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The Technical and Economic Impact of Using Solar Cells Connected to the National Grid on the Roofs of Public Schools in the Center of Kirkuk Governorate

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Abstract: Kirkuk is one of the regions that suffer from economic instability due to the emergence of the problem of continuous power outages in all schools, and due to the increase in electrical loads on the networks, and given the important and vital role that government schools play in providing services to citizens, and the high consumption of electrical current in schools, it was necessary to research About an alternative energy system in generating electricity, which is the use of photovoltaic solar cells due to their efficiency and as environmentally friendly projects that protect them from pollution. This research addressed the issue of using solar cell systems in schools in the center of Kirkuk Governorate and analyzing the technical and economic impact of using solar energy in schools, based on the Salah School District in Kirkuk Governorate, and the extent of its impact on reducing electricity bills whose value ranges between (60,000-100,000). One thousand Iraqi dinars per month, as the maximum power values required by photovoltaic systems range between (3000 - 4000) watt-hours. Thus, these savings are achieved between (1,000,000 - 1,250,000) thousand Iraqi dinars during the year for invoices, and within time periods not exceeding 4 years, the cost of the projects can be recovered. In addition to reducing pollution, according to the Civil Defense Centers, the energy generated annually from solar cell systems. When the world began discussing the issues of climate change caused by the use of fossil fuels, the use of solar energy appeared in various forms. Current schools are responsible for using the largest amounts of energy for lighting, heating, and cooling. Therefore, the will of governments and societies must be high to replace fossil fuels with free solar energy that is available everywhere. A country's growth can be measured directly from its increasing energy demand. If energy demand is not met in a timely manner, it will severely hamper growth leading to economic collapse. It is known that weather conditions in a particular area can have a significant impact on the amount of electricity produced by a photovoltaic system.

Keywords: Solar Panels, Environmental Conditions, PV Performance, Solar System, Social Awareness and Acceptance.

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1. Introduction

Solar energy is the most universal, cost-effective and abundant direct energy source, and can be used in the most diverse ways. [1]. The most prominent exploitation of direct sunlight aims to heat and illuminate buildings. Through the use of solar cells, solar energy can be converted into electricity or direct heating. Therefore, solar energy offers two important possibilities, a solar thermal path and a photovoltaic path. Photovoltaic (PV) electricity generation is on the rise and is therefore being widely introduced on grids around the world. According to an International Energy Agency (2015) (IEA) publication, 70% of global energy consumption is derived from fossil fuels in the form of oil, coal and natural gas.

These sources are non-reusable, unsustainable and highly polluting, leading to increased greenhouse gas emissions and thus an increase in global temperature which will lead to many other environmental issues. Hence, it is highly recommended to move to renewable and sustainable energy sources. Despite all the possible uses and abundance of collectible energy, direct solar technologies account for only 2.2% of the global energy supply in 2016 [2].Many different technologies compete to find the right place for each, but a strength in diversity and safety in redundancy is largely untapped is the potential of solar radiation, annually the global average is about (180 Wm-2) on the Earth's surface, which is equivalent to about (80x109 TWh) over the course of a year [3]. Despite the importance of the sun for the evolution of life, the radiation it provides is still an unused commodity by modern society. The Earth is exposed to solar radiation equal to more than 7,000 times the world's energy consumption [4]. Thus, using just a fraction of solar radiation can lead to significant improvements in living standards. Harvesting energy from the sun can take different forms, but the most elegant form is the use of solar cells. Solar radiation is converted directly into electrical energy, and for a conventional semiconductor photovoltaic module. As such, the life of solar cells can be very long [5] . Research on solar cells began in the 19th century with Becquerel's discovery of the photoelectric effect with an electrochemical cell [6]. The first published study was conducted on a solid-state device, on which most modern solar cell technologies are based [7]. In 1877 Charles Fritz demonstrated the first solar panels based on selenium-coated gold, known as Fritz cells [8].

The Objectives of the research

In order to develop the national electricity system and enhance the shortage of electricity in public schools .

1. Providing accurate data regarding the generation of electricity from solar radiation in schools in Kirkuk city center using photovoltaic panels.
2. Determine the conditions necessary to improve the harvesting of electricity from solar energy.
3. Collect data from schools of the governorate center.

1.1. Awareness and social acceptance

There is a significant lack of awareness about renewable energy technologies and the benefits they can bring to communities; this is largely due to insufficient awareness programs aimed at educating the public about the advantages of installing photovoltaic panels on the roofs of public schools compared to the monthly payment of generators scattered in residential neighborhoods, and practical information related to financing from local banks and financial institutions is also limited, preventing residents from taking this option into account as in Figure (1).

Figure 1. Reliance on solar energy in a school in the West Bank, State of Palestine

1.2 Calculation of electrical loads for a particular school (medium Salah)

One of the schools has the following electrical appliances: 20 watts light bulb, 100 Operating time 6 hours Electric fan 50 watts, 24, operating time 6 hours The law of calculating electrical power is represented by the following equation:

Electric power = voltage× Power supply

$$p = V\ I \qquad \dots\dots\dots\dots (1)$$

P: Electric power (Watt)

V; voltage (V)

I; Power Supply (Ampere)

The electrical load will be as follows

Lamps: 10 × 20 × 10 = 2000 w. h

Fans: 2 × 50 × 5 = 500 w. h

The depreciation cost of the school can be calculated through equation (2)

$$cost = p(Kw)\ x\ t(h)\ x\ \ unit\ price\ \frac{Dinar}{kw-h} \qquad \dots\dots\dots\dots\dots(2)$$

1. The cost of lamps:

$$cost = 2(Kw)\ x\ 6(h)\ x\ \ 100\ \frac{Dinar}{Kw-h} = 1200\ Dinar$$

2. The cost of fans:

$$cost = 1.2(Kw)\ x\ 6(h)\ x\ \ 100\ \frac{Dinar}{Kw-h} = 720\ Dinar$$

Thus: the total electrical load is 3000 watt-hours, meaning that the total cost per school during one month is 60,000 thousand Iraqi dinars.

2. Working principle of solar cell

The process of photoelectric effect, which is the creation of charge carriers by absorbing photons of light, is the basic process for the functioning of solar cells. The photoelectric effect is similar to this effect, the light that falls on the material has a frequency, and this frequency is greater than the threshold frequency of the material, what happens is that electrons are released from the material when they absorb light. The p-n junction shown in Figure (2 - a) is a primary solar cell. In the dark, the p-n junction device has the characteristics of a modified diode. In the dark and under light, the characteristic curves (IV) in Figure (2 - b) show the p-n intersection.

$$I = I_0\,[exp\ (\frac{qV_D}{nkT}) - 1] - I_L \qquad \text{------------------}(3)$$

where I_0 is the diode leakage current under the dark or dark saturation current, and IL is the output light current.

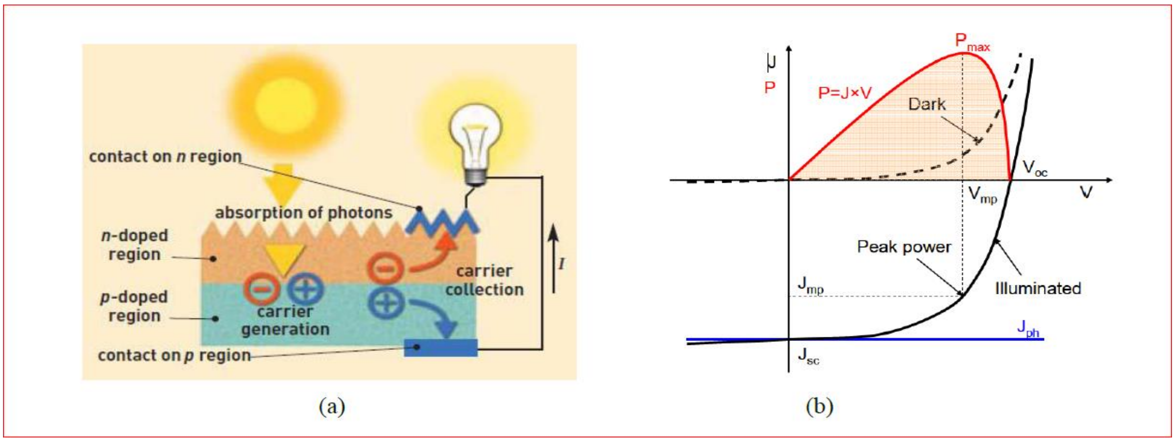

Figure 2: a- Example of a p-n junction solar cell. b- Characteristics of the curve IV [9].

2.1 Factors that describe the performance of a solar cell

The main factors used to describe the performance of solar cells are maximum power, short-circuit current density, open-circuit voltage, and (FF) filling factor. These factors are determined from the curve of the luminous IV property as shown in Figure (2-b). The conversion efficiency is determined (η) of these factors, and the following are some explanations and summary formulas of these factors for the simple n-p junction device:

A. Short circuit current density J_{sc}

This current is referred to as ISC and is the largest amount of current flowing in a solar cell when the load is equal to zero (R_L=0). The voltage of the solar cell is equal to zero at the highest Isc value. The aggregation and production of light-generating carriers is what causes the Isc to flow. It is mainly determined by the amount of photon incident, as well as the spectrum, the region of the solar cells, optical properties and the possibility of collecting light-carrying waves. [10]

B. Open circuit voltage V_{oc}

This voltage is referred to as V_{oc}, which represents the largest amount of potential that can be obtained from a solar cell when the load resistance is infinity ($R_L=\infty$). If the solar cell circuit is open and there is no associated load around it, the flow is at its lowest level (0), while the voltage is at the highest level [11].

C. Filling Factor ff

The filling factor is indicated by the symbol (FF). Its value can be found by dividing the greater force (which we find by multiplying the greater current Imax by the greater voltage Vmax) by the theoretical force (which we find through the product V_{oc} by I_{sc}). Equations (4 and 5) are shown below [12].

$$FF = P_{max}/P_t \qquad (4)$$

$$FF = V_{max} I_{max}/V_{oc}\, I_{sc} \qquad (5)$$

D. Conversion efficiency η

The ratio between the maximum energy generated by the solar cell and the energy falling on it is indicated by the conversion efficiency. This can be calculated using the equation below. The external energy of a solar cell can be expressed through [13].

$$\mathbf{P_{max}} = V_{max} \cdot I_{max} \qquad (6)$$

$$H = \frac{P_{max}}{P_{in}} = \frac{V_{max} \cdot I_{max}}{P_{in}} \quad \ldots\ldots\ldots\ldots\ldots (7)$$

3. Result

Solar cells are widely used at the moment as an effective means of generating electrical energy. One of the potential uses of solar cells is their installation on school roofs. The use of solar cells in schools is an innovative and useful idea, as it can have a positive impact on the environment and society. Solar cells provide numerous benefits when used in schools First, power generation through solar cells is a clean and environmentally friendly system, as it does not produce any harmful emissions or air pollution. In addition, the use of solar energy reduces the dependence of schools on traditional energy sources such as coal or oil, reducing greenhouse gas emissions and contributing to reducing negative impacts on the climate. Second, solar cells can be a sustainable source of energy generation in schools. Schools are a suitable environment for installing solar cells, as there are ample spaces on the roofs of buildings that can be used to generate energy. In addition, energy generated through solar cells can be used to power school lighting, air conditioners and heaters, reducing traditional energy consumption and saving more resources for schools. Third, the use of solar cells in schools can be an opportunity to teach students about renewable energy and sustainability. Schools can include solar cell installation in their educational programs, where students learn about how solar cells work and how to use them to generate energy. This can contribute to raising awareness of the importance of using renewable energy and motivating young people to take action to preserve the environment. In addition to their environmental and educational benefits, solar cells can also provide economic benefits to schools. In the long run, installing solar cells may help reduce the electricity bills of schools, as part of their needs are generated through renewable and inexpensive sources. But there are some challenges to consider when using solar cells in schools. One of these challenges is the upfront cost of installing solar cells, which can sometimes be prohibitive. However, it should be borne in mind that the costs of installing solar cells may be made over a long period by saving electricity consumption bills and revenues from the sale of excess energy. In addition, the solar cell system must be properly designed and installed to ensure its optimal performance. The selection of the appropriate location for the installation of solar cells should be carried out based on criteria such as the availability of sunlight, shade conditions and available space. Solar cells must be maintained and cleaned regularly to ensure their continued performance. Table 1 shows the results and study of the cost of solar cells in schools.

The first part is data collection.

Table 1. Results of Public Schools' Consumption of Electrical Energy

	School Name	Consumed capacity (w)	Number of panels $\frac{\text{القدرة}}{550}$	Number of batteries [14]	Inverter size Kw [14]	Full Cost ($)with monument [14]
1	Intermediate / Al Salah for boys	11000	20	4	11	6500
2	Preparatory / Euphrates for boys	12000	22	4	11	6700
3	Medium / Spring	10000	18	4	8	6300
4	Medium / Gamal Abdel Nasser for boys	12000	22	4	11	6700
5	Medium / Hamza bin Abdul Muttalib for boys	11000	20	4	11	6500

6	Secondary School / Iraq Distinguished Boys	40000	72	4	11 (2)	18250
7	High School / Kirkuk Distinguished Girls	41000	74	4	11 (2)	18500
8	Preparatory / Kirkuk for boys	30000	54	4	11 (2)	14700
9	Preparatory / Qadi Muhammad (Kurdistan) for boys	12000	22	4	11	6700
10	Preparatory / Garmian for boys	15000	27	4	11	7700
11	Primary / SA Roran Mixed	6500	12	4	6	4200
12	Medium / Al Fares for Boys	12000	22	4	11	6700
13	Medium / Saberi for boys	10000	18	4	11	6300
14	Preparatory / El Shorouk for Girls	42000	76	4	11 (2)	18800
15	Primary / Arab Nation	5500	10	4	6	4000

3.1 Details of materials used

1. Longi Facial type panels 550 watt Half Seal Cut with the latest(5Hi-mo) technology, the company ranked first in the world for two years.

2. Voltronic type inverters are one of the best international companies in the manufacture of inverters with a two-year maintenance guarantee.

3. Tubler type batteries from the import of MCSMA, which is rich in definition, the battery size is 200 amperes 10 c with a one-year warranty.

3.2 The second part is energy export

It could give schools the opportunity to sell excess energy generated by solar cells to the public grid, enabling them to generate additional income. The Smart Export Guarantee tariff, launched at the beginning of 2020, through which you can get money for any excess renewable energy you export back to the national grid [15]. By subscribing to the program, you will be paid for any surplus electricity you generate and be returned to the national grid.

4. Conclusıon and Recommendatıon

In conclusion, this study addressed a variety of properties that are believed to be important for the performance of solar energy systems. The performance of solar energy storage devices is still greatly influenced by environmental conditions to a large extent. These environmental consequences include shading, reproduction, changes in solar radiation, and observing the sun, which indicate the direction and angle of inclination of the photovoltaic module. Customers are one of the most important factors contributing to the solar industry's ongoing need for innovation. After a consumer gets an incandescent bulb or a solar-powered radio, they challenge businesses to innovate so they can provide solar-powered products such as a solar-powered TV or refrigerator. For example, the above progress can be compared specifically to the electricity leaderboard that starts with only an electric staircase, then gradually tries to climb into solar devices, and then moves to distribution networks that have sufficient facilities that can provide power to schools, hospitals, and industries. This power ladder may start with the power ladder. Rooftop solar projects are now being promoted by governments around the world that have an abundance of solar energy. This is done so that every household and commercial facility can be a proud producer and user of renewable radiation. Surplus energy generated from solar energy can be recycled directly to the associated conventional grid by many government facilities around the world, which in turn allows the benefits of this technology to be transferred to homes and industrial facilities. These technologies have been used by the facilities of many countries and companies around the world. Because of this configuration, traditional utilities will need to generate less power in order to meet grid requirements, which will ultimately lead to lower fossil fuel consumption.

4.1 Suggestion

Based on the encouraging results of this preliminary resource assessment, the city of Kirkuk may be able to use electricity generated by solar panels in the near future as an energy source that would provide additional energy supply. It is proposed that the following initiatives be implemented in the future in order to gain a deeper understanding of this work and contribute to its progress:

1. Continuation of the project so that measurements can be taken for a number of consecutive years so that a more accurate evaluation can be made.

2. Facilitate the measurement process by utilizing automated data records to monitor the voltage and current of solar panels, as well as environmental conditions.

3. Climate variation in Kirkuk governorate should be studied through the use of automated data records installed in the work area because of their significant impact on the amount of electricity that can be generated by solar panels.

4. The idea can be developed by integrating charging storage batteries and measuring the level of charge in batteries (or electrical power). Battery discharge and charge cycles are also crucial variables that require further research.

5. Employing various electrical loads such as lighting fixtures, electric motors, water pumps, etc. to make the project comparable to the project I recommend.

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