NORTHERN ARIZONA UNIVERSITY

Memorandum

Design4Practice (D4P) Program

To: Professor David Trevas

From: Richard Hamilton, Vertical Farming (20Su5)

Date: July 5, 2020

Re: Individual Analysis, Power consumption

Introduction

For the Vertical Farming's team project, many electronics must be used to circulate water, allow plant growth indoors, distribute nutrients, and monitor the water level. All of these components require electricity to run for various amounts of time during the day and night. In this memo, power consumption for these devices will be estimated and an overall cost for running the system will be obtained.

Assumptions for Calculations

For the project, nothing has been set in stone for products being used to I will need to estimate running costs based on equipment and information I have found. This will lead to some calculations being not accurate to the final product however the numbers should be similar. For the water heater, I am assuming a value of 4 watts per gallon as the information I have found mentions 3-5 watts a gallon. Using a tank size of 48 x 24 x 24 inches, a value of 27,648 cubic inches can be found for cubic inches of water in the tank. This equates to just under 120 gallons. The water in the rain gutter troughs the team is using needs to be about ¼ in tall with the trough being 5in deep and 48in wide. This gives us approximately 0.25 gallons per trough. With these estimations, rounding up, we can come out with about 125 gallons in the system total.

Based on a teammate's research, a total of 100 gallons per hour need to be moved through pumps. Altogether, either one 100 gph pump or multiple smaller pumps will consume a maximum of 30 watts. For the lights, based on a teammate's research, we will need 500W worth of led grow lights. We will most likely be using 5 100W lights to accomplish this. The Arduino Uno, as well as the water sensors and alarms, should consume significantly less than 5W, a negligible amount of extra power consumed. The fish tank water heaters are estimated by using a value of 3-5W per gallon. I used 4W for my calculations and using the 125 gallons found above, we need about 500W worth of fish tank heaters, either as one unit or 2 smaller ones. I also assumed that the heaters would not be active 24 hours a day due to water retaining heat, local climate control helping maintain temperatures, and heat from LED lights heating the water.

I also assumed that this device would be operating in the standard US household with wall sockets providing 120 Volts and a maximum of 15 Amps. Based on what I learned in EE-188, Amps * Volts = Watts. This means that the maximum wattage a household outlet can supply is about 1800 Watts [1]. If the design exceeds that, one outlet cannot supply all the power and a second outlet must be used.

Equations

```
Calculations for Power consumption

Tank/Water Heaters
    4W/Gallon
    145 Gallons
        4* 145 =500Watts

Pump
    100 gallons per hour
    About 30Watts

Lights
    5 Lights
    100Watts each
        5*100 = 500Watts

Arduino
    <= 5Watts

Total Wattage allowed thorugh plugs
    1800Watts

Total Maximum Wattage
    5 + 500 + 30 + 500 = 1035 Watts

    1035 < 1800 True

    1035 Watts * 10^(-3) = 1.035KWatts

Average cost of electricity in USA
    %0.1328 Per KW/Hr [2]
    Round up to $0.14
```

Figure 1: Part 1 of power calculations

```
Cost of running each component
    Pump
        0.03KW * 24Hours = 0.72KW/Day

    Lights
        0.5KW * 16Hours = 8KW/Day

    Heaters
        0.5KW * 14Hours (MAX) = 6KW/Day
        Heaters may not be on this often as local climate
        control and LED light heat will help maintain
        water temperature.

    Arduino
        0.005KW * 24Hours = 0.14KW/Day

Cost of running entire system
    0.72 + 8 + 6 + 0.14 = 14.84KW/Day
    Round up to 15KW/Day
    15KW/Day * $0.14 = $2.10 Per Day
    $2.10 * 7 Days = $14.70 Per Week
    $2.10 * 365 Days = $766 Per year

    Growth Cycle ~ 100 days
    $2.10 * 100 Days = $210 Per Growth Cycle
```

Figure 2: Part 2 of power calculations

Referenced sources

[1]"How much electricity from an outlet or circuit?", *Michaelbluejay.com*, 2016. [Online]. Available: https://michaelbluejay.com/electricity/maxload.html. [Accessed: 16- Jul- 2020].

[2]"EIA - Electricity Data", *Eia.gov*, 2020. [Online]. Available: https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a. [Accessed: 16- Jul- 2020].

Results

The results of my power calculations as seen in figures 1 and 2 show that the total wattage in the system is below the maximum output of a typical household outlet with room to spare. This means that we can still add a nutrient dispersal and monitoring system and be below the required output. As the team has not chosen a nutrient dispersal and monitoring system, I did not include it in the calculations. However, as the system will only be monitoring for the majority of the time, it should not require much power. Looking at the total amount of power consumed, we can use 1-2 household outlets to supply power to a surge protected power strip and power our electronics from that keeping everything safe from power outages.

The cost to grow these plants is not small as it will currently be about $210 per growth cycle. We can help to reduce this cost by maximizing the number of plants grown per cycle. Currently, our preliminary design can grow up to 21 plants per cycle. This means that each plant is about $10 to grow. While this might cost more than just buying the food, when self-grown, you can be sure that the plants are the freshest possible.