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Evaluation of Three Industrial Cities in Iran Based on Solar Energy Potential Using Fuzzy Analytic Hierarchy Process Method

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Abstract

Energy is a vital factor in economic development of nations. Nowadays, based on IEA institute census, it has been remarkably demanded. One of the best ways to reduce this consumption is to benefit from renewable energies. Solar energy is one of those energies which consumption, power station, establishment and location of its optimized place are of specific importance. Thus, for developing this technology, locating place for solar power house establishment must be a priority. This article is presented with the aim of finding out the most appropriate spot among choices of Shiraz, Kerman, and Esfahan. At the end, the best city is selected based on some criteria including energy production capacity, operation and maintenance, repair costs, and the quality of CO_2 emission and the degree of social acceptance for solar station establishment. In this study, the Fuzzy Analytic Hierarchy Process method was used.

Keywords: renewable energy, solar energy potential, location, the Fuzzy Analytic Hierarchy Process method.

Introduction

Human kind life has had a direct relation with the quality of production and consumption of energy from beginning and throughout the history. In the last few years, using renewable energies has become a concern for man communities, because they are numerous and various as well as being renewable. Wind energy, Bio energy, Waves energy, Gradient energy, geothermal, fusion energy, water energy and of course solar energy are different kinds of renewable energies that technology growth enable mankind to control them. Solar energy is one of these energies that have a lot of usage with the aid of physics of energies science physic of energies. In 1973, an increase in oil price made the developed industrial countries, to think of substitute energies. They have concluded that optimizing energy consumption in industry and construction could decrease energy utilization by 30 or 40 percent. Central bank survey indicates that if developing countries had applied optimizing energy consumption politics, they would have been able to save daily 4 million oil barrels.

Despite the fact that, Iran is an oil-rich country and have huge natural gas resources, fortunately it has a suitable bed for administering solar plans and solar energy use in cities and 6000 scattered villages across the country.

The sun is one of the main sources of renewable energies which can be employed as an effective and provident resource in most area around the world. The sun is the agent and origin of many energies in the nature such as fossil fuel stored in the depths of the earth, waterfall and wind energy, plants growth, animals and mankind, all organic materials which are changeable to thermal and mechanical energy, the waves of the seas, tide energy, resulting in the earth gravity and its movements around the sun and the moon, which are all symbols of solar energy. The solar energy received by the earth within a year is estimated to be 1000 times more than the energy comes from are fossil fuel burnt within the same year.

Moreover, its consumption has no unpleasant effect and is the most apt way in order to develop economically for those countries which lack underground resources. Among its advantages, we can mention to the quality of being pure and clean and not pollutant (stop greenhouse gases like CO2from being emitted) unlimited and abundant, free of cost, available and the effect on decreasing fossil fuel use. Regarding its flaws, we can refer to the point that the sun is a fully unstable source, that is, it varies during seasons, months, night and day. In addition, the density of its energy is short (little)

Iran has approximately 300 sunny days and in terms of the amount of this energy, is considered one of the best countries. Therefore, solar energy consumption not only is necessary but also exploiting is unavoidable in the near future. In fact, given the geographical vastness and condition as well as ampleness of village dispersion from city centers, the pure source of sun is the most prone way of producing energy which its application needs no expensive transition network.

In Iran, the issue of exploiting solar energy has been taken into consideration for a while, and of course, since few years ago, using sun light for electric production using photovoltaic way has begun in the country and 11 solar energy projects have administrated by the ministry of power in the country. Given the specific ecological condition of Iran and the fact that the sun shines almost in most of the days, we can expect our country to change into one of the main poles of exploitation solar energy in the world over in the future. Simple technology and not polluting the air and environment and most importantly, storing fossil fuel for posterity or transforming them into the valuable materials and products using petrochemical processes, are main reasons that reveal the need to use solar energy.

Consuming this energy, unlike nuclear energy, has no danger. Moreover, for those countries that lack natural underground energy resources, it is the most suitable way to access energy and economic growth. Nowadays, solar energy is applied and exploited using different systems and for different purposes. The most important of them are warmth of the sun, solar energy, solar chemistry, photovoltaic systems, photo biologic systems, photo chemical systems and thermic and cryogenic systems.

Review of related literature

In this paper, first, the factors affecting solar energy are discussed and incorporated into the GIS; the more vulnerable areas in the province are identified. This analysis includes a cloud in the sunny hours, days, dust, humidity, altitude and annual rainfall was realized in the GIS environment. According to the Southern California cities, Ramhormoz and small garden area of the property and Branch as appropriate areas for solar power plants have been proposed (Alipour, 2014).

This study aimed to analyze the utility of the land(the city of Chabahar) for locating thermal power plant based on environmental criteria and are evaluated based on multiple criteria, such as view of internal resources and experiences of other countries to identify effective environmental measures discussed in locating plants

According to the characteristics and requirements of the region under study, as well as information needed for this purpose, 17 environmental criteria in this study, and fuzzy logic were used to standardize the criteria drawings. Given that, each criterion has a different role in the process of locating Analytical Hierarchy Process (AHP) and paired comparison method was used for weighing criteria.

The findings show that the limiting environmental factors, about 81% of the city of Chabahar is bad for plants and only%0.79 of the cities for more than 150 plants are the primary utility. Therefore, suitable for zone12 (the average utility of the range 149 to 193) for plants in the city of Chabahar were identified and ranked (Karimi Mehrabadi, 2014).

In this study, a multi-criteria decision method was used to select and prioritize the proposed locations of the GIS and has been used as a powerful tool for data processing, and after selecting the parameters needed , the location of the areas of fuzzy logic as a method for the production of maps was used.

In conclusion, nine regions were selected as the best places for solar power plants and finally Fuzzy TOPSYS options proposed method is the best place for plants were identified and prioritized (Khankh, Ehsani and Farahani, 2013).

In this article, the significance and reason of attractiveness of renewable energies particularly solar energy is discussed. Also, various factors involved in order to decide and using AHP method and identifying different parameters for deciding are discussed. This article attempts to assess the best spot for operating solar cells economically, environmentally and socially, etc. (Khankh, Ehsani and Farahani, 2013).

Also, we examined the application of solar energy especially in the form of solar panels, the status of exploiting them in the world plus environmental and technical and economical debates related to using them will be discussed; Furthermore, the feasibility study for setting up manufactories based on solar panels production, job creation as well as subsequent independency in the city of Mashhad are examined (Solar Energy Technology and Industry Outlook, 2012)

This article selects Tehran province which possesses almost 19 percentage of country population and has good substructures. In addition, in this article, we used Fuzzy methods to standardize the data and Fuzzy Analytic Hierarchy Process method to give weigh to location criteria (Shokri, 2010)

To use solar powerhouse, we should initially analyze and examine suitable spots to establish them. Given the unfit application of some multi criteria deciding way in this area, this article attempts to take step to solve the problem by introducing and using Promethee method. To achieve a proper result, we first analyze and examine the effective factors in locating solar powerhouse.

Afterwards, using Decision Lab software, the problem is solved in a way that the best choice could be located for operating solar power stations among several suggested choices (Mostafavi-Pour, 2013)

Given the importance of huge solar energy sources, this article attempts to examine positive and negative points of exploiting this source as well as the status of exploiting it in the world and in Iran. It also emphasizes high potential of this source in providing clean energy the need to employ it in current condition of world along moving to persistent development (Moradi, 2014).

Materials and methods

Methods and models in this area are generally included two models of flat and hierarchical models. Models in the form of a flat surface and a surface is used to define all criteria but the second type of models based on the significance criteria or other characteristics that define the different levels . One of the most famous one is Analytical Hierarchy Process (AHP).

Fuzzy Analytical hierarchical process

The Analytic hierarchy method was introduced by Saaty for the first time in 1980. This method is one of the most useful multi-criteria way for deciding .In classic hierarchical analysis method, experts' judgments were displayed in the form of definite numbers ,while the definite numbers are not able to consider indefiniteness in company with human perception. Thus ,in this article ,given the fuzzy condition ruling available criteria for measuring alternatives .The fuzzy hierarchical method is applied .By fuzzy condition ,we mean indefiniteness and alternation scope for grading a criterion .

In literature of fuzzy hierarchical process, several solutions are proposed. Whereas the developed method of Chang has more simple steps in comparison with other fuzzy hierarchical process methods, we have adopted this method in this article.

In matrix of paired comparisons, the triangular fuzzy numbers are used.

A triangular fuzzy number is represented in this form , in this form $l \leq m \leq u$.

$\widetilde{M} = (l, m, u)$ In the developed Chang analysis method, the amount of $\widetilde{S_J}$ (which is a triangular number), for each matrix of paired comparisons is calculated from the following "Equation (1)":

$$\widetilde{S_J} = \sum_{j=1}^{n} \widetilde{M_J} \cdot \left[\sum_{k=1}^{m} \sum_{j=1}^{n} \widetilde{M_J}\right]^{-1} \quad (1)$$

In this formula $\widetilde{M_J}$ (j=1,…, n) are also fuzzy triangular numbers. In the Chang method, we should calculate the large degree of $\widetilde{S_J}$ in relation to each other, after calculating them. In general, if there are two triangular fuzzy numbers, the large degree of M_1 over M_2 (V ($\widetilde{M_1} \geq \widetilde{M_2}$)) is defined in the "Equation (2)" form of following:

$$V(\widetilde{M_1} \geq \widetilde{M_2}) = hgt(\widetilde{M_1} \cap \widetilde{M_2}) = \begin{cases} 0 & if\ m_2 \geq m_1 \\ 1 & if\ l_1 \geq u_2 \\ \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & 0.W \end{cases} \quad (2)$$

For comparing $\widetilde{M_1}$ &$\widetilde{M_2}$, we need to calculate the quantity of V ($\widetilde{M_1} \geq \widetilde{M_2}$) and V ($\widetilde{M_2} \geq \widetilde{M_1}$). The large degree of a triangular fuzzy number calculated from p number of triangular numbers is counted from "Equation (3)":

$$V(\widetilde{M_p} \geq \widetilde{M_1}, \widetilde{M_2}, \widetilde{M_{p-1}}, \widetilde{M_{p+1}}, \widetilde{M_n}) = V(\widetilde{M_p} \geq \widetilde{M_1}) \& V(\widetilde{M_p} \geq \widetilde{M_2}) \& \dots \& V(\widetilde{M_p} \geq \widetilde{M_n}) = \text{Min } V(\widetilde{M_p} \geq \widetilde{M_j}) = d'(cj) \ \& \ j \neq p \quad (3)$$

So, the indexes weight vector is in this "Eq (4)":

$$W' = (d'(c_1), d'(c_2), \dots, d'(c_n))^T, j = 1, 2, \dots, n \quad (4)$$

In fact, W' is the no normalized weight vector of the fuzzy hierarchical analysis method by which the normalized weight vector is calculated from the following "Equation (5)":

$$W = \left(\frac{d'(c_1)}{\sum d'(c_j)}, \frac{d'(c_2)}{\sum d'(c_j)} \cdots, \frac{d'(c_n)}{\sum d'(c_j)}\right) \quad (5)$$

Implementing the fuzzy hierarchical analysis method and prioritizing alternatives

Given the aim of this research, selecting the best city for establishing solar powerhouse, some criteria including energy production capacity, maintenance and repair costs, the amount of CO_2 dispersion and the degree of social acceptance are considered.

Figure 1 shows he hierarchical tree for selection the best choice, based on criteria and Table1indicates the matrix of paired comparisons of main criteria considered in terms of the total aim, by implementing the fuzzy hierarchical analysis method, and finally table 2 shows the final weight of criteria.

Given the final weight of criteria, the criterion "the degree of social acceptance" is identified as the most important criterion for assessing alternatives, with the highest credit equal 0.43. Similarly, given the above algorism each alternative is compared and weighted based on each single criteria. At the end for calculating the final weigh of each considered alternatives, the matrix of final weigh of alternatives must be multiplied by the matrix of the final weigh of criteria .The final result can be observed in table3.

Paired comparison of alternatives (cities), against defined criteria, shows that Shiraz is selected as the best city in order to establish solar power house with the confidence level of 0.541.

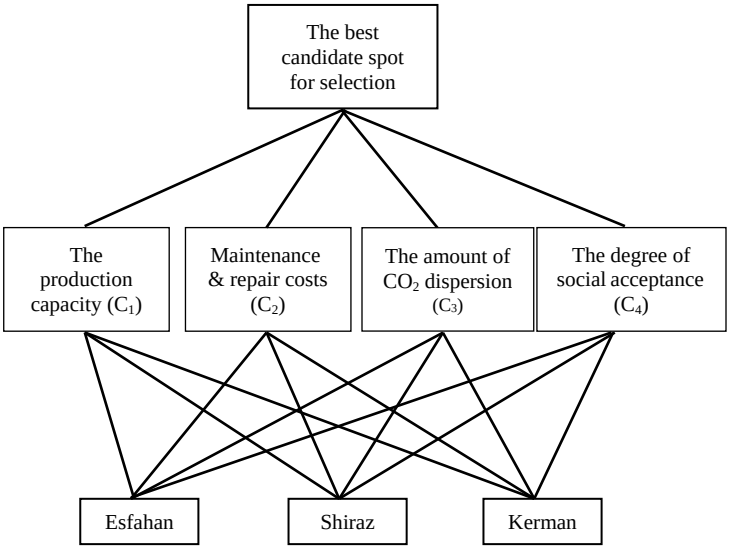

Figure1 .The hierarchic tree for selecting the best candidate spot for establishing solar powerhouse

Table 1. Paired comparison of considered criteria

	The criterion of energy production capacity	The criterion of maintenance & repair costs	The criterion of the amount of CO_2 dispersion	The criterion of the degree of social acceptance
The criterion of energy production capacity	(1,1,1)	(1,2,3)	(2,3,4)	(1.6,1.5,1.4)
The criterion of maintenance & repair costs	(1.3,1.2,1)	(1,1,1)	(1.3,1.2,1)	(1,2,3)
The criterion of the amount of CO_2 dispersion	(1.4,1.3,1.2)	(1,2,3)	(1,1,1)	(1.3,1.2,1)
The criterion of the degree of social acceptance	(4,5,6)	(1.3,1.2,1)	(1,2,3)	(1,1,1)

Table 2. the final total of criteria

Criteria	The final weight of criteria
The criterion of energy production capacity	0.287
The criterion of maintenance & repair costs	0.177
The criterion of the amount of CO_2 dispersion	0.155
The criterion of the degree of social acceptance	0.380

Table 3. The final weight of each city

Alternatives (cities)	The final weight
Shiraz	0.541
Kerman	0.263
Esfahan	0.196

Conclusion

The results of the calculation software, and the ultimate weight in every place show that on the resulting weights, options are ranked. Every place that has more weight is a greater priority. The important point in this calculation is the sum of the obtained final weights must be equal to 1. These numbers indicate that Shiraz is preferred to Isfahan and Kerman based on criteria needed to establish a solar power plant.

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