# Building an Energy Smart Home

MISSOURI DEPARTMENT OF NATURAL RESOURCES

**GRADE LEVEL:**

Upper Middle School/ High School

**SUBJECT AREAS:**

Sciences, Art

**DURATION:**

Preparation Time: 30 minutes

Activity Time: three 50-minute class periods

**SETTING:**

Classroom

**SKILLS:**

Application, Analysis, Synthesis

**KEY WORDS:**

Insulation, Conduction, Convection, Architecture

**SUMMARY**

*In this activity, students will work as part of a group and build a simple model home that incorporates energy saving design strategies. The students will present the approaches they implemented to the rest of the class. Following the group exercises, each student will adopt the role of an architect and design a modern home that incorporates some of the concepts learned during the class. The goal of the students is to create an attractive home that will excel in conserving energy.*

## OBJECTIVES

**THE STUDENT WILL:**

- Work in a group setting to explore various approaches in designing energy efficient homes.
- Work in a group setting to construct a simple model building that incorporates some specific energy saving design elements.
- Prepare a presentation that will explain the energy saving design elements their group utilized.
- Adopt the role of an architect and design and draw a building that incorporates some of the energy saving principles explored as a class

## MATERIALS

- A cardboard box per group (photocopier paper boxers or equivalent work well)
- Misc. construction paper
- Aluminum foil
- Poster board
- Scrap cardboard
- Styrofoam cups or packing peanuts (used to simulate insulation)
- Plastic wrap or sandwich bags (for windows)
- Tape
- Glue
- Modeling Clay
- Scissors
- Colored markers
- Bucket of sand or gravel (for earth-contact home)
- Tree and bush clippings (to model energy saving landscaping)

## BACKGROUND

The average American will spend from 15 to 50 percent of their budget on home energy needs. How a building is designed can significantly affect the amount of energy required to achieve a comfortable environment. Energy efficient building designs are one of the simplest ways to decrease the amount of energy consumed by our society. A home does not have to appear radical or unconventional to save energy.

### SOLAR ENERGY DESIGNS

Passive solar buildings use south-facing windows that are designed to let in the warmth of the Sun during the winter months. In the summer, when the Sun is higher in the sky, window awnings or roof overhangs are employed to decrease sunlight. Window shutters, glazes (reflective coatings) and trees can also be used to deflect solar heat helping to keep a building cooler in summer.

Passive solar buildings are often also designed to use sunlight for lighting needs. These designs are especially useful in the Midwest and can significantly reduce energy costs associated with heating and lighting.

*Several tips on energy efficient homes are found in the Great Homes Checklist-Passive Solar Design.*

GEOTHERMAL DESIGNS

These homes take advantage of the stable temperatures found everywhere in the Earth's crust just 10 to 15 feet below the surface. At these shallow depths the ground has a constant temperature (in Missouri this is 50 to 60 degrees Fahrenheit).

A type of heating and cooling system called a geothermal heat pump can be used to take advantage of these stable temperatures. Typically, plumbing for a ground heat exchanger is buried under or next to the building. Fluid is pumped through the length of the exchanger and cycled through the main heating and cooling unit. In the winter a ground source heat pump does not have to overcome the cold winter air to provide inside heating. Conversely, in summer the system uses the cooler ground temperature as a starting point for providing cooled air rather than attempting to cool the hot summer air, as would a conventional air conditioner. A variation on this idea is the earth-contact home. In such cases one or more sides of the home are built in contact with the earth by digging in part of the building or pushing soil up to the side of the structure. Earth-contact homes take advantage of the ground as a heat-sink and as a result such homes are easier to heat in winter and to cool in summer.

HOME INSULATION:

A properly insulated home will require less energy to create comfortable temperatures for its residents. Insulation can be applied to the walls, the roof and the home foundation. Properly insulated water lines and water heaters can reduce the amount of energy associated with hot water use. Generating hot water is a leading source of energy consumption in homes.

Insulation is used to decrease the transfer of thermal energy to a home from its surroundings. Heat flows from areas of high thermal energy towards areas of low thermal energy in three basic ways. The first is radiation and involves the transfer of heat by light energy. The heat we feel from the sunlight is an example of this process. Homes can use lighter colored shingles on the roof to decrease the amount of energy absorbed from the Sun. Reflective window treatments can be used to reduce the amount of energy gained from Sun. Many modern home insulation layers employ a reflective silver lining to decrease energy transfer via radiation.

Another way heat is transferred is by conduction. This occurs when two objects transfer thermal energy by physical contact. Different materials have different conduction abilities. Metals are very good conductors while wood, foam and rubber are poor conductors of thermal energy. Metal-framed windows can lose energy via conduction unless properly insulated. During construction, most modern homes often install insulation between the concrete foundation and the surrounding earth in an effort to decrease conductive heat loss. Single pane windows can promote conductive heat loss. Modern energy efficient double and triple pane windows are designed to decrease conductive heat loss from a home.

A final way heat can be transferred is by convection involving the transfer of thermal energy by flowing currents of air. Cold air pulled through an open window into a warm house is an example of convective processes. Infiltration of outside air is often a significant source of energy loss in a home. Older homes often can benefit from application of seals to windows, doors and vents in an effort to decrease convective heat loss.

ENERGY EFFICIENT LANDSCAPING

A home can often conserve energy by considering location and type of plants and trees that surround the building. Appropriate landscaping can save as much as 30 percent of the winter heating costs and as much as 50 percent of the summer cooling costs.

Strategically placed trees can provide shade in summer when the leaves are on the trees. Conversely when the leaves are down in winter, a summer shade tree will allow the Sun's energy to reach the home. Shrubs and bushes can be used to decrease convective heat loss by shielding the side of a home from the wind.

*For more information please refer to Grow Your Own Savings on the Youth Education website.*

ENERGY EFFICIENT APPLIANCES

Energy efficient appliances can help reduce the amount of energy used by a home. The cost of operating the appliance over its lifetime is as just as important as the initial purchase price. This information is provided as part of an energy guide label on the side of larger appliances. Another tip is to look for an energy star label. This identifies appliances that have been determined by the U.S. Environmental Protection Agency and the Department of Energy as being an energy efficient choice. Using fluorescent light bulbs versus incandescent bulbs can reduce home energy use by as much as 20 percent.

ENERGY SENSITIVE HOME DESIGN:

Many times energy can be saved by designing the home's basic layout with energy use in mind. For example, installing the hot water heater closer to the main bathroom will reduce heat loss from the water distribution system. Entryways can be designed with a foyer (small room) and a second door to reduce convective heat transfer when the large outside door is opened. Main living areas can be located in areas that receive favorable natural lighting. Central wood burning fireplaces can be designed into the main living room to provide supplemental heat. Rooms that receive only periodic use can be designed so they can be isolated from heating and cooling needs. Heavy ceramic tiles can be used along with thicker foundations to take advantage of the Earth's geothermal temperature stability. Such changes are often very difficult to "add on" to an existing home and are best applied as part of the initial building plans.

## PROCEDURE

**WARM UP**

Set the stage by asking the students:

- Can you guess how much your parents spend on heating and cooling your home?
- What resources and components are required to provide energy for your home?
- Brainstorm what an energy efficient home would look like.

**ACTIVITY**

Review with the class some basic approaches to energy efficient building designs. Divide the class up into groups. Assign each group the task of constructing an energy efficient cardboard home.

*The instructor can either assign each group a particular energy design (passive solar, earth-contact, energy efficient landscaping, and insulation approaches) or each group can work free form and create their energy efficient model home. The groups can also be allowed to research home designs on the web to generate ideas for their project.*

After the groups have completed their model home, they should prepare a brief oral presentation or a poster in order to explain to the rest of the class the energy saving approaches they utilized.

## ASSESSMENT

Instruct each student to adopt the role of an energy efficient architect. They should consider the various approaches to home design explored by the class and how these approaches could be incorporated into a modern home. The students should try to design a home that is both attractive and excels in conserving energy. The students should create a drawing of the home they have designed, along with a written explanation of the energy saving approaches they incorporated into their design.

## EXTENSIONS

Have the students construct a generic basic cardboard home and place a thermometer inside. Subject the home to a heat source (a lamp can be used) to model the solar input. The class can then systematically modify the structure with window awnings, darker or lighter roof, enlarged windows, shade from model trees, insulation or building orientation to the light source. Have the class measure the effects of each change on the temperature of the model building and discuss how the results can be used to design an energy efficient structure.

## GOING FURTHER

Contact a local architect and invite them to come talk to the class. Ask the architect to discuss the practical implications of the student's designs in terms of zoning laws, client expectations, construction cost, etc.

MISSOURI LEARNING STANDARDS: Grades 6-8 [K-5 Correlations]

**SCIENCE GRADE LEVEL STANDARDS:**

**Engineering, Technology, and Application of Science**

**ETS1 — Engineering Design**

**Concept A: Defining and Delimiting Engineering Problems**

- **6-8.ETS1.A.1:** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific principles and potential impacts on people and the natural environment that may limit possible solutions.

**Concept B: Developing Possible Solutions**

- **6-8.ETS1.B.1:** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.
- **6-8.ETS1.B.2:** Analyze data from tests to determine similarities and differences among several design solutions to identify the best characteristics of each that can be combined into a new solution to better meet the criteria for success.

**Earth and Space Sciences**

**ESS3 — Earth and Human Activity**

**Concept C: Human Impacts on Earth's Systems**

- **6-8.ESS3.C.1:** Analyze data to define the relationship for how increases in human population and per-capita consumption of natural resources impact Earth's systems. [Clarification Statement: Examples of data include grade-appropriate databases on human populations and the rates of consumption of food and natural resources (such as freshwater, mineral, and energy). Examples of impacts can include changes to the appearance, composition, and structure of Earth's systems as well as the rates at which they change.]
- **6-8.ESS3.C.2:** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment. [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

**Concept D: Global Climate Change**

- **6-8.ESS3.D.1:** Analyze evidence of the factors that have caused the change in global temperatures over the past century. [Clarification Statement: Examples of factors include human activities (such as fossil fuel combustion, cement production, and agricultural activity) and natural processes (such as changes in incoming solar radiation or volcanic activity). Examples of evidence can include tables, graphs, and maps of global and regional temperatures, atmospheric levels of gases such as carbon dioxide and methane, and the rates of human activities.]

**ENGLISH LANGUAGE ARTS STANDARDS:**

**Writing**

**1. Approaching the Task as a Researcher**

**A. Research [K-5 correlation W3A]**

- Conduct research to answer a question, drawing on several sources; integrate information using a standard citation system.

**Speaking and Listening**

**2. Presenting**

**A. Verbal Delivery [K-5 correlation SL4A]**

- Speak clearly, audibly, and to the point, using conventions of language as appropriate to task, purpose and audience when presenting including appropriate volume.

NGSS:

**MS-ETS1 Engineering Design**

- **MS-ETS1-1:** Define the criteria and constraints of a design problem with sufficient precision to ensure a successful solution, taking into account relevant scientific and principles and potential impacts on people and the natural environment that may limit possible solutions.
- **MS-ETS1-2:** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem.

**Earth and Space Sciences**

**MS-ESS3 Earth and Human Activity**

- **MS-ESS3-3:** Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.* [Clarification Statement: Examples of the design process include examining human environmental impacts, assessing the kinds of solutions that are feasible, and designing and evaluating solutions that could reduce that impact. Examples of human impacts can include water usage (such as the withdrawal of water from streams and aquifers or the construction of dams and levees), land usage (such as urban development, agriculture, or the removal of wetlands), and pollution (such as of the air, water, or land).]

**Science and Engineering Practices**

**Asking Questions and Defining Problems**

Asking questions and defining problems in grades 6-8 builds on grades K-5 experiences and progresses to specifying relationships between variables, and clarifying arguments and models.

- Define a design problem that can be solved through the development of an object, tool, process or system and includes multiple criteria and constraints, including scientific knowledge that may limit possible solutions. (MS-ETS1-1)

**Engaging in Argument from Evidence**

Engaging in argument from evidence in 6-8 builds on K-5 experiences and progresses to constructing a convincing argument that supports or refutes claims for other explanations or solutions about the natural and designed world.

- Evaluate competing design solutions based on jointly developed and agreed-upon design criteria. (MS-ETS1-2)

**Constructing Explanations and Designing Solutions**

Constructing explanations and designing solutions in 6–8 builds on K–5 experiences and progresses to include constructing explanations and designing solutions supported by multiple sources of evidence consistent with scientific ideas, principles, and theories.

- Apply scientific principles to design an object, tool, process or system. (MS-ESS3-3)

**Disciplinary Core Ideas**

**ETS1.A: Defining and Delimiting Engineering Problems**

- The more precisely a design task's criteria and constraints can be defined, the more likely it is that the designed solution will be successful. Specification of constraints include consideration of scientific principles and other relevant knowledge that are likely to limit possible solutions. (MS-ETS1-1)

**ETS1.B: Developing Possible Solutions**

- There are systematic processes for evaluating solutions with respect to how well they meet the criteria and constraints of a problem. (MS-ETS1-2), (MS-ETS1-3)

**ESS3.C: Human Impacts on Earth Systems**

- Human activities have significantly altered the biosphere, sometimes damaging or destroying natural habitats and causing the extinction of other species. But changes to Earth's environments can have different impacts (negative and positive) for different living things. (MS-ESS3-3)
- Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3), (MS-ESS3-4)

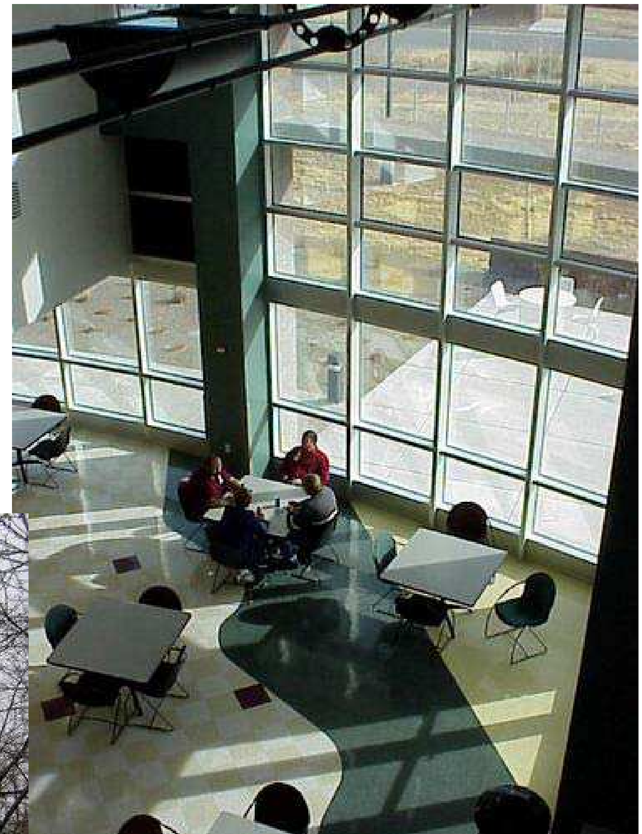
**Crosscutting Concepts**

**Influence of Science, Engineering, and Technology on Society and the Natural World**

- All human activity draws on natural resources and has both short and long-term consequences, positive as well as negative, for the health of people and the natural environment. (MS-ETS1-1)
- The uses of technologies and limitations on their use are driven by individual or societal needs, desires, and values; by the findings of scientific research; and by differences in such factors as climate, natural resources, and economic conditions. (MS-ETS1-1)

**Cause and Effect**

- Relationships can be classified as causal or correlational, and correlation does not necessarily imply causation. (MS-ESS3-3)



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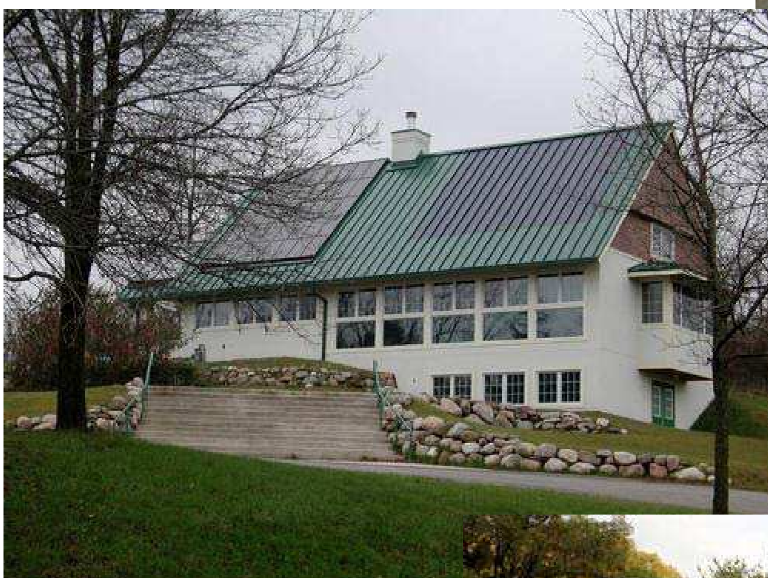

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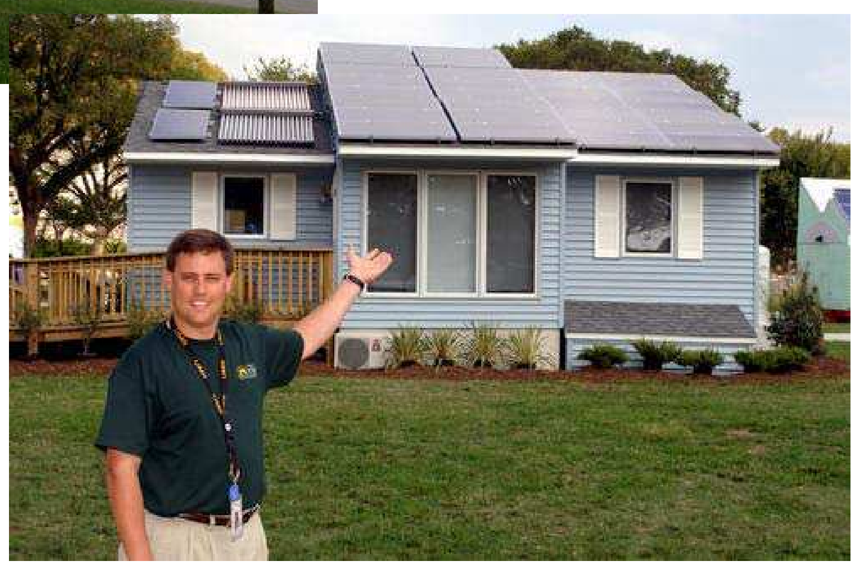

Showing off this Solar Decathlon home; University of Missouri—Rolla Image: Gretz, Warren

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