Renewable and Sustainable Energy Reviews 57 (2016) 765–775

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Identifying the effective factors on implementing the solar dryers for Yazd province, Iran

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ARTICLE INFO

Article history:
Received 3 July 2015
Received in revised form
7 November 2015
Accepted 15 December 2015

Keywords:
Solar dryer
Statistical analysis
Factor analysis
Risk
Yazd province

ABSTRACT

Solar energy is a kind of entirely free, clean, and renewable energy resource that has been used in many countries. One of the solar thermal energy applications is solar dryer, which is usually used to dry agricultural and food products. Various types of solar dryers have been designed and manufactured in the past. Different factors are effective in the process of designing, constructing and using solar dryers in different regions. The purpose of this study is to identify the effective factors and risks which may impact on the use of solar dryers. In this research work, data for Yazd province in Iran was used for analysis. Factor Analysis (FA) methodology was performed using SPSS software; a questionnaire was designed to collect the data and finally the validity and the reliability of acquired data was investigated. Results of analysis reveal that there are six major factors and three risk types impacting the process of designing, constructing and implementation of solar dryer systems in the province.

Contents

1. Introduction

With the rapid increase of the world population, fuel consumption rate is now constantly growing. Exceed use of the polluting fuels and particularly fossil fuels not only results in the depletion of the fossil fuel resources, but also exerts negative environmental impacts. Water pollution, air pollution, rupture of the ozone layer , the climate changes and acidic rains are the environmental impacts of using fossil fuels [1–3]. Hence, the world attention has been, recently attracted to the development of the renewable energies, such as atomic energy, solar energy, hydroelectric energy, geothermal energy and wind energy [1].

Solar energy is a clean, free and environmental-friendly energy resource, and is also cost-effective, particularly in the countries geographically located at 0–50°. Meanwhile, the cost of solar energy has been decreased fast in the recent years, and in the sunny countries, the electronic and thermal solar systems engaging in a tight economic competition with the traditional systems using the fossil fuels [4]. However, despite the rapid decreasing of

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http://dx.doi.org/10.1016/j.rser.2015.12.060
1364-0321/

the investment costs and increasing the fossil fuel costs, the solar technologies related to the power generation activities cannot compete with the traditional power generation technologies. Yet, considering the issue environmentally, the solar systems are much better than the fossil fuels; however, these systems may encounter various economic, technological, financial as well as organizational barriers [5]. Therefore, extensive studies should be done to overcome the existing barriers and problems. Furthermore, the government should support and invest in the required infrastructures and strengthen the private sector in order to play a significant role in renewable energy sectors [6].

Solar energy can be used in different systems, such as photo biologic, chemical, photovoltaic, and thermal systems. The applications of thermal solar energy include solar water heater, solar bath, heating and cooling, solar air conditioning systems, solar water desalination, solar dryer, solar oven, and solar chimney [7–9]. In this study, solar dryer feasibility has been studied. The solar dryers are used to dry vegetables, fruits, and agriculture products. These systems, at the level of the national and international standards, are capable of drying vegetables and fruits in a clean and healthy manner with a zero energy charge. These systems also save energy and time, occupy less area, improve nutrition-quality of the agricultural products, increase the efficiency and protect the environment. The solar dryers have great advantages in comparison to the traditional ones; they are characterized as faster operation, higher efficiency, and healthier approach. Moreover, they are cheaper and this is assumed as the most important feature of these machines [10].

Many factors are engaging the development of the solar dryers, from the designing to the implementation stage. Therefore, in this study different factors and risks affecting the design, production and implementation of solar dryers in Yazd are covered through using factor analysis method.

The rest of the study is organized as follows: Section 2 explains solar dryers thoroughly including literature reviews. Geographical description of Yazd is presented in Section 3. The hypotheses and research methodology are covered in Section 4. Section 5 explains the obtained data and the results. Finally, the conclusions are presented in Section 6.

2. Solar dryer as a renewables source

Many studies have been done on all kind of the renewable energies. Mohammadi et al. [11] evaluated the wind energy potential and its characteristics in Aligoodarz, Iran. The analysis results showed that there is a nearly stable wind pattern in different hours, which demonstrated that this region is suitable for harnessing wind energy to meet the electricity demand. Mostafaeipour et al. [12] evaluated the wind energy potential as a power generation source for electricity production in Binalood, Iran. They found that Binalood has available great wind energy potential. Mostafaeipour [13], and Mohammadi et al. [14] also evaluated wind energy potential in different parts of Iran. Among all the renewable energies, solar has found a particular importance. Mohammadi et al. [15] assessed both solar and wind energy potentials for three zones of Iran; Chabahar, Kish and Salafchegan. The results showed that all regions have great potentials for utilizing different solar energy systems. Khorasanizadeh et al. [16] evaluated solar energy potential in Tabas, Iran. They established a diffuse solar radiation model for determining the optimum tilt angle of solar surfaces.

Also, Enjavi-Arsanjani et al. [17] assessed solar energy and performance of solar power plants in Iran. They identified talented regions of Iran to install solar power plants from 21 selected cities. The results showed that Bandar-e Abbas, Bushehr, Esfahan, Kerman, Shiraz, and Yazd have more solar energy potential to install solar power plants in Iran. In this study, solar dryer feasibility has been studied in one of the most solar radiation potential cities in Iran, Yazd [17] using factor analysis.

Factor analysis is a multivariable statistical method, which includes a larger set of variables looking for a way to decrease the data volume or summarize the data into a smaller set of factors or variables.

Factor analysis is usually done with the assumption that the measured variables are a linear combination of the basic assumed variables. In general, factor analysis identifies those conceptual dimensions hidden from the researcher's view, summarize a lot of variables into distinct groups, and specify appropriate variables for the following analysis [18]. Numerous literatures around the world have used factor analysis to consider related factors in different fields. Um et al. [19] have studied the effective factors on Gejo-island sediments using factor analysis and found out nine related major factors. Lau et al. [20] have studied the amount of availability of solar radiation in houses located in tropical regions with high amount of solar radiation as well as the effective environmental parameters on the tropic residents' life; they have used a questionnaire to collect the data and finally identified ten related factors. Also, Silva et al. [21] have proposed eight principal factors to consider Portuguese sleep habit and then found out five major factors using factor analysis. Cheniaux and Filgueiras [22] also have identified six items to consider what is the major character of mania syndrome and then found out that high energy is the main characteristic of mania syndrome using confirmatory factor analysis. In the energy field. Mani and Dhingra [23] have studied energy policy in India using factor analysis and finally found out 21 related variables including 5 major factors. As it can be seen from the existing literatures, factor analysis has been mostly used for the social and psychological issues and has been rarely used in the energy field and particularly for solar dryer. Thus, in this study, confirmatory factor analysis has been used to identify the factors affecting the implementation of solar dryer.

Chandel et al. [24] investigated the potential and the cost-effectiveness of a solar photovoltaic power plant at the garment zone of Jaipur city in India.

Belessiotis and Delyannis [25] reviewed different types of solar dryers. They considered the factors important for each type selection, such as the cost-effectiveness, initial capital, personnel skill level etc. Pirasteh et al. [26], also studied different solar drying applications in Malaysia. They have discussed the economical, political and environmental aspects of using solar dryers. They have presented and compared different methods to economic analysis of solar drying applications, which have been used in different countries.

Recently, solar applications have significantly been considered due the importance of protecting environment by governments. Government policies can obviously reduce the energy crisis and the effects of global warning. Governments can provide great interest and motivation in using solar technologies, include solar drying systems by applying policies such as renewable portfolio standard (RPS), feed-in-tariff (FIT), and incentives [26]. Solangi et al [27] also, studied the solar energy related policies that was implemented in various countries including the united states, Germany, Spain, China, Australia, Pakistan, France, Malaysia, and Canada. Most of these policies deal with the environmental issues and reducing energy.

Kokate et al. [28]used solar dryers to dry plastic. They analyzed the solar dryers and found that solar dryer can reduce the energy consumption and thus result in economic production of plastic products. Collector efficiency and therefore depends on design parameters, such as absorber material, collector inclination and collector materials. Environmental parameters such as solar