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Investigating the Efficiency of Employing Renewable Wind and solar Energy in Generating Electrical Energy

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ABSTRACT
This study aims toinvestigate the efficiency of employing renewable wind and solar energy in generating electrical energy. The methodology used is a qualitative methodology based on last studies, books, and papers. The results of this study show that the world dependence on wind and solar energies has grown in a fast way because they have many benefits such as lower bad effects on the environment and its components also it depends on minimal utilize of natural resources. Moreover, they support the minimization and reduction the costs of the supply chain, Take a place in the development and modification of energy efficiency. In addition, they support the minimization of the irregular fluctuations of prices and its spillovers, Participates in the development of the living standards, and Support the reduction of the bad impacts on humans and the environment. However, the efficiency of wind and solar power still in low values because many factors having a big role on it, such as the amount of solar irradiation, the wind speed, the initial cost of installation, the installation area of these systems, and the season or the time of the year. On the other hand, solar energy has the fastest-growing type of renewable energy, that increasing yearly by percent reached 8.3%. However, the use of renewable energy in electricity generation is still in low percent reached to 20% and the most amount of electricity is generated by burning fossil fuel, which has very bad effects on the environment and increases greenhouse gases emissions.

Keywords: Sun,Energy, Wind, Renewable, Electrical,Efficiency,Generation.

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I. INTRODUCTION

Nowadays, there is a big global needing for large amounts and new sources of energy to meet the requirements of the fast population growth. currently, the main source of energy used in the world basically depends on fossil fuel, which is nonrenewable source of energy that has high efficiency in power production such as petroleum, natural gas, and coal, this type of nonrenewable energy have a very bad effects on the environment and the atmosphere also it will be depleted shortly. However, many factors must be taken into consideration in the use of sources of energy such as environmental effects, efficiency, stability, cost, and cleanliness. The world is trending today toward renewable sources of energy such as solar, wind, hydropower, geothermal, biomass, tidal energy which can be obtained from a limitless source, have high efficiency in energy production, sustainable, and have clean effects on the environment(Shahzad, 2015).

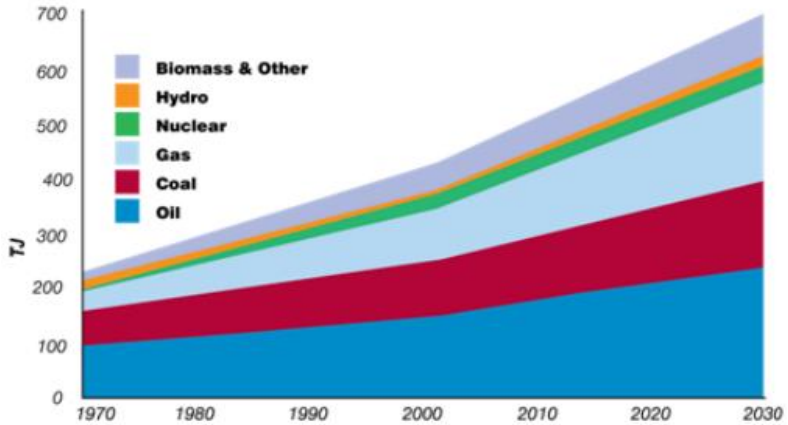


Figure (1): World Predominant Energy Supply(Bujac, 2011)

Figure (1) shows World Predominant Energy Supply and that indicates the large dependency of the world on fossil fuel source of energy and the limited use of other renewable sources of energy.

currently, the Renewable energy supplies the world with18% of the total electricity generation so The Effective use of renewable energy will provides the world with the needed energy production and decrease the use of fossil fuel shortly or Eliminates it. One type of these sources is the solar energy that obtained by using heat and photovoltaic engines in electrical energy production, and the second type is wind energy that depend in natural airflows in the run of wind turbines to produce electrical energy(Shabbir, Siddiqui, Salman, Abdullah, & Abrar, 2010).

According to the importance of the above information, this paper will investigates the efficiency of employing renewable wind and solar energy in generating electrical energy.

Problem and questions

This study aims to investigate the efficiency of employing renewable wind and solar energy in generating electrical energyby answering the following questions:

1. What is electrical power generation?
2. What is the solar energy?
3. What is the wind energy?
4. What is the efficiency of solar energy in generating electrical energy?
5. What is the efficiency of wind energy in generating electrical energy?

II. METHODOLOGY

The methodology used in this study is qualitative, based on other studies, books, and articles.

Electrical power generation

Electricity is an important part of modern life and very essential for every country because it used in every step in life such as cooling, heating, lighting, refrigeration. In addition, it can be used in transportation systems, and for operating appliances such as machinery, electronics, and computers. However, the need for electricity is increasing around the world with time and the amount of electrical power must be produced is increasing too. on the other hand in the united states only the amount of electricity used in 2018 around 16 times greater than the amount of electricity used in 1950. Different types of power generation systems are used to generate electricity, these systems differ in the amount of electricity generated with the dependence on the source of energy. Figure (2) shows the amount of electrical power produced in the United States by major energy sources such as (U.S EID, 2019):

- Petroleum.
- Renewable energy.
- Nuclear energy.
- Natural gas.
- Coal.

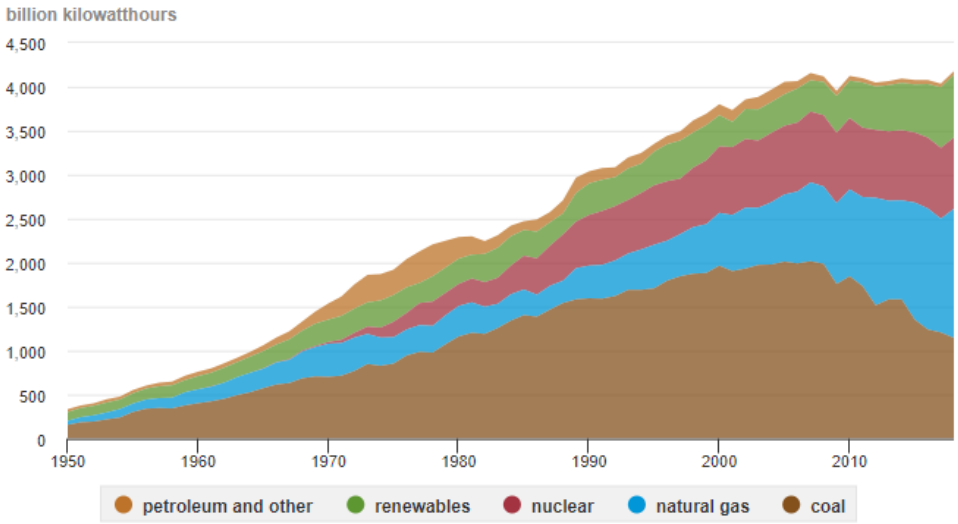


Figure (2): United States electricity generation by major energy sources (1950-2018) (U.S EID, 2019)

The traditional methods in electricity generation that depends on fossil fuel are not sustainable, so the use of sustainable sources that can guarantee sufficient, reliable, safe, and clean electricity supply may save our world from the effect of greenhouse gases and the global warming. Additionally, the use of these sustainable sources may have many benefits such as(DEUTSCH, 2018):

- have low bad effects on the environment and its components such as soil pollution, water, and air,

also it depends on minimal utilize of natural resources such as resource needs, land usage, primary energy

- The solutions used in these systems are eco-friendly.
- Support the competitiveness and the development of the market entry and the markets.
- support the minimization and reduction the costs of supply chain
- Take a place in the development and modification of energy efficiency.
- Support the minimization of the irregular fluctuations of prices and its spillovers.
- support the equality between the generations.
- Participates in the development of the living standards.
- Support the reduction of the bad impacts on humans and the environment.

The electrical power plants can use renewable and non-renewable sources of energy to operate it , alltypes of electricity generation technologies are classified below(SCHINKE, et al., 2017):

1. Solar power technologies (renewable).
2. Wind power (renewable).
3. Hydro-electric power(renewable).
4. Nuclear power (renewable).
5. Coal-fired power (non-renewable).
6. Gas-fired power (non-renewable).
7. Oil-fired power (non-renewable).

In this paper,the renewable solar and wind power technology will investigated in details also all factor that may affect the efficiency of these systems in electricity generation will investigated too.

Solar energy

Electricity can generated by solar radiation using two groups of solar technologies. The first one is Concentrating Solar Power (CSP), which works by using the energy captured from solar radiation in the production of heat the use of a conventional thermal cycle to convert heat into electricity. And the second one is Photovoltaic (PV) cells which produce electricity directly from solar radiation. However, these two methods are described below(SCHINKE, et al., 2017):

- Photovoltaic (PV) cells

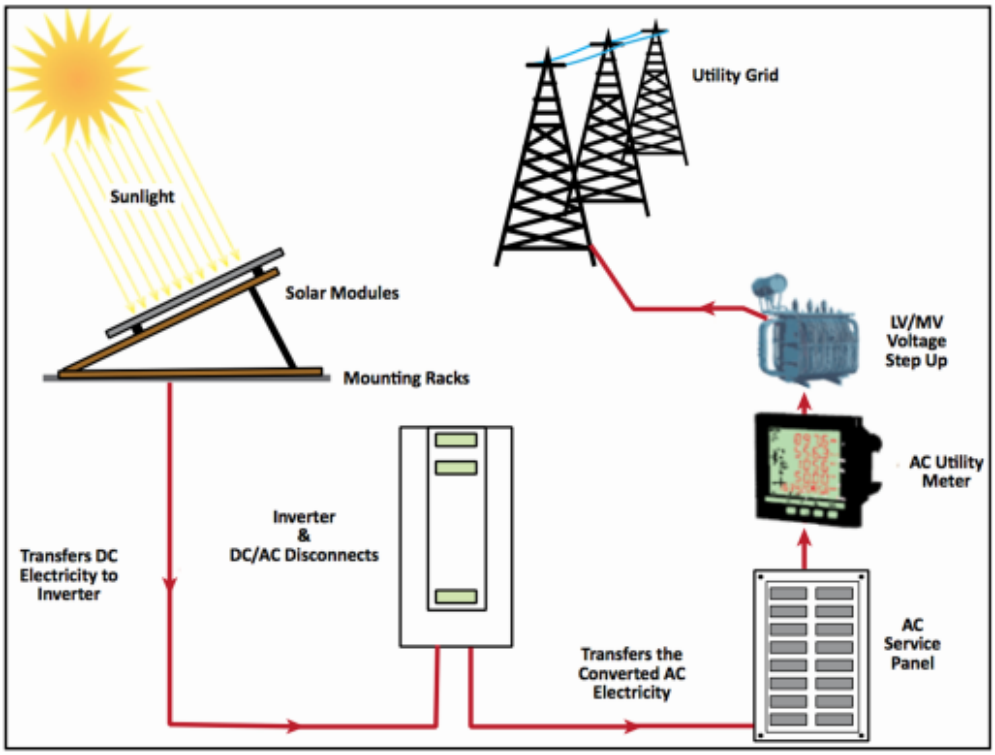


Figure (3): Schematic overview of a PV power plant (SCHINKE, et al., 2017).

These cells produce electricity directly from solar radiation by utilizing semiconductor materials in order to exploit the photovoltaic effect33. additionally, this process does not need moving parts in its operation also it can work in cloudy days with an acceptable efficiency by using diffused and direct solar radiation34 to make its operation. These cells are combined in parallel or in series together to form a panel or PV module in order to make higher voltage.The PV technologies are classified into three groups according to their commercial maturity and basic materials used as shown below:

1. First-generation PV systems: the type of material used in this system is crystalline silicon (c-Si) wafers that can be either polycrystalline silicon (multicrystalline, mc-Si)wafers or monocrystalline silicon (single crystalline, sc-Si) wafers. the cells that composed of polycrystalline silicon the most commonly used type in the world by a percent reached 90% regardless it has lower efficiency PV systems formed from c-Si (see Figure 4) but also they are cheaper to manufacture.
2. Second-generation PV systems: this PV system manufacturing process is based on depositing a thin layer (thin-film) of photosensitive substance on a cheap substrate. the distinguish of thin-filmm technologies can be done using their main families like copper indium (gallium) diselenide (CIGS), copper indium selenide (CIS), cadmium telluride (CdTe), and micromorph silicon (a-Si/µc-Si) and amorphous (a-Si). Second-generation PV systems are cheaper than first-generation PV systems but have lower efficiency(see Figure 4).
3. Third-generation PV systems: this type of system is in a pre-commercial stage and it needs more research and development. these cells are composed of organic solar cells, dye-sensitized solar cells (DSSC), and Concentrating PV (CPV). this technology can offset the high costs by give a higher efficiency than other PV systems.

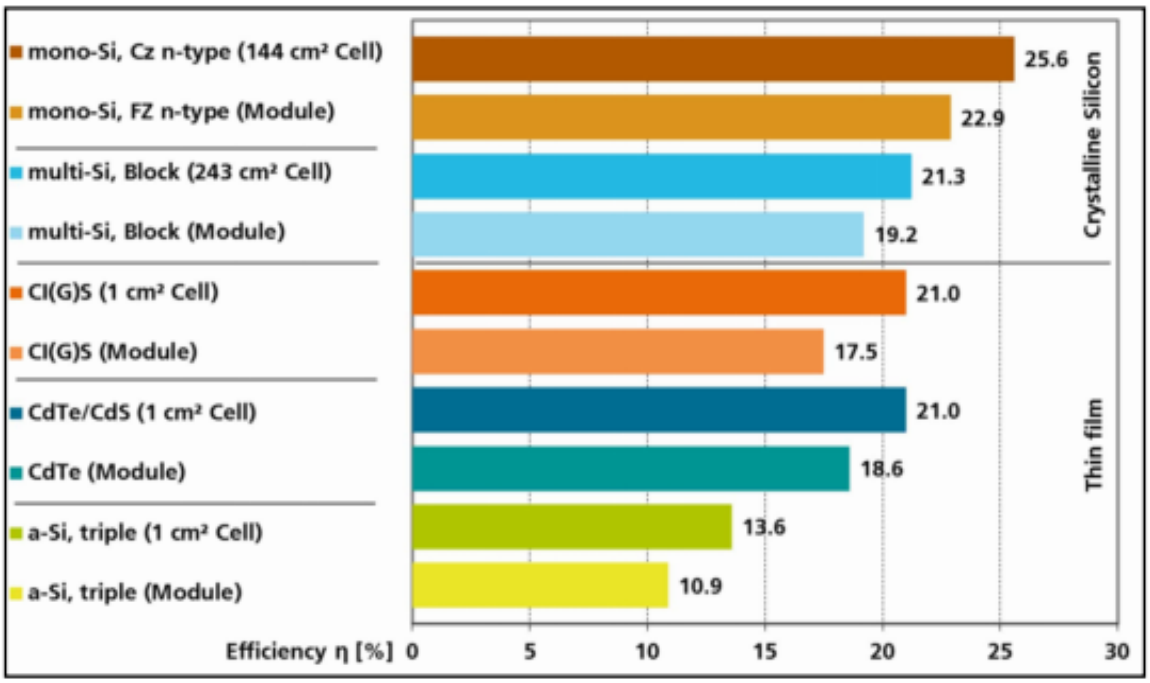
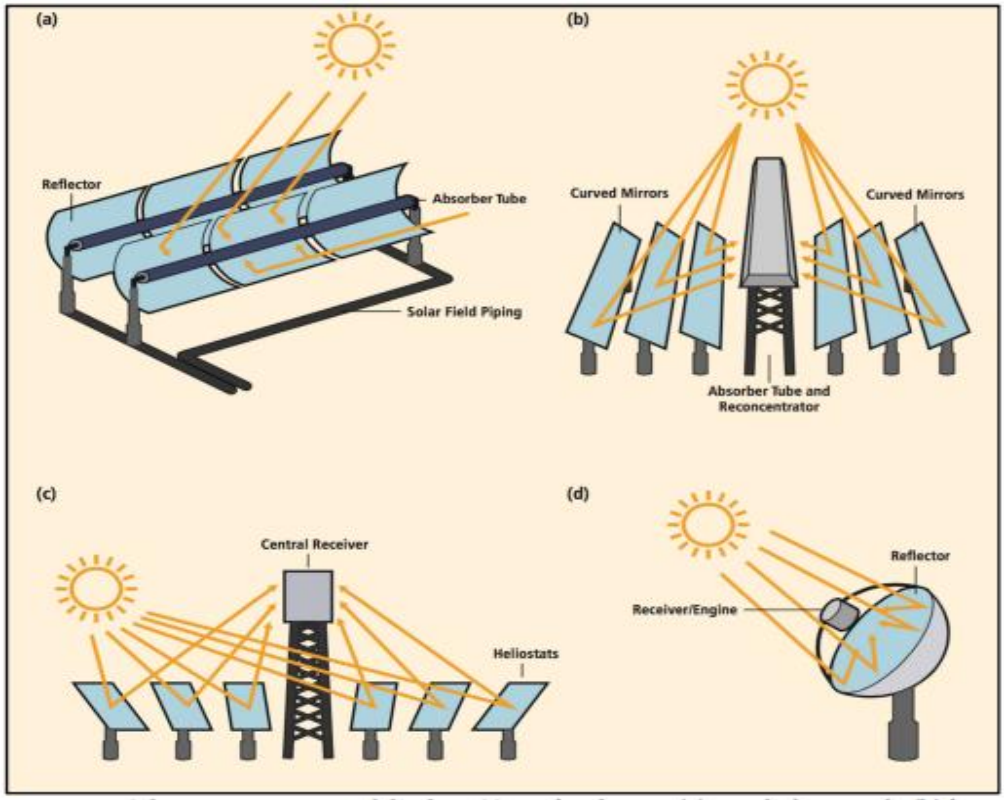


Figure (4): Efficiencies of crystalline silicon and thin-film based PV cells and modules.

Concentrating Solar Power (CSP)

The process of operation of this system is based on a collection of mirrors with different types of CSP technology that concentrate and reflect the solar radiation toward a specific receiver. this receiver will collect all solar radiation and convert it into thermal energy, then the thermal energy will transformed using a steam turbine into mechanical energy at the end the mechanical energy will generate electricity using a generator. this system works only in the presence of the direct ingredient of sunlight so it will have difficulty in the days with full with clouds so is basically used in the global sunbelt that included parts of China, Australia, the southwestern United States, South Africa, and the MENA-region. CSP technologies are classified according to the way used in the concentration of solar radiation into the receiver as mentioned below(see figure 5):

- Parabolic Trough Collector technology
- Linear Fresnel Collector systems
- Central Receivers
- Dish-engine systems



Figure(5): Schematic overview of the four CSP technologies (SCHINKE, et al., 2017).

Many important points that pertaining to the solar power plants using CSP technology are(Ahmadi, et al., 2018):

1. The feeding of thermodynamic cycles by the high-temperature inputs will give a high electricity generation efficiency.
2. Concentrated solar power uses the direct ingredient of solar radiation but the reflected and diffuses ingredient of solar radiation will be lost.
3. The Concentrated solar power will act excellently in the location with elevated magnitudes of Direct Normal Irradiation (DNI).
4. The Concentrated solar power needs high capital cost so it does not suitable for the power generation system in small scales.

The advantage and the disadvantage of utilizing the solar power technology in electrical power generation are mentioned below(Shaikh, Waghmare, Labade, Fuke, & Tekale, 2017):

- There are many advantages of solar energy such as:

1. It can reduce the energy cost with percent reached 20%.
2. In can use in different location even in Remote Locations.
3. Its process of installation easy because it does not need any cord or wires.
4. It can be installed and generate electricity for every commercial user or domestic users because it is not limited to space in the area.
5. It does not need an additional amount of fuel it just needs sunlight.
6. It does not have moving parts in its installation.
7. It is renewable and eco-friendly.

- The disadvantages of solar energy are :

1. It will not produce electrical energy in the absence of sunlight or solar radiation.
2. The initial cost of installation is high.
3. In the application of alternating current, there is a need for an inverter and a mean of storage at night.
4. The use of single silicon crystals in PV systems Production is time, energy consuming and technically challenging.

Wind energy

Wind technology is working by Exploit the wind kinetic energy in moving the turbines. Most of these turbines are composed of three blades fixed in the horizontal axis at the topmost of a tower; these blades are connected to a roter, which is connected to a shaft that moves the generator in order to produce electrical energy (see figure 6). The wind turbines generation capacity varies from one to another because it depends on the blade length and hub height but most of them can produce 2 kW to 8 MW. Additionally the higher hop heights of the turbine can guarantee the existence of consistent and faster wind speeds(Logan, et al., 2017).

The modern and new wind turbines can have 600 kW to 5 MW of total rated power. However, the power output of the tower turbines depends on the many factors such as(Shabbir, Siddiqui, Salman, Abdullah, & Abrar, 2010):

1. The cube of the wind speed: As the speed of the wind, increases the power output of turbines will increases.
2. Area: the turbines need areas with stronger, faster, and more constant wind flows to work efficiently, such as high altitude sites and offshore.

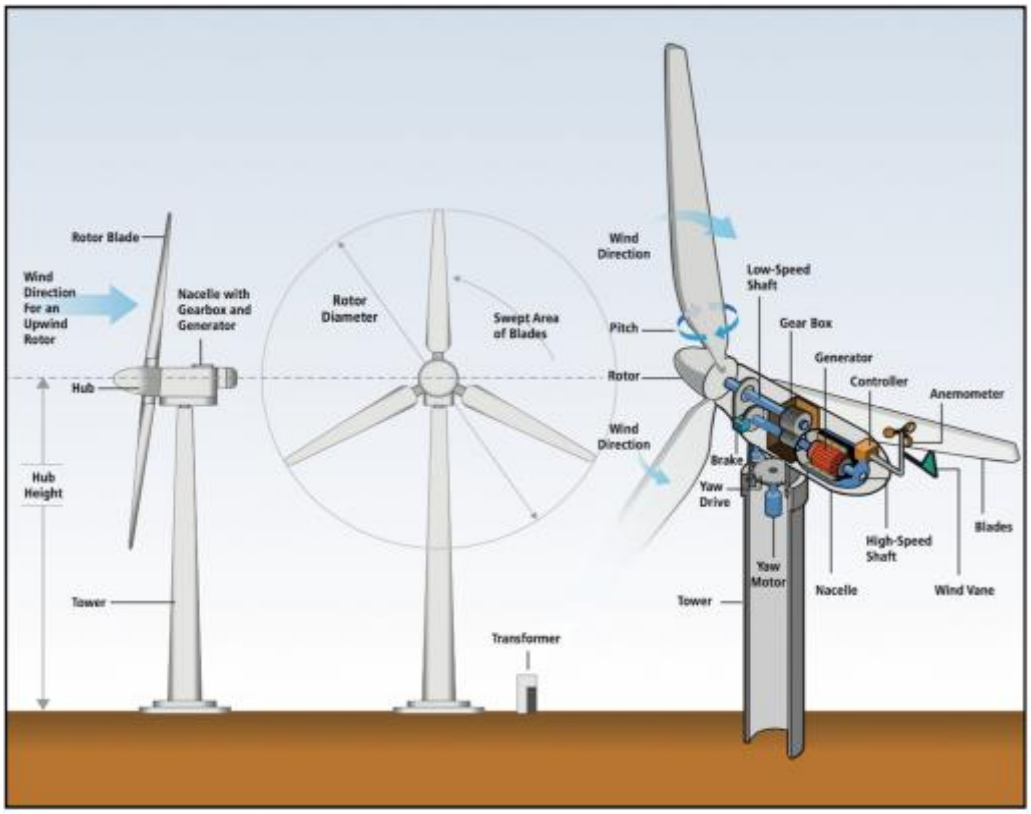


Figure (6): Schematic overview of a wind turbine (SCHINKE, et al., 2017)

The installation of the Off-shore wind farms are more costly than the on-shore, but it has higher potential efficiency due to the wind speed difference between the off-shore and on-shore areas. Wind power systems are classified with a dependance on many factors such as(SCHINKE, et al., 2017):

1. wind turbines orientation such as Horizontal axis wind turbine, which is the most common and dominant type and Vertical axis wind turbine that have a negligible share in electrical energy production and are fully mature and commercial.
2. Their grid-connection type (standalone or connected), the standalone systems used in the small-sized layouts in remote areas.
3. Number of technical aspects like the rotor placement and type, blades number, the design of the gearbox and the hub connection to the rotor.

There are many benefits in utilizing the wind energy in electricity generation as mentioned below(U.S. DEPARTMENT OF ENERGY , 2015):

1. Wind energy systems are cost-competitive compared with other fuel sources.
2. Wind energy can creates chances for jobs.
4. Wind energy systems can give economical revenues for ranchers and farmers, and provide the communities with economic profits.
5. The wind energy system is a renewable source of energy.
6. In wind energy system, Wind turbines do not need water, so there is no water consumption.
7. Wind energy is clean energy.
8. The costs of operation for Wind energy systems is low.
9. Possibility of utilizing of Wind energy in many applications.

Investigating The Efficiency of Employing Renewable Wind and solar Energy in Generating Electrical Energy

Through a study done by (Tripanagnostopoulos1, Souliotis, & Makris, 2017)about "Combined Solar and Wind Energy Systems" they install a small wind turbine (WTs) and Photovoltaics (PV) on buildings. They noticed that

the maximum value of irradiance was in July where it reached 555.06 Wm-2 and the minimum value reached to 262.79 Wm-2 in December, and the overall efficiency of the Photovoltaics (PV) subsystem was 6.1%. On the other hand, the mean conversion efficiency of the small wind turbine (WTs) was 5.7% So the amount of electrical power generated depends on the time of the year (see figure 7).

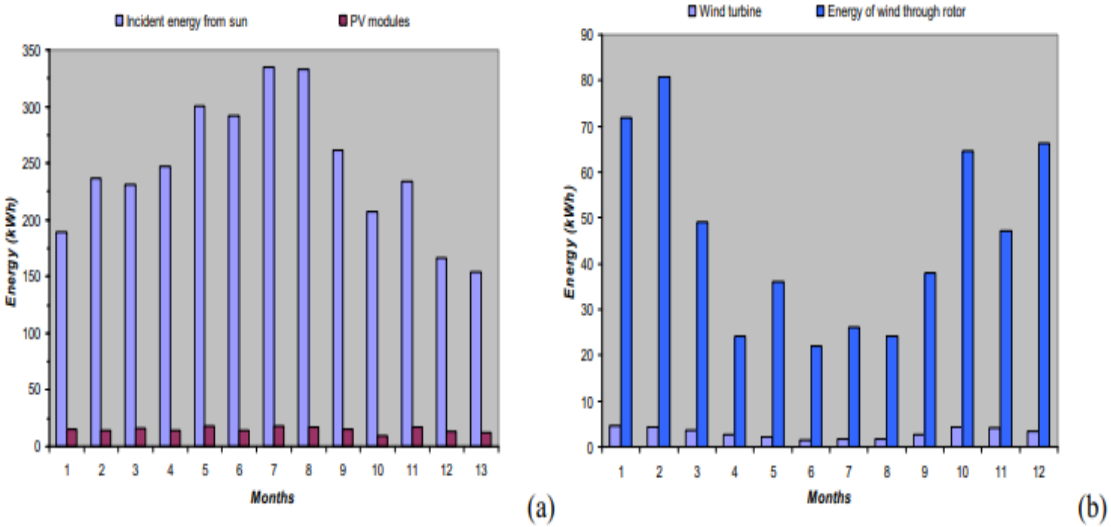


Figure (7): (a)-(b) Total generated energy from PV module and wind turbine(Tripanagnostopoulos1, Souliotis, & Makris, 2017).

According to U.S Energy Information Administration, all renewable energy sources contribute with 20% of the total United States electricity generation. However, the wind energy system contributes with 7% and the solar energy system contributes with 2% of the total the United States electricity generation, and the other renewable systems such as hydropower, biomass, and geothermal power Plants contribute with 11%(U.S. Energy Information Administration, Electricity in the United States, 2019).

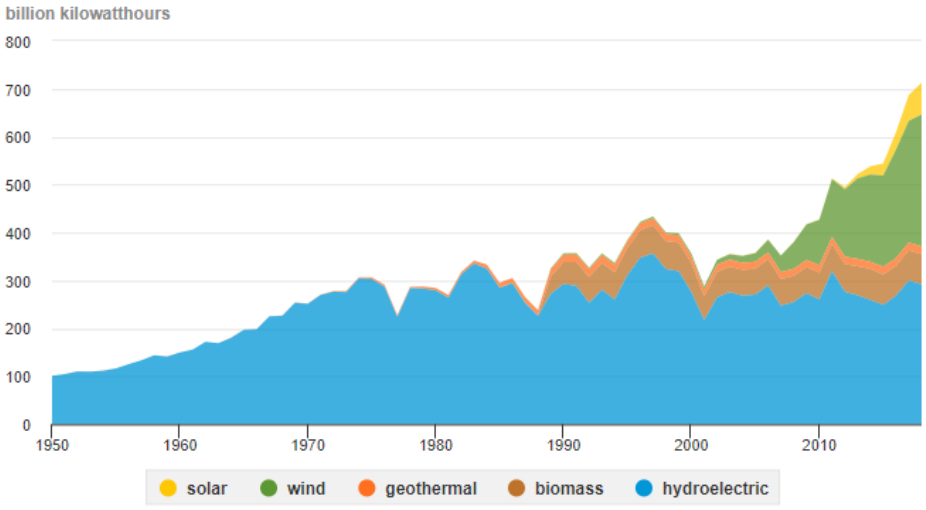


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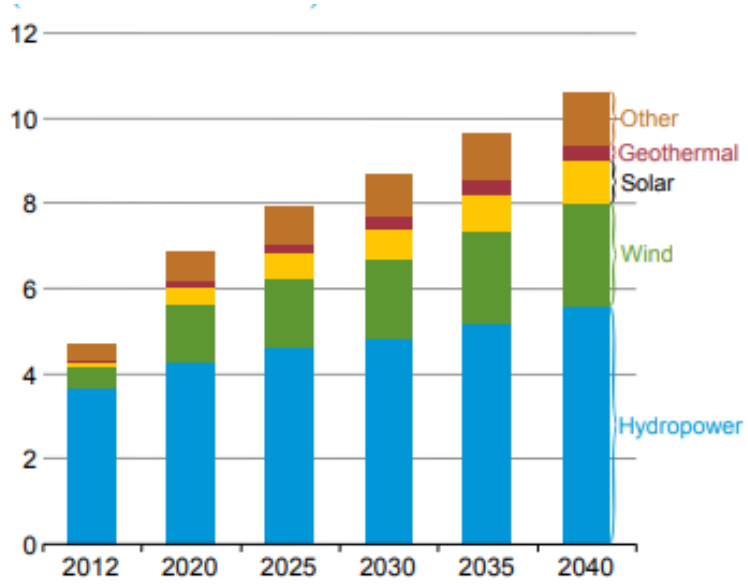
Figure (8): (1950-2018) electricity generation from renewable energy sources.

Renewable energy sources shares are growing in fast way in total electricity generation in the world. However, the renewables rise the total electricity generation yearly by 2.9%, as the renewable energy sources contribution of world electricity generation increases from 22% in 2012 to 29% in 2040. On the other hand, solar energy has the fastest-growing type of renewable energy that increasing yearly by percent reached to 8.3%. (U.S. Energy Information Administration, 2016), figure (9)

show the World net electricity generation from renewable power by fuel, 2012–2040 (trillion kilowatthours).



Figure(9): World net electricity generation from renewable power by fuel, 2012–40 (trillion kilowatthours).

Table (1): Renewables Comparison Wind vs. Solar Energy(U.S EID, 2019).

Energy source	Solar	Wind
Durability/ Maintenance	Minimal maintenance. Predicted 30-year life span.	Gearbox type requires annual maintenance. Predicted 20-25 year life span.
Location/Integration Options	Location have little limitation. Must be facing the Sun	Must be located in more than 500 feet high. Must be located in remote areas unfavorable in urban areas.
Noise	Silent system	Produces very bad noise and it can be bothersome near houses.

III. CONCLUSIONS AND RECOMMENDATIONS:

In this study, many sections used to investigate the efficiency of employing renewable wind and solar energy in generating electrical energy. The first system discusses the electrical power generation system. The second section discusses solar energy technology and the types of solar technology used in generating electricity. The third section discusses the wind energy technology, and the last section investigates the efficiency of employing renewable wind and solar energy in generating electrical energy. The research found out that the world dependence on wind and solar energies has grown in a fast way because they have many benefits such as lower bad effects on the environment and its components also it depends on minimal utilize of natural resources. Moreover, they support the minimization and reduction the costs of the supply chain, Take a place in the development and modification of energy efficiency. In addition, they support the minimization of the irregular fluctuations of prices and its spillovers, Participates in the development of the living standards, and Support the reduction of the bad impacts on humans and the environment. However, the efficiency of wind and solar power still in low values because many factors having a big role in it, such as the amount of solar irradiation, the wind speed, the initial cost of installation,the installation area of these systems, and the season or the time of the year. On the other hand, solar energy has the fastest-growing type of renewable energy, that increasing yearly by percent reached 8.3%. However, the use of renewable energy in electricity generation is still in low percent reached to 20% and the most amount of electricity is generated by burning fossil fuel, which has very bad effects on the environment and increases greenhouse gases emissions.

Based on the above results it recommended to have more studies about the efficiency of

renewable wind and solar energy in generating electrical energy.

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