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Mobile source of energy based on renewable energy sources to improving irrigation systems

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ABSTRACT: Improvement of irrigation methods in fruit and vegetable growing in Uzbekistan requires sufficient and guaranteed electricity supply to local farms. The purpose of the study is to substantiate mobile methods of electricity supply based on renewable energy sources in improving irrigation methods in fruit and vegetable growing. These goals can be achieved by applying modern methods for selecting the optimal design and energy parameters of mobile solar and wind stations. A systematic approach to the analysis of a complex power supply scheme is selected. When studying processes in the power supply system using RES, the main provisions of theoretical electrical engineering and mathematical statistics are used. Based on the results of calculations to determine the daily, seasonal and annual schedules of electricity consumption, we concluded that it is important to take into account specific operating modes that depend on agricultural needs and seasonality for mobile power supply. A prototype of the Solar-wind mobile power plant has been developed, which generates = 4.5-4.7 kWt·h in the daytime and 0.8-1.0 kWt·h in the evening. It is necessary to develop systems of measures for the introduction of mobile power plants "Sun-wind", providing for the creation of a service service, training of service personnel, etc. This, in turn, increases the level of reliability and efficiency of power supply, creates favorable conditions for the widespread introduction of modern resource-saving electrical technologies in remote areas.

I. INTRODUCTION

Research results show that in Uzbekistan, improving irrigation methods can save up to 54% in horticulture and vegetable growing, significantly increasing productivity. In this regard, the drip irrigation system is effective not only from the point of view of rational use of natural resources (saving water resources, improving soil, saving energy and fuel, reducing emissions, etc.), but also from an economic point of view.

For this reason, Uzbekistan is actively taking measures to accelerate the introduction of modern energy-saving, intensive technologies in horticulture and vegetable growing. In order to implement modern technologies, the relevant ministries and departments have established close cooperation with researchers and specialists from China, Russia, Turkey, Japan, South Korea and a number of other countries. [3]

World practice shows that, for the widespread introduction of modern irrigation methods, it is necessary to diversify the structure of electricity supply, including Autonomous and mobile power plants based on renewable energy sources (hereinafter-RES) together with centralized networks.

II. LITERATURE REVIEW.

In the theoretical and practical development of solar and wind energy, extensive researches are being carried out by scientists from different countries. The following is a summary of the published most relevant work on the topic.

In the dissertation, Sheryazova S.K. on the topic "Methodology for the rational combination of traditional and renewable energy resources in the energy supply system of agricultural consumers" the goal is to develop a methodology for the rational combination of traditional and renewable energy resources in the energy supply system of agricultural consumers to reduce the cost of energy consumption. The combined energy supply system for agricultural consumers using solar and wind power plants was chosen as the object of study [8].

Chandel SS, NagarajuNaik M, Sharma V, Chandel R. in their research notes that one of the problems with solar photovoltaic technologies is a decrease in the power of solar cells by 0.8% per year due to the prolonged exposure to climatic conditions of India [15]

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Matius Sau, Hestikah Eirene Patoding, Agustina Kasa in his works claims that the type of load (load profile) is one of the important words in a hybrid system. For each different profile load, a hybrid system with a specific composition of the system can be achieved. [4]

In x's research Vanga, A. Palazoglu and n. El-Farra presented a methodology for systematic formation of a hybrid renewable energy system (GRES) consisting of solar, wind and diesel generators as a backup resource, as well as a battery.the system is Calibrated with energy flows in order to obtain an optimal combination of photovoltaic (PV) panels and wind generators. [5]

YandraShivrat of JNT Indian University, in her article on “Cost Analysis of Small Solar and Wind Energy Systems”, hypothesizes that in the next few years, when the cost of solar PV modules drops below $ 1 per Watt, small wind turbines will become more expensive due to the cost of the structures, necessary to support the wind generator. And also, if the technical and commercial threat from the market is not eliminated, small manufacturers of wind turbines will lose competition in the near future to manufacturers of solar PV modules [6].

Have pialiGanguly, Akhtar Kalam and Aladin of Seeg note that the renewable energy system consisting of solar and wind energy, is environmentally friendly and economically viable option for rural electricity supply compared to traditional sources. A properly designed hybrid solar-wind system with a backup battery increases their reliability in offline mode [7].

In the work of M. A. Tsimbalova on the example of the Zhambyl region of southern Kazakhstan the substantiation of a choice of a combined energy system based on renewable energy sources to supply rural communities with the required capacity of 100 kW. [9].

In the dissertation, Yarmukhametova U.R. on the topic “Solar power plants with a tracking system for the sun for the energy supply of agricultural consumers”, the regularities of changing the performance of solar power plants depending on geographical latitude, climatic conditions, design parameters and the degree of orientation of the receiving surface on the Sun are selected as the subject of research. The aim of the work was to increase the efficiency of solar power plants with tracking systems for the Sun [10].

An plantation in Sicily uses a system of sensors and actuators powered by PV power only through which all main agriculturally agricultural activities are monitored and acted upon. A simple wireless system transmits all data using radio frequency including the values of the pressure in the waterworks, the level of water, air temperature and ground humidity to optimize irrigation, to a “cloud” server. [11]

Currently, the Tashkent Institute of irrigation and mechanization of agriculture under the guidance of Professor A. Rajabov is conducting research on creating a combined "Solar-wind" mobile power plant. This station performs the function of accumulating a certain amount of energy (charging batteries), along with the implementation of direct power supply to consumers. [12]

With the increase in electric vehicles, the infrastructure for charging them should develop no less dynamically. Taking into account the continuous improvement of batteries, it is expected that EV stations will be widely used in the near future. As a result, the transition to electric vehicles in the agricultural sector will gradually increase. [13]

III. SYSTEM ANALYSIS

In Uzbekistan, more than 55% of the land under cultivation is provided with a centralized power supply network. About 10% of territories seasonally use mobile diesel generators. More than 35% of households are located away from centralized power grids. As a result, there are problems with the introduction of modern irrigation systems in remote areas. In the future, it is necessary to address the issues of local and mobile electricity supply to remote areas based on renewable energy sources in order to implement effective irrigation systems. (Figure 1.)

The inefficiency from the economic and technological point of view of the centralized power supply of drip irrigation systems in the separated territories will be justified for the following reasons:

- Relatively low power consumption of electrical equipment for drip irrigation systems;
- Seasonal consumption of electrical energy;
- Constantly changing consumption schedules due to crop rotation requirements.

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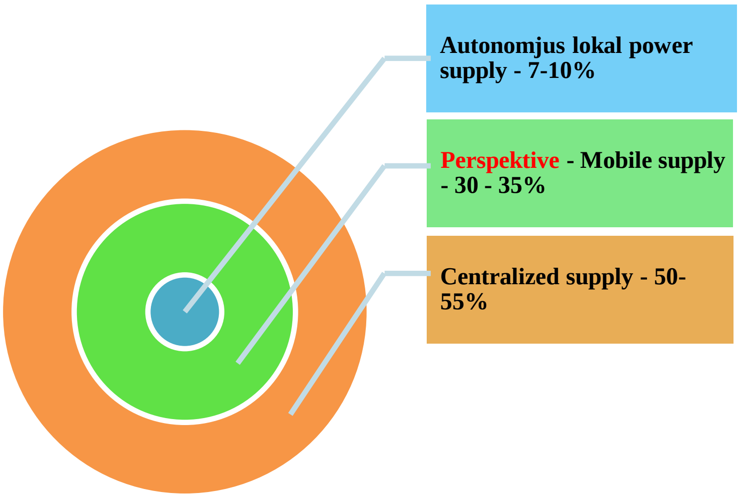

Fig. 1. The current state and prospects of electricity supply in the agricultural sector

In Uzbekistan, drip irrigation methods are recommended under the following conditions:

- areas in a further distance where there is a shortage of water resources;
- in desert, slope and foothill territories;
- in areas where conventional irrigation methods are ineffective.

In horticulture, drip irrigation systems can be used for irrigation of apricot, apple, peach, sweet cherry, vineyard, tomato, pepper, cucumber, strawberry, watermelon, melon and other crops, as well as in greenhouses for vegetables.
The analysis of the effectiveness of measures to introduce drip irrigation systems was carried out on the example of the Beruni district of the Republic of Karakalpakstan. Based on the data obtained from JSC “Karakalpak Electric Lines”, a table was compiled reflecting the volume of electricity consumption in the Beruni district for 2017. Table 1.

Table 1.

Volumes of electric energy consumption of the Beruniy district for 2017.

		2016	**2017**	**Includingquarterly**			
				1st	2stquar	3stquar	4stquar
Totalconsumptionbydistrict							
Fromcentralizedlines		millionkWt·h					
		107.7	**120.2**	**31.1**	**29.8**	**28.4**	**30.9**
including in the agricultural sector (30%)							
		millionkWt·h					
Fromcentralizedlines	Total:	**32,3**	**36,1**	**9,3**	**8,9**	**8,5**	**9,3**
	Population, social objects	**17,1**	**20,7**	**5,2**	**5,15**	**5,15**	**5,1**
	Pumping station	**12,6**	**12,7**	**3.4**	**3.1**	**2.8**	**3.4**
	Agricultural production	**2,6**	**2,7**	**0,7**	**0,65**	**0,55**	**0,8**

The analysis of the state of electricity supply was continued using the example of the Beruni Congress of rural citizens (hereinafter referred to as the CCG). The territories are divided into 6 sectors and conducted separate studies for each sector.

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IV. MOBILE POWER PLANTS BASED ON RENEWABLE ENERGY SOURCES

The energy control strategy plays a vital role in the optimal design and efficient utilization of hybrid energy systems, as it affects the available power supply and the overall lifetime of the system components. [12]
Need for mobile stations. Currently, in developed countries, along with centralized power supply systems, autonomous-stationary and mobile methods of power supply to consumers based on renewable energy are being developed and implemented.
Low-power hybrid stations can operate in stand-alone, network and mobile modes, are relatively inexpensive, have a short start-up time, which is why they are currently in great demand. Considering that, in Uzbekistan, more than 35% of farms with more than 1 million hectares of land resources are located far from centralized electric networks, there is a sufficient amount of demand for hybrid mobile stations based on RES.

V. FORMULATION OF THE PROBLEM

The purpose of the research is to study and analyze the effectiveness of electricity supply measures when introducing drip irrigation systems in the conditions of the Republic of Uzbekistan.
Drip irrigation systems consist of low-power electrical equipment, are located far from each other in terms of power supply and are seasonal in nature. Accordingly, the power supply networks of regions where drip irrigation systems are used 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, which can constantly provide electric energy to small farms located far from centralized networks. Our research is focused on the introduction of mobile power supply for drip irrigation through the creation of a combined mobile power plant “Sun-wind", with energy storage in batteries. [14]

The daily and monthly energy consumption indicators of fruit and vegetable farms in drip irrigation processes by sectors are used in the construction of daily and annual load schedules. Based on the variety of plants and agrotechnical requirements, we will calculate the consumption of electric energy by drip irrigation.
At each site, a drip irrigation system was introduced on areas from 4 to 5 hectare (Fig. 3), the calculation of the consumed electric energy of which is given below.

VI. METHODOLOGY

In studies, a systematic approach to the analysis of an integrated power supply scheme was chosen. The basic principles of theoretical electrical engineering and mathematical statistics are used in the study of processes in the power supply system using renewable energy sources.
Corresponding calculations were carried out to determine daily, seasonal and annual consumption schedules. Based on the data in Table 2, further calculations were carried out for 280 hectares of area of remote fruit and vegetable farms where it is planned to introduce drip irrigation systems.
It is known that agricultural consumers of electric energy have specific operating modes, which mainly depend on agrotechnical requirements and seasonality. Therefore, we introduce the so-called simultaneity coefficient K, which determines the dependence of the calculated values of the loads of several consumers on the values of their maximum loads.
Given that in the processes of growing and processing horticultural products, several consumers at the same time do not work. Therefore, when calculating the loads in the power supply, the arithmetic mean sum of the values of the power of simultaneously operating equipment is accepted multiplied by $K < 1$.

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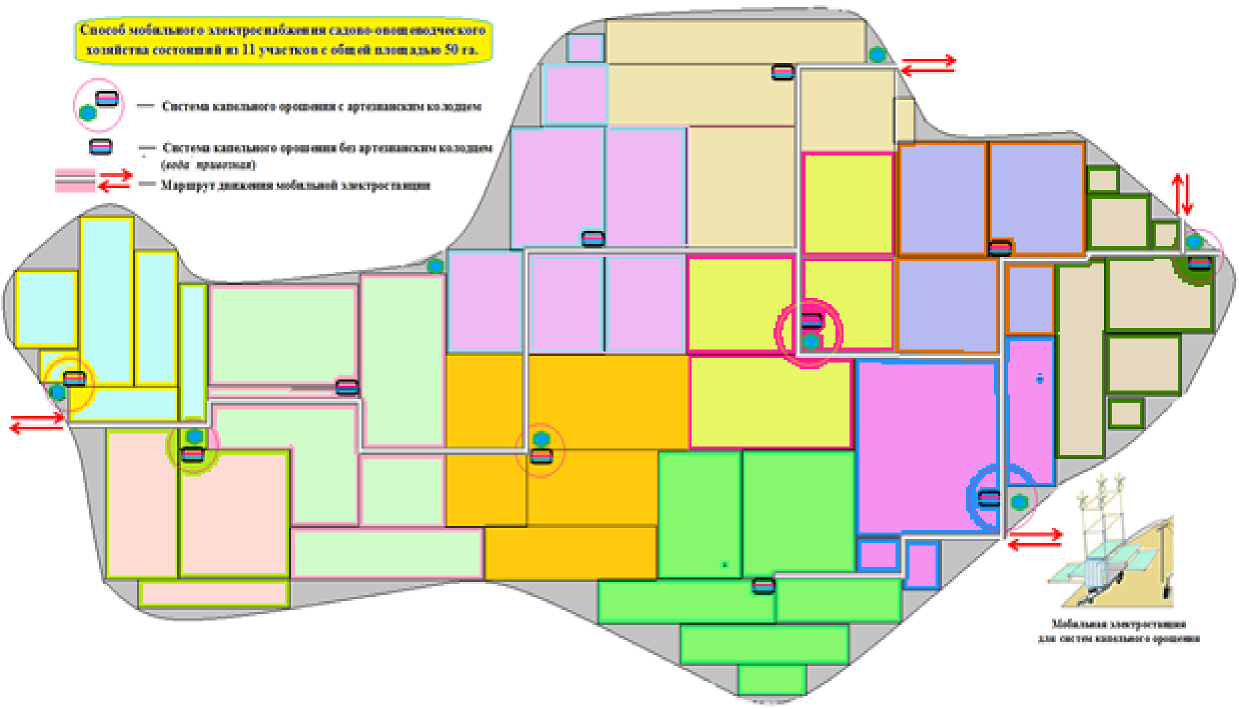

Fig. 3. The proposed method for the use of mobile power supply with drip irrigation on the example of 11 sites located 50 hectares of area.

VII.METEOROLOGICAL AND LOAD CALCULATIONS

In addition, the calculations must take into account the seasonality of work. For this, we use the K_{seasn} value - given in table-3

Table-3.

The value of the seasonality coefficient of consumers of electric energy in agriculture

Consumption type	Season			
	winter	spring	summer	autumn
Ordinary	1.0	0.8	0.7	0.9
Irrigation	0-0.1	0.3-0.5	1.0	0.2-
Electrical	0.3	1.0	0	0
Fall-winter	0.2	0	1.0	1.0

On average, the irrigation rate for each plantation of horticultural crops is from 10 to 60 liters, depending on age, and the number of irrigations averages up to 10-15 times in dry and 6-7 times in wet years.
The irrigation rate for 1 hectare of tomato furrow method is 800-1000 m^3. With drip irrigation (*planting scheme 60 x 40, the number of plants per 1 hectare - 41666 pieces. the estimated rate of water per plant-2 liters*), the irrigation norm is 83 m^3 of water, which is 12 times less than with furrow irrigation. [15]

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The calculation of energy consumption takes into account the speed of the water flow, the total dynamic pressure, as well as the performance of the pump and drive (motor). For electric pumps, the energy consumption is calculated according to the well-known formula - (1):

$$\boldsymbol{P} = (\boldsymbol{Q} \cdot \boldsymbol{H})\ (\mathbf{102} \cdot \boldsymbol{E}_{\mathbf{r}} \cdot \boldsymbol{E}_{\mathbf{t}});\ (1)$$

where - P-energy consumption (kW); Q-level of water flow (Liter/sec); H-total dynamic pressure (m); E_r- pump capacity; E_t-engine capacity.

When calculating operating costs, such parameters as the level of electric energy consumption by the electric motor, the cost of electricity, the pump operating time are calculated according to the following formula (2):

$$\boldsymbol{C} = \boldsymbol{Px} \cdot S_{\boldsymbol{e}} \cdot \boldsymbol{T};\ (2)$$

where - C-operating costs; P_x is the volume of energy consumption (kW); S_e cost of electricity (per 1 kWh); T-time of the pump (hours).

To select an electric pump, we will make calculations using the example of a farm in the Beruni region that has 5 hectare of land (2 hectare of garden, 2 hectare of tomatoes and 1 hectare of eggplant).

From the above regulatory information, we determine that with drip irrigation of gardens (*a 5x6 meter planting scheme, the number of trees per 1* hectare *will be 335 nb),* 17 m^3 of water will be required for 1 hectare of garden. For 1 hectare of tomato and eggplant *(planting pattern 60 x 40, the number of plants per 1 hectare-41666 nb.*), The irrigation rate is 83 m^3 of water. [8] Determine the total need formula (3):

$$\sum \mathbf{Q} = \mathbf{Q}_{\mathbf{garden}} + \mathbf{Q}_{\mathbf{vegetable}} = \mathbf{34\ m^3 + 249\ m^3 = 283\ m^3}\ (3)$$

Average vegetative period N for vegetables makes 100-120 days. During this period, watering is done on average 8 times. From here we determine the average one-time irrigation rate. Formula (4), (5):

$$\boldsymbol{Q}_{\text{br.veg}} = \boldsymbol{Q}_{\text{veg}}/\boldsymbol{N} = \mathbf{249}\boldsymbol{m}^3/8 \approx \mathbf{31,\ 1}\ \text{м}^3 \qquad (4)$$

$$\boldsymbol{Q}_{\text{br.garden}} = \boldsymbol{Q}_{\mathbf{garden}}\ /\mathbf{30} = \mathbf{34/30} = \mathbf{1,\ 13}\ \text{m}^3\ (5)$$

In Uzbekistan, a three-phase asynchronous electric motor is often chosen as the engine for drip irrigation pumps. The efficiency of which can reach up to 95%. They require minimal maintenance, and with high-quality service can last a long time. To choose a pump with optimal performance, it is necessary to determine the hourly water flow rate - $\mathbf{Q}_{\mathbf{hourly}}$ which depends on the time of irrigation - $\mathbf{T}_{\mathbf{watering}}$. Formula (6):

$$\boldsymbol{Q}_{\text{hour}} = \boldsymbol{Q}_{\text{watering}}\boldsymbol{T}_{\text{watering}} = \mathbf{35,\ 65} = \mathbf{7,\ 12}\ \text{m}^3\ (6)$$

Based on the calculated water volume, we select a 2-4CP centrifugal pump with the following technical characteristics: Type - 4CPm100-C, power consumption - P = 0.75 kW, capacity - Q = 7.2 m^3 / hour, lifting height - H = 11 meters , the motor operation mode is S_1. On the rise of 1 m^3 of water spent 104.2 Watts of electrical power. In practice, such pumps are used for water supply, for irrigation of vegetable gardens and gardens, etc.

VIII. RESULTS AND DISCUSSION

Analysis shows that more than 40% of all land resources of the beruniysky SSG are located outside the area of centralized power supply systems. The energy supply indicator for this section is considered low from the point of view of the current level of development of electrical technologies. Power supply to all agricultural facilities in the region depends on centralized power lines. This, in turn, has a negative impact on the widespread introduction of modern energy-efficient lines on remote farms. In table 4. The indicators of energy consumption in technological processes are given on the example of fruit and vegetable farms.

For the implementation of mobile power supply, a draft of the Sun-Wind mobile power station has been developed, which in the daytime can generate an average of $P_{mb.d.}$= 4.5-4.7 kWh, and the evening hours are $P_{mob.night}$ = 0.8-1.0 kWh of electrical energy.

Based on the results of the research, it is necessary to develop initial requirements and project documentation for the mobile power plant "Sun-wind"

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From the point of view of economic feasibility of introduction of mobile solar stations it is necessary to proceed from the fact that at present the cost of solar panels and other accessories is relatively high. But in recent years, research has produced encouraging results. Especially in terms of hybrid solar panel applications.

Table 4.

Indicators of power consumption of fruit and vegetable farms in the processes.

№ Sectors	Croparea*(ha)*		Estimated volume of water per season m^3		The required electrical energy. kWh		
	Vegetables	Gardens	vegetables	Garden	vegetables	garden	Total
1	13	8	1079	136	112,8	14,2	127,0
2	18	9	1494	153	155,7	15,9	171,6
3	24	10	1992	170	207,6	17,7	225,3
4	38	22	3154	374	328,7	39,0	367,7
5	44	21	3652	357	380,5	37,2	417,7
6	53	20	4399	340	458,4	35,4	493,8
Total:	190	90	15770	1530	1643,0	159,4	1802,4

Using the above analysis results, we determine the estimated volumes of daily, seasonal and annual required capacities. From expression 4 we determine the daily need for electric energy for water rise. Formula (7):

$$P_{day} = 104,2 \cdot (Q_{br.veg} + Q_{br.gar}) = 104,2 \cdot (31,1 + 1,13) \approx 3,4 \text{ kWh} \quad (7)$$

For example, in their research, Paul Berto, Catherine Kader, Henriette Mueller, Philip Blechinger, Robert SEGUIN, Christian Breuer notes that in rural areas of Tanzania, electricity is mainly generated by diesel power plants. To reduce generation costs the introduction of photovoltaic (PV) and battery storage is a viable option. For an implementation strategy, diesel plants are localized with a geospatial analysis and the potential for hybridization with PV and battery systems is investigated by simulating a PV-battery-diesel system.

Thereby a maximal potential for 23.6 MWp PV and 56.8 MWh of battery capacity resulting in a cost reduction of 17 ct€/kWh is discovered. Battery costs should be below a threshold of 475 €/kWh to become a significant part of the hybrid system.

RES, being inferior to traditional energy sources for large-scale energy production, are already very effective in small Autonomous power systems under certain conditions, being more economical (compared to energy sources using expensive imported organic fuel) and environmentally friendly. [16]

1. 1. Improving irrigation methods in Uzbekistan allows you to save up to 54% in horticulture and vegetable growing, significantly increasing productivity.
2. 2. taking into account the relatively low energy consumption of drip irrigation systems, the seasonality of irrigation and frequent changes in location and load schedules, we consider it effective to introduce a mobile power supply method when improving the irrigation system in remote areas.
3. 3. the mobile power plant "Sun-wind" with a capacity of 4.5 kW * h (in daytime) is in demand when improving the irrigation system in regions that do not have centralized power supply networks.
4. 4. it is Required to develop a science-based system of measures for the introduction of mobile power supply, including the creation of an appropriate service, training of service personnel, etc. This, in turn, increases the level of reliability and efficiency of power supply, creates favorable conditions for the widespread introduction of modern resource-saving electrical technologies in remote areas.

IX. SCOPE

Consequently, the PV share rises due to the increased storage capacity. Furthermore, with reaching a higher share of renewables the study shows that hybridization of diesel-based off-grid systems with PV and storage systems can lead to a significant electricity cost reduction. The proposed mobile power plant "Sun-wind" due to similar weather and climate conditions is in demand in the republics of Central Asia, States located in the Northern part of Africa and in some South Asian countries.

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If we take into account that in the future the fleet of equipment with electric drive will increase and such mobile stations can be used for charging electric vehicles and electric tractors, the geography of demand will expand significantly.

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