SMMC PROBLEM SOLUTION

Summary:

Due to the constant electricity outages, Syrians started installing solar panels to face this obstacle. But many problems arose such as arguments between residents. Therefore, it is necessary to install solar panels in the most proper way that maximizes the produced energy for summer and winter. In our model, we build up a formula that calculates the optimal slope angle of the panels, which makes the solar radiation perpendicular to the panel depending on the concept of solar altitude and azimuth angle. It was proved that panel shadowing will decrease its efficiency. We used a formula to calculate the maximum length for the shape and consider it while installing the panels. Then, we found a formula that calculates the maximum produced energy by the panels depending on the solar insolation, incidence angle, and conversion efficiency. In addition, we needed to verify if the produced energy will be enough for the building residents. This was done by dividing the appliances into categories (High, medium, and low consuming), and the model was evaluated depending on the percentage of the supplied appliances. After we applied our model to different installation possibilities, it showed that installing panels in one plane is the best choice to gain maximum power. Laterally and Longitudinally installations were accepted in cases of medium consumption. Placing two panels in height fixed longitudinally did not satisfy the residents' needs.

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Introduction:

According to what the manager of the Government Institution for Electricity Production (Najwan Khouri) said " the amount of the electricity production in Syria equal 25% to the total amount needed." To face this challenge, Syrians started installing solar panels to meet their needs. During these procedures, many obstacles arise such as orientation, shade, and the building roof suitability. In addition, arguments may occur between the residents of the same buildings. That's what led the researchers to find the best installation method for solar panels.

Related Works:

Several interesting articles **(** (Heywood, 1971), (Kern, 1975) , (Garg, 1982), (Duffie, 1991), (Lewis, 1987), (El-Kassaby, 1988), (El-Naggar, 1988)**)** have been devoted to this problem. Most of these articles treat the problem qualitatively and quantitatively, while only two of them [(Kern, 1975), (El-Naggar, 1988)] give an analytical treatment. It is reported in the literature that in the northern hemisphere, the optimum orientation is south facing and the optimum tilt angle depends only on the latitude. No definite value is given by researchers for the optimum tilt angle. For example, (Heywood, 1971) concluded that $\theta = La - 10°$, (Lunde, 1980) and (Garg, 1982) $\theta = La \pm 15°$, and (Duffie, 1991) suggested $\theta = (La + 15°) \pm 15°$, where θ is the optimal angle slop of the solar panel and La is latitude of the location and where plus, and minus signs are used in winter and summer, respectively. Theoretical models for θ were suggested by (Lewis, 1987), who considered two different models for θ corresponding to, as $\theta = La \pm 8°$ (El-Kassaby, 1988) introduced an analytical equation to get the daily optimum angle at any latitude. They showed that the maximum angle between the obtained value for θ using the analytical equation, and the θ based on experiments, did not exceed 3%. They also concluded that the optimum tilt angle for any period could be obtained by integrating the analytical equation over the required period. (El-Kassaby, 1988) determined the optimum tilt and the surface azimuth angles for an absorber plate covered by one or two glass covers. He reported that using two glass covers instead of one did not appreciably affect the value of θ. The previous studies do not recommend any definite value of the tilt angle.

Further review of literature shows that there is a wide range of θ as recommended by different authors, and they are mostly for specific locations. Detailed analysis of the previous mentioned approaches shows that:

1. All of the above approaches are too approximate and they are mostly for specific locations.
2. None of the analytical methods can be used when $DE \neq 0$ (The Declination, which is the angle between the plane of the Earth's equator and the line to the sun).
3. The analytical method presented in (El-Naggar, 1988) can be applied only in the heating seasons, i.e., from 21 September to 21 March in the Northern Hemisphere, and from 21 March to 21 September in the Southern Hemisphere. Moreover, the model suggested in (Lewis, 1987) was concerned with a narrow range rang of La (between 30° and 35°).

4. The use of some analytical methods [(Kern, 1975), (El-Naggar, 1988)] one must know several meteorological parameters such as monthly average daily hemispherical radiation; monthly average daily beam radiation, and monthly average daily diffuse radiation on a horizontal surface.
5. The use of some analytical methods is very complicated (in (El-Naggar, 1988) for example).

Restatement:

We were asked to install solar panels in a way that gain the maximum profit of the roof building and to verify if it meets the residents needs and self-sufficiency of electricity in Summer and Winter considering four cases of panels installation:

- a- All panels in the same plan.
- b- Panels are installed one by one longitudinally.
- c- Panels are installed one by one Laterally.
- d- Two panel in height fixed longitudinally.

Assumption and Justifications:

1) We assume that the roof of the building is empty.
2) We assume that the roof is totally lighten. There is no Tree or building that shade on the roof.
3) The calculations will differ between Summer and Winter. For the difference in electricity consumption, the change of the optimal angle slope of solar panels and solar panels numbers during both seasons.
4) We assume that the panels should be distributed in a way that does not shade on each other. For the shadow affect negatively the solar panels and decrease of its performance.
5) We assume that the effect of the temporary conditions- like clouds block sunlight - is neglected. For the natural conditions are temporary.
6) We assume that the shadows of the solar panels are soft shadows at the early morning and the sunset.
7) We assume that solar panels work from 8:00 till 15:00 in winter and from 7:00 till 18:00 in summer.

Variables and Constant:

Variable or constant	Description
La	Constant that represents the latitude of a location of object on Earth
Al	Is the solar panel's altitude angle
DY	Is Day of the Year
De	Declination is the angle between the plane of the Earth's equator and the line to the sun

HA	hour angle is the angle between the local meridian and the hour circle of the sun
Az	azimuth angle is the angle between due south and the projection of the line to the sun onto the horizontal plane
η	Is the natural conditions coefficient
λ	Is the maximum conversion efficiency of the solar panel
T	Is the temperature of the solar panel (in degrees Celsius)
T_0	Is the reference temperature (in degrees Celsius)
D	Is the amount of dust on the solar panel
V	Is the air speed
$\beta, \gamma, and\ \alpha$	Are coefficients constants provided by the manufacturer represent the impact of temperature, dust, and air speed on the conversion efficiency, respectively.
Ins	Solar insolation is the amount of solar radiation that falls on the panel.
E	Is the Energy Produced.
Inc	the angle of incidence is a measure of the directness of the sunlight.
θ	Is the Optimal Angle of the Solar Panels
C_s	is the consumption value (in watts) of electricity for a season s
$\mathrm{A_i}$	is the consumption value (in watts) of electricity for the i_{th} appliance
$\mathrm{H_i}$	is hourly usage of the i_{th} appliance per day
U_i	is number of units of the i_{th} appliance
D_i	is day frequency usage per month for the i_{th} appliance
θ_s	Is the optimal Angle slope for Summer
Al_s	Is the Solar altitude angle for summer solstice
θ_w	Is the optimal Angle slope for Winter
Al_w	Is the Solar altitude angle for Winter solstice
S	Is the area of solar panel
K	$K \in R$
L	Represent the length
W	Represent the width

Optimal Angle of the Solar Panels:

In order to best make use of sunlight, we need to find the optimal value of the angle slope to maximize the energy produced by the solar panels. Several factors will contribute:

1) Altitude angle (Al) :is the angle between the horizontal plane and the line to the sun. It varies throughout the day and is highest at solar noon. The solar altitude angle also changes depending on the latitude of the location on Earth. The higher the latitude, the lower the maximum solar altitude angle will be. So, we can represent it by the following formula:

$$\mathrm{Al} = \arcsin(\sin La \times \sin De + \cos La \times \cos De \times \cos HA)$$

Where:

- La is the angular distance of a location north or south of the Earth's equator.
- De is the declination angle which is the angle between the plane of the Earth's equator and the line to the sun, which can be calculated using the formula:

$$De = 23.45° \times \sin\left(\left(\frac{2\pi}{365}\right) \times (DY - 81)\right)$$

- HA is the angle between the local meridian and the hour circle of the sun, which can be calculated using the formula:

$$HA = (15° \times (local\ solar\ time - 12))$$

(Kalogirou, 2009)

2) Azimuth angle (Az): Solar azimuth angle is the angle between due south and the projection of the line to the sun onto the horizontal plane. It changes throughout the day as the sun moves across the sky from east to west. The solar azimuth angle also changes depending on the latitude and the time of year. We can represent it by the following formula:

$$Azimuth = arccos\left(\frac{\sin Al \times \sin La - \sin De}{\cos Al \times \cos La}\right)$$

(Kalogirou, 2009), (Boxwell, 2017)

So, the optimal slope can know be calculated by the following formula:

$$\theta = Al - La$$

(Kalogirou, 2009)

By using this formula, the angle slope of the solar panel can be determined for any location on Earth and any time of year, allowing for optimal energy production from solar panels. But if we want to calculate the optimal angle for summer and the optimal for the winter, we can by making the following adjustments to the formula:

Summer: For the summer months, we can calculate the optimal angle slope for the solar panel by using the solar altitude angle for the summer solstice, which is typically around June 21st. We can adjust the formula by using the solar altitude angle for the summer solstice instead of the current solar altitude angle, such as:

$$\theta_s = Al_s - La$$

Winter: For the winter months, we can calculate the optimal angle slope for the solar panel by using the solar altitude angle for the winter solstice, which is typically around December 21st. We can adjust the formula by using the solar altitude angle for the winter solstice instead of the current solar altitude angle, such as:

$$\theta_w = Al_w - La$$

This will allow us to determine the optimal angle slope for the solar panels twice a year, which should maximize the amount of sunlight the panels can capture during the summer and winter months.

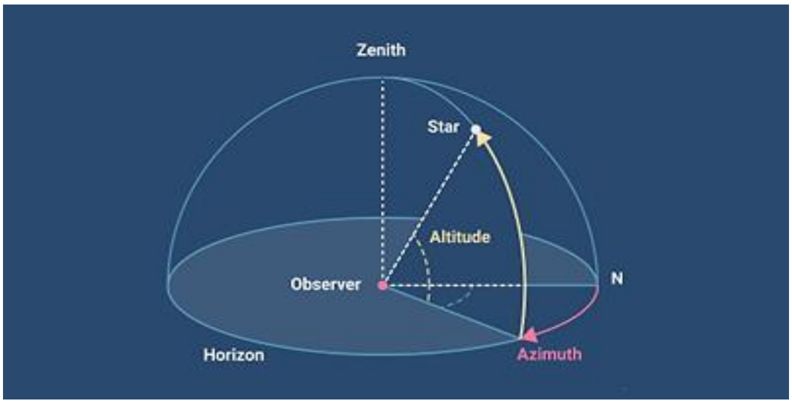


Figure 1 illustrating the azmuth and the altitude angle

Maximum number of solar panels that can be instilled on the roof:

1- Calculating the shadow:

There are two kinds of shades that block solar panels. The first one is called soft shade which can be described as simply lowering the intensity of the irradiance levels, without causing any form of visible separation of shaded and unshaded regions. For example, the shade caused by cirrus.

The other kind of shade is hard shading occurs when a physical object, such as a tree shade, chimney shadow, or shadow from one panel falling over another, obstructs sunlight, resulting in obvious lit and unlit regions on an array.

Shading just one cell in a module to half reduces the power generation by half the quantity. No matter the number of cells available in the string, the shaded cell will generate the module's output power to fall to zero.

Proper placement of the panel and consideration of the shadow length will eliminate shading problems. (Maheswari, 2022)

To calculate the length of panels' shadows we assumed a plan in which x axis represent north south line and y axis represent the east west line. We depended on Al, Az, θ and the length and the width of the panel l, w respectively.

We can describe the light beam by a line represented by the following equation:

$$x = \mathrm{k} \cdot \cos(Al) \cdot \cos\,(Az)$$

$$y = \mathrm{k} \cdot \cos(Al) \cdot \sin(Az)$$

$$z = \mathrm{k} \cdot \sin(Al)$$

Therefore, the vector $\vec{v}$ that has the same slope of the light beam is :

$$\vec{v} = \begin{pmatrix} \cos(Al) \cdot \cos(Az) \\ \cos(Al) \cdot \sin(Az) \\ \sin(Al) \end{pmatrix}$$

Then we found the parametrization of the line d that pass-through point $M(x_0, y_0, z_0)$ and parallel the vector $\vec{v}$:

$$d : \begin{Bmatrix} x = \mathrm{t} \cdot \cos(Al) \cdot \cos(Az) + x_0 \\ \mathrm{y} = \mathrm{t} \cdot \cos(Al) \cdot \sin(Az) + y_0 \\ z = \mathrm{t} \cdot \sin(Al) + z_0 \end{Bmatrix}$$

And to find the coincident of d and the base plane the value of z should be equal to zero:

$$0 = \mathrm{t} \cdot \sin(Al) + z_0$$

$$\mathrm{t} \cdot \sin(Al) = -z_0$$

$$t = -\frac{z_0}{\sin(Al)}$$

Then the value of x and y will be:

$$x = -\frac{z_0}{\sin(Al)} \cdot \cos(Al) \cdot \cos(Az) + x_0$$

$$y = -\frac{z_0}{\sin(Al)} \cdot \cos(Al) \cdot \sin(Az) + y_0$$

And because the farthest point of the shadow is caused by the angles of the panel we need to find the coordinate of this points.

This coordinate could be calculated in terms of $l, w \; and \; \theta$:

$$M_1(l \cdot \cos(\theta), 0, l \cdot \sin(\theta))$$

$$M_2(l \cdot \cos(\theta), w, l \cdot \sin(\theta))$$

Then we applied the previous formula to find the coincident:

$$M_1' = \left(\left(-\frac{l \cdot \sin(\theta)}{\sin(Al)} \cdot \cos(Al) \cdot \cos(Az) + \; l \cdot \cos(\theta)\right), \left(-\frac{l \cdot \sin(\theta)}{\sin(Al)} \cdot \cos(Al) \cdot \sin(Az) + 0\right), 0\right)$$

$$M_2' = \left(\left(-\frac{l \cdot \sin(\theta)}{\sin(Al)} \cdot \cos(Al) \cdot \cos(Az) + \; l \cdot \cos(\theta)\right), \left(-\frac{l \cdot \sin(\theta)}{\sin(Al)} \cdot \cos(Al) \cdot \sin(Az) + w\right), 0\right)$$

Then we can calculate the required distance between the panels to avoid the shadowing problem:

$$x_r = w + x_{M_1'}$$

$$y_r = l + \max\left(\left|y_{M_1'}\right|, \left|y_{M_2'}\right|\right)$$

Where x_r and y_r represent the requested length and width values for each panel. So, after finding the values of x_r and y_r we can calculate the number of panels that fit in the dimensions of the roof.

The energy produced by solar panels:

The are several factors that affect the ability of solar panels to produce power. Including:

1) Area of solar panel: the energy produced of a panel is correlated positively with its area.
2) Solar insolation: it is the amount of solar radiation that falls on the panel
3) Angle of incidence: is the angle between the incoming sunlight and the surface of the solar panel.
4) natural conditions:
    - temperature: As the temperature of the solar panel increases, its efficiency tends to decrease. This is because higher temperatures can cause the electrical resistance of the panel to increase, leading to losses in power output. (Swapnil Dubey, 2012)
    - Dust: Accumulation of dust and other debris on the surface of solar panels can reduce their efficiency by blocking sunlight and reducing the amount of energy that reaches the photovoltaic cells. (Monto Mani, 2010)
    - Air speed: excessively high winds can cause damage to the panels or their mounting structures. (Iqbal & Nadeem Ahmed Sheikh, 2017).

The energy produced by a solar panel can be calculated using this formula:

$$E = S \times Ins \times \lambda \times \eta \times \cos(Inc)$$

Where:

- E indicates the produced energy
- S is the panel's space
- Ins is the solar insolation
- λ is the maximum conversion efficiency of the solar panel which is indicated by the manufacturer. It represents the maximum percentage of solar radiation that is converted into electrical energy by the panel.

The multiplication of these three variables can be represented by a single variable which is the panel capacity.

- η is the natural conditions coefficient which represent the effect of temperature, the amount of dust on the panel, and the air speed. It can be represented mathematically using the following formula:

  $$\eta = (1 - \beta\ (T - T_0) - \gamma D - \alpha V)$$

  Where:
    - T is the temperature of the solar panel (in degrees Celsius)
    - T_0 is the reference temperature (in degrees Celsius)
    - D is the amount of dust on the solar panel (as a decimal)
    - V is the air speed (in meters per second)

- β, γ, and α are coefficients that represent the impact of temperature, dust, and air speed on the conversion efficiency, respectively the coefficients β, γ, and α are typically determined experimentally and can vary depending on the specific type of solar panel and the environmental conditions. In general, a higher value of β indicates that the conversion efficiency decreases more rapidly with increasing temperature, a higher value of γ indicates that the conversion efficiency decreases more rapidly with increasing dust accumulation, and a higher value of α indicates that the conversion efficiency decreases more rapidly with increasing air speed.
  - To find the values of α, β, γ using linear regression, where we assumed that the weights of the linear function are α, β, γ and bias is equal to zero.
- Inc represents the angle of incidence:

The cosine of the angle of incidence is included in the formula because the energy produced is proportional to the amount of direct sunlight that falls on the panel, and the cosine of the angle of incidence is a measure of the directness of the sunlight. When the angle of incidence is zero (i.e., the sunlight is perpendicular to the panel), the cosine of the angle of incidence is 1, and the panel receives the maximum amount of direct sunlight. And we can represent it by the following formula:

$$inc = arccos(sin(La) \times sin(De) \times cos(HA) + cos(La) \times sin(De))$$

(Iqbal & Nadeem Ahmed Sheikh, 2017), (Swapnil Dubey, 2012).

Our model was applied to find out the panels number and the most efficient installation of them in summer and winter that satisfy all residents.

Four installation possibilities were considered when it was applied:

a- Distributing Solar panels in the same plane:

Since all panels are in the same plane, they did not block each other. Therefore, there is no need to make distances between them. And the maximum value of energy will be obtained when the slope angle of the panels is optimal. And in order to make the most use of the roof surface, panels are distributed in a way that covers the surface. The number of the used panels is calculated as follows:

- Panels number in the row is the result of the floor division of the roof width on the panel width.
- Panels number in the column is the result of the floor division of the roof length (after dividing it on the cosine of the optimal angle) on the panel length.
- The total number of the installed panels is the multiplication of their number in the row with their number in the column.

It can be noticed that the number of panels used in summer differ from the ones used in winter since the optimal slope angle value is different.

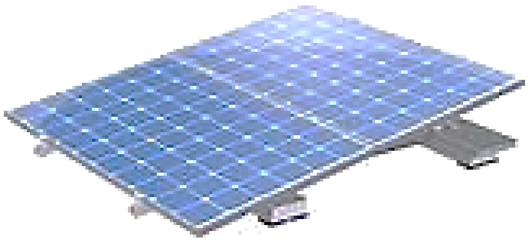


Figure 2 all panels in same plan

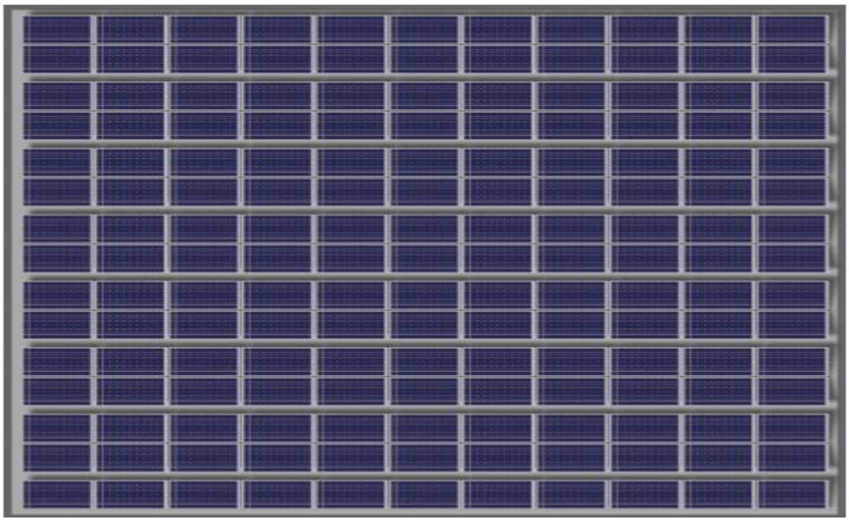
b- in this case we should take in consideration the shadowing, and to calculate the best coordination to installing the panels we used the equation that use the shadow formula with the constants: $l = 210\ cm$,$w = 105\ cm$. In the summer case we choose θ to be equal to 20.58° and $Al = 19.56°, Az = 74.54°$.

And in the winter, we choose θ to be equal to 47.36° and $Al = 13.53°, Az = 131.99°$.

Figure 3 Solar panels installed longitudly

c- this case is similar to the previous one but with a change in the constant: $l = 105\ cm$,$w = 210\ cm$.
In the summer case we choose θ to be equal to 20.58° and $Al = 19.56°$,$Az = 74.54°$.

And in the winter, we choose θ to be equal to $47.36°$ and $Al = 13.53°$, $Az = 131.99°$.



d- the change in this case is close to the changes in the last one the variables that changes are the diminutions of the panel $l = 420\ cm$, $w = 105\ cm$. In the summer case we choose θ to be equal to $20.58°$ and $Al = 19.56°$, $Az = 74.54°$. And in the winter, we choose θ to be equal to $47.36°$ and Al= 13.53°, $Az = 131.99°$.

Electricity Consumptions of residents:

In order to calculate the consumption for each department we built a data set containing the most important electric devices and their rating in watts and the number of units for each device and the hours of usage.

We split the devices into three groups. The first group is the high consumption; this group consists of devices that require over 1000 watts. The second one is the medium-consuming group requires between 200 and 1000 watts. The last group is the low consuming which requires less than 200 watts.

Then we evaluated the four installation possibilities depending on the three groups as follows:

- If the installation produces power enough to run all the devices, then it will be highly efficient.
- If the installation produces power enough to run all the high-consuming devices except one at maximum and all the medium-consuming devices except two at maximum, then it will be considered acceptance.
- Otherwise, the installation will be considered as low efficient.

Conclusion:

We build our solution in several stages. First, we write formulas to calculate the optimal value of the angle slope of solar panels in summer and winter. Second, we depend on shadows calculation to calculate the maximum number of solar panels that can be installed on the roof for each way of installation and compared them with them. Then we calculate the produced energy of the solar panels by finding the relationship between the optimal values and other factors like temperature and how it affects the energy. Finally, we calculated the consumption of the energy of the residents and compare it to the produced energy of the panels to verify if it meets their needs.

Results:

1) The optimal angle slope of the solar panels is 20.58° in the summer and in the winter is 47.36°
2) The average of produced energy by each panel 369.6watt in winter and in summer is 394.68watt
3) The consumption of residents of the buildings in winter is 162.4Kwatt at maximum consumption and the average value of consumption is between 65.28-142.4Kwatt. In summer is 170.4Kwatt at maximum consumption and the average value of consumption is between 73.28-136Kwatt.

4) The maximum number of the solar panels on the roof in the following cases:
   a- when all the panels installed are in the same plane are in summer 190 and in winter 266.
   b- when Panels are installed one by one longitudinally in summer are 40 and in winter 20.
   c- when panels are installed one by one Laterally in summer are 80 and in winter 36.
   d- and Two panels in height fixed longitudinally in summer are 24 and in winter are 12.

5) The maximum energy produced by all the panels in each case:
   a- All panels in the same plan in winter is 739027.8 watt and in summer is 824881.2 watt.
   b- Panels are installed one by one longitudinally in winter is 51744 watt and in summer is 173659.2 watt
   c- Panels are installed one by one Laterally in winter is 93139.2 watt and in summer is 347318.4 watt.
   d- Two panel in height fixed longitudinally in winter is 31046.4 watt and in summer is 104195.52 watt.

   As we can notice from the results:

   1- A installation is the best installation at summer and winter.
   2- A and C meet the needs of the residents in summer easily, while B hardly meet the needs.

3- C hardly meets the needs in winter.
4- B doesn't meet the needs of the residents in winter.
5- D doesn't meet the needs of residents in both seasons.

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Appendix:

Our excel model to find out the consumption of electricity by residents depending on the seasons:

The consumption in the Winter

No	Appliances	Rating (W)	Hourly Usage per Day	# of Units	Consumption per Day	Day Frequency Usage per Week	Consumption per Week	Day Frequency Usage per Month	Consumption per Month
1	Television	150.00	5.0	1	0.75	7.0	5.25	30.0	22.50
2	Air Conditioner - Panasonic	1,000.00	6.0	1	6.00	7.0	42.00	30.0	180.00
3	WiFi Modem	10.00	24.0	1	0.24	7.0	1.68	30.0	7.20
4	Mobile Phone Charger	3.00	3.0	4	0.04	7.0	0.28	30.0	1.20
5	Cable TV Setup Box	25.00	24.0	1	0.60	7.0	4.20	30.0	18.00
7	Refrigerator	105.00	24.0	1	2.52	7.0	17.64	30.0	75.60
8	Laptop	50.00	3.0	1	0.15	7.0	1.05	30.0	4.50
9	Electric Iron	400.00	0.5	1	0.20	1.0	0.20	8.0	1.60
10	Satellite dish	70.00	5.0	1	0.35	7.0	2.45	30.0	10.50
11	Vacuum Cleaner	870.00	2.0	1	1.74	2.0	3.48	8.0	13.92
12	Water Heater	4,500.00	2.0	1	9.00	2.0	18.00	8.0	36.00
13	hair dryer	1,750.00	1.0	1	3.50	2.0	4.67	8.0	18.60
14	Oven	700.00	1.0	1	0.70	7.0	4.90	30.0	21.00
15	Washing Machine	500.00	2.0	1	1.00	2.0	2.00	8.0	8.00
16	LED Light Bulb - 7	7.00	10.0	4	0.28	7.0	1.96	30.0	8.40
17	LED Light Bulb - 9	9.00	10.0	4	0.36	7.0	2.52	30.0	10.80

1) Our machine learning model:

```
[1] from sklearn import linear_model
    import numpy as np
    import matplotlib.pyplot as plt
```

```
[72] df = pd.read_csv('/content/Data train.csv')  # load data set
     # split the data to the features and target values
     X = df.drop('Conversion efficiency',axis= 1)
     y = df['Conversion efficiency']
```

```
[76] reg = LinearRegression(fit_intercept=False).fit(X, y) # train the model
```

```
[77] print("the value of the vector W",reg.coef_) # get the value of the wights W

     the value of the vector W [ 0.00454276 -0.0010896  -0.01089603]
     the value of the  0.0
```

2) Our code that calculates the number of solar panels in case of installing in one plan (A).

```
[85] from math import cos
     from math import radians
     def max_rectangles(a, b, n, optimal_angle):
         # Calculate the maximum number of a*b rectangles that can fit inside an n*m rectangle
         rows = n // a
         cols = (n/abs(cos(radians(optimal_angle)))) // b
         return rows * cols

     # Example
     print(max_rectangles(1.05, 2.1, 20, 60))

     361.0
```

Temperature (°C)	Dust amount (decimal)	Air speed (m/s)	Altitude (m)	Conversion efficiency (decimal)
20	0.1	1	100	0.20
25	0.2	2	200	0.15
30	0.3	3	300	0.10
35	0.4	4	400	0.05
40	0.5	5	500	0.01
20	0.2	2	150	0.18
25	0.3	3	250	0.13
30	0.4	4	350	0.08
35	0.5	5	450	0.03
40	0.1	1	550	0.02
20	0.1	1	100	0.25
25	0.2	2	200	0.20
30	0.3	3	300	0.15
35	0.4	4	400	0.10
40	0.5	5	500	0.05
20	0.2	2	150	0.23
25	0.3	3	250	0.18
30	0.4	4	350	0.13
35	0.5	5	450	0.08
40	0.1	1	550	0.03
20	0.1	1	100	0.30
25	0.2	2		