EFFECTIVE UTILIZATION OF SOLAR ENERGY IN SUSTAINABLE AGRICULTURAL IRRIGATION
A Provincial Example from Turkiye

by

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Food supply security is one of the most important problems facing the world today. Although fertile agricultural lands are decreasing day by day due to climate change caused by global warming, the demand for food is increasing with the increasing population from around the world. In addition, energy input costs in food production are increasing day by day. One of the energy input costs is the energy spent for agricultural irrigation. Meeting the energy required for agricultural irrigation from the Sun will both prevent environmental problems caused by fossil fuels and reduce agricultural irrigation costs. In this study, the province of Mus, which is one of the least developed cities in Turkey, with a high potential for agriculture and solar energy, is considered as a case study. In this study, firstly, the equipment that can be used in the solar-powered irrigation system was determined, after the necessary formulas and calculations were made in detail, finally, the cost analysis of this irrigation system was made and the time that the system could pay for itself was calculated. With this study, when the size of a field and the distance of the water source from the field are known, the required water pump size, PV panel size and installation cost can be easily calculated. Thus, a tool has been developed that can be easily used by every farmer. It is believed that this program will make a great contribution to encouraging farmers to engage in irrigated agriculture by utilizing solar energy.

Key words: *Mus plain, renewable energy, solar energy, irrigated agriculture, water pumps, sustainable agriculture*

Introduction

Mankind needs agricultural production to survive. Energy is also required for the realization of agricultural activities. The rapid population growth in the world and the increase in the welfare level in developing countries lead to a dramatic increase in energy consumption. This situation, on the one hand, causes an increase in the prices of fossil fuels, on the other hand, it causes the rapid depletion of these limited and non-renewable energy resources [1]. In addition, the energies obtained from these fossil fuels cause an increase in GHG emissions. This causes global warming and causes global climate change. Global climate change also threatens the sustainability of agricultural activities by causing damage to the agricultural product range and ecosystem. This situation forces countries to

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spend more time on alternative RES [2]. One of these alternative energy sources stands out as solar energy. By replacing conventional fossil fuels with solar energy, which is a renewable and clean energy, CO_2 emissions in the atmosphere can be reduced, which can help control GHG emissions. This situation makes solar energy, which is a RES, attractive [3]. Solar energy is an energy that can be used directly or indirectly. Solar energy is not energy specific to certain geography like fossil fuels, but it is an abundant and clean energy source that exists in countries more equally on a global scale. Therefore, it stands out as one of the most competitive options among all renewable energy types [4]. In addition, different methods have been developed and continue to be developed in order to benefit from the different features of solar energy in the agricultural sector. In the last quarter century, since solar radiation has been converted into other types of energy such as chemical energy and especially electrical energy, its use has become widespread in all areas of life. In order to benefit from solar energy more efficiently, great importance has been attached to the studies of conversion methods. In addition, many researches are carried out to ensure the widespread use of solar energy in agricultural production activities. This use certainly not only alleviates energy shortages, but also offers the opportunity to utilize a cheap, easy, abundant and widely available energy source all over the world throughout the year. This alone brings with it the development of more innovative solar energy technologies, with the widespread use of solar energy in various machinery such as water pumping, lighting, pesticide spray, and tractors. However, such use of solar energy in agriculture is still limited, and much awareness-raising research is needed to take advantage of these blessings and hope for future energy needs [5, 6].

Plants, which form the first link of the basic food chain, need Sun and water to perform photosynthesis. The meeting of plants with water is called irrigation. Irrigation, in its simplest form, is to ensure that water reaches the plants by using the height difference (potential energy) from the water source to the area to be irrigated, giving the water movement (kinetic energy). Water sources are not always higher than the area to be irrigated, and sometimes even tens of meters below or underground. In this case, the water must be conveyed to the agricultural land by pumps. Therefore, a mechanical system must be installed. This system will have installation, maintenance, and energy costs. Internal combustion engine water pumps are needed for irrigation of rural areas where electrical power lines do not pass, or electric water pumps are used where access to electricity is possible. In both cases, the energy bill is added to the agricultural production costs. Global warming and many environmental problems occur with it due to the carbon released to the environment while energy is obtained from fossil fuels. While the harms of fossil fuel sources for the environment are obvious, the costs of these fuels are increasing day by day [2]. For all these mentioned reasons, countries have started to focus more on alternative clean RES and provide different supports for the effective and efficient use of these resources. As a result, electricity generation from sources such as solar, wind and geothermal is increasing day by day on a global scale. In particular, great progress has been made in evaluating solar energy, which is more common in the world [7]. In this context, huge increases in electricity generation from solar energy have been achieved in recent years in Turkey with large-scale grants and incentives [8].

The city of Mus was chosen as an example for the analysis of solar energy use in agricultural irrigation, since its agriculture-based economy and solar energy potential are above the country average. Due to the terrestrial climate of the city, the months of agricultural planting and harvesting are June-August, which are the months when the province has more sunshine [9]. The aim of this study is to deal with all the processes related to realizing high agricultural production by utilizing underground and surface water resources with the help of low-cost solar water pumps for agricultural lands where irrigated agriculture is not currently practiced in Mus, necessary engineering calculations were made and return cost analysis was carried out. For this, first of all, the equipment that can be used in the irrigation system working with solar energy was determined and the necessary formulas and calculations were made in detail. Then, the cost analysis of this irrigation system to be established was made, and the time that the system could pay for itself was calculated. While calculating the payback period, the grant support provided by different public institutions in Turkey is also taken into account.

Agricultural potential of Mus province

Approximately one third of Turkey surface area (783577 km^2) consists of agricultural lands. As of the end of 2017, only 6.5 million hectares of 8.5 million hectares of land with irrigation facilities could be irrigated. Individual irrigation is also carried out on an area of approximately 1 million hectares. By the end of 2023, two million hectares of land that has not been irrigated is targeted to be brought into irrigated agriculture by the General Directorate of State Hydraulic Works [10]. Although Turkiye is not rich in water, it is predicted that water resources will decrease even more in the future. Therefore, these insufficient resources should be used effectively in agricultural irrigation. Mus is located in the Upper Murat-Van Section of the Eastern Anatolia Region. The surface area of Mus province is 8196 km^2 and approximately 3443 km^2 is arable land. Most of the arable land of the province is cultivated with dry agriculture. Mus is home to the Mus Plain, Turkey third largest inland plain. The height of the Mus Plain above sea level is 1250-1400 m. The plain is in the shape of an ellipse and is surrounded by high mountains. Mus Plain is a tectonic plain and has a length of 80 km, a width of 30 km and a surface area of 1650 km^2. The Mus Plain is surrounded by the Serafettin Mountains in the north, which exceeds 2000 m, and the Southeast Taurus Mountains in the south. The floor of the plain is covered with alluviums up to 200 m thick in places. Other plains in Mus province are: Malazgirt Plain is 450 km^2, Bulanik and Liz plains are 525 km^2 and are in the form of a wide steppe [9]. As a result, 42% of the lands in the city of Mus consist of arable lands and 34% are pasture lands that provide suitable conditions for animal husbandry. The fact that 76% of the total area consists of fertile agricultural and pasture lands reveals the great agriculture and livestock potential of the city [11]. Since large-scale conventional agriculture has not been carried out in these agricultural lands until today, they have not been exposed to intensive chemical fertilizers and pesticides and have remained clean. Therefore, organic farming can be done without any additional expense. It makes it possible for these lands to produce organic crops with high added value that can provide the economic welfare required by the city.

Solar energy potential of Mus province

Turkiye is one of the countries with high potential with an annual average solar energy of 1315 kWh/m^2. Despite these high potential, it is seen that Turkey could hardly utilize its solar energy potential until 2014. However, in the last ten years, a great development has been achieved with the state inclination towards infrastructure investments related to the promotion of RES and with the attractive incentives and supports it provides. While Turkiye had a solar installation capacity of 40 MW until 2014, it increased to 9.4 GW installation capacity at the end of 2022 [12-14]. It is thought that encouraging the installation of large-scale SPP power plants within the scope of the Renewable Energy Resource Area (YEKA) and the requirement that the equipment used in these power plants be produced in Turkiye play a major role in this capacity increase.

The annual sunshine duration of Mus province is above the Turkiye average. The annual global radiation value of the province is 1591.70 KWh/m² per year [15]. Annual sunshine duration is 2686 hours. While the Sun reaches the province of Mus with an angle of 23.73° on December 21, these values become 51 °C on March 21 and September 23. On June 21, the longest day of summer, the Sun rays reach the ground at 74.27 °C [16]. This situation also affects the efficiency of solar panels in electricity production. Since irrigation will be carried out in the summer months covering the June-July-August period, system planning should be done based on the data close to the data on June 21. Since energy production will be provided with maximum efficiency from solar energy in this season, less solar energy panels will be used and the installation cost will be lower. This will reduce the installation costs in agricultural irrigation.

Utilization of surface or underground water resources in agricultural irrigation by means of solar powered water pumps in the city of Mus is very important since it is a low-cost and environmentally friendly practice. Irrigation costs can be minimized by using solar-powered pumps instead of diesel-powered pumps in the irrigation of the fields located on the banks of the Murat and Karasu rivers. Another important issue in agricultural irrigation is to determine the right type of irrigation in order to provide optimal water consumption. For example, irrigation of the field with the drip system with the brought water will provide effective irrigation of the soil with less water. While the drip system saves water along with the loss of soil fertility, it also saves energy.

Photovoltaic powered irrigation systems

The amount of water used for agricultural activities constitutes approximately 70% of all fresh water consumption [17]. Therefore, since the agricultural sector ranks first in the world in water consumption, it also stands out as an important area in energy consumption. Instead of conventional pumps in irrigation, the use of electric pumps that can operate through solar panels, which have low maintenance costs and long life, can provide significant energy savings [18]. In systems working with SPP, the energy required is met by electricity produced through solar panels. This energy is first converted into mechanical energy and then into the required hydraulic power by means of pumps. There are pumps operating with DC or AC electrical energy in the market. In direct conversion, the DC motor can be operated directly with the electricity obtained from the sun, or by converting the electricity into AC current with the help of an inverter, the electrical energy required by the pump operating with this current is met. There are multiple factors in pump selection. These factors are the size of the area to be irrigated, the height at which the water will be pumped, the energy provided by the panels, the operating time of the pump and the amount of water needed instantly. In irrigation systems with SPP, pumps should be selected by considering elements such as elevation difference to the place where water will be transferred, instant water requirement, efficiency, and parameters such as maintenance costs and longevity as well as pump costs. Pumps are examined in two groups as volumetric (positive) pumps and rotodynamic (acceleration) pumps. While volumetric pumps are mostly used in industries requiring power, rotodynamic pumps provide the transfer of water from deep wells to the ground or between surfaces with elevation difference.

Solar panels are systems that convert the light from the Sun at a certain wavelength into electrical energy with a certain performance (10-25%) [19]. Issues to be considered in the installation of the system and each element affects the cost such as the area to be irrigated and the instant water requirement, the location of the water source (well-river-pond), whether there will be a need for a water tank. In Turkey, solar energy is used in drip irrigation systems by using PV panels. The choice of the right systems prevents both the efficiency of agricultural production and irrigation from damaging the soil structure of agricultural lands. In drip irrigation, water is dripped onto the plant roots in very small drops, thanks to long-hole hoses. If irrigation is done in the evening or very early in the morning, the water will be used efficiently since evaporation will be less. Therefore, if irrigation is preferred in the evening or at night, the water tank of suitable height and capacity is filled by taking advantage of the Sun during the day. In the evening, irrigation is done by using the water in the water tank. Solar energy irrigation systems operating according to the PV principle have a long service life and low maintenance costs. For this reason, it is more preferred. These systems have provided an increase in efficiency with the development of technology, while reducing the cost [6].

Materials and methods

With the increasing population in the world, the importance of protecting agricultural lands, cultivating them cheaply and growing healthy products has increased. The aim of this study is to contribute to the irrigated agriculture of lands that cannot benefit from agricultural irrigation networks and are far from energy transmission lines. In this study, the city of Mus, which has the third largest inland plain of Turkey, Mus Plain, Bulanik Plain, Liz Plain and Malazgirt Plain, has been examined. It has been tried to show that it is economically feasible to develop and expand the cost-effective and environmentally friendly irrigation systems by using solar energy instead of fossil fuels for agricultural lands that have water access problems in this city. Since Mus has a high solar energy potential, pump types have been researched in order to realize agricultural irrigation by utilizing solar energy and pump selection criteria have been determined for water supply from underground waters and streams. After all researches and investigations, an irrigation system that can operate optimally with solar energy has been designed. Here, first the required pump power for the area to be irrigated is calculated, and then the required PV panel size to feed this pump efficiently is determined. Finally, the investment cost of this system was calculated. Then, the return of the investment cost was calculated according to the different grant rates provided by the state through different institutions.

Solar pump power calculation

Straight pipe losses are calculated by:

$$H_{bk} = f \frac{L}{D_{ic}} \frac{V^2}{2g} \tag{1}$$

where H_{bk} is the straight pipe losses, f – the pipe friction coefficient taken from tab. 1, L [m] – the total pipe length, D_{ic} [m] – the inner diameter of economic pipe, V [ms^{-1}] – the velocity of fluid in straight pipe, and g [9.81 ms^{-1}] – the gravitational acceleration.

The velocity of the fluid is calculated by:

$$V = \frac{4Q}{\pi D_{ic}} \tag{2}$$

where Q [m^3s^{-1}] is the flow rate. The flow rate selection is determined by filling the used water tank.

The losses in the pipe joints are found by:

$$H_{dk} = \sum_i K_i \frac{V^2}{2g} \tag{3}$$

where H_{dk} is the losses in pipe joints, Σ – the number of elbows of the same type, and K_i – the elbow loss coefficient and is taken from the tab. 2.

The total loss is the threshold value for transferring a unit amount of water and is the minimum amount of energy [JN^{-1}] required for the system to operate:

$$H_m = H_{bk} + H_{dk} + H_h \tag{4}$$

where H_h [m] is the total height and the vertical height between where the water is taken and transferred.

The pump output power is determined by:

$$P_{cg} = \rho g Q H_m \tag{5}$$

where P_{cg} [W] is the pump output power and ρ – the density of water and is taken as 1000 kg/m^3.

The effective power is calculated by:

$$P_e = \frac{P_{cg}}{\eta_p} \tag{6}$$

where P_e [W] is the effective power and η_p – the pump efficiency, taken as 0.8.

The required engine power is calculated by:

$$P_{mg} = \alpha P_e \tag{7}$$

where P_{mg} is the required engine power and α – the efficiency of electric motor:

$$P_e < 6.8 \text{ kW}, \alpha = 1.3$$

$$6.8 \le P_e < 34 \text{ kW}, \alpha = 1.2$$

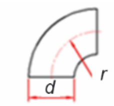
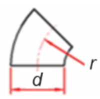
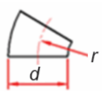
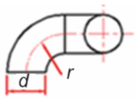
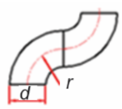
$$P_e \ge 34 \text{ kW}, \alpha = 1.1$$

Note: Generally, these values should be rounded and the engine selection closest to the values available in the market should be chosen.

Table 1. The *f* coefficient of straight pipe losses [20]

Pipe type	Pipe diameters									
	DN6-DN10	DN15-DN20	DN25-DN32	DN40-DN50	DN55-DN80	DN110-DN150	DN200-DN250	DN300-DN400	DN450-DN600	DN650-DN800
Steel pipe (smooth inside)	0.027	0.023	0.020	0.018	0.016	0.015	0.013	0.012	0.011	0.010
Steel pipe (rusty inside)	0.080	0.060	0.050	0.040	0.035	0.030	0.025	0.023	0.020	0.018
Steel pipe (very rusty inside)		0.080	0.065	0.055	0.045	0.040	0.030	0.025	0.023	0.020
Stainless steel pipe	0.034	0.027	0.023	0.020	0.018	0.016	0.015	0.013	0.012	0.011
Galvanized pipe	0.050	0.040	0.035	0.030	0.025	0.023	0.018	0.017	0.015	0.013
Bituminous pipe	0.045	0.035	0.030	0.025	0.023	0.020	0.017	0.015	0.014	0.013
Plastic aluminium copper	0.015	0.013	0.012	0.011	0.010	0.0095	0.0090	0.008	0.007	0.007
Concrete pipe		0.100	0.080	0.065	0.065	0.045	0.035	0.030	0.028	0.024

Table 2. The *K* Elbow loss coefficients [20]

	Elbows coefficient of resistance, *K*							
	Figure	*r*/*d*						
		1	1.5	2	3	4	5	6
90° elbow		20*f	15*f	12*f	12*f	14*f	16*f	17*f
45° elbow		15*f	10*f	8*f	8*f	9*f	10*f	10.5*f
30° elbow		13*f	8.5*f	7*f	6.5*f	7*f	8*f	8.2*f
90° double elbow		40*f	30*f	24*f	24*f	28*f	32*f	134*f
		60*f	45*f	36*f	36*f	42*f	48*f	51*f
		80*f	60*f	48*f	48*f	84*f	96*f	100*f

Symbol * represents multiplication and the pipe friction coefficient, f, is available in tab. 1.

Calculation of solar panel area

The power of the PV system that will feed the motor must be greater than or equal to the power of the pump calculated before:

$$P_{\text{pv}} \geq P_{mg} \tag{8}$$

where P_{pv} is the power of the PV system and P_{mg} – the required engine power.

The power of the photovoltaic system is calculated by:

$$P_{\text{pv}} = G_r A \eta_r \tag{9}$$

where G_r is the maximum irradiation (1000 W/m^2), A [m^3] – the PV panel area, and η_r –the cell efficiency and is taken from tab. 3 under standard test conditions (1000 W/m^2, 25 °C).

Table 3. Performance values and space requirements of solar cell materials [21]

Panel type	Performance [%]	Area [m^{2}kW^{-1}p^{-1}]
High performance	17-18	6-7
Monocrystalline silicon	12-15	7-9
Polycrystalline silicon	11-14	7-10
Thin film copper indium solenoid	9-11	9-11
Thin film cadmium tellurium	6-8	12-17
Thin film amorphous silicon	5-7	14-20

The efficiency of the PV system is calculated by using eqs. (10) and (11) together.

$$\eta_{\text{pv}} = \frac{P_{\text{pv}}}{IA} \tag{10}$$

where P_{pv} [W] is the amount of electricity produced by the panel and I – the light intensity for Mus province (592 W/m^2).

$$\eta_{\text{pv}} = F_m[(1-\varphi(T_c - T_r)]\eta_r \tag{11}$$

where η_{pv} is the efficiency of PV system, F_m – the plant installation loss factor taken as 0.85, φ – the cell temperature factor (0.004-0.005 °C^{-1} for monolicon panels, 0.001-0.002 °C^{-1} for polysilicon panels, T_c – the average daily temperature of the months between May 15 and September 15, when the system will operate [22] and T_r – the temperature under standard test conditions (25 °C).

A sample irrigation system application designed for the City of Mus. Here, necessary engineering calculations for system design will be made. The cost analysis of this application will be made under the heading of section *Cost analysis.*

Given:

– The data used in this example were obtained from the General Directorate of Agricultural Research and Policies [23].
– Tomatoes will be planted in a 50 m × 100 m field with an area of 1 ha.
– The distance between the pipes will be 1 m. (200 pipes with drip system will be used.)

- There will be 50 cm between drips (200 × 100) 20000 seedlings will be planted.
- Approximately 300 m^3/ha of water is needed for one-time irrigation for 1 ha of tomato.
- The total number of irrigation (12-20) fields will be irrigated 16 times in total.
- Irrigation period (5-10 days) An irrigation period of 8 days was selected. (Saving storage will be achieved by irrigating 1/8 of the field every day.)
- Total water requirement (16 × 300 m^3) 4800 m^3
- A 5 ton water tank was selected.
- Engine running time is in the most efficient time between 11:00 and 16:00
- It is planned to pump water from the system for 5 hours
- Pipe length: 33 m
- Pipe inner diameter: 0.75 m

Note: By adding a time counter to the motor control circuit, the motor is provided to operate within the specified time interval. Thus, with Q =1 m^3/h, a 5 ton warehouse is 5 × 1 = 5 m^3.

Table 4. Irrigation data according to plants [23]

Amount of water to be given at a time			Irrigation	
Products	Ha/mm	Ha/m^3	Number of irrigation	Irrigation intervals (days)
Grains	100-150	1000-1500	2-3	20-30
Vegetables	20-70	200-700	12-20	5-10
Fruits	70-100	700-1000	4-5	20-25
Plantation	50-80	500-800	8-10	10-15
Clover	100-125	1000-1250	4-8	20-30

Requested: How much power and voltage should a DC motor be selected by making the necessary water pump calculation to fill 5 tons of tanks by working for 5 hours? The area and number of panels that will generate the electrical energy to run the required engine will be calculated.

Engine calculation: Using eq. (2), the velocity is found as V = 6.87 m/s. The f = 0.0011 is selected from tab. 1. Straight pipe losses are calculated from eq. (1) as H_{bk} = 17.46 J/N. From tab. 2, K was chosen as 0.22 and pipe connection losses are found by eq. (3) as H_m = 52.04 J/N. Total losses are found as H_m = 52.04 J/N with eq. (4). The pump output power is found as $P_{çg}$ = 137.83 W with eq. (5). Effective power is found as P_e = 173.29 W with eq. (6).

Since P_e < 6.8 kW, α = 1.3 is selected and then the required motor power is found as P_{mg} = 223.98 W with eq. (7).

Note: As a result of the calculations, the pump sold closest to 224 W was selected in the market as a 250W 24 V 11 A DC Solar Submersible Pump.

Calculating solar panel area: Now let's calculate the panel size that will meet the energy need of this selected engine.

For this, the $P_{pv} \geq P_{mg}$ condition must be met. Since the polycrystalline panel is chosen as the solar panel, the η_r cell efficiency is found as 14 from tab. 3 and the panel size required to operate the 250 W pump is found A = 1.78 m^2 using eq. (9).

The closest standard polycrystalline panel size to this value in the market was chosen as 2 m^2. The power to be produced by a 2 m^2 polycrystalline panel is found as $P_{pv} = 280$ W with eqs. (10) and (11).

The $P_{pv} \geq P_{mg}$ condition must be met for the pump to operate. As can be seen, 1 piece of 2 m^2 polycrystalline panel selected has a power generation capacity of 280 W, which is above the power required for the irrigation pump (250 W).

Cost analysis

The approximate cost of the equipment used in the irrigation system will be calculated. Finally, the payback period of the irrigation system investment cost will be calculated.

Table 5. Cost of selected irrigation system

Equipment name	Approximate cost
250 W and 11 A DC Solar Submersible Pump	1950 TL
1 piece of 2 m^2 polycrystalline panel	3250 TL
Time counter	180 TL
5 ton water tank	6850 TL
Total cost	12230 TL

House type subscription unit price of electricity is 1.73 TL including taxes (Mus Vedas, 2022). *Note:* To pump 300 m^3 of water 16 times: 40 hours × 16 times = 640 hours of electricity is consumed. The amount of electrical energy to be spent per hour is calculated by:

$$P = UI\text{Cos}0 \tag{12}$$

where P [kW] is the amount of electricity consumed by the pump in one hour, U – the effective voltage of home network, I [A] – the current used by the motor, and $Cos0$ – the power factor.

Since the effective voltage of the household networks in Turkey is 220 V, the current of the pump used is 11 A, $Cos0 = 1$.

The amount of electricity consumed in 1 hour is:

$$P = 220 \times 11 \times 1 = 2420 \text{ W} = 2.42 \text{ kW}$$

A total of 16 irrigations will be made for 5 hours and 8 days of irrigation per day. The amount of electrical energy consumed for one season irrigation is calculated as 2.42 × 5 × 8 × 16 = 1548.80 kW. Cost of consumption = 1548.8 × 1.73 = 2679.42 TL

Calculation of non-grant set-up cost payback period: The installation cost payback time is found to be 12230/2679.42 = 4.6 years.

Grant-supported set-up cost payback period calculation: The Ministry of Agriculture and Forestry provides 60% grant support for solar irrigation system installation costs in Turkey [24]. Agriculture and Rural Development Support Institution (ARDSI), on the other hand, provides at least 65% of the cost plus 18% VAT tax exemption with grant supports [25]. This corresponds to approximately 77% grant support. If a farmer successfully makes the necessary application to ARDSI. The ARDSI will pay 12230 × 77/100 = 9417 TL as a grant.

The remaining 2813 TL will be covered by the farmer. The recovery of the 2813 TL installation cost spent by the farmer for the irrigation system will take place in approximately

1.1 years. Considering the life of the irrigation system as 20 years, it is seen that the farmer will not pay the energy bill for irrigation for 18.9 years.

Note: In this work, the cost of common equipment used in each system was not taken into account. Because these equipments are used in all irrigation systems in any case. The aim is to clearly determine the cost of a solar-based irrigation system and the payback period of this investment cost.

Conclusions

Technological innovations that increase efficiency in production by facilitating agricultural activities have further increased the demand for energy. Providing energy supply mainly from fossil fuels releases harmful emissions to the environment, threatening the life of living things and causing climate change. Climate change also reduces agricultural production capacity by causing fertile agricultural lands to shrink day by day. In addition, the increase in demand for fossil fuels with limited reserves causes energy costs to increase day by day. In order to overcome these problems, there is a need for cheap, abundant, clean and RES that do not harm the environment. The Sun is one of the most important of these renewable energy sources.

In this study, the issue of meeting the energy required for irrigated agriculture from solar panels was investigated in detail. Engineering and cost calculations were made for the solar powered irrigation system. By applying this on a sample of a province in Turkey, it was tried to see how much it reduced irrigation costs. Although the province of Mus has large agricultural areas, it is seen that the cultivated areas are very limited. In order to make effective use of the Mus Plain, which is the third largest inland plain of Turkey, and the Bulanik, Liz and Malazgirt plains in the province of Mus, it is necessary to expand the agricultural production based on science and technology, together with the irrigation of agricultural lands. There is no fixed cost other than the installation cost in meeting the energy needed for irrigation of agricultural areas with a photovoltaic system. Assuming that 77 of the installation investment cost is covered by ARDSI as a grant, it is seen that the investment cost recovery period is as short as 1.1 years. Considering that the life of the system is 20 years, it is seen that the irrigation cost will be 18.9 years free of charge. It is obvious that this situation will make a great contribution to the welfare of farmers who carry out small-scale agricultural activities living in a socio-economically underdeveloped city such as Mus, which is predominantly rural and lives on agriculture and animal husbandry. It is thought that this example presents a convincing perspective that solar energy can be easily applied to all cities, both as an economical and environmentally friendly option, in the conversion of agricultural lands to irrigated agriculture on a global scale.

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