# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Anousha A. Athreya

**Project Number**
**J0201**

**Project Title**
## The Effect of Organic Dye on Dye-Sensitized Solar Cell Efficiency

**Abstract**

**Objectives/Goals**
The objective of this project is to find how different types of organic dyes affect the efficiency of dye-sensitized solar cells in both natural (sunlight) and artificial light (incandescent light). This information can help guarantee our future generations a clean and healthy future!

**Methods/Materials**
Step 1: To construct the dye-sensitized solar cell, I created the titanium dioxide (TiO2) suspension using TiO2 powder and white vinegar and applied it uniformly onto a conductive glass plate. Then, I dried and annealed the coated plate to form a thin film of TiO2. Next, the TiO2 coated conductive glass plate is soaked into the dye (blackberry juice) to form the electrode. Many natural dyes possess a chemical group that can attach to the TiO2 surface. A layer of dye is absorbed into each particle of TiO2, which acts as an absorber of light. Place a carbon-coated plate (counter electrode) on top of the electrode plate and binder clips secure the glass plates. This process is repeated 3 more times to make different dye-sensitized cells using different dyes (blueberry juice, raspberry juice and turmeric).
Step 2: I placed the solar cells with the TiO2 side facing the light and measured the voltage and current. I calculated the power by multiplying the voltage and current for all the dye-sensitized cells in both sunlight and incandescent light.

**Results**
My hypothesis was partially correct. Per my research, I had hypothesized that only darker dyes would produce higher power as they are dark in color and have high anthocyanin content. The blackberry dye solar cell generated the maximum power, the turmeric dye solar cell produced the second most power, and there was only a 10% variation of their power output. Blueberry dye sensitized cells with the poor voltage and current output, had the least power of all the dyes. In both the lighting conditions, the test results turned out to be similar; there was a 40% drop of power from sunlight to incandescent light for all the solar cells.

**Conclusions/Discussion**
In conclusion, the blackberry and the turmeric dyes are the best dyes to turn to when making the most efficient dye-sensitized solar cells (DSSC) because they produce the maximum power due to light absorption or high electron sensitivity. I researched further and found that certain types of natural dyes (e.g. turmeric) have curcumin content that help in electron sensitization to produce higher power.

**Summary Statement**
The purpose of this project is to understand which organic dye produces dye-sensitized cells with maximum power; it helps us understand how electron sensitization and color of organic dyes play a key role in yielding the maximum power.

**Help Received**
My Science teachers, Mr. Takemoto and Mrs. Makhijani, reviewed my project and provided me necessary guidance. My family helped me get the materials and provided the supervision throughout the project.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Josh C. Benson

**Project Number**
**J0202**

**Project Title**
## Increasing the Useful Lifetime of Solar Panels

**Abstract**

**Objectives/Goals**
Over time, solar panels lose efficiency in electrical voltage and current. The objective of my project was to learn if I could find an affordable way to expand the useful lifetime of solar panels. If we can keep solar panels efficient for a longer period of time, then they will last longer and be used more frequently.That is good because solar power is renewable and less polluting than fossil fuels, which our planet is quickly running out of.

**Methods/Materials**
My materials included 5 old poly-crystalline solar cells, 3 furnaces, a multi-meter, floodlight, and a stopwatch. I also had safety equipment including safety googles, a heavy lab coat, and gloves. I heated (annealed) the solar cells in the three furnaces at various temperatures and for different lengths of time. The floodlight was securely mounted to a wall in a dark room. I used the multi-meter to measure the cells' voltage and current. For each test, three trials were done.

**Results**
The data demonstrated that at 550 Celsius there is a significant drop off in current even after just 30 minutes in the furnace. We saw the same drop off in current at 400 C after 24 hours.
The data also indicated that there is a significant drop off in voltage after 24 hours at 550 C.
200 C was not hot enough to make any statistically significant changes in voltage or current.
At 400 C after 30 minutes in series one there was an 8 - 10 percent increase in current. That result was not replicated in series two (when I repeated the experiment to validate the initial results).

**Conclusions/Discussion**
Measured drop offs in current were likely due to cracking aluminum grid lines that deliver the electricity to the multi-meter.
The apparent reason for such an immediate drop off in current at 550 C, and a similar drop off at 400 C after 24 hours, is that that the effect of temperature is exponential. This means that temperature has a greater effect than time.
The drop off in voltage at 550 C after 24 hours was the only major change in voltage, and that was likely due to the main aluminum strip cracking.
With regard to the potential increase in voltage, more testing needs to be done to get conclusive results regarding whether heating the panel at 400 C for 30 minutes is truly beneficial to the cell or if the some of the tests performed were outliers.

**Summary Statement**
This project tested an affordable, efficient method of using intense heat to increase the electricity output (voltage and current) of older solar panels.

**Help Received**
My mentor, Ryan Need, who is a doctoral graduate student at UCSB, granted me access to his shared lab which provided me with equipment critical to accomplishing this project (furnaces, microscope, and safety equipment).

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**

R Rik Bose

**Project Number**

**J0203**

**Project Title**

## Power Beneath Your Feet: Energy from Piezoelectric Elements

**Abstract**

**Objectives/Goals**

The purpose of my Science Fair Project is to design and build an energy harvesting system that will provide a source of energy. This project involves the use of piezoelectric transducers for harvesting energy that is produced from stepping on a tile. When the tile is engineered with piezoelectric technology, the charge produced by the kinetic force is captured and converted into an electrical charge by piezo materials and electronic components, which can then be stored and used as a power source.

**Methods/Materials**

A piezoelectric transducer was connected to a breadboard with diodes in a bridge rectifier formation. A capacitor was connected to the board to store the DC voltage. A LED was used as a load to check if the energy that was being stored in the capacitor could be used. Multiple variables were used to test the hypothesis.

**Results**

When a mechanical stress is applied to a piezoelectric element by adding pressure or by bending, it generates voltage. There is a direct relationship between the mechanical stress and voltage output. The output of the piezoelectric element can be increased by connecting them in series.

The capacitance (ability to store an electrical charge) of the capacitor is also a factor for storing the charge. The increase in load requirement (adding more LED bulbs) drained the capacitors much faster.

**Conclusions/Discussion**

Based on my experiments, and results, my hypothesis was proved correct. In my experimental circuit, deformation of piezoelectric element creates alternating current, which is then converted into direct current by using a bridge rectifier and can be stored for future use. I calculated the energy in joules, which would be generated by each tap/step on a piezoelectric element. I also researched the energy requirement in joules to light a LED bulb and captured sufficient voltage in the capacitors to provide DC voltage to the light bulb.

**Summary Statement**

My experiment showed, with the circuit I constructed, that kinetic force can be converted into an electrical charge by piezo materials, which can then be stored and used as a power source.

**Help Received**

My father helped me with design of the circuit and soldering. My mother helped me with the printouts and display of the science board.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Jake D. Bringetto

**Project Number**
**J0204**

**Project Title**
## Solar Energy: Increasing Power with Helio-Trackers and Fresnel Lenses

**Abstract**

**Objectives/Goals**
My goal was to determine whether or not you can increase the power generated by a solar panel by using concentrated lenses and tracking the sun with a helio-tracker (Sun-tracker).

**Methods/Materials**
The main things used in the experiment were solar panels, a Fresnel lens, lights and motors. I used Lego Mindstorms motors to move the lights in an arc to simulate the sun. I then used a multimeter to measure the voltage of the panel with the Fresnel lens, the helio-tracker, and the standard mounted panel at different points during the day. The panels were then wired to small DC motors that powered a custom gearbox, that pulled three small cars up a ramp. The distance that the cars traveled was proportional to the amount of power generated by the solar panel.

**Results**
The results from my tests showed that over the course of a day, the helio-tracker is around 20 percent more efficient than both the ordinary panel, and the panel with the Fresnel lens. The result reveals that you can increase the power of a solar panel when it tracks the sun.

**Conclusions/Discussion**
The results support my hypothesis because I predicted that the helio tracker would generate more power, and it ended up doing so. This expands the category of renewable energy engineering because is helpful to building more efficient solar panels and better ways to capture energy. This is very important because the more renewable energy we have the less reliant on fossil fuels we are. Plus, in the long run you end up saving money because you have 20 percent more energy than if you had a regular panel.

**Summary Statement**
My project was about determining if you can increase the power generated by a solar panel using helio-trackers and Fresnel lenses.

**Help Received**
I designed, built, and conducted the experiments myself with the exception of the skillsaw work conducted by my dad in building the project platform.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**

Remy S. Campbell

**Project Number**

**J0205**

**Project Title**

## Sawmill Waste Biomass Powering the Future

**Abstract**

**Objectives/Goals**

The goal of my project was to determine what wood-based waste material produces the most British Thermal Units (BTUs).

**Methods/Materials**

Douglas fir, coast redwood, and a mixture of both of these wood byproducts from a sawmill were used for my experiment. A Moisture Balancer was used to determine the BTUs based on the moisture content and densities of the woods.

**Results**

The mixture of Douglas fir and redwood material produced the most BTUs, while the redwood material produced the least amount of BTUs, informing me that the mixed material is the most effective source of energy out of the three.

**Conclusions/Discussion**

My conclusion is that the mixed product produced the most BTU#s because the Douglas fir burns up really fast releasing a lot of BTU#s while the redwood burns up slower but producing less BTU#s. Together the mixture produces an increased amount of BTUs over a longer period of time.

**Summary Statement**

I showed that a mixture of wood waste materials produces more BTUs over a longer period of time

**Help Received**

I learned how to use the Moisture Balancer machine and the industry standards from the manager of the power plant

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Nicholas A. Drain

**Project Number**
**J0206**

**Project Title**
## Artificial Turf Pool Heating

**Abstract**

**Objectives/Goals**
There are over 4,544,000 pools in the United States of America, most of which are heated using natural gas. Solar pool heating saves gas and energy every year. One problem with solar pool heating is not having enough roof space. In this project I set out to find out if water pumped under artificial turf would heat a tank of water as well as traditional solar heating.

**Methods/Materials**
I set up a system with three separate model pools and used irrigation tubing and a pond pump to make a solar heating system. One model pool was heated with traditional style solar heating. One model pool was heated with a solar heating system that ran under artificial turf. The final model pool was heated by ambient air alone.

**Results**
I found that the traditional solar heating model increased the final water temperature an average of 17.41 degrees Fahrenheit. The pool model with heating that went under the artificial turf increased the final water temperature an average of 13.5 degrees Fahrenheit.

**Conclusions/Discussion**
My data suggests that artificial turf may be an effective alternative to traditional solar pool heating when sufficient roof space is not available.

**Summary Statement**
I developed a solar swimming pool heating system that can effectively heat a pool by pumping water under artificial turf instead of onto the roof.

**Help Received**
My mom and dad helped me build my solar heating systems and proofread my papers. My science teacher proofread my papers.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Victoria E. Eichhorn

**Project Number**
**J0207**

**Project Title**
## Waste to Power

**Abstract**

**Objectives/Goals**
The purpose of my project was to determine what type of waste would generate the most energy. I used beef, apples, and dried grass clippings as my fuel source. I believed that the beef would generate the most energy.

**Methods/Materials**
I used a Microbial fuel cell(I made it), 1/2 pounds of beef, 1 medium apple, 3oz. of dry grass, multimeter, 18 kg of salt, 18 packages of 25g Telephone agar, about 24 L. of water, and 18 electrodes. Each material (meat, apples, grass) was replaced twice, for a total of 9 different experiments. Each experiment required 8 days of readings three times a day.

**Results**
The amount of energy generated was quite surprising. The dried grass actually generated significantly more energy than the beef or apples. It also remained high for longer period of time. 3oz of grass clippings generated 450 milli-watts for over a week. Whereas the apples and beef started around 100 milli-watts and dropped.

**Conclusions/Discussion**
The 3 tests of each type of waste showed that the dried grass was already decomposing. It could generate the most amount of energy. I believe I got the astonishing results because the dried grass is a home to electrogenic bacteria. The electrogenic bacteria is like tiny nano wires that are highly conductive. They decompose the waste while conducting power into the electrode.

**Summary Statement**
The results indicted that my hypothesis is to be rejected. The results show that the dried grass clippings was the type of waste that generated the most enegy.

**Help Received**
I designed the project myself after reading various articles online, the main one from Penn State .

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**

Ryan S. Hogue

**Project Number**

**J0208**

**Project Title**

## How the Concentration of Platinum in a Fuel Cell Membrane Electrode Assembly Affects Its Performance

**Abstract**

**Objectives/Goals**

The objective of this project is to determine how different concentrations of platinum in a fuel cell Membrane Electrode Assembly affect its power output.

**Methods/Materials**

This project used a hydrogen/air fuel cell, a meter able to measure amperage and voltage at different loads, and an electrolysis cell. Home-built fuel cell was constructed using soft graphite plates, single-sided copper circuit board, and a silicone gasket. Membrane Electrode Assemblies were acquired from commercially available source.

**Results**

Several Membrane Electrode Assemblies were tested in reference fuel cell. Multiple test trials were run to confirm consistency in results. Higher concentrations of platinum in the MEA resulted in higher power output.

**Conclusions/Discussion**

Testing showed that higher concentrations of platinum in the MEA of a fuel cell resulted in higher power output. This is important because it is beneficial to balance the power output and cost when designing a fuel cell.

**Summary Statement**

I was able to determine that higher concentrations of platinum in the MEA of a fuel cell result in a higher power output.

**Help Received**

I had help from my father in acquiring the materials needed to build the fuel cell. I also was helped by Daniel, from Fuel Cells Etc, who provided information on the platinum loadings of the fuel cells I used.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Kenny Hua

**Project Number**
**J0209**

**Project Title**
## Waste Heat Recovery

**Abstract**

**Objectives/Goals**
The objective of this study is to find a way to capture heat energy produced from electrical appliances and recycle it into usable electrical energy.

**Methods/Materials**
40 watts light bulb, electrical wires, 40mm x 40 mm thermoelectric cooler (TEC) module, 40mm x 40 mm heat sink, and a digital multimeter. I constructed the apparatus and used it to collect and convert thermal energy into electrical energy. The experiment was conducted with the TEC placed at three different distances from the heat source (light bulb) and 10 trials were done at each distance. The multimeter was used to measure the amperage and voltage that were produced by the waste heat recovery apparatus.

**Results**
After placing the TEC at three different distances from the light bulb in an attempt to recycle the heat energy, I found that placing the TEC at 0cm away from the heat source produced the greatest result. When the TEC was 4cm away from the light bulb, only 0.0009 watts were produced. 0.0018 watts were produced when the TEC was placed 2cm away from the light bulb and 0.0054 watts at the distance of 0cm. This indicates that it is possible to recycle heat energy into a usable electrical energy.

**Conclusions/Discussion**
As a result of the experiment, I have managed to ascertain that it is possible to recycle heat energy and convert it into electrical energy that can be used for other purposes. This means that any equipment that is capable of producing heat can serve as a potential source of energy through this particular method of waste heat recovery.

**Summary Statement**
I devised and constructed a system to recycle heat energy and converted it to electrical energy.

**Help Received**
I designed and constructed the apparatus, and performed the experiment by myself.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**

Masha Korolik

**Project Number**

**J0210**

**Project Title**

## Solar Energy Concentrator Integrated into Windows: Smart Solar Energy Conversion

**Abstract**

**Objectives/Goals**

Converting solar energy into electricity has become very common. Modern buildings have many windows, which receive a lot of sun light. Is it possible to engineer an energy converter within windows? Is it possible to use large window areas to concentrate solar energy and direct it towards the solar cells embedded in the window sides? Our objective is to make a solar energy concentrator by coating the glass with a luminescent compound that can absorb and emit photons. We can use layers of glass to restrict the spatial region in which the light can propagate through. Energy concentration efficiency for luminescent solar concentrators is predicted to depend on the nature of luminescent compound, mainly the absorption and emission spectra of the luminescent compound, as well as its concentration and amount.

**Methods/Materials**

In our engineered window, the top and bottom layers were glass and the middle layer was a polymeric layer with a luminescent compound. A piece of glass was coated with the mixture of polymer and luminescent compound. Another piece of glass was placed onto the luminescent coating and solar cell was attached to the side of the glass structure. A lamp was used to illuminate the sample. The light irradiated by the luminescent compound generated the current in the photovoltaic cells. We measured this current using a voltmeter. We studied the effect of the nature of luminescent compound, concentration, total amount, and the nature of the polymers on the electric current generated.

**Results**

We were able to concentrate the light re-emitted within glass layers and guide it towards the sides of the glass. Samples with fluorescent pigment generated higher voltages compared to glass samples with no pigment. This increase in voltage became larger with the increase in sample thickness and concentration of the pigment. Blue Pigment was most effective in generating the electrical current. Purple Pigment was least effective in generating additional voltage signal.

**Conclusions/Discussion**

It was possible to integrate glass window with a solar panel. Electrical current generated in sample increases with increase in luminescent layer thickness and with increase in pigment concentration. Stronger visual luminescence of the pigment corresponded to higher voltage boost.

**Summary Statement**

It is possible to create a power-generating window by using a luminescent layer to capture and redirect solar energy towards solar panels located at the edge on the window.

**Help Received**

I designed and built the solar energy concentrator by myself. I got help in understanding the physics of waveguides from Dr. K. Mikhaylich in the Applied Materials, Corp.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Cristofer Lortz

**Project Number**
**J0211**

**Project Title**
## Oceanic Power: Oscillating Water Column Generator

**Abstract**

**Objectives/Goals**
My hypothesis was that we can use the ocean's powerful tidal and wave action to produce renewable electricity to power homes, businesses and cars.

**Methods/Materials**
I began my research at the library and online for background information. I got my initial design idea from Science Buddies (website). I choose to build an Oscillating Water Column (OWC) Generator to prove my hypothesis. My dad helped me with the design, modifications and construction. Most of the materials were from our garage and back yard.

The methodology for the experiment was to plunge the OWC generator down into the pool water (Independent Variable), which will force water to flow into the inlet hole at the bottom of the generator. The incoming water will begin to fill the volume/area inside of the pipe (Control/Constant Variable), displacing the ambient air inside the pipe (Dependent Variable). The exhaust air will spin the fan and generator producing electricity to light 4 LEDs and measured with a multimeter.

**Results**
I had great results in both testing phases of this experiment.

Design Test Phase: I was able to modify the original Science Buddies design and make it much more efficient. This test phase also allowed my testing team to develop a rythmic plunging method for final test phase consistency.

Final Test Phase: I was able to produce increasing (progressively) voltages and amperages during the 4', 5', and 6' plunges. The OWC Generator what was tested as the 10.5' model. All LEDs were illuminated and the electricity was measured with a multimeter.

**Conclusions/Discussion**
I concluded that my hyptohtesis was valid. We moved the OWC generator in an up/down oscillating motion in the pool, the water displaced the air from inside the tube, forced it out through the exhaust holes, spun the fan/motor. The electricity produced lit the LEDs and was read on a digital multimeter. Each of the three experiments were successful in making electricity.

**Summary Statement**
The power and motion of the ocean can be harnessed to produce renewable and clean energy.

**Help Received**
The people who helped me were my Fleming STEM teacher: Oscar Espinoza, my dad: John Lortz and my family.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**

Gunner H. McCormick

**Project Number**

**J0212**

**Project Title**

## Stomp: Building an Energy Floor in Search for More Renewable Energy Sources

**Abstract**

**Objectives/Goals**

The objective of this project was to build a working prototype of an energy floor. An energy floor is a type of pressure plate that generates energy when stepped on.

**Methods/Materials**

Wood, plexiglass, springs, gears from crank flashlights, wires, multimeter, and levers. Build energy floor, test 10 trials of amps and volt. Multiply them to get watts.

**Results**

I successfully built three working models of an energy floor. The amount of energy from them went up successively. My first model generated .011 watts, my second model generated .128 watts, my third model generated .214 watts.

**Conclusions/Discussion**

My prototypes generated enough energy to power a lightbulb. If I used resistors, and filtered the energy into a battery, I could power something larger. Energy floors would be useful to be put in high foot traffic areas.

**Summary Statement**

I built a working Energy Floor that generated electricity from footsteps.

**Help Received**

My science teacher LeighAnn helped to keep me on a timeline throughout the project. My father helped me put the floor together from my blueprints. My mother edited my writing, and helped me make my board. MS Builders helped to cut the wood and plexiglass.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**

Jeremy M. Ngo

**Project Number**

**J0213**

**Project Title**

## Efficient Solar Panel Cooling for Power

**Abstract**

**Objectives/Goals**

Solar panels can diminish and produce less power when exposed to high temperatures. The objective of this experiment was to develop an efficient method of cooling down solar panels to increase their lifetime, as well as power production/efficiency.

**Methods/Materials**

The experiment used three sets of solar panels, each containing three panels. The first set was a control with no modifications to cool it down. The second set was experimental and used a pump with running water to cool the panel down. The third set was also, experimental, but it used a passive aluminum heat sink to cool down the panel. The solar panels were tested for voltage and current at specific temperatures. The formula V x C / SI was used to calculate efficiency, where V represented voltage, C represented current, and SI represented the sun#s intensity at specific temperatures.

**Results**

After the experimentation was complete, it was noted that the water cooled panel produced the most voltage, and the heat sink panel produced the most current. However, their voltages and currents were equally balanced, so their efficiencies were the same. Unlike the two experimental groups, the control panels had very low voltages and efficiencies. The water cooled panel ended up with the lowest temperature, the heat sink cooled panel ended up with an average temperature, and the control panel ended up the highest temperatures.

**Conclusions/Discussion**

After determining trends in the data, it was concluded that low temperatures produce the most voltage, but not exactly higher efficiencies. Even though the two experimental groups had the same efficiencies, the panel cooled by water produced the most power. This is most likely because the controlled, weather-free environment eventually prevented the heat sink cooled panels to function properly, as there was no wind. Therefore, the most reliable, effective method of boosting solar panel efficiencies is to cool them with running water.

**Summary Statement**

Solar panels degrade and produce less power when exposed to high temperatures, and this project tests an efficient way to boost their power production by cooling them down.

**Help Received**

My dad helped me design my solar panels, and my science teacher helped me research my project before experimentation.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Sahil D. Patel

**Project Number**
**J0214**

**Project Title**
## Developing a Piezoelectric Roof

**Abstract**

**Objectives/Goals**
This project investigated a renewable source of energy that could be used on a roof to make homes more energy efficient and sustainable. The goal for the piezoelectric model is to successfully generate any amount of electricity from the impact of rain and wind.

**Methods/Materials**
I built a model with piezoelectric sensors to generate electricity from the impact of rain and wind on the roof. The building of the model consists of two main parts: the roof structure to mimic a house and the testing surface, made to create electricity from applied force. To make the testing surface, I used two piezoelectric sensors made of Polyvinylidene fluoride and imbedded them within a sheet of vinyl. Next, I made the roof structure using polycarbonate sheets. I then attached the two, using spacers and foam, creating my piezoelectric roof. I used a multimeter to record the highest volts, amps, and watts produced within a minute when force was applied. I tested the piezoelectric model against three different strengths of rain, using a hose nozzle and wind, using a fan and a hair dryer, five times each.

**Results**
The wind tests averaged 0.0124 microwatts on the low setting. The medium setting measured 0.0599 microwatts, and the high setting yielded 0.1686 microwatts. The rain tests averaged 0.0682 microwatts on the low setting. The medium setting created 11.6397 microwatts, and the high setting obtained 87.9923 microwatts. Throughout the tests, the piezoelectric model successfully created electricity from the impact of rain and wind, which met the original requirements for the model. This shows that the technology is possible to use for a roof application.

**Conclusions/Discussion**
Throughout the tests, the data showed that the impact of rain generated more electricity than the impact of wind. This was expected, because rain has a larger mass than wind. I found that the reason for the low amperage was because of an error I made in the circuitry design, by not adding a resistor. With more time, I could create a new iteration in which I add a resistor to the circuit to correct the issue of extremely low amperage. The piezoelectric model demonstrates it is possible to make energy from the simplest, most common resources, like rain and wind. In the future, we could incorporate this technology into solar panels, floors, roads, and buildings. Energy, in the form of kinetic waves, could be converted into harvestable electricity.

**Summary Statement**
This project developed a piezoelectric roof that generated electricity from the impact of rain and wind.

**Help Received**
My father cut the polycarbonate sheets and helped test the piezoelectric model. My mother also helped test, and bought the materials for my model. Mrs. Work provided general oversight and helped me fill out this application.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Arya Rajesh

**Project Number**
**J0215**

**Project Title**
## The Effect of the Layout of Piezoelectric Crystals on the Amount of Electrical Energy Generated

**Abstract**

**Objectives/Goals**
One of the ways to use less fossil fuels is by energy harvesting. Piezoelectric crystals can be used to transform the pressure applied on them into electrical energy, which can then be stored and used to power electronic devices. It is a clean way of power generation which helps to reduce global warming. Piezoelectric crystals are expensive which adds to the overall cost of the project. My experiment is to find an optimal layout where you use fewer crystals to generate the same amount of electrical energy, thereby reducing the cost of any piezoelectric project. My hypothesis is that the piezoelectric crystals when placed in an "S" layout will generate the most electrical energy, when compared to the "V" or "Clustered in the center" layouts.

**Methods/Materials**
I used cream of tartar, soda ash, and distilled water to make rochelle salt which is a piezoelectric crystal. Other piezoelectric crystals are Topaz and Quartz crystals. I cut up three styrofoam platforms and made small dips in each to hold the piezoelectric crystals. I used eight crystals to assemble each of the three layouts. Using a soldering iron, electrical wires, and aluminum foil, I connected the crystals in series. I attached the probes of a multi meter to the first and last crystals in each layout. I applied pressure by placing heavy books onto the platform and measured the generated electrical energy using a multi meter.

**Results**
Among the three layouts, the "S" layout generated the most electrical energy (average of 148.8 milli Volts). The "V" and the "Clustered" layouts generated electrical energy with an average of 135.2 milli Volts and 133.4 milli Volts respectively. Hence my hypothesis was supported.

**Conclusions/Discussion**
The results from my experiment can be used in real-world applications such as placing piezoelectric crystals in the sole of running shoes to charge electronic devices. I have come up with a model of a shoe sole which can be used to store the generated power in a battery pack. The battery pack can then be used to charge electronic devices such as smartphones and tablets. In my model design the crystals are placed in the heel and front part of the shoes where more pressure is felt due to the runner's weight, and the middle part holds the bridge rectifiers and the two battery packs. The battery packs will be removable, and the entire setup must be designed such that it can be transferred easily from one shoe to another.

**Summary Statement**
My experiment results can be applied to a real-world application such as in running shoes to generate power to charge smartphones, and this helps to reduce global warming.

**Help Received**
Mrs Pronati Mondal, Science Teacher, Challenger School - Almaden Campus.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Rohit Ravi

**Project Number**
**J0216**

**Project Title**
## Solar Tracker: An Optimal Method to Generate the Highest Energy

**Abstract**

**Objectives/Goals**
The objective of this experiment is to determine which angle of incidence and which reflective material would generate the highest energy output from the solar panel. The second objective is to design and a build a dual axis solar tracker to move the solar panel for both earth's tilt and spin.

**Methods/Materials**
A multimeter was used to measure the energy output of the solar panel in all the tests. As a first test, the experiment was conducted with a solar panel at different angles from the vertical. Next, the energy was measured with different reflective materials placed in front of the solar panel. The third test was done with a solar panel facing the sun at 11 a.m. and with the direction of what it would have been at 2 p.m. and vice versa. Due to the different positions of the sun relative to the earth throughout the day and year, a dual axis solar tracker was built. This solar tracker was coded through the Arduino platform and moves through the servo when one Light Dependent Resistor detects more light than the other.

**Results**
Based on my experiment, I observed the following results:
1) At 30 degrees, the highest energy (averaged 1.91 watts) was absorbed and reduced gradually at other angles.
2) The highest energy was noted when the solar panel was perpendicular to the sun's rays at 11 a.m. and 2 p.m.
3) The dual axis solar tracker successfully changed the solar panel's direction for both earth's tilt and spin.

4) The aluminized Mylar reflector (averaged 2.34 watts) reflected the highest amount of light energy.

**Conclusions/Discussion**
The observations supported all the hypothesis. Thirty degrees in Northern California during January was the angle perpendicular to the sun's rays allowing it to absorb the most direct energy. At 11 a.m. and 2 p.m., the solar panel produced the highest energy when it faced the sun directly. A dual axis prototype solar tracker built helped the panel to stay perpendicular to the sun's rays at all times. The aluminized Mylar reflector reflecting up to 99% of light caused the high energy generation. Compared to other energy sources, solar energy is a free, clean energy available abundant throughout the globe.

**Summary Statement**
I designed and built a solar tracker which is capable of moving a solar panel to stay perpendicular to the sun's rays at all times. In addition, I found the aluminized Mylar reflector reflected the most sunlight.

**Help Received**
My dad, Ravi Ammamuthu, helped me by drilling holes in the plywood board, soldering the jumper wires to the solar panel, and buying the components for the solar tracker.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**

**Anna T. Rioux**

**Project Number**

**J0217**

**Project Title**

## Engineering Clean Energy: Measuring Energy Production of a Microbial Fuel Cell Using Waste Materials

**Abstract**

**Objectives/Goals**

The purpose of this experiment is to build mediator-less Microbial Fuel Cell (M.F.C.) and test fuel sources to determine which has the best potential for use in large scale application such as a dairy, food industry or wastewater treatment facility. Animal waste (manure), green waste, and distilled water as a control were tested as fuel sources in a 3,785 g capacity fuel cell. I hypothesized animal waste would produce the greatest amount of energy, for the longest period of time.

**Methods/Materials**

Three mediator-less M.F.C were built including an anode, cathode, salt bridge, and electrode. This phase required several redesigns, and took several weeks until a successful salt bridge was achieved. Plastic storage containers (3.785L) were used as the chambers. Carbon cloth and copper wire were used as the electrodes. A solution of water and agar, cording and a compression fitting were used as the salt bridge. An aquatic air pump was used to aerate the cathode. Manure was collected from a local dairy. Green waste was collected from a local food processing plant. Then, twice daily voltage readings were taken from each of the three fuel cells. Each trial consisted of 10 days.

**Results**

The results indicated that manure produced a stable electrical output. Electrical output was noted after the first day, and continued for the duration of the trials; concluding voltage output reached 243 mV, 488 mV, and 525 mV respectively for each trial. Green waste produced a varied electrical output and was not a stable source of energy production. The output varied dependent on the composition of the waste. In only one trial green waste produce a stable electrical output ranging from 13.8 mV to 498mV. Distilled water did not produce a stable electrical output for the duration of the trials.

**Conclusions/Discussion**

My hypothesis was proven partial correct. Manure produced the greatest amount of electricity for the longest period of time. While green waste produced an electrical output, it was inconsistent and unstable. To further this experiment, a modification of the electrode size was tested to see if a larger electrode would increase electrical output. The larger electrode was inconclusive when tested with the three fuel sources. Further testing is necessary. This fuel cell holds 3,785 g, transferring this design to a 2 ton tank capacity, using a larger electrode and manure as the fuel source could help to fuel a dairy

**Summary Statement**

Three mediator-less microbial fuel cells were built to harvest electricity produced from animal waste(manure), green waste(household/industry waste from food production plant), and distilled water to determine the best fuel source.

**Help Received**

My dad helped me using the drill, my mother/teacher helped to edit my written report and gave guidance for research information. Robert Sisneroz, Water treatment Supt. gave me a tour of The City of Hanford#s waste-water treatment facility, answered questions about the water treatment process. Jared Fragoso

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Diptanshu Sikdar

**Project Number**
**J0218**

**Project Title**
## Effect of Shapes of Solar Panels on the Generation of Electricity

**Abstract**

**Objectives/Goals**
One way to use the abundant energy from Sun is to convert it into electricity using solar panels. Improving the efficiency of solar panels, currently under 20%, means more energy for us with minimal environmental impact. The efficiency depends on the angle of incidence of sunlight. However, the angle of incidence varies during a day and during seasons. So, in a system without tracking or tilt adjustments, the shapes may affect its power output. My experiment explores the effect of different shapes of solar panels on the generation of electricity. Based on my research, I form the hypothesis that a dome shaped panel would produce more electricity overall.

**Methods/Materials**
I used the same number of flexible solar modules to form cuboid, dome, cylinder, and flat shaped panels to keep the same solar cell area. In each panel, ten solar modules were connected in parallel. Next, I planned five different positions of the light source corresponding to different times during a day from morning to evening modeling the path of sun during summer. Placing a 75W light bulb in each of these five positions, I measured voltage and current of all four solar panels using a digital multimeter. Next, measurements were done for five different positions modeling the path of sun during equinox and winter. The experiment was repeated for a total of three trials.

**Results**
When I calculated the power multiplying the voltage and the current, the cuboid shaped panel produced the least amount of power. The peak power were similar between the flat and dome shaped panels. To find the overall effect of the shapes, I calculated the total power for five different positions (in a day) of the light source. For all three trials, the overall power of the dome shaped panel was better than the next best shape (cylinder) by about 16% during summer, 5% during equinox, and 29% during winter.

**Conclusions/Discussion**
The results show that for a given position of the light source, the power output varied depending on the shapes of solar panels. Based on the overall power across different positions, the dome shaped panel produced the maximum power. Hence my hypothesis is supported. In real world application, solar modules covering a helmet or a car could be optimized in shape for generating more electricity to charge up electronic devices.

**Summary Statement**
This project explores the effect of different shapes of solar panels on the generation of electricity.

**Help Received**
My science teacher suggested OEM solar modules, and my parents helped me to purchase them along with other materials.

# CALIFORNIA STATE SCIENCE FAIR
## 2016 PROJECT SUMMARY

**Name(s)**
Toby J. Still

**Project Number**
**J0219**

**Project Title**
## How Does Temperature Affect Solar Cells?

**Abstract**

**Objectives/Goals**
To determine if solar cells generate more power at colder or hotter temperatures.

**Methods/Materials**
Set up a light source a fixed distance away from the solar cell and test voltage (volts), current (amps), surface temperature (degrees Celsius), and lux (lumens per square meter), at different places with varying temperatures. Take measurements three times at each location.
These places include: Walk-in refrigerator and freezer, a cold garage at night, a cool laundry room, a regular bedroom, a hot bedroom, and a hot sauna at the YMCA.

**Results**
The hotter the location the more power the solar cell generated. The voltage dropped at greater temperatures, but the current increased, with a net result of greater power. We also measured lux input part way through the testing, and discovered that the light source (power in) fluctuated slightly during our tests.

**Conclusions/Discussion**
Testing demonstrated that a solar cell does generate more power at higher temperatures, proving my hypothesis correct.

**Summary Statement**
Understanding how temperature affects the power output produced by a solar panel, by measuring the voltage and amperage produced in rooms of varying temperatures.

**Help Received**
Ross Cathie (salesman for PlanetSolar), provided initial guidance and advice as well as a small solar cell panel with wire leads. The light was borrowed from Greencoast Hydroponics. My father helped me build the PVC light holder and solar assembly, and create the Excel data graph.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**

Surya C. Tallavarjula

**Project Number**

**J0220**

**Project Title**

## To Characterize the Energy Loss for Different Types of Light Bulbs, and Ways to Recover & Reuse Some of the Energy Loss

**Abstract**

**Objectives/Goals**

The light emitted by lamps in the backward direction is not useful. The purpose of my project is to make an efficient device to collect the wasted light by studying optimal location of a solar cell for three different types of lamps (Incandescent, Fluorescent and LED). When applied in industrial or residential lighting this method can create energy that will help to conserve our planet#s resources in a small way. Also in space exploration when there is no sun light this method can be useful.

**Methods/Materials**

Solar cell current and voltage were measured (with a multimeter) by increasing the distance between the lamp and the cell (from 1-15 cm). Solar cell angular orientation was changed from 0°-170° and was compared amongst the three lamp types. Two solar cells were mounted on the lamp shade and are connected in series to show that the voltages can be added. The solar cell current/voltage dependence on the distance from the lamp helps to understand how much the cell output can be increased. From the angular distribution, the amount of light emitted in the backward direction was estimated.

**Results**

As distance increased cell current decreased as predicted by $1/r^2$ relationship. Incandescent lamp showed constant angular distribution (till 150°), while CFL and LED lamps showed their peeks at 50° and 100° respectively. Fraction of backward emission is 40% for CFL while it is 46% for Incandescent and LED. LED lamp was the brightest but incandescent lamp showed 5 times higher current. Two mounted Solar cells when connected in series showed that voltages were added.

**Conclusions/Discussion**

More than 40% of light is wasted for all three lamps. Incandescent lamp spectrum goes beyond the visible wavelength range (400-750nm). Silicon solar cell absorbs up to 1200nm. My method recovers from unused angular distribution and unused energy beyond visible range. For incandescent lamp, open circuit voltage of 3.65 V and closed circuit current of 9.68 mA were measured for a single cell. Two solar cells in series can generate 7.3V. Six pairs in parallel circuit can produce 58 mA. Twenty incandescent lamps connected in parallel can increase current to 1.16 A, enough to charge an iPhone in 50 hours. Incandescent lamps can generate 5 times more energy compared to LED or CFL. Output can be further increased by 35% by bringing the cells 1 cm closer to the lamp.

**Summary Statement**

My project shows that it is possible to recover a small amount of wasted energy by using solar cells in the back of a lamp shade.

**Help Received**

I made the angular measuring device and measured the cell current, voltage and distance dependence myself. I mounted the solar cells on the lamp shade. My dad helped me to analyze crystalline silicon solar cell response to spectra from the three types of lamps.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**

Kaushik Sai Tota

**Project Number**

**J0221**

**Project Title**

## Developing Magnesium Air Fuel Cells

**Abstract**

**Objectives/Goals**

My project is an alternative source of electricity that can help slow down global warming. My objective was to build a fuel cell that could generate useful electricity with clean energy sources. My fuel cell uses magnesium, salt water, and oxygen from the atmosphere to generate electricity.

**Methods/Materials**

I created a design for my fuel cell which is a 3-inch cube made of 9 sub-cells. The sub-cells are all connected in one frame. I 3-D printed this frame. Each of these subcells contain a strip of magnesium, saltwater, and carbon fabric. The carbon fabric lets oxygen into the cell, and covers the border of each sub-cell. The cotton holds saltwater, which is the electrolyte in the fuel cell. In the center of each sub-cell is a strip of magnesium. This magnesium is oxidised as the reaction occurs, and it fuels the reaction. The sub-cells are wired so that there are 3 parallel rows of three cells in series. These sub-cells are all connected to a PowerBoost, which has a USB port. This allows a phone to be charged with the fuel cell. As soon as saltwater is poured in all of the cells, electricity starts running through the cell, and the fuel cell is able to light an LED and charge a phone.

**Results**

My fuel cell, at full capacity, generated 3.47 volts and .74 amperes. I successfully generated enough voltage and current using the fuel cell to charge a smartphone and light an LED at the same time.

**Conclusions/Discussion**

I was able to accomplish my goal of building a fuel cell that uses clean energy sources to generate electricity. My fuel cell had a portable design, and could charge a smartphone and light an LED.

**Summary Statement**

I built a fuel cell that generates electricity using salt water, magnesium, and oxygen from the atmosphere.

**Help Received**

I created the design for my fuel cell, and put together the fuel cell. My mentor, Dr. Ismail from Schmahl Science Workshops, helped me gather materials.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Adam Yang

**Project Number**
**J0222**

**Project Title**
## Pee for Power: An Exp. to Find the Opt. Concentration of Urine to be Introduced to a MFC to Produce the Highest Voltage

**Abstract**

**Objectives/Goals**
The goal of this experiment is to find the best concentration of urine that will produce the most power when it is introduced to a microbial fuel cell (MFC). It is expected that the MFCs will produce the most power when the urine is added in a moderate concentration. This is expected because urine contains nutritional content and dangerous chemicals that can support or destroy microbial life. If the experiment is successful, then it is possible to introduce waste water into efficient microbial fuel cells to create power.

**Methods/Materials**
Three Mudwatt MFCs will be setup. The bacteria in the MFCs will be allowed to develop into healthy colonies for anywhere from two weeks to a month. After those two weeks, urine will be introduced to two of the MFCs: one with the urine half diluted, and another one that isn#t diluted. The last MFC will act as the control and won#t have any urine. Once the urine has been introduced, the power of the MFCs will be recorded for at least one to two weeks for two trials.

**Results**
The MFC with the moderate concentration of urine produced significantly more power than the other MFCs in both trials of experimentation. The moderate concentration of urine boosted the power of the MFCs much more than the other concentrations of urine.

**Conclusions/Discussion**
Urine can help a MFC produce more power, but the urine has to be introduced in a moderate concentration to a MFC to avoid killing any bacteria. With further developments and research, this method can be applied to sewage treatment plants to produce power.

**Summary Statement**
It was discovered that a moderate concentration of urine causes a microbial fuel cell to produce the highest voltage compared to other concentrations.

**Help Received**
I assembled the microbial fuel cells by myself, along with the project board, but my science teacher helped me streamline my project and introduced me to the scientific method. I consulted many different online sources and databases for the research of this project.

# CALIFORNIA STATE SCIENCE FAIR
# 2016 PROJECT SUMMARY

**Name(s)**
Franchesca E. Yonan

**Project Number**
**J0223**

**Project Title**
## Power It Up! A Study of Solar Power vs. Angle and Time

**Abstract**

**Objectives/Goals**
Given that Bakersfield California is located at a latitude of 35.37 degrees, I believe a Solar Panel will have optimal electrical output during the hours of 12:00pm through 4:00pm when it is set outdoors in the sunlight at approximately a 50 degree angle in the Winter months and approximately a 20 degree angle in the Summer months. This is calculated by adding 15 degrees to your current locations latitude for Winter months (35 + 15 = 50 Degrees) , because the Sun is lower in the sky during Winter months and by subtracting 15 degrees from your current locations latitude for the Summer months (35 - 15 = 20 Degrees) , because the sun is higher in the sky during Summer months.

**Methods/Materials**
I conducted this experiment from October 16, 2015 through November 14, 2015 from 8:00am to 5:00pm . The Solar Panel was located in the same fixed location for all 30 days during the entire time of the experiment. The Solar panel was attached to a stand with an affixed protractor. The Solar Panel stand and Protractor were constructed specifically for this experiment. The variables that changed during this experiment was the angle of the Solar Panel and the time of the day. The electrical output was tested with a voltmeter. The Solar Panel angle was tested at angles from 0 (zero) to 90 (ninety) degrees in 5 (five) degree increments.

**Results**
From the analyzed data it has been shown that my experimental results support my hypothesis. The experimental data has shown that when the solar panel was set at a 50 degree angle between 12:00pm through 2:00pm during Winter months, the solar panel consistently generated the highest amounts of electricity.

**Conclusions/Discussion**
From this experiment I conclude that given a certain fixed location and latitude, the angle of a solar panel and the time of the day has a direct effect on the optimal amount of electricity produced by the solar panel. This experiment has shown that the optimal amount of electricity can be produced by adjusting the angle of a Solar Panel to your locations latitude plus or minus 15 degrees for Winter and Summer months.

**Summary Statement**
This experiment was conducted to determine at which angle and time of day would a fixed Solar panel located at a specific latitude need to be set at in order to produce the optimal amount of electricity during a given time of the year

**Help Received**
I received help from my Father (Mr. Sharil Yonan) who assisted me with purchasing the needed items for this experiment. My Father also assisted me in building the solar panel stand that was used to adjust and test the various angles. My Father also assisted at some times to help record the data.