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# The Economic Feasibility of using Renewable Energy in Iraqi Oil Fields

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## Abstract

This study included over all about competition of renewable energy to the conventional energy, and the economic growth on the demand for renewable energy technology especially solar energy, and the increasing on its annual cost decline. Also, highlight on the most important projects applied in the oil fields in the Middle East and America.

In this study, a design and economic simulation of the solar energy system was conducted as a source for generating electricity with a capacity of 1 megawatt and a comparison of the capital and operation cost between the solar energy system, diesel generators, government and private sectors stations at the same operating time and the same energy. The economic simulation has shown that there is a big difference between the capital costs, as the cost of the solar energy system is about (40-37%) higher than the cost of diesel generators and investment stations, respectively, for a maximum operating capacity of 1 megawatt/hour, but on the other hand, it is characterized by The solar energy system has a depreciation factor of 0.75% compared to its counterparts, which reaches 10%, and the standard of its energy cost is low, reaching 0.22 $/ kilowatt compared to other sources of energy. In addition, Payback period of the solar energy system was 9 years by saving fuel cost and its low operating cost that reach to 0.0183 $/kWh, compared to its counterparts from government sector station, diesel generators, power stations. (Fuel from the investor), and private sector stations (fuel from the investor), whose operating costs are (0.1, 0.076, 0.038, 0.1) $/kWh, respectively. The results showed that the solar system economically feasible, with lifetime 25 years, while the generator lifetime ten years only. The solar radiation system limits carbon emissions, as the amount of carbon emissions per kilowatt of energy using conventional fuels is (185-265) grams of $CO_2$ per kilowatt.


**Keywords**: solar; capital; operation cost; generator.

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# الجدوى الاقتصادية من استخدام الطاقة المتجددة في الحقول النفطية العراقية

**الخلاصة**

تتضمن هذه الدراسة نظرة شاملة عن منافسة مصادر الطاقة المتجددة لمصادر الطاقة التقليدية إضافة الى النمو المتزايد على طلب تكنلوجيا الطاقة المتجددة وخصوصا الطاقة الشمسية. علاوة على ذلك تضمنت الدراسة تكاليف تكنلوجيا الطاقة المتجددة عموما والشمسية خصوصا ومقدار الانخفاض السنوي المتزايد لها حيث ازداد الطلب على الطاقة المتجددة في الربع الاول لعام 2020 بنحو 1٪ عن عام 2019 مقارنة بمصادر الطاقة الأخرى نظرا لانخفاض التكاليف التشغيلية لها وبلغ الاعتماد على الطاقة المتجددة حوالي 30 % لتوليد الطاقة الكهربائية على مستوى العالم، وبمعدل نمو لها وصل الى 5% على الرغم من العوامل المعرقلة التي نجمت عن أزمة Covid-19 وبمتوسط سعر اقل من 0.030$/كيلوواط ساعة. أيضا تم القاء الضوء على اهم المشاريع المطبقة في الحقول النفطية في الشرق الأوسط وامريكا أيضا تمت في هذه الدراسة اجراء محاكاة تصميمية واقتصادية لمنظومة الطاقة الشمسية كمصدر لتوليد التيار الكهربائي بطاقة 1 ميكاواط ومقارنة الكلفة الرأسمالية و التشغيلية بين منظومة الطاقة الشمسية ومولدات الديزل والتجهيز الوطني والمحطات الاستثمارية خلال نفس الفترة الزمنية للتشغيل ونفس الطاقة وقد اثبتت المحاكاة الاقتصادية عن وجود فارق كبير بين الكلف الرأسمالية حيث ان كلفة منظومة الطاقة الشمسية اعلى بحوالي (40-37%) من كلفة مولدات الديزل والمحطات الاستثمارية على التوالي لطاقة تشغيلية قصوى 1 ميكاواط/ ساعة ولكن من جهة اخرى تمتاز منظومة الطاقة الشمسية بمعامل اندثار 0.75% مقارنة مع نظيراتها والتي تصل الى 10% وبمعيار تكلفة الطاقة لها منخفضة لتصل الى0.22 $/كيلوواط مقارنة بالمصادر الاخرى للطاقة، اضافة الى ذلك يمكن استعادة الكلفة الراسمالية لمنظومة الطاقة الشمسية خلال 9 سنوات من خلال توفير كلفة الوقود وانخفاض كلفتها التشغيلية وتبلغ 0.0183$/كيلوواط ساعة مقارنة بنظيراتها من التجهيز الوطني، مولدات الديزل، المحطات الاستثمارية (الوقود من الجهة المستفيدة)، والمحطات الاستثمارية (الوقود من المستثمر) والتي تبلغ كلفتها التشغيلية (0.1، 0.076، 0.038، 0.1) $/كيلوواط ساعة على التوالي. تعتبر المنظومة الشمسية جيدة من الناحية الاقتصادية حيث تستخدم لفترة 25 سنة في حين ان المولد عشر سنوات فقط بمعنى ان الحكومية تتحمل كلفة مضاعفة مرة ونصف في حال تم اختيار مولد الديزل خلال فترة 25 سنة وبالمقابل ستتحما الجهة المستفيدة تكاليف ومصاريف اضافية تضاف على الكلفة الكلية للمولد.وتحد منظومة الاشعة الشمسية من الانبعاث الكاربوني حيث ان كمية الانبعاث الكربوني لكل واحد كيلو واط من الطاقة باستخدام الوقود التقليدي بحدود (185-265) غرام $CO_2$ لكل كيلوواط.

## 1. Introduction

At present, there are significant fluctuations in oil and gas prices around the world due to political, economic and environmental motives. Accordingly, oil and gas companies have begun to explore sustainable alternatives power source, such as renewable energy resources. This shift to renewable energy is supported by its many advantages, such as reduced reliance on fossil fuels and the harmful greenhouse gas emissions that affect the environment, as well as lower operating costs. In the previous decade, major oil and gas companies in the United States had invested billions of dollars in renewable energy technologies.[1]

According to current policies, global demand for oil and gas is expected to increase annually. As demand increases, traditional oil and gas reserves are decreasing, prompting the use of enhanced oil extraction techniques (EOR).

According to the International Energy Agency (IEA) statistics 2019, energy policies can be divided into four categories: climate change treatment policy (ACCP) renewable energy policy

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(REP), energy efficiency policy (EEP), and energy efficiency policy (BEEP). In particular, the proposed Paris Agreement in 2015 saw a global consensus on increased global warming aimed at controlling the average global temperature rise to 2 degrees Celsius in this century.[4]

One way to meet the growing demand for energy, in conjunction with reduced emissions, is to integrate renewable energy generation technologies into oil and gas operations. Integrating renewable energy technology and reducing the amount of fuel used to produce, transport and refine oil can reduce both energy costs and emissions. The oil and gas industry has many aspects that require the integration of renewable energy technologies. Production facilities are often in remote locations and require large amounts of electricity that can be generated from renewable sources (wind and solar power).

### 1.1 Demand for renewable energy

Demand for renewable energy in the first quarter of 2020 increased about 1% over 2019 compared to other energy sources due to lower operating costs as in Figure (1). Reliance on renewable energy was about 30% for electricity generation worldwide, with a growth rate of 5% despite the disruptive factors caused by the Covid-19 crisis. [6].

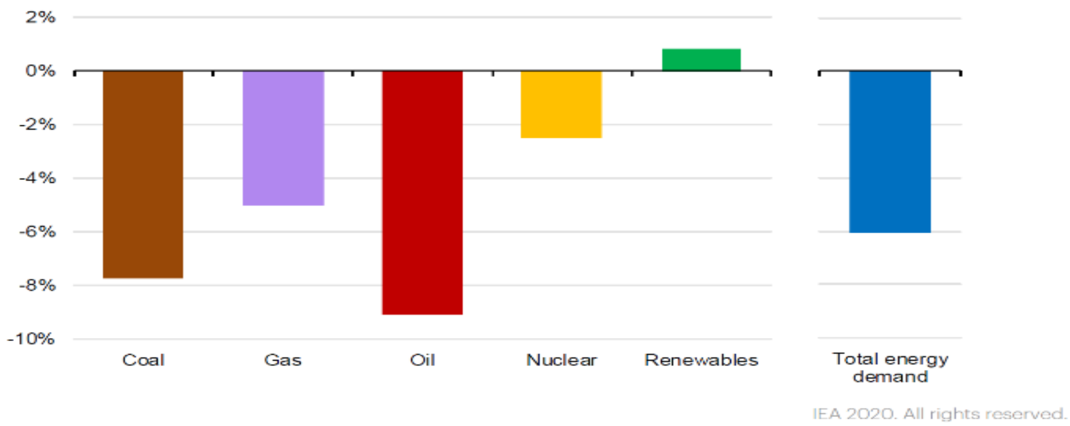


**Fig. (1): Change in demand for energy sources for 2020 compared to 2019[6]**

Renewable energy is expected to be the fastest growing primary energy source over the next 20 years, globally, accounting for about two-thirds of global investment in power plants until 2040, as in Figure (2).

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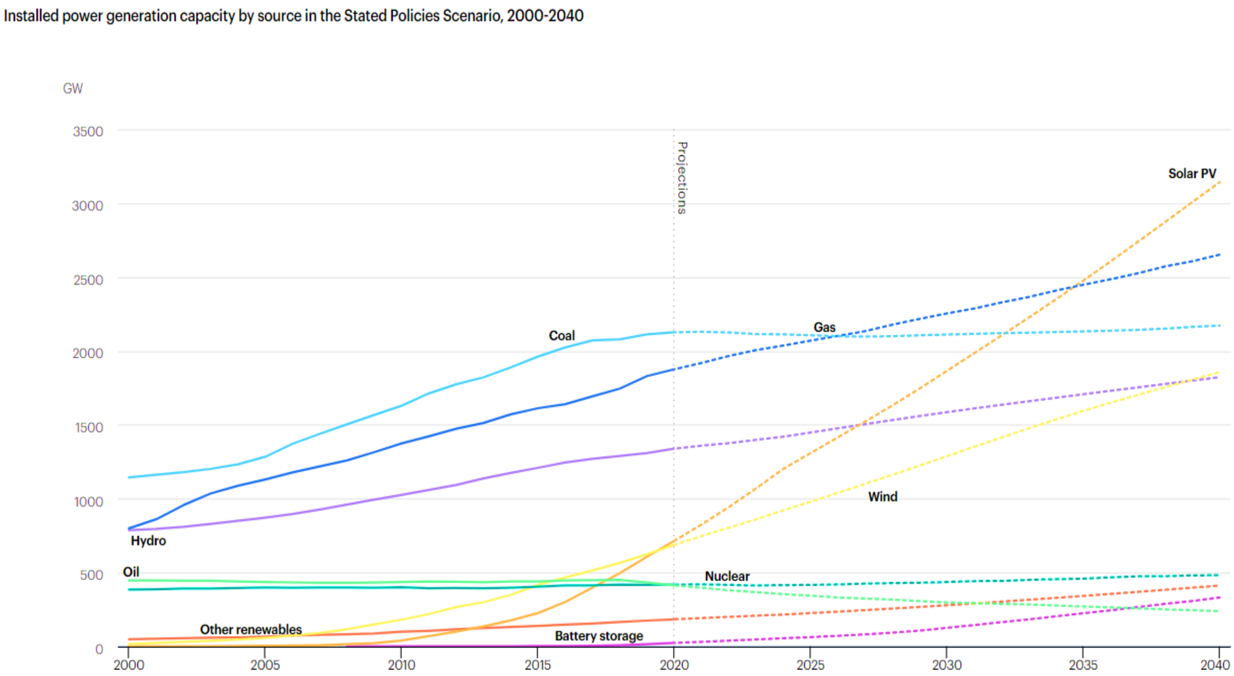


**Fig. (2): Global Renewable Energy Growth Forecast for 2000-2040**

According to BP's 2018 Energy Outlook, renewable energy will be the fastest growing energy source, growing fivefold by 2040, saving about 40% of global primary energy at this future stage of time. As a result of faster-than-expected lower solar costs, the rapid decline is partly due to faster technological gains. As shown in Figures (3) and (4).[8]

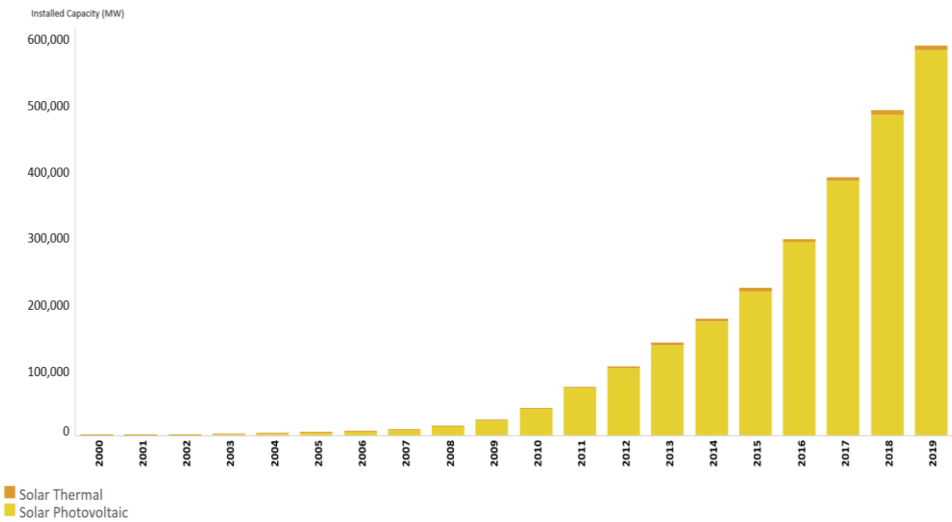


**Fig. (3): Increased solar power processed until 2019[9]**

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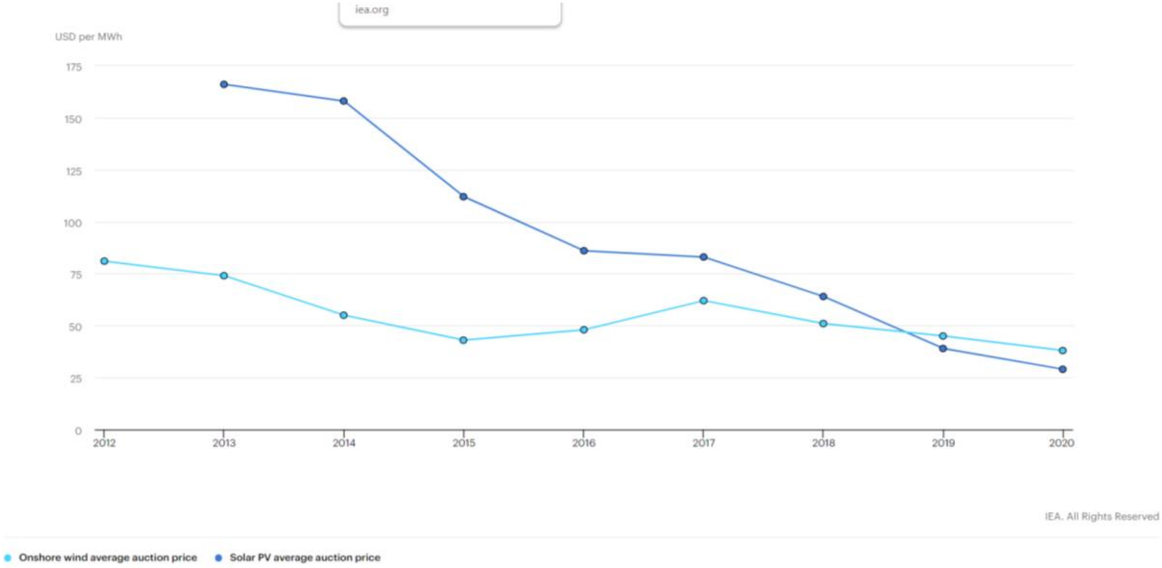


**Fig. (4): Average wind and solar PV prices by 2012-2020**

At the end of 2019, electricity production capacity from renewable energy sources reached 2,537 KW, a difference of 176 KW higher than in 2018.Hydropower and solar energy account for about 46% and 23% of total renewable energy sources, respectively, as in Figure (5).[9]

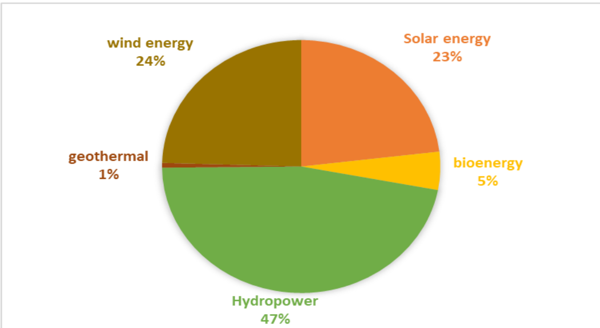


**Fig. (5): World Renewable Energy Production Capacity for 2019**

## 1.2 Solar energy

The International Energy Agency (IEA) and International Solar Alliance (ISA) are working together to accelerate the deployment of solar energy in many different areas by integrating solar energy with energy systems, including buildings, industry and mobility.

Solar energy attracted the largest share of new investments in renewable energies, followed by wind power. Solar investments of US$140 billion (42.5%) represent all new renewable energy investments. While annual investment decreased by (13%), newly produced solar PV energy increased by about (5%) to more than 107 GW in 2018. Until 2006, Japan and Europe controlled

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solar cell production. In 2014, a new trend emerged to rapidly increase production capacity in other Asian countries such as India, Malaysia, Thailand, the Philippines and Vietnam. The PV industry has changed dramatically over the past few years. China has become the main manufacturer of cells and solar units, followed by Taiwan and Malaysia as in Figure (6) and the competitiveness of photovoltaic solar energy depends on the cost of installation (including the price of panels and the cost of installation) and the degree of brightness of local sunlight and the alternative cost of the price of electricity to the consumer plus support. [10].

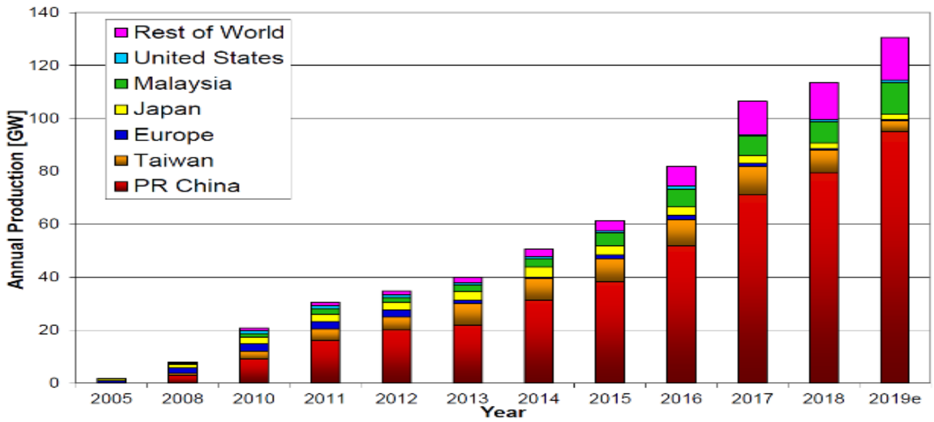


**Fig. (6): Global Production Capacity of Solar Systems 2005-2019**

### 1.3 Solar investment in oil and gas industry

In the oil and gas industry, renewable energy technology is used to solve the problems of providing electricity for production and providing the thermal energy needed for enhanced oil extraction technology. Solar energy is used for the purpose of providing electricity to some equipment in oil fields such as (well pumps, cathode protection of pipelines) and is used to supply energy to water treatment units in oil fields, in addition to meeting the energy needs of refineries.

Most oil fields are located within the area of high solar radiation, which allows the use and utilization of solar energy as an energy source, which is considered economic, especially if solar thermal technology is used.

Photovoltaic systems have been used in many oil and gas fields such as Midway-Sunset, Kern River and Louisiana Bayou in the United States of America. In addition to the oil fields in the Rocky Mountains of the United States of America and Fort Yard in Canada. Solar thermal systems have also been installed in the oil fields of McTrike, Kaolinga in the United States of America and Amal in Oman.

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**Mirror Solar Project - Oman**

Amal field shares hope with many other fields in the country, in a large reserve of heavy oil (API 20), so the usual techniques of extracting oil are not effective, so steam is injected to heat heavy oil and reduce its wife. In partnership with GlassPoint Solar, Oman Oil Development Company built one of the world's largest solar steam plants at peak. The total capacity of the four groups is more than 100 MW, generating 660 tons of steam per day. [13] [14].


**Fig. (7): Mirror Project - Oman**

**Sidra 500 Project - Kuwait**

The Sidra 500 plant is connected to the Ministry of Electricity network through a secondary plant belonging to KPC, so electricity from solar energy is not stored as the related pumps get electricity from the solar plant during the day and from the Ministry of Electricity network at night. Sidra 500 plant feeds 29 electric oil pumps in um Kadir fields in western Kuwait, which reduces the electricity needed by KPC from the Ministry of Electricity and if the production of the plant increases the need for oil pumps, excess electricity will go to the grid, which may be enough to light up to 1,000 houses. The Sidra 500 is unique in the world as it is the first solar power plant to operate submersible pumps to extract oil from the ground. It avoids producing 250,000 tons of CO2 and since trees absorb CARBON DIOXIDE from the air, it is equivalent to planting 500,000 trees. The Sidra 500 project provides economic benefits as well as environmental benefits as it provides the equivalent of 500,000 to 700,000 barrels of oil during the project's working period. It has 10 megawatts in prime time, approximately 32,450 solar panels extending over an area of 600×600 square meters, equivalent to 50 football pitches. Solar panels at Sidra 500 station track the sun's movement during the day to obtain the largest production of electricity as in Figure (8)[15][16].

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**Fig. (8): Sidra 500 Project - Kuwait**

**Belridge Solar Belridge Solar-California**

Ira Energy, one of California's largest oil and gas producers, has partnered with glass point to build California's largest solar project, located in the Belridge Oil Field west of Bakersfield, the first of its kind in the world to use solar steam and electricity to operate oil field operations, while reducing carbon emissions in the oil field. The project will consist of an 850 MW solar thermal power plant, producing 12 million barrels of carbon-free steam per year, and a 26.5 MW voltage photovoltaic power plant. Ira will use steam and electricity on site, with 4.87 billion cubic feet of natural gas.

**1.4 Challenges facing Iraq in investing solar energy**

Iraq needs a strategy to diversify the energy mix towards alternative sources, including renewable energy sources, as it will provide export-producing oil and gas to finance reconstruction. The transition to renewable energy would contribute reducing $CO_2$ emissions and bring a wide range of social and economic benefits to country, including job creation and contributing to the development of local economies.

The challenges that limit the implementation of renewable energy projects and the development of solar systems in Iraq are technical, industrial, policy and other challenges as follows:

- Environmental conditions: These include climate changes and the geographical nature of the region.
- Weak investment in this sector: Most countries in the world support solar PV projects. While Iraq remains poor on this side for several reasons:
    1. Weak support and development of local solar companies.

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Boring red tape and administrative communications between stakeholders are one of the obstacles to investing in this sector in the case of other sectors, where the requirements of investment license, bank financing and land gender change are a major barrier to these projects. Andthere is no law or instructions governing investment in the renewable energy sector

2. The weakness of the renewable energy culture among people. [18]

### 1.5 Economic cost of solar units

Over the past years, the price of solar units has fallen by about 80%, this development has been driven not only by technological developments, but also by market conditions. As costs have fallen and policies supported by the world's countries, the capacity equipped with solar units increased from just 44 GW in 2010 to 531 GW at the end of 2018 with the support of the International Solar Alliance, which added 135 GW of solar power at the end of 2018.

The continued decline in costs for solar units reduced the price of crystalline silicon photovoltaic units from $80/watt in 1976 to $0.27/watt in 2018. It is expected to fall below 0.1 dollars/watt by 2030. The prices of PV systems still vary depending on the size and type of the system. The reasons for these differences are multiple, ranging from different legal requirements for obtaining permits, licensing and network connectivity to the different maturity of local PV markets, with impacts on competition between manufacturers and investors.

Costs in Figure (9) represent total project costs including the cost of attachments (e.g. cables, shelves and installation, safety and security, network connectivity, monitoring and control..) [19]

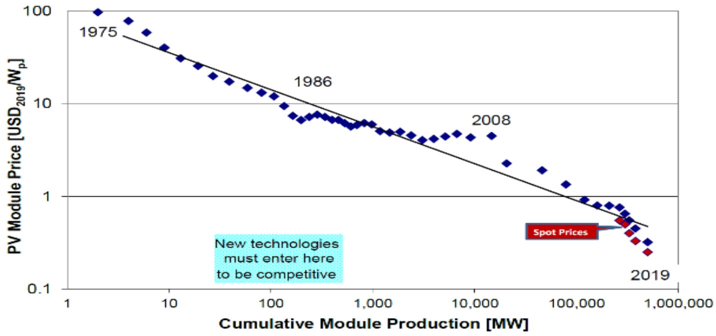


**Fig. (9): Total solar cost for 1975-2019**

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## 2. Calculating the cost of PV systems in Iraq

In this section, an introduction was addressed on the latest simulation programs used globally in the process of designing PV systems and predicting the cost of capital and operational. In addition, the pvsys program was used to design the system with a production capacity of 1 mw and calculate capital and operational costs and net profit.

### 2.1 PV simulation systems

PV systems need to be improved in terms of technological maturity and operational costs in order to maintain a balance between supply and demand for electricity. One way to achieve this improvement is by predicting the use of performance-enhancing PV simulation software and for the purpose of giving a look at the costs of installing and operating systems, which are commonly used globally. Currently, a number of solar PV simulation programs have different features that make them more suitable for some tasks than others. One of the most important design simulations is System Advisor Model (SAM), Photovoltaic Systems (PVSyst)and PVLib. [20]

### 2.2 Photovoltaic System (PVSyst)

In this study the PVSyst simulation program was adopted as a simulation tool centered around modeling, simulation and analysis of PV systems.

**1. Project** identification. Corresponding geolocation and meteo file to use. A number of sites and meteo files are already included in PVSyst databases but the user also has the option of importing his own.

**2. Setting up system variables.:** This is where the user creates a copy of the project account created in Step1. On the interface, the user gets to select the various information

**Run Simulation:** The user manages simulation and generates a variety of graphs and reports for photovoltaic system analysis. PVSyst allows the user to analyze the results in the program[21].

### 2.3 Analysis of Results for Simulation PVSyst

#### 2.3.1 Solar Radiation Identification

To calculate the variables of the solar power generation system, each one was calculated by Mika Watt. Depending on the geographical location of the selected area (east of Baghdad) and the solar radiation obtained through the program as shown in Table (1).

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**Table (1) Monthly Solar Radiation Iraq-Baghdad**

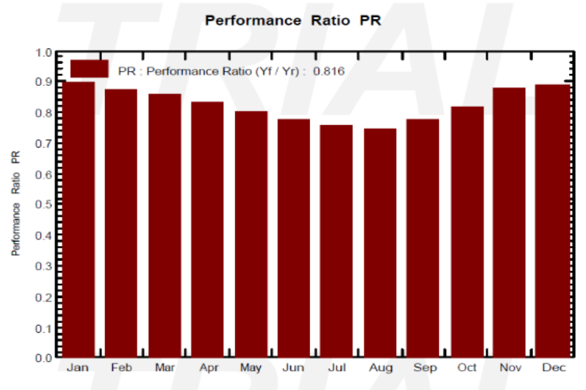
| | GlobHor kWh/m² | DiffHor kWh/m² | T_Amb °C | GlobInc kWh/m² | GlobEff kWh/m² | EArray MWh | E_Grid MWh | PR |
|---|---|---|---|---|---|---|---|---|
| **January** | 106.1 | 38.80 | 9.48 | 161.1 | 158.4 | 147.8 | 144.6 | 0.898 |
| **February** | 116.0 | 45.70 | 15.58 | 156.5 | 153.7 | 139.2 | 136.2 | 0.871 |
| **March** | 162.8 | 63.10 | 17.84 | 194.0 | 190.0 | 169.2 | 165.7 | 0.854 |
| **April** | 189.6 | 72.60 | 23.47 | 200.7 | 195.9 | 169.9 | 166.4 | 0.829 |
| **May** | 227.7 | 77.70 | 29.71 | 219.5 | 214.0 | 179.1 | 175.3 | 0.799 |
| **June** | 242.3 | 75.30 | 34.98 | 222.5 | 216.9 | 175.8 | 172.1 | 0.774 |
| **July** | 247.1 | 74.80 | 38.22 | 231.4 | 225.8 | 178.3 | 174.6 | 0.755 |
| **August** | 230.0 | 68.00 | 38.88 | 234.4 | 229.2 | 178.1 | 174.5 | 0.745 |
| **September** | 180.7 | 62.00 | 34.74 | 207.0 | 202.6 | 163.6 | 160.3 | 0.775 |
| **October** | 142.8 | 53.10 | 27.62 | 185.1 | 181.8 | 154.0 | 150.8 | 0.815 |
| **November** | 109.7 | 39.90 | 14.61 | 161.8 | 159.1 | 144.7 | 141.6 | 0.876 |
| **December** | 97.3 | 36.10 | 12.24 | 152.2 | 149.8 | 138.1 | 135.1 | 0.888 |
| Year | 2052.1 | 707.09 | 24.83 | 2326.1 | 2277.2 | 1937.8 | 1897.2 | 0.816 |

Legends:
GlobHor Horizontal global irradiation
DiffHor Horizontal diffuse irradiation
T_Amb T amb.
GlobInc Global incident in coll. plane
GlobEff Effective Global, corr. for IAM and shadings
EArray Effective energy at the output of the array
E_Grid Energy injected into grid
PR Performance Ratio

### 2.3.2 Number and Energy of Solar Panels

Through the simulation, it was found that the number of panels required was 2,272 tablets/mica watts, with an estimated capacity of 440 watts per panel. The required area for panels is about (4571)m$^2$ as the area of each board is 2 m$^2$.

The two forms (10oop) show the performance of solar panels during the months of the year.



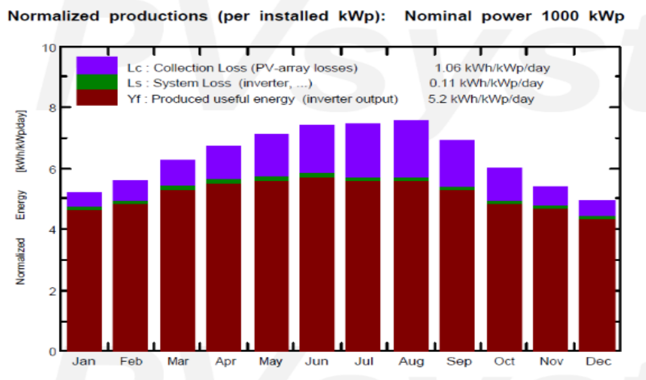




**Fig. (10): Monthly performance of solar panels, B- Energy produced during the months of the year**

### 2.3.3 Capital and operational cost

The economic simulation of the system was carried out by using prices for panels and accessories according to local markets. the capital costs were calculated (CAPEX 508864$/Mwt) as in Table (2) and Figure (11), while the operational cost, which is equivalent to 10% of the capital cost and estimated at about 506 68$/year if the system is operated during daylight hours

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without the need for batteries (on grid), in other hand, when the energy stored in batteries (off grid), the cost of batteries are added to total capital cost, which reach to 1610464$/Mwt, while the operating cost becomes 161104$/year.

**Table (2) Capital costs of capex solar system**

| parameter | no | unit cost, $ | total cost,$ |
|---|---|---|---|
| **PV** | 2272 | 130 | 295360 |
| **inverter** | 2 | 50000 | 100000 |
| **battery** | **4080** | **270** | **1101600** |
| **transport** | 3 | 6000 | 18000 |
| **frame** | 2272 | 22 | 49984 |
| **wiring** | 114 | 200 | 22800 |
| **setting** | 2272 | 10 | 22720 |
| **total** | | | **1610464** |

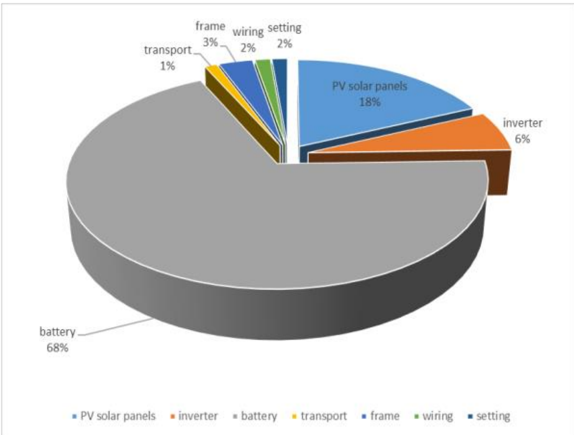


**Fig. (11): CAPEX Capital cost of the solar system**

## 2. Carbon Emission

The shift from fossil fuels in energy production to alternative sources as well as its economic feasibility is important for environmental conservation. The amount of carbon emission per kilowatt of energy using conventional fuel ranges from (0.3-322) grams$CO_2$ per kWh depending on the traditional fuel type used.

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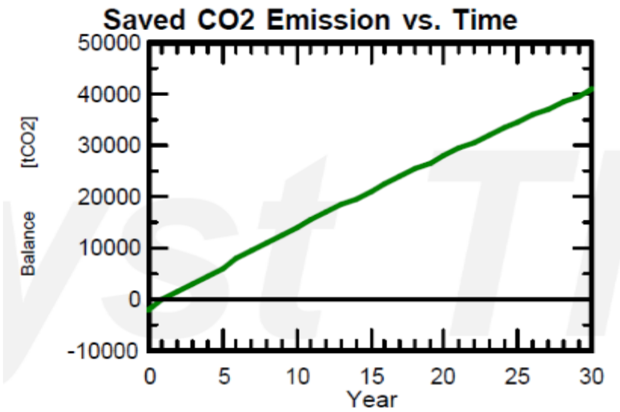


**Fig. (12): Carbon dioxide emissions**

## 2.4 Solar System Costs Compared to other Energy Sources

Capex diesel generators cost between $800,000 and $900,000 for a maximum operating capacity of 1Mwhas shown in Table (3) and Figure (13).

**Table (3) Capital cost of various sources of electricity**

| Capital cost $/MWh | Energy sources |
|---|---|
| 1000000 | **Investment stations** |
| 800000 | **Diesel generators** |
| 508864 | **Solar System (ON GRID)** |
| 1610464 | **Solar System (ON/OFFGRID)** |

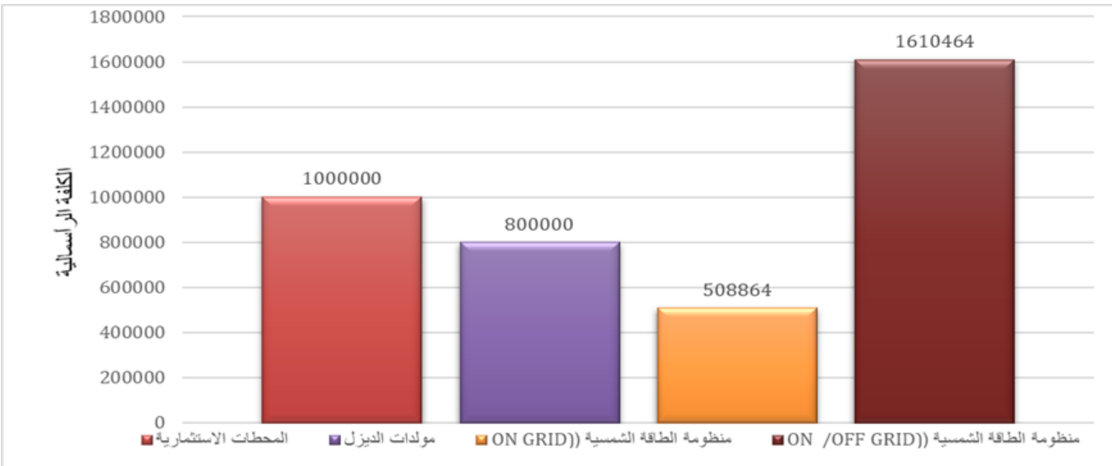


**Fig. (13): Comparing the capital cost of solar energy with other sources of electricity**

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Calculate the operational cost of diesel generators by calculating the cost of the consumer of fuel for generators with a production capacity of 1Mwt, and 24 hours of operation for a full year using the following equation:

$$E\,(kWh) = P \times h \times d \quad .... (1)$$

$$E\,(kWh) = 1000 \times 24 \times 365 = 8760000$$

$$C(liter) = E \times Ckwh \quad ... (2)$$

$$Ckwh = fuel\ load\ (\frac{lit}{hr})/P \quad ... (3)$$

$$C(liter) = 8760000 \times 0.19 = 1664400$$

$$Cost = fuel\ price\ \left(\frac{\$}{lit}\right) \times C \quad ... (4)$$

$$Cost\ (\$/yr) = 0.4 \times 1664400 = 665760$$

Where; E = active electric energy in output of the diesel engine in kWh P = active electric power in output of the diesel engine in kW h = number of hours per day the genset runs d = number of days the power generator runs. $C_{kwh}$ = Consumption of fuel per kWh (usual value is between 0.3 and 0.6 l/kWh) C = Consumption of fuel in liter [22]

Through the equations above, the operating cost, which includes fuel only, is $665,760/year, which is equivalent to $665,760/year per kilowatt without taking into account maintenance and extinction costs. Figure (14) shows the extinction factors for investment plants, diesel plants and the solar system, as investment plants are usually gas-fuel-based generators.

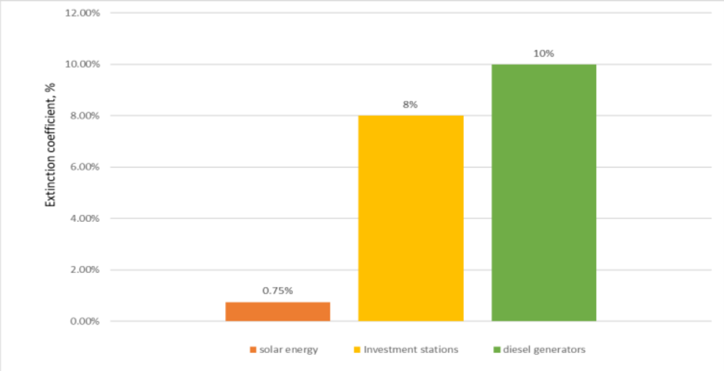


**Fig. (14): Comparing the extinction factors of the solar system and other sources of electricity**

Table (4) and Figure (15) show that the operating cost of solar energy about 81% lower than the cost of government electricity supplying, 75% less than the operational cost of diesel generators and 51% less than the operational cost of investment station that depend on fuel from the beneficiary. The operational and capital cost of the solar system is reduced by less than half

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when operating only during daylight hours and without reliance on batteries, where batteries are the main factor in increasing the costs of the solar capital and operational system.

**Table (4) Comparison of operational cost between different sources of electric power**

| **Power source** | **Operating cost** ($/kWh) |
|---|---|
| National Processing | 0.1 |
| Gas generators (fuel only except oils, generator extinction, maintenance work) | 0.076 |
| Gas generators (fuel, oils, generator extinction, maintenance work) | 0.17 |
| Solar System(ON GRID) | 0.0057 |
| Solar System(ON-OFFGRID) | 0.0183 |
| Investment plants (government fuel processing) | 0.038 |
| Investment plants (fuel processing from the investor) | 0.1 |

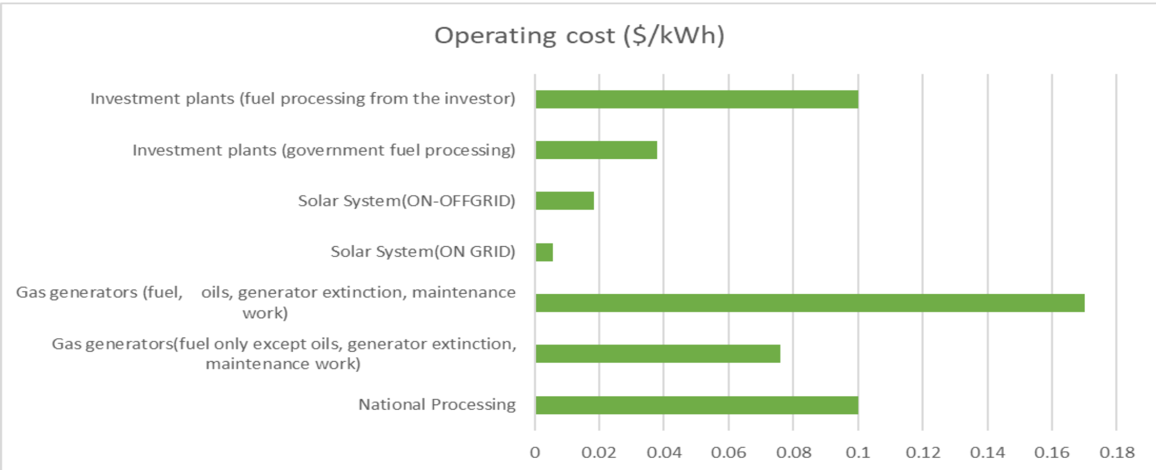


**Fig. (15): Comparing the operational cost of solar energy with other sources of electricity**

From calculations, the possibility of compensating the capital cost of the photovoltaic system after approximately nine years as shown in Figure (16), which refers to the net profit from the solar system resulting from the saving of fuel costs in addition to the significantly reduced operating cost.

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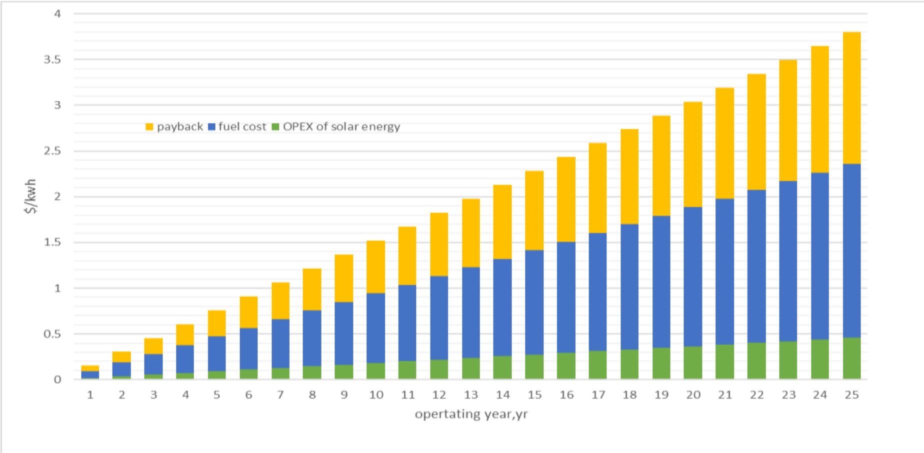


**Fig. (16): Net profit for the solar system**

Table (4) shows the trade-off between two projects (solar energy system and gas generators) by calculating net income or revenues and calculating net present value through equations below:

Sales revenue = annual production capacity *operating cost

Project extinction = project cost /project life

Net profit before tax = sales revenue - project demise

Net return after tax = net profit before tax – tax, Net current value =net income/(1+ discount rate%)^project life

Table (4) Net income or proceeds and current value.

In addition, LCEO (Levelized Cost of Energy) has calculated the energy cost standard, which is used as a standard and assessment of the cost of energy sources. Through the equation below:

LCEO=sum of cost over lifetime/sum of energy produced over life time.

**Table (4) Net return, current value and energy cost standard**

| | Investment plants (fuel processing from the investor) | Investment plants (government fuel processing) | Gas generators (fuel, oils, maintenance work) | Thegas generator only includes fuel. | Solar System(ON GRID) | Solar System(ON-OFFGRID) |
|---|---|---|---|---|---|---|
| Revenue Sales $ | 876,000 | 332,880 | 1,489,200 | 665,760 | 49,932 | 160,308 |
| Extinction $ | 100,000 | 100,000 | 80,000 | 80,000 | 64,418 | 64,418 |
| Net profit | 776,000 | 232,880 | 1,409,200 | 585,760 | 14,486 | 95,889 |

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| | | | | | | |
|---|---|---|---|---|---|---|
| before tax | | | | | | |
| Net return after tax if found$ | 776,000 | 232,880 | 1,409,200 | 585,760 | 14,486 | 95,889.44 |
| Current value | 0.74 | 0.22 | 1.34 | 0.56 | 00000 | 0.0000 |
| Standard energy cost $/kwh | 0.34 | 0.28< (Fuel cost also added) | 0.34 | 0.24 | 0.21 | 0.22 |
| Recovery period | | | | | | 1.54 |
| Internal rate of return | | | | | | 0.077 |

The results indicate:

- Economically Good: The solar project is better and good for the following reasons:
    1. The solar system is used for a period of 25 years, while the generator is only 10 years, meaning that the government will bear a double cost once and a half if the diesel generator is selected within a period of 25 years and in return the beneficiary will have additional costs and expenses added to the total cost of the generator.
    2. LCEO energy cost standard value drops
    3. The solar system is environmentally friendly and does not need fuel or materials that harm the environment in addition to noise absence
- Good accounting: The diesel generator project is better because it achieved more revenue (net flow is higher) but it is not economically considered the reasons above and the goal of the government unit is to provide the best modern non-profit service

Power station emit many gases such as carbon oxides and nitrogen that affect the climate, and the amount of carbon dioxide emissions depends on the type of fuel used in power plants as shown in Figure (17). On the other hand, the solar system is environmentally friendly, it does not

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produce any harmful residues, and solar panels have shown that it does not produce any harmful emissions.

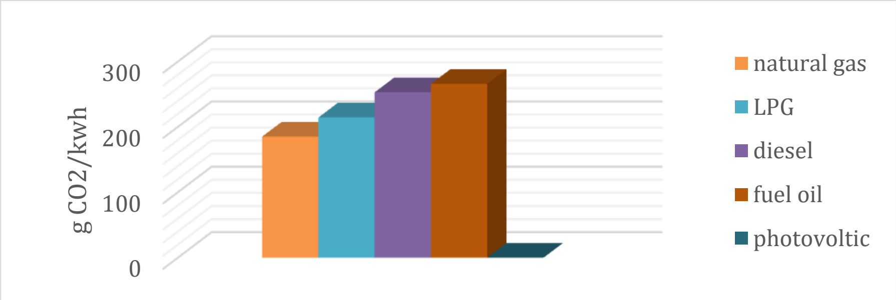


**Fig. (17): Carbon dioxide emissions from different energy sources by fuel type**

## 3. Conclusions

1- The presence of oil fields in open spaces, far from cities and long daylight hours makes them more suitable for installing solar systems.

2- The sharp decline in the costs of installing and operating solar systems has made it an important source of energy and competitive with other and traditional renewable energy sources.

3- Many countries, especially the Middle East, have resorted to the use of renewable energy, especially solar systems in the oil fields, to form a source of energy in addition to a source of steam generation and the promotion of oil production, as in Oman and Kuwait, and there are studies in Libya and Egypt on their adoption in the oil fields.

4- Simulation programs give a preliminary and future view of solar systems in terms of cost and quality in addition to the space required for installation and environmental conditions and according to the requirements of the project to be applied in them. He found the possibility of applying the solar panel system in Iraq and in very competitive terms with the cost of traditional energy sources (diesel generators and national processing).

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