

# Optimal Energy Consumption for Drones

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## Introduction

Everything in the modern world is electric. Although electric usage has existed for over a century, efficiency in production, transmission, and consumption have vastly improved. Efficiency is especially important in situations where energy storage is limited by such factors as weight or cost. Therefore it is important not only to have the most energy dense form of storage feasible, but also to limit the amount of energy consumed by the device. This project concerns the power consumption of drones.

## Battery Selection

### Batteries Considered

There are three types of batteries considered in this paper: Nickel-Cadmium (NiCd), Nickel-Metal Hydride (NiMH), and Lithium-Ion (Li-ion). Differences between manufacturers in each class of battery are not considered, but rather the general characteristics of each class.

### Energy Density and Voltage

Energy density is defined as the amount of energy storage per unit of weight. Having a high amount of energy with a low weight is key for this project. Furthermore, the open circuit voltage must also be considered when choosing a battery such that it is known how many batteries are needed to produce a specific voltage.

Table 1 displays the open circuit voltage and upper limit of specific energy for the three types of batteries:

Battery	Open Circuit Voltage (V)	Upper Limit of Specific Energy (Wh/kg)
NiCd	1.2	60
NiMH	1.2	120
Li-ion	3.2	250

Table 1: Electrical specs. for three different battery types

### Cost

Great performance characteristics are important; however, a designer must be aware of the cost to benefit ratio. NiCd are the cheapest, NiMH are the second cheapest, and Li-ion are the most expensive.

### Energy Consumption

There are a relatively few outlets for increasing energy efficiency in this project. On the hardware side, there is practically nothing to be done as not only would added circuitry add to the complexity, weight, and cost, but also might potentially damage expensive equipment. In terms of software, there are a few avenues. Nearly all the navigation software and firmware was already predetermined and fixed. On the Tello drone, it was feasible to limit the broadcasting of the video since it was not needed. This saved a few minutes of flight time per trial.

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## Conclusion

Although the battery was already purchased, it is important to investigate whether any other avenue could be pursued. This will be helpful in adding future hardware to the drones and powering said hardware.

As new hardware and sensors are added, it will be important to monitor and limit power consumption. This is where limiting computation and broadcasting play a larger part.

## References

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