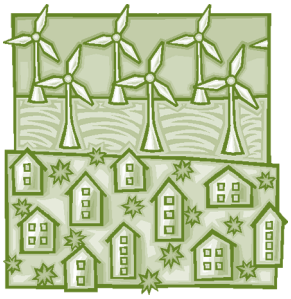


Green Home Design

Summary: Students design plans for a green built house.

Objectives

Students will be able to

- explain green building design;
- understand the four principles of green building design; and
- explain what components go into the design of a green home.

Rationale

Involving students in designing a model home allows them to relate renewable energy and energy efficiency concepts to a practical experience.

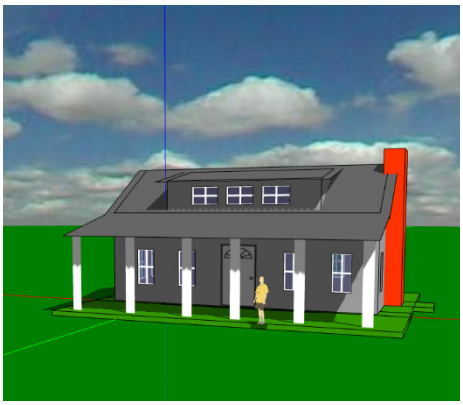
Materials

- Internet and resources on green home design (see **Resources** and the KEEP website)
- Copies of ***Green Home Design Project***
- Graph paper
- Writing utensils
- Computer with Computer Aided Design (CAD) software such as Energy3D, a free download available at http://energy.concord.org/energy3d/index.html.

Background

Over the past several decades, the average square footage of today's houses has greatly increased, while family size has decreased. In the 1950s, an average American family of six would fit into the space of today's family garage. Larger residential and commercial buildings affect land, water, air, and energy elements on which all living things depend for survival more than smaller buildings. Americans spend 90 percent of their lives indoors within built environments that contribute to increases in allergies and health issues. On a global scale, buildings affect the environment drastically; they use 40 percent of global resources, or 3 billion tons of raw materials, 25 percent of hardwoods, and 35 percent of energy resources annually. Of the materials used to manufacture a new building, about

Compare the designs of the home in winter (above) and summer (below) to see where the shadow falls on the house. Are there benefits to where the shadows fall?



30 percent end up as construction and demolition debris. Buildings create half of the global outputs of greenhouse gases.

The green building approach reduces the adverse effects of building construction. There are varying aspects and degrees to building "green." For example, green buildings include traditional and manufactured houses built with natural materials, as well as solar- and wind-powered homes. On the whole, green built houses are more energy efficient and healthy.

Energy use is one of many aspects considered in green home construction. Green homes can be powered with renewable energy sources such as passive and active solar, wind, or geothermal when

Grade Level: 9–12

Subject Areas: Family and Consumer Science, Mathematics, Science, Technology Education

Setting: Classroom or Computer lab

Time:

Preparation: One hour
Activity: Three to five 50-minute periods

Vocabulary:

Active solar, Energy analysis, Energy efficient design, Green building, Green design, Passive solar, Whole-building design

Major Concept Areas:

Theme III

- Quality of life
  - Lifestyles
  - Economic

Theme IV

- Management of energy resource use

Standards Addressed:

Wisconsin Model Academic:
FCS: C.3
MA: C.12.1, D.12.3
SC: A.12.5, G.12.1, G.12.3, G.12.4, H.12.5
TE: A.12.2, A.12.7, B.12.2, B.12.4, B.12.5, C.12.2, C.12.4, C.12.6, C.12.9, D.12.4

Common Core ELA: RI.9-12.4, WHST.9-12.1, WHST.9-12.7, WHST.9-12.9

Common Core Math: MP1, MP3, 7.G.1, 7.G.6, N-Q.1

NGSS: HS-ESS3-4, HS-ETS1-4 SEP: Constructing Explanations and Designing Solutions
DCI: ESS3.C: Human Impacts on Earth Systems
CCC: Stability and Change

practical. The places we live in rely on incoming energy to function. The majority of homes are connected to natural gas supply lines or LP tanks, the electric grid, water supply lines, and sewer systems. The energy efficiency of a home depends not only on the energy source a home utilizes, but ultimately on how the resources are used in the building envelope, mechanical equipment, and appliances once they reach the home. Green buildings can reduce energy use 50 percent over the state building code. Decreased energy consumption reduces use of fossil fuels and global warming contributions. One unit of electricity generated or saved by a green building prevents three or four units of fuel (often coal) from being burned at a power plant to generate electricity. An average green built home in America reduces CO_2 emissions by almost 90,000 lbs over a 30-year timeframe versus a standard-built home.

Energy is just one component of the principles of green design. See the ***Four Principles of Green Design***. This is not an exhaustive list; rather, it highlights some of the more important elements to consider when designing a green building. See the **Resources** section for additional comprehensive listings and rating systems.

Other components considered in green building include utilizing materials and furnishings intended to sustain the quality of the environment. Green homes are designed to assure a healthy indoor environment for their occupants. They typically have lower operating and maintenance costs. These factors combined result in a home that is better for the occupants and for the environment. Green buildings have fewer negative effects on the environment, on human health, and on our pocketbooks.

Procedure

Orientation

Ask students if they know of any homes in the community built to be resource and energy efficient. If so, ask them to list aspects of the home that they think are efficient or "green." Ask students if they have considered what their dream home may be like. Have them imagine the building's shape, location, including its orientation (North, South, East, or West), as well as its color, and surroundings (trees, other buildings, etc.). What ideas do they already have that incorporates "green" design? Will the home's energy bill be relatively high or low each month? Why? Are there features that make the home a healthy place to reside?

The term "dream home" may bring to mind a huge mansion for some, or a small cabin in the woods, or apartment condos for others. This activity will have you consider the environmental and health impacts of what it takes to build and live in your dream home. First, you will evaluate the principles of green design. Second, you will incorporate green design principles into your own green home design. Third, you will create the design of a green home using a computer-aided model or drawing and describe a model on paper. Not only will you get to sketch and see what your green home looks like, you will also estimate how much energy the home uses and/or generates using renewable energy.

Steps

1. Introduce the concept of green home design, discussing the ***Four Principles of Green Design***. Encourage students to research further into the green design principles by browsing the Internet and visiting the library. Explore terms used in the principles such as "active" versus "passive" solar and HVAC to ensure students understand the terminology and systems used in home building and operation. If possible, invite guest speakers, such as green architects, ENERGY STAR certified builders, Leadership in Energy and Environmental Design (LEED) certified consultants, or home energy auditors, such as those who provide Home Energy Rating System (HERS) scores, to share information with students on green design.

2. Tell students they are going to practice green home building design. Have students work in small groups, providing each group with a copy of ***Green Home Design Project***. Make sure students understand the assignment. NOTE: The activity involves students creating floor plans to illustrate their designs. If time and resources are available, students can build three-dimensional models.

3. Allow students one week to design their homes. Given the potential scope of this project, it might be wise to have students focus primarily on one component, such as energy efficiency and renewable energy. Continue to remind them, however, of the importance of all the principles including whole-building design. Have them support their design process with research from the Internet, library searches, and communications with home owners and designers. Visit the KEEP website for additional illustrations and links to green home design.

Closure

Have students share their home design and reasoning for site, product, and design decisions. Post the design principles on the board and have each group identify how their plans address the principles. Ask the class to assess the positive and negative aspects of each home. Ask the class to share their views about the importance of green home design.

Assessment

Formative

- Did the students incorporate green design elements, including energy efficiency and renewable energy components, into their home design?
- Have students list the principles of green home design.
- Can students explain the importance of incorporating the green design principles into home building?

Summative

Have students write a paragraph detailing what choices they made in their design that are essential to developing a green home. Give the students an example of a poorly designed home in terms of green building principles and have them suggest ways of improving the design.

Extensions

Have students modify their home design to provide all of the typical amenities of modern living (heat, electricity, hot water, etc.) but functioning as a completely off-grid unit. All electricity, heat and hot water must be produced or harvested on-site. Remind students to analyze appliances used, and the lifestyle changes they will need to make to adapt to the conversion. Have students give a detailed description of the systems they plan to use, the technology involved, and a discussion of cost relative to a conventional system.

Another extension is to have students analyze the home or apartment that they live in currently (See KEEP Activities "So You Want to Heat Your Home?" and "At Watt Rate"). What changes could be made to increase energy efficiency and sustainability at home? What lifestyle and economic requirements would these changes require?

Four Principles of Green Design

1. Design the building and orient it on the site with natural elements in mind to use:

- Prevailing winds (for natural ventilation)
- Solar access (for daylighting and passive and active solar design)
- Landscaping (e.g., trees that provide shade)
- The ground (e.g., building into hillsides, avoiding areas with heavy traffic)

2. Design for resource efficiency:

Water efficiency

- Water efficient site landscaping (e.g., use of native species, rain gardens, cisterns, green roofs)
- Indoor water use reduction techniques (e.g., appliances, fixtures)

Energy efficiency in the design

- Use renewable energy (e.g., solar electric, solar thermal, wind, geothermal, wood)
- Energy efficient design, construction, and mechanical and fixture choices (e.g., lighting fixtures, Energy Star appliances, HVAC, electronics)

Building materials efficiency

- Materials efficiency in design
  (1) Minimize the building's footprint (avoid redundant spaces like having both a formal living room & family room)
  (2) Avoid use of excessive or superfluous building materials
  (3) Maximize the building's insulation level while still providing healthy air exchange with the outdoors
- Locally or regionally extracted materials (rather than importing from environmentally sensitive or endangered regions of the world)
- Renewable, reused, recycled materials, ENERGY STAR appliances

3. Create a healthy home:

- Non-toxic materials and finishes (e.g., glues, paints, cleaning products, non-absorptive materials such as hard surfaces versus carpet)
- Design for proper ventilation
- Design for maximum human comfort. Consider light or paint colors that create the environment you want through the day. Consider landscaping or locations that would support human preferences (this will differ by person).

4. Take an integrated "whole-building" design approach:

Whole-building design considers all construction components during the design phase. It integrates how all the subsystems and parts of the building work together to save energy and reduce environmental impact. This whole-building philosophy considers site, energy, materials, indoor air quality, acoustics, natural resources, and their interrelation. For example, a building that uses daylighting techniques will not need as much artificial lighting, reducing the amount of heat given off by light fixtures, resulting in the need for a smaller air conditioning system.

Green Home Design Project

Project Guidelines

You have two options for designing your green home: drawing floor plans on graph paper or using a computer-aided design (CAD). Follow the appropriate directions according to the option you choose or are assigned.

On paper:

1. Indicate which direction your graph paper is oriented by drawing an arrow and indicating which direction is north. Indicate if there are trees, buildings, or other landscape features surrounding the home.
2. Draw building plans on graph paper including a scale of measurement, the height and length of each wall, window, and door. Include a drawing of floor plans that include room identification, permanent fixture identification, and square footage for rooms and the whole house. Indicate where renewable energy systems may be located.

Computer-aided design:

1. Use a computer software program that shows the building's orientation to north. The software should show the trees, buildings, and other landscape features surrounding the home.
2. Using computer software to design walls, ceiling, windows, doors, and renewable energy systems showing the dimensions (length, height, etc.) of each.

Both the paper and computer models need to include the following:

3. Notes on how your design addresses the following green design principles:
   - Consideration for the natural elements of the building site
   - Resource efficiency, including energy (see #4 below)
   - Promoting healthy living
   - Whole-building design
4. Below is a limited list of energy design considerations. Note how you might use these or other energy efficiency and renewable energy components in your home. Include definitions and information about each component and how it is integrated, used, or built into your home.

Selected Energy Efficient and Renewable Energy Design Considerations

Photovoltaic solar panels	Heating, cooling, and ventilating systems
Energy efficient lighting options (ENERGY STAR® qualified LEDs)	Energy efficient appliances & electronics (ENERGY STAR qualified)
Passive solar design	Masonry stoves
Window design, type, and orientation	Low VOC furniture, paint, and carpet
Insulation & R-value	

5. Put together the following as a portfolio of your full design:
   A. Either a paper or CAD representation of your home's design. The design must show:
      1) The home's location (city, state or province (if applicable), and country)
      2) Orientation of the home
      3) Representation of the home. In other words, show what the home looks like.
   B. List of the components that make your home green. Describe each component.
      1) What materials are used for the walls and roof? Are they "green" materials? If yes, why?
      2) What appliances are used in the home? What may or may not make them "green" appliances?
      3) What paints, carpeting, furniture, and other fixtures are used in the home? What makes them "green?"
   C. (Optional) List the costs associated with the building and its operation.
      1) What are the construction costs? Did the "green" components costs differ from conventional building materials?
      2) Do "green" appliances cost more?
      3) What are the energy costs, or costs to heat the home and provide electricity each year? Are your "green" home's cost of energy different than a conventional home's cost of energy?