

# Dr. Becker's Sterile Modular Cleanroom

F23toSp24\_02

Electrical load Analysis for backup battery

By

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**Introduction**

This team is tasked with creating a modular ISO 7 cleanroom. A cleanroom is a room which uses Fan Filter Units (FFUs) in order to constantly recycle the air within the room through filters to remove particles from the air. The class specifies the maximum size and number of particles present in the room.

The purpose of this report is to analyze the load of the FFUs that will be used in the Cleanroom, and to use that information to prepare a list of options for the required back up battery or uninterruptible power supply (UPS) based on cost and back up time. The FFUs that will be used are WhisperFlow Fan Filter Units which have 3 settings for fan speed that consume different amounts of power, and we will be using 5 for the clean rooms themselves, and a 6<sup>th</sup> for the fume hood that is already in use.

## Method

First, the power consumption in Watts (W) of the FFUs and the Volt-Amp-hour capacity of all battery/UPS options. A simple equation [1] is used to calculate backup time for each battery/UPS option.

### Equations

$$Backup\ Time = \frac{Rating\ (Ah) * Rating\ (V) * Number\ of\ Batteries * Battery\ Efficiency}{Load\ (W)} \quad [1] \quad (1)$$

$$Load_{total} = \sum Load_{individual} \quad [2] \quad (2)$$

Backup Time is measured in hours, Battery rating is measured in amp-hours (Ah) and volts (V), load is measured in Watts (W)

Finally charts will be made to compare the cost of the battery options with the back up time in order to select the top options.

## Calculations

Table 1. Power consumption of the FFUs depending on speed setting [3]

Filter	Motor HP	Voltage	Full Load Amps	Frequency (Hz)	Power Consumption (Watts)		
					HIGH	MED	LOW
HEPA	1/4	120	3.8	60	420	380	360

Using Eq. 2 the total load of the system is 2520 W on high, and 2280 W on medium. The low setting has already been determined not strong enough to effectively clean the air in the clean room, so can be ignored.

Rating and efficiency are found for each Battery option from the seller's website [4][5]. The numbers are used with Eq 1 to find backup times of all the battery options.

Table 2. Backup time calculated for each option given the loads using 5 or 6 FFUs on medium or high setting

Ah	Medium (5)	High(5)	Medium (6)	High(6)

5	0.03157895	0.028571	0.02631579	0.02381
10	0.06315789	0.057143	0.05263158	0.047619
20	0.12631579	0.114286	0.10526316	0.095238
50	0.31578947	0.285714	0.26315789	0.238095
100	0.63157895	0.571429	0.52631579	0.47619
200	1.26315789	1.142857	1.05263158	0.952381

Only the 200 Ah option would provide back up power for an hour or more, as the client requested. This is an expensive battery however, and since batteries can be wired together a cost effectiveness ratio is found by dividing the time by the back up time, and cost is plotted against time to visualize this.

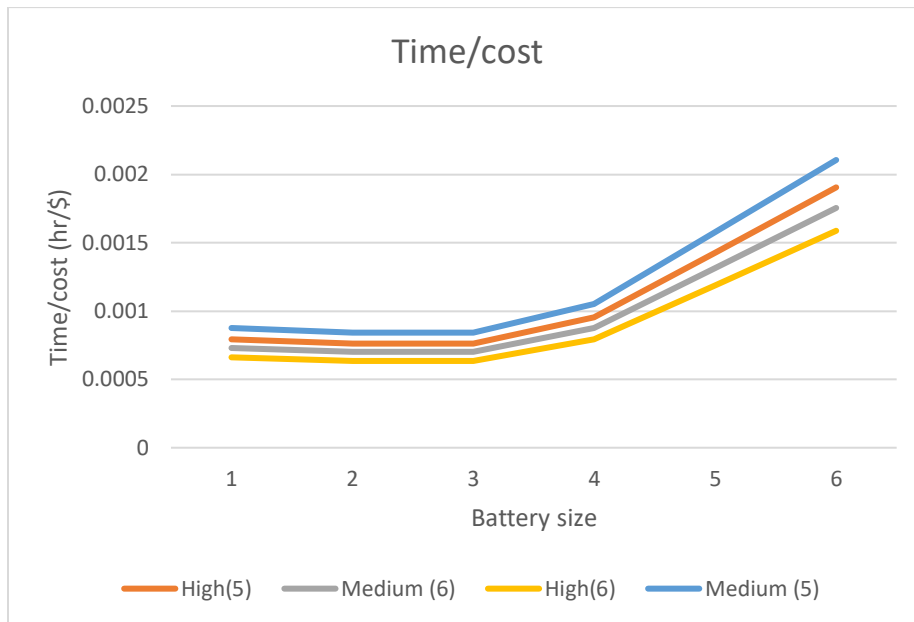


Figure 1. Time/cost (hr/\$) vs batter size (5Ah, 10Ah, 20Ah, 50Ah, 100Ah, 200Ah)

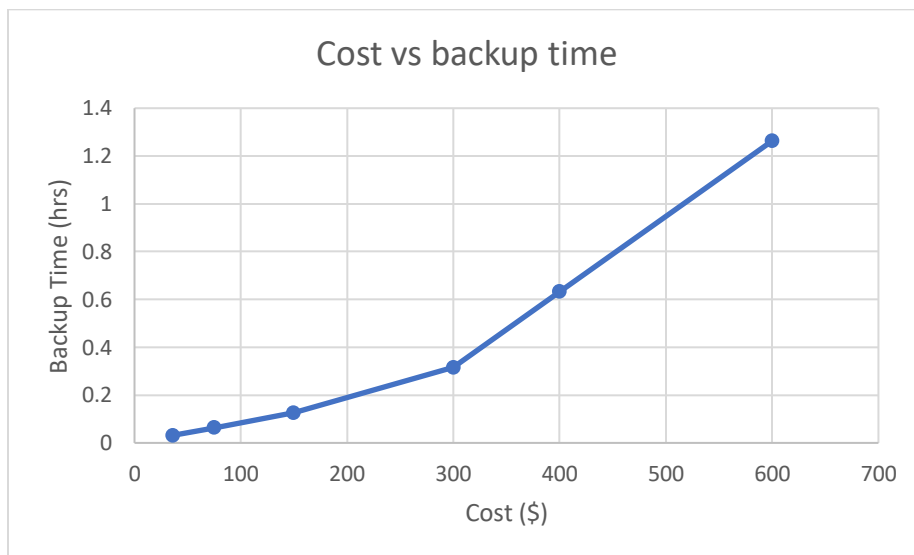


Figure 2. Backup time (hrs) vs cost (\$)

From figures 1 & 2 we see that the cost effectiveness ratio increases with the size of the battery in Amp-hours, meaning buying multiple smaller batteries would not be cost effective. For the batteries the only option appears to be the 200Ah battery at a cost of \$600.

## **Conclusion**

The cost of the backup battery will be significant, with more time spent shopping it may be possible to bring the cost down somewhat, however as a baseline the cost will be \$600 for the battery or higher when including inverter costs and efficiency. This will allow the cleanroom to run through nearly all blackouts on Northern Arizona University campus. Since the budget of the project is fairly low compared to the cost of the other parts of the project, a closer look at the backup battery currently in use should be had in order to determine whether it could meet the requirements given by the client or some of it, allowing the team to buy a cheaper option listed above.

- [1] Gennex Technologies, “Backup time of online ups : How long do they last?,” Gennex Technologies, <https://gennextechnologies.com/backup-time-of-online-ups-how-long-do-they-last/#:~:text=Therefore%2C%20with%20a%20load%20of%20500W%2C%20the%203kVA%20will%20last,of%20the%202kVA%20Online%20UPS>. (accessed Dec. 6, 2023).
- [2] J. W. Nilsson and S. A. Riedel, *Electric Circuits*, 11th ed. Hoboken, New York: Pearson, 2023.
- [3] Terra Universal, *Terra Universal Product Manual: WhisperFlow Fan Filter Units*. Fullerton, CA: Terra Universal Critical Environment Solutions.
- [4] “UPS Service & Support: New/refurbished UPS Systems, Batteries & Parts,” Somerset Power Systems, <http://www.somersetpowersystems.com/> (accessed Dec. 6, 2023).
- [5] “Lifepo4 Series,” ExpertPower Direct, <https://www.expertpower.us/collections/lifepo4-batteries> (accessed Dec. 6, 2023).

