Effect of heat and solar radiation on photovoltaic cells

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Abstract- Most of us think that sunlight falling on panels or solar cells when they are stronger and hotter will increase the electrical energy that these panels generate. The temperature and solar radiation falling on the ground are among the most important factors that affect the amount of electrical energy we get from solar cells. Although temperature does not affect the amount of sunlight a photovoltaic cell receives, it does affect the amount of energy produced. Solar cells are made of semiconductor materials such as crystalline silicon, which are the most commonly used in the manufacture of these panels. The paper aims to study the availability of solar radiation in the city of Tajoura for three months, and the effect of temperature on solar cells and their efficiency.

Index Terms- Electrical,Energy,Radiation,Panel,Soral.

I. Introduction

Human is always looking for new sources of energy to cover their increasing needs in life applications in the developed environment in which we live, and the disadvantage of many energy sources is their depletion and the high cost of exploitation, and the negative impact of their use on the environment, and man has alerted in the modern era to the possibility of benefiting from the sun's rays, which is characterized as renewable and permanent energy that is inexhaustible, he was well aware of the great danger posed by the use of other and common sources of energy (especially oil and natural gas) contribute to environmental pollution and destruction, making solar energy the best option. That is why solar energy has become in our time a national income for some countries even in the Arab Gulf countries[1], which are considered one of the most oil-rich countries in the world, Solar energy mainly and effectively Solar energy has been used to generate electricity in many applications, including power plants electricity and water desalination, operation of traffic lights and street lighting, and operation of some devices Electrical devices such as watches, calculators, and satellite and vehicle operation and space stations. The sun is the main source of the Earth's energy and has great importance, from it we derive warmth despite the reflections, scattering, and absorption of solar radiation before it reaches the Earth through the Earth's atmosphere, so almost all ultraviolet rays disappear and a certain part of the infrared rays disappear, but the solar energy that It reaches the Earth within one year, exceeding the world's energy needs by ten thousand times [2].

II. FUTURE OF RENEWABLE ENERGY IN LIBYA

Libya is located in the center of North Africa in the high sunny belt. It has a long beach on the Mediterranean Sea of about 1900 km, with an area of 1,750,000 km^2, and a population of 6,700,000, most of whom live in the Sahel region and 88% of the area of Libya is desert. The daily average of solar radiation on a horizontal plane is 7.1 kWh/day in the coastal region, and 8.1kwh/m2/day in the southern region, with an average sun duration of more than 3500 hours per year [3].

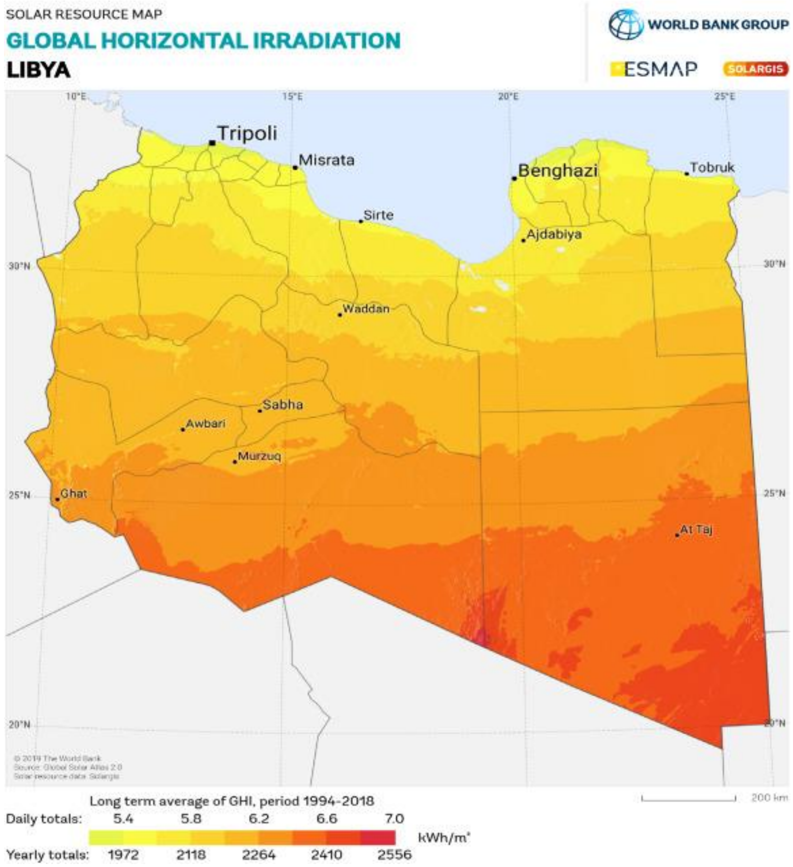

Figure 1: Libya's map of horizontal Irradiation

However, solar energy has not been utilized to meet the country's energy needs. The total installed capacity of electricity in Libya is entirely dependent on fossil fuels, as it consumes about 20% of oil production, which reached one million barrels in 2021. However, domestic demand for the electricity supply exceeds the expansion in capacity, which leads to increased power outages. Electricity production in Libya is about 5,000 megawatts, while the electricity deficit is 2,000 megawatts.in 2019[4], about 68.5% of the population of Libya had access to electricity, down from 100% in 2000, according to estimates by the World Bank. Libya is working to diversify its energy mix and harness the country's potential from solar and wind energy, as it aims for 22% to come from Generating electricity from renewable energy by 2030. Shortly, it is possible to benefit from solar energy by making a project that will make Libya one of the largest exporters of electric energy produced from solar energy to Europe and transfer it through submarine cables and then distribute it to all parts of Europe and thus contribute to reducing carbon dioxide emissions.

III. METHODOLOGY, AND RESULTS.

The study was conducted in the city of Tajoura, which lies east of the Libyan capital, Tripoli, 21 km from the center of Tripoli.[5] This paper used a set of research methods represented in fieldwork and data collection for the rate of solar radiation in this city for three months May, June, and July Interviews were conducted with experts and engineers working in the field of solar energy.

IV. SOLAR RADIATION IN THE CITY OF TAJOURA

Solar radiation is defined as the amount of solar radiation falling on a certain area and capable of generating electrical power. It only affects the earth about one part in two thousand million parts of the sun's rays, which is estimated at 130 megawatts /m^2 of the surface of the sun, and this small amount is responsible for all thermal energy on Earth's surface and atmosphere [6]. A set of data was collected through the readings of the climate data station at the solar power station at Tajoura Research Center during the period from 1st May to 31 of July, From 8:00 a.m. to 7:00 p.m. [7] as shown in the following table

Average time ofMay	Average of DNI w/m²
8:00 AM	507
9:00 AM	668
10:00 AM	778
11:00 AM	800
12:00 PM	814
1:00 PM	820
2:00 PM	744
3:00 PM	735
4:00 PM	637
5:00 PM	509
6:00 PM	439
7:00 PM	222

Table (1): Monthly average of solar radiation in May

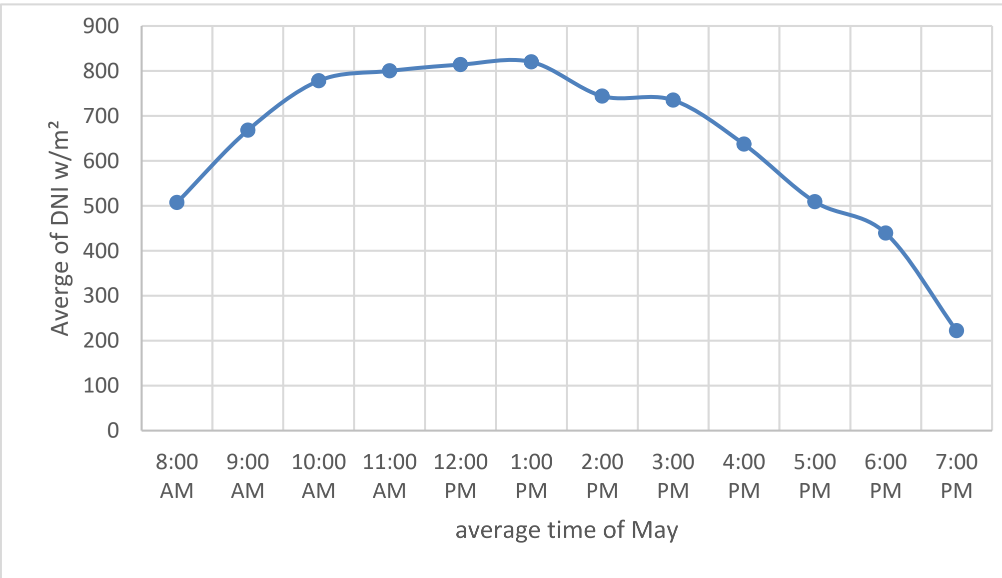

Figure (2) Average solar radiation for May

Figure (2),(3), and(4) shows the relationship between the average daily time for three months May, Jun, and July which starts from 8:00 am until 7:00p.m, and the intensity of direct solar radiation(DNI), where we note that the intensity of solar radiation begins to increase from 8:00 a.m after sunrise and reaches its peak at 1:00 p.m and then begins to decline after 2:00 pm, and the radiation decreases after this hour until it reaches its lowest level at 7:00 p.m We note from the data we obtained that the maximum value of radiation was in June, reaching 875 watts/m^2.

Average time of Jun	Average of DNI w/m²
8:00 AM	658
9:00 AM	769
10:00 AM	826
11:00 AM	812
12:00 PM	825
1:00 PM	875
2:00 PM	863
3:00 PM	841
4:00 PM	703
5:00 PM	630
6:00 PM	577
7:00 PM	404

Table (2): Monthly average of solar radiation in Jun

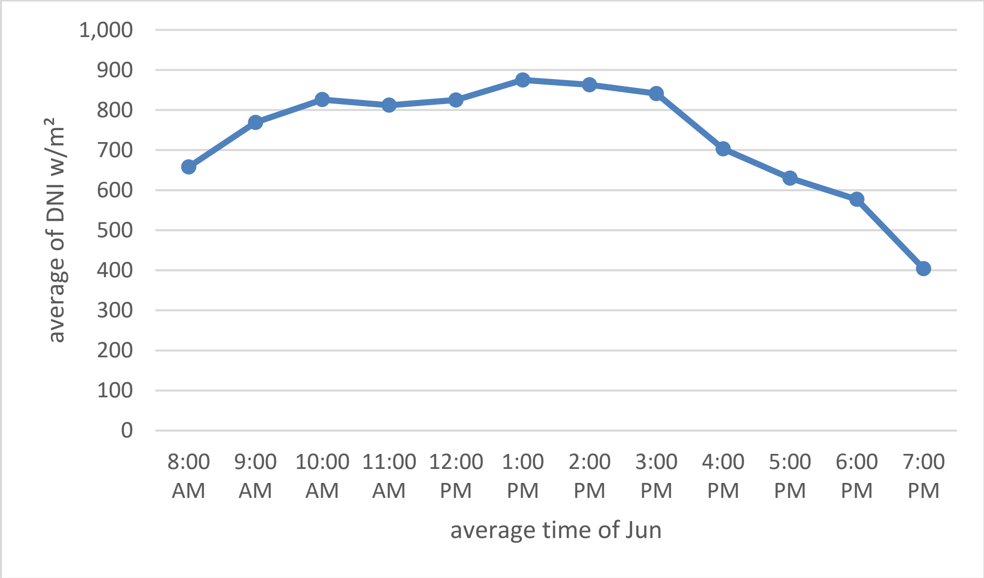

Figure (3) Average solar radiation for Jun

Averag of July	Average of DNI w/m²
8:00 AM	518
9:00 AM	635
10:00 AM	731
11:00 AM	742
12:00 PM	778
1:00 PM	817
2:00 PM	828
3:00 PM	827
4:00 PM	789
5:00 PM	710
6:00 PM	585
7:00 PM	407

Table (3): Monthly average of solar radiation in July

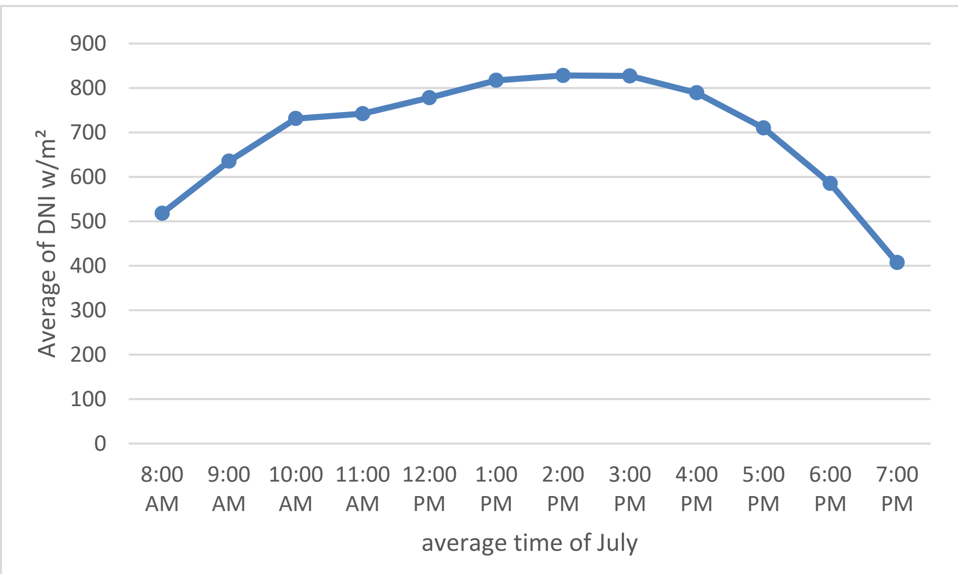

Figure (4) Average solar radiation for July

Figure (2),(3), and(4) shows the relationship between the average daily time for three months May, Jun, and July which starts from 8:00 am until 7:00p.m, and the intensity of direct solar radiation(DNI), where we note that the intensity of solar radiation begins to increase from 8:00 a.m after sunrise and reaches its peak at 1:00 p.m and then begins to decline after 2:00 pm, and the radiation decreases after this hour until it reaches its lowest level at 7:00 p.m We note from the data we obtained that the maximum value of radiation was in June, reaching 875 watts/m^2.

V. THE EFFECT OF HEAT ON SOLAR CELLS

Solar cells produce electricity from sunlight, not the heat generated by it. Solar panels are negatively affected by high temperatures, contrary to what some expect. And you may be surprised when you know that all satellites operate with high efficiency with solar energy, even though the temperature in space is 10℃[8], with permanent solar brightness and a complete absence of clouds and rain. If you look at the datasheet provided by the cell manufacturer there is a paragraph called pMax temperature parameter. This value is given in the form of a negative percentage and reveals the effect of heat on cells Panels are tested at 25°C pMax is the change in efficiency down or up when the change in cell temperature is one degree Celsius. For example, if the pMax is -0.5%, and the cell temperature is 35, this means that the solar panel is less efficient by 5% when the cell temperature is 35.It is noted here that pMax depends on the cell temperature and not the air temperature. We always find that the cell temperature is higher than the air temperature as a result of the

cell's exposure to direct sunlight, and the program here has already taken into account this element and calculated the loss or addition in the productivity of the panel based on the cell temperature and not the air temperature.
Steps for calculating cell temperature:
The Homer equation is used to calculate the cell temperature[9]
1- Solar radiation is calculated in kilowatts per square meter at noon:
The equation of the ellipse plane = daily solar radiation x 4 / number of hours per day x 3.14
For example, if the average daily radiation = 660watts /m^2
The number of hours of the day from sunrise to sunset = 12.5hours.
Radiation through the noon = 0.66x 4 / 12.5 x 3.14 = 0.663 kWh/m2
2- To get the cell temperature we have to calculate two variables from 2 equations .."A" and "B
A= (NOCT – 20) / 0.8
where NOCT is a constant value present in the cell specification[10].
If we have NOCT = 45
A = (45 -20) / 0.80 = 31.25
where 20 is the ambient temperature.
0.8the amount of solar radiation to which the cell is exposed.
B = 1- cell efficiency/0.9
Where cell efficiency It is the efficiency of the cell and its value is in the specifications
Example: cell efficiency = 17%
B = 1- (0.017/0.90) = 0.81111
Solar cell temperature = Ambient temperature + Solar radiation at Midday × A × B
Example: Air temperature = 40°C
Solar cell temperature =40+0,663×0,811×31,25 = 56,8℃
Calculating the loss due to the increase in cell temperature:
Calculation of ∆T is the difference between the cell temperature and the temperature of 25℃ the cell temperature under standard test conditions
∆T = cell temperature – 25
Example: cell temperature = 56.8℃
∆T = 56.8℃ -25 = 31.8℃
The lost = ∆T × pMax
pMax = -0.4% (this is a fixed number written on the back of the solar pane).
The lost = 31,8×0,4 = 12,72 %
We conclude from the previous equations that the power generated by solar cells is affected by the temperature of the cell. If the cell temperature increases, the efficiency decreases.

VI. CONCLUSION

Libya is characterized by high solar radiation throughout the year, with average solar radiation ranging from 3000 to 3500 hours per year. Solar energy technology in Libya is still very low, although Libya's location is considered optimal for the exploitation of this energy and makes it a great source of oil and gas. The solar radiation was studied in the city of Tajoura for a pe three months, and the results showed that this city enjoys high solar radiation, especially in the afternoon, where the average radiation was about 870 watts The effect of temperature on the efficiency of the solar cell was also studied, and the results showed that the power generated by the solar cells is affected by the increase in the temperature of the solar cell If the cell temperature increases, the generating capacity of the cells decreases, and this depends on the cell temperature coefficient written on the back of the cell pMax.

REFERENCES

[1] Lamia Al-Qallab, "The UAE aims to produce 24% of its electricity needs from clean sources" Ministry of Energy, United Arab Emirates, July 27, 2014. Website: http://www.zawya.com/ar/story/ZAWYA20140727192313/
[2] Mahfouz M and Muhammed Bin Saleem 1996, Solar Radiation Journal of Science and Technology, Issue 34
[3] NASA Atmospheric Science Data Centre, NASA Surface Meteorology and Solar Energy: Available from: http://eosweb.larc.nasa.gov/, Last Accessed 5th March 2013.
[4] General Electric Company 0f Libya GECOL, Annual Report 2019.
[5] "Shabiyat of Great Jamahiria" General People's Committe of Libya accessed 5 September2009.
[6] Antonio Luque, & Steven Hegedus, "Handbook of Photovoltaic Science and Engineering", John Wiley & Sons Ltd, (2003). https://ara.timegenie.com/latitude_longitude/country/ly
[7] The climatic data station at the solar research center in Tajoura city during 1st of May to 31 of July2020.
[8] A Day in the life aboard the International Space Station / NASA http:// www.nasa.gov/au

[9] Duffie JA, Beckman WA (1991), Solar Engineering of Thermal Processes 2nd edition, Wiley, New York, NY
[10] PV normal operating cell temperature Homer pro 3.11

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