Battery Analysis to deliver power for IOT Remote Weather Stations

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Background

For our IoT weather stations to function we need to analyze the feasibility for multiple different power supply options within this project. In this we will discuss options available with different materials, performance estimates in cold weather, and pricing.

Lead Acid Batteries

Lead-acid batteries is a type or rechargeable batteries that were invented in 1859. They are made using lead grids with active material being applied to create positive and negative charge. They are separated by a porous membrane called an envelope separator. They are then sealed and filled with electrolytes. They have relatively low energy density when compared to modern rechargeables; however, they have a relatively large power to weight ratio and are quite cheap. The amount of power we get from these would be sufficient enough to run the project for more than a week per node at normal temperatures. In cold weather though there is an issue. In temperature at -30 °C we can expect to lose about 50% of our capacity, so unless properly insulated the performance during the winter when this needs to be running will be dismal. As such I do not recommend this route unless we properly insulate our device. As for pricing they tend to end up in the price range of $35 - $329.

AGM

AGM batteries or Absorbent Glass Mat batteries are similar in construction to lead acid batteries with a few major differences. Rather than using a porous membrane, AGM batteries instead us glass mats. This helps to protect the fragile lead plates inside. They also don't use a free-flowing electrolyte, instead using the glass mat to contain the electrolyte. These differences allow the battery to discharge at a much slower rate than conventional lead acid batteries. Winter time performance Is much better than that of a conventional lead acid battery. Typically, AGM batteries have higher CCA ratings than lead acid batteries which when combined with the lower discharge rate is the reason for this performance difference. The price range for AGM batteries range from $50 - $730.

$LiFePO_4$ Batteries

With the recent developments of the battery industry lithium batteries have become much more accepted in the industry at large. This is due to their high energy density, low discharge rate, and low maintenance. Despite these they still come with the nasty reputation of being volatile and exploding if not properly cared for. This has changed in recent years though with the introduction of lithium iron phosphate batteries. These batteries have a lower energy density but by nature are non-combustible and have made them safe enough to power todays EV cars. These batteries are suitable for most temperature in the range of -20 - 60°C which should be sufficient for most situations seen in this project. There are still limitation in the form of the electrolyte freezing in lower temperatures than the stated range and power loss will still occur. The final tidbit is that this improved efficiency and cost comes at a price, these batteries range in price from $300 – $13,000 depending on the solution chosen.

Solar Cells

Solar cells are a renewable energy technology that will allow a device to harness the power of the sun in order to power a device. They use PV cells to generate electricity and use an internal electric field in the cell to direct the electricity. Solar cells are widely used to charge batteries for use in other applications such as powering a car, camper or house. In this project due to the low power draw there is a chance for a solar cell to completely charge a battery powering an IoT device during the limited sun. Even if not using a solar cell to drip charge the battery would extend the length of time a battery could run before having to be replaced. While the performance of a cell is about 50% better in the summer due to the increased sunlight hours, solar cells still get two benefits in the winter, first the colder temperatures mean that the electricity has the ability to flow more easily, and two snow can reflect sunlight back to the cell allowing it to get more light than otherwise would be available at that time. Depending on the size and features of a cell these panels can cost from $20 - $7,000.

Project Analysis

All the above are investigations into a more permanent solution. For our proof of concept device we will instead be using more disposable or smaller battery cell packs based on our requirements. Bellow will be some calculation with some assumptions being made. First, we will assume we are using a Raspberry Pi and an Arduino as our devices that draw power, second we will assume consistent power draw, and three we will assume the batteries to be new, have max capacity, and drain until empty. With this in mind we will use the following formula to calculate the predicted length of time that the device will be powered:

$$battery\ life = \frac{Battery\ Capacity\ (mAh)}{Load\ Current\ (mA)}$$

10000 mAh battery pack:

Raspberry Pi (575 mA): 17 Hrs 23 Mins

Arduino (200 mA): 50 Hrs

4 AA battery cells (11116 mAh):

Raspberry Pi (575 mA): 19 Hrs 19 Mins

Arduino (200 mA): 55 Hrs 34 Mins

9V battery (550 mAh @ 9V):

Raspberry Pi (575 mA): 57 Mins

Arduino (200 mA): 11 Hrs

D Battery (20 Ah):

Raspberry Pi (575 mA): 34 Hrs 46 Mins

Arduino (200 mA): 100 Hrs