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Research Article

MONTHLY OPTIMIZATION OF A NEW HYBRID RENEWABLE ENERGY SYSTEM CONSIDERING ENERGY AND AGRICULTURAL EFFICIENCY

Selmin Ener Rusen[1]*, Buket Bezgin Carbas[1]*, Abdurrahman Ulker[2]

[1]Department of Energy Systems Engineering, Karamanoglu Mehmetbey University, 70100, Karaman, Turkey

[2]Department of Advanced Technologies, Karamanoglu Mehmetbey University,70100, Karaman, Turkey

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Abstract

Clean and cheap energy in agriculture play a key role in improving agricultural productivity, environmental sustainability, and economic performance. This paper presents the result of the monthly optimization analysis for enhancing energy efficiency and conservation in a new hybrid system composed of pumped-storage (PHS) power plant integrated PV platform and wind turbine (WT). The monthly performance of this new hybrid system is analyzed for Karaman which has high solar and wind energy potentials by reason of its climatic and regional factors. Using the data for one year, a preliminary study has been carried out for the selected station which produced important information for an extended work. The monthly optimization analysis results have been determined by using earth observation data of solar and the wind which are registered in this region. According to the wind and solar data, the optimum month was found as July considering energy and agricultural efficiency. Results can be used either to increase the performance of the new hybrid system or to analyze long-term agricultural and energy studies with more efficiently.

Keywords*- Hybrid Renewable Energy System, Optimal Energy Production.*

1. Introduction

Energy is one of the biggest requirements for humanity since the first ages. In the modern age, energy has been indispensable for us in houses, agricultural regions, industrial regions, public utilities and outdoors with different needs. Most of these energy demands are met from fossil sources [1-3]. Fossil sources have been decreasing and for that reason more pollution has occurred day by day. Therefore, new energy sources are necessary to meet the energy needs [4, 5]. It is known that the renewable energy resources like as sun, wind, hydro, biomass and geothermal should be evaluated for the future of our world in view of the environmental effects such as global warming, climate change, and carbon emission.

* Corresponding Authors;
selmin.enerrusen@gmail.com
bcarbas@kmu.edu.tr

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They come to mind first between clean energy resources, the sun has the biggest energy potential among them. Researchers are under way of progress in by forming this huge potential for the benefit of humanity like solar PV technology [6-8]. Wind energy is also other one of the most promising renewable power generation technologies nearly as large as solar energy potentials and also it is, used widely as a cheap source of energy for local energy requirements in all over the world. The capacity of modern wind turbines generated in recent years is quite high [9,10].
It is difficult to provide uninterrupted power with the solar and the wind renewable energy sources alone because these kinds of systems are dependent on the weather conditions. The design of hybrid systems is the necessary in order to ensure uninterrupted energy from these systems [11]. Since different renewable energy sources can implement to each other, multi-source hybrid alternative energy systems provide higher quality and quality power to people than a system based on a single resource. The thought of taking advantage of the hybrid renewable energy

systems come the first and foremost when taken together with the environmental and economic impacts in today's conditions [12-14].
In the hybrid system studies, system components are usually installed to detached and large areas. In this case, it causes to gradually decrease in agricultural lands and limits the application of renewable energy systems. With this study, a new hybrid renewable energy system was designed. All system components are collected on a greenhouse enable to using agricultural land. In addition, optimum energy production was determined according to working performance of the system on a monthly basis.

2. Material and Method

This study focuses on, environment-friendly energy deposition, an effective usage of agricultural land and obtaining maximum energy per unit area. All components of this new system are illustrated in Figure 1.

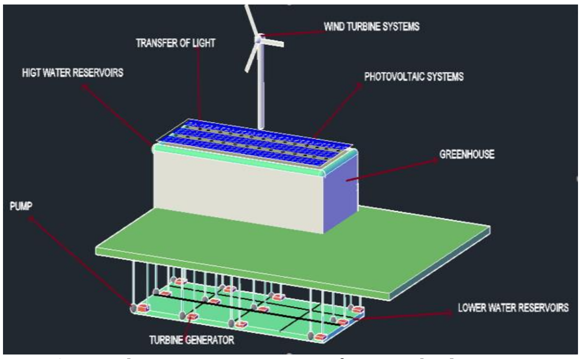

Fig. 1. Schematic representation of New Hybrid Systems.

System Components

1) Photovoltaic System (PV): Photovoltaic solar panels generate electricity energy from solar radiation directly [15]. In this study, Si-poly module was selected according to the reasonable price and performance properties that are the important factor for selection of panel [16]. Totally 450 panels, which are specified during the design of panels connected in series. These panels are located on the greenhouse which has 20x50 m² area. Monthly output power performances of the selected photovoltaic system are given in Figure 2.

2) Wind Turbine System (WT): Wind turbines firstly convert the kinetic energy of the wind to the mechanical energy and then electrical energy [17]. The selected wind turbine has 34 m rotor diameter, its stepping area of horizontal axis 904 m and it has maximum 250 kW output power [18]. In of Karaman province and horizontal axis wind turbine that works at least %45 efficiency [10]. Monthly output power performances of selected wind turbine are given in Figure 3.

3) Pumped Hydroelectric Power Station System (PHS): Pumped hydroelectric power station system is a clean energy deposition method which has an upper-bottom reservoir and mechanical parts. It enables to deposition of energy on water, and works without any chemicals. There are lots of studies about pumped hydroelectric systems [19-23]. With this new system design, it is aimed to store excess energy via PHS system for use when there is no power production is provided. This PHS system with 92 kW total instantaneous powers was designed. Pelton turbine was selected according to capacity and physical properties of the system.

4) Light Transmission System: In the designed hybrid system, photovoltaic panels were located on the top of the greenhouse that is application area of the system. But they block the light transmission in the greenhouse. An efficient light transmission system which is located on shading distance of photovoltaic panels light transmission in the greenhouse is provided when the plants need at certain times. In this way, sufficient light transmission in the greenhouse is provided. The light transmission system is given in Figure 4

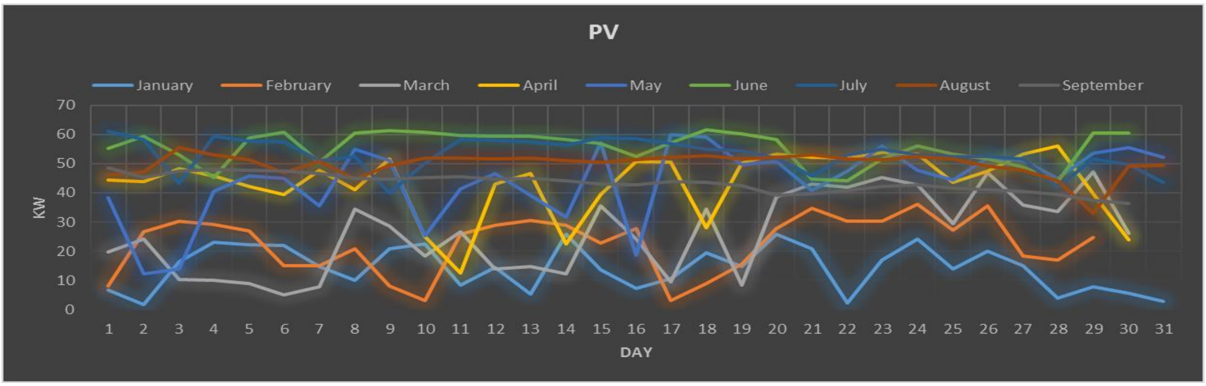

Fig. 2. Annual power performances of photovoltaic system.

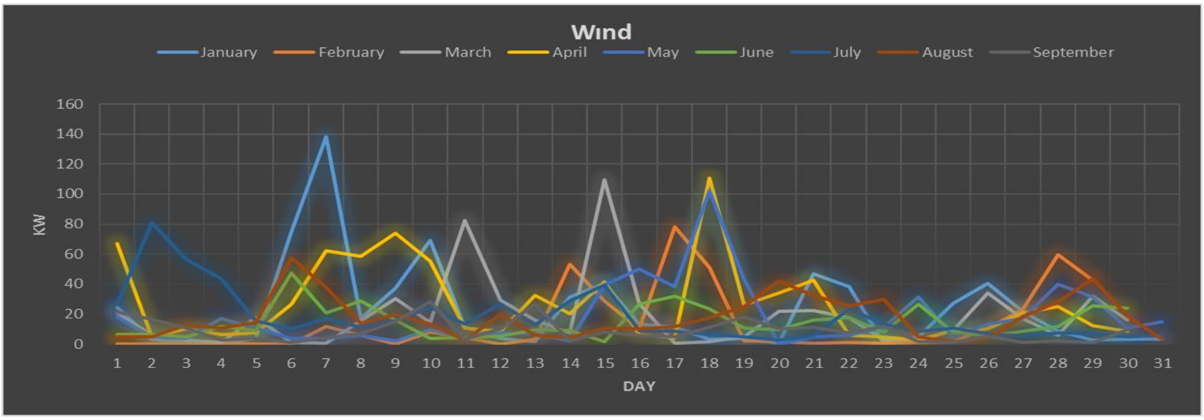

Fig. 3. Annual power performances of wind turbine system.

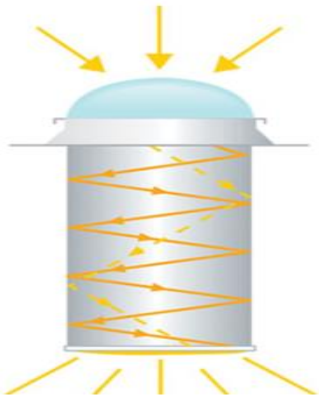

Fig. 4. Schematic representation of the light transmission system.

5) Plant-House: Greenhouses protect of plants and provide increasing of their yield and quality by keeping the indoor temperature in appropriate circumstances. The existing agricultural fields will be brought to the more efficient state thanks to greenhouse without being affected by seasonal differences. These systems have been used for a long time in the world and in our country. In this proposed new system a greenhouse with 20x50 m² area was selected.

3. Research Results and Cost Analysis

In this study, electric production for new designed hybrid renewable energy system was calculated. Annual solar radiation, wind and temperature data for Karaman was used for calculations. The maximum electric production was observed in July by data on a monthly base. In addition cost analysis of the new designed system is detailed in Table 1. As a result of the installation of the system and calculation of the total investment payback period was calculated as 4.09 years.

4. Conclusion

In this study, a new hybrid renewable energy system was designed for the nature-friendly electric production without harming to agricultural lands. The performance of the designed system has been examined separately for each month of the year using one-year data of Karaman. The best electric production performance for this system has been determined in July. In addition, the total payback period was calculated as 4.09 years. According to research results, it is predicted that this new system is practicable for Karaman due to its geographical and climatic features. As a result, the proposed new system will support the expansion of the use of renewable energy systems that will be built in the future, because it provides high output power and high performance from the field of agricultural production, as well as being nature-friendly.

Table 1. Results of calculations for new hybrid renewable energy system

	System Components			
	PV Systems	**Light System**	**WT**	**PHS**
Yield	%15-17	%90	%45	%80
Number	450	20	2	12
Generated Power	117 kWh	15 kWh	250 kWh	92 kWh
Investment Amount	90000 $	3000 $	300000 $	30000 $
Maintenance and Repair expenses	1000 TL/year		5000 TL/year	500 TL/year
Generated Electricity	256736 kWh/year		116037 kWh/year	244946 kWh/year
Payback Period	4.09 year			
Benefit	Daylight was distributed uniformly in the greenhouse, and electric energy was obtained.		Electric energy was obtained	Greenhouse is cheaper, regular and heating was provided with a constant temperature.

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