

Home Sustainable Home: Green Building and Design Alternatives

Unit Overview

This unit is designed to give students an understanding of some of the environmental impacts of building design and introduces strategies for making built spaces more sustainable. Students will learn how building construction and design can mitigate environmental impacts of development while meeting human needs for health, comfort, functionality, affordability and beauty. The activities in this lesson are designed to help students recognize and evaluate green building elements, and to challenge students to consider how these elements impact the affordability and functionality of homes and other built environments.

Using the Unit

Students begin this unit by reading an essay that outlines some core concepts behind the creation of sustainable built environments. They learn about a series of green building objectives and some specific actions that can be taken to meet them. Students will then use this information to complete an activity in which they “shop around” for a home -



weighing cost, sustainable features and other desirable traits in their decision. In the final activity, students learn about the economic concept of “discounting” by examining tradeoffs between investing in the present to gain future benefits and saving money in the present. Students will consider how the achievement of sustainable development goals may be affected by how much a society discounts future benefits.

Grade Levels: High School (9-12)

SOLS: Earth Science 7; Land Science 12

Skills: comparing, planning, analysis, evaluating

Key Terms/Concepts: discounting, green building, tradeoffs

Background for Teachers

“Green building” is one solution to the dilemma of our increasing need for built environments to accommodate population and economic growth while minimizing harm to the natural environment. The essay included in this lesson outlines the general principles of green building and posits solutions that further these goals.

For green building to contribute to global sustainability it must be adopted on a large scale. This brings up questions of equity and affordability. If green building practices are more costly than conventional building practices, but are required by law, will poorer members of the community get “left out in the cold”? How can green building be made affordable? One way is for homeowners to trade off up-front costs on their home against future savings over the life of the home through savings on energy bills and maintenance costs. This poses a question: are people willing to pay more today for benefits that they will reap in the future? This question is vital, not only for the potential success of green building solutions, but also for many of the general goals of sustainable development and natural resource management. A society that values present rewards more heavily than future ones will be disinclined to change practices and policies so that more sustainable outcomes may be achieved.

Unit Context

In the context of our Hard vs Soft Green Framework (see Chapter 2), some Hard Green enthusiasts advocate that the key to a sustainable future lies in the use of technology to produce more energy from our natural resources base. Conversely, Soft Green thinkers focus on consuming less energy by incorporating principles of “natural capitalism” such as “biomimicry”- designing materials like windows and roofs with some organic compounds that are resilient to heat and stress, yet water and sunlight permeable where helpful. Perhaps they are both right?

Learning Objectives

- Explore building and development techniques that minimize environmental impacts.
- Analyze tradeoffs between green building objectives and affordability in choosing a home.
- Utilize the economic concept of discounting to consider how individuals and society trade off current benefits against future ones.

Materials

- Copies of Green Building and Development: Creating Sustainable Spaces (GB 1-5)
- Copies of Handouts for Activity A: Each student should receive copies of the three different “Home Profiles” (GB 6-8) and one copy of the Home Buyer Ranking Sheet (GB 9)
- Copies of How Much Do You Discount the Future? (GB 10)

Procedure

Activity A:

1. Begin the lesson by having students read the handout [Green Building and Development: Creating Sustainable Spaces \(GB 1-5\)](#) which outlines the need for and principles of green building and design. Discuss.

2. Give students the handouts for [Activity A \(Home Profiles \[GB 6-8\] and the Home Buyer Ranking Sheet \[GB 9\]\)](#). Explain that they can use the information given in the essay to help them complete this activity. In Activity A, students are to simulate being in the market for a home. Their real estate broker has given them descriptions of three different homes for consideration. Students are to read these descriptions carefully and use the ranking sheet to help them evaluate the relative merits of each home. The ranking sheet encourages awareness of qualities of sustainability in each of the homes presented. Students should recognize that there is no “right answer” to this exercise. They



They should correlate the information given in the essay with information in the handouts to evaluate the presence or absence of green building elements. Students should be reminded that they are not expected to have a thorough understanding of the building elements presented and that they should use their own values and desires as well as the information available to them in the essay in their home selection process. It is useful for students to recognize that homebuyers must weigh many different factors in making their choices. A “green” home that does not meet other important needs for location, livability or affordability will have a hard time competing in the market. It is also important to note that the average homeownership is 5-7 years, thus there may not be sufficient time to recoup all of the costs of the initial investments through savings in energy bills and such. However, when it comes time to sell the house, the “green” features may add value to the home and make it more marketable and desirable. In addition, some communities feel that many “green” features are important on a societal level as well as a personal level and thus offer

tax incentives to encourage homeowners to install them.

3. When students have completed their evaluations and have ranked their preferences, have them share their choices and reasons for making those choices with the class. If they chose one of the homes with few green features, what were their major reasons for doing so? What qualities would a green home have to contain to make it a desirable choice for that individual? In a class discussion, have students extrapolate their choices to the larger market. Did this exercise tell them anything about opportunities and challenges for green building principles becoming widespread?

Activity B:

1. Begin the activity by introducing the concept of tradeoffs between present benefits and future ones. For example, would you be willing to pay more for a house today if you knew that the extra money you spent would come back to you in the form of savings on utility bills over the years? Giving up things in the present affords you benefits that accrue slowly and extend far into the future. However, this limits what you are able to spend on other things now and the secure nest egg in your pocket. For some people this represents a difficult sacrifice, for others it represents a minor one, or none at all.

2. Handout *How Much Do You Discount the Future?* (GB 10). Explain that the table represents five different scenarios illustrating tradeoffs between short term and long term benefits. Each row represents additional investment in a \$100,000 home to increase its energy efficiency. The cells to the right represent the amount paid by the homeowner over time in energy bills. Have students answer the questions at the bottom of the handout. Ask each person in the class to carefully evaluate which case they would choose for themselves based upon how they

personally value savings in the present over the possibility of savings in the future.

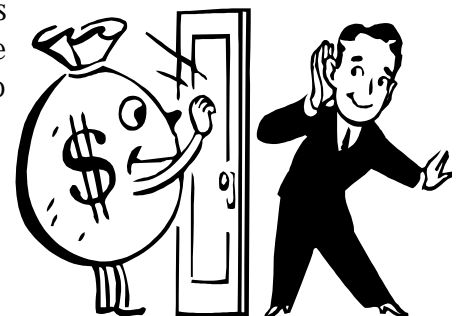
Remind students of what can be purchased with \$500, \$2,000 or \$6,000 in the present. By putting these dollars into increased energy efficiency, they are perhaps giving up new furniture, a television or stereo system for the home in the short term.

Tabulate the results on the board and explain that this information represents the classes collective discount rate on future benefits. If the majority of the students chose case A or B then the class has a high discount rate. If more people chose options C or D, they have a lower discount rate.

3. Explain the concept of “discounting” to students.

We attempt to measure how people value present vs future tradeoffs, as individuals and as a society, using the concept of discounting of future benefits. When someone values present gains much more than future ones, we say that they have a high discount rate ($> 10\%$) because benefits that accrue today are more desirable than those which are expected to come back to us in the future even with added benefits. A high discount rate for an individual (or society) may come from a “live in the moment” mentality where the future is left to take care of itself. It may also be influenced by uncertainty about the future and a lack of trust that future benefits will actually be realized.

If a person is willing to sacrifice short term gains for anticipated long-term payoffs they are said to have a low discount rate ($< 10\%$) on future benefits. This person tends to believe that some sacrifice or investment in the present is worthwhile in order to reap future benefits. Like the ant in the



tale of the grasshopper and the ant, they do not trust that the future will take care of itself. They tend to believe that future gains are a direct result of actions taken in the present. They also trust that present investments will actually pay off in the future.

Enrichment:

Discuss the following with the class:

The concept of discounting has important implications for sustainability. Many of the objectives of sustainable development require that we have low “social” discount rates. It means, hopefully, that we are willing to take actions as a society that may seem difficult today for the sake of preserving natural resources and the environment for future generations.

If students had to guess at the United States’ social discount rate, would they assume it to be high (> 10%) or low (< 10%)? Why? What evidence exists to support their assumption? Are our values as a society conducive to achieving sustainability? If not, how can a nation of 280 million people collectively lower their social discount rate so that sustainability might be an achievable goal? What types of things might encourage such change?

Resources

American Institute of Architects., *Environmental Resource Guide* (John Wiley and Sons), 1997.

Hawken, P., *et al.*, *Natural Capitalism: Creating the Next Industrial Revolution* (New York: Little Brown & Company), 1999.

Johnston, David., *Building Green in a Black and White World* (Washington D.C.: Home Builder Press, National Association of Homebuilders), 2000.



Lstiburek, Joseph., *Energy efficient Building Association Builder’s Guide: Mixed Humid Climates* (St. Paul, Minnesota: Energy Efficient Building Association), 2000.

Wilson, Alex. “Inexpensive Strategies for Green Building,” *Fine Homebuilding*, 92-97. Vol. 2000.

Center of Excellence for Sustainable Development www.sustainable.doe.gov

Energy Efficiency and Renewable Energy Network www.eren.doe.gov

Energy Environmental Building Association www.eeba.org

Environmental Building News. www.buildinggreen.com

EPA’s Energy Star Program www.energystar.gov

Green Building Resource Center www.greendesign.net/gbrc

Oikos Green Building Source www.oikos.com

Rocky Mountain Institute www.rmi.org

Renewable Energy Policy Project www.crest.org

Sustainable Buildings Industry Council (SBIC) www.sbicouncil.org

United States Green Building Council www.usgbc.org

Governor’s Green Government Council www.gggc.state.pa.us

Southface Energy Institute www.southface.org

Green Building and Development

Creating Sustainable Spaces



What's the Problem?

The built environment is an essential part of our lives, necessary to provide spaces to live, work, play, shop and learn. However, the design, construction, maintenance and operation of our built environment have a tremendous impact on the natural environment and resource base. Already there are more than 76 million residential buildings and 5 million commercial buildings in the U.S. and 38 million more will likely be constructed by the year 2010.

Traditional building practices often overlook the interrelationships between building and the environment. A standard wood-framed home consumes over one acre of forest and the global building industry accounts for almost one half of the world's demand for wood. Run-off from roads and built landscapes is a major source of water pollution. Heating, cooling and providing electricity to buildings contributes significantly to air pollution and accounts for more than one third of the world's energy consumption. Buildings account for 40% of our consumption of raw materials like copper, steel and plastics. The standard wood-framed house creates an average of 3-7 tons of waste created during construction. Homes, roads, office complexes, shopping malls and parking lots are creeping across the landscape at ever-increasing rates, consuming land that was previously farm, forest or open space.

"Green Building" as a Solution.

The good news is that a range of new solutions and techniques are being developed which lessen environmental impacts of building and development. These techniques come under a wide umbrella often termed "Green Building Practices". They encompass strategies that:

- improve energy efficiency in homes,
- reduce consumption of raw materials,
- better manage water resources,
- better preserve open spaces,
- minimize production of waste from construction,
- make buildings which work with the natural elements of their immediate environment.

Examples include: Taking maximum advantage of sunlight to heat and light homes, reducing unnecessary land disturbance, working with the landscape to minimize threats to soil and water quality and protecting ecological diversity.

According to Roodman and Lessen of the World Watch Institute, sensitive design using available technologies in the US could cut total energy use by 60% percent in commercial buildings. Paul Hawken, in "The Ecology of Commerce", states that residential energy conservation with ceiling insulation and double-glazed windows can produce more oil than the Arctic National Wildlife Refuge at its most optimistic projections, at about 5% of the cost, simply through cutting down on wasted energy.

Green Building and Development

Creating Sustainable Spaces

Basic Principles of Green Building:

It is important to recognize that there is no universal formula for building green. What can be considered “green” depends heavily on climate, vegetation, availability of local materials, relative costs and an array of other factors.

There is often debate about which building practices are in fact “more green”. Is it more ecologically sound to use a recycled plastic carpet, which is produced from waste but must be land filled eventually, or to use wood floors, which can be expected to last longer and come from a renewable resource, but require cutting down trees? The answer is not always clear.

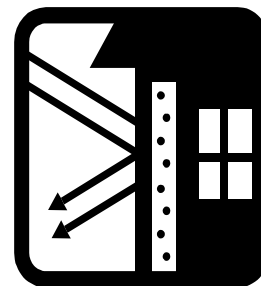
Although techniques may differ, there is a general agreement about the goals of building green. The goals of green building are to increase the overall efficiency, energy and otherwise, of buildings, cut down on the consumption of raw materials, use land, soil and water resources sparingly and efficiently and minimize the creation of waste from construction. All of these factors combine to lessen the “ecological footprint” that built spaces create.

Achieving the Goals:

The following are green building techniques often put into practice to meet the overall goals.

- **Maximize Energy Efficiency**

- Design buildings from the outset to maximize energy efficiency, especially in heating and cooling, rather than trying to make a structure energy efficient after it is built.
- Build a “tight” house that has few if any air leaks and provide for a mechanized ventilation system to allow for adequate air circulation.
- Use energy efficient appliances such as those certified as “energy star” by the US Department of Energy.
- Consider use of alternative heating/cooling such as geothermal (ground based) systems or radiant floor heating.
- Use well-sealed, energy efficient windows and insulated doors.
- Orient and construct buildings to take advantage of natural lighting and passive solar heat gain in winter.
- Use vegetation to provide shade and cooling in summer.
- Build close to work, shopping and other activities to minimize driving and therefore gasoline consumption.



Green Building and Development

Creating Sustainable Spaces

- **Use land resources efficiently and ecologically.**
 - Avoid sprawl in designing building sites. Cluster buildings or build “up” instead of “out” to preserve open spaces.
 - Build in areas that are already impacted by development, filling in vacant spaces where possible, tearing down deteriorating buildings and replacing them with new ones or renovating older buildings that are still structurally sound.
 - Revitalize abandoned areas or “brownfields” such as warehouse districts, old industrial centers, abandoned lots etc. with new building that makes the area functional once again.
 - When building on a previously undeveloped site, identify and protect natural amenities such as wetlands, streams, forested areas and zones of ecological diversity.
 - Protect the soil when building by avoiding steep slopes, providing ground cover, preserving and replacing topsoil when grading.
- **Efficient and Innovative use of Materials**
 - Build small, using good design to maximize comfort and usefulness of spaces. Smaller buildings require less material to build (and heat!).
 - Use environmentally friendly materials such as recycled content decking, carpets, countertops, roofing tiles, certified sustainable lumber, cellulose insulation, engineered lumber, low VOC paints, etc.
 - Use good design to allow builders to do more with less material.
 - Use long lasting materials that are of high quality so that they will not have to be replaced or repaired often.
 - Design buildings to suit standard dimensions of common building materials so less waste is produced.
 - Use building materials that can be re-used or recycled after the end of the useful life of the building. These include metal roofs, good quality wood flooring, paving stones etc.
- **Minimize Impacts on Water Resources**
 - Install low-flow showerheads, faucets, toilets and other appliances in the home.
 - Use drought tolerant, low maintenance, low pesticide landscaping.
 - Decrease the amount of paved surfaces by cutting down on asphalt roads, driveways, parking lots etc.
 - Take advantage of natural rainfall by collecting roof runoff for yard and other outdoor applications.

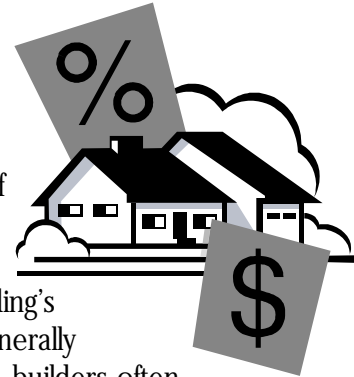


Green Building and Development

Creating Sustainable Spaces

But What about Affordability?

Employing the elements listed above will lead to buildings that are much healthier for the environment. But can people afford to build and buy them? This is one of the biggest questions facing builders and buyers who would like to create buildings that are green. It has generally been considered true that building “green” will increase the initial costs of construction a minimum of 5 percent above the cost of conventional construction.



One factor that offsets increased initial costs is the savings a building's occupant will reap over time from decreased energy bills and generally lower costs of repair and maintenance. In spite of these savings, builders often feel that it is too risky to build houses that cost more than typically constructed ones when most of the improvements are hidden from the eye of the buyer. In addition, most homeowners move every 5-7 years making it difficult to recognize the full benefits of the green features. However, this can be offset by a higher market value when they decide to sell and tax incentives for green features given by local and state governments. For green buildings to truly achieve sustainability, they must also be considered affordable, or few people will buy them.

Some builders are beginning to find creative ways to meet this challenge. Gabriel Enterprises in Newport, Virginia has developed several affordable-home communities that feature their “Healthy-E” homes. These homes sell for the same price as conventional homes but are designed to use 50 percent less energy than conventional homes and meet indoor air quality standards set by the American Lung Association. They were able to keep costs down through careful planning and some give-and-take in design, according to company president Jay Epstein. For example, the dense cellulose insulation in the walls costs 30 percent more than conventional fiberglass insulation, but this was compensated for by design that allowed non-weight bearing walls to have studs that were 24 inches apart instead of 16 inches, requiring less wood.

Another example of affordable green building is the Erie-Ellington Homes of Boston Massachusetts. The homes were built in a run-down section of the city but feature state-of-the-art “EcoDynamic” energy and environmental technologies that were developed by the GreenVillage Company. These include energy-efficient panelized construction, a “tight” building envelope to promote comfort and durability, high quality materials such as energy-saving windows, EPA Energy Star rated appliances and natural linoleum floors. These measures are expected to save 50% annually on overall energy use as compared to standard homes, and 46% annually on total operating expenses for water, electricity, and heat. The builder managed to include these improvements and still keep building costs at \$95 per square foot, which is standard for conventional homes.



Green Building and Development

Creating Sustainable Spaces

Conclusion

Creating and maintaining built spaces will always have some impact on our natural environment, but changes in the way these spaces are designed and built will allow for a softer “ecological footprint” which meets human needs while minimizing pollution and impacts on land, water and other natural resources. The sooner these changes become affordable and widely demanded, the greater the potential for sustainable outcomes in the United States and around the world.



HOME 1: Suburban Colonial



FACTS AND FIGURES:

Windows Standard double paned storm windows. Large picture window in family room facing north.

Siding Mix of PVC vinyl siding and brick foundation.

Roof Dark gray fiberglass shingles.

Paved Surfaces 15 foot wide asphalt drive way leading to three car garage.

Heating/Cooling System

Gas furnace, forced air heating and cooling system using duct work to distribute warm air through house. House is built with standard insulation package. No mechanical ventilation system is used since there is enough air exchanged through “natural” air leaks in structure.

Average Annual Energy Consumption

Average electricity and gas bills amount to about \$180 per month. Fuel used in automobile commuting is high since little in the way of shopping, school, or work places are closer than a 10 minute drive.

Appliances Standard appliances installed.

Landscaping Majority of parcel is in lawn grass. Small stand of trees near fence line to east of home remain, and several saplings were planted in yard after construction to provide beauty and shade after they grow to maturity.

Waste from Construction

4.5 tons of construction waste produced in creation of this home. All waste was land filled.

HOME 2: State of the Art Townhome



FACTS AND FIGURES:

Windows

Energy efficient windows. More windows placed on south side to take advantage of passive solar heat gain in winter.

Siding

Brick and cementitious fiberboard (An alternative to wood and vinyl siding which, uses less wood, has a long life and requires minimum maintenance).

Roof Fiberglass shingles (30 year life)

Paved Surfaces Stone path from parking to front door, brick patio in back of home.

Heating/Cooling System

The house was designed with extra insulation – cellulose insulation from recycled materials instead of fiberglass, and “tight” construction that allows very little leakage of heat or air. A mechanical ventilation system was installed to ensure adequate air exchange for health without loss of heat. Heating and cooling provided by most efficient electric heat pump available.

Average Annual Energy Consumption

Average electric bills work out to about \$55 per month. Automobile fuel consumption is typically minimal given proximity to public transportation and shopping near by.

Appliances Energy-star rated appliances installed. All showerheads are low-flow.

Landscaping Minimal landscaping due to small front yard and fenced-in back yard. Back yard vegetation is hardy and low maintenance.

Waste from Construction

Waste from construction was minimized by planning construction of many similar town-house units simultaneously. Design of homes took advantage of typical building material dimensions wherever possible.

HOME 3: Rural Retreat



FACTS AND FIGURES:

Windows

Energy efficient windows. Large ones on south side of home for passive solar heat gain, smaller ones on other sides of house.

Siding

Certified sustainable wood siding (Internal structure also made from certified sustainable lumber.)

Roof: Long lasting metal roof.

Paved Surfaces Parking area made from porous paving, gravel drive from main road.

Heating/Cooling System

Ground-based geothermal heating and cooling system. Natural cooling in summer from shade trees. Ceiling fans installed in several rooms. Solar cells provide water heating and generate part of the home's electricity.

Average Annual Energy Consumption

Monthly electric bills average \$15/month. House is located a 15 minute drive from the nearest shopping area and a 45 minute commute to the nearest downtown area.

Appliances

Appliances such as refrigerator, stove, lights and washers are all "Energy-star" rated as the highest energy efficiency levels. Low flow shower heads are installed as well as low-flow toilets and washing machine.

Landscaping

Natural, low maintenance landscaping, drought tolerant plants, requiring minimum pesticide and herbicide usage. Trees planted to promote cooling of house in summer. Small wetlands preserved and enhanced on site.

Waste from Construction

By chipping and composting wood waste and through careful planning during construction, construction waste was reduced by 20% over typical levels.

Home Buyer Ranking Sheet

You are in the market for a new home. In each category rank the three homes featured on a scale of 1-5. Your final preference need not reflect the home that ranks the highest in total points. Instead it should reflect the home that you would be most likely to choose for the reasons that YOU consider most important.

RANKINGS

	Home 1: Suburban Colonial	Home 2: Town Home	Home 3: Rural Retreat
Aesthetics/ Attractiveness:			
Affordability:			
Energy Use:			
Land Use:			
Materials Use:			
Water Use:			
Preference:			
TOTAL			

1. What factors most influenced your home choice?
2. Which green elements, if any, exhibited in any of the featured homes or in the essay would you consider important in buying or building your own home? Why?



How Much Do You Discount the Future.... Pay Now or Pay Later?

The following table illustrates the concept of discounting by representing tradeoffs between extra money spent on energy efficiency in a home's construction and savings in energy bills over time. Which of these scenarios would YOU choose if faced with these options?

Assume a base price of \$100,000 for the home. The following figures represent additional up front expenditures to increase energy efficiency of the home and the correlated expenditures on energy bills over time.

Additional Investment in Home

Construction on

Energy Efficiency

Energy Bills Over Time:

Year:	1	2	3	4	5	6	7	8	9	10
A \$0	\$2,400	\$2,400	\$2,400	\$2,400	\$2,400	\$2,400	\$2,400	\$2,400	\$2,400	\$2,400
B \$500	\$2,300	\$2,300	\$2,300	\$2,300	\$2,300	\$2,300	\$2,300	\$2,300	\$2,300	\$2,300
C \$2000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000	\$2,000
D \$6000	\$1,200	\$1,200	\$1,200	\$1,200	\$1,200	\$1,200	\$1,200	\$1,200	\$1,200	\$1,200

Note that in reality several conditions presented in this table would not likely hold true:

1. Energy prices will tend to fluctuate over a ten year period – not remain constant as shown.
2. All dollars spent on increased energy efficiency are not created equal. Simply spending more money does not guarantee a certain decrease in energy bills over time. Some high-impact improvements may be low cost and some low-impact improvements may have a high cost.

1. How many years in each case does it take to “pay back” the initial investment through savings in energy bills?

2. How much money is saved in energy bills over 10 years in cases B, C and D?

3. Based upon how YOU value savings now vs. savings in the future, which scenario would you choose?

