Where does U.S. energy come from today?

<table>
<thead>
<tr>
<th>Type</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Petroleum (Oil)</em></td>
<td></td>
</tr>
<tr>
<td><em>Coal</em></td>
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<tr>
<td><em>Natural Gas</em></td>
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<tr>
<td><em>Nuclear</em></td>
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<tr>
<td><em>Hydroelectric</em></td>
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<tr>
<td><em>Geothermal/Wind/Solar/Biomass</em></td>
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<th>Type</th>
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<tbody>
<tr>
<td>Petroleum (Oil)</td>
<td>37%</td>
</tr>
<tr>
<td>Coal</td>
<td>21%</td>
</tr>
<tr>
<td>Natural Gas</td>
<td>25%</td>
</tr>
<tr>
<td>Nuclear</td>
<td>9%</td>
</tr>
<tr>
<td>Hydroelectric</td>
<td>5%</td>
</tr>
<tr>
<td>Geothermal/Wind/Solar/Biomass</td>
<td>3%</td>
</tr>
</tbody>
</table>

Source: www.eia.gov
The Potential of Solar Energy
How can we capture the Sun’s energy?

- Passive

Credit: U. S. Department of Energy-Solar Decathlon
How can we capture the Sun’s energy?

- Solar Concentrators
How can we capture the Sun’s energy?

- Photovoltaic panels

Credit: U. S. Department of Energy-Solar Decathlon
How can we capture the Sun’s energy?

- Solar Water heating
How do we measure electricity usage?

- **Watts** - A watt is a unit of power. It is a Newton meter per second, or can be given as a joule per second.

- **Kilowatts** – 1,000 watts equals one kilowatt (kW)

- **Kilowatt-hours (kWh)** – A device such as a plasma TV, which uses 1,000 watts for one hour consumes one kWh of power.
How do Solar Panels work?
How do Solar Panels work?

Credit: rsc.org

p-type
n-type

ACS Chemistry for Life™
How do Solar Panels work?
How do Solar Panels work?
How are Solar Panels made?

Credit: Solar World
How are Solar Panels made?

Credit: Solar World
Challenges for 1st Generation Solar Panels

- They don’t work at night and work poorly in cloudy weather.
- Production uses toxic materials including greenhouse gases and must be treated to prevent release
- Takes energy to produce solar panels (1-3 year ‘energy payback’)
- Expensive
- End-of-use recycling needs to be developed
- Research in new solar panel technologies needs to continue, improving efficiency, cost, usability.
2\textsuperscript{nd} Generation Solar

- Cheaper
- More flexible – more uses
- Lighter
- Not as efficient
Examples of 3rd generation solar panels
TiO₂ Dye-Sensitized Solar Cells

How do they work?  What do they look like?

1. A dye, adsorbed on TiO₂ is excited by light

2. The excited dye injects an e⁻ into the TiO₂

3. The electron leaves the TiO₂ and is carried through as current

4. The e⁻ returns to the device and reduces the electrolyte

5. The dye is reduced by the electrolyte
Bioinspiration
Blackberry Solar Cell Lesson Plan

Standards and skills
NS.9-12.1 SCIENCE AS INQUIRY
NS.9-12.2 PHYSICAL SCIENCE
NS.9-12.4 EARTH AND SPACE SCIENCE
NS.9-12.5 SCIENCE AND TECHNOLOGY
NS.9-12.6 PERSONAL AND SOCIAL PERSPECTIVES

Lesson activities
• Learn how traditional solar panels are made
• Consider this process against the 12 principles of green chemistry
• Construct a dye sensitized solar cell
• Evaluate and compare the differences in solar cell technologies
Making the cell with your students!
TiO$_2$ Dye-Sensitized Solar Cells
Using Solar Power

On the grid
Using Solar Power

Off the grid
U.S. Department of Energy
Solar Decathlon
The Solar Decathlon Events

**The 10 Contests of 2009**

**Appliances:** Using only solar power, ensuring that a refrigerator stays cold, a freezer keeps food frozen, and clothes are washed and dried.

**Architecture:** Look and style of the house, including size and arrangement of the various rooms in the house.

**Comfort Zone:** Inside temperature and humidity (maximum score if inside temperature between 71°F (22.2°C) and 76°F (24.4°C) and relative humidity below 60%).

**Communications:** Presence of displays, Web sites, videos, or photos that inform the public about major features of the house and how they work.

**Engineering:** Functionality and efficiency of basic systems of the house, such as heating, ventilation, and air conditioning.

**Home Entertainment:** Ability to hold two dinner parties and one movie night for neighbors.

**Hot Water:** Ability to deliver 15 gallons (56.8 liters) of hot water (110°F/43.3°C) in 10 minutes or less.

**Lighting Design:** Presence of functional, energy-efficient, and aesthetically pleasing lighting systems.

**Market Viability:** How attractive the home might be for buyers.

**Net Metering:** How much energy the house produces and consumes.
Team Germany
Team California
Appalachian State University
Phase Change Wallboard

Fiberglass Mat

Enhanced Mold Resistant Gypsum Core

Micronal®

Gypsum Crystals

Photo: National Gypsum
Measuring heat of phase change.

- Measuring temperature vs phase change
Measuring heat of phase change.

- Measuring temperature vs phase change
Measuring heat of phase change.

- Heat of fusion lab
Measuring heat of phase change.

- Heat of fusion lab

Specific heat capacity of paraffin $\approx 2 \text{ J/g} \times {}^\circ\text{C}$

$H_f$ of paraffin $\approx 200 \text{ J/g}$
Educational Resources for Teachers

The U.S. Department of Energy Solar Decathlon provides teachers with numerous opportunities to introduce renewable energy, energy efficiency, and science activities into their curricula. The resources provided below offer lesson plans and student activities that can be integrated into classrooms today.

Solar Decathlon Curriculum

The U.S. Department of Energy Solar Decathlon is proud to offer its own educational curriculum. The Solar Decathlon curriculum is intended for middle school and high school students and is focused on solar energy.

General Educational Resources

These educational resources are appropriate for students of a variety of ages.

U.S. Department of Energy

- **Energy Education & Workforce Development**
  This Office of Energy Efficiency and Renewable Energy Web site features links to energy-related educational and training resources.

- **Solar Energy Technologies**
  Learn about photovoltaics and solar heating from the Office of Energy Efficiency and Renewable Energy.
Solar Decathlon Curriculum

The U.S. Department of Energy Solar Decathlon presents an incredible learning opportunity for schools, educators, students, and community members worldwide to explore the potential of solar energy. The Solar Decathlon is an inherently educational event that challenges college students to demonstrate best practices for solar power and energy efficiency, and the Department of Energy wants to extend this learning opportunity to as many classrooms and educational settings as possible. The educational resource packet presented here helps accomplish this goal.

The full lessons and educational resource packet will be posted in the coming weeks.

Lesson 1: The Importance of the Sun. An Introduction and Overview of Solar Energy

In this lesson, students will investigate the development and use of solar power. They will examine the role of the sun as a source of energy and explore how humanity has used the sun as a way of life. Solar technologies, from passive solar to solar thermal to the latest developments, will be discussed. Students will explore pre-Industrial Revolution uses of solar energy and be given an overview of technological advances using a Solar Decathlon 2011 house as an example. In addition, this lesson will cover the potential energy inherent in the sun’s daily output and will involve activities designed to enhance student understanding of our daily connection with and reliance on the sun.

Lesson 2: How Solar Panels Work

In this lesson, students will explore how sunlight is used for energy. Specifically, students will first examine the basic building blocks of matter, including electrons, protons, and neutrons. From there, they will inquire into how such building blocks, particularly electrons and the element silicon, are employed to produce energy. Students will perform two interactive activities to further understand this concept. Finally, students will perform a career investigation and subsequent report concerning the burgeoning solar industry to explore career opportunities related to energy from the sun.

Lesson 3: Solar Panels — A Life Story

As solar power gains popularity, solar panels are quickly becoming a part of everyday life. However, for such a common item, the public knows surprisingly little about these energy sources. For example, where do solar panels come from? How do they work, and how much do they really cost? This lesson plan will guide students toward answers by exploring the many factors that influence where solar panels originate and how they are best used.

Lesson 4: Solar Power and Me: The Inherent Advantages

In this uniquely interdisciplinary lesson, students will identify and understand the basic concepts of how photovoltaic solar panels work as a renewable energy source and use best-fit mathematical regression models using a TI-83 or TI-84 calculator to make predictions and solve real-life problems concerning solar energy in the United States. This lesson uses real data from a 2-kW photovoltaic solar panel system at a rural high school in North Carolina and historical energy statistics from the U.S. Energy Information Administration on solar growth in the United States to teach students the basics of renewable energy—especially photovoltaic solar.
Solar Hot Dog Cooker
Use the heat of the sun to cook.

This project is for older students or for younger students with adult supervision.

A reflective hot dog cooker can be built from a cardboard box, tin foil, and posterboard. Sunlight hits the reflective surface and focuses on the hot dog held in the center. Students can work in pairs or individually if there are enough materials.

What do you need?

1. A cardboard box
2. Tin foil
3. Posterboard

What to do?

1. Select a long narrow box; the longer the box the more heat collection is possible. Choose a focal length between 5” and 10” and design a parabolic curve as seen in the picture. One template could be used for all the cookers. Trace the curve on the open end of the box so that it is centered and straight.

2. Cut out the curve with a utility knife. Stress the importance of being exact. Measure and cut a piece of posterboard that will fix flush against the opening to the box. Attach this with tape beginning at the center and working toward to edges.

3. Cover the curve with white glue and apply aluminum foil shiny side out. Start in the middle and smooth toward the edges. Try not to wrinkle or fold the foil; you want it as smooth as possible.
Resources


• ChemMatters – www.acs.org/chemmatters

• Beyond Benign-Blackberry Solar Cell Activity - http://www.beyondbenign.org/K12education/highschool.html

• Solar World - http://www.solarworld-usa.com/

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