Solar Energy as a Solution for Iraq's Power Outages

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Othman Hassan
Department of Electrical -Electronics Engineering
Karabuk University
Karabuk, Turkiye
232813108@ogrenci.karabuk.edu.tr

***Abstract*—Iraq is facing a shortage in electricity supply during the summer months. The current work analyses this energy crisis and its significant impact on citizens, which has started in more last three decades. The study focuses on getting the benefit of solar energy to provide a sustainable energy source to the country. It addresses the fundamentals of solar energy, its suitability in the Iraqi context, and how it could drive transformative change in the energy industry. In addition, the environmental and economic impacts of the use of solar energy are assessed and a comprehensive perspective is provided on its impact on Iraq. In this study, we discuss the solar system as a whole and the challenges we may face due to natural effects**

Keywords— solar energy, photovoltaic (PV), Iraq

I. Introduction

After the American invasion of Iraq, Iraqis suffered from constant power outages, especially in the summer. Iraqi governments have spent billions of dollars to solve the electricity problem, but due to corruption in the administration, successive governments have been unable to solve this problem. The Iraqi government expressed hopes in May 2014 regarding its plan to increase electricity generation by 8,000 MW, reaching a capacity of 20,000 MW by December 31, 2015, to ensure 24-hour power supply. Importantly, the Ministry of Electricity admitted a grid loss of over 8,000 MW. Although Iraqi nationals typically have a maximum of five to eight hours of daily power supply under the best conditions, as noted, they are concerned about the ministry's recent commitment to increase production to 12,000 MW by summer 2015 [1].The shortage in electricity supply in Iraq is a long-standing problem where the electricity struggled for many years. The persistent imbalance between energy demand and supply in Iraq, in turn, led to an estimated annual loss in the Iraqi economy of $40 billion. In addition, the growing need for electricity associated with a daily cut of energy for up to five hours, is a widespread problem [2]. Accordingly, with the current world's transformation towards renewable energy, by the use of natural phenomena including sunshine, wind, rain, ocean waves, and tides, renewable energy such as solar photovoltaic technology is an important solution to the Iraqi energy crisis. This includes the use of both small, off-grid solar systems and large, grid-connected solar infrastructures. It can be used as a power source of variety systems such as vehicles, heating water pumps, lights, solar-powered cars, trains, and many other systems [3]. In Iraq, the use of photovoltaics remains low despite the country's great solar energy prospects. The absence of strong government policy and financial incentives hinders homeowners from installing solar panels on their homes and motivate the development of large-scale projects by investors[2]. The Ministry of Electricity has outlined a forward-looking strategy to meet over 25% of the country's future electricity needs from renewable sources. The goal is to expand the power grid by 500 to 1,000 megawatts annually. Achieving this goal requires increased legislative and regulatory efforts.

II. The Location And The Claimt of Iraq

A. *Iraqi location*

Iraq is located in the Northern and Eastern Hemispheres of the Earth at coordinates of 29°5' N - 37°22' N latitude and 38°45' E - 48°45' E longitude in the south-western part of Asia.. Baghdad, which is 34 m above sea level, is the capital of Iraq and is located at coordinates 33.3406° north latitude and 44.4009° east longitude[5].

Fig. 1. The location of Iraq republic

B. *The weather of Iraq*

Iraq has weather conditions that are due to the subtropical climate and are characterized by long, dry summers and a wet winter season. There are two main weather conditions in Iraq: an unbearably long summer with high temperatures and a very short winter with moderate to bitter temperatures. Precipitation is negligible over a four-month period and does not exceed 15 millimeters in the remaining warm months of the cycle.There is a wide range in temperature difference between winter and summer in Iraq. For example, in January, the temperatures are between 7°C and 12°C with moderate snowfall observed in the mountainous areas. While in July, the temperature sometimes reaches over 50 °C [6].

C. *The population growth in Iraq*

Iraq's growth rate is one of the fastest in the world. Population numbers show that Iraq's population has grown from about 3 million people in 1927 to 39.5 million people in 2020. Because of this, Iraq needs to make more energy to meet its growing energy needs.

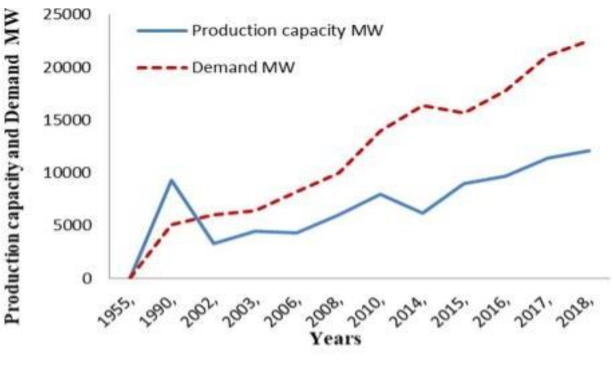

Fig. 2. Electricity production and demand in Iraq [8]

TABLE I. POPULATION GROWTH RATE ESTIMATION [3]

Year	Population (million)	Growth rate (%)
2003	26	5.4%
2005	27.1	2.6%
2006	28.1	3.2%
2007	29	3.3%
2008	29.8	3.1%
2009	30.7	2.4%
2010	31.7	2.3%
2011	32.67	2.3%
2012	33.45	2.3%
2013	34.22	2.0%
2014	35	2.0%
2015	35.81	2.0%
2016	36.81	2.0%
2017	36.52	2.0%
2018	37.25	2.1%
2019	38.76	2.0%
2020	39.53	2.0%
average		2.7%

III. THE ELECITRICITY IN IRAQ

Many countries, such as Iraq, have established electricity generation systems as part of their economic framework. The disruption to Iraq's energy system was influenced by military activity in the country that has been ongoing for two decades. Likewise, the conflict has negatively influenced the structure of the system over the past three decades. Accordingly, cumulative production in 1990 averaged 9,300 MW. However, global economic sanctions were imposed following Iraq's invasion of Kuwait in August 1990, and subsequent military actions in Kuwait invasion damaged most of the power grid. This reduced The overall capacity of available power connection to just 340 Mega W. Some efforts to rebuild the electric power system were made between 1992 and 2002, but were destroyed in 2003. Therefore, the current status is that the country only supplies electricity for 12 hours[7]. Solar systems could therefore be a solution to the current electricity problem in Iraq.

IV. PV SYSTEM

A. Angles of the sun

Various definitions of angles can be employed to ascertain the relationships between direct solar radiation and the orientation of a plane on Earth. The computation of solar energy for an inclined plane in the Northern Hemisphere involves the use of angle measurements, namely beta and gamma. Figure 3 demonstrates that the solar azimuth angle and solar elevation angle together fully describe the position of the sun. Sun angles are formed by the position of the sun and the Earth's surfaces, creating connections between these angles.. [9-10].

B. Radiation from the sun

Nuclear fusion, which takes place in the sun's core and turns hydrogen gas into helium, is the source of solar energy. A measurement of 1370 Watt/m² was made of the solar irradiance that is measured above Earth's atmosphere. But because of atmospheric effects, the amount of solar energy received might vary from zero to one hundred hundred W/m² when it reaches Earth's surface.. Thus, even a minuscule fraction of this energy source At its 150 million kilometer distance from the Sun, Earth receives energy at a rate twenty thousand times higher than our yearly energy requirement. Atmospheric reflection accounts for roughly 30% of solar radiation, whereas absorption accounts for around 50%. As a result of this absorption, the surface of the Earth warms, making it an ideal environment for life. Patterns of wind, precipitation, and ocean currents are all directly influenced by solar energy. The number ten.

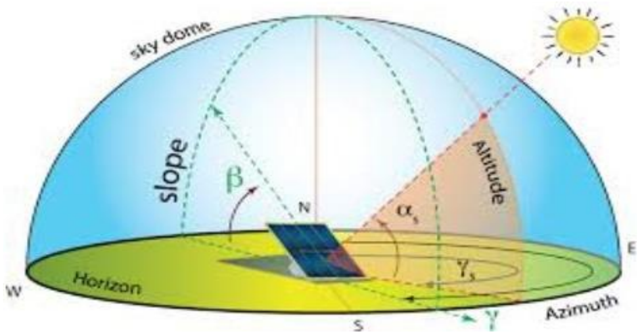

Fig. 3. The sun's rays at various inclinations [9]

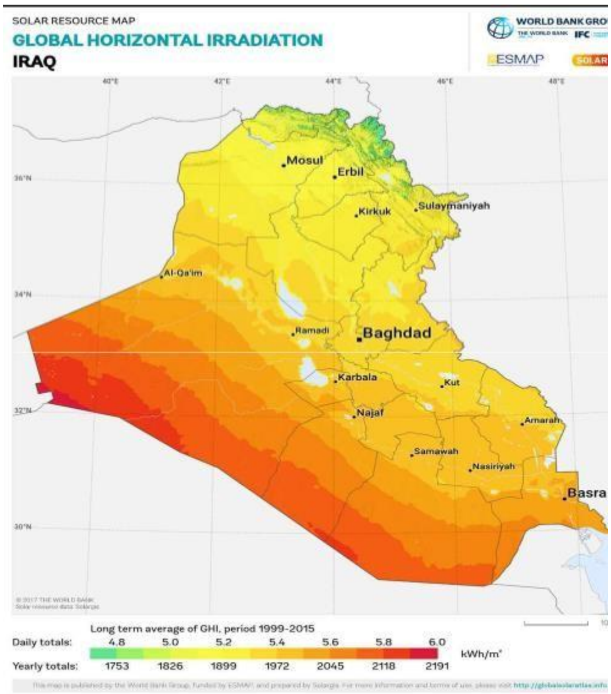

Fig. 4. Horizontal radiation across Iraq on a worldwide basis.

In a nutshell, below are the Republic of Iraq's radiation requirements:

- Nearly 200% in the southern region. Summer months see 27 MJ/m² of solar radiation, while winter months see 13 MJ/m²..
- 300% in the north. In June the values are 23 MJ/m² and in December equal to 7 MJ/m².
- Midway point: 50%. The following are the variations in the months in question: June sees 24 MJ/m² and January sees 8 MJ/m². Out of all the indications, the north–south solar radiation intensity differential stands out more than the others. Wintertime sees it rise even higher, while summertime sees it fall.

- Annual average daily energy demand of the Iraqi zone (2000 to 2500 kWh/m2) from global solar radiation as as depicted in Figure. 4[11,2].

C. Solar panel system

A solar panel system comprises an interconnected structure, known as an array, composed of photovoltaic (PV) solar cells. Solar power cells employ photovoltaic technology to turn solar energy into electrical energy by directly converting the sun's photons. The power production, measured in V or W, fluctuates according on the specific system and kind of solar cell employed. The whole system is composed of solar modules or panels, each including a metal frame housing a cluster of solar cells. A typical solar panel is composed of either sixty, seventy-two or ninety-six photovoltaic cells. Light travels via several wavelengths with varying energy levels across the electromagnetic spectrum, and the solar panel does not capture all of these wavelengths. [2]. The energy of sunlight that may be Utilized by photovoltaic panels and converted The conversion of energy towards electricity can be measured in eV. approximately comparable to 1.1 V [12-13]. When photons of greater energy levels collide with the plate, there is energy depletion. In order to enhance the absorption of photons, other materials can be employed in compact solar panels, but at the expense of reducing the panel's voltage. As solar panel technology progresses, there is a delicate equilibrium between material selection and electric field strength, as the energy produced by these panels is determined by the multiplication of current and voltage. It is worth noting that these panels only possess a p junction [2].

D. Grid-connected photovoltaic electricity generation system

Grid-connected PV systems supplement the existing power grid. They differ from standalone solar systems in that they allow the user to consume electricity generated by solar energy and, when there is insufficient sunlight, check power from the grid. This involves an alternating current flow and a constant power supply. The components of a grid-connected system include:

- Solar panels: are devices that capture sunlight and transform it to direct current.
- Solar inverter: It converts the electricity generated into alternating current for use in households.
- Net meter: Also known as a bidirectional meter, it records the flow of energy. Since a lot of heat and electricity is generated during the day, some of it is fed into the grid, and when the sun goes down, the vehicle is powered to run the systems.
- Grids: The power grid is an e-power backup whenever you generate more power your energy is transmitted to the grid, and whenever you fail to produce enough power, you withdraw energy from the grid.
- Mounting structures: Ensure that the panels are securely attached with a shelter[10,14-15].

V. How To Chose a Suitable Solar Panel

Currently, companies such as SunPower, LG, Panasonic and JinkoSolar are well-known manufacturers of monocrystalline solar modules. A specific group of companies compete for recognition for producing the most effective rooftop solar panels. These special modules, currently available on the market, can convert just over 20% of solar energy into electricity. When selecting an appropriate solar system, several variables must be taken into consideration:

The wattage (W) of a solar panel represents its standard energy production under certain test circumstances conditions consist of an irradiation of 1000 W/m2 and an environmental temperature of 25°C.. For instance, if a 300W solar panel is used under standard test conditions (STC) for five hours, it may generate 1,500Wh, which is equal to 5 times the power output of 300W or 1.5 kilowatt-hours (kWh). The cost of a solar module is mostly determined by its rated power capacity. The range of numbers is from 2 to 4, inclusive. [2-4].

Efficiency indicates what percentage of the sunlight absorbed by a solar module is converted into usable electricity. The efficiency of residential solar models is usually expressed as a percentage and is usually in the range of 16-22%[2,16] Solar modules are predominantly made from polycrystalline silicon or monocrystalline silicon cells. While polycrystalline modules are more economical, monocrystalline modules offer higher efficiency and a more elegant appearance

The warranty period for solar panels is typically 10 to 25 years, ensuring longevity and performance reliability. A solar module's \"performance guarantee\", also called a \"linear performance guarantee\", The module is ensured to maintain a specific proportion of its initial production after a predetermined amount of years, often ranging from 80% to 90% after 25 to 30 years. [2].

The term "temperature coefficient" denotes the proportional decline in performance for every incremental increase in degrees Celsius over 25°C. As a result, solar panels have a minor decrease in efficiency in hotter weather conditions, often with a temperature coefficient of approximately [17]. The size of solar modules is of utmost importance when choosing them, particularly in cases where there is limited roof space. The normal size of a solar panel is approximately

2 square meters. However, manufacturers have created smaller variants to accommodate various spatial constraints. Weight is a factor to consider for fragile roofs, as heavier panels may not be appropriate. Lightweight panels are a necessary choice for individuals who are looking for alternatives owing to their concerns about the structural integrity and weight-bearing capacity of roofs. [18].

VI. The Pv Nature Challenging In Iraq

As already mentioned, the weather in Iraq is harsh. Weather and natural factors affect the operation of the solar energy system. These impacts include:

A. The temperature Effect

Iraq meets all the mentioned requirements: its proximity to major population centers, flat terrain, and abundance of sunshine. Every year, this country is exposed to scorching temperatures for about six months: June to August are its hottest months. What is more, research indicates that only a little temperature increase significantly degrades the efficiency of solar power systems if they use photovoltaic cells, especially crystalline silicon ones. The electricity is produced through the absorption of light, but for it to function best, the light that it absorbs should increase, too. Instead, the cells produce heat, which is why the actual performance he here below rather than above theoretical values. That additional heat not only decreases the power output – it also degrades the physical properties of the PV modules [19] which in turn lowers their performance. Some areas of Iraq experience particularly high temperatures, which reduce the efficiency and power output of solar panels. To address this issue, potential strategies involve implementing cooling systems such as water or air conditioning, or integrating hybrids solar PvT technologies.

B. *The effect of Humidity*

Efficiency of Photovoltaic systems can be heavily influenced by the hydrolysis of polymer components, glass, metal networks, and connecting lines. Air humidity may infiltrate photovoltaic cells (PV cells) through their pores. The infiltration of water into the solar cell body leads to the activation of weak adhesive connections at interfaces, resulting in a series of detrimental effects. PV panel delamination, increased openings, and deteriorating welded seams. Corrosion is mostly caused by water, and it spreads rapidly, particularly in hot and humid environments.

Temperatures above 40 °C and humidity levels below 60% induce long-term degradation. Relative humidities between 75% and 95% can also cause surfaces to become sticky, which is ideal for fungal development.

C. *Wind Effect*

The efficiency of PV systems is directly affected by the speed of the wind, as these systems are always exposed to it. The sun has an indirect impact on wind energy, whereas the average wind speed is mostly influenced by the Earth's resilience.Furthermore, wind could contribute to the improvement in PV-modules' efficiency through the reduction of the relative humidity, as well as via the development of the natural and forced convection. Moreover, the cooling effect of the wind under the sun's radiation equal to 1000 W/m 2 and the wind speed of 10 m/s allows reducing temperatures by 15-20°C. However, there are some disadvantages that have to be taken into account. For example, specialists understand that wind's power can damage to cell's structure, and they are also aware that using the special technology, such a flying sand and dust can reduce the amount of energetics received by the surface of cells; in its turn, it can cause the decrease in the photovoltaic efficiency.. [20].

D. *The effect of Dust*

Pollen, bacteria, and fungus are all examples of the small, solid particles that make up dust. Their diameter is usually less than 500 micrometers. Environmental elements (such as location and weather), human actions, surface characteristics (such as roughness, slope angle, humidity, and wind speed), and the dust's chemical and physical qualities are all factors that affect its deposition. Dust on photovoltaic (PV) panels reduces their efficiency because it prevents light from reaching the cells, which in turn reduces the amount of electricity generated. Dust collection is common in dry, hot places like North Africa and the Middle East, making this problem much more severe. Notwithstanding these obstacles, the abundance of solar radiation and the availability of land resources in these places make them ideal for PV installation. [21].

VII. CONCLUSION

The findings of the research show that solar energy can indeed assist Iraq to solve its energy crisis. In particular, the research emphasizes that Iraq can become energy self-sufficient and end power outages by efficiently integrating solar technologies. Thus, it is possible if policymakers enact the necessary regulatory reforms and make the required infrastructure investments to ease the integration of solar power into the grid. The conclusion calls for immediate action, suggesting that solar energy systems shall exponentially enhance the lives of Iraqis while promoting advancements in all socio-economic aspects. Importantly, this means that both the government and the private sector must collaborate to tap the solar power and solve Iraq's long-lasting struggle with energy.

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