

ASSESSING SOLAR-ENERGY APPLICATIONS IN ZAHEDAN-SOUTH EASTERN OF IRAN

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ABSTRACT

Zahedan, the capital of Sistan and Baluchistan province, is located in South Eastern part of Iran. Located in a region with considerable amount of Sun radiation, it has got the necessary conditions for the exploitation of solar energy. The main goal of this research is to investigate solar climate in Zahedan during a 13-year interval and how to use the solar energy in this region correctly. The main tools for this research are statistics, meteorological Organization reports, and interviews with relevant authorities .The results of this research showed that Zahedan has the conditions of using solar energy because of having more than 3000 hours of sunshine in a single year as well as being located in high sun- radiation region. Among all technologies of solar energy, using method of direct conversion of solar energy in to electricity (photovoltaics) is the most functional technology which is approachable in Zahedan. Non-power plant applications of solar energy seem essential regarding to specific features of solar climate in Zahedan ,lack of fuel ,and lack of adequate healthy freshwater. To implement solar-energy plans, more attention of authorities and private sectors are vital to be attracted for accurate planning of solar-energy optimum usage.

KEYWORDS: Photovoltaics, Region with high amount of sunshine, Solar energy, Zahedan.

INTRODUCTION

The Sun's radiant energy has an essential role in energy supply due to having plenty of benefits such as the absence of harmful environmental effects and its availability to everyone. Although Sistan and Baluchistan suffers from shortage of oil, gas, and jungle supplies, a considerable number of other benefits such as wind, sun radiation, and mines have been gifted by God and they have altered Zahedan in to a unique collection of modern energies in Iran. Path of powerful winds of Sistan and Sun's radiant energy with more than 6 kw/h in day are two given renewable energies resulting in best conditions for the region. Zahedan has the capability of solar-energy exploitation as a result of having hot dry weather because of being located in high sun- radiation region as well as lack of fuel in that clean electricity can be produced on organizations, schools and even houses roofs by installing solar cells .Initial studies in terms of solar energy in Sistan and Baluchistan reveals that sun radiation in Zahedan, Khash, and from Saravan to Northern Chabahar has annually been estimated more than three thousand hours (Sargolzaee, 2013). Similar conducted researches on assessing solar-energy usage in heating systems of residential regions and buildings in Azerbaijan point out that using heat-production systems by the help of solar energy in various regions of this province is highly beneficial with respect to being cold and having long cold winters for keeping residential buildings warm and using hot water. (Jahan Bakhsh and Edalat Dust, 2008). Furthermore, potential of applying solar energy in Southern Khorasan because of being mostly located in high sun- radiation region points out that this inexhaustible energy can be used in order to produce electricity and create job opportunities in the region (Saberifar, 2010).

MATERIALS AND METHODS

To assess solar energy applications in Zahedan, regional climate data according to reports and statistics of provincial meteorological Organization during a 13-year course (2000-2013) including temperature, sun-shine hours, cloudy and semi cloudy days has been used .Other main tools of this research include library studies and interviews with relevant authorities. In this study, after reviewing the climate data, the process of climate- element change in relation to sun radiation has been investigated. Then necessary studies and investigations were done to determine appropriate technology of solar energy application.

LOCATION OF THE REGION UNDERSTUDY

Zahedan, Capital of Sistan and Baluchistan province, in located in south eastern part of Iran with latitude of 60 degrees and 52 minutes eastern and 29 degrees and 29 minutes of northern and it is as large as 36581 square kilometers (figure

1). The population of this city is 575116 (Statistics center of Iran,2011) .Zahedan`s weather is hot and dry and it is too hot in summer days and gets noticeably cold at nights .It has got 8 to 14 hours of sun radiation during the day .Wind path in this region is from south west toward north east. Sistan 120-day winds are indirectly effective on reduction of temperature in Zahedan.

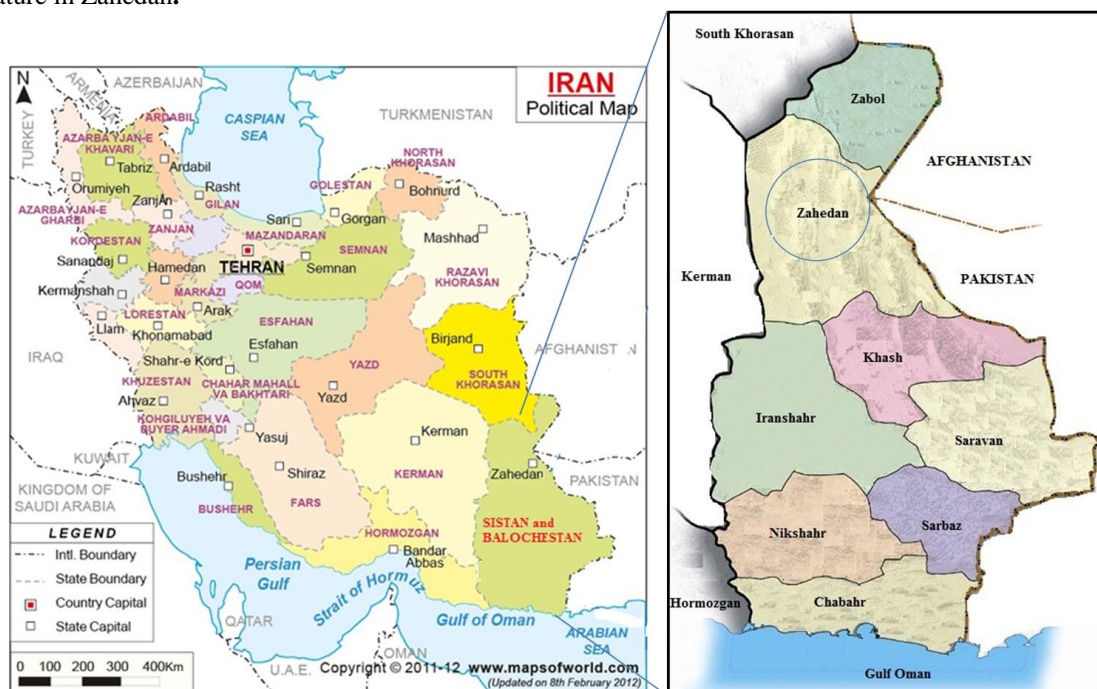


Figure 1. Location of Zahedan (National Cartographic Center, 2014)

THE LOCATION OF ZAHEDAN IN TERMS OF SUN`S RADIATION

Iran is situated on Northern radiation belt meaning that it has the highest amount of sun`s radiation reception in the country and, in this regard , Northern and central parts of Sistan and Baluchistan, in particular Zahedan, is located in the most ideal condition of sun`s radiation (Sargolzaee, 2012). The province`s condition in general solar map of Iran for erecting solar farms and power plants shows 2.5 to 4.5 kw/h for each square meter of radiation.

TEMPERATURE FEATURES AND DETERMINING SOLAR CLIMATE OF ZAHEDAN

Investigating minimum average temperature of Zahedan station during 13-year period, it is observed that the highest temperature average for summer is 18.7 and annual temperature of 10.8 degree centigrade (Table 1).

Table 1: Minimum average temperature of Zahedan ,during 2000-2013

City	Annual temperature	Spring	Summer	Fall	Winter
Zahedan	10.8	16.9	18.7	4.7	3.1

Investigation of Sun`s location in various months of the year in Zahedan shows that the height, side, and angle of the Sun by degree are the highest degree in comparison with horizon in April May, June and July which indicates proper positioning in terms of radiation(table 2). This, particular feature provides favorable conditions to use solar energy beneficially in this season in Zahedan compared to other ones and other parts of the country.

Table 2: Calculation of Sun`s location in Zahedan during 2013

Month	Plunge(Degree)	Azimuth the Sun(Degree)	solar altitude (Degrees from horizontal)
december	-20.88	0.6293	38.99
January	-12.23	0.7395	47.69
February	-1.62	0.8459	57.77
March	10.23	0.9281	68.14
April	19.17	0.966	72.02
May	23.35	0.9799	78.5
June	21.3	0.9786	78.14
July	13.63	0.9492	71.66
August	2.52	0.8713	60.61
September	-9	0.755	49.03
October	-18.81	0.6381	39.65
November	-23.33	0.5871	35.95

According to data of meteorological Organization in Sistan and Baluchistan, the number of clear days in Zahedan, especially in summer and fall during this 13-year interval (2000-2013), is averagely 250 days in a single year. Total sum of sunny hours in a single year in Zahedan is between 3250 to 3583 hours during the days. Regarding geographical conditions of Zahedan and little annual precipitation, number of regional cloudy days is few (less than 29 days in a year) and total number of semi cloudy days in these 13 years has been investigated between 49 to 105 days (Table 3).

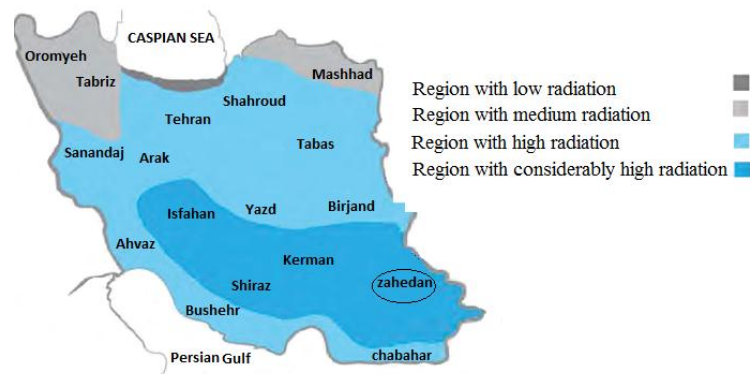
Table 3 : Sunny hours, cloudy and semi cloudy days in Zahedan during 2000-2013

Year	Semi cloudy days	Cloudy days	Total sum of sunny hours
2000	49	10	3555
2001	63	12	3484
2002	71	17	3500
2003	78	19	3423
2004	71	19	3508
2005	73	29	3429
2006	105	25	3277
2007	80	20	3413
2008	92	22	3250
2009	103	23	3359
2010	59	11	3583
2011	64	17	3416
2012	73	18	3320
2013	94	21	3476

SITUATION OF ZAHEDAN IN RADIATION MAP OF THE COUNTRY

In terms of annual sun`s radiation, Iran has been divided in to four following sections (Map 1).

1. Region with radiation less than cal/cm^2 in day.
2. Region with medium radiation between 350 to 390 cal/cm^2 in day
3. Region with high amount of radiation between 390 to 430 cal/cm^2 in day
4. Region with considerably high radiation more than 430 cal/cm^2 in day (Saberi Far 2010).



Map 1: Division of Iran in terms of Sun's radiation and location of Zahedan in the map.

According to Map 1, a considerable part of Sistan and Baluchistan province and in particular Zahedan is located in region with high amount of radiation. Therefore, conditions to use solar energy is highly appropriate in mentioned city. Entering equipment and applying solar energy, not only this inexhaustible energy can be used more and better, but also the possibility of attracting investment and increasing job opportunities will rise.

ADVANTAGES OF SOLAR POWER PLANTS

Obvious plus points of solar power plants include not needing substantial amount of water, not polluting the environment, not needing experts, and limited need to spare parts (Dehghani and colleagues, 2012). According to mentioned merits, using solar power in Zahedan can be beneficial.

NON-POWER PLANT APPLICATIONS OF SOLAR ENERGY

Non-power plant applications of solar energy include a frequent number of issues including solar water heater and bathroom, solar heating and cooling, solar desalination, solar cooker, solar dryers and solar furnaces (Dehghani, 2012). Thus, using solar water heater and bathroom in order to provide hot water for residential and public places especially in Zahedan seems necessary as a result of providing and lack of fuel. Moreover, since the region is hot, they can be used, besides hot water and heating, for cooling residential building in warm months of the year by adding absorption refrigeration systems to solar system. Since one of major problems of Zahedan residents is lack of drinkable fresh water and drinkable water for residents of this region is provided through Chah Nime in Zabol which is 200 Kilometers north of Zahedan, solar desalinations can be used to provide fresh water in the region. On this basis, existing salty water in the region is evaporated as result of heat from the Sun, then evaporated water can be distilled and changed in to fresh water. Considering climate condition of the region, using such facilities as solar dryers, solar cookers, and solar furnaces can save fuel consumption. Therefore, non-power plant applications of solar energy seem essential because of special features of solar climate in Zahedan, lack of fuel and transferring fuel, frequent amount of salty water, and shortage of healthy fresh water in the region.

TECHNOLOGY OF USING SOLAR ENERGY IN ZAHEDAN

Estimation of energy-consumption percentage in different boroughs of Zahedan shows the fact that residential and office buildings are the main energy consumers and they are considered as the main users of solar energy in coming years. On the other hand, increasing demand of fossil fuels and other types of energy, prominent climate of the region, problems of fuel provision, and population growth will rise the need to apply solar energy for heating internal spaces, providing hot water, and generally energy supply of the region. Determining appropriate technology for applying solar energy in various sectors of the region for providing necessary energy will be far more effective. Solar-energy systems include solar heating panels, collectors, and photovoltaics tools used based on the climate condition of the region (Jahanbakhsh and Edalat Dust, 2008).

EFFICIENCY OF PHOTOVOLTAICS SYSTEMS IN ZAHEDAN

The amount of produced power for photovoltaic systems is usually between 2 to 5 kw. A single photovoltaic system made for home application with 2-kw power production is able to produce 3600 kw/h electricity. This amount can save 4.3 tons of coal energy in a year (Saber Far, 2010). Investigations reveal that essential electric energy for family residents of Zahedan can be supplied by applying solar panels on the roofs of homes. In addition, the best method for

applying solar energy is conversion method of solar energy in to electricity (photovoltaics system) which is provided by installing these systems independently from the city power .Of main advantages and other important factors to use this technology in this region are occupying a limited amount of space and not having movable parts which leads to complexity reduction of installation and adjustment. Other merits of this technology is saving extra produced energy during night and unpleasant weather (Dehghani, 2012).

ADVANTAGES OF USING SOLAR ENERGY IN ZAHEDAN

Using solar energy in Zahedan can lead to positive results such as fuel provision considering fuel shortage in the province, preserving exhaustible fossil fuels, paying less expenses of energy for families, as well as creating permanent employment in the region.

PROBLEMS AND OBSTACLES OF USING SOLAR ENERGY IN ZAHEDAN

The main problems of using solar energy in Zahedan include lack of governmental finance and lack of security in the region in that sometimes big investments do not happen. Another challenge for investors in Sistan and Baluchistan province is related to instability in this section (Barakati, 2012). Therefore, more attention of authorities and private investors for accurate planning in order to use solar energy in this region is necessary for implementation of solar-energy projects.

RESULTS AND DISCUSSION

Considering the fact that Iran is located in a pleasant area in terms of Sun`s radiation, efficiency of applying solar energy was investigated in different provinces such as Southern Khorasan and Azerbaijan .In this research ,assessing solar-energy usage was conducted since Zahedan is located in high Sun`s radiation region. Like other conducted researches in other parts of Iran, this renewable energy can be used in Zahedan for heating buildings and hot water of residential buildings instead of exhaustible fossil fuels. According to conducted researches in cold areas of Iran as well as Zahedan`s hot area, obtained results show that solar energy in both cold and hot areas can considerably help families to reduce fossil-fuel consumption. Investigation of solar climate of Zahedan during this 13-year course reveals that it has the possibility of using solar energy as a result of having more than 3000 hours of Sun`s radiation in a single year and being located in high radiation region . Investigation shows that necessary electric energy of families can be provided by applying solar panels on residential houses` roofs .Among technologies of applying solar energy, method of direct inversion of solar energy in to electricity, (photovoltaics) is raised as the most important functional technology for Zahedan. According to specific solar climate of Zahedan, lack of fuel supply and transferring, and lack drinkable fresh water, non-power plant applications of solar energy seem necessary in this region. The most important problems of using solar energy in Zahedan include lack of governmental finances and lack of security in that sometimes big investments do not happen. Thus , using solar energy in Zahedan can have positive results including providing fuels, preserving exhaustible fossil fuels ,paying less for fuels, and creating permanent employment, to name a few. It is suggested that more attention of authorities and private investors for using solar energy in Zahedan is attracted in order to implement solar-energy plans.

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