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Renewable Energy Resources in Iraq: A Review

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Abstract

Depending on fossil fuels such as crude oil is becoming a big environmental and economic dilemma. Fossil fuels release carbon oxides which hurt the environment by forming greenhouse effect which leads to the global warming and climate change. Moreover, countries over the world and especially Iraq use the crude oil and natural gas daily which makes this fuel expensive and threatened to be stopped one day. In this study, a simple review focuses on renewable energy as a clean and cheap energy that they could be recommended to use safely in Iraq. In conclusion, the renewable energies are the optimal solution to avoid the increased cost of the crude oil and reducing the risk of the environment pollution.

Key words: Renewable Energy, Iraq Resources, Bioenergy

1. Introduction

Fossil fuels emissions represent the most dangerous effect on the environment globally because it forms the greenhouse effect which is the main reason of the climate change and/or the global warming [1, 2]. Therefore, this study will focus on Iraq as one of the growing countries over the world and because of its depending on fossil fuels in providing the energy. Table 1 shows percentages of the various types of fuel with respect to the total fuel usage in Iraq [3, 4].

Table 1: Iraqi fuel consumption with respect to the total usage

Year	Oil (%)	Natural Gas (%)	Hydro-electric (%)	Renewable Energies (%)	reference
1980	9	1	0.1	0	[5]
2010	32	6	0.4	0	[5]
2017	75.58	23.36	1.062	0	[4]
2018	71.51	27.37	1.304	0.19	[3]
2019	66.8	31.8	0.91	0.46	[4]
2020	75	37	0.5	0.1	[5]
2035	92	66	1.2	0.4	[5]

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In this table, it is shown that the use of crude oil is increasing rapidly except the period between 2018 and 2019 where the depending on natural gas increases. It displays also the natural gas increased because the governmental roles of using the excess natural gas instead of rid of it.

Before 1990, there were 32 thermal and hydropower stations have been operated to generate about 10.2 GW which exceeding the country demand [6]. In reality, the wars destroyed about 90% of the ability of power production [7]. The period from 1990 to 2003, 24% of the total demand in Iraq of the electricity has been produced by using hydropower source [8]. After 2003, the electric power crisis started when the demand increased rapidly and the production decreased because the war and the unsteady life situations [9]. To overcome this problem, Iraq started importing the electricity from its neighbors [10]. Table 1 also showed a slight contribution of the renewable energy resources compared to the fossil fuel in the power production.

Iraq has sunny weather most of the year and mostly windy especially during winter and autumn. Also, it has offshore and wide planted regions for biomass energies. The present study is an attempt to review the possibility of applying each type of renewable energies in Iraq by displaying the advantages and the disadvantages of each type. Therefore, this review aims to increase the understanding of the renewable energies as efficient and sustainable energy resources. Therefore, it will receive more attention. Understanding the importance of the renewable energies is a good path to reduce the dependency on fossil fuel and reduce the possibility of environment damage.

2. Importance of using the renewable energy in Iraq

1. Iraq is one of rich country in term of renewable energy choices. Iraq has solar weather most the time, wide areas are perfect to be considered as wind turbine fields, two long rivers with mountains are perfect for hydropower, good areas with forests which are good to be used as Bioenergy.

2. Iraq depends on fossil fuels currently but this energy resource is threatened to be stopped one a day. With increasing of electricity demand, the republic of Iraq is expected to produce the electricity from the renewable energy about 222 GW.

3. Renewable energies are contributing in preserving the environment by reducing the pollution because the renewable energy is easy to use and clean.

4. Most countries which incorporate in OPEC plus union are turned to renewable energy production because it sustainable and long term supporting to their economy more than the fossil fuels.

3. Renewable Energy Resources

The ministry of electricity in Iraq, Renewable Energy Center has been established to focus on solar and wind energy as the main resource of power in Iraq.

Kazem and Chaichan [11] reviewed and discussed the current and future exploitation of renewable resources in Iraq. They showed that the solar, wind and biomass energies are not being used sufficiently in Iraq currently. Moreover, offshore wind energy at the southern part of Iraq at the Arabian Gulf is not investigated well.

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In the next section, up to date types of the renewable energies will be reviewed. The principle of operation, advantages and disadvantages of each type will be outlined here to increase the people awareness about the renewable energies and understand its cheapness and sustainability.

3.1. Solar Energy

The climate variety of Iraq is characterized by a hot weather through summer months (June, July and August) where the temperature differs from 43 to 50 ^{o}C while the weather during winter months (January, February and March) is moderated with temperature rounded by 1 to 8 ^{o}C [12, 13]. The irradiation rate is measured as 6.5 to 7 kW-hr/m^2. Moreover, the brightness of sun is ranging from 2800 to 3300 hr/year. These features of weather in Iraq give the country an excellent qualification to exploit solar energy [14].

Solar energy represents one of the best and great sources of energy over the world. It is green and renewable energy because of the massive amount of the energy that transfer from the sun to the earth daily. It can be harvested through photo-voltage panels or directly by the solar power plants [15]. Iraq represents a good sunny country compare to other regions because of the large deserts which covers about 30% of the total lands of Iraq. Figure (1) shows the sunny regions distribution in Iraq.

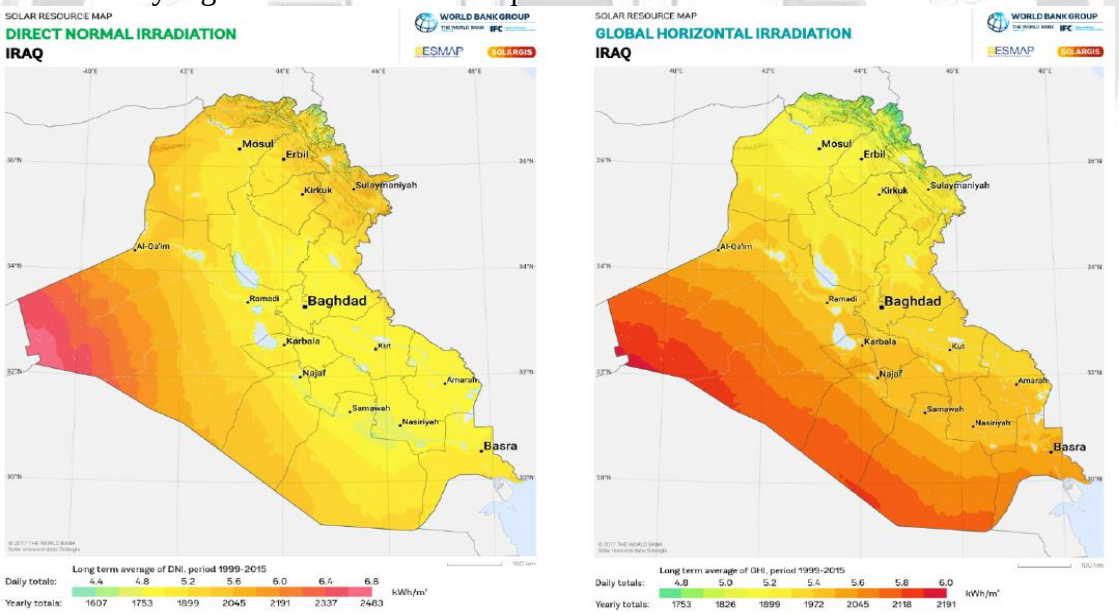

Figure (1): Solar irradiance distribution in Iraq [16]

Iraq can collect more than three thousands hours of solar energy. The radiance varies from 416 W/m^2.hr in January to 833 W/m^2.hr in June [17] compare to the average global horizontal irradiance (170 W/m^2. hr). In spite of this large amount of energy, harvesting of waste heat through solar resource did not get efficient attention and needs more interesting to utilize it.

Currently, numerous reports talk about using solar energy widely in Iraq and some scientists say that the Iraqi people have the enough knowledge about this type of resource to be ready to avoid depending on fossil fuels [18]. Moreover, the ministry of electricity of Iraq took the first step about establish solar power plants in many of Iraq to provide about 755 MW by the end of 2020 and invited the solar power companies to take part with this trend

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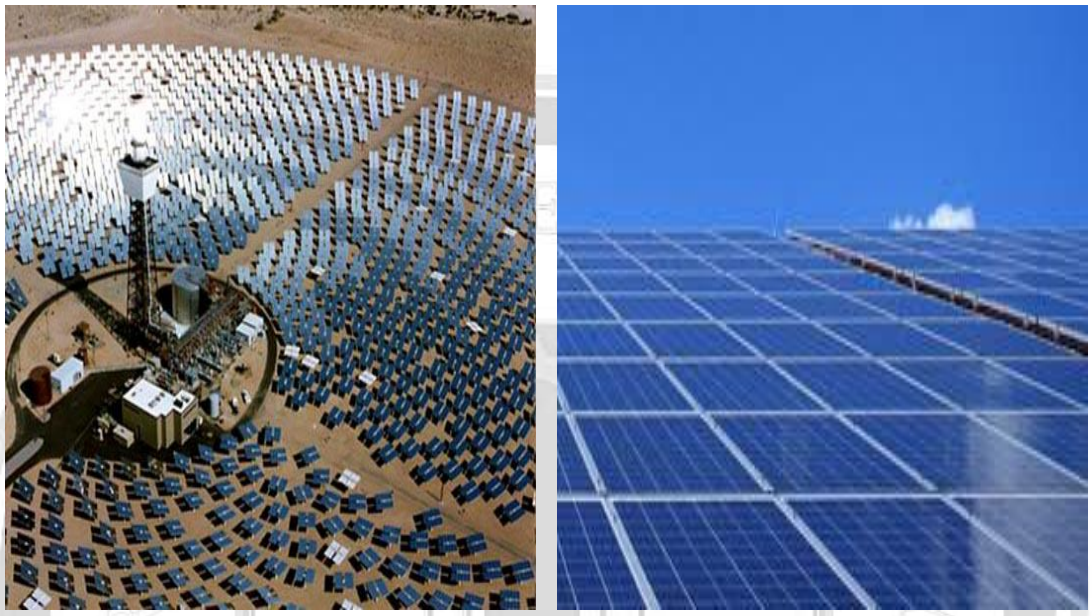
[19]. Solar energy can be used in many applications including the cooling and electricity production indirectly through the panel collector or reflectors fields as shown in figure (2a) or directly as in the using of solar panels in figure (2b)



(a) (b)

Figure (2): Using of solar energy a) solar collectors b) solar panels

It is easy to lustrate the using of solar energy relates to its application as in the figure (3).

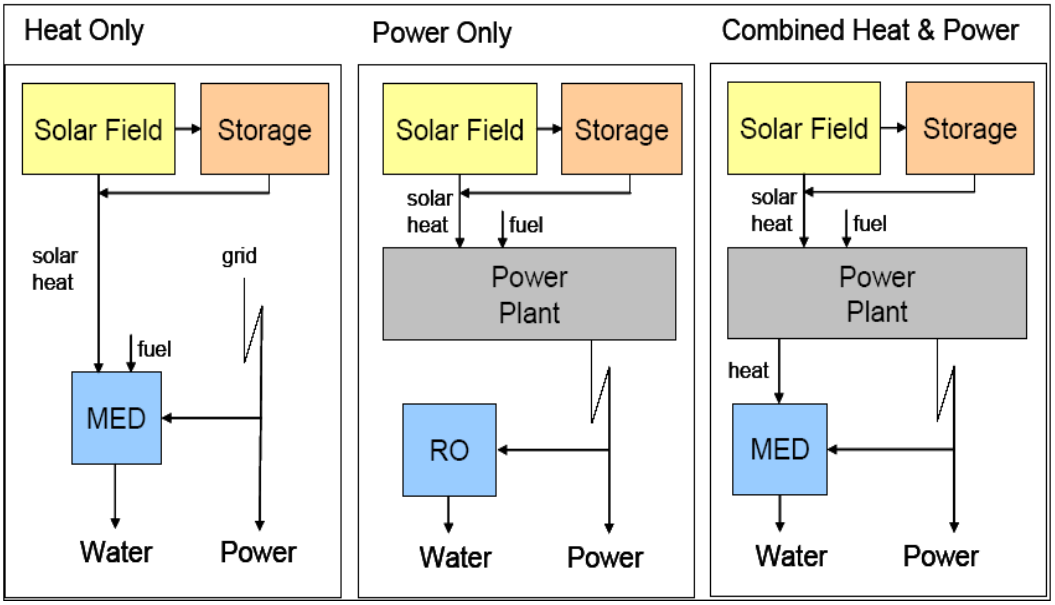


Figure (3): The various applications to the solar energy [20]

New strategic agreement with the Iraqi government to develop the solar energy projects to generate at least 2 GW by 2030 [21, 22] is promoted by an international company called International renewable energy and sustainability in 2022. Through this agreement, Iraqi

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government intended to increase and enhance the clean energy production in central and southern parts of Iraq.

Maan [23] reviewed the applications of solar energy in Baghdad which is the capital governorate of Iraq. The review focused on the possibility of using several applications, such as domestic heating water to reduce the electricity consumption in winter, thermal storage, solar ponds, concentrated solar power and photovoltaic panels.

There are many advantages about using solar energy in Iraq which are given below [24]:
1. It has not emissions so solar energy will be perfect technology to stop increasing the global warming and avoid the climate change.
2. It could be used in whole days of the year including cloudy times where lower amount of energy can be produced.
3. It can be return back to the company in case of there is an excessive amount.
4. There are no limitations about the locations in which they are installed.
5. Solar energy efficiency can be improved more than the other conventional methods to produce the energy.

However, the solar energy has many disadvantages, such as:
1. High initial cost for the materials and the installation
2. High power requests need to use wide panels or collectors since the efficiency is not high. In fact, it is only 13% now.
3. Needs for large capacity batteries to store the lightly time to be used at night.
4. With the advantage in point (4) above, it still depends on the geographic location of the installation.
5. Low production of the power in winter session.

In conclusion, the solar energy as free and sustainable source, still good choice in spite of the many disadvantages. Many researchers worked on the design of the solar collector [25, 26, 27, 28, 29], it could be referred for more information.

3.2. Wind Energy

It represents the most important energy resource as renewable and clean energy. The wind turbine is the main part of the wind energy station because the turbine is the responsible of converting the kinetic energy of the flowing air (the winds) to mechanical energy and then to electricity via an armature as shown in figure (3).

a b

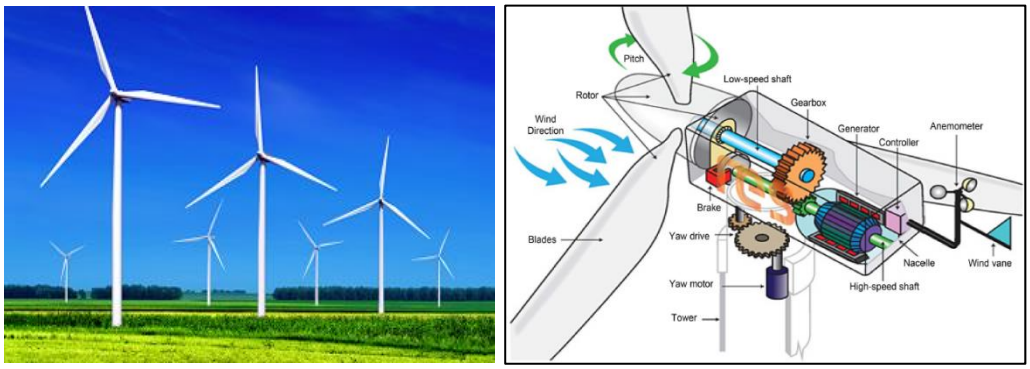

Figure (3): Wind turbines a) farm [30] b) schematic construction [31]

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Several researchers worked on wind turbine and tried to improve the efficiency and suggested some recommendations about this energy resource. Wind turbines can be established offshore and on shore according to the rate of wind. It is found that the offshore energy produced is more than the onshore one because the sustainable wind blowing.

In the literature, many researchers studied the possibility of using wind turbine in Iraq [32, 33]. Bashaer et al. [34] investigated and analyzed the wind energy over selected locations in Iraq. They developed a MATLAB code to analyze and select the optimal location based on the minimal cost per kWh production or according to the maximum efficiency of the wind turbine station. The code is named by "WIND ENERGY ANALYSIS". By this program, the authors are able to study the wind speed, correlated the analysis coefficients and display complete details about Weibull distribution parameters based on standard deviation and energy pattern methods, so that they can select the optimum wind turbine for specific location depending on maximum power generation and the cost of each kwh of the electricity.

Wind energy has the advantage and disadvantage same as other energy resources but it can be seen that the positives are more than negatives, the advantages of the wind energy are [35]:

1. It is fairly free energy and unlimited to be provided.
2. It is an occurrence naturally because it is just a harvesting to the kinetic energy of the flowing air and it has no effects on the currents or the cycles.
3. It is zero emissions and eco-friendly resources for electricity.
4. It is a safe way to use.
5. It could be installed wherever needed and especially offshore places where the sustainability of wind blowing more than that on the lands.

In fact, there are two major disadvantages in the working in wind energy which are:

1. It is expensive to construct the turbines and the wind facilities.
2. It is still encountered an experience shortage of this technology.

The other minor disadvantages are:

a. Many people think that the wind turbine blades will have bad effect on the beauty of the nature and one will focus of these machines more than the surrounding nature.
b. The wind turbines have a serious risk on the animals where they can easy kill the birds and no information available about their effect on the marine animals yet.
c. For efficient results about the electricity production, wind turbines are installed in the empty places outside towns because the turbine noisy and this is advantage for safe operation but it will be expensive for maintenance missions and dangerous somehow when the maintenance happens offshore.

3.3. Hydro Power

Hydropower represents one of the renewable energy resources that is clean and sustainable as the water falls from the high level to low level. As shown in Figure (4), this type of energy resource has been used in Iraq since the ancient ages of Mesopotamia and Babylonian civilizations [36] until now.

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Figure (4): Hydro power wheel using in the ancient ages [37]

Hydropower energy is a good choice to be used in energy crises or the pollution of the environment which are happening from the growth increasing in economy and population such as Chine [38]. In 1988, however, the Iraqi ministry supported studies about the feasibility of using hydropower resources. Table 2 showed the important hydropower plants which are built since 1959 and their overall capacity about 2.5 GW.

Table 2: important hydropower plants in Iraq [39]

Location	Water source	Produced Power (MW)
Mosul	Tigris	1050
Haditha	Euphrates	660
Dokan	lake	400
Derbandikan	Diyala	249
Samarra	Tigris	84
Hamrin	Diyala	50

However, this capacity is reduced to about 1.3 GW because of the decreasing of water levels behind the dams because the policies of using water for irrigation working [39]. This type of energy covers the tidal and river energies.

3.3.1. Tidal Energy

It is one of the most important types of the renewable energies for the regions which are near to the seawater or occasions. It uses the motion of the water in a tidal aspect to generate electricity. Iraq country lies on the Arabian Gulf in the governorate of Basra. Many locations have been studied to investigate the possibility of establishing tidal power stations. Main locations have been studied numerously are Um Qasr and Al-Faw [40]. The power generating volumes of Um Qasr location were about 98.85 and 197.7 MW in case of one and two ways generation while the power generation of Al-Faw location was 31.4 and 62.73 MW for same conditions of generation [41]. The basin area which was undertaking in the study is 4 km^2 only, if basin area is enlarged to 8 km^2, this requires to double turbine number and this leads

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to multiple the power generation of one case by four times because of the two way generation is twice the one way case usually [41] .

3.3.2. River Energy

Slightly improvement has been displayed in the using of hydroelectric power plants via hydro-turbine but it decreased afterward because of the water rivers problem with neighbor countries. Iraq represents the unique country that has two long rivers and too many sub-rivers. The rivers originate from the foothills in the north of the Islamic Republic of Iran and Turkey. Many agreement have been signed between the countries in which the river flows through their lands to share the water between them [42], this is a good idea to build dams to exploit the rivers in Iraq efficiently to produce the electricity via hydropower plants.

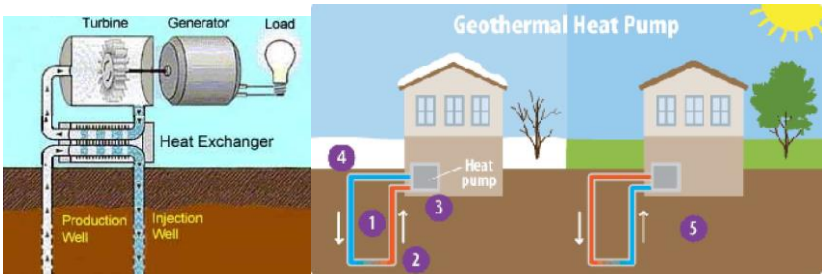
Iraq has two rivers: Tigris and Euphrates. These rivers are starting flow from Turkey and Syria. They enter Iraq and continue flowing until ending in Arabian Gulf finally. Through years of the past century, many dams and canals have been built on these rivers for irrigation and electricity production especially in 1960s. the electricity generated by these two rivers is about 11.35 GW [43] by installing 32 dams. Moreover, 8 dams are under construction and 13 more are planned to build to increase the volume of electricity production [44]. More information about these types of hydropower energies are found in reference [45]. The advantages of the hydropower are:

1. High efficiency and reliability.
2. Low operation and maintenance expenses with easy to use.
3. Has the ability to be adjusted according to the input water level change.
4. It is zero emission resource
5. It can be installed beyond dams, water flow gates and downstream of the reservoirs.

The main disadvantages of Hydropower energy are the high initial cost and its bad side effect on the nature, and people housing places. It can increase temperature of the flow and the pressure drop will be a risk to the houses and the changing in water levels can hurt the marine animals and fishes as well.

3.4. Geothermal Power

It is defined as the energy that stored under the earth surface such as the heated slugs in a volcano. This heat can be used to turn on the power plants such as steam turbine to produce the mechanical energy which is turned to electricity through the generators as shown in Figure 5 a and b



a **b**

Figure 5: Using Geothermal Source a) Electrical Power Generation [46] and b) heating houses [47]

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The temperature of the geothermal heat is depending on how deep is it. On average increment, the temperature of the soil will increase in rate of 25 ^{o}C for each one kilometer of depth [48]. Figure (6) shows the relation between the temperature and the depth from the outside earth surface.

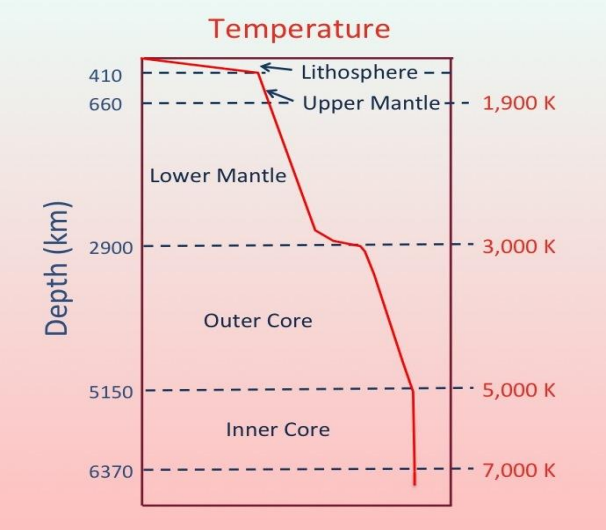

Figure (6): Geothermal temperature vs depth from the earth surface [48]

Italy is the first country that used the geothermal energy in the 1900th [49] then passed through a tunnel of research and development in the USA until current time, so the United States represents the main leader in the using of geothermal energy. US turns on about 77 plants over its lands and the plant at Geysers is largest one [50]. In 2010, the international geothermal association displaced a report showed the total production of 25 countries about 10.72 GW which could be used to generate 67.25 GW per hours of electricity [51] while the reports confirmed that the capacity of the geothermal will form about 75% of the total production of energy by 2018 [52]. Table 3 shows the geothermal production of 12 countries over world.

Table 3: The Pioneer countries in geothermal production [46]

Country	Iceland	Philippines	Salvador	Costa Rica	Kenya	Nicaragua
N.P.%	30	27	25	14	11.2	10
Country	New Zealand	Indonesia	Mexico	Italy	USA	Japan
N. P. %	10	3.7	3	1.5	0.3	0.1

N.P.: National production

In this table, the countries of Iceland, Philippines and Salvador are the pioneer countries in using the geothermal energy where the national production is 20%, 27% and 25% respectively. On the other hand, Thailand is the country with the lowest rate of production.

3.4.1. Advantages of the Geothermal Heat source:

1. The steam is available in geothermal power station because of the underground water which is usually liquid at high temperature. As the water flows upwardly near the surface of the earth, it temperature will cool down, this will turn the liquid into steam at high pressure which is fitting to use in driving the turbine blades.

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2. Free cost for region with low temperature.
3. Small size and simple structure comparing to other steam turbine power plats

3.4.2. The Disadvantages the Geothermal Heat source

1. It is very dangerous to work near volcanoes and it is costly for these unsafe places.
2. The generated power is far away from the consumers, so that, it needs to additional station for storing and/or transmitting.

3.5. Bioenergy

Nowadays, bio-energies or biofuel energies play dominant roles as common renewable energy resources that can be used for different life sectors, such as transportation, agricultures, and electric generation. These utilities can be achieved through gathering the biological and chemical energies. This promising energy sources aimed to solve the weather critical issues as well as solved the sharp fossil traditional depletion.

The electricity production is majority of direct combustion process which depends on solid fuel. Combustion is a chemical reaction and produce heat or thermal energy that use directly or indirectly in thermal machine called an engine simply [5].

Biomass can be defined as a renewable energy that is produced from live things such as the plants materials or their wastes that are predicted by animal beings such as the animal manure. These materials are called the “biofuel”. These materials or biofuel materials are renewable because they can be formed during a certain limited period in contrast of the fossil fuel which needs to Millions of years to be formed.

Actually, plants growth and the continuous waste of human beings are the reason of considering the biomass energy will not be finished and will be renewable.

3.5.1. Biofuel Types

There three types of biofuels are:

3.5.1.1. Solid Biofuels or biomass

They can be also called as biomass. They are in reality solid slugs producing energy through their combustion. This type of biofuel covers animal and plants wastes, such as the wastes of sugar and juice factories. Coal, garbage, dried shells of seeds and the woods are including in solid category too.

3.5.1.2. Liquid Biofuels or bio-oils

They are representing any kinds of liquids that can be used as a biofuel such as the diesel fuel which is produced from the animal and plant fats, pure plant oils, ethanol that produced from corn seeds and B-series which is new fuel that produced from the connection of the ethanol by some materials from garbage manufacturing.

3.5.1.3. Gas Biofuels or Biogas

This type of fuel is released from plants defective and the animal wastes such as Methane which represents the main component of the natural gas. Future works focus on Methane that produced from garbage as an efficient way to product hydrogen. Hydrogen is useful to operate the fuel cells which are the devices those convert the hydrogen into electrical power and pure water.

a) Advantages of the Biofuels

1. Environmental friendly and renewable.
2. Cheap and easy to product it nationally.
3. Can reduce the garbage pollution.
4. It can be used with other types of fuels easily.

b) Disadvantages of the Biofuels

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1. By continuous depending on the woods or plant wastes, biofuel will reduce the plantation areas and increase the desertification phenomenon.
2. Not available in everywhere over the country.
3. It still needs to be mixed with the fossil to operate machines because the impossibility to fully depending on biofuels.
4. No whole machines can be operated by using the biofuel without further design modifications.
5. This type of fuel has the sustain problem of moisture which decreases the combustion efficiency of the fuel.

4. Conclusion

Expensive resource of energy such as the fossil fuel led the researchers to look for sustainable energy resources such as the renewable energies. Iraq is one of the country that does not use the renewable energy effectively and entirely because the availability of crude oil wells everywhere. Depending on fossil fuel have some consequences such as pollution. Pollution with greenhouse gases is the main dangerous to the environment.

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مصادر الطاقة المتجددة في العراق: مراجعة

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الخلاصة

أصبح الاعتماد على الوقود الأحفوري مثل النفط الخام معضلة بيئية واقتصادية كبيرة. يطلق الوقود الأحفوري أكاسيد الكاربون التي تضر بالبيئة من خلال تكوين تأثير الاحتباس الحراري الذي يؤدي إلى تغير المناخ. علاوة على ذلك، فإن دول العالم وخاصة العراق تستخدم النفط الخام والغاز الطبيعي يوميًا مما يجعل هذا الوقود غالي الثمن ومهدّدًا بالتوقف يومًا ما. تتضمن هذه الدراسة، مراجعة بسيطة للطاقة المتجددة كطاقة نظيفة ورخيصة يمكن التوصية باستخدامها بأمان في العراق. وخلاصة القول إن الطاقات المتجددة هي الحل الأمثل لتلافي التكلفة المتزايدة للنفط الخام وتقليل مخاطر تلوث البيئة.

الكلمات الدالة: الطاقة المتجددة، موارد العراق، الطاقة الحيوية.