Argonne National Lab's
Sustainability Workshop
Activity Lesson Plans
http://teachers.anl.gov/lesson_plans

Argonne National Laboratory's

Mission
Argonne integrates world-class science, engineering, and user facilities to deliver innovative research and technologies. We create new knowledge that addresses the scientific and societal needs of our nation.

Vision
We will lead the world in providing scientific and engineering solutions to the grand challenges of our time: sustainable energy, a healthy environment, and a secure nation.

Sustainability is paramount to the work of the Laboratory. As a natural segway to educational outreach, the Sustainability Workshop for Middle School Teachers was conceived, designed and implemented. The goals of this workshop included knowledge and awareness of alternative energy technologies, their advantages and limitations; the key issues and impacts of technologies related to climate change; to extend the resources of sustainability and encourage energy literacy. The teachers were asked to synthesize their experiences and knowledge gained into a useable lesson plan. The plans presented in this unit are a compilation of those lessons.

Solar Cars

Background information:
Solar powered cars run on a plentiful free alternative energy source – the sun. The cars use solar panels, which convert the sun's energy into electricity, which then charges the batteries or can directly run an electric motor. The solar panels are usually photovoltaic and will capture and convert the sun's energy.

Grade Level: Middle School

Goal/Objectives: Students will
• become familiar with how solar panels function
• explore clean energy; research and discuss solar power as an energy source
• show that solar energy can be easily collected and converted to electrical energy
• experience basic wiring and electrical circuits

• understand the relationships between time traveled, distance, and speed, and mathematically calculate them
• explore energy transfers and conversions; design, build, and evaluate devices that convert one form of energy into another
• design controlled experiments
• collect and analyze data
• study the effect of the Sun's position and angle as it relates to the movement of a solar car
• examine the potential role of solar energy as an energy source for the automobile industry

Activity Description:
Students will learn about solar panels and photovoltaics. They will then construct a model solar car. They will explore the photovoltaic effect as the solar panel provides electrical energy to the motor. Using time and distance, students will calculate the speed of their solar car. They will race their cars four times during the year, in different seasons. Each time the students race their cars, they will also chart the date, their latitude, the angle of the sun, light intensity, amount of cloud cover, and time of day. In this way, students will use their data as evidence to determine what factors most affect the speed of their solar car. There are **many** extensions that the teacher may decide to include in their students' study of solar cars, see the "Extensions and Resources" section for further ideas.

Materials:
Kid Wind-Solar Car Kits, one per team
Rubber mallet or hammer
KidWInd Movie, *Solar Car Assembly* *http://store.kidwind.org/videos#video-stage*
KidWind Solar Car Assembly Manual, found at http://store.kidwind.org/solar-kits/solar-electric-kits/solar-car
Vernier Go!Motion Sensor (or other motion sensor) with Laptop, one per team
Open space with smooth level surface
Meter sticks
Masking tape
Stopwatches
Teacher created solar car model

Video of Photovoltaics,
http://www.thefutureschannel.com/dockets/science_technology/solar_power/

Popular Science Video of Student-Made Solar Car beating world speed record
http://www.popsci.com/cars/article/2011-01/new-worlds-fastest-solar-powered-car-crowned-australia

Solar Angle Calculator, found at http://solarelectricityhandbook.com/solar-angle-calculator.html

Time needed: 4-8 class sessions

Strategies/methodology:
Whole group discussion, small group discussion and activity, designing, guided inquiry, measuring, experimental testing, data collection and analysis, comparing, diagramming, graphing, communicating, descriptive and scientific writing

Procedure:
Teacher note: Assemble a solar car and conduct test runs to make sure the batteries and motion sensors work, and to anticipate student questions. View the KidWInd assembly video if needed, here http://store.kidwind.org/videos#video-stage

Introduction: 1 class session

1. Give the students the following scenario:
Your group of automotive engineers must present data that will support or oppose the use of solar panels as a reliable energy source for Brand X's new concept car. Questions to address include: How effective will this car be in geographic locations with 4 distinct seasons? Does the position of the sun affect the efficiency of the energy output? Does the time of day affect this vehicle's efficiency? Does the intensity of the sun affect the car's performance?

Show students the short The Futures Channel video on photovoltaics, found at http://www.thefutureschannel.com/dockets/science_technology/solar_power/

2. Ask each team of students to research solar energy questions (you might want to assign different questions to each team) and report back to the class with their findings. Examples include, How are solar panels made? When is the collection of solar energy most efficient? What are the means of storing solar energy? Is the solar energy received different at different latitudes or at times of the day? Have students share what they have learned about solar energy in a discussion, with each team providing a visual to help explain their findings.

Plan and Construct Solar Car: 2 class sessions up front, 3 more class sessions later in year

3. Provide each team of students with a solar car kit and directions sheet (available with the purchase of the cars). Allow the teams to assemble the solar cars. Teams should choose which of the three Velcro positions to use to attach the solar panel to the car.

4. Discuss with the class experimental design, such as controlling the variables in their testing. Variables to consider are: time of day, race track location, race track surface, race track length, car construction, location of the solar panels, mass of the cars, size of the solar panels, and so on.

5. Set up the race track outside, using meter sticks to measure the distance and masking tape to mark the starting and ending lines. As the students' solar cars are racing, remind them to record the distance and time (using a stop watch) of their car's race, and calculate its speed. If you have access to laptops and motion sensors, use them to record the time of the car's race.. Students should record this information in a team-created data chart in their lab journals.

6. In addition, they will need to record information on the time of day, cloud cover/light intensity, and date. Using a solar angle calculator (such as the one here http://solarelectricityhandbook.com/solar-angle-calculator.html), they will create a chart of the sun's angle for their latitude, and include it with their data.

7. Plan to repeat this race 4 different times throughout the school year, during different seasons.

Closure/Sharing/Reflection: 1 class session
After testing the car four times during the school year, have the students evaluate how the cars' speeds varied given different positions (angles) of the solar panel to the Sun. Since different teams used different positions of their solar panels, they can assess how the angle of the solar panel on the car affects the timed speed of the car. After hearing from each team, allow students time to create a short Powerpoint presentation on their findings. Compile the slides to make one class presentation. Share the presentation with the whole class. Decide as a class, which variables recorded had the most impact on the speed of the solar cars.

Assessment:
Use a teacher-created rubric as a summative assessment for: the quality and thoroughness of the students' data collection, involvement in discussions, cooperative teamwork, and safety behavior. Be sure to include the students' explanations of how they used data to explain the effect different variables have on the speed of their solar cars, and their team's Powerpoint slide summaries.

Students with special needs may have assistance in developing their data charts and recording their data. They may choose oral explanations to support their findings, rather than written summaries. The assessment information can inform teacher instruction for the following school year. Some activity-related vocabulary words include: Force, Motion, Speed, Mechanical Energy, Solar Power, Motors, Mechanical Engineer, Automotive Engineer.

Extensions and Resources:
The experiment described above is only the beginning!
Students can wire ~~solar~~ rechargable batteries using series and/or parallel circuitry to determine if the speed of the cars increases proportionally with the number of batteries. Students can then determine how an increased mass of the cars with batteries influences speed. To practice the new physics concepts of speed and velocity, they can calculate the speed of the car while varying distance and time. Students can perform more trials during year, including comparing partially sunny and full sun days in the same seasons. They can try the car at various times during the same day, and measure its differences in speed. Students can try strategies to concentrate the amount of sunlight hitting the solar panel, such as using reflectors. They can learn about how gearing affects the speed by changing out the gears for ones with different numbers of teeth. Students can try solar car races based upon distance, by attaching string to either side of the track and screw eyelet bolts into deck. You might consider

contacting a sister school at a different latitude, and comparing results for the same experiments.

Create a sun path chart for your town/school from University of Oregon's Solar Radiation Monitoring Laboratory
http://solardat.uoregon.edu/SunChartProgram.html

Toshiba/NSTA Laptop Learning Challenge, *Lesson Plans for Solar Race Cars*
http://www.nsta.org/publications/interactive/laptop/lessons/m5.htm

Toshiba/NSTA Laptop Learning Challenge, *pdf Activity for Solar Race Cars*
http://www.nsta.org/publications/interactive/laptop/lessons/solar.pdf

KidWind, *simple solar car kits available for purchase*
http://store.kidwind.org/solar-kits/solar-electric-kits/solar-car

KidWInd Movie, *Solar Car Assembly* *http://store.kidwind.org/videos#video-stage*

KidWind Solar Car Assembly Manual, found at http://store.kidwind.org/solar-kits/solar-electric-kits/solar-car

Pitsco. Science equipment, including solar powered cars: http://www.pitsco.com/

Sunwind. Solar energy education and kits http://www.web.net/~sunwind/

Vernier Go!Motion Sensor, http://www.vernier.com/products/sensors/motion-detectors/go-mot/

The Futures Channel, Photovoltaics Movie,
http://www.thefutureschannel.com/dockets/science_technology/solar_power/

Popular Science Video of Student-Made Solar Car beating world speed record
http://www.popsci.com/cars/article/2011-01/new-worlds-fastest-solar-powered-car-crowned-australia