AnalysisThe Availability of Using Concentrated Solar Power (CSP) as Electricity Source in Al-Hilla City

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Abstract

The needing of using clean energy increases every year because of the negative impact of emissions from electricity power plant and to reduce the costs of generating power by using natural energies like solar, wind, and other sources.

The availability of using solar energy as source of producing electricity in Al-Hilla city by using Concentrating Solar Power (CSP) was investigated in this research. The major parameters in this study were the city position, and the annually amount of solar received, also, number of charts related to solar parameters for the management of CSP were derived and showed in this research.

The using of CSP as electricity power can be important solution to force the problem of high cost of electricity power fuel needed and the lack of power produced because of increasing of power consumed specially in summer season.

Keywords: Concentrated Solar Power, Consumption of electricity, Solar angle, Latitude Azimuth angle

الخلاصة:

ان الحاجة لاستخدام الطاقة النظيفة يزداد سنويا بسبب التاثير السلبي للمخلفات المتطايرة من محطات توليد الطاقة و لتقليل الكلفة في انتاج الطاقة الكهربائية باستخدام طاقة طبيعية مثل الشمس او الهواء و غيرها.

ان امكانية استخدام الطاقة الشمسية كمصدر للطاقة الكهربائية في مدينة الحلة تمت دراستها في هذا البحث و ذلك باستخدام محطات تركيز الطاقة الشمسية. ان العوامل الرئيسية التي تمت دراستها هي موقع المدينة و كمية الطاقة المستلمة سنويا. كذلك تم اشتقاق و عرض مجموعة من المخططات الخاصة بالاشعاع الشمسي وذلك لادارة محطات تركيز الطاقة. ان استخدام محطات تركيز الطاقة يمكن ان يكون من الحلول المهمة ليواجه مشكلة الكلفة العالية للوقود المطلوب في محطات توليد الطاقة و كذلك مشكلة القصور في انتاج الطاقة المطلوبةخصوصا في فصل الصيف.

كلمات مفتاحية: طاقة تركيزالاشعاع الشمسي، استهلاك الطاقة الكهربائية، زاوية الاشعاع الشمسي، خط الطول ، زاوية التسامت

1- Introduction:

Countries in the Arabian Peninsula have not adopted solar energy because of the cheap and plentiful supply of oil. At present, governments and the public have no incentive to consider alternative forms of energy, and protecting the environment is not a high priority in the region (Al-Douri and Fayadh , 2016). For sustainability issue , the planning and applying of using renewable energy must take place in Al-Hilla city, the center of Babylon governorate in Iraq. One of this type of energy is solar energy which can be used by converted its thermal power to electric power by using mirror or lenses to concentrate solar bands towardreceiver to rise temperature near to 1000℃ with known as concentrating solar power (CSP).

2- Al-Hilla city and electricity consumption:

There are about 970,000 capitaliving in AL-Hilla city (Wikipedia the free encyclopedia , 2016) distributed around the two sides of Al-Hilla river and the sides of the main streets like 40^{th}, 60^{th} , and 80^{th} streets and other places.

According to the Iraqi Ministry of Electricity, the average monthly consumption of electricity in Iraqi resident unit (four residents) can be shown in the table below(IraqiMinistry of Electricity, 2016):

Table (1): Average monthly consumption of electricity in Iraqi resident unit

No.	Device name	Monthly consumption (watt)
	Economical bulb	36000
	Refrigerator	72000
	Freezer	126000
	Displayer + Receiver	90000
	Washing machine	6000
	Fan	144000
	Cooling machine	108000
	Iron	75000
	Water pump	12000
	Cooling unit	720000
Total monthly consumption		1389000

Because the previous table included the monthly consumption for four resident family, The hourly consumption can be calculated from the following equation: (Iraqi Ministry of Electricity, 2016)

Hourly consumption (KW)/ person = 1389000/ 4 * (1/30* 24) *(1/1000)= 0.4823

The consumption of electricity increases annually because of the increasing in population and the daily activities

3- AL-Hilla city and solar energy:

The center of Al-Hila city laying on longitude 44° 26' and latitude 32° 29',city elevation about 29 meter (Wikipedia the free encyclopedia, 2016), for applying the aim of this research, longitude and latitude have been used for derivation a formula of solar radiation to optimize the operation of CSP

For calculating the solar energy, number of parameters must be measured or calculated as follows: (David, 2016)

Sun rays angle (δ): it is the angle between the rays toward center of earth and rays toward specific longitude on earth.

Latitude (φ): is defined as horizontal circles surround earth including Equator

Solar angle (α): angles of rays toward specific area on earth

Hour angle (ω): is the angle between the rays toward longitude of specific position on earth and rays toward longitude front sun in specific time

Azimuth angle (A):the angle when of sun path from north and it measured clockwise.

The equation of (**δ)** angle is:

$\delta = \sin^{-1}(0.39795 * \cos(0.98563 * (N - 173)))$…....(1)(David, 2016)

Or :

$\delta = 8442 * \sin\left(\frac{284+N}{365}\right)$…. (2) (Solar energy Development Program,2016)

Where "N" is the number of days after 1/January

The equation of angle of solar elevation (α) is:

α = 90 - (φ - δ)…..(3) (Holbert, 2007),(David, 2016)

The equation of Hour angle (**ω**) is:

ω= 15 * (t-12)…….(4) (Holbert, 2007), (David, 2016)

Where t is the time in hour before or after noon.

The positions of solar radiation parameters on earth planet can be explained in the following figure (David, 2016):

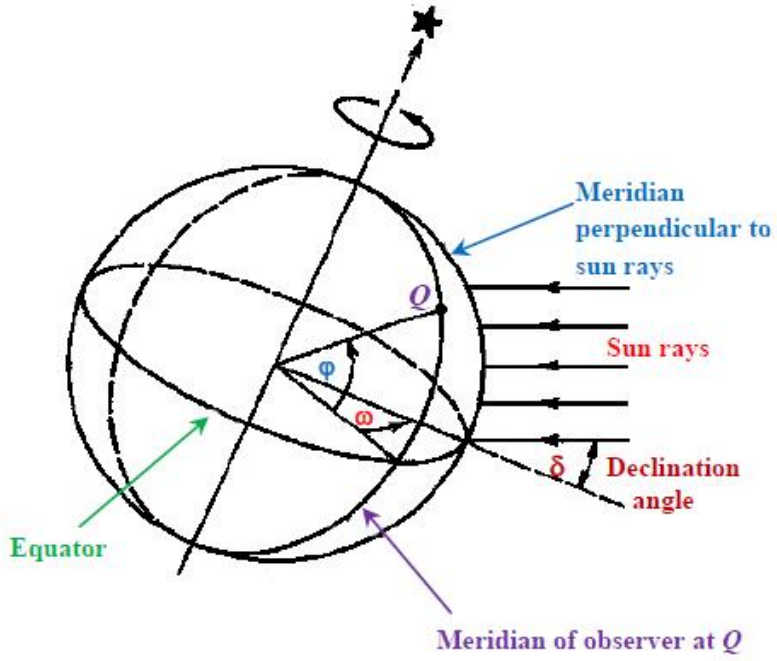

Fig (1): Solar radiation Parameters

For AL-Hilla city, thesolar energy parameters have been shownin following table:
Table (2): Solar energy parameters

Date (day/month)	Linda angle	Alpha angle	Number of hours before noon	Day time (hours)
1/1	-23.12	34.40	4.95	9.90
1/2	-17.73	39.79	5.22	10.44
1/3	-8.69	48.83	5.63	11.26
1/4	2.49	60.01	6.11	12.22
1/5	13.47	70.99	6.59	13.18
1/6	21.39	78.91	6.97	13.93
1/7	23.45	80.96	7.07	14.14
1/8	21.39	78.91	6.97	13.93
1/9	13.47	70.99	6.59	13.18
1/10	2.49	60.01	6.11	12.22
1/11	-9.42	48.10	5.60	11.20
1/12	-18.75	38.77	5.17	10.34

For converting solar energy to electricity in Al-Hillacity , two methods can be used first: Concentrated Solar Power and second: solar cells networks.

4- <u>Concentration solar power system:</u>

CSP plants generate electric power by using mirrors to concentrate (focus) the sun's energy and convert it into high-temperature heat (Solar energy Development Program, 2016) .The system includes two major parts: mirrors for collection and reflection of solar incidence and collector for heating the liquid and using steam to product electricity.

For making the (CSP) works with good efficiency the glass mirrors in the system must be in optimum positions toward the sun to reflect all available solar energy toward main collector in the heart of the system, also the amount of heat reflected proportional positively with solar intensity.
The solar intensity (w/m^2) can be calculated from the following formula:
(Mohamad, 2016), (Jasmina and Amelija, 2001):

$$\mathbf{I = 1362^* (1+0.033^*\cos(360^*N/365))^*(\sin(\delta)^* \sin(\varphi)+\cos(\delta)^* \cos(\varphi)^* \cos(\omega))} \quad .. (5)$$

When the solar bands pass through atmosphere, the conditions of temperature and air density and other parameters lead to reduce the solar intensity for 25% − 30%(Jasmina andAmelija,2001)
The following table contains solar intensity and its correction for AL-Hilla city
Table (3): Solar intensity and its correction of AL-Hilla city

Date (day/month)	Solar intensity (W/m^2)	Correction of Solar intensity (W/m^2)
1/1	791.39	553.97
1/2	845.98	592.19
1/3	993.47	695.43
1/4	1136.21	795.35
1/5	1290.83	903.58
1/6	1292.61	904.83
1/7	1306.62	914.64
1/8	1326.47	928.53
1/9	1254.29	878.00
1/10	1159.58	811.71
1/11	997.01	697.91
1/12	831.47	582.03

For optimizing reflecting process, two parameters are effecting the angle of solar: **Solar angle (α)** and **Azimuth angle (A)**

Azimuth angle is the horizontal angle for unit mirror in CSP with respect to north direction, the benefits of knowing the values of azimuth angle along all sunny hours in year are to decrease the number of mirrors used and that lead todecrease the overall cost, the following figure explained the Azimuth angle in CSP mirror unit (David, 2016)

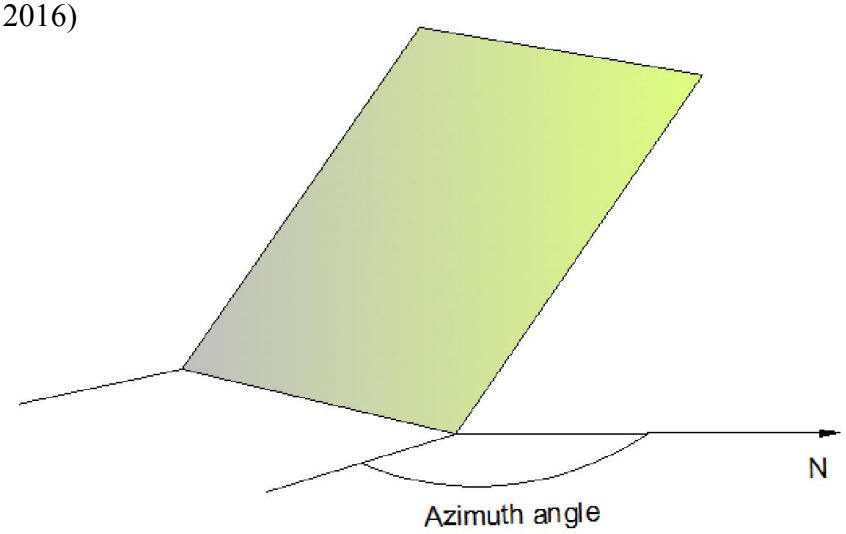

Fig (2) : Azimuth angle in CSP mirror unit

The amount of heat reflected toward main collector in CSP system depends mainly on solar intensity (I (W/m^2)), from changing the unit of W/m^2 to Btu/m^2. Hour , were Btu is a British thermal unit which increases the degree of heat of one pound of water by one Fahrenheit .

Heat flux (Hf) :

1 W/m^2= 0.3171 Btu/h · ft^2(1 Btu = 0.555 C)(1 pound = 0.453 liter)

So the amount of heat flux for one liter per hour (C/h) reflected from 1X1 foot mirror with 90% reflection efficiency toward collector can be found from the following formula:

Hf (C/h) = I (W/m^2)* 0.3171* 0.555*0.453*0.9

Hf(C /h) = I (W/m^2) * 0.0717 …….. (6)

The following table contains the heat flux at noon along the year in AL-Hilla city

Table (4): Annually heat flux at noon in AL-Hilla city

Date (day/month)	Solar intensity (W/m^2)	Heat flux (C/h)
1/1	553.97	39.72
1/2	592.19	42.46
1/3	695.43	49.86
1/4	795.35	57.03
1/5	903.58	64.79
1/6	904.83	64.88
1/7	914.64	65.58
1/8	928.53	66.58
1/9	878.00	62.95
1/10	811.71	58.20
1/11	697.91	50.04
1/12	582.03	41.73

The previous solar radiation values calculated for the noon time when the solar intensity be at maximum, the CSP efficiency effecting by the amount of solar received and that because in one day the reflection changes from low value at sunrise to maximum at noon the decreases gradually toward sunset, the parameter which influences the amount of collected light in day time is hour angle (ω) because the equation of solar radiation contains the term (cos (ω)) as mentioned in this research .

For instance, in 1/January:

The day time is 9.9 hr ,hour angle (ω) and solar radiation in AL-Hilla city changes along the hours before and after noon as follows table:

Table (5): Hourly solar intensity and heat flux in 1/January of aL-Hila city

Time	Hour angle	Solar intensity (W/m^2)	Heat flux (C/h)
8:00 am	-60	250.04	12.55
9:00 am	-45	475.98	23.89
10:00 am	-30	649.33	32.59
11:00 am	-15	758.29	38.06
12:00	0	795.46	39.92
1:00 pm	15	758.29	38.06
2:00 pm	30	649.33	32.59
3:00 pm	45	475.98	23.89
4:00 pm	60	250.04	12.55

The hourly changes in solar radiation and heat flux in AL-Hillacity can be shown in the following figure:

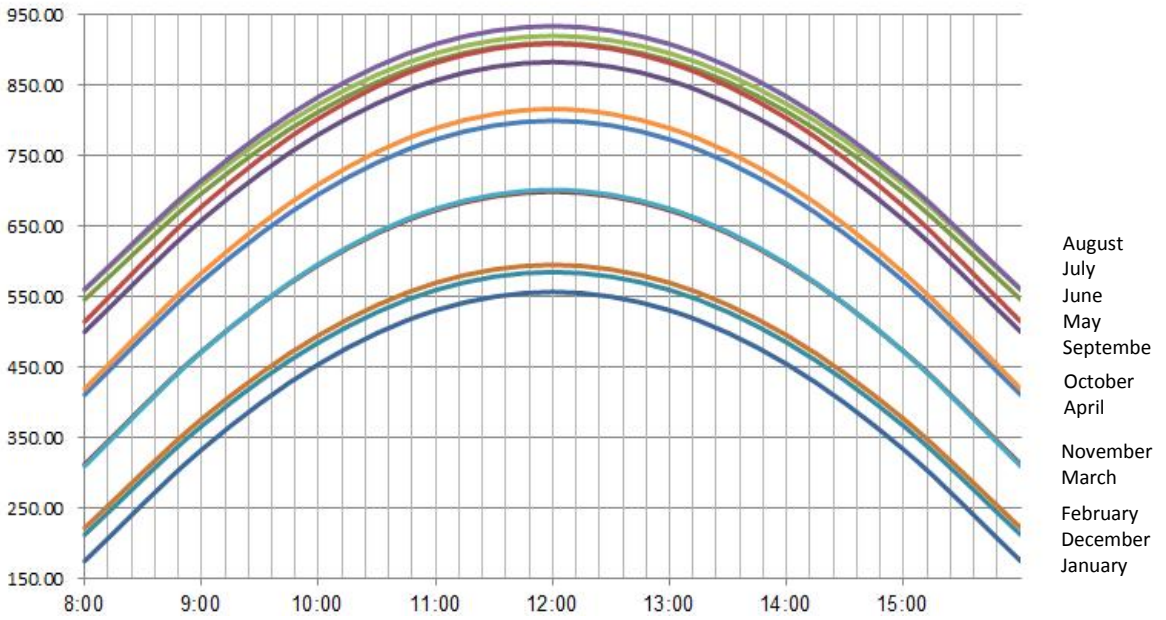

Fig (3): Hourly solar radiation in AL-Hilla city

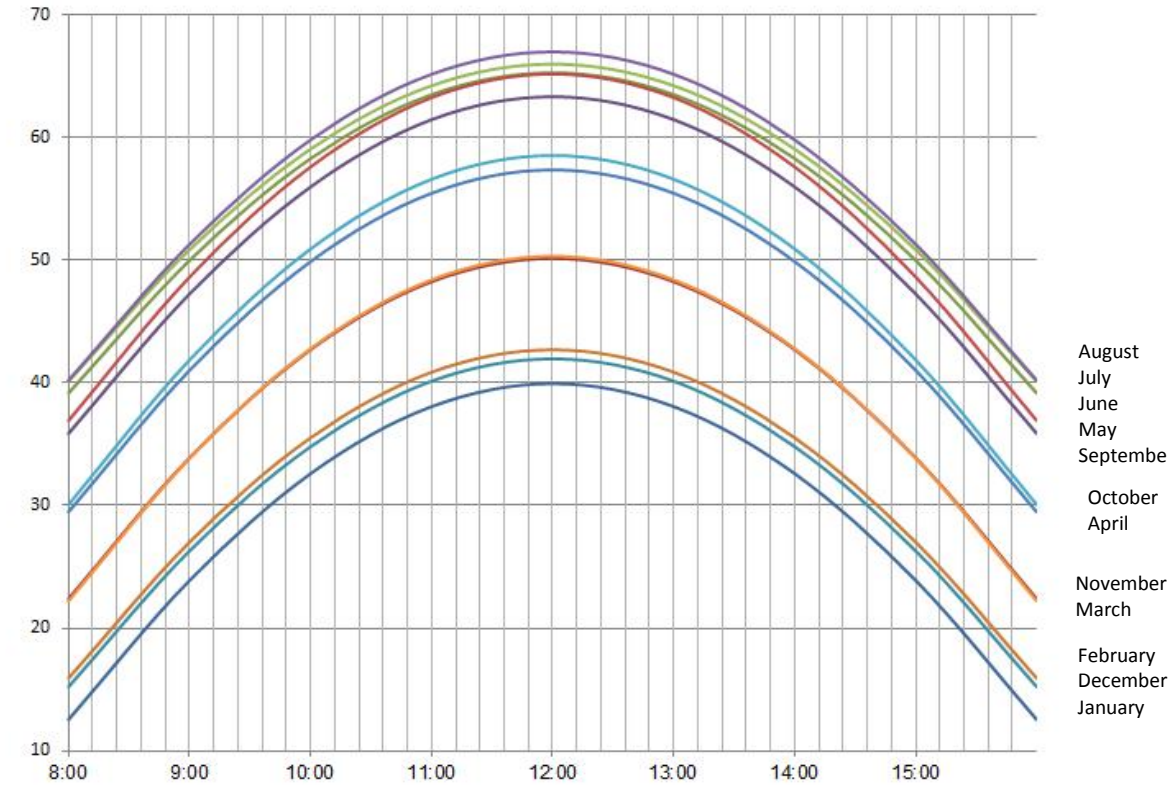

Fig (4): Hourly Heat flux in AL-Hilla city

Results:

The water consumption in CSP varies according to weather temperature and electricity production, the hourly consumption range from (750-920) gallon of water for 1MW of output power(Nicole and Richard, 2009), (U.S. Department of Energy 2001).

gal/ MW. h = 3.785 liter/ MW. h

The hourly consumption of electricity for one person in AL-Hilla city as mention above is: 0.4823 KW

The maximum amount of water needed to operate CSP is:

Water needed in CSP / person= 920*3.785 * 0.4823*(1/1000) = 1.68 liter

For AL-Hilla city population (970,000 capita), water consumption / hr is :

Water needed in CSP= 1.68*970000 /1000 = 1630 cubic meter/ hr

The water consumption can be recycling so the amount of water will not be doubled next hours

Conclusion:

Concentrated Solar Power is one of the ways of using renewable energy to product electricity, the solar radiation in AL_Hilla city can be transformed using CSP system,especially in summer months because of huge amount of solar radiation received comparing to other places in earth planet, the previous charts of annually solar radiation and heat flux are very useful to operate the system with good efficiency.

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