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Estimating the Electrical Energy Generated from Solar Radiation in the City of Tripoli - Libya

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Abstract

The aim of this work is to determine the possibility of producing electrical energy based on solar radiation in the city of Tripoli-Libya. The solar radiation data were taken from the NASA POWER platform.

The results indicate that there is a high possibility of producing electrical energy during most months of the year, especially during the summer season. Where the highest value is reached in June 2022, and the lowest value is reached in December 2017. For the electrical capacity of solar cells, the highest value is reached in July 2022, and the lowest value is reached in December 2017. This type of research is an essential step in planning renewable energy projects.

Keywords: electrical energy, solar radiation, electrical capacity, Tripoli.

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تقدير الطاقة الكهربائية المولدة من الاشعاع الشمسي في مدينة طرابلس– ليبيا

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الملخص

في هذه الدراسة تم حساب الطاقة الكهربائية التي يمكن انتاجها من الاشعاع الشمسي كذلك القدرة الكهربائية للخلايا الشمسية من خلال التحليل الشهري للإشعاع الشمسي في مدينة طرابلس– ليبيا للفترة من شهر يناير لسنة 2015 الي شهر ديسمبر لسنة 2024 ومن خلال النتائج المتحصل عليها نلاحظ ان اكبر طاقة يمكن الحصول عليها في فصل الصيف، فقد كانت اكبر طاقة من الاشعاع الشمسي في شهر يونيو لعام 2022 ، واقل قيمة كانت في شهر ديسمبر لسنة 2017، وكذلك تم حساب القدرة الكهربائية فكانت اكبر قيمة لها في شهر يونيو لسنة 2022، اما اقل قيمة كانت في شهر ديسمبر لسنة 2017.

الكلمات المفتاحية: الطاقة الكهربائية، الإشعاع الشمسي، السعة الكهربائية، طرابلس.

1. Introduction

Solar energy is considered to be one of the most important renewable energy sources in the world because it is environmentally friendly, less expensive, and a renewable source compared to other energy sources. Countries around the world are seeking to invest in the field of solar energy to produce electrical energy, so much research have been conducted on this subject. [1][2][3][4][5][6][7][8]. Solar radiation has a direct impact on life. It is a natural and permanent source, but it has not been greatly exploited. Despite the huge amounts of solar energy that can be produced, there are challenges that we must overcome.

Libya has one of the highest rates of solar radiation in the Mediterranean region. [1]. which makes it an ideal location for harvesting solar energy. Therefore, this paper was completed to estimate the electrical energy generated by this natural resource. This type of research is an essential step in planning renewable energy projects.

The main objective of this study is to calculate the amount of electrical energy that can be produced based on solar radiation in the

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city of Tripoli - Libya, and the electrical capacity of solar cells through monthly analysis.

2. Materials and methods

In this work, the city of Tripoli -Libya, has been chosen to calculate the amount of energy that can be produced from solar radiation, also to calculate the electrical capacity of solar cells and the efficiency of converting solar energy into electrical energy through monthly and quarterly analysis of solar radiation.

2.1 Solar radiation

The solar radiation data were taken from the NASA POWER platform. The monthly rates of total solar radiation values for the period from 2015-2024 are presented in Table 1 and figure 1.

As we can see from table 1, the average of monthly rates of total solar radiation produced during most months of the year, and the highest value of the average of monthly rates of total solar radiation was in the summer season. The highest value was in June 2022, which was 8.002 kW.hr/m^2/day, and the lowest value was in December 2017, which was 2.366 kW.hr/m^2/day.

TABLE 1. The monthly rates of total solar radiation values (kW.hr/m^2/day) for the period from 2015 to 2024.

yr / Mo	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Jan	2.88	3.167	2.959	3.272	2.694	2.985	3.031	2.684	3.041	2.929
Feb	3.445	4.046	4.122	3.506	3.615	4.269	3.892	2.922	3.764	3.891
Mar	4.771	5.454	5.306	5.383	4.963	5.024	5.390	4.927	5.511	5.544
Apr	6.542	6.410	5.755	6.239	6.090	6.304	6.039	5.937	6.388	5.592
May	7.506	6.732	7.335	6.954	6.920	7.146	7.254	7.548	6.400	6.875
Jun	7.56	7.264	7.796	7.439	7.665	7.641	7.349	8.002	7.362	7.429
Jul	7.902	7.804	7.906	7.603	7.946	7.963	7.796	7.875	7.770	7.687
Aug	6.581	7.124	7.179	6.880	7.097	7.247	6.956	7.039	6.875	7.004
Sep	5.656	5.589	5.808	5.683	5.760	5.141	5.766	5.716	5.867	5.239
Oct	3.886	4.239	4.29	4.294	4.374	4.232	4.182	4.658	4.728	4.300
Nov	3.095	3.067	3.236	3.146	3.307	3.320	3.021	3.447	3.472	3.521
Dec	2.642	2.399	2.366	2.797	2.693	2.809	2.783	2.947	2.553	2.457
Avg	5.209	5.278	5.345	5.277	5.269	5.343	5.297	5.400	5.319	5.210

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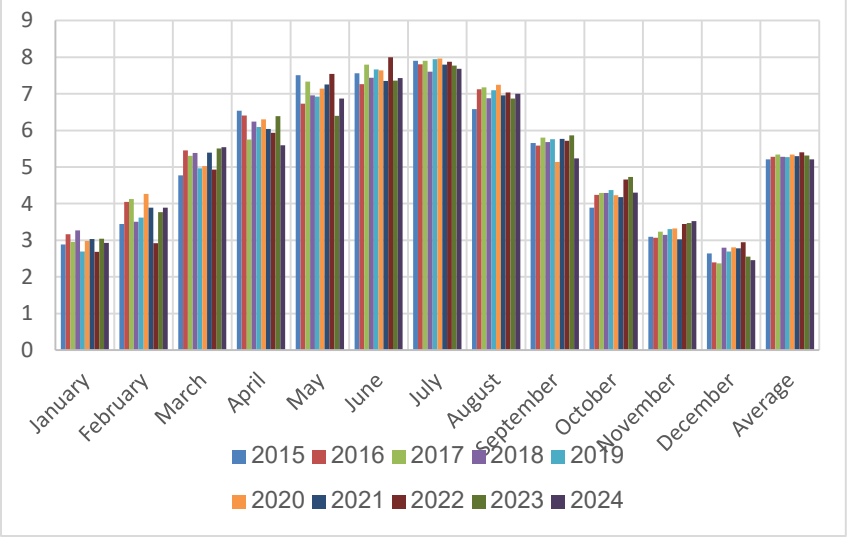

Figure 1: The monthly rates of total solar radiation values (kWhr/m^2/day) for the period from 2015-2024.

2.2 Calculating the Electrical energy generated by solar radiation

The electrical energy generated by solar radiation with solar panel can be calculated by using equation 1.[1].

$$E = G \times 1.1116 \quad (1)$$

Where E is the energy generated, G is the solar irradiance (kWhr/m²/day).

2.3 Calculating the electrical capacity of solar cells

The electrical capacity generated by solar radiation can be calculated by using equation 2. [1].

$$P = 0.002\, G_{hr} + 4882.1 \quad (2)$$

Where P is the electrical capacity, and G_{hr} is solar irradiance in (W/m^2).

3. Results and discussion

The electric energy was measured during the daytime, and the Calculating of monthly rates of electrical energy generated by solar radiation values, and electrical capacity of solar cells values for the period from 2015-2024 present in table 2, and 3, and shown in figure 2, and 3.

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TABLE 2. The monthly rates of electric energy values (kW.hr/day) for the period from 2015-2024.

yr / Mo	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Jan	3.205	3.52	3.289	3.637	2.995	3.318	3.369	2.984	3.380	3.256
Feb	3.829	4.498	4.582	3.897	4.018	4.745	4.36	3.248	4.184	4.325
Mar	5.303	6.663	5.898	5.984	5.517	5.585	5.992	5.477	6.126	6.163
Apr	7.272	7.125	6.397	6.935	6.77	7.008	6.713	6.600	7.101	6.216
May	8.344	7.483	8.154	7.730	7.692	7.943	8.064	8.390	7.114	7.642
Jun	8.404	8.075	8.667	8.269	8.52	8.494	8.169	8.895	8.184	8.258
Jul	8.784	8.675	8.788	8.451	8.833	8.852	8.666	8.754	8.637	8.545
Aug	7.315	7.919	7.980	7.648	7.889	8.056	7.732	7.825	7.642	7.786
Sep	6.287	6.213	6.456	6.317	6.403	5.715	6.409	6.359	6.522	5.824
Oct	4.320	4.712	4.769	4.773	4.862	4.704	4.649	5.178	5.253	4.780
Nov	3.44	3.409	3.597	3.497	3.676	3.691	3.358	3.832	3.856	3.914
Dec	2.937	2.667	2.63	3.109	2.994	3.122	3.094	3.276	2.838	2.731
Avg	5.79	5.867	5.942	5.866	5.857	5.939	5.888	6.003	5.913	5.791

As we can see from figure 2 there is a high possibility of producing electrical energy during most months of the year, especially during the summer and spring seasons. The highest value was reached in June 2022, which was 8.895 kW.hr/m^2/day, and the lowest value was reached in December 2017, which was 2.63 kW.hr/m^2/day.
We can see that the average values of the electrical energy ranged between 5.79 in 2015, and 6.003 in 2022, and the average values of electrical capacity ranged between 5.141 in 2022, and 5.132 in 2015, and 2024.

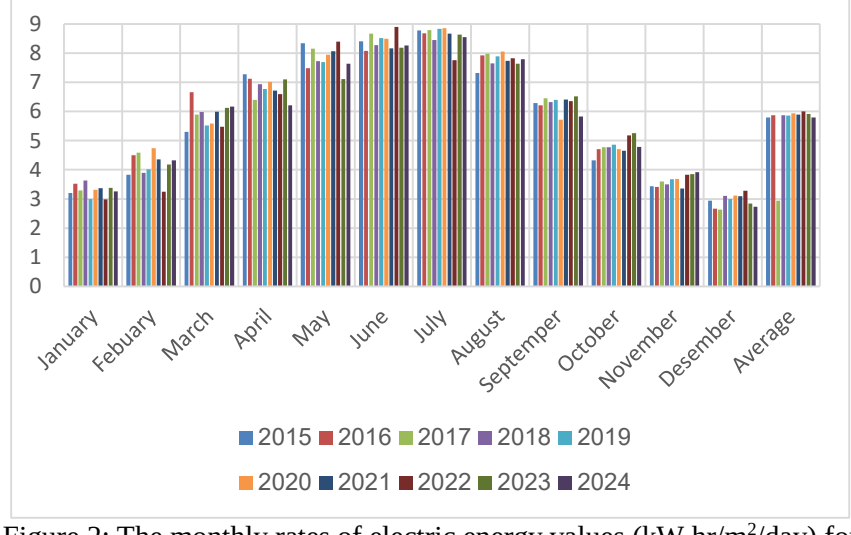

Figure 2: The monthly rates of electric energy values (kW.hr/m^2/day) for the period from 2015 to 2024.

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The energy we obtain from solar radiation is not constant and varies from one season to another. In some months, the energy obtained is large and the surplus can be stored in batteries such as lithium-ion and lead-acid batteries.

TABLE 3. The monthly rates of electric capacity values (kW/m^2) for the period from 2015-2024.

yr / Mo	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Jan	5.02	5.034	5.024	5.039	5.011	5.025	5.028	5.011	5.028	5.023
Feb	5.047	5.076	5.076	5.050	5.055	5.087	5.069	5.022	5.063	5.069
Mar	5.111	5.144	5.137	5.140	5.120	5.123	5.141	5.119	5.147	5.148
Apr	5.196	5.190	5.158	5.182	5.174	5.185	5.172	5.167	5.189	5.151
May	5.242	5.205	5.234	5.216	5.214	5.225	5.230	5.244	5.189	5.212
Jun	5.245	5.231	5.256	5.239	5.250	5.249	5.235	5.266	5.235	5.239
Jul	5.261	5.257	5.262	5.247	5.264	5.264	5.256	5.261	5.255	5.252
Aug	5.198	5.224	5.227	5.212	5.223	5.230	5.216	5.220	5.212	5.218
Sep	4.882	5.150	5.161	5.155	5.159	5.129	5.159	5.156	5.164	5.134
Oct	5.087	5.086	5.088	5.088	5.092	5.085	5.083	5.106	5.109	5.089
Nov	5.031	5.029	5.037	5.033	5.041	5.041	5.027	5.048	5.049	5.051
Dec	5.009	4.997	4.996	5.016	5.011	5.017	5.016	5.024	5.005	5.000
Avg	5.132	5.135	5.139	5.135	5.135	5.139	5.136	5.141	5.137	5.132

As we can see from figure 3, the highest value of electrical capacity for solar cells was reached in July 2022, which was 5.266 kW/m^2, and the lowest value was reached in December 2017, which was 4.996 kW/m^2.

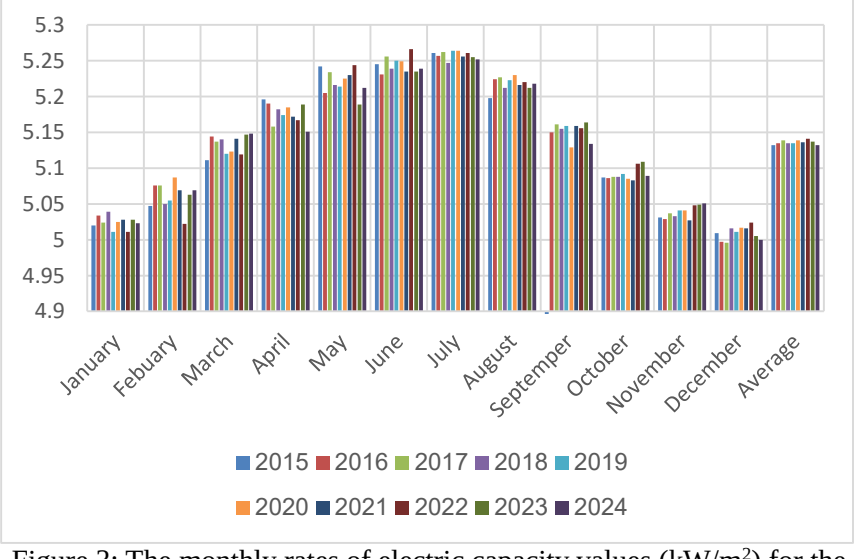

Figure 3: The monthly rates of electric capacity values (kW/m^2) for the period from 2015-2024.

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The calculation of annual rates of total electrical energy generated by solar radiation values for the period from 2015-2024 is shown in figure 4.
As we can see from figure 4, the highest value of annual rates of electric energy for solar cells was reached in 2020, which was 26.001 MW.hr/yr, and the lowest value was reached in 2024, which was 25.346 MW.hr/yr.

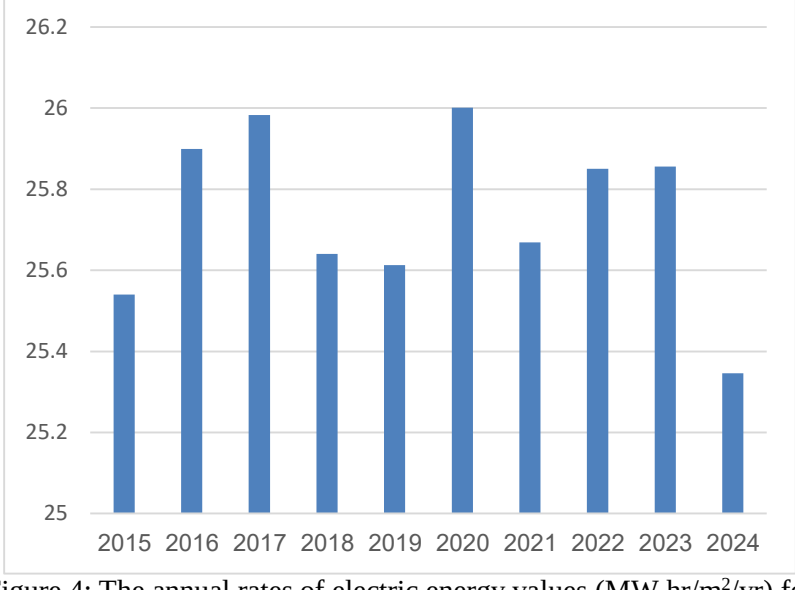

Figure 4: The annual rates of electric energy values (MW.hr/m^2/yr) for the period from 2015 to 2024.

Conclusion

The aim of this work is to calculate the amount of electrical energy that can be produced from solar radiation, and the electrical capacity of solar cells through monthly analysis. The maximum value of the calculated electrical energy reached 8.895 kW.hr/m^2/day in June 2022, while its lowest value was reached 2.63 kW.hr/m^2/day in December 2017. The maximum value of the calculated electrical capacity reached 5.266 kW/m^2 in June 2022, while its lowest value was reached 4.996 kW/m^2 in December 2017.
The amount of electrical energy that can be produced from solar radiation through annual analysis has been calculated, the highest value was reached 26.001 MW.hr/yr in 2020, and the lowest value was reached 25.346 MW.hr/yr in 2024.

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