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The Use of Renewable Energy Sources in Electrified Crop Production Systems

Ziyodullo Eshmurodov, Sardor Saifiev

Doctor of Technical Sciences, Professor, (Navoi State Mining and Technology University) of the Republic of Uzbekistan, Navoi,
Senior lecturer of the Department of electrical (Karshi Institute of Economic Engineers) of the Republic of Uzbekistan, Karshi.

ABSTRACT: Agriculture, which determines the country's food security, is one of the energy-intensive industries. A long-term forecast in the field of development and improvement of agricultural machinery shows that one of the promising areas for increasing yields and labor productivity in crop production, especially for technological processes associated with large production volumes, is the use of electrified systems. Electrified crop production systems are high performance universal electrified machines and units that perform a wide range of basic, auxiliary and transport operations. Such high-performance universal machines include bridge units.

KEY WORDS: electrified systems, bridge units, electric drive, electric energy, renewable energy, solar energy, sprinkler machine, autonomous power supply system

I. INTRODUCTION

Agriculture, which determines the country's food security, is one of the energy-intensive industries. Limited reserves of organic fuels and the continuous increase in the cost of their use require the search for ways to use energy resources efficiently. One of the ways is to use renewable energy sources (ECS [1]).

Further development of agricultural production is impossible without its technical re-equipment. A long-term forecast in the field of development and improvement of agricultural machinery shows that one of the promising areas for increasing yields and labor productivity in crop production, especially for technological processes associated with large production volumes, is the use of electrified systems. Research on the creation of electrified crop production systems (ECS) is widely carried out in our country and abroad [2-3].

The introduction of electrified systems in crop production makes it possible to increase labor productivity and equipment utilization by 1-2 times, while reducing energy costs by 15-20%. The use of bridge farming systems increases productivity up to 1.6 times, increases the prestige of agricultural labor. At the same time, the environmental situation in the area of system operation is improving [3-4].

Electrified crop production systems are high–performance universal electrified machines and units that perform a wide range of basic, auxiliary and transport operations. Such high-performance universal machines include bridge units.

The ECS includes a large number of mechanisms and devices equipped with an electric drive (EP) and automation tools. The range of these electric motors is wide: the number of electric motors can reach one hundred or more, the power is 1.1 – 250 kW, the rotation speed is from 750 to 3000 min-1, the load characteristics of working machines are different. The EPS ERP control system belongs, as a rule, to the class of multilevel automated process control systems [4].

Bridge units can be made on the basis of the Mini Kuban FSH sprinkler machine with frontal and circular motion (Fig. 1, a,b).

Fig. 1, a, b shows bridge units of protected and open-ground farming systems.

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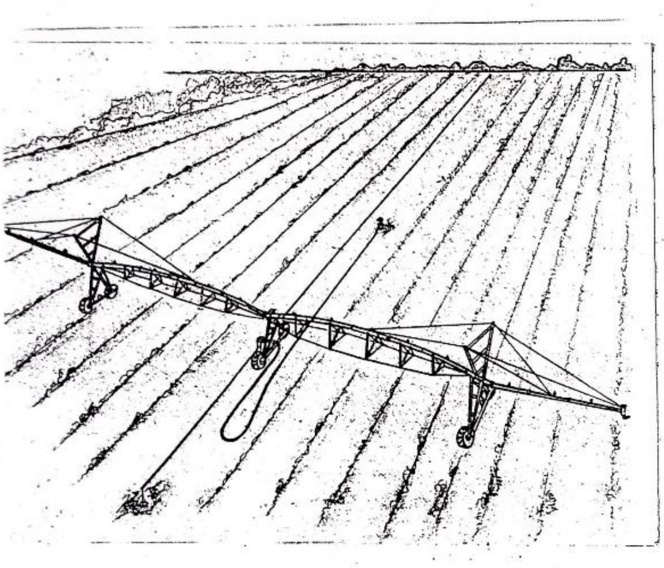


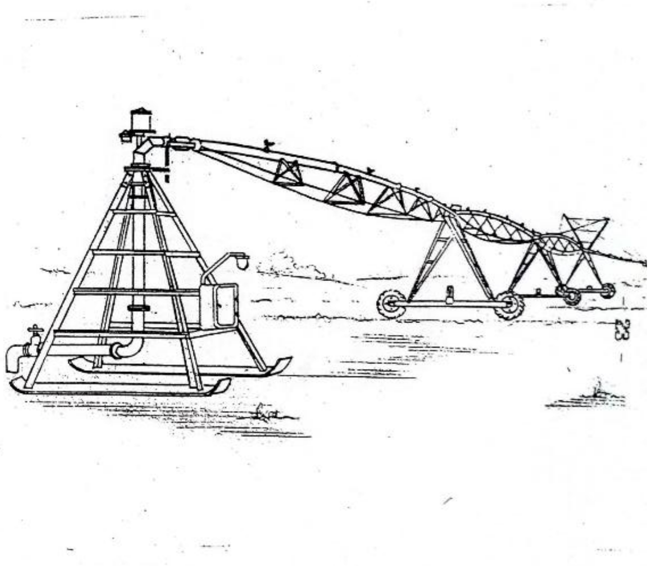
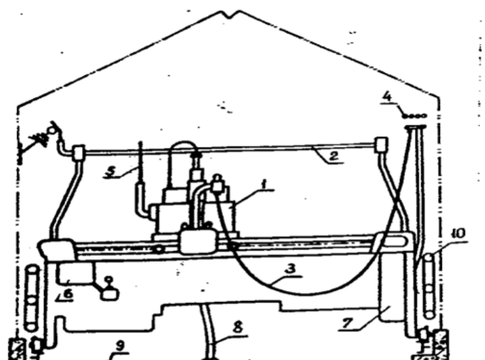


Fig 1a. multi-span bridge unit for frontal movements

Fig. 1b. multi-span bridge unit for frontal movements

The bridge unit includes various mechanisms and devices equipped with an electric drive (EP) and automation tools (Fig. 1,6,): mechanisms for moving the bridge unit, mechanisms for moving the working body, working bodies, transport mechanisms, water supply device, mechanisms for lifting and lowering working bodies, etc.



1-working trolley, 2-in/out trolleys of the working trolley, 3-flexible cable, 4-in/out trolleys of the bridge unit, 5-in/out current collector of the working trolley,6-operational control panel, 7-automation cabinet, 8-universal working body, 9-subsurface heating system and irrigation, 10-radiators

Fig. 2. General view of the bridge unit.

II. SYSTEM ANALYSIS

Agro-bridge technologies for the production of crop production are based on the use of machine systems based on a mobile energy system with a bridge-like design. Unlike the tractor-combine machine system, the bridge system allows for: reducing soil compaction by agricultural machinery; performing agricultural practices in the required time, regardless of the degree of moisture and bearing capacity of the soil; high adaptability of agricultural practices; performing operations inaccessible to tractor technology (cultivating intermediate crops, etc.); eliminating agricultural losses. materials and products; the possibility of complex automation of crop production. The implementation of the bridge system will allow for: programmed crop cultivation; eliminate environmental degradation, reduce plant damage,

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specific consumption of non-reproducible resources, and labor costs. According to approximate estimates, the use of a bridge system provides, in comparison with a tractor productivity increase up to 1.6 times [4].

The rising cost of energy, the aggravation of economic and environmental problems require an increasingly well-founded and thorough development of principles for the use of natural resources and a strategy for the development of energy supply to the agro-industrial complex. In this regard, the issue of finding and developing alternative energy sources becomes relevant. A real way to increase the efficiency of agricultural energy supply is the development of renewable energy sources based on solar energy, hydro and wind energy resources, bioenergy resources - products of agricultural waste processing [4-5].

The economic potential of renewable sources is great, and their share in global energy consumption may amount to 10-12% .[6]

Among the renewable energy sources, the most promising in terms of accessibility to consumers are the use of solar and wind energy. There is a large fleet of solar and wind power plants in the world with a total capacity of more than 200 GW. In the conditions of advanced solar and wind technology, the most urgent issues are their effective use by coordinating the modes of supply and consumption of renewable energy. In this regard, State and sectoral plans and programs are being formed to replace traditional organic fuels due to the potential of renewable sources available in the republic. The geographical location of Uzbekistan has led to the presence of significant solar energy potential in the country. Figure 1 shows a map of the solar availability of the republic's territory according to [6-8].

The abundance of solar energy in Uzbekistan and the severity of the problem of energy supply, the constant increase in electricity tariffs make the problem of creating efficient and cost-effective power supply systems based on solar power plants for autonomous consumers especially relevant, especially since the country is forming prerequisites for the decentralization of energy supply. Such systems should be reliable, automated, easy to operate, have a long service life and at the same time provide an opportunity to solve the problem of water supply.Data on solar energy arrivals in the months of the year for Uzbekistan are shown in Fig. 3 [6].

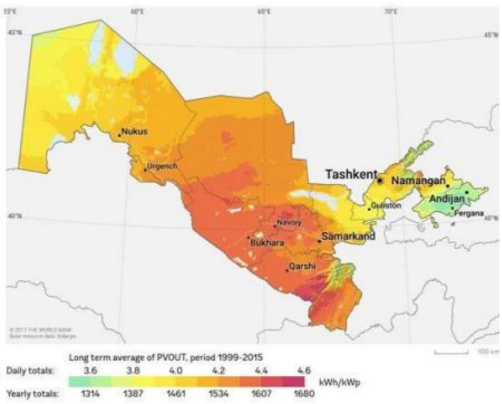

Fig. 3. Map of solar availability in the Republic of Uzbekistan

The potential of renewable energy sources in 2022 in Uzbekistan is shown in Figure 4.

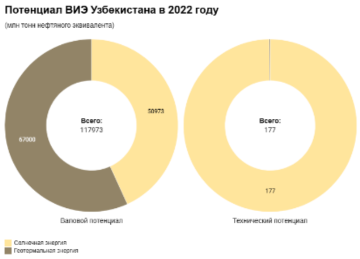

Fig.4. Uzbekistan's renewable energy potential in 2022.

Data on solar energy arrivals in the months of the year for Uzbekistan are shown in Fig. 4.

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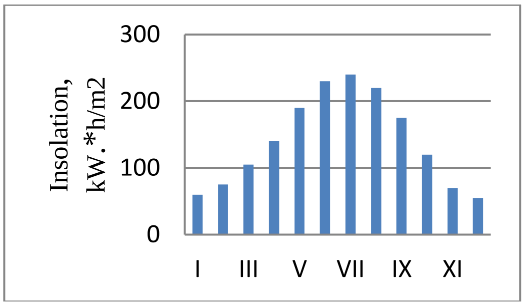
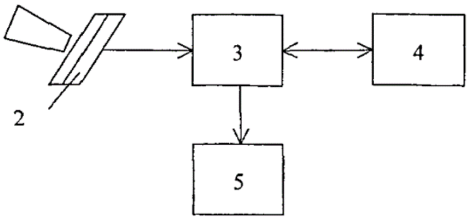


Fig. 5. Energy received from the sun during the year

The annual supply of solar energy per 1 m^2 in Uzbekistan is more than 1600 kWh [7].

Thus, it has been established that on the territory of our republic the intensity of solar radiation has a pronounced character, which confirms the expediency of using solar energy for working electricity consumers, such as the mobile sprinkler system of the bridge unit [8].

One of the most important issues is the development of a methodology and theoretical justification of the parameters of an autonomous solar power plant. It is established that the power plant should be created for the mobile module of the bridge unit. There are technologies that allow the use of renewable energy sources in the operation of sprinkler equipment. All electric receivers can be powered with a voltage of 12 V DC, the following system of an autonomous solar power plant has been adopted (Fig.6) [9].



1 - concentrator, 2 - photoelectric converter, 3 – switch; 4 - battery with charge mode controller, 5 - consumers of direct current electricity

Fig. 6 – Block diagram of an autonomous power supply system based on photovoltaic converters with battery backup

In the above system, the connection with energy sources and consumers (boundary subsystems of the energy system) is taken into account in the form of disturbing influences, which include

It is advisable to use renewable energy sources (RES) to charge the sprinkler batteries. Firstly, the operating conditions of the DM allow the use of renewable energy in the open air under the influence of direct sunlight.

III. RESULTS AND DISCUSSIONS

For the spread of solar power plants, it is necessary to increase the efficiency of their use, and for this it is necessary to increase the efficiency of solar panels. It depends on the technical capabilities of the photovoltaic conversion process. In addition to technical features, the power generated is influenced by external factors, both controlled and uncontrolled. Controlled factors include the quality of electrical connections, dustiness of the module surface, etc., and uncontrolled factors include weather conditions (cloud cover, ultraviolet radiation index, etc.). According to [10-13], factors affecting the generated power of the SB are taken into account using coefficients:

coefficient of energy conversion losses inside the solar cell; depends on the development of developed materials - solar cells, for monocrystalline k_{PM} = 0.25;

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The coefficient that takes into account energy losses in the installation and connection schemes of the solar battery, k_{PS} = 0.9 A coefficient that takes into account the energy loss from the angle of inclination of the solar panel to the sun's rays;

Coefficient, taking into account energy losses in the installation and connection schemes of the solar panel, k_{PS} = 0.9;

Coefficient accounting for energy loss from the angle of inclination of the solar panel to the sunlight; at 90° k_U = 1.0; at 50° k_U = 0.76;

A coefficient that takes into account the contamination of the solar panel surface).

Table 1. – Types of solar panels and their characteristics

Name	KPD, %	Specific output capacities, Vt/m^2
Monocrystalline	20	143
Polycrystalline	17	152
Amorphous (Film –like)	10	178

When choosing an SB, it is necessary to focus on its main characteristics (see Table 1). According to the best practices [14], A system with monocrystalline solar cells is preferred. Their peak power at the same parameters is higher than that of polycrystalline ones (Figure 7).

Figure 7 shows the families of volt-ampere and volt-watt characteristics of the SilaSolar 200 W solar cell for TSTC=25 °C at SI intensities of 1000, 800, 600, 400 and 200 W/m^2.

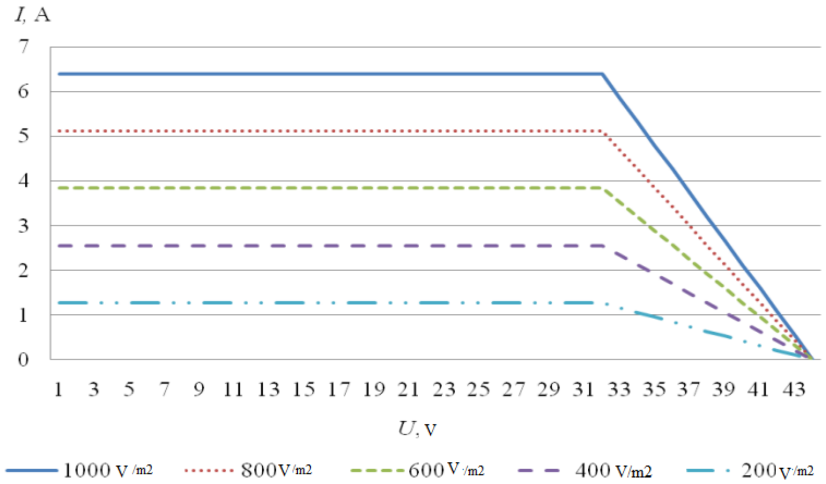

Fig.7 – Volt-ampere characteristics of the SilaSolar 200 W solar cell at TSTC

The peak power of a solar cell is the main characteristic taken into account when connecting a load to it. Maximum power of R_{max} generated by 1 m^2 of solar cell area:

$$P_{max} = U_{mp} I_{mp} , \qquad (1)$$

where Ump is the voltage at the point of maximum power, V; Imp is the current at the point of maximum power, A. Due to the instability of the value of the generated power of solar panels, they are used in conjunction with an additional power source. Such a source can be rechargeable batteries, the energy of which will compensate for the decrease in energy from the SB due to the effects of adverse factors.

It has been established that when selecting the parameters of the battery supply (voltage at the load terminals, capacitance, connection circuits), the duration of movement of the extreme section in continuous operation mode should

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be taken into account when PV% = 100%. It has also been established that the use of renewable energy sources in the ratio of 15-20% of the stored battery energy per day with a probability of M(t) = 0.9 will avoid resource costs in the structure of total operating costs. In the operating mode of the electric drive of the support trolley of the extreme DM section, PV% = 100% will take 5-7 days to fully charge the battery (which is the same as the technological downtime between watering), and at PV% = 10% − 1 day [11-13].

During the irrigation season, the solar panels are operated independently. For example, a sprinkler designed to irrigate an area of 30 hectares, equipped with solar panels of 18 m^2, allows you to work 24 hours a day, 7 days a week. In cloudy weather, the autonomous use of a sprinkler with solar panels reaches 48 hours [15-18]. The movement of the sprinkler machine is carried out by means of an electric drive of movable sections. This process is the most energy-intensive in DM operation. Thus, it is relevant to develop a system based on the use of renewable energy sources for irrigation, this system will allow the use of solar energy to drive running equipment, as well as ensure the operability of electronic systems and units of the robotic complex.

IV. CONCLUSION

Thus, it can be concluded that the battery power supply allows the DM to be operated in conditions difficult for centralized power supply. In comparison with a portable generator, the battery can be mounted on mobile support trolleys, which eliminates the use of expensive current collectors and cable lines for energy transmission. With battery power, machine motion control can be performed at a lower energy level, for example, powering all motion synchronization devices in line (PSL) from 12 V DC, which will reduce energy consumption for the control device.

The energy efficiency of the use of autonomous power supply for circular sprinklers with a solar and rechargeable battery source is estimated. It has been established that due to the use of a SUB, energy losses during transmission are eliminated, since the battery can be mounted on a support trolley next to the electric drive. Together, it is possible to reduce energy consumption for DM water distribution from 0.20 to 2.01%.

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