AI Design Contest – Activity 3: Designing for Smart Energy Management

Team Name:

Team Member Names:

Purpose:

- Teams will analyze power usage and energy consumption data obtained from their selected devices to understand relationships between overall home performance and individual device power schedules.
- Teams will consider how demand-based variations in the cost of electricity can influence their strategies for scheduling device operations.
- Teams will design a new power schedule for their home devices that address power usage and energy consumption goals dependent upon a possible real-world scenario.
- Teams will model the use of data and conditions to understand how AI ideas and concepts can be used to control device operations.
- **Teams should use this activity to implement their quantitative and qualitative understanding of power usage and energy consumption into design criteria that facilitate smart energy management.**

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Part 1: Max/Min Performance for Different Device Types

Now you want to take a closer look at the features of your graphs to compare different states of total power usage between your short-term and long-term devices. You are going to analyze the following for each device type: **maximum total power usage, minimum total power usage,** and **total energy consumption in both states.**

Instructions: Follow steps 1-6 to complete Table 3.1 below. You will use the two graphs you created in Activity 2 for your "(2) short-term" and "(3) long-term devices".

1. What was the **maximum total power usage** for each type of device in a 24-hour period?
    a. This will be the **highest value** on the **total power usage** line in each of your short-term and long-term graphs from Activity 2. Enter these values into column 1 of Table 3.1.
2. How long over 24 hours did your devices operate at **maximum total power**?
    a. Add up the **total time** in all the **time slots** for the **highest value** on the **total power usage** line in each of your short-term and long-term graphs from Activity 2**.** Enter these values into column 2 of Table 3.1.
3. How much **energy was consumed** in 24 hours while your devices operated at **maximum total power?**
    a. **Multiply** your values from columns 1 and 2, across each row of Table 3.1. Enter the results into column 3 of Table 3.1.
4. What was the **minimum total power usage** for each type of device in a 24-hour period?
    a. This will be the **lowest value** on the **total power usage** line in each of your short-term and long-term graphs from Activity 2. Enter these values into column 4 of Table 3.1.
5. How long over 24 hours did your devices operate at **minimum total power**?
    a. Add up the **total time** in all the **time slots** for the **lowest value** on the **total power usage** line in each of your short-term and long-term graphs from Activity 2**.** Enter these values into column 5 of Table 3.1.
6. How much **energy was consumed** in 24 hours while your devices operated at **minimum total power?**
    a. **Multiply** your values from columns 4 and 5, across each row of Table 3.1. Enter the results into column 6 of Table 3.1.

Table 3.1: Maximum and Minimum Power and Energy Data by Device Type

Device Type	1. Maximum total power (W)	2. Total time at max (hrs)	3. Total energy at max (W hr)	4. Minimum total power (W)	5. Total time at min (hrs)	6. Total energy at min (W hr)
1. Short-Term						
2. Long-Term						

Instructions: Answer questions 7 to 14 by comparing the data values you organized into Table 3.1 (above). Type your answers in the space below each question.

7. Did the short-term or long-term devices use a greater maximum total power? Explain why using insights from your power schedule in Activity 2.

   >

8. Did the short-term or long-term devices use a greater minimum total power? Explain why using insights from your power schedule in Activity 2.

   >

9. Are your answers to questions 7 and 8 the same type of device? What does this tell you?

   >

10. Did the short-term or long-term devices consume more total energy over 24 hours while operating at maximum total power? Explain why using insights from your power schedule in Activity 2.

    >

11. Did the short-term or long-term devices consume more total energy over 24 hours while operating at minimum total power? Explain why using insights from your power schedule in Activity 2.

    >

12. Are your answers to questions 10 and 11 the same type of device? What does this tell you?

    >

13. Did the type of device operating at greater maximum total power also consume more energy over 24 hours? (Did you identify the same type of device in questions 7 and 10?) Explain why using insights from your power schedule in Activity 2.

    >

14. Did the type of device operating at greater minimum power also consume more energy over 24 hours? (Did you identify the same type of device in questions 8 and 11?) Explain why using insights from your power schedule in Activity 2.

    >

15. In the space below, write a 1-3 paragraph summary of your main takeaways about the minimum- and maximum-power states of your two device types. Did maximum or minimum power usage always contribute to greatest or least energy consumption? How was this related to the schedule ("on"/"off" time slots) of your devices? How could you change the amount of energy consumed at total maximum power?
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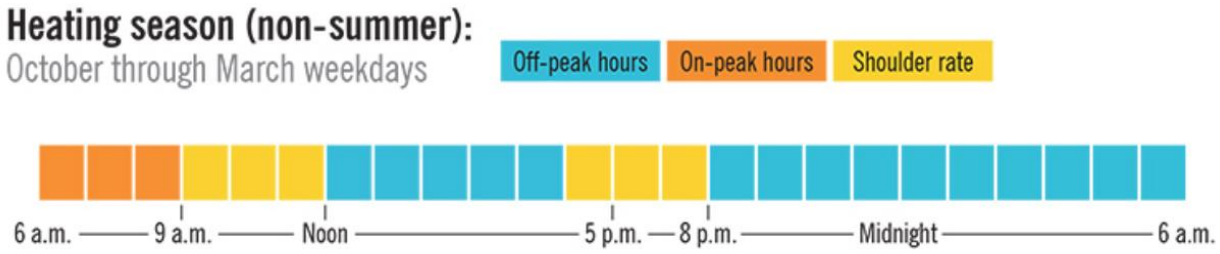
Part 2: Time-Based Changes in the Cost of Electricity

Introduction: Duke Energy offers a "time-of-use" cost schedule that allows homes to pay different prices for electricity based on when they use that electricity. Over a 24-hour day, electricity is cheaper at times when the demand for power is lower, and electricity is more expensive at times when the demand for power is higher. "Lower demand" means that consumers' homes need more power at that time, and higher demand means that consumers' homes need less power at that time.

Time-of-Use Pricing Schedule: You will analyze electricity pricing data provided by Duke Energy to see how different schedules for your home's device operations can lead to reductions in cost. The graphic below shows an example of how Duke Energy sets different electricity prices for different times of the day. This graphic shows that energy is most expensive during "on-peak" hours, shown in orange, and least expensive during "off-peak" hours, shown in blue. Energy purchased during "shoulder rate" hours, shown in yellow, is priced in between.



https://www.duke-energy.com/business/billing/time-of-use-rate/how-it-works

Instructions: To answer questions 1-5, compare the "on" time slots of the power schedule you completed in Activity 2 to the Duke pricing schedule above. Consider all 8 of your devices.

1. Which of your devices were turned on during "on-peak" hours?

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2. Which of your devices were turned on during "shoulder rate" hours?

>

3. Which of your devices were turned on during "off-peak" hours?

>

4. Was the type of your devices related to the price of the electricity they consumed? Explain what patterns you observed.

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5. Based on whether your devices were on during "on-peak", "shoulder rate", or "off-peak" hours, how could you change the power schedule of your devices to lower your home's electricity bill? Give specific examples based on the "on" time slots you recorded for your different devices in Activity 2.

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Part 3: Designing Device Operations for A Specific Scenario

Introduction: A smart energy management system can use IoT devices to (1) sense how much power and energy are consumed by your home's devices over time, and (2) control what times your different devices operate. To design a smart energy management system, you can develop a new "on"/"off" power schedule for how your home's devices operate during different home scenarios. To make a good schedule, you have to create goals for the total power usage and energy consumption of your home's devices during a specific scenario. These goals can be created by considering the power usage data from your devices.

In this Activity, you will create one new power schedule to address one specific home scenario.

Instructions: Read the list of possible home scenarios below and choose one. Based on the scenario you choose, you will create new goals for the power usage and energy consumption of your home's devices. Using these goals, you will think about how the features of your "(1) All Devices" graph from Activity 2 need to change. By making those changes, you will create a new "on"/"off" power schedule for your devices.

Home Scenarios:

A. **Planning for a Vacation**: The members of your home are going on vacation, and you want to prevent wasting energy throughout the day while everyone is away.
B. **Accommodating Guests**: You are having guests over for an event, and some of your devices must be able to complete tasks for more people at different times of the day.
C. **Responding to a Power Shortage**: There is a power outage in your home's region, and your devices must operate at a lower total maximum power over the course of a day.
D. **Maintaining a Budget**: The cost of electricity has increased, but you want your electricity bill for the day to remain the same.
E. **Preventing an Overload**: Your home has older circuits, so your higher-powered devices should operate at different times throughout the day.
F. **Having Diverse Applications**: You want your home to be able to use different types of devices to complete different tasks at different times throughout the day.

Instructions:

1. Type the scenario you chose in the space below.

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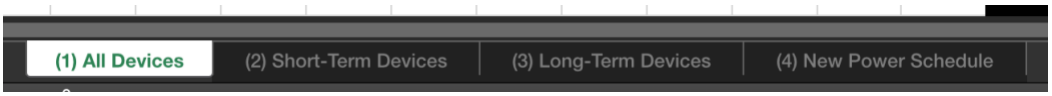
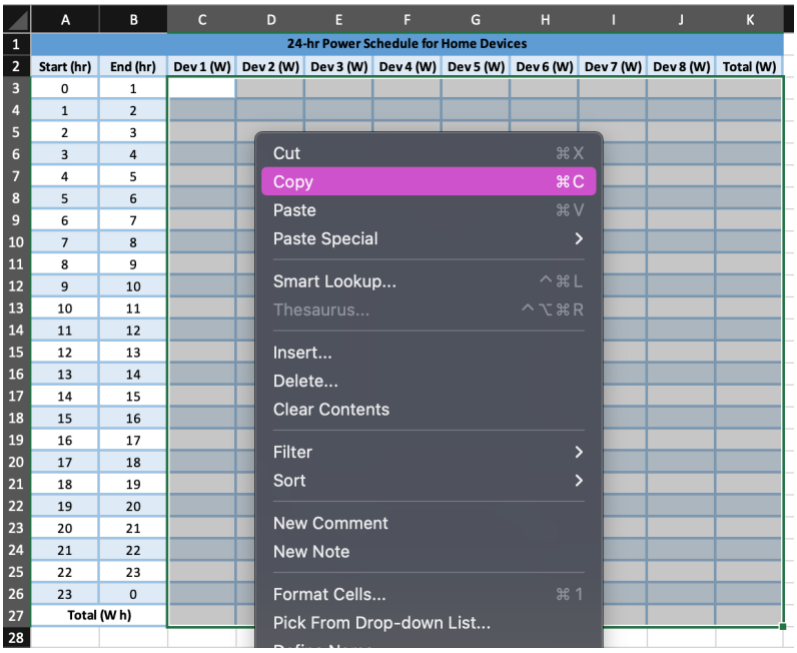
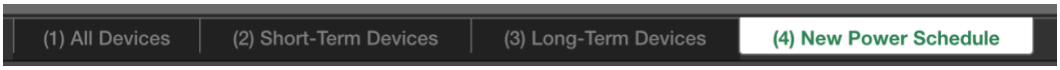
2. Open the "PTC_24_MS_2_Graphing Power Schedules" Excel spreadsheet from the "Activity 2" folder and click on the "(1) All Devices" tab to look at the graph that shows the power schedule of all 8 of your devices.



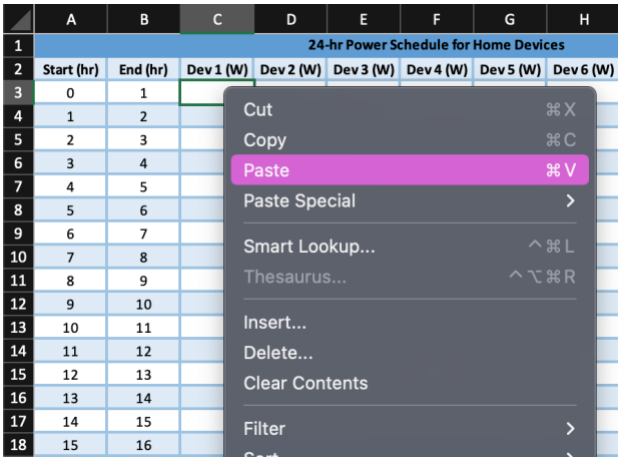
3. Left click in cell C3, then hold and drag your cursor to cell K27, so that all your data from the table in tab (1) is selected. Right click anywhere in the highlighted area and select “Copy”.



4. Open the “(4) New Power Schedule” tab of the spreadsheet.



5. Left click cell C3 of that spreadsheet to select the cell, then right click and select “Paste”. This will transfer your original data from tab (1) into an identical table in tab (4), and the graph in tab (4) will automatically update.



Goal: At first, the "(4) New Power Schedule" tab just shows a copy of your 8-device data table from Activity 2. It also shows the graph you made using your 8-device data. In order to design a new power schedule for you specific home scenario, you will need to figure out how new power usage and energy consumption goals require you to make changes to (1) the energy consumption values you calculated using the Excel data table, and (2) the power usage features you showed in your Excel graph.

Instructions: To think about how you will design your new power schedule, begin by reading through questions 6 and 7. Once you have an idea of the process, you will decide on a final power schedule by changing the data table and graph in the "(4) New Power Schedule" tab of your spreadsheet.

6. Answer parts a through f to summarize why and how you must change the "on"/"off" time slots of all 8 devices to design for the scenario you chose.
   a. Based on your scenario, what are your new goals for the (1) individual and (2) total power usage of all 8 of your devices? Explain how these goals came from your scenario.
      >

   b. To reach your power usage goals, what features of your graph need to change, and how?
      >

   c. How can changing the "on"/"off" time slots of your devices change your Excel graph to meet your new power usage goals?
      >

   d. Based on your scenario, what are your new goals for the (1) individual and (2) total energy consumption of all 8 of your devices? Explain how these goals came from your scenario.
      >

   e. To reach your energy consumption goals, how does the data you calculated in your Excel table and then recorded into Tables 2.3 (from Activity 2) need to change?
      >

   f. How can changing the "on"/"off" time slots of your devices change the energy consumption data you calculate in your Excel table to meet your new energy consumption goals?
      >

7. Based on what you discussed in question 6, enter the "on" and "off" power values (which you already recorded in Activity 2) into new time slots in the Excel data table of the "(4) New Power Schedule" tab. As you change your time slots to meet the goals of your home scenario, the **total power usage** and **24-hour energy consumption**, within cells of the data table that used the SUM calculation, will change. Moreover, the graph of your initial power schedule will be changed into the graph of your new power schedule. You will probably need to try out different time slots to obtain values and graph features that meet your scenario-specific goals.
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8. In the space below, copy and paste the final graph of your new power schedule that you created in the "(4) New Power Schedule" tab.
   >

9. Fill out Table 3.2 below to show the (final) new power schedule for all 8 of your devices, designed for your specific scenario. You can copy the corresponding cells directly from your data table in the "(4) New Power Schedule" tab. Also, type the number of the scenario you chose in the title (first row) of Table 3.2.

Table 3.2: Device Power Schedule for Scenario ___									
Start (hr)	**End (hr)**	**Dev 1 (W)**	**Dev 2 (W)**	**Dev 3 (W)**	**Dev 4 (W)**	**Dev 5 (W)**	**Dev 6 (W)**	**Dev 7 (W)**	**Dev 8 (W)**
0	1								
1	2								
2	3								
3	4								
4	5								
5	6								
6	7								
7	8								
8	9								
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22	23								
23	0								

Part 4: Modeling Controls for a Smart Energy Management System

Introduction: A smart energy management system can use AI to automatically create and update a device operating schedule, based on data it collects from your devices, and the power/energy goals you create for your home. For AI to do this, it needs to know how you, the user, want it to make decisions. You can teach AI to make decisions by creating **conditions** for how the AI uses your data to turn devices "on" or "off". One way to model the relationship between your data and conditions is by using a **flow diagram**.

Instructions: Using the new power schedule you made in Table 3.2, you will enter your operating conditions and device data into an empty flow diagram to show how your devices should operate during the home scenario you chose.

1. In the "Activity 3" folder under the "Files" section of your Teams channel, open the PowerPoint file called "PTC_24_MS_3_Flow Diagram". Follow the instructions on the first slide, which explain how to fill out the flow diagram model on the second slide.
2. Once your flow diagram is complete, paste a screenshot of it below. You can copy the PowerPoint slide you created and paste it into your final design presentation.

Part 5: Main Takeaways

Instructions: Write a 1-3 paragraph summary, in the space below, of your main takeaways about what you learned from this activity. Explain how you decided on the different conditions for your model of a smart energy management system, and explain how you would use IoT devices and AI to design your home's response to those conditions.

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Part 6: Submit this Activity

- Meet with your team's mentor to check your work and make changes as needed.
- Save this document as a PDF with the title **Activity_3_[Team Name].pdf** and then have your **quality engineer** submit your PDF here: https://ufl.qualtrics.com/jfe/form/SV_0020ZwvCFoQoZj8