Solar Powered Street Lighting System

- I decided to fulfill the energy requirements of a residential street, like brockhouse way, that is in front of the hatch workshops.

Which type of solar panels should we use?

- There are 3 main types of solar panels:

1. Monocrystalline
2. Polycrystalline
3. Thin-film solar panels

- I compared them with the following rubrics:

1. **Efficiency:** Monocrystalline solar panels are the most efficient, followed by polycrystalline and thin-film. Monocrystalline panels, made from single-crystal silicon wafers, are up to 20% efficient. These are especially useful when you have limited installation space.
2. **Durability:** Monocrystalline panels are more durable. They can withstand rain, snow, and harsh temperatures.
3. **Maintenance Costs:** Monocrystalline panels require minimal maintenance, which is ideal for applications where regular maintenance may be challenging.

- **Aesthetics:** Although this should be of least concern, but the sleek design of monocrystalline panels will increase the beauty of the campus.
- The last and most important rubric was which panel works best in **local conditions**. As we know, Hamilton has a harsh winter climate, so we need to account for that. Monocrystalline panels have the best efficiency in low-light conditions, and they experience a smaller decrease in efficiency in cold temperatures. They also have a smoother surface, which allows the snow to slide off the surface.

These points led to my decision of choosing monocrystalline panels for the residential street light system.

Which type of light should we use?

- There are many types of light out there, like the incandescent, high-pressure sodium and mercury vapor, but I chose **LED** for my design. Following are the reasons:

1. **Energy Efficient:** Due to their low heat output, LEDs are far more energy-efficient than their conventional counterparts. In addition, they need very little electricity to provide the exact quantity of light. The energy efficiency of LED lighting is between 40 and 60 percent higher than that of conventional lighting.
2. **Few Emissions:** LED streetlights use less energy and produce fewer pollutants than their conventional counterparts. As per the reports, switching to LED outdoor lighting can lessen carbon emissions greatly.
3. **Longer lifespan:** The extended lifespan of LED lighting products, which outlives conventional illumination, is another advantage of LED street ights. For instance, LED lights can last 30 times more than incandescent lights and three to five times more than fluorescent lights.

- **High color rendering:** LED street lighting' outstanding color rendering mimics natural light and portrays colors in a more lifelike manner. It assists drivers and pedestrians to see the objects during the nighttime, which enhances safety and reduces traffic circumstances.

Reference: A Complete Guide To Types Of Street Lights - Vorlane

What control and safety circuits should we use?

- **Charge Controller**: A charge controller is a critical component that regulates the voltage and current coming from the solar panels to prevent overcharging and over-discharging of the battery bank. It also optimizes the charging process to maximize battery life.
- **Disconnect Switch**: A disconnect switch or circuit breaker allows you to disconnect the solar panels from the rest of the system for maintenance or in case of an emergency.
- **Overcurrent Protection:** Fuses or circuit breakers are used to protect the wiring and components of the solar power system from overcurrent or short circuits.
- **Battery Disconnect Switch:** A battery disconnect switch allows you to isolate the battery bank from the rest of the system for maintenance or in case of emergencies.
- **Voltage and Current Monitoring:** Monitoring equipment, such as voltage and current meters, allows you to keep track of the performance of your system and detect any issues promptly.

- **Proper Wiring and Conduit:** Use appropriate wiring and conduit to protect against electrical hazards and environmental factors. This includes ensuring wiring is properly sized for the current and voltage levels in your system.

- **Reference:** Conductors, currents, and circuit protection – The AC side – IAEI Magazine
- Solar Charge Controller Sizing and How to Choose One - Renogy United States
- Safety & Protection Devices Used in off-Grid Solar Electrical Installations ▸ Clever Solar Power

Design considerations of the mounting and enclosure

- **Mounting Considerations:**

1. **Where to install?** I decided to install the solar panels on the poles of the streetlights, rather than having them on-ground, which will take up space on-campus, and is also vulnerable to damage. It will be far from reach of unauthorized access, and it causes less of a safety concern being away from people.
2. **Optimal Orientation and Tilt:** Solar panels should be mounted at an angle, so it is exposed to maximum sunlight, to increase electricity production.
3. **Shading:** We need to avoid the shading of the solar panels from other structures, and nearby tree branches. This could lead to great energy loss.

- **Enclosure considerations:**

1. **Weatherproof Enclosure:** All the components of the solar system should be placed in a durable enclosure which is IP65 rated. This will protect them from rain, snow, dust, and harsh weather conditions.
2. **Ventilation:** There should be proper ventilation to allow the heat to escape from the system, which can potentially cause overheating and damage to the system.
3. **Accessibility:** It should be easily accessible for routinely checkups and repairs.

Technical aspects of the system:

- Before I include my schematic, I want to explain my system a bit more.
- To decide on which rating of a solar panel to choose, I decided on how many energy is required for each light.
- Wattage of the LED should be 30W, considering the 4-5 m height of the pole, and it can illuminate an area of 25m^2, while width of road is 6-8m.
- **Reference:** Wattage of Street Lights: How Many Watts Do They Use? - Mokolight

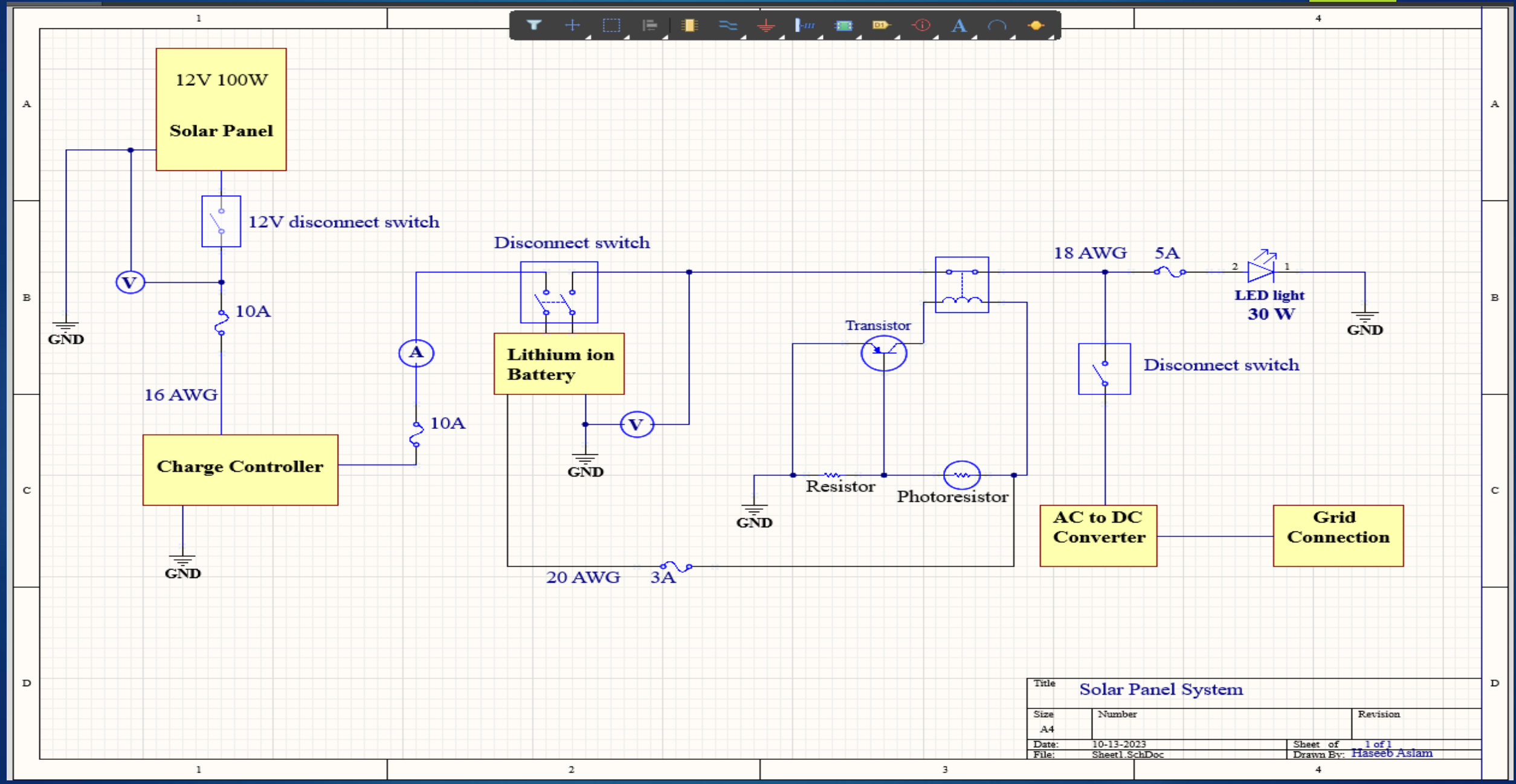
- Our energy requirements in winters is higher, as we have longer nights, but that means we also have shorter days. Therefore, I wanted to make my solar system account for those factors. The least amount of hours of sunlight Hamilton has in winters is 2.5 hours, and the longest night duration is 15 hours and 45 minutes. This means that our system should produce a maximum of 472.5W of electricity. For this, we need two 100W and 12 V solar panels, with 19% efficiency. One 100W solar panel produces 250 Watt-hours of power per day in winters, so we need two of them per pole, to meet the energy needs.
- P=VI
- I am also using 40 Amp-hours and 12 V battery in the system.

Which battery to use?

Lithium Ion	Lead-Acid	Nickel-Cadmium	Nickel-Hydride
Light	Heavy	heavy	heavier
Last 3 years	3-5	10-15	3
High output voltage	High	High current	Used for powerful devices
Holds charge longest	Best	Low capacity	Better capacity
Expensive, and contain a flammable electrolyte	Contain lead, a toxin	toxin	High discharge rate, don't contain toxin

Therefore, I decided to choose lead-acid battery.

Schematic


12V 100W
Solar Panel
12V disconnect switch
10A
16 AWG
Charge Controller
GND
GND
10A
A
Disconnect switch
Lithium ion Battery
V
GND
20 AWG
3A
Transistor
Resistor
Photoresistor
GND
18 AWG
5A
LED light
30 W
GND
Disconnect switch
AC to DC Converter
Grid Connection
Title
Solar Panel System
Size
A4
Number
Revision
Date:
10-13-2023
File:
Sheet1.SchDoc
Sheet of
1 of 1
Drawn By:
Haseeb Aslam

Schematic explanations:

- There are disconnect switches to protect or isolate solar panels and the battery respectively, for things such as repairs.
- There is photosensor on the right which closes the switch in dark, and turns on the light, as the resistance of the photoresistor increases. During the day, the resistance is low, so current flows through the ferrous material, causing it to attract the arm downwards, breaking the circuit, and light turns off.
- On the extreme right, there is a grid connection to the light, so for example: when there is a cloudy winter week, and the solar system wasn't able to produce much of its own electricity, we still need the lights to turn on, so for that we need a grid connection, only turned on when necessary. It also has a AC to DC converter as our light only works on DC circuits.
- We have voltmeters and ammeters in the circuit, to monitor system performance, and help in fault detection.
- We have fuses to protect the components and wire from damage, and wires with enough AWG size to support the current.

That's all folks!
If you have any questions, you are welcome to reach out at:
aslamm14@mcmaster.ca