Before starting using the Renewable Energy kit for experiments, students got an introduction to energy and the world demand for it. They learned about the effects of currently available energy sources such as crude oil and natural gas. Waste products from these fuels heat the earth's atmosphere and pollute the earth's air, water and ground. Students learned that fossil fuels have accelerated the Greenhouse effect and the effects of global warming on the ecosystem. Students were made aware that current energy technologies from fossil fuels are foreseen to be in short supply in the near future as the world population grows rapidly.

The class was then introduced to the energy technologies that can be used to replace fossil fuels. These include solar, wind, hydroelectric power, bioenergy as well as many others. Each of these renewable energy sources has its advantages and disadvantages and are in varying stages of development.

Once the Renewable Energy Education kit arrived, it provided for interesting experiments. The kit has four basic devices for experiments: a solar panel, a wind pitch wind turbine, a polymer exchange membrane (PEM) fuel cell and a PEM Electrolyzer.

Students started with the solar panel activities. Students placed a solar panel in direct sunlight (by the window) and allowed it to heat up. They recorded electrical data at selected times to determine the rate at which the solar panel losses the ability to generate electricity. Then the students cooled the panel with a table fan to remove the built-up heat and witnessed how the panel recovered its power output. Students analyzed and explained the results of the activity. Students came to understand that (1) wind can dissipate the solar panel's heat and provide the better electrical output; (2) solar panel efficiency (ability to convert sunlight to electricity) is negatively affected by heat and improved with cold.

Other activities with the solar panel than can be followed up in the future but we did not get into include the effect of shade on solar panels, the effect of tilt angle and finding the solar panel's maximum power point. Students will come to understand that (1) shade is like turning off an internal power switch that shuts off most of the solar panel; (2) solar panels on space satellites must always be repositioned as they travel in orbit around the world; (3) orienting large commercial solar panels outdoors are based on both geographical location and

the season of the year; (4) maximum power is not maximum voltage or maximum current by itself but when voltage and current combine to produce maximum power.

Students moved to the wind energy experiments. Students started by selecting one of the three types of curved blades supplied for the turbine starting with two blades and recording the power output at the highest fan setting. They added additional blades and repeated experiment until the final number of blades was six. Students analyzed results to determine the maximum power output. Students came to understand that adding more blades created more “drag” and reducing the number of blades may result in higher output power.

Students then experimented by using different blade shapes with only three blades each time. Students measured power output at three different wind speeds with the table fan (low, medium, high). They changed the blade type and re-tested the power output at the same three wind speed settings. Students analyzed and explained the results of using each blade type. Students came to understand that (1) certain blade shapes are better in producing power at higher wind speeds while others are better at lower wind speeds; (2) the blades are designed to aircraft standards and the same as those used in real airplane and helicopter wings (only smaller).

One activity with the wind turbine that can be followed up in the future but we did not get into was measuring the turbine’s revolutions per minute (RPM) to understand that electrical load can slow the RPMs with the same wind speed. The introduction of an electrical load (a variable resistor) will cause the wind turbine blade rotations to slow down in proportion to the resistance.

Our next set of experiments, students learned the principles of electrolysis using wind power and fuel cells. The wind turbine was attached to the electrolyzer with water to create hydrogen and oxygen. The students reversed the process and used the stored hydrogen to power the fuel cell that acted as a power source for the included electric motor. Data was taken during both the hydrogen generation and motor running process. The data was analyzed to determine the energy used to electrolyze the water as well as the energy used to power the motor. Students came to understand that (1) wind power can be used to generate hydrogen and

oxygen in a clean, non-polluting manner, and (2) hydrogen is an “energy carrier” and can be stored for later used in generating electricity.

This year, I gave the students the goal to create an energy source to power their cell phones without using existing chargers that are powered through an electrical outlet. They all chose to arrange multiple solar panels in series and parallel configurations in order to study the voltage, current and power generated. The students started small and took data until they quickly figured out the right configuration. They soldered and wired panels together until they could get enough power to charge their own cell phones. Below is one of the designs.

Finally, I want to thank the Wimberley Education Foundation (WEF) directors for allowing this opportunity for my students. We are making good use of the Renewable Energy kit and still have several more experiments to implement and learn from in the near future.