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Issues Of Introduction Of Mobile Power Plants Based On Renewable Energy Sources And A Multifunctional Electric Tractor

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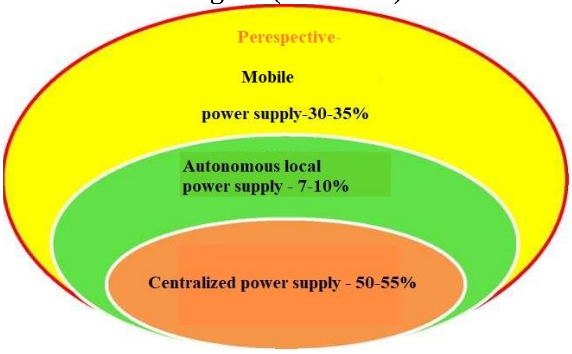
Abstract

For the effective development of the agricultural sector, solving the problems of timely and sufficient power supply is relevant. Due to the absence or inefficiency of the wiring of centralized power supply systems in remote areas, fertile lands are gradually going out of circulation. Based on the study of the experience of developed countries in solving the above problems, the corresponding conclusions were made on the transfer of mobile agricultural machinery to electric drive, the development and production of mobile mini-electric tractors for processing and harvesting in local conditions, mobile power stations based on renewable energy sources for remote territories.
In the agricultural sector, electric energy is mainly consumed for irrigation and electric drive of various equipment and installations. For example, for the introduction of drip irrigation and electric tractors in remote areas from centralized power supply lines in Uzbekistan, the mobile method of power supply is considered effective. The developed prototype of the Solar-Wind mobile power plant can generate an average of 4.5-4.7 kWh in the daytime, and 0.8-1.0 kWh of electric energy in the evening hours. The annual production of electric energy is more than 20,000 kWh of electric energy. Taking into account the return of fertile lands into circulation, and the cost of the resulting crop, the payback of the station does not exceed 4-5 years.

Keywords: Agricultural power supply, mobile power stations, electric drive, electric tractors, plant processing, mobile charging station, charging station infrastructure. renewable energy sources.

1. Introduction

An analysis of the state of electricity supply in the agricultural sector shows that in Uzbekistan about 55% of fertile land resources are covered by a centralized power supply network. More than 10% of territories use mobile diesel generators of low power. More than 35% of farms are located far from centralized electrical networks, as a result of which problems arise in remote areas with the introduction of modern energy-efficient technologies. (Picture 1.)



Picture 1. Current state and prospects of electricity supply in the agricultural sector of the Republic of Uzbekistan

The analysis of the table shows that due to the non-diversified power supply system, more than 40% of the total volume of land resources are outside the coverage area of centralized power supply systems. According to this, the indicator of energy supply from the point of view of the current level of development of electrical technologies is considered low.

For the implementation of mobile power supply, a project of a solar-wind mobile power plant has been developed, which can generate an average of $P_{mobile\ day}$ = 4.5-4.7 kWh, and the evening hours are $P_{mobile\ night}$ = 0.8-1.0 kWh of electrical energy (Picture 2).

Inefficiency of centralized power supply in remote areas from an economic and technological point of view is characterized by the following reasons:

- Relatively low amount of energy consumption in the field;
- Seasonality of electric energy consumption;
- Constantly changing consumption schedules due to the requirements of agricultural machinery

The main obstacle to the effective development of the agricultural sector at present is the problems of timely and sufficient electricity supply and energy availability of farms. In this regard, fertile land resources are going out of circulation locally. In animal husbandry, there is an acute shortage of water resources in remote pastures

In many farms in remote regions, when cultivating land and plants, agricultural machinery is idle due to a shortage of fuel and lubricants. As a result, sowing and processing of plants are carried out late or in some cases manually.

With the increase in the fleet of equipment with electric drive, the infrastructure for charging them should be developed in parallel. The results of research by well-known world manufacturers of batteries and chargers show that, in combination with the constant improvement of battery performance, a turning point in the mass opening of EV stations will come in the near future. As with other similar innovative technologies, the transition to electric vehicles will gradually increase.

Piyali Ganduli, Akhtar Kalam and Aladin Zayeg in their study “Solar-wind hybrid renewable Energy System: the current state of research in the field of configurations, management methods and calibration” note that a renewable energy system consisting of solar and wind energy is an environmentally friendly and economically viable option for rural nutrition compared to traditional sources. The disadvantage of these systems is that they are less reliable, since the power generated depends on meteorological conditions [4].

In the research of S. K. Sheryazov on the topic “Methodology of rational combination of traditional and renewable energy resources in the energy supply system of agricultural consumers”, the goal is to develop a methodology for rational combination of traditional and renewable energy resources in the energy supply system of agricultural consumers in order to reduce the cost of energy consumption [5].

M. A. Tashimbetov studied the issues of integrated use of renewable energy sources in the Republic of Kazakhstan. On the example of the Dzhambul region of Southern Kazakhstan, the rationale for choosing a combined energy complex based on renewable energy sources with a capacity of 100 kW to provide electricity to a rural settlement was carried out. The average power generation by the power supply system has been determined and an annual load schedule for consumers has been developed [6].

Ahmed Torki and Ahmed Jailani in their research studied the issues of providing electricity to autonomous rural consumers through the use of renewable energy sources in order to develop autonomous combined power supply systems for farms in Egypt [8].

2. Materials and methods

The purpose of the study is to study and analyze the effectiveness of measures for the power supply of remote territories and the introduction of electric tractors, taking into account the use of modern energy-efficient technologies in the conditions of the Republic of Uzbekistan.
The main electro-technological processes in fruit and vegetable growing consist of low-power electrical equipment, remote from each other and are seasonal. With this in mind, when designing regional power supply networks, they should be based on the integrated use of traditional and various types of renewable energy sources in the design and development of energy supply systems.
These goals can be achieved by using modern methods of selecting the composition and parameters of autonomous and mobile solar-wind devices that can constantly provide electricity to small farms located far from centralized networks [6].

Methodology. The theoretical and methodological basis of the research is the results of the work of scientists on the problems of electricity supply in agriculture. In the course of the study, a systematic approach to the analysis of energy consumption was chosen, in which various tools were used to determine the essence of the analyzed phenomena, processes and patterns.
In the experimental part of the study, computational and analytical methods, correlation and regression methods were widely used, the use of methods adequate to the studied phenomena made it possible to ensure high reliability of the results obtained.
It is known that agricultural consumers of electric energy have specific operating modes, which mainly depend on agrotechnical requirements and seasonality. Therefore, the so-called simultaneity coefficient K is introduced, which determines the dependence of the calculated values of the loads of several consumers on the values of their maximum loads.
Considering that several consumers do not work simultaneously in the processes of growing and processing fruit and vegetable products. Therefore, when calculating the loads in the power supply, the arithmetic mean sum of the power values of simultaneously operating equipment multiplied by $K < 1$ is taken.

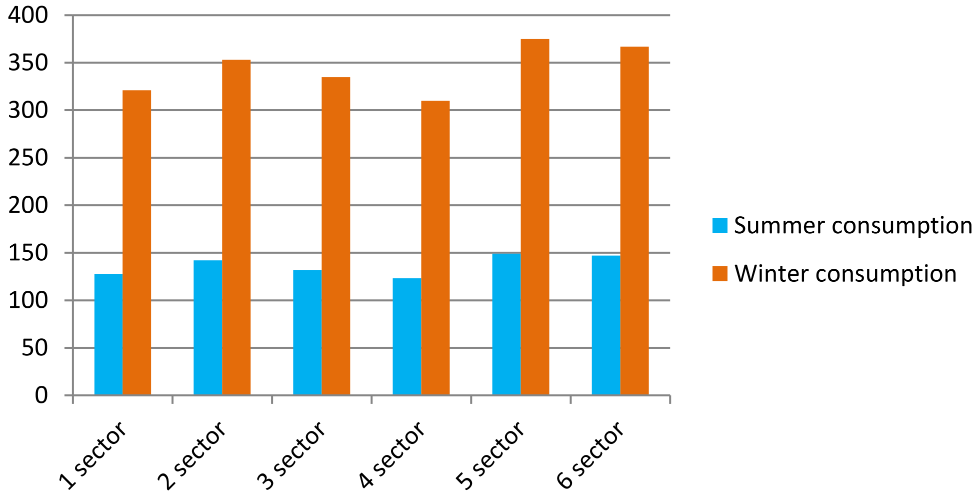
3. Research results. Discussions

In the agricultural sector, several consumers do not work at the same time. Therefore, the calculated power in the power supply is taken at the value of the arithmetic sum of the capacities of consumers operating at a given time, a multiple of the one-time coefficient $Q < 1$. The one-time coefficient is the dependence of the values of the calculated loads of several groups of consumers on the values of their maximum loads.
The calculation of the electrical load for farms is carried out using the K_{season} - the seasonality coefficient given in Table 1.

Table 1. Coefficients of seasonality of electricity consumers in agriculture

Types of consumers	Season			
	Winter	Spring	Summer	Autumn
Ordinary consumers	1.0	0.8	0.7	0.9
Irrigation	0-0.1	0.3-0.5	1.0	0.2-0.5
Closed ground for electric heating	0.3	1.0	0	0
Autumn-summer consumers	0.2	0	1.0	1.0

Indicators in the context of sectors by daily and monthly energy consumption of processes from the cultivation of fruit and vegetable crops to collection and storage on the territory of the OFI “Beruni” of the Beruni district give us the basis for drawing up daily and monthly schedules of electricity consumption for each sector.



Picture 2. Winter and summer levels of electricity consumption in fruit and vegetable and horticultural farms of “Beruni" of the Beruni district of the Republic of Kazakhstan.

In the agricultural sector of Uzbekistan, electric energy is mainly consumed for irrigation and electric drive of various equipment and installations. For example, for the introduction of drip irrigation in areas remote from power lines, a mobile method of electricity supply is required. The developed prototype of the Solar-Wind mobile power plant is designed for these purposes.
Based on the above, we will calculate the pump power when handling, taking into account the water flow, the total dynamic pressure and the performance of the pump and the electric motor. The energy consumption for electric pumps is calculated by the formula:

$$\boldsymbol{P}=\frac{(\boldsymbol{Q}\cdot\boldsymbol{H})}{(\mathbf{102}\cdot\boldsymbol{E_p}\cdot\boldsymbol{E_m})};\qquad(1)$$

where: R - energy consumption (kW); Q-volume of water consumption (liter/sec); H-total dynamic pressure (m); E_p - pump performance; E_m-engine performance.
When calculating operating costs, parameters such as the level of electric power consumption by the electric motor, the cost of electricity and the operating time of the pump are calculated using the formula:

$$\boldsymbol{C}=\boldsymbol{P_x}\cdot\boldsymbol{S_{ex}}\cdot\boldsymbol{T};\qquad(2)$$

Where C- is operating costs; P- is the amount of energy consumption (kWh); Se- is the cost of electricity (per 1 kWh)*; T- is the operating time of the pump (h).
Let's make a calculation for choosing an electric pump using the example of the Beruniysky district farm, which has 5 hectares of land (2 hectares of vegetable garden, 2 hectares of tomatoes and 1 hectare of eggplant).
From the above regulatory data, we determine that for drip irrigation of gardens (the planting scheme is 5x6 meters, the number of trees per 1 ha will be 335), 17 m^3 of water per 1 ha is required for watering gardens. For 1 hectare of tomatoes and eggplants (planting scheme 60 x 40, the number of plants per 1 hectare is 41666.), the irrigation rate is 83 m^3 of water. We determine the general need:

$$\boldsymbol{Q}_{\boldsymbol{common}}=\boldsymbol{Q}_{\boldsymbol{garden}}+\boldsymbol{Q}_{\boldsymbol{vegetables}}=\mathbf{34\ m^3}+\mathbf{249\ m^3}=\mathbf{283\ m^3}\qquad(3)$$

The average growing season for a vegetable is N = 100-120 days. During this period, watering is carried out on average 8 times. From here we determine the rate of average one-time watering.

$$\boldsymbol{Q_{once\ vegetables}}=\frac{\boldsymbol{Q_{vegetables}}}{\boldsymbol{N}}=\frac{\mathbf{249}\ \boldsymbol{m^3}}{\mathbf{8}}\approx\mathbf{31,1}\ \boldsymbol{m^3}\qquad(4)$$

$$\boldsymbol{Q_{once\ a\ garden}}=\frac{\boldsymbol{Q_{garden}}}{\mathbf{30}}=\frac{\mathbf{34}}{\mathbf{30}}=\mathbf{1,13}\ \boldsymbol{m^3}\qquad(5)$$

For drip irrigation pumps in Uzbekistan, a three-phase asynchronous electric motor is chosen. Their efficiency reaches 95% and requires minimal maintenance, and in conditions of high-quality operation they can last for a long time.
In order to choose the pump of optimal performance, the watering time T, depending on the K, the water consumption per hour must be determined

$$\boldsymbol{Q_{sentry}}=\frac{\boldsymbol{Q_{watering}}}{\boldsymbol{T_{watering}}}=\frac{\mathbf{35,6}}{\mathbf{5}}=\mathbf{7,12}\ \boldsymbol{m^3}\qquad(6)$$

Based on the estimated volume of water, we choose a centrifugal pump of the brand 2-4SR with the following technical characteristics: Brand – 4SRM100-K, power consumption –P = 0.75 kW, productivity – Q = 7.2m^3 / h, lifting height – H = 11 meters, operating mode of the electric motor - C1. In practice, such pumps are used for water supply, for watering vegetable gardens, etc.

The conducted analyses show that, for cultivation per one ton of apple trees with drip irrigation with a lower threshold of soil moisture of 70, 80 and 90% HB, the irrigation water consumption varies on average from 127.1 to 197.2 m/t. With furrow irrigation, it averaged 227.8...305.8 m/t, depending on the year of research and the apple variety.

A mobile power plant in the daytime can generate an average of 4.5-4.7 kWh, and in the evening 0.8-1.0 kWh of electric energy. The annual production of electric energy is more than 20,000 kWh of electric energy. If translated into monetary terms, the annual output may amount to 8 million 700 thousand soums.

One mobile station creates opportunities to return more than 100 hectares of fertile land resources that have gone out of circulation. If we take into account that from each ha it is possible to receive in monetary terms for more than 15-20 million. sum of products, then the payback of the station does not exceed 4 years.

Mobile technical means used in the agricultural sector are powered by organic fuel, as a result of which the energy efficiency of agrotechnical measures carried out is low. Taking into account the high cost of production, storage and delivery of fuels and lubricants, the joint use of electric tractors and mobile power plants based on renewable energy is considered effective. Figure 3 shows a mobile power plant and a multifunctional electric tractor based on renewable energy sources and methods of its application.

Picture 3. Mobile station in transport position and field tests of an electric tractor

1- Rod sprayer; 2 – Grounding; 3 – Charger; 4 – Working fluid tank;
5-high voltage transformer; 6- solar panel.

The developed multifunctional electric tractor is designed to perform the following agrotechnical activities:

- Autumn and spring top dressing (suspension spraying) of cereals, orchards and vegetables;
- Agrotechnical measures for plant protection;
- As transport platforms in greenhouses.

A mobile power plant and a multifunctional electric tractor are in demand in operation and can be used in all regions of the Republic of Uzbekistan. Since the above problems are typical for neighboring republics, it is gradually possible to organize the export of these products. The project is aimed at solving the problem of efficient use of technical potential and land resources. With the correct organization of measures for the introduction of modern equipment and technologies, the proposed multifunctional electromechanical device – BAA-1E and mobile "Solar-wind" power plant is in demand in operation and can be used in all regions of the Republic of Uzbekistan. Since the above problems are typical for neighboring republics, it is gradually possible to organize the export of these products.

Conclusions.

Solar energy, by its general availability, is gradually increasing its share among other energy resources. Over the past decades, the price of electric energy received from solar energy has been declining rapidly. The share of investments in the development of solar energy is growing, taking into account the long-term and less exposure to inflation of the invested financial resources.

Currently, Uzbekistan has sufficient scientific potential in this area. Regarding the increase in the share of the use of photovoltaic plants in the energy system of Uzbekistan, the construction of photovoltaic plants has sharply accelerated in recent years.

But, the main problem of the introduction of solar energy in the agricultural sector remains decentralization, facilities, seasonality of consumption modes and relatively low power consumption. Therefore, the introduction of photovoltaic plants in remote regions should be carried out not as an additional, but as the main source of energy.

Based on the results of design and technical and economic calculations, relevant economic tests, taking into account certain natural and climatic conditions of Uzbekistan, a mobile power plant and a multifunctional electric tractor based on renewable energy have been developed and implemented in the Nuriyev Madiyar farm of the Beruniysky district of the Republic of Karakalpakstan.

To widely implement the results of the conducted research, it is necessary to perform the following tasks:

- development and approval of the relevant regulatory and technical documentation (initial requirements, technical specifications, design documentation) of a multifunctional electric tractor and a mobile power plant "Sun-wind";
- production of prototypes for conducting extensive economic tests.

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