Energy House

Students learn about efficiency, conservation, and economic returns by using various materials to insulate a cardboard house and then test its efficiency.

Grade Levels:

- Elementary
- Intermediate
- Secondary

Subject Areas:

- Science
- Technology
- Math
- Engineering

NEED

National Energy Education Development Project

Teacher Advisory Board

NEED Mission Statement

The mission of The NEED Project is to promote an energy conscious and educated society by creating effective networks of students, educators, business, government and community leaders to design and deliver objective, multi-sided energy education programs.

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Teacher Advisory Board

In support of NEED, the national Teacher Advisory Board (TAB) is dedicated to developing and promoting standards-based energy curriculum and training.

Energy Data Used in NEED Materials

NEED believes in providing teachers and students with the most recently reported, available, and accurate energy data. Most statistics and data contained within this guide are derived from the U.S. Energy Information Administration. Data is compiled and updated annually where available. Where annual updates are not available, the most current, complete data year available at the time of updates is accessed and printed in NEED materials. To further research energy data, visit the EIA website at www.eia.gov.

NEED
National Energy
Education Development

1.800.875.5029
www.NEED.org

Energy House

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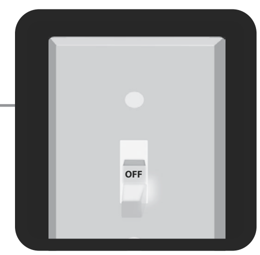


Standards Correlation Information

https://www.need.org/educators/curriculum-correlations/

Next Generation Science Standards

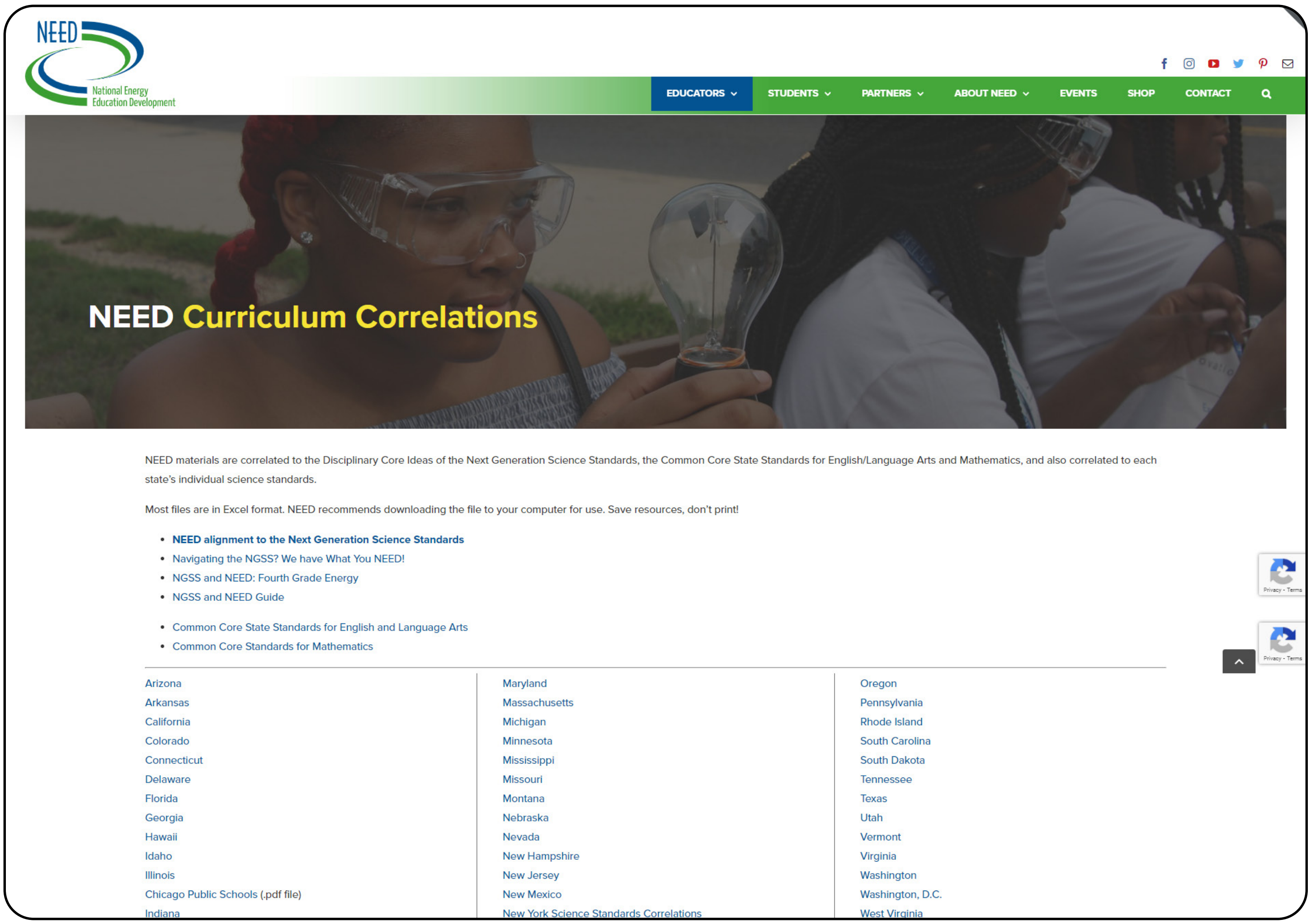
- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's curriculum correlations website.

Common Core State Standards

- This guide has been correlated to the Common Core State Standards in both language arts and mathematics. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED curriculum correlations website.

Individual State Science Standards

- This guide has been correlated to each state's individual science standards. These correlations are broken down by grade level and guide title, and can be downloaded as a spreadsheet from the NEED website.



Teacher Guide

Background

Insulation is a material used to limit the movement of thermal energy or heat. Students will be challenged to build a model home out of cardboard that 1) meets the required building code rules outlined below and 2) uses insulation to slow or stop the movement of thermal energy (heat) into and out of the home.

Objectives

- Students will be able to describe efficiency and conservation measures for the home.
- Students will be able to justify and explain why efficiency and conservation measures make sense economically.

Concepts

- Heating and cooling uses more energy than any other energy task in the home.
- Insulators are materials that do not conduct (or move) heat well.
- Many materials can be used to reduce the energy needed to keep houses at comfortable temperatures.

Materials

MATERIALS NEEDED FOR THE CLASS	MATERIALS NEEDED PER GROUP
▪1 Roll of aluminum foil	▪Thermometers
▪Scissors	▪Meter stick
▪1 Package or roll of small bead caulking	▪Pencils
▪Rulers	▪Cardboard boxes
▪1 Package of small self-stick weatherstripping	▪Sheets of heavy transparency film
▪1 Roll of bubble wrap	▪Poster boards
▪1 Roll of cotton batting	▪Resealable quart-sized plastic bags
▪Ice cubes	▪Rolls of mailing tape
▪1 Roll of padded mailing paper	*Most materials listed above can be bought at an office supply store or hardware store.*

Preparation

- Familiarize yourself with the *Teacher* and *Student Guides*. Preview the extensions and full instructions to develop a good implementation plan that fits your students and the time available.
- Make one copy of the *Student Guide* for each student. If desired, make a copy of the optional *Cost Sheet* for each student.
- Procure the materials needed from the list above and set up a Construction Center for the students.
- Make a master or digital projection of the master on page 10 to share with the class.
- Pre-determine student groups of three.
- Gather play money and divide it up for groups to use if opting to incorporate a budget. (optional)

Procedure

1. Introduce the activity to the class using the *Insulators and Conductors* master. Discuss the materials in the pictures that are conductors and insulators (see the answer key starting on page 7 for suggestions). Explain to the class that conductors are materials such as metals that move thermal energy easily; insulators are materials that do not move thermal energy well. Have students discuss what they know about common materials (wood, plastic, glass, metal, leather, water, cement, fabric) and categorize them as conductors or insulators.

Grade Levels

- Elementary, grades 3-5
- Intermediate, grades 6-8
- Secondary, grades 9-12

Time

- 1.5-2.5 hours

Additional Resources

Check out NEED's *Building Science* module on our website, shop.NEED.org, to explore the science and energy behind keeping buildings comfortable and functional. This unit also includes a house design project with additional challenges built in, and could serve as an amplified challenge for students after this unit.

Materials Note

Students can use uniformly sized boxes or provide their own cardboard. NEED often uses 9x9x9 boxes in workshops.

2. A good way for students to think more clearly about objects as conductors or insulators is to consider that all the materials in the room are at the same temperature. The students' hands are warmer than the room. Do the objects feel warm or cool when they are touched? Conductors move heat away from the students' hands, making the objects feel cooler. Insulators do not move heat well, so the objects feel warm. Have the students think about stepping from the shower with one foot on a rug and one on a tile floor. Both the rug and the tile are at the same temperature. How do they feel? Which is the conductor and which is the insulator?
3. Distribute the *Student Guide* to the students and place them into the groups you have set up. Review the procedure for the activity with the class, making sure to expressly outline the building code. If necessary, make sure the building code is visible on the board or screen as well. Be sure to highlight any group work and lab safety rules you may have and remind students safe procedures for cutting with cardboard.
4. Show the class the materials in the Construction Center. If you are incorporating the optional *Cost Sheet* and budgeting, make sure to discuss costs of the materials and how this will factor into the testing at the end. It may be helpful for groups to pre-determine the supplies they will use (and prepare a preliminary budget, if applicable) before visiting the Construction Center. Show the class the materials in the Construction Center.
5. Clearly define how much time groups will have for construction. Remind them that their goal is to use insulation to slow or stop the movement of thermal energy. They will test for this at the end by cooling the inside of their home with ice to see how well it stays cool when warm air/lamps are placed outside. A sample rubric is provided on page 7. Discuss the rubric if desired.
6. Distribute boxes/cardboard if you are providing them to students. If students are providing their own cardboard, make sure to identify any size parameters and limitations you wish to incorporate outside of the building code.
7. Allow groups to begin planning, acquiring materials from the Construction Center, and construct their homes. Monitor group work, enforcing the building code and any safety measures necessary. Give time check-ins regularly so groups are aware of the remaining time for work.
8. When groups are finished, decide if you will inspect homes for building code violations. Provide each group with a thermometer. Take the houses to the place where testing will occur. If it is a warm day, take the houses outside. If conducting indoor tests, set up the houses so that incandescent or heat lamps will be equally trained on each home. Ask each group to insert the thermometer into their home in the top of the door (with the door closed). They should allow their thermometers to normalize for a minute and record the temperature as a baseline temperature.
9. Distribute plastic bags to each group, each filled with 8 ice cubes (or a similar mass of ice). Instruct groups to open their doors and place the ice inside the center of the home and close the door. If indoors, turn on any lamps that are providing heat and allow them to remain on.
10. Record the temperature after 10-15 minutes. Students will slide the thermometers back into the closed door, and allow them to normalize and record the final temperature.
11. Ask students to review their data as a group and identify design elements that might have improved their results or contributed to their results.
12. Discuss that insulation works both ways. While we often think of insulation keeping something hot, it can also help to keep an air-conditioned home cool, or a warmed home warm. Discuss the energy savings that insulation can produce, related to cost—the more insulation you use, the more energy savings. At some point, however, the increase in cost is not economically worthwhile. The cost up-front may outweigh the energy saved, or you may reduce the amount of usable space too much. Materials that are really good insulators usually cost more than less-efficient insulators, so you need to consider the trade-offs and balance the energy saved with the cost. While the energy savings may not be obvious in this activity, homeowners can look at their bills to calculate savings. Discuss why homes in warmer climates might choose to opt out of insulation.
13. Discuss other materials the groups could have used as insulation, such as foam board. Discuss what each group would change if they could do the activity again with additional materials. Ask students why they think building codes are necessary and discuss how the building code can have benefits and limitations.
14. Evaluate the activity with the class using the Evaluation Form on page 15.

Extension Activities

- Substitute a handwarmer in place of ice cubes to represent heating in colder climates.
- Have students draw blueprints of their houses to scale and devise written plans to insulate their houses before they begin the activity.

- Have students devise an experiment to test and determine the insulating qualities of the insulating materials prior to insulating the houses. One simple experiment is to insulate cold drink cans with various materials to see which material keeps the liquid the coldest.
- Give students two boxes. One will be fully insulated, and one will be designed identically without any insulation, to act as an experimental control.
- Have students devise an experiment to explore the insulating qualities of materials with which houses are made, such as wood, brick, stucco, cinder block, etc.
- For an added challenge, assign the groups a maximum budget for construction. They must provide the best insulation without exceeding the homeowner's budget.
- Ask one member of each group to join a team of "Building Inspectors" who look for building code compliance errors.
- Have a building contractor or certified energy manager visit the class to discuss energy-saving materials and techniques in the building industry.
- Have students survey their own homes to determine how well their homes are insulated and what measures could be undertaken to make their homes more energy efficient. See *Energy Conservation Contract,* available for free download at shop.NEED.org, to teach students how to save energy at home with their families.
- Have students survey the school to determine how well the building is insulated and what measures could be undertaken to make the school more energy efficient. See *School Energy Experts,* available for free download at shop.NEED.org, to teach students how to survey buildings and learn about conservation and efficiency measures at school.

☑ Answer Key For Insulators and Conductors Master

- **Metal Pan with Plastic Handle:** Metal is a conductor—it conducts heat to the food inside to cook it efficiently. Plastic is an insulator—it does not conduct heat from the pan to a person's hands.
- **Metal Kettle with Wooden Handle:** Metal is a conductor—it conducts heat to the water inside to warm it efficiently. Wood is an insulator—it does not conduct heat from the kettle to a person's hands.
- **Metal Spoon with Plastic Handle:** Metal is a conductor—it conducts heat. Plastic is an insulator—it does not conduct heat from the spoon to a person's hands.
- **Fabric Oven Mitt:** Fabric is an insulator—it does not conduct heat from hot pans to a person's hands. Discuss blankets and clothes as insulators. What would happen if the fabric mitt got wet? Is water a conductor or insulator? (conductor)
- **Thermos (Vacuum) Bottle:** There is a space between the inside liner and the outside material of a vacuum bottle in which most of the air has been removed. Since heat travels from molecule to molecule, a space with few molecules is a good insulator. Double pane windows work on the same principle.
- **Ceramic or Plastic Cup:** Ask the students whether the cup would be hotter if made of ceramic or plastic. (ceramic) Which is the better insulator? (plastic)

☑ Sample Rubric For Evaluating Homes

▪ Follows building code	_________ / 15 points
▪ Budget (lowest = 10 points / highest = 0 points)	_________ / 10 points
▪ Insulation Effectiveness ($\Delta T°$) (greatest ΔT = highest score, lowest ΔT = lowest score)	_________ / 20 points
▪ Aesthetics	_________ / 5 points

*Assess budget and insulation effectiveness on a sliding scale. If, for example, you have 10 groups, the group that measures the greatest temperature drop will receive 10 points. The next best temperature will be awarded a 9 out of 10, and so forth.

Student Guide

✪ Challenge

You have been chosen to build a house that meets the local building code, while efficiently insulating the home in order to save the homeowners energy costs for years to come. A well insulated home will be able to maintain a different temperature than outside conditions.

Question

What materials will most efficiently insulate your energy house?

Building Code

- ✓ You must have at least 1 door, at least 10 cm x 6 cm. The door must open and close.
- ✓ You must have at least 2 windows, each at least 5 cm x 5 cm. The windows must be transparent (you can see through them).
- ✓ The ceiling must be at least 5 cm above the top of the door.
- ✓ Insulation on the floor and walls cannot exceed 1 cm in thickness.
- ✓ No insulation can be exposed. All insulation must be covered by a ceiling, wall, or floor (poster board).

✔ Procedure

1. Assemble your box home so it stands up, but do not apply tape to all sides yet, as you will need to be able to install insulation. You will seal your home as the last step before you test!
2. Draw your windows and door to fit the building code requirements. These can be located on any side or face of your house.
3. Carefully cut out the windows and the door, leaving one side of the door attached. The door should remain open and unsealed. Windows will be covered with transparency paper and sealed closed. Additional doors and windows are allowed, but all must fit within the building code requirements. If you add a storm door, it also must open and close.
4. Examine your home to determine its insulation needs. Look at the materials available and read the building code thoroughly. Decide which materials you want to use and the amount you will need of each. Follow the Building Code and place the desired insulation materials in your home. Use the mailing tape as the method to secure and affix your insulation and attach wall coverings. Remember, no insulation can be exposed.
5. Seal the home with tape and utilize weather stripping as needed. You may make your roof flat or pitched, based on your desired architectural design.
6. Take your home to the desired testing area (as outlined by your teacher). Place your home so it receives equal amounts of direct light or shade. All houses tested should be in similar conditions, where possible.
7. Measure and record the temperature of your home to start. Inserting the thermometer into the home through the top of the door. Wedge the door closed so the thermometer stays inside but the door is mostly closed. Turn the thermometer on and wait 30 seconds to allow the thermometer to adjust. Record this as your starting temperature.
8. Gather the bag of ice from your teacher. Make sure the bag is sealed and place the bag flat on the floor in the center of your home. Close the door. Allow your home to stay outside for the time prescribed by your teacher. This ice will act as a “cooling unit” for your home, creating a temperature difference outside versus inside. This “cooling unit” will also help you demonstrate how well the insulation you designed does its job to hold the temperature inside. Warmer air will want to come inside and cooler air will want to escape - insulation acts like a security guard to stop this from happening. If your insulation does its job, your home will be cooler at the end of the test than the outside air when you started.
9. After the time has passed, record the temperature of your home by inserting the thermometer into the home through the top of the door. Wedge the door closed so the thermometer stays inside but the door is mostly closed. Turn the thermometer on and wait 30 seconds to allow the thermometer to adjust. Record this temperature as the final temperature.
10. Calculate the total temperature change for each home. Record observations about the ice cubes after taking your measurements. How much has melted? How much longer do you think the ice would take to melt completely? Why?

Student Guide

Data & Observations

1. Room temperature (°C): ___________

2. House temperature (°C): ___________

3. Difference (Δ) in temperature (°C): ___________

4. If I did the activity again, I would change_____________ about my house:

⁂ Conclusion

1. Analyze your home design, the insulating materials you used, and your budget. How efficient was your home at maintaining its temperature? How did your cost for materials compare to the temperature change? What would you do differently if you could design your house again? Cite evidence from your trial in your response.

2. Compare your results with other groups. What did other groups do differently and why?

Cost Sheet

AMOUNT				TOTAL COST
_________	Mailing Tape	@	$0.50 roll	_______________
_________	Plastic Film	@	$0.25 each	_______________
_________	Aluminum Foil	@	$0.20/meter	_______________
_________	Poster Board	@	$0.50 each	_______________
_________	Bubble Wrap	@	$1.00/meter	_______________
_________	Cotton Batting	@	$0.75/meter	_______________
_________	Padded Paper	@	$0.50/meter	_______________
_________	Caulking	@	$0.01/cm	_______________
_________	Weatherstripping	@	$0.01/cm	_______________

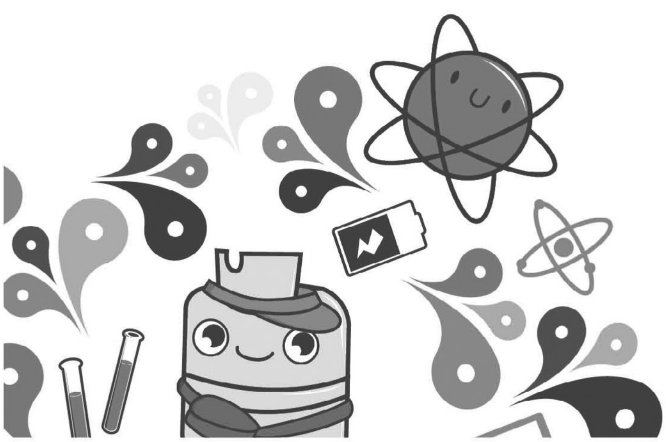
Total Cost for Materials: _______________

Insulators and Conductors

YOUTH ENERGY CONFERENCE AND AWARDS

The NEED Youth Energy Conference and Awards gives students more oportunities to learn about energy and to explore energy in STEM (science, technology, engineering, and math). The annual June conference has students from across the country working in groups on an Energy Challenge designed to stretch their minds and energy knowledge. The conference culminates with the Youth Awards Ceremony recognizing student work throughout the year and during the conference.

For More Info: www.youthenergyconference.org



YOUTH AWARDS PROGRAM FOR ENERGY ACHIEVEMENT

All NEED schools have outstanding classroom-based programs in which students learn about energy. Does your school have student leaders who extend these activities into their communities? To recognize outstanding achievement and reward student leadership, The NEED Project conducts the National Youth Awards Program for Energy Achievement.

Share Your Energy Outreach with The NEED Network!
This program combines academic competition with recognition to acknowledge everyone involved in NEED during the year—and to recognize those who achieve excellence in energy education in their schools and communities.

What's involved?

Students and teachers set goals and objectives and keep a record of their activities. Students create a digital project to submit for judging. In April, digital projects are uploaded to the online submission site.

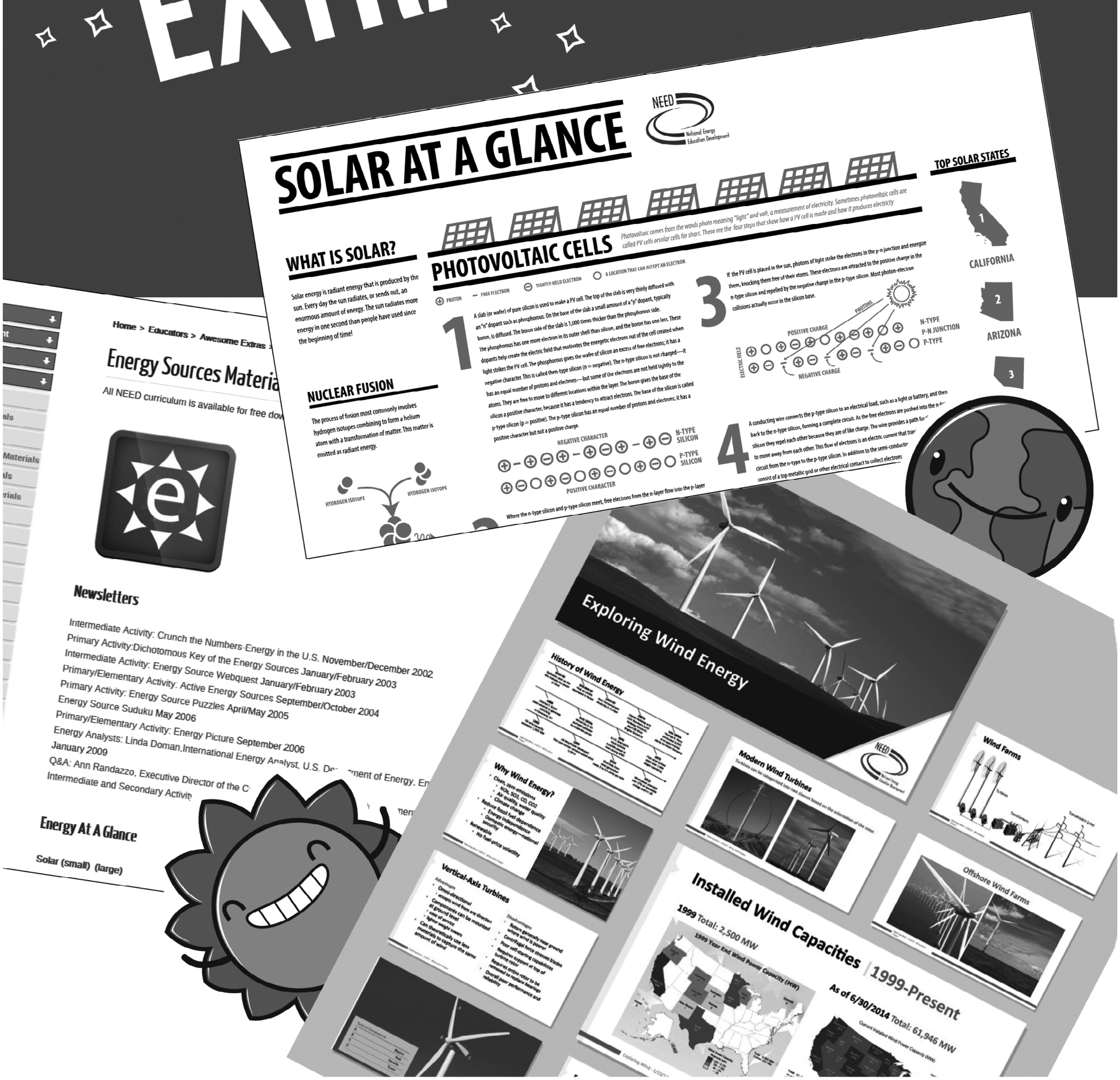
Want more info?

Check out **www.NEED.org/need-students/youth-awards/** for more application and program information, previous winners, and photos of past events.

AWESOME EXTRAS!

Our Awesome Extras page contains PowerPoints, animations, and other great resources to compliment what you are teaching!

www.NEED.org/educators/awesome-extras/



Energy House Evaluation Form

State: ____________ **Grade Level:** ____________ **Number of Students:** ___________

1. Did you conduct the entire activity?	❑ Yes	❑ No
2. Were the instructions clear and easy to follow?	❑ Yes	❑ No
3. Did the activity meet your academic objectives?	❑ Yes	❑ No
4. Was the activity age appropriate?	❑ Yes	❑ No
5. Was the allotted times sufficient to conduct the activity?	❑ Yes	❑ No
6. Was the activity easy to use?	❑ Yes	❑ No
7. Was the preparation required acceptable for the activity?	❑ Yes	❑ No
8. Were the students interested and motivated?	❑ Yes	❑ No
9. Was the energy knowledge content age appropriate?	❑ Yes	❑ No
10. Would you use this activity again?	❑ Yes	❑ No

Please explain any 'no' statement below.

How would you rate the activity overall?	❑ excellent	❑ good	❑ fair	❑ poor
How would your students rate the activity overall?	❑ excellent	❑ good	❑ fair	❑ poor

What would make the activity more useful to you?

Other Comments:

Please fax or mail to: **The NEED Project**
8408 Kao Circle
Manassas, VA 20110
FAX: 1-800-847-1820

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