Bitlis Eren Univ J Sci & Technol
6 (1), 26-28, 2016

E - ISSN 2146-7706

Research Article

Cost Comparison of Constant and Tracking System PV Panels with Stirling Motor-Operated Systems

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Abstract

At the present days, quick consumption of fossil-basic sources and damages that fossil fuels give to environment have caused people to tend towards alternative energy sources. As energy need has been increasing constantly, renewable energy sources are needed in the event that energy bottleneck does not occur in the future. One which is most and easily found among renewable energy sources is solar energy and our country has got high potential in terms of sun potential. On this study, as solar energy potential over world and in Turkey, methods to produce energy from sun and literature information have been mentioned, the relation of cost and efficiency-performance for electric production of sun from past to today has been analyzed,.various stable PV panel systems, sun tracker systems and SMGTS sample designs have been examined. Suggestions to increase yield with electrical basic have been made as cost analysis has been made for SMGTS's with stable and moving PV systems. Consequently, it has been determined that electric production capacity from sun would be increased much more in regions with high temperature average as using intensive solar energy systems such as Stirling engine system which its application is made.

Keywords: Stirling Engines, Heat Pumps, Solar Tracking System, Photovoltaic Panel System, Energy Efficiency, Renewable Energy

1. Introduction

Today there is constant increasing of human population, industrialization effects and global warming accordingly there happens climate base changes. With the effect of industrial revolution, the production raised after 1850s, technological development started to improve and big industrial establishments towards the needs of consumer were built. At the beginning of 1900s as the population of world was 1 billion, today human population closes to 7 billion. So requirement of more energy was formed. In our day energy is formed with traditional sources (coal etc.), using raw materials such as natural gas and fuel oil. Using of traditional sources brings about climatic changes by releasing greenhouse gases to atmosphere that cause global warming. By year 2015 there happened 2°C of temperature increase due to global warming in the world. The temperature average of the world increased from 15°C to 17°C. The temperature increase at global base were expected to be happened between years 2040 and 2050. However the increase in population and fast release of greenhouse gases have withdrawed global warming to 2015. In some countries and regions as living creatures were affected from this change in a positive way and became in a situation benefitting from this change, in some regions temperature increase would expose creatures more negative conditions. In places such as North European countries there is heavy snowing, with average temperature increase of the world snowing turns to raining and the productivity in agriculture increased. But in the region that is called as Mediterrenean trench where our country is, climate effects such as desertification and experiencing hot climate denser. In our country seasons started to resemble semi-arid and tropical climate characteristics. In recent years the half of autumn and spring resemble winter whereas the other half resembles summer. For example in hinterlands of our country snowing is observed in April and in recent winters relatively hotter climatic characteristics are observed. Starting from this point, energy source that will be used in the future should not be primarily on fossil base. Because usage of more fossil base energy production means the world is getting more heated. The world has already been getting hotter with vital activities of human day by day. Accordingly using of renewable energy should be provided in production of energy primarily. Among renewable energy sources methods that heating characteristics of sun which is found in Mediterrenean trench can be used for energy production of our country. In this study Stirling motor-operated electric production model from sun in which thermal heating characteristic of sun can be used, is adopted.

Sun energy is a subject that has been comprehensively studied on in recent years due to its advantages such as applying on every point having suitable production conditions, has a simple technology and does not produce polluter wastes. Since fuel reserve of the world is limited, insufficient usage of present resources and low usage of renewable energy sources show an increase of energy problems. Sun energy is comprehensively provided for direct or indirect heating, cooling and especially in production of energy.

Received 26 April 2016
Available online June 2016

Many studies have been done both in our country and in the world to contribute energy productivity by using smart and micro networks. These studies are done in the form sometimes as solving problems encountered in energy transmission lines with new methods and sometimes as productivity directly [1-7].
With this aim in recent years in scientific literature the number of researches about elecrical devices and on usage of renewable energy sources in industrial plants has been increasing to benefit from either wind energy or sun energy at maximum level [8,9].

As a result of these efforts, energy conservation which is as important as energy productivity gained importance. In many studies new suggestions are given for economical usage of equipments having high consumption such as compression, lightining, pump, motor with filtration methods especially in industrial plants. In our country studies of electrical train and rail systems having high electrical consumption that are planned to be built by public by the year 2016, are encountered [10-14].

Today theoretical studies towards productivity in energy-optimization by using either artificial neural nets (machine learning) or other statistical estimation methods (gamma, castigating etc.) with different methods have been continuing in science world besides all these applied conservation and productivity studies [15-20].

2. Solar system cost analysis

The most important reasons of preferring PV systems are that they can transfer sun energy to electric energy directly, they do not pollute environment as well as they have simple structure and application [18-21]. PV systems can be used two different ways as on grid and off grid and are designed as constant and tracking system.

The application was done as off grid and sun tracking systems. Also system mounting costs were provided with the mounting of Dish type Stirling motor operated system on moving mechanism. The picture of focalization of system was shown in Figure 1.

Figure 1. The effect of burden in motor mil on the efficieny

The off grid aystems are generally used for compansate energy requirement in places away from grid. The systems are usually consisted of PV panel, charge regulator, storage battery group and inverter. As cost calculation of using production expenses are done, it should be decided if the system is on grid or off grid then if it will be moving or not. In on grid systems starage battery group whereas in constant PV panel systems tracking mechanism is not used. In tracking mechanism systems since PV panels are installed on moving system, constant construction is not used for mounting on ground. In this study the cost comparison of installation of 3 different off grid systems, were done. These installed 3 systems arecConstant PV panel system, Sun tracking system PV panel and SMGTS. The installation costs of various systems for solar production are given in Table 1.

Table 1. The installation costs of various systems for solar production

Generation System	Material Type	Property		Cost
Fixed PV Panel	PV Panel	24 V_{DC}, 100 W, monocrystalline	1 Pc.	2.420 TL
	Battery Group	12 V_{DC}, 45 A,	1 Pc.	
	Battery Charger	24 V_{DC}, 10 A,	2 Pc.	
	Invertors	24 V_{DC}-220 V	1 Pc.	
	Dashboard		1 Pc	
	Solar Cable	Solar	20 m	
	Other Mounts	Connectors and bolts	N/A	
	Fixed Construction	Galvanized angle bar	N/A	
Solar Tracking System PV Panel	PV Panel	24 V_{DC}, 100 W, monocrystalline	1 Pc.	3.270 TL
	Battery Group	12 V_{DC}, 45 A,	1 Pc.	
	Battery Charger	24 V_{DC}, 10 A,	2 Pc.	
	Invertors	24 V_{DC}-220 V	1 Pc.	
	Dashboard		1 Pc.	
	Solar Cable	Solar	20 m	
	Other Mounts	Connectors and bolts	N/A	
	Solar Tracking Mechanism		1 Pc.	
Solar Tracking System Stirling Engine	Stirling Engine	including manufacturing and materials,100 W	1 Pc.	3.320 TL
	Dish Reflector	covered with reflective foil	1 Pc.	
	Battery Group	12 V_{DC}, 45 A,	1 Pc.	
	Battery Charger	24 V_{DC}, 10 A,	2 Pc.	
	Invertors	24 V_{DC}-220 V	1 Pc.	
	Dashboard		1 Pc.	
	Solar Cable	Solar	10 m	
	Solar Tracking Mechanism		1 Pc.	

As daily average for Constant PV panel 241 Wh, for Sun tracking system PV panel 303 Wh and for SMGTS 319 Wh was created in 3 different systems that were installed. According to cost research analysis done with actual prices of 2016, Constant PV Panel cost 2.420 TL, Sun Tracking System PV Panel cost 3.270 TL and SMGTS cost 3.320 TL (in case of serial production the cost of Stirling motor-operated system can be reduced as 33%).

With actual prices as the cost of electricity per kwh by 2016 is 0.411 TL, Constant PV Panel system was installed with the cost corresponding the sum of 5.888 kwh, Sun Tracking System PV Panel was with the sum of 7.956 kwh and SMGTS was with the sum of 8.077 kwh energy. So a consumer that spends 400 kwh monthly and pays 164.40 TL electricity bill will pay this cost in 15 months with Constant PV Panel, in 20 months with Sun Tracking System PV Panel and SMGTS. Accordingly in each 3 systems system installation costs can be compansated in short term.

In terms of installation costs Sun Tracking System PV Panel is 35% more expensive compared to Constant PV Panel whereas SMGTS is 37% more expensive compared to Constant PV Panel. However in terms of electrical efficiency for a period of month Constant PV Panel produces 7.248 Wh energy, Sun Tracking System PV Panel produces 9.113 Wh energy and SMGTS produces 9.568 Wh energy. According to this as Sun Tracking System PV Panel is 25% more efficient than Constant PV Panel in terms of production, SMGTS is 32% more efficient than Constant PV Panel in terms of production.

3. Conclusion

As the results that were obtained from each 3 production system are evaluated, it was seen that SMGTS is the most effective production method althought it is a bit expensive than the others. In terms of system balance that is cost-productivity performance, it was also seen that SMGTS can be used in places having high average temperature values.

Acknowledgement

This work has been supported by the Scientific and Technological Research Council of Turkey (TUBITAK) under Grant EEEAG-115E680.

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