CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)
Kendra L. Barker

Project Number
J0201

Project Title
Follow the Light: Maximizing Solar Cell Efficiency

Abstract

Objectives/Goals
One of solar energy's setbacks is its efficiency. A solar cell only obtains its full energy potential when the sun is directly above it. Based on the speed of earth's rotation, this only occurs for less than 15 to 20 minutes a day. Once the sun is no longer directly above the solar cell, its efficiency drops.
The overall objective was to design, prototype, and build a device that allowed a solar panel to track the sun on one axis. This would permit maximum efficiency the entire day, versus the short period that the sun is directly above it (in the case of a stationary solar cell).

Methods/Materials
The circuit design was tested on a solderless breadboard, perfected, and replicated onto a regular circuitboard. The sensor component consists of two photoresistors, each in a small black tube to block interfering light. Each photoresistor reads a voltage drop (the more direct the sunlight is with the photoresistor, the lower the voltage drop). These voltages are what drive the motor system in the hardware one direction or another. This motor system is geared down to allow the platform with the solar cell to turn towards the light until the voltage difference zeroes out. This means both the sensor and the platform are aligned with the sun.
To compare the device's efficiency with that of a stationary solar cell, a testing device was built to eliminate variables that might make the results inaccurate. This testing device, using a cardboard box and a pinhole camera, simulates the angles during the day that the sun would be, in relation to a stationary solar cell. The solar cell was mounted to the front of the box and the voltage of it was measured at each of the 10 degree increments. (tests repeated 5 times)

Results
The data given from the simulation of a stationary solar cell showed an arc in efficiency, dropping as the sun became less direct. The data from my tracking mechanism showed how effectively it was able to overcome that efficiency drop by tracking the sun.

Conclusions/Discussion
The conclusion reached was that my device allowed the solar cell to harness its full energy potential for the entire day, versus facing the drop in efficiency as the earth rotates away from the sun, like the case of a stationary solar cell. Using my design, solar companies could increase solar energy's popularity as well as efficiency.

Summary Statement
The project's goal was to build a device that tracks the sun on one axis, allowing a solar cell to harness its full potential of energy throughout the entire day, as opposed to facing the drop in efficiency as the sun becomes less direct.

Help Received
Father taught student how to solder a breadboard, but actual project was performed entirely by the student.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Alexandra A. Bayard; Kiran S. Hamkins

Project Number

J0202

Project Title

Maximizing Solar Cell Performance

Abstract

Objectives/Goals

Our objective was to see which among five different methods of sunlight exposure would maximize the output of voltage and current in a solar cell. We hypothesized that a solar cell in combined direct and reflective sunlight would put out the most voltage and current.

Methods/Materials

Four 7-volt solar cells were placed in direct sunlight, reflective sunlight using a hand mirror, shade (under a porch roof), magnified sunlight using a magnifying glass, and combined direct and reflective sunlight. At each position, a digital multi-meter was used to measure the voltage and current that each solar cell gave out. Data was collected over four trials and analyzed to determine which configuration produced the most voltage and current on average.

Results

The average voltages in direct sunlight, reflected sunlight, magnified sunlight, shade, and combined direct and reflected sunlight were 7.7 V, 7.5 V, 7.9 V, 6.2 V, and 7.8 V, respectively. The corresponding average current values were 32.7 mA, 21.6 mA, 43.8 mA, 2.5 mA, and 43.9 mA, respectively.

Conclusions/Discussion

We generally got the most voltage from the combined direct and reflective sunlight. However, the current was generally largest in the case of magnified sunlight. We believe this occurred because the magnifying glass gathered light from a larger collection area than the mirror used to reflect the sunlight. These overall results partially support our hypothesis, but further indicate a potentially better method to improve solar panel performance than our original hypothesized result. This could be useful in everyday life if one wanted to maximize their solar panel efficiency and save money.

Summary Statement

We wanted to determine whether there was a simple technique that could be used to improve solar cell performance.

Help Received

Our parents purchased the materials, provided transportation and advice on project format, and help with using computer software.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Allen K. Cheung; David N. Hoang

Project Number

J0203

Project Title

Small Tiles for Big Purposes

Abstract

Objectives/Goals

Most public areas such as malls and convention centers use up a lot of energy invested into lighting, heating, and air circulation. These areas gain energy usually through sources such as fossil fuels(e.g. petroleum, natural gas, etc.,) or nuclear power. Our objective is to come up with a green energy-generating method which harvests energy from footsteps. Our goal is to design a tile that can generate sufficient power, durable enough to withstand everyday usage, and simple to make.

Methods/Materials

We started by building a prototype of the tile using a 1 x 1 ft. wooden plank and 5 piezoelectric sensors. We wired up these sensors on the bottom side of the top tile using electrical wire. This prototype generated electricity by having the top tile (with the sensors) slightly bend down due to person's weight and therefore bending the sensors. This prototype did not work well, so we switched to hammer design instead, where the hammers would strike the sensors when a person stepped on the tile. This new tile would consist of nine piezoelectric sensors and have foam to cushion the top tile. The same electrical wire was used.

Results

The new tile that we created worked quite well, so we created another identical tile to test how the tile would work together. The tiles seemed to be quite durable as well. each tile costs about fifteen dollars; the highest costing material being the piezoelectric sensors at $4.50 per tile. Each tile was tested to generate about five milliwatts, which is way below our design goal of 250 milliwatts(0.25 Watts). We found out it is due to the limited output of piezoelectric devices. A better piezoelectric device is needed to achieve a higher output power. This engineering project proves that it is indeed possible to harvest electrical energy simply from footsteps.

Conclusions/Discussion

From our experiment, we can conclude that these tiles have a potential to replace traditional energy sources in powering places with heavy foot traffics. They can be made at lower costs and higher durability using today's manufacturing technology. That means that deploying a mass amount of tiles would result in significant decrease in energy spending costs. One downside is that a few tiles don't create significant amount of energy, but when combined with hundreds and thousands of tiles, they could become the alternative energy sources of today.

Summary Statement

Our project shows that it is possible to generate electricity from footstep as an alternative energy source.

Help Received

Adults helped cutting wood tiles using power tools. Adults helped training on how to solder wires using soldering iron.

Name(s)
Lucas Fox; Olivia Nouriani

Project Number
J0204

Project Title
From Crap to Zap: Using the Microbial Fuel Cell to Extract Electricity from Waste

Abstract

Objectives/Goals
This experiment uses mud taken from streams as a substitute for wastewater, and compares the amount of electricity produced from the different streams.

Methods/Materials
Five variations of Microbial Fuel Cells that contained different mud were tested to see how much energy they produced. Every day for twenty-four days the voltage and current produced in each MFC were measured and recorded. The purpose of this experiment was to compare the different amounts of electricity produced by each sample.

Results
The energy produced followed a pattern. Throughout the cells this was similar. Within the first 13 days the numbers peaked, and then declined. After that, the measurements were generally consistent. Another question was which variation would produce the most energy. Although it was predicted that the control would produce the most electricity, that variation ended up producing negative numbers. Variation four produced the most.

Conclusions/Discussion
Variation four produced the most because it was taken from the Santa Ana River. This mud sample resembled mud more than sand. This was the second pick for which variation would produce the most electricity. The control produced negative electricity because the carbon cloth fell off the electrodes, which then rusted. The hypothesis was correct about variation 4, and was incorrect about the control. The hypothesis was also correct about the pattern. The MFCs worked best with mud from a rich environment, when it was thick and not very grainy. This means that only specific bacteria will work well with MFCs.

Summary Statement
Microbial Fuel Cells took advantage of the respiration proccess of bacteria in mud and used this process to extract electricity.

Help Received

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)
Max Freedman

Project Number
J0205

Project Title
Get It While It's Hot: Harvesting Waste Heat with Peltier Devices

Abstract

Objectives/Goals
Data centers and supercomputers generate a large amount of excess heat, which is wasted into the environment. This waste heat could be harvested, and utilizing thermoelectric technology, could be transformed into an alternative energy source. I tested a thermoelectric unit that I built with Peltier devices under various conditions to generate electricity.

Methods/Materials
I set up a thermoelectric unit by assembling 8 Peltier devices in series between an aluminum heat sink (cold side) and a copper panel (hot side). The thermoelectric unit was tested under three different temperature conditions to create delta T (deg K). The three conditions are: Hot (cold side exposed to room temp air, hot side heated with heating pad), Cold (cold side submerged in alcohol with dry ice, hot side exposed to room temp air), and Null (cold side exposed to room temp air, hot side exposed to room temp air). Fifty data points were collected for each temperature condition. I analyzed the data by making a scatter graph to show all of the results together on one plot. I color-coded it to show the three conditions. Using a bar graph, I compared hot and cold condition for the same delta T (deg K). The experiment demonstrates the Seebeck-Peltier equation: V(volts) = A(volts/deg K) * Th-Tc (deg K) where (V) voltage is generated by (A) the Seebeck coefficient (or thermoelectric sensitivity V/K) multiplied by the delta of (Th) hot side deg K minus (Tc) cold side deg K .

Results
The data suggests that comparing similar delta T under hot and cold conditions shows (A) the Seebeck Coefficient is constant (not changing) with the different conditions. Both hot and cold conditions generate similar amounts of electricity. When delta T increases, voltage increases. Low delta T generates little voltage.

Conclusions/Discussion
The data suggests that the thermoelectric sensitivity, (A) in the Seebeck/Peltier equation, does not change with different temperature conditions. My findings can be used to help develop industrial applications for Seebeck/Peltier devices.

Summary Statement
The objective of the project is to test a thermoelectric unit under three different conditions to see which is best for generating electricity.

Help Received
John Rible for teaching me electronics, helping me design my thermoelectric unit. Dr. David Bernick UCSC for explaining concepts in physics and abstract review. Joshua Freedman for help with data analysis. Patty Freedman for background research and data recording.

Name(s)
Sierra G. Freitas

Project Number
J0206

Project Title
Off the Grid by a Yard

Abstract

Objectives/Goals
My project was to determine if I could generate enough energy in my backyard, equivalent to my part of the electricity bill, using a solar panel, a wind generator and a biogas generator.

Methods/Materials
For my biogas generator, I built a bellows, a scrubber (removed hydrogen sulfide from methane), filter (removed CO_2) and connected hoses/pipes to two 275 gallon tanks and my septic tank; built the mounting structure for my pulleys, bellows, motor and generator. I pulled raw methane via the bellows into the scrubber and filter to clean the methane before sending it to my 3.5 hp engine which turned pulleys to pulse the bellows and turn my generator. I connected the generator to my test and monitoring station which included a volt meter for measuring voltage, a precision resistor load box (generator load) and a computer for tracking data. I ran the biogas generator for as long as it could run on the methane. Once the gas was expended, the motor would stop. I tested the generator under different loads -- 4, 8 and 16 Ohms.
I built a stand for my solar panel out of wood. I connected it to my test and monitoring station. I recorded voltage different resistor loads -- 4, 8 and 16 Ohms. I took stored results and plotted them on a graph on the computer.

Results
The wind generator produced an average of 2.966 watts/hour and generated for about 9 hours/day equated to an average of 26.69 watts/day. Escondido does not experience sufficient wind to produce a significant amount of energy.
The solar panel produced about 482 watts per day.
The biogas generator and one section of my septic tank produced about 8 ft# of methane which equates to about 3,050 BTUs (890 watts/day). However, due to system inefficiencies and limits of my storage tank, I achieved 24 watts during 3-5 minute runs.
My average total daily electrical production was 532 watts/day.

Conclusions/Discussion
I could not produce enough energy in my backyard to power my part of the electricity bill. My testing revealed I needed more efficient designs and significantly more capacity on all of my sources to produce 2.72 kWh/day.

Summary Statement
I generated electrical power from biogas, solar and wind generators in my backyard to try to produce an equivalent amount of my part of the electricity bill.

Help Received
Technology teacher helped with electrical/electronics, friend built my pulleys; Dad helped me build the bellows, wind generator, solar stand, filter seals and assemble equipment on mounting board.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Erika Y. Hathaway

Project Number

J0207

Project Title

A Brighter World: Evaluation and Enhancement of Solar Conversion Devices

Abstract

Objectives/Goals

As traditional energy resources such as petroleum oil diminish, we need to explore alternative energy sources, including nuclear energy, hydro power, wind energy, and solar energy. Due to safety and environmental concerns, all must be eliminated, except for solar energy, which is a new, safe, and environmental friendly source of power. Unfortunately, solar energy is too expensive. In the experiment, the scientist tests different solar cells in combination with normal household materials to evaluate efficiency enhancement techniques. The goal is a knowledge base that the public can exploit to improve solar cell energy output.

Methods/Materials

The hypothesis was: A decrease in temperature, an increase in light intensity, or changing the color of light input to a solar cell should improve the efficiency. Materials used included common household items. This experiment consisted of 36 individual experiments; variables included Red, Blue, and Yellow color filters; Hot and Cold temperatures, and High & Low light intensities. Two companies (Hanwa Solar and Yingli Green Energy) supplied samples of silicon solar cells of various types. A solar light from Hampton Bay & another from Malibu Company were procured from Home Depot. Experiments were repeatedly conducted from 10 AM to 2 PM.

Results

Initially, data showed that the output of the solar cells under color filters, different intensities, and different temperatures were less efficient than the energy output at ambient. Yellow light filters worked the best, then red and finally blue. The temperature results showed no clear affect. Hi and Low light intensities both degraded the output level. As a result, the hypothesis was rejected.

Conclusions/Discussion

After reviewing solar cell efficiency research, supplemental experiments were added to determine if the original data was somehow flawed. Results showed that with a larger, better quality magnifying sheet, and an angle facing more directly towards the sun, the output of the solar cells increased 315% from the baseline. Cooling the cells increased their output 4.2%. In conclusion, solar cells that receive intensified light, while pointed at the sun, and cooled will produce optimized output power. In the future, another research idea would be to use water to magnify the light input, while cooling the solar cells.

Summary Statement

"A Brighter World: Evaluation and Enhancement of Solar Conversion Devices" is a project about adjusting the color of light, intensity of light, and temperature of solar cells to increase their efficiency.

Help Received

Father helped understand how to work the Digital Volt Meter and use a cutter knife to strip wire.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

John Heath; Joseph Oh

Project Number

J0208

Project Title

Super Solar Cells

Abstract

Objectives/Goals

The Plan was to find the best photosensitizer (light-sensitive dye) to apply to the Gratzel Solar Cell so that it creates the most energy. If given the Beta Carotene, Passion Tea, Ruthenium, Pomegranate extract, and a dyeless cell, The Ruthenium was expected to work the best because it#s been proven to work well with professional cells, and its skeletal structure suggests it will bond with the TiO_2.

Methods/Materials

The Dyes were purified with a Rotor Evaporator and a Silica tube. The ITO was smeared with a mix of TiO_2 and Vinegar until a full coat covered the conductive side, and baked in the furnace. These covered slides had the dye dropped onto them until the TiO_2 was clearly dyed to the sensitizer. The cell was finished by coloring another piece of ITO with Graphite, placing it on top of the TiO_2 coated one, and dropping the electrolyte inside. The voltages were measured individually.

Results

The average results between the different types of light show that Pomegranate did the best, but only beat the passion tea by .0007. The least effective cell was the Ruthenium, which lost just behind the control (no dye) by .014 volts.

Conclusions/Discussion

In conclusion, our hypothesis was wrong, as the pomegranate did the best, not the ruthenium dye. Out of the dyes that we chose, the dye that produced the most energy was the pomegranate, and this shows that natural dyes like those found in a pomegranate would probably be the most energy efficient.

Summary Statement

The goal of our project was to find the most efficient dye to apply to the Gratzel solar cell.

Help Received

Used lab equipment at Cal tech under the supervision of Dr. Heath

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Krystal E. Mendez

Project Number

J0209

Project Title

Catching Rays: Analyzing Maximum Solar Efficiency as Related to the Sun's Position throughout the Day

Abstract

Objectives/Goals

My objective is to determine the time of day that produces the maximum solar efficiency as is measured by the time it takes for a solar car to travel a preset distance.

Methods/Materials

The materials needed for my experiment are: a project kit miniature solar car, a meter stick, and a timer. I will construct a solar powered car from a kit; the solar panel will be on top of the car. I will use a meter stick to measure out four meters on the ground (the distance the car is to travel). At three preset times throughout the day, I will time how long (in seconds) it takes the car to travel the four meter distance. I will record the results and repeat the experiment for a total of fifteen times each preset time. I will repeat the process over a period of days.

Results

The overall results of my project confirm that the afternoon time produces the most efficient solar energy.

Morning average time: 74.4 seconds
Afternoon average time: 28.467 seconds
Evening average time: 744.0 seconds

Conclusions/Discussion

I learned that the angle of the sun does affect the amount of energy produced by solar panels and so therefore my hypothesis was supported. The afternoon time was the most efficient and caused the car to travel the distance in the fastest amount of time. I think that this is important because solar engineers, scientists, and people like me who do solar projects can use the angle of the sun to their benefit.

Summary Statement

My project is about determining the time of day and the angle of the sun that causes the solar panels to produce the most amount of energy.

Help Received

Brother helped to construct the solar car; science teacher helped with editing and advising

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Sean M. Mignosa

Project Number

J0210

Project Title

Getting Solar Energy into Focus

Abstract

Objectives/Goals

My project was to find out what happens when the solar cell in a parabolic solar concentrator is at a variety of points in relation to the focal point of the parabolic mirror, in order to learn more about making solar concentrators more efficient. I believe that the concentrator with the solar cell closest to the focal point of the parabola will have the highest efficiency and generate the highest output voltage.

Methods/Materials

I built a parabolic mirror from wood, posterboard and Mylar, mounted a solar cell on a PVC tube and set up a notch to enable me to put the solar cell at different heights above the vertex of the parabola. I then wired the solar cell to a voltmeter so I could measure the output. Using the sun as a light source, I performed my experiment by recording the output voltage of the solar cell when mounted different heights from the focal point, with 3 trials for each height.

Results

The average output voltages when the solar cell was 1cm above and 1cm below the focal point were as expected - lower than the average output voltage for the focal point. However, the average output voltage for higher points (2, 3, and 4cm above the focal point) were increasingly larger than that of the focal point.

Conclusions/Discussion

My hypothesis of the concentrator with the solar cell closest to the parabola's focal point having the highest efficiency was not supported because even though 3 data points supported my hypothesis, the 3 others did not. I discovered from research afterwards that solar cell output was not meaningful below 10v and could be inaccurate by up to 1v - so the range of values I got could be misleading. However, I also discovered afterwards that the solar cell at points much higher than the focal point could be picking up light that had been reflected twice - first hitting one wall of the mirror and passing through the focal point and bouncing against the other wall to finally hit the solar cell at a higher position. That opens up new possibilities for experimenting with improvements to solar cell efficiency by using solar cells at multiple heights and generating more electricity.

Summary Statement

My project explores one way to get the highest output voltage from a parabolic solar concentrator.

Help Received

Teacher helped clarify project idea; mom helped with soldering, some typing/printing; dad helped buy materials, saw wood, trouble-shoot connections.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)
Vaibhav Naidu; Ansh Roge; Atharva Shirke

Project Number
J0211

Project Title
Eco-Torch Elite: A Device for Generating Electricity from Human Energy

Abstract

Objectives/Goals
The objective is to design a simple and reliable device that turns human energy into electricity that can be generated anywhere or everywhere with little investment unlike other methods of energy generation that depend on fossil fuel or other non-renewable energy sources.

Methods/Materials
The device was developed with simple mechanism that converted vertical motion into circular motion using simple building blocks such as Lego pieces, spring and motor from toys. Multiple gears helped with faster rotation of the generator rotor. The rotor was attached to the axle and the whole mechanism was enclosed in a small cardboard box. A simple circuit to store the electricity in a capacitor was implemented. The diode prevented the capacitor from discharging and a switch was used to turn the LED On.

Results
Using the device we successfully converted simple human steps to rotate the generator and generated about 2V across capacitor that was sufficient to light a LED for about 10 seconds. On an average a human takes about 7200 steps a day, that would be sufficient to light a LED for about 10 mins.

Conclusions/Discussion
Our conclusion is that, human energy can be successfully and reliably be converted to electrical energy with a cheap and simple device. By using this new method we successfully demonstrated with a working prototype that electricity can be made available to everyone, everywhere! With circuit enhancements and better mechanism more electricity can be generated. Circuit can be modified to charge rechargeable battery and can be used for charging other mobile devices such as cellphones. This device can be used in third world countries as a simple source of electricity or in developing countries in case of emergency.

Summary Statement
Eco-Torch Elite: A device for generating electricity from human energy

Help Received
Parent taught the circuit concepts and helped in soldering the components. Science teacher, Mrs. Patel provided overall guidance.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Anshul Narain

Project Number

J0212

Project Title

Effect of Wind Powered Electrics vs. Gasoline Powered Generators on Car Battery Life

Abstract

Objectives/Goals

The objective of this project is to validate the hypothesis that a commercial wind turbine can produce a minimum 12 volts of electricity to charge a car battery, thereby reducing the amount of gasoline used; to establish how the distance between the wind source and the turbine and varying speeds affects the amount of voltage produced

Methods/Materials

Materials used : Magnetic wind turbine kit with propeller,anemometer,voltmeter, hairdryer, leaf blower and measuring tape

Methods : Assemble the wind turbine apparatus.Connect propellor to the turbine and the 2 wires from the turbine to the voltmeter.

Set hairdryer on high speed and test voltage and wind speed reading from a distance of 2, 4, 6, 8, and 10 inches respectively to see which one produces maximum voltage and at what distance the turbine stops.

Repeat the experiment using a leaf blower and changing distance to 2, 3 and 4 feet.

Then set distance at 5 inches and calculate voltage produced for low and high settings on the hair dryer

Results

Hair Dryer Distance : The farther away the hair dryer was from the turbine, more voltage was produced. Maximum average voltage of 0.159 Volts was found at 10 inches.

Leaf Blower Distance : The closer the leaf blower was to the turbine, higher voltage was produced. Maximum average voltage of 1.49 volts was found at 2 feet.

Har Dryer speed : The high speed on the hair dryer was able to produce an average of .128 volts. On the low level of the hair dryer, the turbine was not able to turn and produce any voltage.

Conclusions/Discussion

I have come to a conclusion that the turbine used was too small to produce enough voltage to charge a car battery. Voltage produced by the hair dryer increased the further it got from the turbine. This is probably because when the hair dryer was closer to the turbine, the wind would disperse in many directions,as was unable to turn the turbine as fast as it could from a further distance. In the case of the leaf blower the voltage produced didn't vary significantly with distance and will need more trials at larger distances to arrive at a conclusion.

Summary Statement

Can we use wind to reduce the quantity of gasoline used to charge a car battery

Help Received

Dad helped buy the materials and Mom helped print the report

Name(s)
Rajiv K. Nelakanti

Project Number
J0213

Project Title

How Do Different Natural Dyes Affect the Longevity and Power Output of Nanocrystalline Dye-Sensitized Solar Cells?

Abstract

Objectives/Goals

As new ways for clean energy are introduced, it is important to find out which ways are more efficient and cleaner than others. The purpose of this project is to understand which natural dye produces cells with the best (open circuit) voltage, the best (closed circuit) current and the least degradation over time.
I hypothesized that darker dyes like blackberry, raspberry, and blueberry would yield cells with higher voltages and currents. I also hypothesized that cells from lighter dyes from green citrus leaves and spinach leaves would degrade the least over time.

Methods/Materials

In Part 1 of my experiment, I constructed the solar cells using GrA#tzelâ##s method of cell construction. First, I prepared the titanium dioxide (TiO_2) suspension. Next, I applied the suspension onto conductive glass plates. Afterwards, I soaked raspberry, blackberry, blueberry, green citrus leaf, or spinach leaf dye onto the TiO_2 coated conductive glass plates to form the electrode. Then I carbon coated the counter electrode with a graphite pencil. Finally, I assembled the cell by attaching the electrode to the counter electrode with binder clips. I placed electrolyte between the plates using capillary action.
In Part 2 of my experiment, I measured the voltage and current over time for the constructed solar cells by using a multimeter. Here, I controlled the amount of light each cell received. In total, I made 18 solar cells (each dye and negative control in triplicate).

Results

The blackberry dye solar cells produced the best current, the spinach dye solar cells produced the best voltage, and the blackberry dye solar cells deteriorated the least over time. Furthermore, the blackberry cells had the highest maximum power, which was derived by multiplying the voltage by the current.
Blueberry dye yielded cells with the worst voltage and current output, and had the worst maximum power of all the dyes. The negative control cells yielded extremely low, and unstable current, and power. Their voltage had ups and downs as well, high in the beginning and low towards the end.

Conclusions/Discussion

The results of my experiment show that blackberry is the best dye to turn to when making the most efficient dye-sensitized solar cells because they produced the highest current and maximum power and degraded the least over time.

Summary Statement

The purpose of this project is to understand which natural dye produces solar cells with the best voltage, current and power and the least degradation over time.

Help Received

My science teacher provided me with some of the materials. My father (advisor) supervised and assisted me with my experiment. My mother helped me with the project board. My brother proofread my procedures.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Divita Pandita

Project Number

J0214

Project Title

Save the Earth

Abstract

Objectives/Goals

To create a more efficient and economically feasible alternative energy source, that could potentially save our planet from global warming and pollution by using the surplus of human waste.

Methods/Materials

I used a two chamber microbial fuel cell to produce electricity. The main material s used were containers, carbon cloth/paper, copper wire, Agar and salt, air pump, Benthic / top soil, water and few other miscellaneous materials.

Results

Microbial fuel cell was capable of producing electricity right away, but its electric production was inconsistent.

Conclusions/Discussion

Yes, the microbial fuel cell can be used to create a more efficient and economically feasible alternative energy source, that could potentially save our planet from global warming and pollution by using the surplus of human waste. In the future for mass production of microbial fuel cell a capacitator can be used to increase the efficiency of the microbial fuel cell.

Summary Statement

Creating a new alternative energy source that can potentially save the Earth.

Help Received

Parental supervision in using sharp objects.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Sankalp Panigrahi; Gautham Pasupathy; Vikram Pasupathy

Project Number

J0215

Project Title

Power of Density: A Catalyst for Hydroelectricity

Abstract

Objectives/Goals

Last November, over 8 million people were left without electricity for weeks after Hurricane Sandy. Such natural calamities impact our country every year. Portable hydroelectric generators in residential areas will definitely improve such electricity crises. But what liquid would work best for the generator? The objective of the project is to determine the impact of the density of a liquid on the amount of electricity generated by a hydroelectric generator. Based on our study of hydroelectric power generation, we hypothesize that, higher the density of a liquid, greater the amount electricity that will be generated.

Methods/Materials

We built a hydroelectric generator using a rotor, a stator and a turbine. For the rotor and stator, we cut a foam board into 2 circular disks. On the rotor disk, we marked the polarity of the magnets using a magnetic compass and hot glued the magnets, reversing the polarity each time. For the stator disk, we made 4 coils of magnetic wire, and hot glued them on the disk in different directions. For the turbine, we drilled a hole on the center of a cork and made seven slits on the cylindrical surface. We stuck seven spoons into the slits. Next, we drilled a hole in two opposite sides of a water can. We stuck the dowel through the holes and then attached the cork, stator, and rotor onto the dowel. With this, the hydroelectric generator was built. We poured the liquid from a fixed height onto the turbine. We recorded the volts generated using a multimeter. We repeated these steps with different liquids.

Results

With higher density liquids, more electricity was generated. The density of salt water was 1.25 g/ml, sugar water was 1.2 g/ml, water was 1 g/ml, and Diet Coke was 0.997 g/ml. Salt water generated an average of 11 volts, water and sugar water generated an average of 10 volts and Diet coke generated 8.67 volts.

Conclusions/Discussion

Our hypothesis was proved correct and was supported with the data collected by our experiment. We conclude that, the higher the density of the liquid, more electricity is generated. Although in our experiment, the difference in voltage was less between different liquids, the difference in power generation would be much higher when made on a larger scale.

Summary Statement

This project demonstrates the impact of density on the amount of electricity generated by a hydroelectric generator.

Help Received

Our project sponsor was our mentor.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Tovah H. Popilsky

Project Number

J0216

Project Title

Watts Up with Solar Energy?

Abstract

Objectives/Goals

The objective of my project was to determine whether placing a solar panel under an "aqua lens" (a magnifying glass constructed of hot water poured on plastic) at different heights makes the panel generate more energy.

Methods/Materials

I built a 4ftx8ft platform with one 4ft wooden post at each corner and attached a frame on the top, which was similar to the structure of the base (see specific materials), and stapled painter's plastic (4 gauge) and poured one gallon of hot water on each section of the frame. I then made three stations with milk crates to place my three "home-made" solar cells on each station, to measure their volt and amp measurements to find watts. Then I averaged the watts for each test (1, 2, and 3) then the overall watts measurement of all three panels for each test.

Results

When the panels were placed under the aqua lens at 2ft above the base, the average amount of watts produced was approximately 1-1.6 watts. Overall the averaged watt measurements were anywhere from 1.2-1.6 watts. In order from most watts produced was 2ft above the base, 1ft above the base, Control (not under lens) , and then at the base.

Conclusions/Discussion

Overall I determined that placing a solar panel under a magnifying lens like object helps to increase the amount of energy the panel produces. Specifiacally, I discovered that placing a solar panel 2ft above the base (under the lens) helped the solar panel generate the most watts/energy. I think my results were they way they were because when the panel was placed closer to the light beam, the panel was almost completely covered with the focused light and heat. It did better compared to the panels placed lower under the lens because when the panels were placed at the base the beam generated by the lens wasn't as strong or sharply focused so wasn't as efficient.

Summary Statement

The aim of my project was to determine whether placing solar cells under an aqua lens increases the amount of energy it produces.

Help Received

Family friend helped to build aqua lens

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Zoe S. Reifel

Project Number

J0217

Project Title

Solar Tracking Robot

Abstract

Objectives/Goals

Solar panels collect the most energy when pointed directly at the sun. Most solar panels are mounted in a fixed position. My project tests if a panel that tracks the sun generates more power than a typical panel with its fixed position. I predicted that by tracking the sun, more energy will be collected.

Methods/Materials

To make this comparison, a small solar panel was connected to multimeters to measure its output. Measurements were recorded throughout several days. Some with the panel in a typical fixed position, and others with the panel pointed directly at the sun. My control was a fixed position solar panel, and my variable was one that tracks the sun.

My approach was to build a small dual axis solar tracker. It uses a computer and two motors to orient the panel towards the sun.

Results

I ran my experiment three times, each time collecting a full set of data. On January 21st, a bright and sunny day, I collected 12.5 watt-hours of energy with my fixed solar panel, and 16 watt-hours by using my solar tracker. This resulted in 27% more energy collected by tracking the sun.

Conclusions/Discussion

My data supported my hypothesis that tracking the sun is beneficial. My experiment showed conclusively that more energy can be generated by continually pointing the solar panel directly at the sun.

To expand on this experiment, I would like to do more research on whether the increased energy generated justifies the additional installation expense. I would also be interested in collecting data throughout a year to understand the seasonal factors of tracking the sun. Another area of exploration would be to determine the optimum way to track the sun. Some trackers use sensors, and some use mathematical calculations, like I did, to predict the sun's position.

Summary Statement

Do solar panels that track the sun generate more energy than those with a fixed position?

Help Received

My father helped with the design concepts, and advised on construction and computer programming.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Andrew J.N. Takata

Project Number

J0218

Project Title

Renewable Energy from Ocean Waves Using Piezoelectric Crystals

Abstract

Objectives/Goals

Can ocean waves bend piezoelectric crystals enough to produce energy?

I predict that the greatest amount of energy extracted from ocean waves using piezoelectric methods will be found in waves generated during a high tide.

Methods/Materials

1 Assemble voltage measuring board containing 5 40mm X 10mm X .5mm STEMINC Steiner and Martins Inc. Piezo electric Parallel Bimorph Actuators; construction details are in report. 2 Travel to San Clemente Pier with nylon string and weight. 3 Travel to south end of pier after the first light post past the guard tower. 3 Tie string to scale on board. 4 Tie string to weight. 5 Turn all mulimeters to 2000mv. 6 Cast weight into the water. 7 Film readings on meters for 1 minute. 8 Repeat processes 5 more times at high and low tide respectively. 9 Return home and record time, tide, and height of tide. 10 Play film on computer and pause the video every second. 11 Record readings on pre-made chart. 12 Graph data. 13 Draw conclusions.

Results

The voltage readings this investigator obtained proved that low tide produced larger voltage readings than high tide on all three days of data gathering. For the average high and low tide readings on January 1, 2013, the low tide values ranged between 2.4 mV to an excess of 700 mV (absolute values), while the high tide readings were lower at 0.04 mV to 95mV (absolute values). On January 7, 2013, the low tide readings ranged between 0 mV and 400 mV (absolute value), and the high tide readings were lower at 0 mV to 199 mV (absolute value). Finally, for the average high and low tide readings on January 9, 2013, the low tide readings ranged between 1.2 mV and 500 mV (absolute value), while the high tide readings were lower at 0 mV to 206 mV (absolute value).

Conclusions/Discussion

This investigation demonstrated that low tides produced the greatest voltage readings compared to high tides. These results are the opposite of what the hypothesis predicted. However, articles about the motion of waves from Michal Kerrigan, in Coastline, and Darlene Stille, in Waves, are consistent with the data analysis. According to Kerrigan and Stille the energy of the waves is constant, but in shallower water the same energy results in a higher taller wave that displaced the T Bar more and thus acted to bend the piezoelectric actuators more generating greater voltage readings.

Summary Statement

It was demonstrated that ocean waves can deform piezoelectric crystals to produce a voltage and that waves during low tide produce greater voltages than waves during high tide.

Help Received

Thank you to Mom for buying my supplies and taking me to the pier even at night. Thank you to Dad for helping me design and construct the measuring board. Thank you to my brother for taking the video of the trials. Thank you to Mrs. Rivero for trusting outside-the-box thinking and Ms. Jenkin for being patient

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Macy J. Wood

Project Number

J0219

Project Title

Power in Storm Drains?

Abstract

Objectives/Goals

The objective is to see if storm drain water can create electricity and to determine if the amount of energy created would increase at the same rate that pressure is increased. The hypothesis was that a storm drain system can generate hydroelectricity and that when pressure is increased by a certain percentage, the power will increase, but not by the same percentage of increase.

Methods/Materials

A pressure tank filled with 2 liters of water and was pumped up to the desired P.S.I. A voltage meter was then connected to ends of the wire attached to the generator/motor. While directing the clear tube towards the water wheel, the valve was opened releasing the water and pressure which turned the water wheel and electric motor/generator. The highest voltage indicated was recorded. Materials:Water pressure test gauge(10-200 P.S.I),pump/sprayer, ½" brass ball valve, ½" I.D.clear tubing, ½" x ½" x ½" pvc plastic tee, ½ x ¼ brass bushing, ½" poly tubing,pipe clamps,teflon tape, 1" pvc sch.40 pipe,plastic roof vent,electrical tape(white), 3/8" fiberglass pole,blue painters tape,misc.wood screws, 2x4 fir wood support, 4x4 fir wood support, 4x4 I.D.plastic post slips, 1-1/2" rubber plug, 8 plastic spoons,voltage meter,wood skewers,toothpicks, plastic straw,brass hoop, 2 metal axles w/plastic end(misc.plumbing drain), metal gear motor(1.5-3vdc),electrical wire(20 gauge),plastic bin/basin

Results

The data collected during the trial sets concluded that the average storm drain could be directed to generate electricity at various rates. There was an increase in electricity(voltage)generated from 15 P.S.I.(.02 volts)to 20 P.S.I.(.04 volts);however from 20 to 25 and from 25 to 30 P.S.I. there was no increase in voltage as the maximum voltage achieved was(.04 volts).

Conclusions/Discussion

The hypothesis did support that storm drain water can be used to generate electricity. The experiment also confirmed that additional pressure will result in additional electricity being generated, however the experiment only showed an increase in electricity from 15 to 20 P.S.I. and there was no change observed at 25 & 30 P.S.I. With the demand for electricity always increasing, this concept could be applied in areas that receive high amounts of rainfall and that have large amounts of slope, or elevation change. That combination would create the ideal conditions to generate substantial amounts of electricity from the common rain storm.

Summary Statement

Can a local storm drain system generate hydroelectricity and when the amount of pressure is increased by a certain rate, does the amount of power (voltage) generated, increase at the same rate?

Help Received

My dad helped me refine my design and construct the project, Grandpa provided the voltage tester, my science teacher, Michelle McDaniel was helpful in providing inspiration and advice as the project developed, and my Mom helped me with the presentation.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Daniel S. Yacoubian

Project Number

J0220

Project Title

A Novel Method of Improving Home Solar Panel Output: A Fundamental Concept with Profound Implications

Abstract

Objectives/Goals

The objective of this experiment is to determine if home solar panel electric output can be increased without using any extra energy. This is tested by using a unique method of cooling the solar panel. This method consists of a novel tubing apparatus, which redirects airflow produced by an outdoor air conditioning condenser to a solar panel. Science has shown that solar panel energy production works most efficiently at cooler temperatures. I hypothesize that my original tubing apparatus will successfully re-direct airflow to the solar panel and decrease its temperature thus increasing electric output.

Methods/Materials

The voltage and temperature of an experimental solar panel versus a control solar panel were tested simultaneously. The experimental panel received airflow from a novel insulated flexible air tubing system designed to connect the home air conditioning condenser to the solar panel. Data was gathered over the course of three days and analyzed. The percentage of voltage increase of the experimental panel and its temperature change was calculated and compared to the control panel.

Results

The results demonstrate that there is an 8% increase in the voltage output of the experimental solar panel receiving airflow from the air conditioning condenser as compared to the control solar panel.

Conclusions/Discussion

I conclude that my hypothesis is correct, and it is possible to significantly increase the electric output of a solar panel, without using any extra energy, by cooling the solar panel with airflow from a home air conditioning condenser. This experiment represents the first time that airflow from an air conditioning condenser has been used to cool a solar panel and successfully increase electric output. The implications for energy conservation in such a system are great. This system can add great economic value to existing solar energy systems and may provide incentive for home or business owners to install new systems. In addition, this concept can influence design of new systems that would take advantage of the airflow from an air conditioning condenser.

Summary Statement

Solar panel electric output can be increased without using any extra energy by cooling the solar panel using the airflow produced by an outdoor home air conditioning condenser unit.

Help Received

Father helped assemble tubing apparatus. Mother assisted in typing.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)
Jacob Yoshitake

Project Number
J0221

Project Title
Excellent, Efficient, and Economical Solar Tracking

Abstract

Objectives/Goals
The overall objective is to improve solar panel efficiency by aiming the solar panels at the sun. Improved efficiency allows fewer panels to produce the required electric energy. In addition, the difference in efficiency between a static solar panel and a tracking panel will be evaluated. The goals are to reduce overall system cost and reduce the roof space needed for the solar panels.

Methods/Materials
Methods followed three (3) steps: designing and building a working model sun tracker using an innovative shadow box sun sensor, measuring the power output of solar panel at various sun angles (power vs. sun angle), and evaluating data to determine if the system is cost-effective.

Materials:
Demonstrator model: a wood frame, innovative shadow box sun sensor, amplifier, battery and actuator.
Power measurement vs. sun angle experiment: small scale solar panel, non-reflective test box, shop light and meters.

Results
It is feasible to build an effective, simple and inexpensive shadow box driven solar tracker. Testing showed a static solar panel was 54% less efficient than an east-west tracking solar panel thereby demonstrating that solar tracking more than doubles efficiency. The shadow box tracking system would cost 45% less than a static system providing approximately the same power output. Tracking the sun north to south is much less important and was determined to be unnecessary.

Conclusions/Discussion
Solar panel efficiency was substantially improved with a sun tracker. The shadow box sun sensor was shown to be inexpensive while doubling the power output and was therefore determined to be cost-effective. The tracker reduces both roof space and panel cost. Complex sun sensors and logic used by many described in the literature is eliminated using an innovative shadow box sun sensor. The project demonstrator shows it operates well.

Summary Statement
Designing, building, and testing an innovative, shadow box driven solar tracker proved that solar tracking can be cost-effective, double the power output of a static solar panel, and decrease the roof space required for solar panel systems.

Help Received
Philip Lane (grandfather, mentor and retired aerospace engineer) assisted with understanding reports on other sun trackers, higher level math, and electrical circuitry work. Mrs. Elaine Gillum guided me through the project stages. My mom, a CPA, helped with Excel spreadsheets.

Name(s)

William W. Follett, V

Project Number

J0296

Project Title

Air Cathodes for Better Microbial Fuel Cells

Abstract

Objectives/Goals

The objective is to determine which type of air cathode (Gore-Tex, Tyvek, Windex cloth or Teflon) can produce the most power for the least cost in a microbial fuel cell (MFC).

Methods/Materials

I developed a unique MFC design that allows air cathodes to be easily compared while controlling for changes in the microbe community. This improves on last year's design by replacing the expensive proton exchange membranes with less expensive air cathodes, and shrinking the size by 9X for better efficiency. I spent a long time searching for MFC designs, and as far as I know mine is the only air cathode MFC to control for the microbes. I was recognized by Penn State University and my latest MFC is on their website.

The air cathodes are initially all covered with plastic to block air flow. The one to be tested is selected by removing the plastic. To determine the power output, the electrodes are connected to various resistances and the voltage is measured. The power is calculated at each resistance by using the formula V^2/R to find the maximum power. The maximum power is divided by the cost of the membrane, which gives watts per dollar. This is repeated for the various air cathode devices. Microbe samples were cultured to check for contamination.

Results

Gore-Tex produced the most peak power (0.019 microwatts), while Tyvek cost the least investment per watt generated ($0.05/microwatt, compared to $0.32 for Gore-Tex and $3.34 for Teflon.) The power changed by a factor of 6 between tests, but after scaling the results based on power, the results were repeatable because the relative performance ranks of the air cathodes stayed the same for all tests. The significant changes in power show the importance of controlling for the microbes.

Conclusions/Discussion

The hypothesis that Tyvek would provide the best value as a diffusion layer in terms of watts per dollar invested is supported by the data. Since Tyvek required a coating of Scotchguard to remain water resistant, Gore-Tex or a different type of Tyvek may be a better choice for an industrial application.

The real world application of MFCs is to generate electricity from wastewater treatment plants. The potential energy in U.S. wastewater today is equivalent to 15-20 nuclear power plants. Besides wastewater treatment, MFCs are also good for applications where batteries are hard to replace such as underwater sensors, space rovers and heart pacemakers.

Summary Statement

This project investigates the effect of different air cathodes on microbial fuel cell performance.

Help Received

Father provided guidance, Mr. Jensen loaned a kiln, Ms. Ligeti loaned a microscope, Dr. Logan suggested I try a smaller MFC.

Name(s)

Colin S. Takeda

Project Number

J0297

Project Title

Electricity from Garbage: Using a Microbial Fuel Cell to Create Energy from Food Waste

Abstract

Objectives/Goals

It is estimated that the average American throws out 33 pounds of food waste each month. For my family of four, that adds up to 1,584 pounds a year or about 4/5 of a ton. At the same time the world is facing an energy crisis by depending on fossil fuels, which will run out and are ruining our climate. My goal was to study if Microbial Fuel Cells could be a possible solution to both of these problems. Specifically with this project, I wanted to find out what types of food waste produce the greatest amount of electricity in a Microbial Fuel Cell (MFC).

Methods/Materials

I built a two-chambered MFC out of PVC pipes and fittings. I used agar-agar and table salt to create a salt bridge between the chambers, replacement parts for a power drill as carbon electrodes, and commercially available septic tank treatment as a source of anaerobic bacteria. In a series of experiments I measured the electrical output of the MFC over one hour after adding a pureed sample of three food groups (fruits, vegetables and meats) as well as a mixture of all the food groups together. I also measured the output when sugar was added to the MFC. I measured the output of the MFC with only the septic tank treatment in it as the control. My independent variables were the different food blends and sugar. My dependent variable was the amount of electricity produced by the MFC.

Results

All the food blends and sugar raised the electrical output of the MFC over the control. Sugar had the highest average output of 381.2 mV followed by fruits at 302.4 mV, the food mixture at 235.1 mV, meats at 210.0 mV, and vegetables at 195.4 mV. The control had an average output of 77.6 mV.

Conclusions/Discussion

My hypothesis was correct: foods that release sugar faster (have a higher glycemic index) will generate more electricity. Sugar (sucrose) and fruits had a greater output then meats and vegetables. The food mixture sample had an output in the middle of these groups. I can see a future in which our houses are equipped with MFCs. It could be buried in the backyard and be attached to the garbage disposal underneath our kitchen sinks. This study, and other studies like it, could help us learn what it takes to maximize the electrical output of a home MFC. Having a home MFC would not only put to use all that food waste we now throw out, it would also decrease our dependence on fossil fuels.

Summary Statement

This project evaluates the energy output of food waste when used for fuel in a Microbial Fuel Cell.

Help Received

My Mother help me with some of the cutting for my display board and my father taught me how to use Adobe Photoshop and Apple Numbers.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Shakson K. Isaac

Project Number

J0298

Project Title

Soil Bacteria Battery: Can Soil Bacteria Save the Earth?

Abstract

Objectives/Goals

My objective was to see if soil bacteria could generate energy as in a battery by decomposing organic matter. Theoretically speaking if this worked it could be put into a generator and charge the house. My goal was to achieve the power of the soil bacteria getting to a point until it reached a voltage over one. If this worked in the future I would want to make a generator and use different ratios of the type of organic matter (coffee grounds, sugar water, or compost) to the soil. I would also like to have a microscope to see which bacteria make the voltage higher.

Methods/Materials

In the experiment, I had one control and four manipulating variables regular soil (200g), coffee ground (4 tbs.) with soil, compost (2 tbs.) with soil, 10% sugar water mixed with soil, and 10% salt water mixed with soil. Then you would put the moisture level (5 out of 10) the same. Next you would add copper and zinc to make a battery. After that you cover each of the 5 cups up with plastic wrap. Finally you would check the voltage using a multimeter.

Results

The coffee grounds clearly performed the best out of all the three experiments and made the highest voltage of 1.02. In experiment 1 sugar water had the highest voltage overall. Compost had the second highest voltage and coffee ground had the third highest voltage overall. In experiment 2 coffee grounds had the highest voltage overall. Sugar water had the second highest voltage and compost had the third highest voltage. In experiment 3 coffee ground had the highest voltage overall. Compost had the second highest voltage and sugar water had the third highest voltage. When I checked the voltage of the 3rd experiment again 3 months later from January coffee ground had a voltage of 1.01.

Conclusions/Discussion

In my conclusion I learned that when soil bacteria decompose organic matter they do generate electricity. I suppose coffee ground went over 1.00 voltage because it was moist and the soil bacteria probably ate the coffee grounds slower and conserves the energy more than sugar water soil. I think that sugar water soil has a high voltage but wasn#t as high as coffee ground soil because the soil bacteria probably ate the sugar water quickly and after that it doesn#t have a very high voltage anymore.

Summary Statement

This project displays the effect of the soil bacteria voltage when it decomposes organic matter.

Help Received

My mother helped me start a schedule. Mr. Tyler answered some of my questions. My dad helped me with materials.

CALIFORNIA STATE SCIENCE FAIR
2013 PROJECT SUMMARY

Name(s)

Dylan L. Beyermann

Project Number

J0299

Project Title

Solar in the Cold

Abstract

Objectives/Goals

The objective of this experiment was to study how temperature affects the maximum power produced by a photovoltaic. The performance of batteries decreases when the temperature is lowered because the chemical reactions that produce the electrical energy slow down. If photovoltaics work like batteries, then the maximum power they produce should decrease at lower temperatures.

Methods/Materials

A photovoltaic was connected to a load resistor. When lit with a halogen light, the current and voltage produced by the photovoltaic depends on the value of the load, which is called the operating point. Two multimeters were used to measure the current verses voltage curve of the photovoltaic as the load was changed. From these data the power was calculated for different operating points. These measurements were repeated with the photovoltaic at room temperature, in a refrigerator and in a freezer.

Results

The current-voltage graph changed with temperature. The power produced by the photovoltaic was a maximum at an intermediate operating point. When the power was calculated from these graphs, the maximum power was produced at a higher load resistance, and the power at the maximum increased from 83.0 mW to 98.1 mW as the temperature decreased from 37 °C to -10 °C.

Conclusions/Discussion

The experimental data showed that the peak power produced by a photovoltaic increased as the temperature was lowered. This contradicts the hypothesis, which means the operation of a photovoltaic does not rely on chemical reactions in the same way as a battery. This is important for determining how much energy can be collected from photovoltaics in different climates. Also, this project showed that the operating point for the maximum power changes with temperature, so the load resistance has to be readjusted to optimize performance.

Summary Statement

This project examines how the maximum power produced by a photovoltaic changes with temperature.

Help Received

My father helped me build the box and circuit. My mother helped me prepare the display board. My parents purchased some materials. The two multimeters were borrowed from University of California, Riverside.