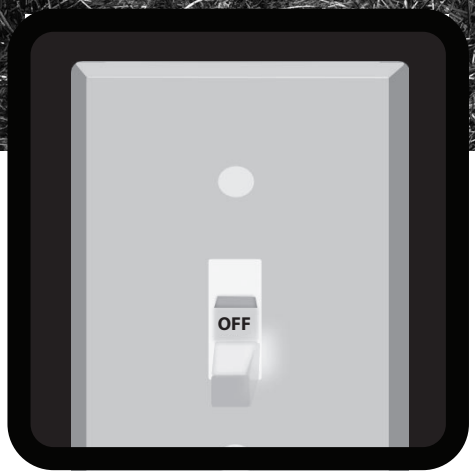
Energy House

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



Grade Levels:

Elem Elementary

Int Intermediate

Subject Areas:

Science

Social Studies

Math

Technology

NEED

National Energy Education Development Project

Teacher Advisory Board

Constance Beatty
Kankakee, IL

James M. Brown
Saratoga Springs, NY

Amy Constant - Schott
Raleigh, NC

Nina Corley
Galveston, TX

Shannon Donovan
Greene, RI

Linda Fonner
New Martinsville, WV

Samantha Forbes
Vienna, VA

Michelle Garlick
Long Grove, IL

Erin Gockel
Farmington, NM

Robert Griegoliet
Naperville, IL

Bob Hodash
Bakersfield, CA

DaNel Hogan
Tucson, AZ

Greg Holman
Paradise, CA

Barbara Lazar
Albuquerque, NM

Robert Lazar
Albuquerque, NM

Leslie Lively
Porters Falls, WV

Jennifer Mitchell - Winterbottom
Pottstown, PA

Mollie Mukhamedov
Port St. Lucie, FL

Don Pruett Jr.
Puyallup, WA

Judy Reeves
Lake Charles, LA

Tom Spencer
Chesapeake, VA

Jennifer Trochez MacLean
Los Angeles, CA

Wayne Yonkelowitz
Fayetteville, WV

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.

Permission to Copy

NEED curriculum is available for reproduction by classroom teachers only. NEED curriculum may only be reproduced for use outside the classroom setting when express written permission is obtained in advance from The NEED Project. Permission for use can be obtained by contacting info@need.org.

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

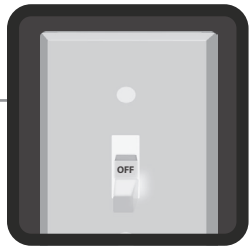
1.800.875.5029
www.NEED.org

© 2017

Printed on Recycled Paper

Energy House

Table of Contents



Standards Correlation Information

www.NEED.org/curriculumcorrelations

Next Generation Science Standards

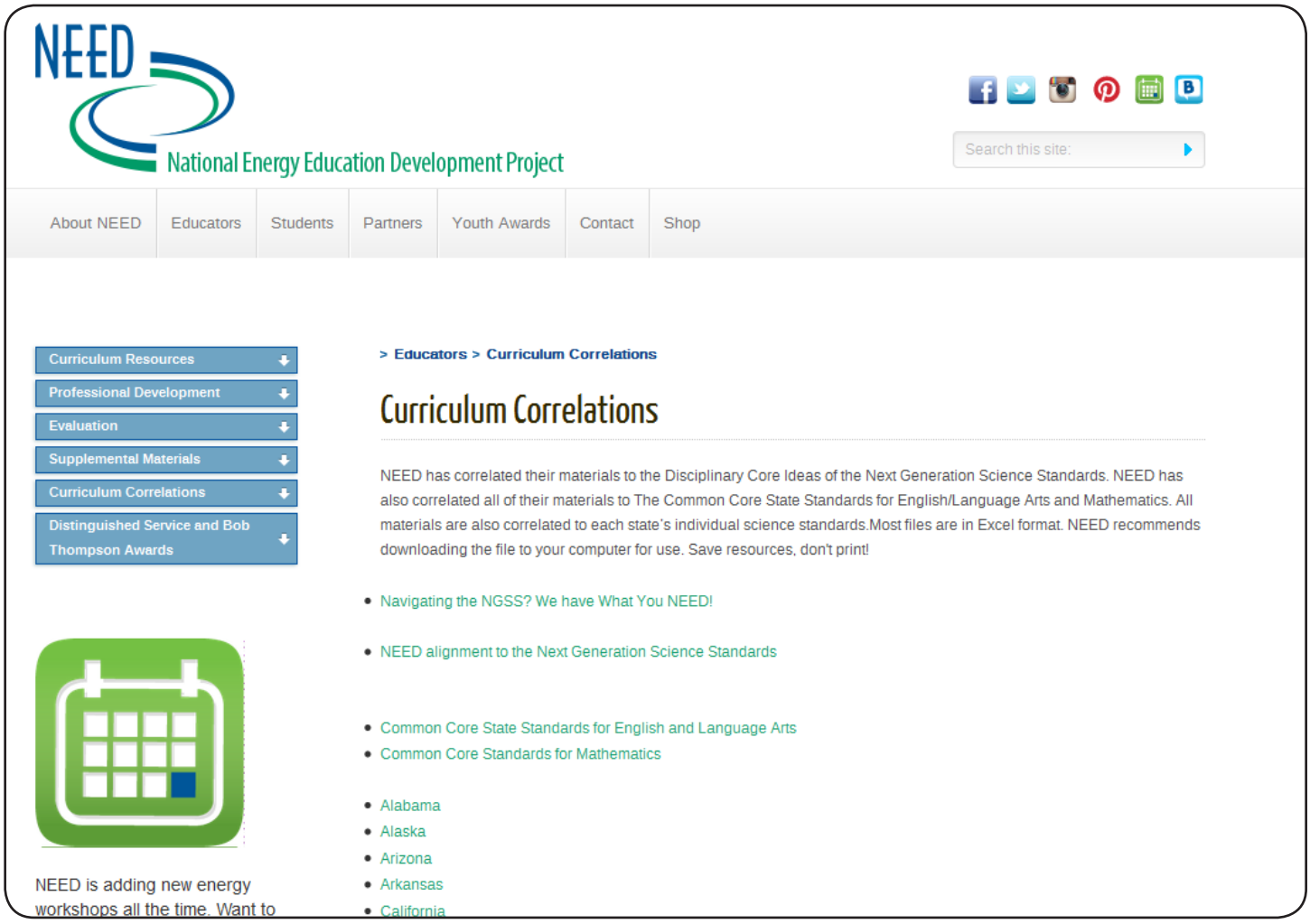
- This guide effectively supports many Next Generation Science Standards. This material can satisfy performance expectations, science and engineering practices, disciplinary core ideas, and cross cutting concepts within your required curriculum. For more details on these correlations, please visit NEED's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

Students will purchase and install insulation, caulking, weatherstripping, and windows into a cardboard box house, then test the efficiency of the house.

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 ▪Scissors ▪1 Package or roll of small bead caulking ▪Rulers ▪1 Package of small self-stick weatherstripping ▪1 Roll of bubble wrap ▪1 Roll of cotton batting ▪Ice cubes ▪1 Roll of padded mailing paper ▪Thermometers ▪Meter stick ▪Pencils	▪Identical cardboard boxes (approximately 12″ x 12″ x 12″) ▪Sheets of heavy transparency film (approximately 12″ x 12″ x 12″) ▪Poster boards ▪Resealable quart-sized plastic bags ▪Rolls of mailing tape *Most materials listed above can be bought at an office supply store or hardware store.*

Preparation

- Familiarize yourself with the *Teacher* and *Student Guides*.
- Make one copy of the *Student Guide* and *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.
- Place your students in groups of three.
- Gather play money and divide it up for groups to use. (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 6 for suggestions). Explain to the class that conductors are materials such as metals that move heat easily; insulators are materials that do not move heat 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

Time

- 1.5-2.5 hours

Teacher Tip

Check out NEED's *Building Science* module on our website, www.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.

© 2017 The NEED Project 8408 Kao Circle, Manassas, VA 20110 1.800.875.5029 www.NEED.org

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 Guides* and *Cost Sheets* to the students and place them into groups. See the next page for examples of extension activities.
4. Review the procedure for the activity with the class, along with any group work and lab safety rules you may have. Discuss how you will evaluate the homes. A sample rubric is provided on page 7.
5. Show the class the materials in the Construction Center.
6. Distribute one box to each group. Make sure students have rulers, scissors, and pencils. Instruct the students to cut out the windows and doors of their houses.
7. Instruct the groups to decide the type and amount of materials they want and write them on the *Cost Sheet*.
8. When the *Cost Sheets* are completed, have a representative from each group go to the Construction Center to get the materials. The teacher should act as the Center Manager to distribute materials to the groups.
9. Give groups a specific amount of time (30 minutes to one hour) to insulate their house.
10. When groups are finished, distribute plastic bags filled with ice cubes to each group and have the students close their houses with the bags of ice on the floor of the house.
11. Have the students measure the temperature of the classroom and record it on their *Cost Sheets*.
12. After ten minutes, have each group measure the temperature inside of their houses by carefully sliding a thermometer above the door, and recording the measurement on the *Cost Sheets*.
13. 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 piece isn't evident here, homeowners can look at their bills to calculate savings.
14. Discuss other materials the groups could have used as insulation, such as foam board. Discuss what groups 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.
15. Evaluate the activity with the class using the *Evaluation Form* on page 11, and return it to NEED.

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.
- 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.
- 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 *Monitoring and Mentoring,* 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 spends the least to build their home will receive 10 points. The next lowest budget 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.

❓ Question

What materials will most efficiently insulate your energy house?

✔ Procedure

1. Draw two windows (10 cm x 10 cm) and one door (10 cm x 20 cm) on your house.
2. Carefully cut out the windows and the door, leaving one side of the door attached.
3. Examine your house to determine its insulation needs. Read the Building Code below.
4. Examine the materials available and their cost. As a group, decide which materials you want to use and the amount your group would like to spend. Write them on your *Cost Sheet*.
5. Purchase the materials and insulate your house, following the Building Code. You can purchase additional materials if you need them. Make sure to add them to your *Cost Sheet*.
6. When your house is finished, fill or obtain a plastic bag with eight ice cubes. Place the bag flat on the floor of the house and close the house.
7. Measure and record the temperature of the classroom.
8. After ten minutes, record the temperature of your house at ceiling level by carefully sliding the thermometer into the house through the top of the door, taking care not to allow cool air to escape.
9. Calculate your total cost and total temperature change.

Building Code

- The door must open and close. If you add a storm door, it must open.
- Windows do not have to open but you must be able to 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).

⁂ 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.

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: _____

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:

© 2017 The NEED Project 8408 Kao Circle, Manassas, VA 20110 1.800.875.5029 www.NEED.org

Insulators and Conductors

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

© 2017 The NEED Project 8408 Kao Circle, Manassas, VA 20110 1.800.875.5029 www.NEED.org

National Sponsors and Partners

Air Equipment Company
Alaska Electric Light & Power Company
Albuquerque Public Schools
American Electric Power
American Fuel & Petrochemical Manufacturers
Arizona Public Service
Armstrong Energy Corporation
Barnstable County, Massachusetts
Robert L. Bayless, Producer, LLC
BG Group/Shell
BP America Inc.
Blue Grass Energy
Cape Light Compact–Massachusetts
Central Falls School District
Chugach Electric Association, Inc.
CITGO
Clean Energy Collective
Colonial Pipeline
Columbia Gas of Massachusetts
ComEd
ConEdison Solutions
ConocoPhillips
Constellation
Cuesta College
David Petroleum Corporation
Desk and Derrick of Roswell, NM
Direct Energy
Dominion Energy
Donors Choose
Duke Energy
East Kentucky Power
Energy Market Authority – Singapore
Escambia County Public School Foundation
Eversource
Exelon Foundation
Foundation for Environmental Education
FPL
The Franklin Institute
George Mason University – Environmental Science and Policy
Gerald Harrington, Geologist
Government of Thailand–Energy Ministry
Green Power EMC
Guilford County Schools – North Carolina
Gulf Power
Hawaii Energy
Idaho National Laboratory
Illinois Clean Energy Community Foundation
Illinois Institute of Technology
Independent Petroleum Association of New Mexico
James Madison University
Kentucky Department of Energy Development and Independence
Kentucky Power – An AEP Company
Kentucky Utilities Company
League of United Latin American Citizens – National Educational Service Centers
Leidos
Linn County Rural Electric Cooperative
Llano Land and Exploration
Louisville Gas and Electric Company
Mississippi Development Authority–Energy Division
Mississippi Gulf Coast Community Foundation
Mojave Environmental Education Consortium
Mojave Unified School District
Montana Energy Education Council
The Mountain Institute
National Fuel
National Grid
National Hydropower Association
National Ocean Industries Association
National Renewable Energy Laboratory
NC Green Power
New Mexico Oil Corporation
New Mexico Landman's Association
NextEra Energy Resources
NEXTracker
Nicor Gas
Nisource Charitable Foundation
Noble Energy
Nolin Rural Electric Cooperative
Northern Rivers Family Services
North Carolina Department of Environmental Quality
North Shore Gas
Offshore Technology Conference
Ohio Energy Project
Opterra Energy
Pacific Gas and Electric Company
PECO
Pecos Valley Energy Committee
Peoples Gas
Pepco
Performance Services, Inc.
Petroleum Equipment and Services Association
Phillips 66
PNM
PowerSouth Energy Cooperative
Providence Public Schools
Quarto Publishing Group
Read & Stevens, Inc.
Renewable Energy Alaska Project
Rhode Island Office of Energy Resources
Robert Armstrong
Roswell Geological Society
Salt River Project
Salt River Rural Electric Cooperative
Saudi Aramco
Schlumberger
C.T. Seaver Trust
Secure Futures, LLC
Shell
Shell Chemicals
Sigora Solar
Singapore Ministry of Education
Society of Petroleum Engineers
Society of Petroleum Engineers – Middle East, North Africa and South Asia
Solar City
David Sorenson
South Orange County Community College District
Tennessee Department of Economic and Community Development–Energy Division
Tesla
Tesoro Foundation
Tri-State Generation and Transmission
TXU Energy
United Way of Greater Philadelphia and Southern New Jersey
University of Kentucky
University of Maine
University of North Carolina
University of Tennessee
U.S. Department of Energy
U.S. Department of Energy–Office of Energy Efficiency and Renewable Energy
U.S. Department of Energy–Wind for Schools
U.S. Energy Information Administration
United States Virgin Islands Energy Office
Wayne County Sustainable Energy
Western Massachusetts Electric Company
Yates Petroleum Corporation

©2017 The NEED Project 8408 Kao Circle, Manassas, VA 20110 1.800.875.5029 www.NEED.org