

# Solar Energy as an Alternative Energy than the Conventional Means of Electricity Generation in Iraq

Ali Al-Helal

**Abstract:** This study aims to show the feasibility of using solar power in Iraq as an alternative source of power generation. This research investigated the profits of using solar power economically and environmentally. Also, it addressed a set of important charts such as generated power, oil production, the amount of gas that used in the power plant, the average of delivered electricity hours, and CO<sub>2</sub> emissions. Ten locations are chosen as the best places according to their total annual solar radiation and each location is assumed to have a 10 MW solar park. The results showed saving about 676,000 USD daily (based on 52 USD per barrel) from petrol can be used to generate electricity from the conventional means, offsetting over 200,000 metric tons of carbon dioxide equivalent emissions annually, and around 111 job will be created during the construction stage of each 10 MW.

**Keywords:** solar energy, CO<sub>2</sub> emissions, solar radiation

## I. INTRODUCTION

Renewable energy has become increasingly used recently. It comprises nearly one-fifth of the worldwide energy consumption and about 30 % increasing in the wind energy generation per year. Economically, it plays a major role in improving people life by increasing their income and reducing the cost of living. On the contrary of other conventional energy generation means, it can be found in various regions. Importantly, increasing usage of renewable energy contributes to overcome some energy security and climate issues. Also, there are well over three quarters of the total worldwide energy consumption from the energy that generated by fossil fuels, while only 16.7 % of global energy consumption from renewables. Finally, nuclear power has recorded a minor percentage (2.7 %) in the worldwide energy usage (Council, 2013). In fact, Iraq is suffering from a sever lack in electricity that delivered to people. This problem has been taken place since the Gulf War in 1990 due to the systematic destruction of the vast majority of Iraqi power stations by US forces. From 1991 to 2003, most Iraqi governorates enjoyed just 4–8 hours except Baghdad which reported to have 16 – 24 hours daily. After 2003, most Iraqi cities received eight hours daily. This attributed to the destruction that mentioned above and the damage that happened to the Iraqi refineries (years, 2013). This problem has a dire consequences on the economy, society, and environment of Iraq.

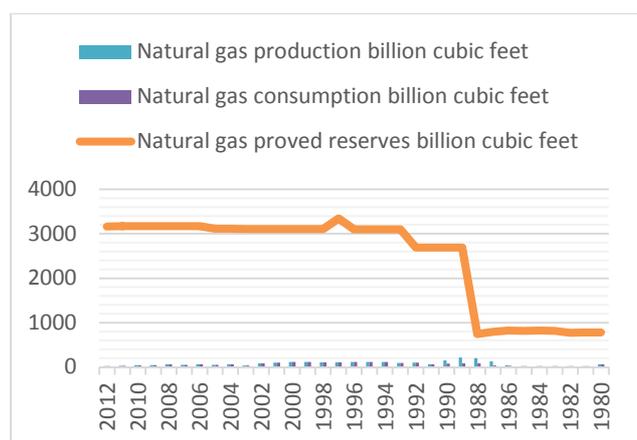
**Manuscript Received on January 2015.**

Ali Al-Helal, has completed his Bachelor Degree from College of Engineering, University of Kufa, Iraq.

Besides, many studies have been conducted that the crude oil may deplete in the next century which raised the concerns about the damage that will take place in Iraq's economy. Based on all mentioned above, the onus is on the Iraqi government and decisions makers to study this problem and solve it seriously. Not to mention that, Iraq has a good financial income from the crude oil and tourism as well as enormous human potentials.

## II. IRAQ GAS AND OIL

In 2009, Iraq was classified as the 12<sup>th</sup> largest oil producer and occupied the third seat of the largest proven petroleum reserves over the world. Although 143 billion barrels were proved in Iraqi reserves, Iraqi experts believed that about 214 billion barrels are there in Iraqi reserves as well as having 325 TCF in gas reserves. Oil sector in Iraq suffered as any sector that was affected by the gulf war which makes it essential to develop oil infrastructure after the US invasion in 2003. Most of Iraqi reserves are unexplored which may make Iraq lead the worldwide oil market in future. Recently, oil production in Iraq has peaked due to opening the doors for all international investors to boost the economy and to develop its oil fields (TEAM, 2013). From economical point of view, more than 90 % of Iraqi economy is derived from petroleum. Also, it is ranked as the first country in the Middle East and North Africa in terms of dependency of oil (Most, 2011).



**Figure 1: Natural gas in Iraq**

(Retrieved from <http://www.eia.gov/countries/country-data.cfm?fips=IZ#tpe>)

Figure (1) shows the amount of natural gas that proved, produced, and consumed in Iraq from 1980 to 2012. As shown in the figure, Iraq consumed all natural gas that produced in the whole period except the years 1986, 1987, 1988, 1989, and 1990 which indicate an increasing in the amount of production. Also, it can be observed that there is

a vast difference between the production, consumption, and the proved of natural gas in Iraq. This means Iraq has a great opportunity to be the biggest producer of gas in the world.

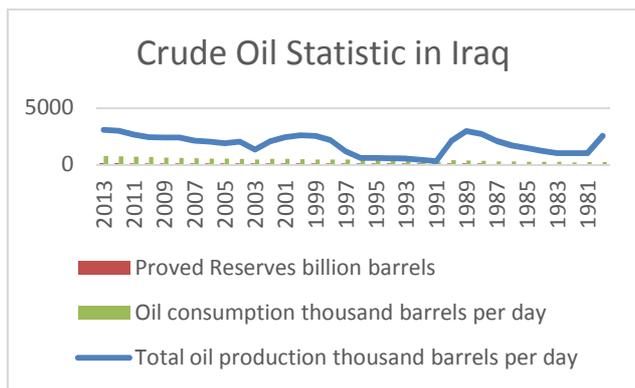


Figure 2: Oil production, consumption, and proved in Iraq

(Retrieved from <http://www.eia.gov/countries/country-data.cfm?fips=IZ#tpe>)

Figure (2) paints a picture about the amount of Iraqi storage, production, and consumption from crude oil from 1980 to 2013. Also, there is a massive distinction among the proved, consumption, and production amounts of crude oil. The consumption increased slightly through the whole period due to using it in the power generation stations and to cover other needs. While, the amount of production fluctuated during this period. Recently, Iraq has produced the highest amount of crude oil over the period from 1980 to 2013.

### III. ELECTRICITY SHORTAGE IN IRAQ

Electricity crises have begun since the second Gulf war in 1990. As mentioned before, the main reason of this problem is the vast majority of Iraqi power stations being destroyed. Many steps were taken place to overcome this dilemma without any observed success due to the sanctions that imposed on Iraq.

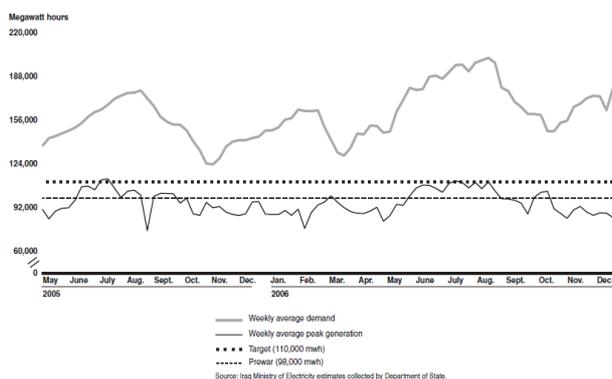


Figure 3: Electricity in Iraq between 2005 and 2006

(Retrieved from <http://www.gao.gov/products/GAO-07-677>)

Figure (3) gives information about the electricity shortage in Iraq between 2005 and 2006. It is worth mentioning that, having detailed information about the electricity file in Iraq is very difficult. It can be seen clearly that there is a wide difference between the weekly average demand and the weekly average generation from electricity from May 2005 until December 2006. This explains why most regions in Iraq have witnessed an increasing number of power cut which sometimes reaches to 18 hours. This raises the curtain

on the urgent need to find out another ways to generate electricity with low emissions, low cost, and clean.

### IV. RENEWABLE ENERGY IN IRAQ

Only one form of renewables has been used in Iraq since 30 years. It is Hydroelectricity that can be found in many sites in Iraq such as Mosul dam, Tharthar Lake, and Alkhlaa regulator. Figure (4) illustrates the amount of electricity that generated from renewables in Iraq from 1980 to 2011. From 1980 to 2004, the amount of energy levelled off in about 0.8 billion kilowatt-hours. Then, it increased sharply from 0.8 to 6 billion kilowatt-hours between 2004 and 2007. Finally, it fluctuated between 2007 and 2009 to record well over 4 billion kilowatt-hours in 2011.

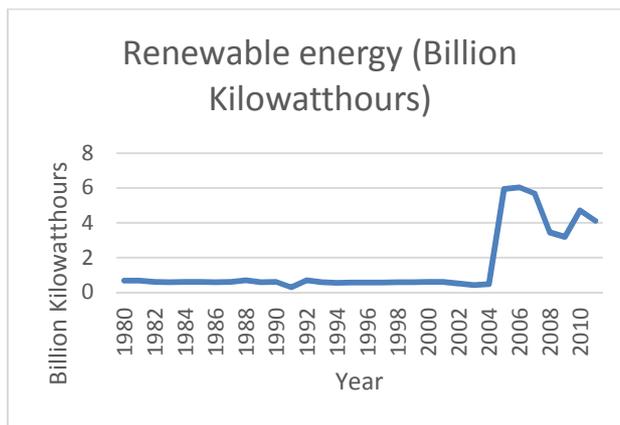


Figure 4: Hydroelectricity in Iraq

(Retrieved from <http://www.eia.gov/countries/country-data.cfm?fips=IZ#tpe>)

### V. WHY SOLAR ENERGY IS MORE SUITABLE THAN OTHER RENEWABLES IN IRAQ

After addressing the electricity crises in Iraq, it is the real time to find an alternative source of electricity rather than the conventional means of generation. There are several factors that indicate solar energy is suitable for Iraqi situation. These factors are:

#### A. Solar Power in Iraq

Although Iraq has an abundant amount of oil over the world, it has to find a reliable and alternative clean energy source to compensate the lack in electricity and to decrease the emissions level that comes from fossil fuel stations, factories, and cars. From a geographical point of view, Iraq has a great opportunity to utilize from solar power because it lies in the high solar belt. Figure (5) gives information about Iraq position in the solar map. It can be seen clearly that Iraq lies in the area that has over 2300 KWh/m<sup>2</sup>horizontal irradiation per year.

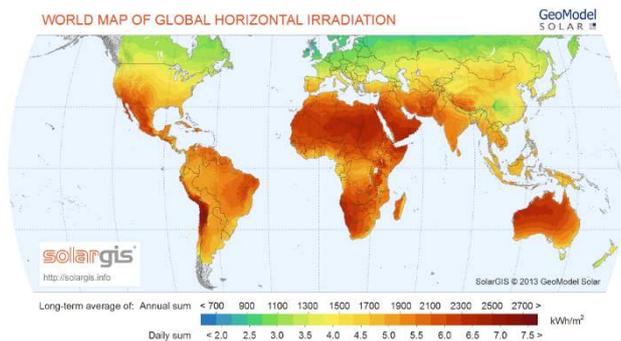
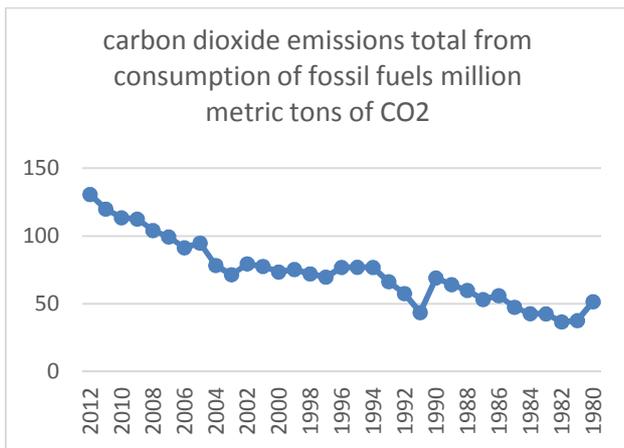


Figure 5: Iraq in solar map

(Retrieved from <https://miningawareness.wordpress.com/2014/06/04/the-ongoing-saga-27-news-updates-tidbits-trivia/>)

**B. CO2 Emissions**

Iraq is affected by global warming phenomena and it is considered as a major challenge that may face this part of the world. If it exceeds the acceptable limits, it could have dire consequences on the environment, economy, agriculture, and Iraqi society at all. Figure (6) illustrates the total carbon dioxide emissions from consumption of fossil fuels in million metric tons of CO2 in Iraq from 1980 to 2012. This figure shows a significant upward trend during the whole period. It ranged from nearly 57 million metric tons of CO2 in 1980 to 130 million metric of CO2 approximately in 2012.



**Figure 6: CO2 emission from consumption of fossil fuels in Iraq from 1980 to 2012 (in million metric tons)**

(Retrieved from <http://www.eia.gov/countries/country-data.cfm?fips=IZ#tpe>)

**C. The Difficulties Of Using Other Forms Of Renewables**

On the contrary of solar power, other renewables sources are limited in Iraq. For examples, hydropower exists in limited locations in Iraq according to the dams and reservoirs. Similarly, the current proposed wind power projects also exists in specific locations according to the wind availability there (Alrikabi, 2014). Not to mention that, these forms of renewables need more money and time to be installed. Along with that, there is a severe lack in raw materials of these forms in Iraq while many solar companies have opened their effective offices in Baghdad and in the North of Iraq recently.

**VI. CASE STUDY**

Many experts have addressed the Iraqi cities that receive the highest global solar radiation annually. The top ten cities in Iraq that have more solar radiation will be presented in this study. Sahib Abdul-Wahid et al (2012) addressed the 16 cities in Iraq that receive the most annual solar radiation. Their calculations based on the sunshine duration, cloud cover, relative humidity, the maximum and minimum temperatures, ground albedo, and sun-earth distance as the input, the models of radiation, the monthly average daily solar radiation on horizontal surface and radiation competent, incoming and outgoing, global solar radiation

and net solar radiation in various locations. Only ten cities are chosen to be the case study of this research which based on what has been achieved by the above researchers. Table (1) gives information about those cities which were sorted in descending order.

	Location	The annual solar radiation MJ/m <sup>2</sup> . Year
1	Al-Samaua	7263.97
2	Al-Basra	7208.56
3	Al-Rutbah	7185.74
4	Al-Hai	7135.2
5	Al-Amarah	7123.67
6	Baghdad	7114.44
7	Karbala	7030.82
8	Al-Najaf	7021.23
9	Al-Diwaniya	7021.23
10	Haditha	6997.46

**Table 1: The total annual global solar radiation for the top ten cities in Iraq. (Wahid, 2012)**

**A. The Scale Of The Proposed Projects**

The project scale is assumed to be 10 MW for each location and photovoltaic systems that are chosen to be the proposed solar system type. This means the overall power generated from all locations is 100 MW as a preliminary stage and it can be extended to a large scale such as 100 MW for each location. The good point which helps to install and expand these parks easily is all these sites have massive areas which are out of use from people and government.

**B. The Capital Cost**

The capital cost of these farms are split into various parts. The estimated cost below is for one farm (10 MW). (Jacobson, 2013) assumed that the capital cost of the whole 10 MW scale around 20 million US dollars. This cost includes PV modules, inverters, civil work, labour, transport and shipping, grid connections, and other categories. Based on that, the overall cost of all locations equals 200 million US dollars. It is worth mentioning that these projects need around 4 years to be fully completed with taking into account the security and harsh weather in Iraq.

**VII. THE BENEFITS FROM THE PROPOSED SOLAR PARKS IN NUMBERS**

In order to present the viability of the proposed solar farms, environmental, jobs creation, and economical benefits will be presented.

**A. CO2 Emissions Offset**

It is expected that the proposed solar parks will displace over 200,000 metric tons of carbon dioxide equivalent emissions annually. This means about 40,000 cars will be taken off the road per year. In other words, the proposed projects will cover the amount of CO2 emissions that produced from using fossil fuels as shown in figure (6). The amount of carbon dioxide that offset by solar parks will play a pivotal role in tackling the global warming problem in Iraq. The benefits from reducing greenhouse gas emissions are not only limited by global warming, but also it could

prevent the premature death according to the recent studies (Choi, 2013).

**B. Jobs Creation**

Any project over the world could has a major impact on the jobs created even if it was small-scale project. The number of jobs that can be created from one project (10 MW) has been estimated at 111 jobs during construction and it may rise during the operation phase. If any project develops and extends to the desired capacity (100 MW), it is predicted that it will provide another 110 jobs in both construction and operation phases (Jacobson, 2013). This result will boom Iraq's economy which suffers from 15.01% unemployment (Unemployment, n.d).

**C. Saving Money**

Iraq has spent 130 thousand barrels/day to generate electricity from the conventional ways recently. There is no recent information about the actual number of barrels that used, however, this number has been increased since 2010. If the proposed solar parks have set up in the preliminary capacity (100 MW overall), this may reduce the number of barrels that consumed by ways that are inherently anti-environment by 10 %. Similarly, if all projects being expanded to 250 MW or more, then the number of exported barrels will be increased. Further, this will finish importing about 400 million litres of gasoline and diesel daily from Iran and Kuwait. Table (2) shows the viability of the whole project.

	Parameter	10 MW scale (for 10 sites)
1	Cost	200,000,000 US dollar
2	Jobs	1110 during construction phase + another full time jobs in the operation phase.
3	Saving money	10 % * 130,000 barrels daily 13000 * 52 US dollar → 676,000 USD daily
4	Environmental impact	200,000 metric tons of carbon dioxide equivalent emissions annually

**Table 2: The overall benefits from the proposed solar parks**

**VIII. SOLAR POWER DRAWBACKS**

The problem that faces solar power projects in Iraq is the amount of dust that can be accumulated on a solar panel. The weather in Iraq is known by receiving massive amount of dust and dirt frequently. This phenomenon has an adverse impact on the efficiency of a solar panel that may be reduced by 30%.Cleaning a massive number of panels should not be done by primitive ways which can be time and money consuming. A fully automated cleaning should be employed so as to keep the panels' effectiveness such as energy- independent robot. With regards to the security, eight out of ten of the proposed locations are considered very safe areas. Also, the harsh weather in Iraq may affect the progress of the work. It characterizes very hot weather in summer with temperature reaches over 50 °C and dry and cold in winter.

**IX. CONCLUSION**

The aim of this study was to address the feasibility of using solar power in Iraq as an alternative source of electricity. Detailed information about Iraq's oil, gas, electricity shortage, electricity from renewables, CO2 emissions, and Iraq position in solar map was presented. After that, a case study has taken place which includes ten proposed sites in Iraq that received the highest amount of solar radiation per year. Every site was assumed to be 10 MW in preliminary stage which will then be expanded to what Iraq needs. Based on that, this study showed the meaningful benefits from installing these solar parks. Those results include displacing over 200,000 metric tons of carbon dioxide equivalent emissions annually, creating about 111 jobs for every 10 MW during the construction phase, and it may save around 10% of 130,000 barrels/day that Iraq is spending currently on generating electricity from power plants that working on fossil fuel. On the other hand, problems that face solar panels in Iraq have been addressed in order to show the actual viability of the whole project.

**REFERENCE**

- [1] al, S. A.-W. (2012). Calculation and Applications of Net Solar Radiation in Iraq. 1 - 9.
- [2] al, S. A.-W. (2014). Estimation of the Global Horizontal Solar Radiation in Iraq. International Journal of Emerging Technology and Advanced Engineering, 587 - 605.
- [3] Alasady, A. M. (2011). Solar energy the suitable energy alternative for Iraq beyond oil. 2011 International Conference on Petroleum and Sustainable Development (pp. 11-15). Singapore: IACSIT Press.
- [4] Alrikabi, N. (2014). Renewable Energy Types. Journal of Clean Energy Technologies, 61-64.
- [5] Analysis, C. (2013, May 30). <http://www.eia.gov/>. Retrieved from US energy information administration : <http://www.eia.gov/countries/country-data.cfm?fips=IZ#tpe>
- [6] Choi, C. (2013, September 22). <http://www.livescience.com/>. Retrieved from livescience: <http://www.livescience.com/39849-greenhouse-gas-emissions-premature-deaths.html>
- [7] Council, W. E. (2013). World Energy Resources. London: World Energy Council .
- [8] Jacobson, W. a. (2013). SOLAR FARM FEASIBILITY STUDY. DISTRICT COUNCIL OF MOUNT REMARKABLE.
- [9] Most, I. (2011, March 30). musingsoniraq.blogspot.com.au . Retrieved from MUSINGS ON IRAQ: <http://musingsoniraq.blogspot.com.au/2011/03/iraq-most-oil-dependent-country-in.html>
- [10] Office, U. S. (2007). Integrated Strategic. Washington : GAO .
- [11] TEAM, I. O. (2013). <http://www.iraqoilgas.com/>. Retrieved from [http://www.iraqoilgas.com/sector\\_in\\_iraq.html](http://www.iraqoilgas.com/sector_in_iraq.html)
- [12] Unemployment, I. (n.d). <http://www.tradingeconomics.com/>. Retrieved from tradingeconomics: <http://www.tradingeconomics.com/iraq/unemployment-rate>
- [13] Years, I. 1. (2013, March 20). <http://www.bbc.com/>. Retrieved from <http://www.bbc.com/news/world-middle-east-21752819>

Ali Al-Helal, has completed his Bachelor Degree from college of engineering/University of Kufa in 2007. He is currently studying master in mechanical engineering technology/ Federation University Australia.

