

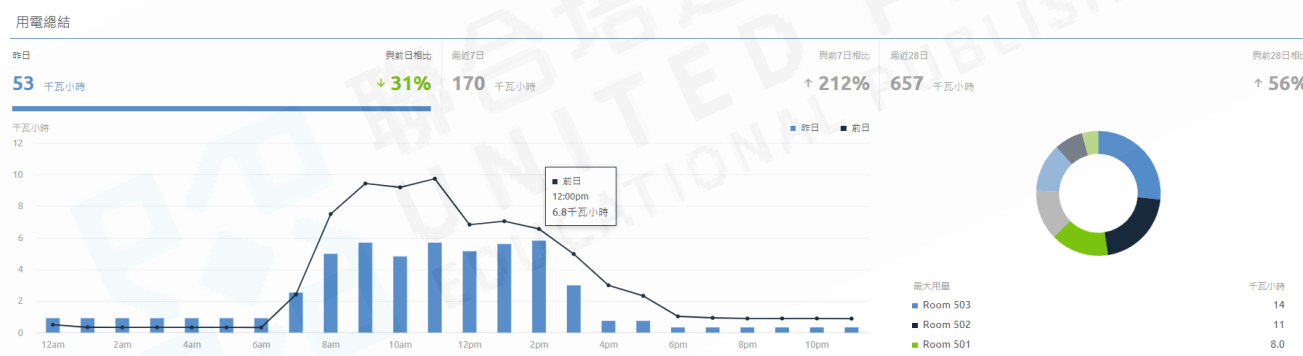
Building a Power Consumption Equation Model for a Classroom

Scenario

Environmental protection is a major global issue. We are working to tackle issues such as climate change and energy shortages through carbon reduction, recycling, and green energy. To protect our planet and our health, countries everywhere are prioritising energy conservation. As members of the community, we all have a role to play in saving energy. However, to make improvements, we first need to understand energy consumption in our daily lives. Today, we will use our classroom's energy-consumption data to develop a power-consumption equation. The model can help us understand the power consumption patterns in our classroom.

(Definition: Power consumption is the energy consumed per unit time, i.e. $P = \frac{E}{t}$)

- Log in to the EMSD SEMS platform to read the energy consumption dashboard and check the real-time overall daily energy usage.



- In a classroom, electrical power is consumed because of the use of electrical appliances. Which type of electrical appliance in a classroom consumes the most electrical power?

3. What major factor leads to higher power consumption in that type of electrical appliance mentioned in question 2?

Assumptions

We need to know the energy consumed and then convert it to power consumption. We must avoid collecting unnecessary data, such as energy consumption from 00:00 to 07:00 in a day. During this period, no one is in a classroom consuming electrical energy.

As classes start at 08:30 and end at 15:35, and lunchtime starts at 12:10 and ends at 13:25, we will only get the data from 09:00-12:00 and 14:00-15:00.

For example, we don't know whether there is any after-school activity in the classroom on a particular day. Obviously, the energy consumption is higher during 15:00-16:00 if there is an after-school activity.

To streamline the real-world scenario, we assume that the maximum temperature remains constant throughout the time period. Additionally, we consider hourly averaged power consumption to reflect the energy usage for that day.

4. Using your own classroom (Room 502) data from the Excel files provided, what was the total energy consumed in the 4-hour period on 2/10/2025?

5. Using the result from question 4, what was the power consumption?

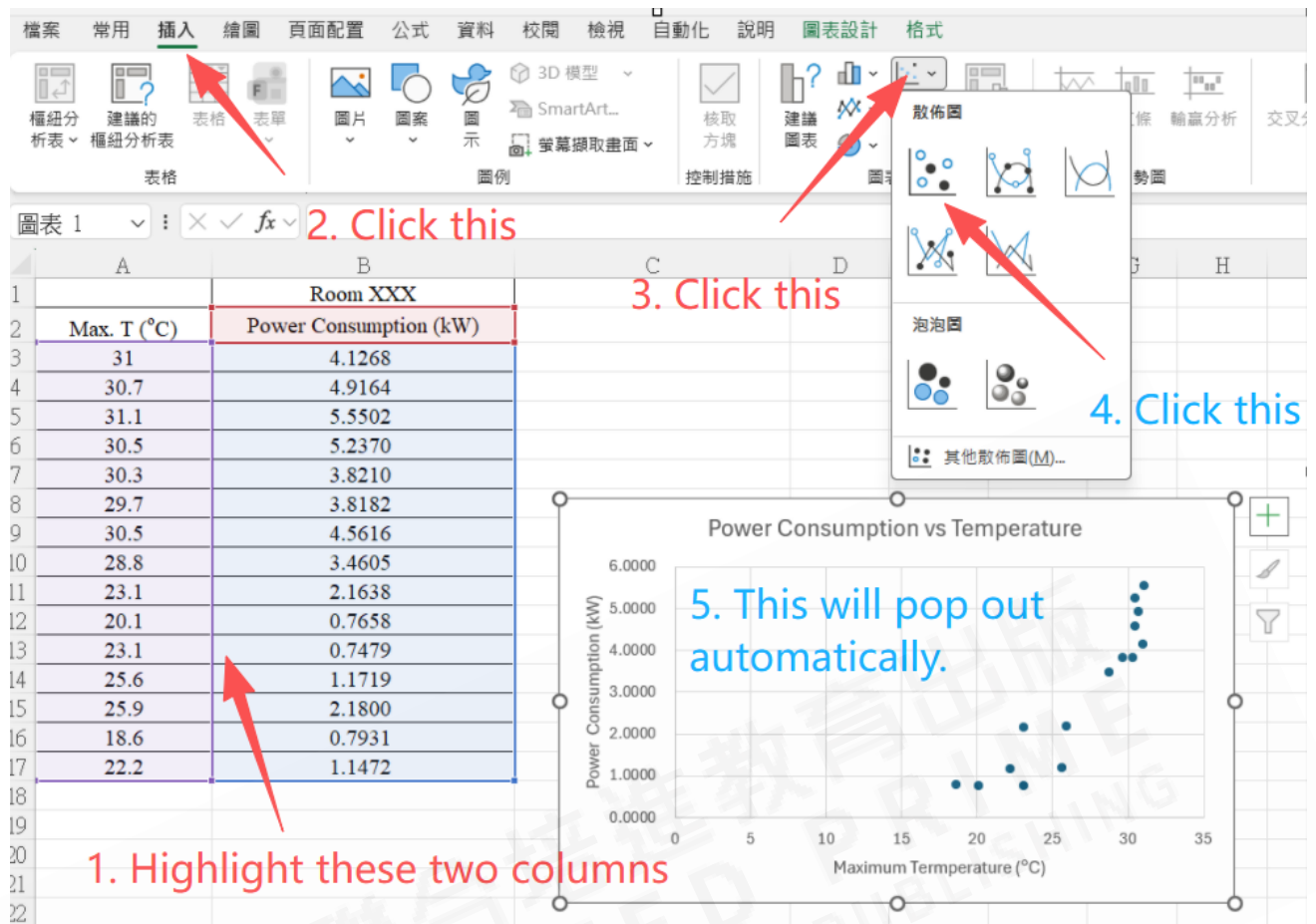
6. Please calculate the power consumption in the 4-hour period on 3/10, 8/10, 9/10, 13/10, 14/10, 15/10, 20/10, 21/10, 22/10, 23/10, 24/10, 27/10, 15/12 and 16/12.

Then, fill in the calculated results and the daily maximum temperature in the following table.

				Room 502
Year	Month	Date	Max. T (°C)	Power Consumption (kW)
2025	10	2		
2025	10	3		
2025	10	8		
2025	10	9		
2025	10	13		
2025	10	14		
2025	10	15		
2025	10	20		
2025	10	21		
2025	10	22		
2025	10	23		
2025	10	24		
2025	10	27		
2025	12	15		
2025	12	16		

7. According to the above table, in general, what is the relationship between the temperature and the power consumption? Why?

[Hint: Please create a scatter plot to support your guess. The figure below shows the procedure of generating a scatter plot.]



8. What do you observe from the scatter plot? (For example, are all data aligned to a specific shape? Are there any clusters of data?)

9. Let's look at the power consumption data for days when the maximum temperature $\leq 23.1^{\circ}\text{C}$.
- (a) What have you observed? What is the possible physical meaning behind your observation?
- (b) Compare the power consumption and temperature of 22/10/2025 and 15/12/2025. What have you observed?
- (c) Compare the power consumption data from 21/10/2025 and 23/10/2025. Although the temperatures on both dates were identical, there is a large difference in their power consumption. Taking also the data of 24/10/2025 and 27/10/2025 into consideration, which date, 21/10 or 23/10, seems to be an "abnormal day" in terms of power consumption? Explain your view.

- (d) Except for the “abnormal day” mentioned in part (c), the data remains relatively constant on days when temperatures are 23.1°C or below. Please exclude this abnormal datum, and calculate the average power consumption of these cooler days. We assume this value to be the background power consumption of a school day.

Formulation

To find the equation, we need to enter the temperature and power-consumption data into an Excel sheet. Then we need to use it to plot the line and find its corresponding equation.

Before entering the data, you need to check for any “abnormal data” which may affect the accuracy of the model. You must either reject the abnormal data or normalize the data, as shown below.

10. Please check the information at time slot 09:00-10:00 on 3/10/2025. Energy consumption is abnormally low compared to other time slots. Why? Please re-evaluate the power consumption by normalizing the data at that time slot.
11. Are there any other abnormal data? If so, please re-evaluate the power consumption by normalizing the abnormal data.

Suggested Mathematical Model

The power consumption equation is in the form

$$\begin{cases} P = k_1T + k_2 & \text{for } T > 23.1^\circ\text{C} \\ P = K & \text{for } T \leq 23.1^\circ\text{C} \end{cases}$$

where P is the electrical power consumption, T is the temperature in $^\circ\text{C}$, K is the constant term found in question 9(d), and k_1 and k_2 are constants.

12. Explain briefly what assumptions have been made for this mathematical model.

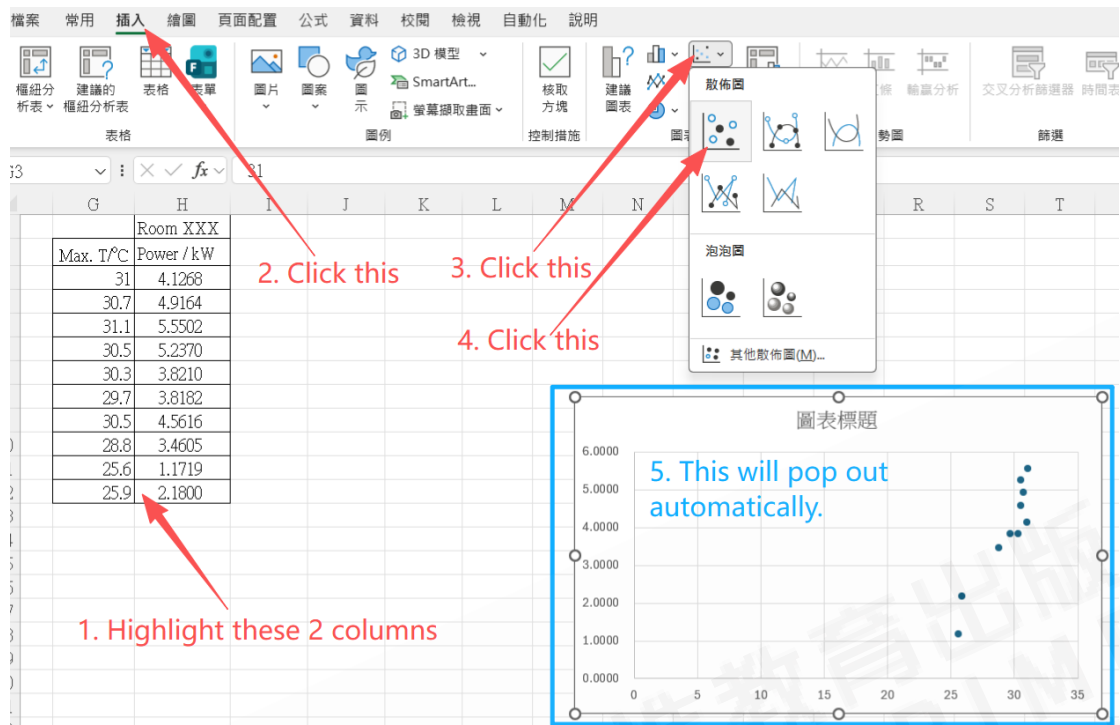
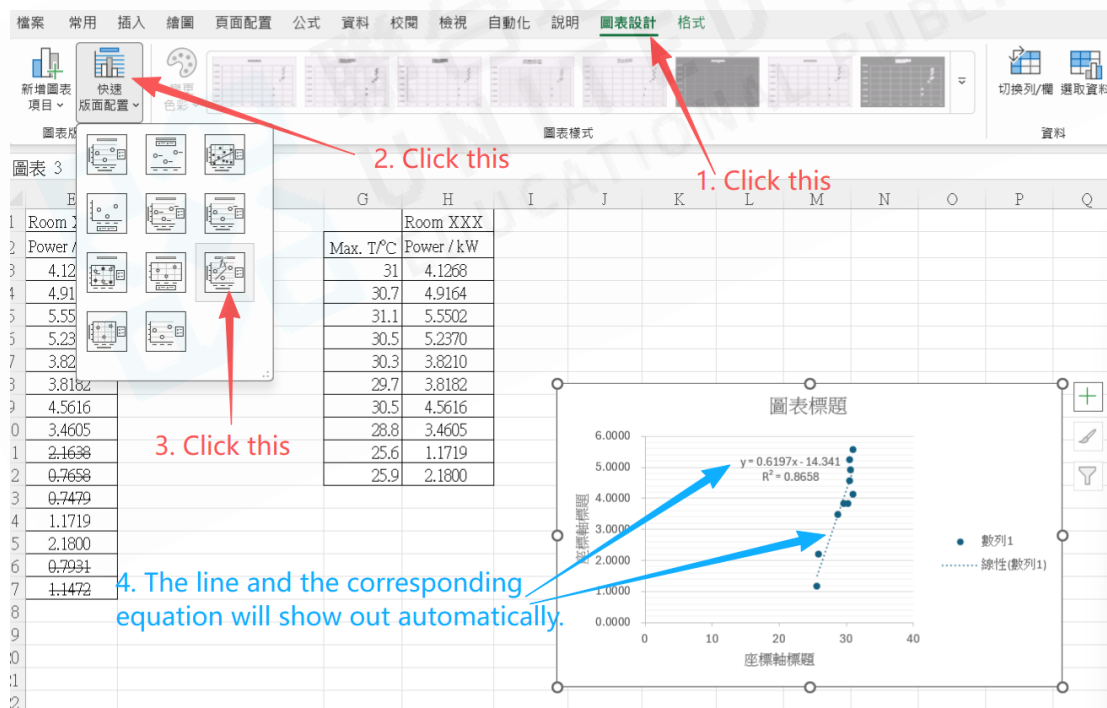
Evaluation

As we are interested in the power consumption equation for temperatures $> 23.1^\circ\text{C}$, we should only enter the information into the Excel sheet for temperatures $> 23.1^\circ\text{C}$.

	A	B	C	D	E	F	G	H
1					Room XXX			Room XXX
2	Year	Month	Date	Max. T/ $^\circ\text{C}$	Power / kW		Max. T/ $^\circ\text{C}$	Power / kW
3	2025	10	2	31	4.1268		31	4.1268
4	2025	10	3	30.7	4.9164		30.7	4.9164
5	2025	10	8	31.1	5.5502		31.1	5.5502
6	2025	10	9	30.5	5.2370		30.5	5.2370
7	2025	10	13	30.3	3.8210		30.3	3.8210
8	2025	10	14	29.7	3.8182		29.7	3.8182
9	2025	10	15	30.5	4.5616		30.5	4.5616
10	2025	10	20	28.8	3.4605		28.8	3.4605
11	2025	10	21	23.1	2.1638		25.6	1.1719
12	2025	10	22	20.1	0.7658		25.9	2.1800
13	2025	10	23	23.1	0.7479			
14	2025	10	24	25.6	1.1719			
15	2025	10	27	25.9	2.1800			
16	2025	12	15	18.6	0.7931			
17	2025	12	16	22.2	1.1472			

The two figures below show the steps for generating the line and its corresponding equation.

Please follow the steps and generate the equation using your data.



Solution and Interpretation

13. The solution is a good example of partial variation where the electrical power consumption (P) is partly constant and partly varies as the maximum temperature (T). By joining the two lines, $P = k_1T + k_2$ and $P = K$, find out the intersection point. Hence, update the temperature conditions for both power-consumption equations. What is the physical meaning of these conditions?

14. Using the mathematical solution,

- (a) Estimate the power consumption when the maximum temperature is 30°C .
- (b) If the classroom is used for 6 hours the next day at a maximum temperature of 30°C , estimate the total energy consumed in kWh.

Possible Improvements

The current analysis relied on the daily maximum temperature. Future studies could explore other metrics, such as the daily average or hourly temperature, to analyze power consumption dynamics in greater detail.

15. Apart from the temperature, what other factors also affect electrical power consumption?

Considering the Humidity factor

In general, if the temperatures on two hot days are the same, then the higher the relative humidity, the higher the electrical power consumption. Higher humidity means that more water vapour is in the air. As the specific heat capacity of water is high, a lot of energy is required for an air-conditioner to lower the temperature by only 1°C when the humidity is high.

16. Please fill in the table below.

					Room 502
Year	Month	Date	Max. T (°C)	Power Consumption (kW)	Relative Humidity (%)
2025	10	2	31	4.49825	
2025	10	3	30.7	5.30966667	
2025	10	8	31.1	6.04975	
2025	10	9	30.5	5.656	
2025	10	13	30.3	4.0885	
2025	10	14	29.7	4.04725	
2025	10	15	30.5	4.9265	
2025	10	20	28.8	3.6335	
2025	10	21	23.1	2.3585	
2025	10	22	20.1	0.83475	
2025	10	23	23.1	0.81525	
2025	10	24	25.6	2.094	
2025	10	27	25.9	2.26725	
2025	12	15	18.6	0.8645	
2025	12	16	22.2	1.2505	

17. For a fair comparison, we have to take the days with similar maximum temperatures into consideration. By comparing the data on 9/10, 13/10 and 15/10, can you reach any conclusions?
 [Hint: Please create a scatter plot with similar maximum temperature to support your guess.]

18. What can we do to reduce power consumption according to our equation model? Please guess the new equation model to do so.