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Climatic potential evaluation for optimal use of parabolic solar collectors: A case study of Iran

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Abstract

Increased demand for fossil fuels has led to climate change, global warming, and declining energy reserves. The use of renewable energy, such as solar energy, is a suitable approach to generating electricity and heat. One of the common systems in using solar energy is parabolic collectors (PTCs), which enable this clean energy by converting the incoming radiation into thermal energy. In the present paper, to assess the potential of climates to make optimal use of PTCs, a numerical model was developed in MATLAB. Then, climate change has been studied in four areas: energy, exergy, economy, and environment. For this purpose, five cities: Rasht, Shiraz, Tehran, Abadan, and Sanandaj, have been selected as representatives of Iran's climate and energy efficiency and exergy, the unit cost of energy and the amount of carbon dioxide produced during the life cycle of the system has been obtained. The results show that Shiraz, with a Semi-Arid Cool climate and thermal efficiency of 72 % and a unit cost of 0.035 $/ kWh, is the optimal climate in the fields of energy and economy, and Sanandaj, with a Humid Continental climate and exergy efficiency of 17.7% is the optimal climate in the field of exergy.

Keywords: Parabolic Solar Collector – Economic Analysis – Life Cycle Assessment – Climates Conditions

1. INTRODUCTION

Due to the global climate, global warming, and fossil fuel reserves worldwide have become a serious threat; there is a need to use fuel and clean energy [1]. Among the various types of renewable energy, wind energy, geothermal energy, tides, Etc., countries have required solar energy due to its inexhaustibility, stability, and easy access [2]. Meanwhile, systems such as photovoltaic panels convert solar energy directly into electrical energy. Systems such as parabolic and linear collectors, Fresnel collectors, and solar protractors convert the incoming radiant energy into heat energy [3]. In recent years, solar collectors have been used due to their logical dimensions and suitable thermal efficiency in domestic and industrial destinations [4, 5]. Solar collectors are divided into two general categories: centralized and decentralized [6]. In cases where high temperatures are required, centralized collectors such as solar dishes and linear parabolic collectors are used [7]. According to experimental and numerical researches performed on parabolic collectors in the topics: numerical simulation, optimization, experimental experiments, energy analysis, exergy, economic and environmental and climatic studies, in this research, the potential of the central climates of Iran In order to use solar parabolic collectors in the framework of energy, exergy, economic and environmental fields, the results are determined to determine the best climate for using the solar potential in each field. In this regard, while selecting five climates in Iran, the performance of the solar collector system in each climate by calculating the factors of energy efficiency and exergy, cost per unit of energy and the amount of carbon dioxide produced (taking into account the life cycle of the system), calculated Turns. Finally, by analyzing the obtained data, the ranking of climatic climates for solar energy potential by linear parabolic collector system is presented.

2. SIMULATION AND METHOD

In order to find the most suitable climate for using solar potential by solar collectors, a numerical modeling was performed in MATLAB software. Then the effect of climate change on energy efficiency, exergy, economic and environmental parameters were investigated. Takes. The inputs of this program include environmental and climatic conditions including ambient temperature, solar intensity, wind speed, and sunny hours. The outputs of this program also include the output temperature of the working fluid, energy efficiency and exergy, economic analysis to determine the unit cost of energy produced and environmental parameters. Figure 4 shows the flowchart of the modeling performed.

3. Results and Discussion

In sequence to analyze the system in the field of energy, it is necessary to determine the distribution of energy in the system. As mentioned before, the distribution of energy in the system is such that solar energy enters the system's boundaries as input and part of it is lost due to heat transfer phenomena. Finally, the remaining amount as useful energy in Fluid heating plays a role. Figure 1 shows the system energy balance in the maximum radiant month (June) for the five cities of Rasht, Shiraz, Tehran, Abadan and Sanandaj.

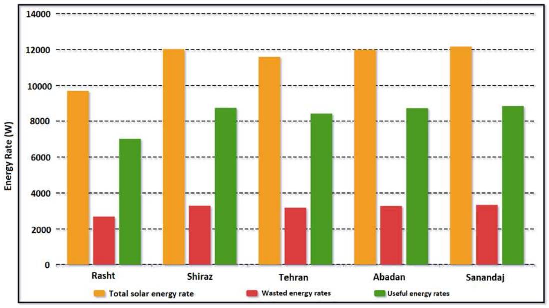

Figure 1 . Different types of energy rates

According to Figure 6, the maximum amount of incoming solar energy and, consequently, useful energy is realized in the cities of Shiraz and Sanandaj, and the minimum amount is in the city of Rasht.

3.1. Economic analysis

In line with the economic analysis of solar collectors, the cost of production per unit of energy is discussed. In this regard, according to the lifespan and interest rate stated in Table 4 and other ancillary conditions such as equipment costs, repairs, and maintenance, as well as equipment and staff insurance, by dividing the total cost by the total energy produced by the solar collector, the cost The production of one unit of energy is calculated per kilowatt-hour. Figure 2 shows the monthly energy cost for each city.

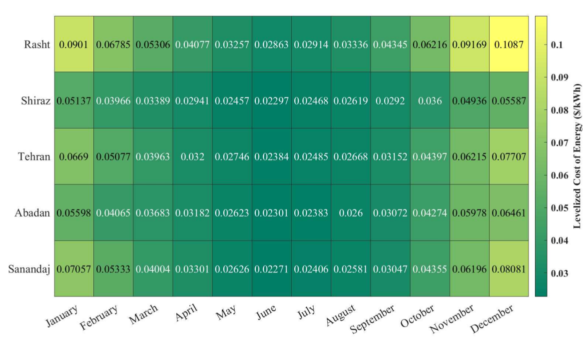

Figure 2 . The average monthly unit cost of energy

Figure 2, shows that considering the same total cost in all cities, the city that produces more power will have a lower unit cost of energy. Therefore, since the highest amount of useful power is related to the city of Shiraz, so the cost of energy units in this city has the lowest amount. Different types of energy rates

4. Conclusions

A study was conducted to study the effect of climatic climates on solar energy potential by solar collectors in the framework of the main areas of energy, exergy, economic and environmental, and while developing a numerical model and validating it with existing experimental results. [8], an overview of solar collector performance in different climates is provided. For this purpose, five cities of Rasht, Shiraz, Tehran, Abadan, and Sanandaj are considered representatives of different country's climatic climates (according to Table 1). With the environmental data of each city, the effect of climate change on energy efficiency Exergy as well as economic and environmental effects have been investigated. The behavior of the system in the fields of energy and exergy, respectively, with thermal efficiency and efficiency of the second law, and its behavior in the fields of environment and economy, respectively, with the amount of carbon dioxide produced during the system life cycle (from both energy and exergy perspectives) and cost The equilibrium of one-kilowatt hour of energy produced has been investigated.

In order to better compare the effects of climates on the fields of energy, exergy, environment, and economy, Figure 3 shows the spider web diagrams of different cities (as representatives of climatic climates) according to their rank in each of the main fields.

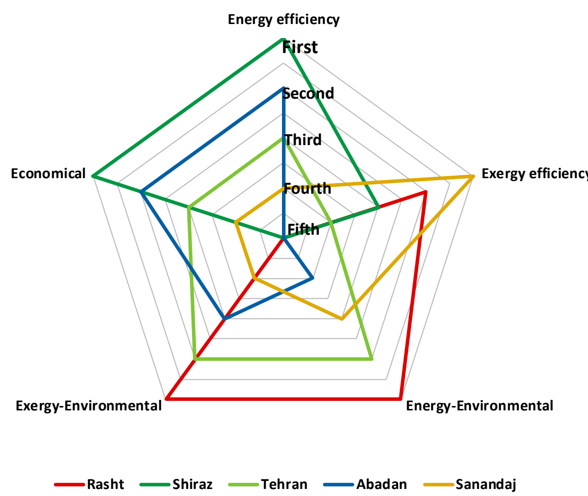

Figure 3 . Spider web graphs of the effects of different climates in the fields of energy, exergy, economics and environment

Finally, according to the diagram in Figure 14, the following results are observed:

- ✓ The city of Shiraz with the "Mediterranean climate" is introduced as the optimal climate of the solar parabolic collector in the field of energy with a thermal efficiency of 72%.

- ✓ In the field of exergy, the city of Sanandaj with a "humid continental" climate is introduced as an optimal climate with an efficiency of the second law of 17.7%.
- ✓ In the field of environment, the city of Rasht, with a "humid temperate" climate in each of the two criteria of energy - environmental and exergy - environmental is introduced as the optimal climate.
- ✓ In the economic field, the city of Shiraz, with the climate of "Mediterranean climate," is introduced as an optimal climate with an energy cost of $ 0.035 per kilowatt-hour.

Finally, considering the obtained results, Shiraz city with “Mediterranean climate” while having the first rank in the field of energy and economy, is proposed as the city and the final climate for the construction of a solar parabolic collector system.

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