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Power Generation Variation Analysis of Solar Panels Coated With TiO_2

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Anahtar Kelimeler
Renewable energy,
Solar panels,
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Photocatalytic materials,
Titanium dioxide

Abstract: Solar energy, which is an inexhaustible, clean and easily accessible energy source, can be converted into electrical energy with the help of photovoltaic (PV) panels. Environmental factors such as dust and dirt cause pollution of PV panels and decrease the efficiency of energy conversion. One of the methods used to reduce the negative effect of dirt on panel efficiency is to coat the surface of the panels with photocatalytic materials. Oxygen and nanoparticles are formed on photocatalytic surfaces with the help of ultraviolet rays in sunlight. These particles form a chemical reaction between the coating and the surface, breaking down and destroying the dirt on the surface. In this study, the effect of titanium dioxide (TiO_2) as a photocatalytic material on the efficiency of solar panels was investigated. Experimental studies were carried out in Bingöl city using two 285 W polycrystalline solar panels. One of the panel surfaces is coated with TiO_2 and no treatment has been applied to the surface of the other panel. When the measured data were analyzed, it was seen that while the powers of the two panels were almost the same at the beginning, with the contamination of the panels, the power obtained from the TiO_2 coated panel was up to 19% higher. In addition, it was observed that the excess power produced as a result of cleaning the PV panels after rainy days decreased again.

TiO_2 ile Kaplanan Güneş Panellerinin Güç Üretim Değişimi Analizi

Keywords
Yenilenebilir enerji,
Güneş panelleri,
Kirlenme,
Fotokatalitik malzemeler,
Titanyum dioksit

Öz: Tükenmeyen, temiz ve kolay erişilebilen bir enerji kaynağı olan güneş enerjisi fotovoltaik (PV) paneller yardımıyla elektrik enerjisine dönüştürülebilmektedir. Toz ve kir gibi çevresel faktörler PV panellerin kirlenmesine ve enerji dönüşüm verimlerinin düşmesine neden olmaktadır. Kirin panel verimi üzerindeki olumsuz etkisini azaltmak için kullanılan yöntemlerden biri panellerin yüzeyini fotokatalitik malzemelerle kaplamaktır. Fotokatalitik yüzeylerde güneş ışığındaki ultraviyole ışınları yardımıyla oksijen ve nano partiküller oluşur. Bu partiküller, kaplama ile yüzey arasında kimyasal bir reaksiyon oluşturarak yüzeydeki kirleri parçalar ve yok eder. Bu çalışmada, fotokatalitik malzeme olarak titanyum dioksitin (TiO_2) güneş panellerinin verimi üzerine etkisi incelenmiştir. Deneysel çalışmalar Bingöl İlinde iki adet 285 W polikristal güneş paneli kullanılarak yapılmıştır. Panel yüzeylerinden biri TiO_2 ile kaplanmış ve diğer panelin yüzeyine herhangi bir işlem uygulanmamıştır. Ölçülen veriler incelediğinde, başlangıçta iki panelin güçleri hemen hemen aynıyken panellerin kirlenmesiyle birlikte TiO_2 kaplanmış panelden elde edilen gücün %19 a kadar daha fazla olduğu görülmüştür. Ayrıca yağmurlu günlerden sonra PV panellerin temizlenmesi sonucunda üretilen fazla gücün tekrar azaldığı görülmüştür.

1. INTRODUCTION

Population growth, industrialization, and the increase in electric powered devices raise the energy demand of countries. As a result of the use of fossil fuels, carbon dioxide is released into the atmosphere. The increasing amount of carbon dioxide causes the greenhouse effect in the atmosphere and thus the average temperature of the world rises. An increase of 1 °C in temperature may lead to visible changes in the world's climate zones. Increases up to 3 °C may cause melting of polar ice caps, rising of seas, drying up of lakes and agricultural drought [1,2]. In addition, many negative factors such as limited fossil energy resources, sudden price changes, foreign dependency in energy causing various political and economic problems make it necessary to turn to renewable energy resources. When the data of the rates of electricity generation from renewable energy sources of the Organization for Economic Cooperation and Development (OECD) countries between 1991 and 2017 are examined, it is observed that there is a continuous increase [3]. In Turkey, the amount of energy production from renewable energy sources has increased every year and today, half of the total installed power is renewable energy sources. As of the end of September 2019, the distribution of installed power by resources; 31.4 percent hydraulic energy, 28.6 percent natural gas, 22.4 percent coal, 8.1 percent wind, 6.2 percent solar, 1.6 percent geothermal and 1.7 percent is other sources [4].

In order to meet the increasing energy demand, the use of solar energy, which is eternal and clean energy, is becoming widespread. Compared to the damage done to the environment while producing electricity from fossil fuels, the production of electricity from solar energy with photovoltaic panels is an extremely clean and environmentally friendly method.

The panels absorb the sunlight falling on them and generate direct current depending on the efficiency of the cells. There are solar cells on solar panels proportional to the power of the panel. Panel efficiency is the ratio of the amount of electrical energy produced to the solar energy coming to the panel surface. There are many factors that affect the efficiency of the panel. Cell type, quality and design, and the quality of glass and other components affect the efficiency of the panel. In addition, factors such as temperature, amount of radiation, shading, angle of incidence of light also determine the amount of power to be produced in the panel.

The installation cost of photovoltaic systems is higher than other electricity generation systems. With the long-term use of the system, this cost can be compensated by spreading over the years. In addition, high efficiency of the system is also important for tolerating the cost.

Due to being outdoors, the surface of the panels is contaminated with particles such as dust, chemical dirt, leaves and bird droppings over time. Due to these dirt accumulated on the panel surface, less sunlight falls on the solar cells inside the panels. Depending on the decrease in the amount of light falling on the cells, the electrical energy produced by the panels also decreases [5]. There have been many studies examining the effect of dirt on panel efficiency [6-9].

The surfaces of the panels in the regions with low rainfall are dustier. Where there is excessive dust, a yield loss of 14% occurs. If the angle of the panels with the horizontal axis is greater than 16 degrees, it can be assumed that the panel surface has been cleaned with rain water. Contamination under these conditions is assumed to cause a yield loss of 6%. However, if the angle of inclination is less than 16 degrees or if there is little rainfall in the region, and if more dirt accumulates on the panel surfaces due to dusting caused by agricultural and industrial activities in the region, this rate is greater than 6%. In a PV system whose surface is cleaned periodically, dust losses are around 5% [10,11].

In this study, the change of panel efficiency in the case of application of photocatalytic materials to solar panels under the conditions of climate, air pollution level, etc. of Bingöl has been revealed. There is no such study in the literature for this region before. In addition, the data obtained sets a precedent for other settlements with similar conditions.

2. MATERIALS AND METHOD

Wind is one of the factors affecting panel efficiency. Wind speed and intensity change the power produced by the panel. The temperature of the panel cells is taken into account in examining the efficiency of solar panels. The formula used for the relationship between temperature and wind is given in Eq.-1 [12].

$$T_c = T_a + \omega \times \left(\frac{0{,}32}{8{,}91 + 2 \times V_f}\right) \times I_T \qquad 1$$

Here, T_c is the panel cell temperature, T_a is the atmosphere temperature, ω is the assembly coefficient, V_f is the wind speed, and I_T is the instantaneous radiation.

Another factor affecting panel efficiency is temperature. As the temperature increases, the output voltage of the panel decreases and the current increases a little. The output power of PV panels varies directly with the amount of radiation and inversely with the panel temperature. In other words, if the panel temperature increases, the panel power decreases. Many studies [13-17] and postgraduate theses [18-20] have been carried out both to examine the negative effects of temperature on panel efficiency and to eliminate these negative effects. The variation of panel power depending on temperature is given in Eq.-2 and Eq.-3 [21].

$$T_C = T_{ORT} + 0{,}0256 \times G \qquad (2)$$

$$P_{PV\text{-}OUT} = P_{N\text{-}PV} \times \left(\frac{G}{G_{REF}}\right) \times [1 + K_T (T_C - T_{REF})] \qquad (3)$$

Here; $P_{PV\text{-}OUT}$ PV cell output power (W), $P_{N\text{-}PV}$ nominal power (W) of PV cell under reference conditions, G solar radiation (W/m2), G_{REF} solar radiation (G_{REF}=1000 W/m^2) under reference conditions, K_T maximum power temperature coefficient (K_T=-3.7x10-3(1/ºC) for mono and poly-crystalline Si), T_C PV cell temperature (ºC), T_{ORT} ambient temperature (ºC), T_{REF} PV cell temperature under reference conditions (T_{REF}=25 ºC)) represents.

Equation-2 and Equation-3 show that temperature has a direct effect on panel power. If calculations are made using these equations, it will be seen that the panel output power will be 221.695 W at 30 ºC ambient temperature and 226.32 W at 25 ºC ambient temperature. This difference for each panel will reach a significant value in large power solar power plants.

2.1. Photocatalysis Phenomenon and Photocatalytic Materials

Photocatalysis and photosynthesis can be compared to each other. By absorbing the sun's rays falling on chlorophyll in plants, it converts water and CO_2 into oxygen and glucose. Similarly, the photocatalyst absorbs the sun's rays by forming radicals (oxide, peroxide and hydroxyl radicals), which are strongly oxidizing species on its surface, and allows the formation of harmless species such as water and CO_2 by breaking down harmful organic molecules. Photocatalysis and photosynthesis events, which are compared in this way, are simply shown in Figure 1 [22].

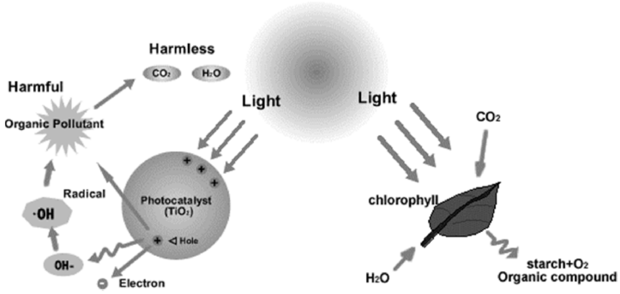


Figure 1. Photocatalysis process as compared to photosynthesis [23]

Recently, panels are coated with nano coating method. With this method, the panel surface is covered with a layer containing particles such as nano-sized titanium dioxide (TiO_2), silicon dioxide (SiO_2), etc. Thus, many different superior properties such as self-cleaning, easy-to-clean, antimicrobial, non-abrasive, scratch-proof and corrosion-proof are given to the material [24,25].

Coating methods are implemented by dipping, spinning, spray, plasma and chemical vapor precipitation methods [24]. Surfaces coated with these methods are called hydrophobic (water-repelling), hydrophilic (water-attracting) or photocatalytic surfaces. The water droplet falling on the surface does not spread on hydrophobic surfaces, but takes the shape of a sphere, while it spreads on hydrophilic surfaces.

TiO_2 is a semiconductor material and has three crystal structures: brookite, anatase and rutile. In photocatalytic applications, TiO_2 in the anatase crystal structure is mostly used.

Thin films containing TiO_2 have many advanced features such as self-cleaning at nanoscale, enabling the creation of antibacterial surfaces, preventing odors, non-fogging, etc., due to their photocatalytic properties and very good hydrophilic surface. Thanks to these superior properties, the use of TiO_2 films has become quite common recently. On the surfaces on which these films are coated, organic dirt adhered to the surface is broken down with the help of UV light, and thanks to the hydrophilic feature, water molecules flow on the surface in the form of a thin film and the fragmented dirt is easily removed from the surface. This allows the surface to be self-cleaning.

2.2. Experimental Study

In experimental system, two polycrystalline solar panels of the same power (285 W) were placed in the construction at the same angle and an experimental application was made in the Central District of Bingöl (Latitude: 38,8851578 Longitude: 40,5072665 Altitude: 1.126 m). Photocatalytic surface consisting of titanium dioxide (TiO_2) material is coated on one of the panels. No treatment has been applied to the surface of the other panel. As of 19.09.2021, the short circuit current and open circuit voltages of the panels were measured at approximately the same time every day, and the measurement results were recorded (Figure 2 and Figure 3). With the help of these measurements, the power produced by the solar panel covered with self-cleaning material (TiO_2) and the power produced by the normal panel were compared.

Figure 2. Experimental system

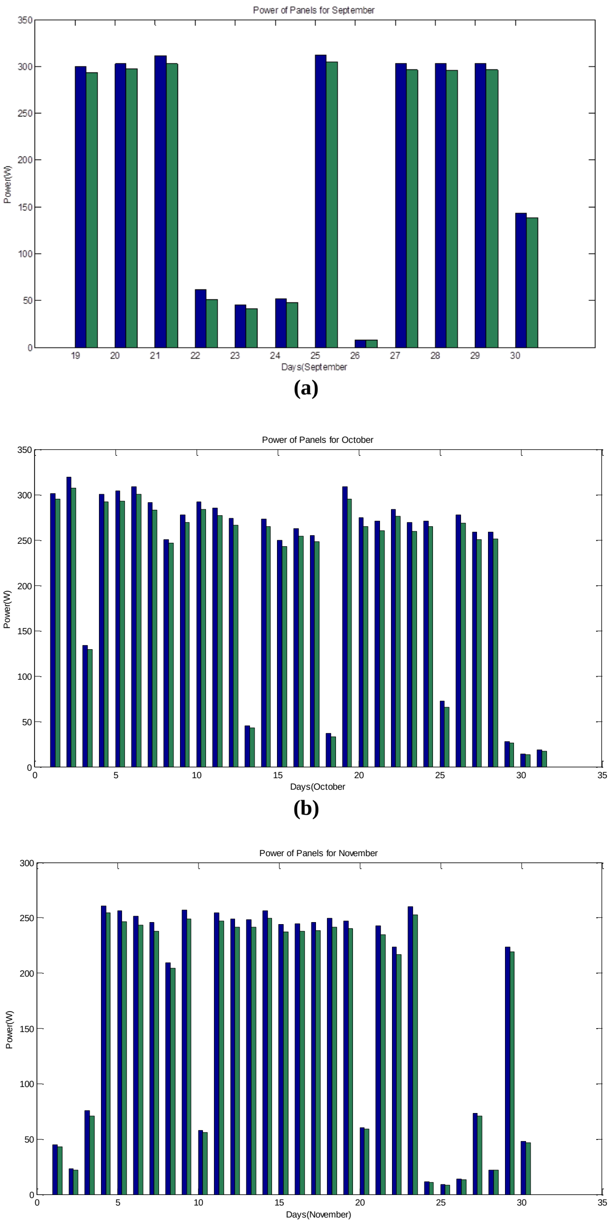
Figure 3. Measurement of short circuit current and open circuit voltage

The short-circuit current and open-circuit voltages of the panels were measured with a measuring instrument every day and the measurement results were recorded (Annex: 1).

When the first measured data on 19.09.2021 are analyzed, it is seen that the power difference between the two panels is 6.64 watts and the percentage difference is 2.26%. However, in the measurements made on 22.09.2021, it is seen that the difference increases up to 10.2 watts and up to 19.74% as a percentage, depending on the contamination of the panels. After it rained on September 24, 2021, it was determined that the power produced on September 25 was close to each other again. With the rain, the power difference produced as a result of cleaning the panels decreased. Again, when the data in the table is examined, it is seen that the power produced on cloudy days and in shady conditions decreases considerably. Based on the measurements made, the average power difference produced between the two panels in the measurements made on September 19-31 was calculated as 5.39%, 4.09% on October 1-31 and 3.18% on November 1-30.

3. RESULTS AND DISCUSSION

Panel powers for each month are shown in Annex-1 as a table and in Figure 4 graphically. When the measured data are examined, the power difference of the two panels was very close to each other at first, but in the following days, the difference approached 20% due to the pollution of the panels. In addition, it was observed that the power difference produced as a result of cleaning the panels after rainy days decreased again.



(a) (b) (c)

Figure 4. Power of panels (a) September (b) October (c) November

The power produced by the photocatalytic coated panel is greater than the power of the other panel under all conditions. In other words, it is seen in the measurements that the power produced by the photocatalytic coated panel is slightly higher than the power produced by the normal panel, both in sunny days, rainy weather and shady conditions, whether there is dirt or not. Because the light falling on the panel is less reflected and absorbed better thanks to the photocatalytic coating.

In addition, in September and October, panel powers were measured over 300 W on sunny days, but a maximum of 260 W was recorded in November. Although there is less pollution in November, the measurement of less power value can be explained by the temperature and wind factor.

Considering all the measured values, it is seen that the panels coated with photocatalytic material in the autumn season in Bingöl show a better efficiency than the normal panels. Although the percentage difference in yield increases to larger values on a daily basis, the seasonal average is around 4%. When the yield amount is compared on a monthly basis, the highest yield rate was 5.39% in September, while it decreased gradually in other months.

4. CONCLUSION

The obtained results show the effects of pollution, temperature and wind on panel efficiency. In addition, when the panel surface is covered with TiO_2, it is seen that the efficiency of the panels increases to a certain extent. The amount of change in yield was presented as daily, monthly and autumn season averages. Considering that the pollination is less in the fall and more in the summer, it is estimated that the production difference between the two panels will be higher in the summer months. In addition, Bingöl is a relatively underdeveloped city in terms of population and industrial development. It is predicted that in similar cities with this feature, the yield increase in TiO_2 coated panels will be the same, while this difference will be higher in crowded and industrially developed cities.

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ANNEX: POWER MEASUREMENT RESULTS OF PANELS

Table 1. Panel power values measured in September

No	Date	Hour	Photocatalytic Panel			Normal Panel			Power Diff. (W)	Per (%)	Explanation
			Current (A)	Voltage (V)	Power (W)	Current (A)	Voltage (V)	Power (W)			
1	19.09.2021	12:41	9.04	33.2	300.1	8.84	33.2	293.49	6.64	2.26	Sunny-27 ºC
2	20.09.2021	11:42	8.82	34.3	302.5	8.65	34.4	297.56	4.97	1.67	Sunny-27 ºC
3	21.09.2021	12:40	9.19	33.9	311.5	8.92	33.9	302.39	9.15	3.03	Sunny-29 ºC
4	22.09.2021	12:40	1.82	34	61.88	1.52	34	51.68	10.20	19.74	Cloudy-28 ºC
5	23.09.2021	12:25	1.35	34	45.9	1.21	34	41.14	4.76	11.57	Cloudy-24 ºC
6	24.09.2021	12:55	1.47	35.6	52.33	1.35	35.6	48.06	4.27	8.89	Rainy-13 ºC
7	25.09.2021	11:45	9.08	34.4	312.4	8.87	34.4	305.13	7.22	2.37	Sunny-18 ºC
8	26.09.2021	16:50	0.26	32.5	8.45	0.25	32.5	8.125	0.33	4.00	Sunny-20 ºC
9	27.09.2021	12:55	9.04	33.6	303.7	8.82	33.6	296.35	7.39	2.49	Sunny-26 ºC
10	28.09.2021	12:30	8.92	34	303.3	8.69	34	295.46	7.82	2.65	Sunny-26 ºC
11	29.09.2021	12:55	8.71	34.8	303.1	8.47	35	296.45	6.66	2.25	Sunny-25 ºC
12	30.09.2021	12:15	4.11	34.9	143.4	3.96	34.9	138.2	5.24	3.79	Cloudy-22 ºC
Average Difference										**5.39**	

Table 2. Panel power values measured in October

No	Date	Hour	Photocatalytic Panel			Normal Panel			Power Diff. (W)	Per (%)	Explanation
			Current (A)	Voltage (V)	Power (W)	Current (A)	Voltage (V)	Power (W)			
1	01.10.2021	12:10	8.70	34.60	301.02	8.48	34.80	295.10	5.92	2.00	Sunny-23 ºC
2	02.10.2021	12:55	9.20	34.70	319.24	8.81	34.90	307.47	11.77	3.83	Sunny-22 ºC
3	03.10.2021	14:02	4.12	32.50	133.90	3.97	32.50	129.03	4.88	3.78	Cloudy-20 ºC
4	04.10.2021	12:00	8.68	34.60	300.33	8.44	34.60	292.02	8.30	2.84	Sunny-19 ºC
5	05.10.2021	12:40	8.82	34.50	304.29	8.49	34.50	292.91	11.39	3.89	Sunny-18 ºC
6	06.10.2021	12:30	8.83	35.00	309.05	8.56	35.10	300.46	8.59	2.86	Sunny-16 ºC
7	07.10.2021	12:55	8.50	34.30	291.55	8.22	34.40	282.77	8.78	3.11	Sunny-17 ºC
8	08.10.2021	10:00	7.26	34.50	250.47	7.13	34.60	246.70	3.77	1.53	Sunny-17 ºC
9	09.10.2021	13:25	8.15	34.10	277.92	7.88	34.20	269.50	8.42	3.12	Sunny-21 ºC
10	10.10.2021	12:40	8.56	34.10	291.90	8.29	34.20	283.52	8.38	2.96	Sunny-22 ºC
11	11.10.2021	12:30	8.55	33.40	285.57	8.29	33.40	276.89	8.68	3.14	Sunny-22 ºC
12	12.10.2021	12:50	8.16	33.60	274.18	7.90	33.70	266.23	7.95	2.98	Sunny-22 ºC
13	13.10.2021	12:00	1.32	33.90	44.75	1.25	34.00	42.50	2.25	5.29	Cloudy-24 ºC
14	14.10.2021	12:00	8.12	33.60	272.83	7.85	33.70	264.55	8.29	3.13	Sunny-24 ºC
15	15.10.2021	11:45	7.27	34.30	249.36	7.05	34.40	242.52	6.84	2.82	Sunny-25 ºC
16	16.10.2021	12:00	7.72	34.00	262.48	7.46	34.10	254.39	8.09	3.18	Sunny-23 ºC
17	17.10.2021	11:00	7.36	34.60	254.66	7.16	34.70	248.45	6.20	2.50	Sunny-21 ºC
18	18.10.2021	11:45	1.06	34.50	36.57	0.96	34.60	33.22	3.35	10.10	Cloudy-16 ºC
19	19.10.2021	12:30	8.77	35.20	308.70	8.36	35.30	295.11	13.60	4.61	Sunny-18 ºC
20	20.10.2021	12:50	8.03	34.20	274.63	7.75	34.20	265.05	9.58	3.61	Sunny-19 ºC
21	21.10.2021	13:10	7.87	34.40	270.73	7.57	34.40	260.41	10.32	3.96	Sunny-20 ºC
22	22.10.2021	11:50	8.30	34.20	283.86	8.05	34.30	276.12	7.75	2.80	Sunny-19 ºC
23	23.10.2021	13:00	7.73	34.80	269.00	7.44	34.90	259.66	9.35	3.60	Sunny-21 ºC
24	24.10.2021	11:00	7.78	34.80	270.74	7.58	34.90	264.54	6.20	2.34	Sunny-19 ºC
25	25.10.2021	12:35	2.02	35.70	72.11	1.82	35.80	65.16	6.96	10.68	Cloudy-14 ºC
26	26.10.2021	13:00	7.72	36.00	277.92	7.44	36.10	268.58	9.34	3.48	Sunny-17 ºC
27	27.10.2021	12:40	7.43	34.80	258.56	7.18	34.90	250.58	7.98	3.19	Sunny-16 ºC
28	28.10.2021	12:30	7.40	35.00	259.00	7.15	35.10	250.97	8.03	3.20	Sunny-15 ºC
29	29.10.2021	11:50	0.79	35.30	27.89	0.74	35.30	26.12	1.77	6.76	Rainy-10 ºC
30	30.10.2021	12:40	0.41	34.60	14.19	0.38	34.70	13.19	1.00	7.58	Rainy-8 ºC
31	31.10.2021	13:40	0.53	34.60	18.34	0.49	34.70	17.00	1.34	7.85	Rainy-11 ºC
Average Difference										**4.09**	

Table 3. Panel power values measured in November

No	Date	Hour	Photocatalytic Panel			Normal Panel			Power Diff. (W)	Per (%)	Explanation
			Current (A)	Voltage (V)	Power (W)	Current (A)	Voltage (V)	Power (W)			
1	01.11.2021	16:15	1.28	34.80	44.54	1.23	34.80	42.80	1.74	4.07	Cloudy-13 °C
2	02.11.2021	12:40	0.67	35.00	23.45	0.62	35.10	21.76	1.69	7.76	Rainy-11 °C
3	03.11.2021	11:20	2.14	35.40	75.76	2.00	35.50	71.00	4.76	6.70	Cloudy-13 °C
4	04.11.2021	12:20	7.52	34.70	260.94	7.33	34.70	254.35	6.59	2.59	Sunny-21 °C
5	05.11.2021	11:10	7.32	35.00	256.20	7.02	35.10	246.40	9.80	3.98	Sunny-16 °C
6	06.11.2021	13:25	7.18	35.00	251.30	6.95	35.00	243.25	8.05	3.31	Sunny-20 °C
7	07.11.2021	13:00	7.03	35.00	246.05	6.80	35.00	238.00	8.05	3.38	Sunny-19 °C
8	08.11.2021	13:40	6.02	34.80	209.50	5.88	34.80	204.62	4.87	2.38	Sunny-19 °C
9	09.11.2021	12:30	7.41	34.70	257.13	7.17	34.70	248.80	8.33	3.35	Sunny-15 °C
10	10.11.2021	12:10	1.63	35.60	58.03	1.56	35.70	55.69	2.34	4.19	Cloudy-11 °C
11	11.11.2021	12:30	7.07	36.00	254.52	6.85	36.10	247.29	7.24	2.93	Sunny-13 °C
12	12.11.2021	11:15	7.01	35.50	248.86	6.79	35.60	241.72	7.13	2.95	Sunny-12 °C
13	13.11.2021	12:00	7.03	35.30	248.16	6.82	35.40	241.43	6.73	2.79	Sunny-14 °C
14	14.11.2021	12:00	7.29	35.20	256.61	7.07	35.30	249.57	7.04	2.82	Sunny-14 °C
15	15.11.2021	11:50	6.72	36.30	243.94	6.51	36.40	236.96	6.97	2.94	Sunny-13 °C
16	16.11.2021	11:30	6.95	35.20	244.64	6.73	35.30	237.57	7.07	2.98	Sunny-13 °C
17	17.11.2021	11:40	6.97	35.30	246.04	6.74	35.40	238.60	7.44	3.12	Sunny-13 °C
18	18.11.2021	12:15	7.05	35.40	249.57	6.83	35.40	241.78	7.79	3.22	Sunny-13°C
19	19.11.2021	11:35	7.02	35.20	247.10	6.81	35.30	240.39	6.71	2.79	Sunny-12°C
20	20.11.2021	12:35	1.64	36.70	60.19	1.61	36.80	59.25	0.94	1.59	Rainy-6 °C
21	21.11.2021	11:40	6.79	35.80	243.08	6.54	35.90	234.79	8.30	3.53	Sunny -12^0 C
22	22.11.2021	13:30	6.26	35.70	223.48	6.07	35.70	216.70	6.78	3.13	Sunny -13^0 C
23	23.11.2021	12:30	7.30	35.60	259.88	7.08	35.70	252.76	7.12	2.82	Sunny -14^0 C
24	24.11.2021	11:20	0.32	34.80	11.14	0.31	34.90	10.82	0.32	2.93	Cloudy -6^0 C
25	25.11.2021	12:10	0.26	34.40	8.88	0.25	34.50	8.63	0.25	2.90	Rainy -7^0 C
26	26.11.2021	11:30	0.39	35.10	13.62	0.38	35.20	13.38	0.24	1.82	Rainy -6^{0}C
27	27.11.2021	12:30	2.01	36.39	73.14	1.95	36.43	71.04	2.11	2.96	Cloudy -8^0 C
28	28.11.2021	12:35	0.62	35.50	22.01	0.61	35.60	21.72	0.29	1.35	Cloudy -8^0 C
29	29.11.2021	12:40	6.20	36.10	223.82	6.06	36.20	219.37	4.45	2.03	Sunny -13^0 C
30	30.11.2021	12:40	1.32	36.10	47.65	1.29	36.20	46.70	0.95	2.04	Cloudy-11^0 C
Average Difference										**3.18**	