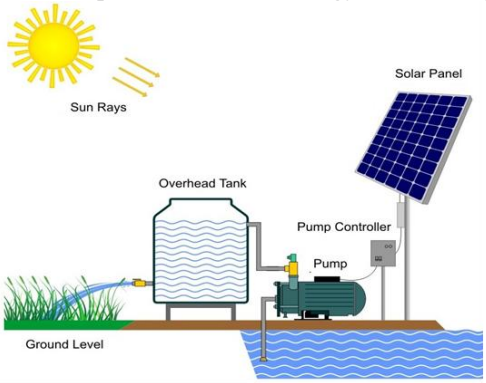

Figure 1. Autonomous solar power plant applied in Agriculture

3.2. Information on Photovoltaic System

The main components of photovoltaic systems are solar panel, controller, and rechargeable battery and in only a constant current is generated from them. The amount of electricity generated depends on the efficiency of the solar cells. The electrical energy generated on the unit surface is typically in the range of values from 10 mW/cm^2 to 25 mW/cm^2, which is equivalent to the efficiency of 10 percent to 25 percent, respectively. The surface area of the solar cells currently in production is 15.6cm x 15.6cm = 243.4 cm^2. The efficiency 19 percent photo element produces 4.6 watts of power at peak performance. Currently, photovoltaic modules (PVMs) range in power from 3 W to 400 W.

The accumulative battery is a device that protects against deep discharge (when a large amount of energy is used) and overcharging (when the accumulative battery is fully charged but produces PVM current) verter (see Figure 2).

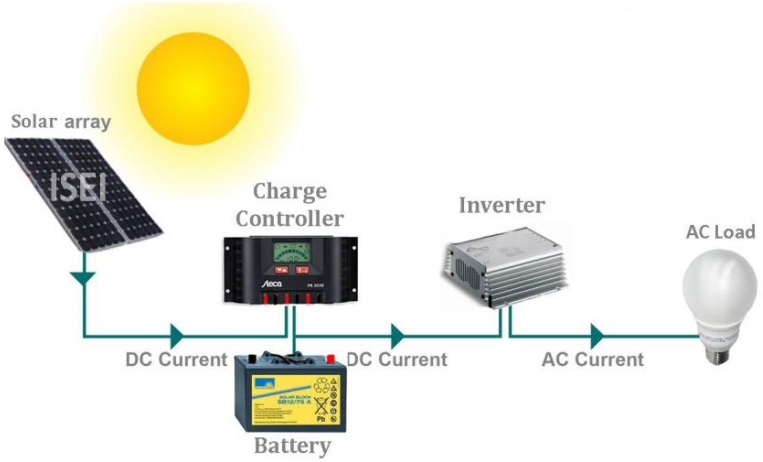

Figure 2. Wiring diagram of a photoelectric system

3.3. Design

In the design of photovoltaic systems (PVS), based on the results of observations and research conducted in Tashkent region, the average daily electricity demand of consumers was taken into account. They are reflected in Table 1 below.

Of the 242 selected sources, 107 were found to be qualitatively beneficial to human health. Table 1 shows the main criteria for assessing (determining) the treatment properties of mineral waters in Uzbekistan. All results obtained in the laboratory were analyzed and sources with medicinal properties were selected based on these criteria (Table 1).

Table 1. Information on the usage of electrical appliances in households

Power of electrical device, W.	Number of devices, *pcs*	Daily usage, *h*	Daily energy consumption, $W \cdot h$
Lighting lamp - 10 W.	4	5	200
Television 32` - 80 W	1	4	320
Laptop 15` - 35 W	1	2	70
*Refrigerator - 643 W (day)	1	10/24	643
Teapot- 900 W	1	0.2	180
Other devices – 100 W	-	-	100
Total:		1513	

Note: Calculated by the authors based on research

* The average annual capacity of A ++ type refrigerators is 235 kW

When choosing a battery used in solar technologies, you must consider the following characteristics:

- Battery capacity and discharge rate;
- Number of cycles and temperature;
- Battery efficiency;
- High charging capacity;
- Good power density, high recharges efficiency, fast recharge.

It is also necessary to pay maximum attention to the fact that all the batteries used in the battery are of the same type, the same manufacturer, the year of start-up and must be maintained at the same temperature.

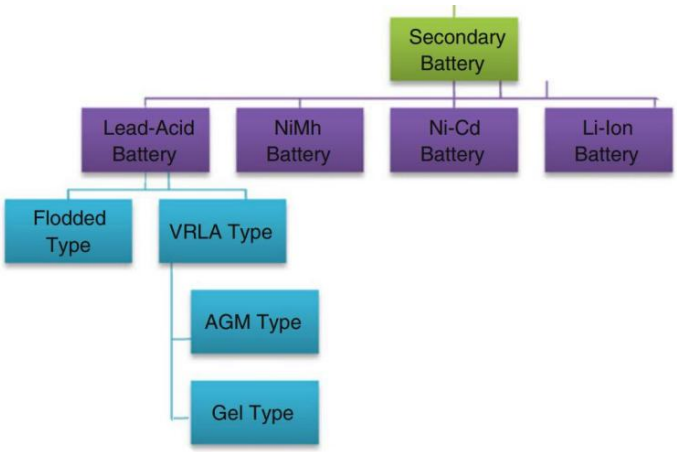

Figure 3. The selection of batteries

There are the following types of batteries: Lead-acid battery (the most common) and Lithium battery.

3.4. Design the dimensions of the battery pack (BP)

When selecting the size of the battery, the required power is divided by the voltage of the system.

$$BP\ [A \cdot s] = 1513\ W: 12\ B = 126\ A \cdot s \quad (1)$$

Where, A-current, s-hour, 12 volts is the voltage of the battery.

3.5. The charge indicator of BP

This indicator shows the charge rating of the accumulative battery. Up to 80% of the battery, charge can be used in FE systems.

$$BP\ capacitance\ [A \cdot s] = 126\ A \cdot s: 0.8 = 158\ A \cdot s \quad (2)$$

In this case, use of 0.8- battery charge up to 80%.

The amount of energy required from PVMs is derived from the sun's lighting hours. In Uzbekistan, this figure is about 8 hours.

In this case, we divide the value (1) by the hour of sunlight.

$$I\ [A] = 158\ A \cdot s: 8\ s = 20\ A \quad (3)$$

The current output from the PVM (A) is reduced taking into account the solar module dusting (5%) and the manufacturer's errors (5%).

$$I\ [A] = 20\ A: 0.95: 0.95 = 22\ A \quad (4)$$

This means that if the FE system is supplied with 22 A current in 1 hour, it will provide the required 20A current. Given that the average power (S) of a common PVM today is 130 W, its current can be determined as follows:

$$I_{PVM}\ [A] = SW: 12\ V = 130\ W: 12\ V = 11\ A \quad (5)$$

3.6. The number of modules in the system

The number of PVMs can be determined by the ratio of the current (4) required to generate electricity to the PVM current (5).

$$N\ [piece] = 22\ A: 11\ A = 2\ piece \quad (6)$$

3.7. Determination of inverter power

The inverter power can be taken to be equal to the power of the loads that can be connected at the same time, and it must have the same magnitude as the system voltage. This ensures that the system can be expanded later if the size is higher.

3.8. Selection of controllers

When selecting the parameters of the controller, it is necessary to operate it at the voltage in the system and to conduct up to 125 percent of the total current.

$$Ic\ [A] = 1.25 \cdot 22\ A = 27.5\ A \quad (7)$$

Based on the studies conducted in the residential areas of Zangiota, Kibray and Parkent districts where the research was conducted, the equipment and key components required for the introduction of solar panels in households were analyzed (Table 2).

Table 2. The structure of the photoelectric system

Device name	Technical indicators	Quantity	Cost, million sum
PVM	130 W	2	1,5
Controllers	27,5 A	1	0,2
Accumulative battery	158 A·s	1	2,4
Inventor (12-220 W)	1500 BA	1	1,5
Total:		5.6	

3.9. Economic efficiency of solar energy use

The project was based on the possibility of 1513 W/day power supply capacity. However, these expenses amount to 5,600,000 sums. If we take into account that currently the payment for 1 kW of energy is 250 sums, the payback period for basic costs is 15-20 years (at current prices).

3.10. Payment and approaches for the use of electricity

Tariffs for the use of energy resources are divided into groups. Consumption payments have fluctuated over the years (Table 3).

Table 3. The information on the increase in electricity prices for domestic consumption

Year	Month	Payment for the rate	The changes relative to the base period, Y_t/Y_{2012}	The changes compared to the previous year %, Y_t/Y_{t-1}•100
2012	October	104.0	1.00	113.5
2013	October	120.0	1.15	115.4
2014	April	131.4	1.26	114.8
2014	October	144.3	1.39	
2015	May	155.0	1.49	116.9
2015	October	167.4	1.61	
2016	April	182.0	1.75	115.7
2016	October	191.0	1.84	
2017	June	204.3	1.96	109.5
2018	April	228.6	2.20	117.1
2018	November	250.0	2.40	

Based on the data in this table, it should be noted that payments for the use of electricity (column 4) could be seen from year to year. It can be seen that payments for energy use (column 5) have increased almost 2.4 times over the years. The average growth rate of payments is 115.9%.

The fact that the price of electricity in the country changes almost once or twice a year has a direct impact on production and consumption costs. If it is possible to provide energy payments at fixed prices for 2-3 years, what will be the change in prices if the established tariffs remain unchanged at the expense of wages and other resources? As a result, it was found that the price change interval during these years could be around 290-330 sums/kW (based on the dynamics of price changes in the period up to 2018).

Second, in the case of long-term pricing, it was found in the calculation process that the current tariff price could be 440 sums/kW if the price policy is stabilized within 5 years.

This means that setting prices unchanged for a certain period allows the use of alternative (alternative) energy resources. As a result, the population's demand for energy resources is formed because of market principles - mutual competition and supply.

4. Discussions and Suggestions

Based on the above analysis and the results obtained, it can be said that the main task is to preserve the existing natural resources and pass them on to future generations. Therefore, it is important to analyze this process from economic, social and environmental perspectives.

On the one hand, the use of solar panels is less cost-effective due to the high cost of installation and repair [26, 27]. For example, with a total cost of 5.6 million sums, the relative advantage may be as follows. The focus is on bank interest rates. In particular, bank deposits should average 20%. The annual interest rate is 1.12 million sums. The annual payment of one family is 273.75 thousand sums. If prices were assumed unchanged, a one-year bank interest rate would allow for an average 4-year payment.

Secondly, the use of solar energy in mountainous and foothill areas, low plains, desert areas, nature reserves and other facilities that are difficult to provide by the state can be implemented on the basis of public-private partnership. It is also necessary to provide continuous (uninterrupted) energy to multidisciplinary hospitals, recreation centers and other social facilities, to direct government subsidies in this direction, because this is a socially important and topical issue as an organizational task of the state.

Thirdly, solar and wind energy can be mentioned as energy sources that are environmentally friendly and do not affect the purity of the environment [28]. In the current situation, energy production using these technologies can be costly, but once natural resources are depleted, it will not be possible to compare it with other sources. Therefore, supporting the use of non-traditional energy sources is considered environmentally beneficial, and conserving the environment is a task for future generations [29-32].

The development of a solar energy application system is promising, but at the same time requires high costs. Therefore, it is necessary to look for effective ways to use solar panels and improve the existing ones. This will require the simplification of the system of state support and funding for this sector.

The main directions of state support for the use of solar panels:

- Stimulation of domestic production of solar collectors and panels;
- Production of high-quality and high-efficiency devices for consumers (users);
- Introduction of additional tax benefits for independent (autonomous) users of solar, wind and other non-conventional energy resources (including the reduction of property tax by 50%, etc.);
- Development of a procedure for issuing bank loans in the amount not exceeding the refinancing rate to support the use of solar panels;
- Amendments and additions to the legislation on separate, joint use and use of solar energy because of public-private partnership;
- Creation of service infrastructure and provision of qualified personnel and organization of other services.

5. Conclusions

In conclusion, it is expedient to create conditions for self-sufficiency of the population in energy resources. This will require the implementation of measures such as providing incentives to manufacturers of solar panels, localization of production of solar panels and solar collectors.

According to the calculations, it is recommended to stabilize electricity payments for a certain period of time (2-3 years). It is also necessary to amend the legislation on the purchase of solar panels and the allocation of bank loans to its users.

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