The consideration of Lut desert potential in the production of electric energy from solar energy

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Abstract

Purpose – This paper aims to study the Lut desert, also known as the Dasht–e–Lut, starting with a summary of its location as a large salt desert in southeastern Kerman, Iran, as well as its climate, being one of the world's driest places. Next, a statistical analysis is performed based on a reasonable minimum level of 10 per cent. The computation of electric energy produced by sunlight in the studied region is, then, provided using a number of high-efficiency and suitable solar cells. Finally, the authors will compare the production of electrical energy to the consumption energy in Iran and Kerman province.

Design/methodology/approach – According to calculations of the present study and the analyses of the tables and charts provided, the use of solar energy and the amount of energy used in different areas was discussed. Lut desert in Iran is one of the touristic attractions of Kerman province: while only a very small area of this desert known as the Kalut is of interest to tourists, the vast remaining area of this desert is currently left without use. Lut and its surrounding towns and villages are not suitable for agricultural due to the lack of water in the region, and relatively poor people live within the area. The findings of this study showed that throughout the region, there is a very high potential for energy supply of Kerman and Iran.

Findings – The practical use of Lut desert potential in the production of electric energy from solar energy, besides its significant role in cost reductions, can also positively affect the living standards of local residents as well as job and income creation for the country. Efficient use of only 10 per cent of the area of Lut desert, via using its solar energy, can produce a considerable amount of energy for the region and for the country in large. Although the present study only investigated the solar energy of the region, it also has a high potential in wind energy and geothermal optimum use. The research team will, hence, continue its work on calculating the amount of energy generated from all types of renewable energy in this area. This paper showed that application of solar cells in this region is appropriate for providing a magnificent amount of electric-energy requirements of Kerman province and of Iran.

Originality/value – In recent years, Iran's nuclear, oil and natural-gas industries have been the subject of intensifying sanctions from certain international communities. Now, the country wants to develop a sector in which it has more leeway, i.e. the renewable energy; wind and solar energies are always available, and no one can put sanctions on them. Also, to provide household electricity in remote areas (which are not connected to the mains electricity grid), energy storage is required for use of renewable energy. Usually, however, renewable energy is derived from the main electricity grid, and this means that as the mains electricity grid is organized so as to produce the exact amount of energy being consumed at that particular moment, the energy storage is mostly not applied. Energy production on the mains electricity grid is always set up as a combination of renewable-energy plants, as well as other power plants (e.g. the fossil-fuel power plants and nuclear power). This combination, nevertheless, is essential for this type of energy supply (i.e. the wind turbines, solar power plants, etc).

Keywords Solar energy, Energy consumption, Renewable energy, Solar cell, Lut desert, Electrical energy, Energy production

Paper type Research paper

1. Introduction

The world's need for energy and electricity is increasing every day, and still we continue to produce this commodity through means which are limited. It is a well-known fact that fossil fuels are an expensive resource and will eventually run out. Due to this, a movement needs to be started so as to promote, create and sustain some sort of environment-friendly, effective and renewable energy. Harnessing the nature's energy sources including those of sun, water and wind can make possible the production of electricity. This would create a cleaner environment for all and still yield electricity for those who require it. Renewable energy is important because of the benefits it provides. The key benefits of renewable energy are as follows: environmental benefits (Hill *et al.*, 2006), energy for coming generations (Musall and Kuik, 2011), jobs and the

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economy (Kammen *et al.*, 2004) and energy security (Kist, 2015). Solar power allows consumers to be more self-sufficient with regard to their energy supply. This energy is one form of renewable energy which can be installed in one's home. For individual consumers and for society in general, solar power is ultimately cost-effective (Lewis, 2007). It is estimated that the world's oil reserves would not last for longer than 30 to 40 years (Shafiee and Topal, 2009). Unlike the fossil fuels, solar-energy taps into an infinite source (Löf, 1973); it is free and renewable, and as long as the sun shines, humans will have this source of energy. Solar energy can be used in remote areas where it is too expensive to extend the electricity power grid (Zhai *et al.*, 2009). The present article will calculate the Lut's potential for electric power production from solar energy.

Figure 1 The Lut desert salt desert in southeast Iran is captured in this envisat image

Source: Reza Eqbali http://sarv.studio/(sarv Atelier management)

The vast desert of Lut with an area of 5,400 km^2 is situated in the eastern and southeastern part of Iran in Kerman province beside Shahdad town; within major part of this desert, there is no flora and fauna. Lut desert stretches about 320 km from northwestern to southeastern Iran and is about 160 km wide (www.iscconferences.ir). Figure 1 shows Lut desert.

2. Approximations and calculations for the study

1 Calculations are for 10 per cent for the area of Lut desert (450 km^2).
2 Global horizontal irradiation in Lut desert is assumed 2,200 kWh/m^2 (Global horizontal irradiation is the most important parameter for evaluation of solar-energy potential of a particular region and the most basic value for photovoltaics (PV) simulations.) (http://solargis.info). Figure 2 shows global horizontal irradiation in Iran.

Figure 2 Global horizontal irradiation in Lut desert

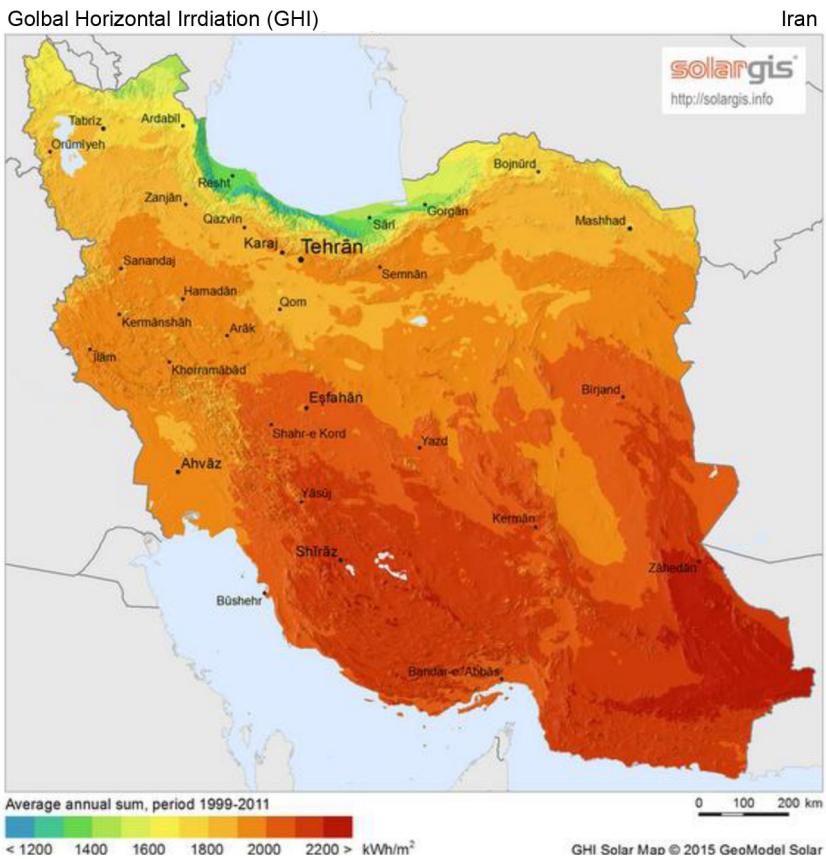


Table I Mean temperature of Lut desert

Month	Minimum temperature (K)	Maximum temperature (K)	Month average (K)
January	286.1	296.1	291.1
February	284.9	294.4	289.6
March	292.1	303	297.5
April	299.2	309.9	304.5
May	304.6	315.8	310.2
June	306.1	318.3	312.2
July	305.6	318.2	311.9
August	302.5	314.4	308.5
September	298.7	309.8	304.3
October	288.2	298.3	293.3
November	283.8	294.1	298
December	282.7	292.3	287.5
Average	294.5	305.4	299.9

3 The four types of suitable solar cells with maximum efficiency have been used to obtain the most amount of energy. These cells include (Green *et al.*, 2015):
   - Si (crystalline);
   - Si (multi-crystalline);
   - GaAs (crystalline); and
   - GaAs/CIS (thin film).

4 The mean temperature of Lut desert is intended to be according to Table I below 299.9 K. (This information is obtained from Kerman Province Meteorological Organization.)

3. The efficiency of solar cells according to the mentioned conditions

Regarding the fact that the efficiency of solar cells depends on such parameters as temperature (Nakade *et al.*, 2002), gap energy (Henry, 1980), air mass (www.pveducation.org), wavelength absorption (Dahal *et al.*, 2009), etc., solar cells that can be used for this area were accordingly selected. Our calculations have also been made according to the environmental conditions mentioned in the Lut desert. Figures 3 and 4 illustrate the infrared and ultraviolet absorption in Lut desert.

Based on Table II, it is evident that the efficiency of Si (crystalline) and Si (multi-crystalline) will decrease along with the increase in temperature and in the power per unit area; GaAs (thin-film) and GaAs (multi-crystalline) increase the canonical conditions. Canonical conditions include the global AM1.5 spectrum (1000 Wm^{-2}) at 298 K.

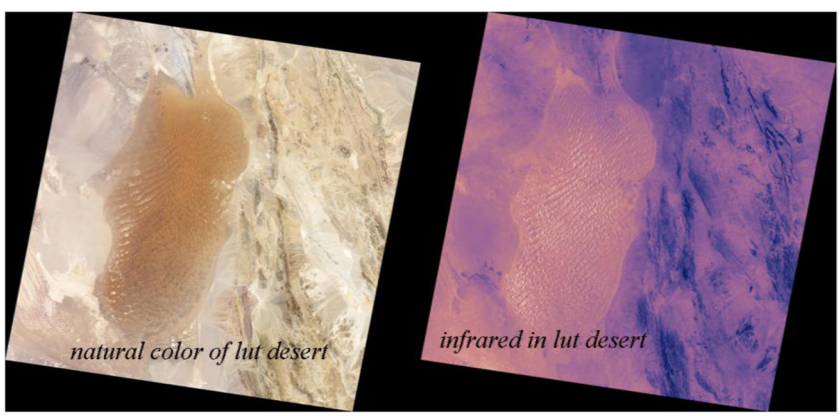
4. The amount of energy produced in 10 per cent area of Lut desert

Located in southeastern Iran in the northeastern city of Kerman (Mildrexler *et al.*, 2011) with an area of 4,500 square kilometers, Lut is the world's 25th largest desert (Betz, 1999); Kerman is the largest province in Iran and has a dry, desert climate (Hemmasi, 1980). Most of this province is desert, and regarding the basic needs of the world's energy supply for renewable sources such as solar power (Dresselhaus and Thomas, 2001) and, on the other hand, the advantages of this kind of energy over the fossil fuels (Sims *et al.*, 2003), in this section, we will study the details for optimum use of solar energy in the desert area of Iran. By calculating the amount of electric energy produced in the 10 per cent area of Dasht-e-Lut and subsequently comparing it with the amount of power consumption in Kerman province and in Iran, we can see that the plains of this province (including the Lut desert) are a great source of energy for Iran and even for the world. Table III represents the amount of electric energy produced by each of the solar cells used.

5. A comparison between the amount of electric-powered energy produced by different types of solar cells and the electric energy consumption in Kerman and Iran

The amount of electrical energy generated by the solar cells is compared with the amount of electrical energy needed for

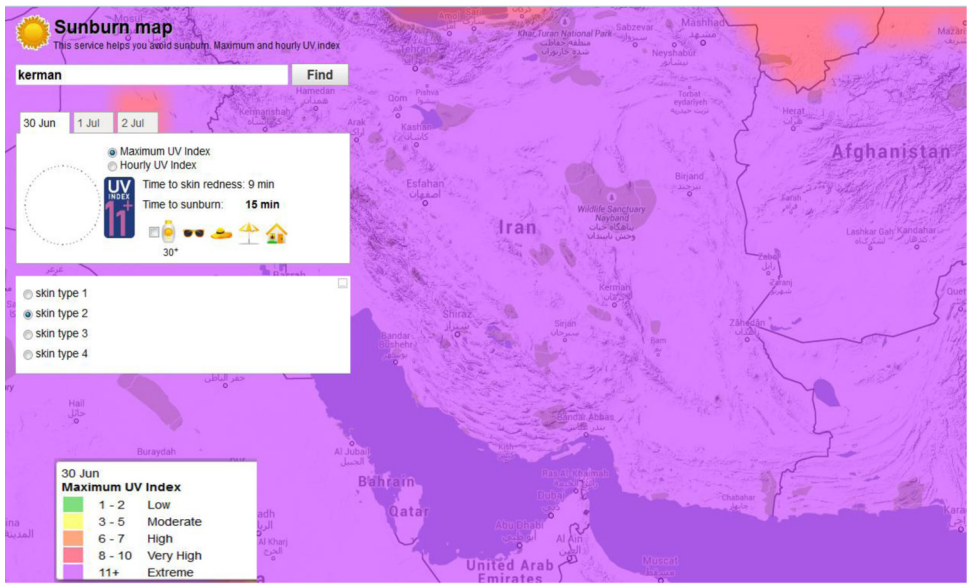
Figure 3 Natural color and infrared in Lut desert



(a) (b)

Source: This image of the Lut Desert was taken by the Landsat 7 satellites on July 6, 1999. Credit: NASA/USGS, Castelletto and Parker (2013), earthobservatory.nasa.gov

Figure 4 Ultraviolet absorption in Lut desert



Source: http://sunburnmap.com/

Table II Types of solar cell and calculate efficiency

Type of solar cell	Bang gap (ev)	V_{oc} (V)	J_{sc} (mA/cm^2)	FF	Efficiency
Si (crystalline)	1.1	0.659	87	83.89	21.86
Si (multi-crystalline)	1.1	0.657	81.3	83.85	20.35
GaAs (thin film)	1.43	1.41	69.67	89.35	32
GaAs (multi-crystalline)	1.43	1.135	54.45	89.31	25

Notes: V_{oc} is the open-circuit voltage; J_{sc} is the short-circuit current; FF is the fill factor

Kerman province and Iran (Table IV). Data in this table show the percentage of electrical energy required for Kerman and Iran which can be provided by solar energy. Figure 5 shows logarithmic chart of comparison of electric energy consumption in Iran and Kerman province with energy production by several types of solar cells.

6. Results and discussion

In recent years, Iran's nuclear, oil and natural gas industries have been the subject of intensifying sanctions from certain international communities. Now, the country wants to develop a sector in which it has more leeway, i.e. the renewable energy; wind and solar energies are always available, and no one can put sanctions on them. Also, to provide household electricity in remote areas (which are not connected to the mains electricity grid), energy storage is required for use of renewable energy. Usually, however, renewable energy is derived from the main electricity grid, and this means that as the mains electricity grid is organized so as to produce the exact amount of energy being consumed at that particular moment, the energy storage is mostly not applied. Energy production on the mains electricity grid is always set up as a combination of renewable-energy plants, as well as other power plants (e.g. the fossil-fuel power plants and nuclear power). This combination, nevertheless, is essential for this type of energy supply (i.e. the wind turbines, solar power plants, etc.). According to calculations of the present study and the analyses of the tables and charts provided, the use of solar energy and the amount of energy used in different areas was discussed. Lut desert in Iran is one of the touristic

Table III Electric energy produced in 10% of Lut desert area

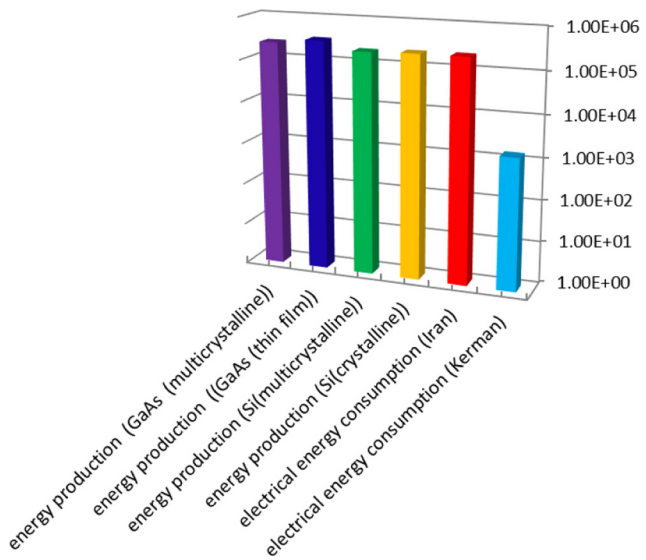
Type of solar cell	Efficiency	Area (m^2)	GHI (KWh/m^2)*	Electric energy produced (MkWh)
Si (crystalline)	21.86	450×10^6	2,200	216,414
Si (multi-crystalline)	20.35			201,465
GaAs (thin film)	32			316,800
GaAs (multi-crystalline)	25			247,500

Note: *GHI (Global horizontal irradiation)

Table IV Comparison the amount of electric energy productions with some types of solar cells and electric energy consumption in Kerman and Iran

Type of solar cell	Energy production	Electrical energy consumption (Kerman) (MkWh)	Electrical energy consumption (Iran) (MkWh)
Si (crystalline)	216,414	1,447	218,933
Si (multi-crystalline)	201,465		
GaAs (thin film)	316,800		
GaAs (multi-crystalline)	247,500		

Figure 5 Logarithmic chart of comparison of electric energy consumption in Iran and Kerman province with energy production by several types of solar cells



attractions of Kerman province: while only a very small area of this desert known as the Kalut is of interest to tourists, the vast remaining area of this desert is currently left without use. Lut and its surrounding towns and villages are not suitable for agricultural due to the lack of water in the region, and relatively poor people live within the area. The findings of this study showed that throughout the region, there is a very high potential for energy supply of Kerman and Iran. The practical use of this potential, besides its significant role in cost reductions, can also positively affect the living standards of local residents as well as job and income creation for the country. Efficient use of only 10 per cent of the area of Lut desert, via using its solar energy, can produce a considerable amount of energy for the region and for the country in large. Although the present study only investigated the solar energy of the region, it also has a high potential in wind energy and geothermal optimum use. Our research team will, hence, continue its work on calculating the amount of energy generated from all types of renewable energy in this area. This article showed that application of solar cells in this region is appropriate for providing a magnificent amount of electric-energy requirements of Kerman province and of Iran. Our calculations delineated that:

- Using Si (crystalline) solar cell in Lut desert can provide an amount of 216,414 MkWh electrical energy; this amount of energy is equal to 149.5 times the electricity consumption of Kerman province and 0.99 times that of Iran.
- Using Si (multi-crystalline) solar cell in Lut desert can provide an amount of 201,465 MkWh electrical energy; this amount of energy is equal to 139.2 times the electricity consumption of Kerman province and 0.92 times that of Iran.
- Using GaAs (thin-film) solar cell in Lut desert can provide an amount of 316,800 MkWh electrical energy; this amount of energy is equal to 218.9 times the electricity consumption of Kerman province and 1.4 times that of Iran.
- Using GaAs (multi-crystalline) solar cell in Lut desert can provide an amount of 247,500 MkWh electrical energy; this amount of energy is equal to 171 times the electricity consumption of Kerman province and 1.13 times that of Iran.

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