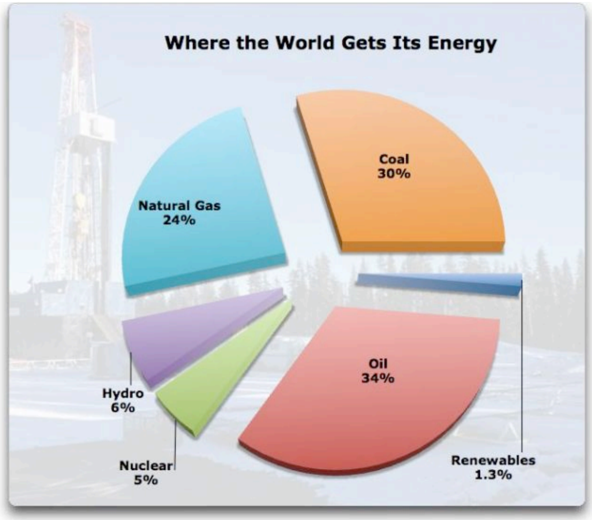
Solar Cells

Motivation:



The main energy sources: coal, oil, and natural gas are fossil fuels that are polluting the Earth. These resources are quickly depleting and becoming extremely expensive. We need to consider renewable energy sources such as solar cells; with an average solar power incident of ~1000W/m^2 on the Earth, we can use solar cells to generate electrical power by converting solar radiation into electricity.

Sample Calculation:

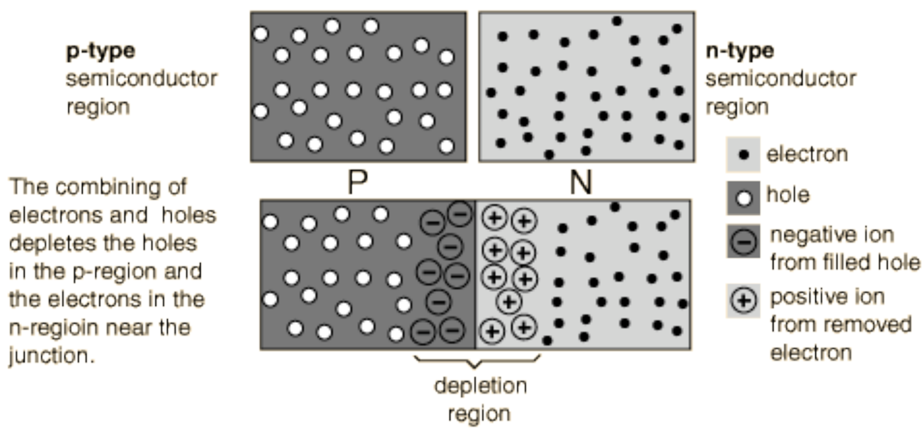
1) The average household in BC Hydro's service area uses about 11,000kWh per year. Under the Residential Conservation Rate, customers pay 6.67 cents per kWh for the first 1,350kWh they use over an average two-month billing period. Above that amount, costumers pay 9.62 cents per kWh. On average, how much does a household pay per month for BC Hydro's service?

2) Sunny would like to set an example for his neighbors by using a renewable resource; the reliability, longevity, and low-maintenance of solar cells is intriguing, but before he commits, he would like to know how much he can save.
   a. In Canada, there is enough solar energy to generate at average of 2500 kWh of energy per year. Assuming 23.3% is lost to DC to AC, how much electricity per year per nameplate kW capacity is produced?
   b. With a 5kW system installed, how much electricity is produced in the first year?
   c. Assuming a system of degradation of 0.5% per year times 25 years, what is the yearly average electricity savings?
   d. Comparing to BC Hydro's rate, how much does Sunny save each month?

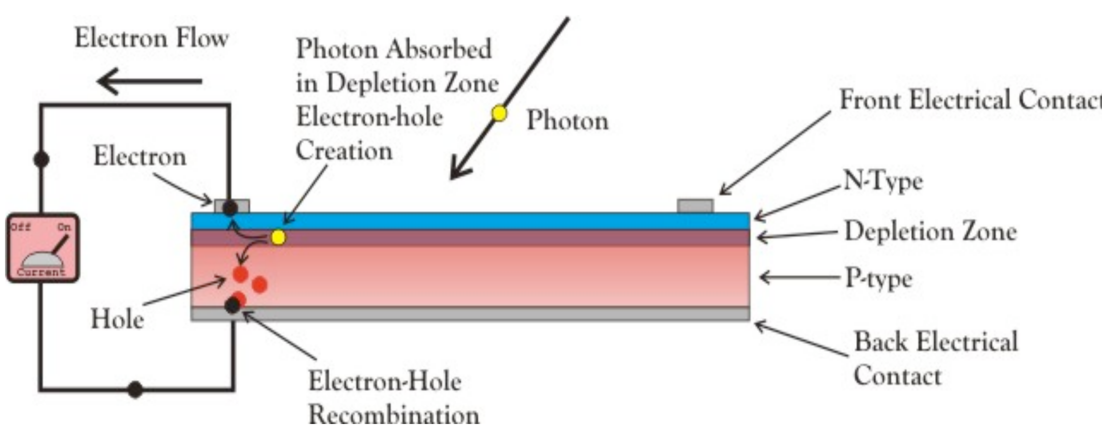
Background Information:

Solar energy is a renewable energy source that we may take advantage of by converting it into electricity via solar cells. Solar cells, also known as photovoltaic cells, produce direct current (DC) electricity and an inverter can be used to change this to alternating current (AC) electricity.

Photovoltaic cells are made from silicon and other semiconductor materials; silicon crystals have all four valence electrons bound with other silicon valence electrons. Semiconductors that are doped with atoms with fewer valence electrons are known as p-type semiconductors and ones that are doped with atoms with extra valence electrons are known as n-type semiconductors. When a p-type and a n-type is brought in contact, an electric field is created and the electrons from the n-type fill the "holes" in the p-type.



When sunlight enters a photovoltaic cell, the light can separate an electron from an atom and the electric field helps move the electrons to charge collecting areas. The electrons are then gathered on the surface of the solar cell by a grid of metal connected to a circuit. The circuit allows the electrons to flow to the back of the cell, where there is a deficit of electrons. Photovoltaic panels are oriented to maximize the sun's light. At what angle should the panels be placed to intercept the most energy? What are the effects of the distance from the light source?



Mini Lab Activity – Testing Photovoltaic Cells

Objective:
The purpose of this activity is to construct a simple photovoltaic (PV) system, using a PV cell and a DC multi-meter, in order to learn how the amount of light affects the generation of electricity.

Materials:
-PV cell
-two electrical leads with alligator clips
-DC multi-meter
-resistor
-source of bright light
-protractor
-meter stick

Procedure:

1) Construct the photovoltaic energy system; set the mulit-meter to be an ammeter and use the light source on the PV cell to check that you are getting a current reading.

Part I: Effect of tilt angle on cell current

2) Make a prediction about how the tilt angle will affect the cell current.

3) Place the PV cell perpendicular to the light source. Using a protractor to determine the angle, slant the PV cell at 15-degree intervals away from the initial position. Record the amps generated at each 15-degree change in the data table below.

Table 1. Effect of tilt angle on cell current

Angle	**Current**
0°	
15°	
30°	
45°	
60°	
75°	
90°	

4) Note your observations.

Part II: Effects of distance from light source

5) Make a prediction about how the distance will affect the cell current.

6) Put your PV cell 40cm under the light source. Measure the current and record it in the data table below. Repeat this for 20cm, and 10cm.

Table 2. Effect of distance on cell current

Distance (cm)	**Current**
40	
20	
10	

7) Note your observations.

Questions:

1) Does light produce more current? Explain.

2) What happens when the solar cell is moved closer to the light source?

Conclusion:

What can you conclude about solar cells from this mini-lab activity? What are some sources of error?