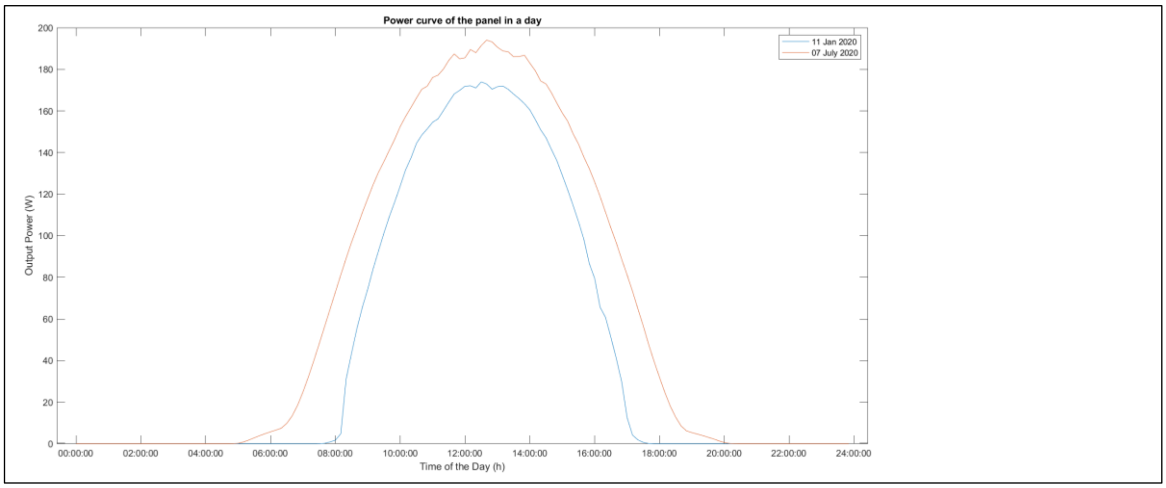
MIDDLE EAST TECHNICAL UNIVERSITY
DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

EE101	**: Introduction to Electrical and Electronics Engineering**
Project II	**: Energy generation and distribution: Can photovoltaics power our department?**
Names	**: Alperen Öztürk – Ömer Faruk Özmermer – Muhammed Emin Özgün**
Student IDs	**: 2575868 - 2516789 - 2575843**

1- Using the data shared with you, plot the power generation vs the time of day graph as shown in the Fig. 3. You need to plot the power generation graph for winter and summer on the same figure. X-axis should read time of the day in hours and y-axis should read power in Watts (Pmpp).



2- Calculate the total energy generation (in kW.h) of the panel in a day for summer and winter.

To calculate the total energy generation, first we need to convert W to kW by dividing it with 1000 and then, since we are given the power data with 10 minutes intervals, we need to convert it to hours by dividing it to 6.

For winter day, total output power is 6.5324e+03 W, and **the total energy generation is 6.5324e+03 W*h / 6000 = 1.0887 kW * h**

For summer day, total output power is 9.0835e+03 W, and **the total energy generation is 9.0835e+03 W*h / 6000 = 1.5137 kW * h**

3- Given that the panel's surface area is 1.64 m^2, calculate the efficiency at peak power values in summer and winter.

To calculate the efficiency, we need to divide the output power to input power and multiply it with the 100. Input power for 1.64 ^{m2} solar at peak power can be found by multiplying the corresponding Input Power Density with the 1.64 m^2.

Peak power value of the summer day is 194.05 W, and its input power density is 1046.29 W/m^2 so **the efficiency for summer is 194.05 W / (1046.29 W / m^2 * 1.64 m^2) * 100 = %11.31**

Peak power value of the winter day is 173.96 W, and its input power density is 812.24 W/m^2 so **the efficiency for winter is 173.96 W / (812.24 W / m^2 * 1.64 m^2) * 100 = %13.06**

4- Choose three different time instants in summer and winter where temperature of the panels are close to one another, but with different irradiance values. Fill the Table 1 by calculating the efficiency of the panel for these three instants and comment on the effect of solar irradiance on panel's efficiency. What would happen if the irradiance is increased while the temperature is kept constant?

SUMMER

Instants	Panel Temperature (◦C)	Irradiance (W/m^2)	Output Power (W)	Efficiency (%)
13:00:00	57.40 ◦C	1029.21 W/m^2	190.63 W	%11.294
13:30:00	57.40 ◦C	1003.26 W/m^2	186.02 W	%11.306
14:00:00	57.50 ◦C	986.18 W/m^2	182.98 W	%11.314

WINTER

Instants	Panel Temperature (◦C)	Irradiance (W/m^2)	Output Power (W)	Efficiency (%)
11:50:00	29.74 ◦C	792.45 W/m^2	169.88 W	%13.072
12:20:00	29.79 ◦C	797.57 W/m^2	171.05 W	%13.077
13:00:00	29.73 ◦C	799.70 W/m^2	171.67 W	%13.089

If the irradiance is increased while the temperature is kept constant, the efficiency would increase. However, since there are other variables that affects the efficiency, it is not as expected when the first and second instants of summer is compared.

5- Choose three different time instants in summer and winter where solar irradiance of the panels are close to one another, but with different panel temperatures. Fill the Table 2 by calculating the efficiency of the panel for these three instants and comment on the effect of temperature on panel's efficiency. What would happen if the temperature of the panel is increased while the irradiance is kept constant?

SUMMER

Instants	Panel Temperature (◦C)	Irradiance (W/m^2)	Output Power (W)	Efficiency (%)
12:00:00	59.53 ◦C	1007.23 W/m^2	185.57 W	%11.234
13:20:00	55.75 ◦C	1011.16 W/m^2	188.41 W	%11.361
13:50:00	56.94 ◦C	1005.97 W/m^2	186.77 W	%11.321

WINTER

Instants	Panel Temperature (◦C)	Irradiance (W/m^2)	Output Power (W)	Efficiency (%)
12:00:00	30.03 ◦C	802.20 W/m^2	171.92 W	%13.067
12:10:00	29.94 ◦C	802.96 W/m^2	172.11 W	%13.069
13:10:00	29.44 ◦C	800.15 W/m^2	172.00 W	%13.107

The efficiency of the panel will decrease if the temperature of the panel is increased while the irradiance is kept constant.

6- In which month in a year would the efficiency be the highest? Similarly, in which month in a year would the energy generation capacity be the highest? Comment using the previous calculations and data.

Parameter	Month	Reasoning
Highest efficiency	January	In January, according to given data, when the irradiance and temperature are lower, efficiency gets higher.
Highest energy generation	July	In July, there are more hours of daylight, sunrays are more intense, and they are more direct in July.

7- Assume that all of the roofs of our department buildings are covered with the same panels and panels are not shaded. Calculate the maximum power generation capacity of the photovoltaic panels on top of the roofs by using the previously given data.

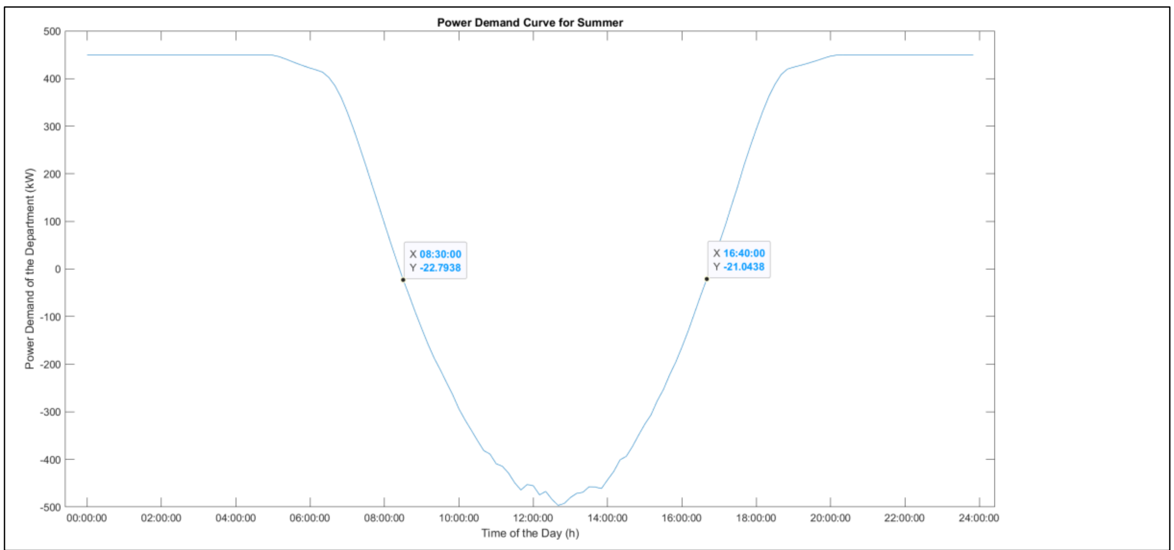
Total estimated area of our department buildings is 8000 m^2, and surface areas of the panels are 1.64 m^2, so it can be assumed that the total solar panel number is going to be **4878** (8000 m^2 / 1.64 m^2). In the second question, it is found that one solar panel generates **1.0887 kW*h** per day in winter, and **1.5137 kW*h** per day in summer.

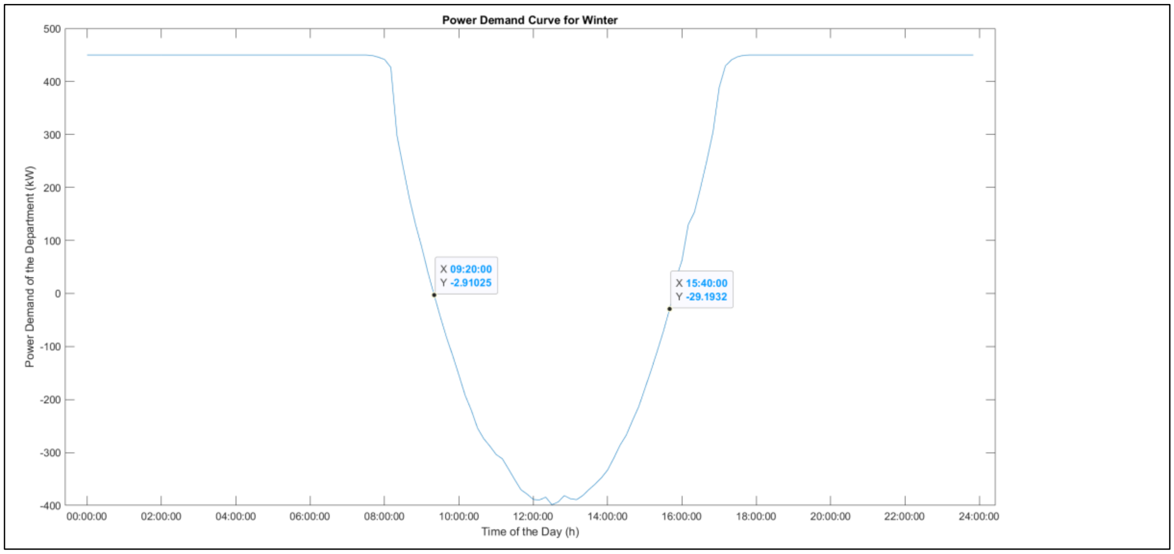
Thus,

For summer, maximum power generation capacity is **7383.8 kW*h.**

For winter, maximum power generation capacity is **4920.4 kW*h.**

8- Assume that our department has a constant power demand of 450 kW throughout the day. How would the power demand curve look like if we covered the roof with photovoltaic panels as you have calculated in part 7? Plot the power demand vs time of day graphs for both winter and summer conditions by assuming that all panels generate electricity with the curves in part 1. Between what hours does the department supply electricity back to the grid?





In summer, **between 8:30 and 16:40**, the department supplies electricity back to the grid.

In winter, **between 9:20 and 15:40**, the department supplies electricity back to the grid.