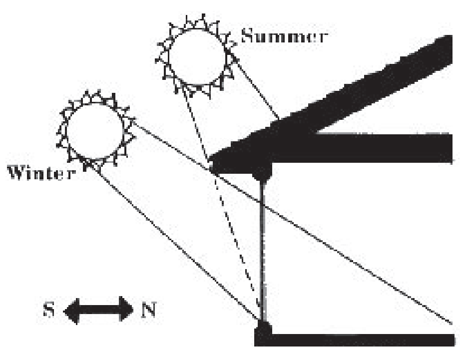
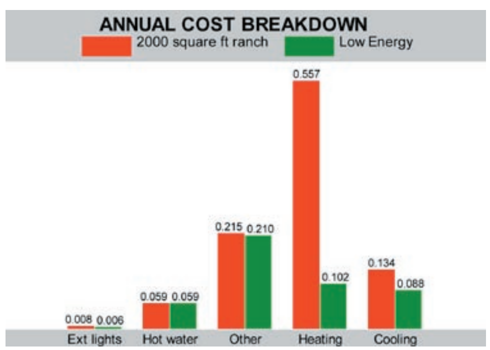
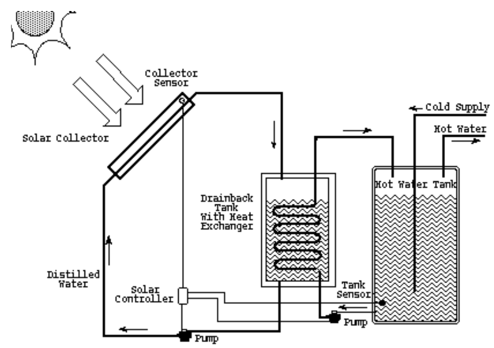
Sustainable Building Methods



Passive solar design (Northeast Sustainable Energy Association 2000).



Modeling energy savings.



A solar water heating system (City of Austin's Green Building Program 1994).

Sustainable Building Methods

Introduction and Background

The roles that buildings play in modern society are as diverse and profound as the persons that use them. It is important to recognize that buildings significantly impact human comfort, productivity, efficiency, and the social legacy and environmental footprint future generations will inherit. Maximization of all these outcomes requires serious study. Through the use of comparative analysis of various building types, using a "whole-building design" approach, many inefficiencies can be minimized, overall comfort can be enhanced, many environmental and economic costs can be reduced, and property value can be increased (Cohen-Rosenthal, et al. 2000).

Whole-building design views buildings as integrated systems of interacting components. This analytic approach offers opportunities for developers, builders, consumers, governments, and the general public to analyze and evaluate the relative effectiveness of various building materials, construction techniques, operating procedures and fates of the materials when the building is ultimately retired (Cohen-Rosenthal, et al. 2000).

This section focuses primarily on the fundamental concepts of resource efficiency and sustainable design. After a brief discussion of building standards and green building certification opportunities, energy and water efficiency and construction technologies for new buildings are detailed. Key passive and active architectural design concepts that may be appropriate for the Joint Planning Area are then identified. Examples of how these and other technologies have been applied are provided with a series of case studies, including payback potential. Finally, primary opportunities for energy efficiency are illustrated for residential and commercial applications with a computer modeling program.

Since financial considerations play a paramount role in any proposed development potential marketable points and environmentally responsible savings ideas are identified throughout this section. Considering that technological advances in products and design methods continually expand the consumer market for sustainable buildings, making many options more widely available and more affordable, continued education and networking is strongly encouraged. For a list of contacts and resources, see Appendix C.

Standards and Certification Options

Standards and certifications are established by various types of entities. In the State of Wisconsin, for example, the Bureau of Safety and Buildings, in the Department of Commerce, is responsible for development and delegation of enforcement responsibility for building codes affecting both residential and commercial development (Wisconsin Department of Commerce 2004). For one and two family residences, uniform dwelling code regulations are covered under Wisconsin Administrative Code Comm 20-25. Commercial buildings in Wisconsin are subject to Comm 61-65. Within these sections of the Code, Comm 22 and Comm 63 specifically address energy conservation measures in residential and commercial buildings, respectively (Wisconsin Department of Commerce 2004).

There are several independent certification programs that develop standards and promote the idea of going beyond minimum building standards to implement construction practices related to sustainable design. Two certification programs promoting higher standards are the Leadership in Energy and Environmental Design (LEED) Standards program and the Green Built Homes (GBH) program.

The LEED program, developed by the U.S Green Buildings Council (USGBC), is a voluntary rating system, that provides a national standard based on consensus for developing high-performance, sustainable buildings (USGBC 2001). Points are earned by implementing a variety of building techniques and incorporating various materials and concepts into the final design. Main topics of interest include the sustainability of the site choices, water efficiency, energy efficiency, material choices, indoor environmental quality, and innovative design ideas.

The Wisconsin Green Building Alliance (WGBA), an affiliate of USGBC, offers local resources for the LEED program. Through their affiliate status, USGBC and WGBA develop joint projects and relationships, promote shared goals, advance green building in the marketplace, optimize resources, avoid duplication, and provide support to businesses and individuals interested in sustainable building practices (WGBA 2004).

The GBH program works similarly to the LEED program in that it is a voluntary green building initiative. GBH was founded in 1999 by the Wisconsin Environmental Initiative (WEI) in partnership with the Madison Area Builders Association. The program provides reviews and certification of homes that meet sustainable building and energy standards (WEI 2004).

LEED and GBH certification are desirable because participants can establish recognition in the green building sector, promote whole-building design practices, raise consumer awareness of green building benefits, help developers and consumers qualify for a variety of state and local government incentives, and market their green building knowledge base to an expanding base of interested consumers (USGBC 2001).

General Conservation Techniques

The layout and design of a building and grounds has an impact on energy and water consumption. A well-planned site will preserve much of the natural vegetation, increase the energy efficiency of the building, and reduce the amount of storm water leaving the site. In addition the amount of excavation required can be reduced, thus reducing construction costs and environmental impacts of the construction process. A comprehensive site design can save money and increase the appeal of a property (National Association of Home Builders 2002).

One goal of resource efficiency is to decrease utility bills, but the ultimate goals are to save energy and reduce pollution (Anderson 1995). According to one estimate, buildings consume more than half of America's primary energy (Cohen-Rosenthal, et al. 2000). In northeastern Wisconsin, home and business owners are often concerned about the costs of heating and cooling throughout the year. Wisconsin weather can be extremely cold from October to April, with temperatures consistently below freezing. In addition, summer temperatures in Wisconsin rise above 90°F (Wisconsin Climate Information 2003). People buying or developing new buildings have a choice: they can pay high energy bills because of inefficient design and appliances or implement a higher efficiency option, which could have a higher upfront cost but will lead to long-term savings.

By implementing efficient technologies that save water and energy, developers, homeowners, and businesses can protect the environment while saving money. Every kilowatt (kW) of power that is not consumed reduces energy bills and decreases the amount of carbon dioxide and other pollutants released into the environment during the generation process. Each gallon of water that is conserved can help protect sensitive environmental areas, such as wetlands and streams, reduce the amount of energy required to clean the water, and lower water and sewage bills. Greater resource efficiency, in the form of energy and water conservation, results in cost savings, more so when several technologies are used in conjunction with each other (Anderson 1993). Table 3.1 shows the average energy savings

Table 3.1. Cost-Effective Energy Saving Potential (modified from Geller 2003).

Sector	End Use	Energy Savings Potential (%)
Residential	Lighting	53
	Refrigeration	33
	Water heating	23-28
	Space heating, new homes	19-39
	Space heating, existing homes	11-25
	Space cooling	16-23
Commercial	Space heating	48
	Space cooling	48
	Refrigeration	31
	Lighting	25
	Water heating	10-20

potential from implementing technologies that were commercially available as of the late 1990s. The savings result from using energy-efficient, new technology rather than nonenergy-efficient/conventional, new technology (i.e. a new, highly-efficient refrigerator will provide 33 per cent potential energy savings over a new, conventional refrigerator).

Residential Energy Efficiency

One significant area of energy use is residential buildings. According to the Rocky Mountain Institute (RMI), the average American family spends approximately $1,500 a year on utility bills (Rocky Mountain Institute 2004). The energy provided to these American homes alone costs over $110 billion a year. The typical, American home produces 25,000 lbs. of carbon dioxide and 113 lbs. of sulfur dioxide emissions annually, through direct consumption of electricity and heating fuels (Yoon et al. 1994).

Homeowners can reduce energy consumption by engaging in simple home maintenance tasks, sound conservation procedures, and wise investment decisions. For example, homeowners can insulate water heaters, repair leaky faucets and toilets, seal windows, and install insulation in attics and walls. According to the Rocky Mountain Institute (2004), homeowners can also conserve energy and reduce utility bills by such practices as turning down the water heater to 120°F, setting the thermostat in winter to 68°F when people are home and 55°F when they are away, closing the drapes on windows during sunny summer days and after sunset in winter to maintain a more constant temperature, and using the energy-saving setting on appliances. They can also save energy by not wasting hot and cold water inside and outside the home.

Homeowners, home buyers, and home builders can save energy by investing in appliances, home renovations, and homes that are energy efficient, but not prohibitively expensive. As they decide to purchase a new appliance or replace an existing one, homeowners can investigate the available models and favor an appliance that is energy efficient. When making some home improvements or purchasing a new home, individuals can consult organizations, contractors, real estate agents, and websites with information on sustainable design to explore the best options and make conservation a major criterion in investment decisions. Appendix C identifies several resources with information about contractors, funding sources, and sustainable building information.

Commercial Energy Efficiency

Owners of commercial buildings face the same basic challenges as homeowners in striving to make their buildings energy efficient. Current technologies and practices offer cost-effective opportunities to reduce energy use by 30-70 percent in new and existing buildings (Cohen-Rosenthal et al. 2000). Like American homes, American commercial buildings produce large amounts of carbon dioxide and sulfur dioxide emissions through direct consumption of electricity and heating fuels.

Commercial building owners need to reduce energy consumption in their buildings by engaging in building maintenance tasks, sound conservation procedures, and wise investments. They must repair leaks, seal windows, and improve the insulation in walls and ceilings. Commercial building owners must also regulate thermostats, use shading techniques and reflective coatings on windows, and encourage water and lighting conservation. Finally, investments must be made in appliances and machinery that are energy efficient.

In addition to these basic challenges, commercial building owners must consider energy efficiency in the areas of lighting and peak production times. Lighting efficiency can be increased by replacing inefficient incandescent bulbs with new bulb models that have electrostatic ballasts. The use of natural light for illumination, a concept known as daylighting, can result in significant cost savings.

Additional benefits for commercial building owners can be derived by identifying machinery with high energy demands and scheduling operation of that machinery at off-peak hours, when electrical rates are lower. In doing so, they can often negotiate additional reduction incentives and rebates beyond the standard off-peak rate from the local power company and lower their overall electricity costs.

The efficiency of traditional buildings depends mainly on three areas: water conservation, appliance efficiency, and insulation and windows. Since changes to these three types of design considerations can be easily implemented without any experience in sustainable design, this section presents additional information on these three areas before proceeding to passive and active design alternatives.

Water Conservation

In many parts of the United States water is often consumed in excess with little or no consideration of the viability of water resources. Many countries and indeed some states in the United States face shortages in potable water supply. Homeowners and businesses have a significant interest in ensuring adequate water supplies because residential and commercial water use accounts for 47 and 53 percent of all water supplied to American communities by public and private utilities, respectively (Top 5 Actions 2002).

People often view measures to conserve water as an attempt by environmentalist to limit economic growth. This is not the case; several opportunities exist to use household water more efficiently without reducing services. Households which use near the U.S. average can potentially save a third or more of what they now use at home, resulting in annual water-heating savings of $20–$40 (Household Water Efficiency 2004). Implementing water efficient practices can also lead to substantial savings on the cost of septic tanks, leachfields, and wastewater treatment infrastructure. These measures combined will not only benefit the environment and the community, they can also create economic savings.

Increasing water efficiency can reduce water-supply and wastewater-treatment needs and their related costs (Household Water Efficiency 2004). The first step in water conservation efforts is stopping leaks, which can account for up to 10 percent of the water used in a home (Top 5 Actions 2002). Leak detection can range from visual inspection of bathroom fixtures to using sophisticated technology to detect silent leaks.

Because toilets represent a home's largest water consuming device, installing water-efficient toilets (about 1.6 gallons per flush) can yield significant economic savings. All new toilets on the market should mention how much water they use and lower capacity toilets should be installed whenever possible. Laundry machines represent the next largest water user in the home. Energy Star™ rated washers with a Water Factor at or below 9.5 will use as little as half the amount of energy and water of non-Energy Star™ appliance (Top 5 Action 2002). Finally, as discussed in the "Environmentally-Friendly

Urban Landscaping" section, choices of landscaping methods and types of plants used significantly affect the amount of water used on a site. The use of native species, which are adapted to local precipitation patterns, will eliminate the need for irrigation and reduce overall water consumption.

Efficient Appliances

An essential aspect of resource-efficient design decisions is realizing the importance of initial investments in reliable technology. Often times, cheaper products are purchased because they are perceived as the better economic choice based purely on purchase price. In terms of buying new appliances, machinery, and office equipment, the more expensive, energy-efficient or water-conserving models actually save money in the long run. By purchasing energy-efficient appliances and office equipment and water-efficient appliances and plumbing fixtures, savings in utility bills will be quickly realized.

There are many choices in both residential and commercial products that will affect energy efficiency. For example, according to the WPS website, purchasing an energy-efficient 18-cubic foot refrigerator provides the homeowner with an annual savings of $17-$28 compared to a conventional model of the same capacity. Office equipment is important for energy savings at work

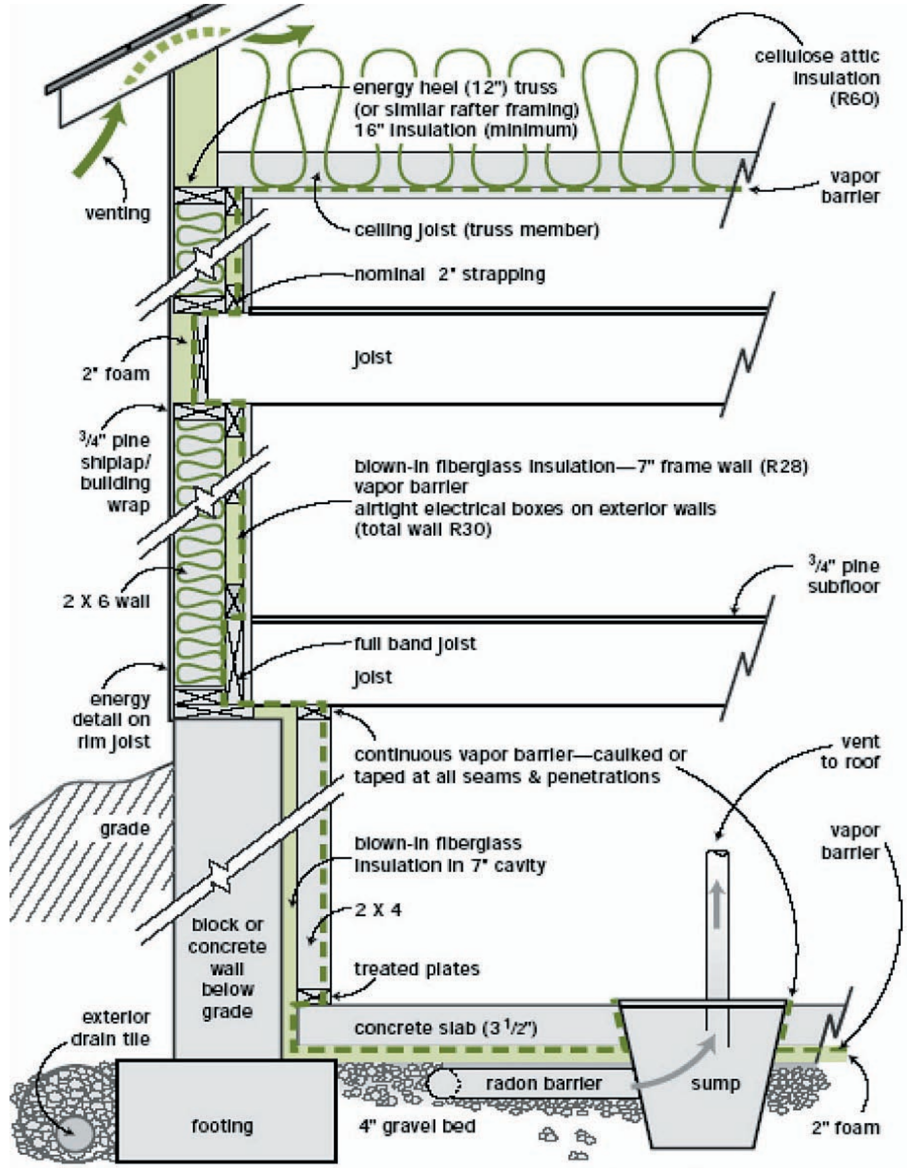


Figure 3.1. A schematic showing how homes can be designed to maximize thermal comfort in temperate climates (Source: Focus on Energy 2003).

Businesses should use ink-jet printers instead of laser printers, whenever it is feasible, because they use 90 percent less energy than laser printers.

Insulation and Windows

Energy efficient design seeks to maintain a level of thermal comfort in a building (Lutz 1995). Thermal comfort is a measure of air temperature, taking into account radiant temperature and air movement. Energy-efficient home design (Figure 3.1) can alleviate the need for costly renovations in the future.

R-values of 28 and 60 are the recommended insulation in walls and attics for the climate of northeastern Wisconsin. Cellulose is one of the better insulation options available and can be made from environmentally-friendly, recycled material. Cellulose has a higher R-per-inch than most comparable fiber insulation materials. Research by University of Colorado reported that cellulose performs 26 percent better than fiberglass in temperate climates and as much as 38 percent more efficiently in cold climates (Cellulose Insulation Manufacturers Association 1998). Once the insulation has been installed, care must be taken to develop a good building envelope to maximize the effectiveness of the insulation (Zaslow and Cox 1999).

Careful choice of windows and proper, tightly-sealed installation contributes to a good building envelope and can lead to significant energy savings. When compared to older, single-pane windows, installation of new, tightly-sealed, single-pane windows provide significant cost savings, but the use of double-pane, low e windows can increase annual savings by a factor of four. For example, Mattison, et al. (2002) found that initially installing single-pane windows with tightly sealed storm windows saves about $35 annually and using double-pane low e windows results in savings of up to $111 annually over single-pane windows. Tight-fitting, insulating shades can add to energy savings, since these shades, which are made of layers of insulating material, decrease heat loss by acting as a radiant barrier and prevent condensation (Rocky Mountain Institute 1995).

Material with a high R-value can also be installed in commercial buildings. Additionally, insulation can be made thicker by adding an inner layer of masonry blocks, a layer of light weight foam, and an impervious, exterior layer, such as brick or metal siding. An additional insulation method for commercial buildings is the proper insulation of hot and cold water pipes. Wrapping individual pipes with foam insulation is a simple, low-cost improvement with immediate benefits.

Passive Design Alternatives

After including every available conservation technique in a building design, the next step in decreasing the energy and water demands of the site are passive building designs. A passive design uses several techniques, included in the actual structural design and lot layout, to significantly reduce the amount of energy needed to heat, cool and light a building and also to reduce the runoff from the site, thus decreasing pollution and increasing infiltration of precipitation. Passive methods do not require any mechanical or electronic devices, so after the design is implemented, minimal additional inputs are required. The costs of passive designs are usually the same as or only slightly higher than conventional designs, making the payback of these techniques relatively short (Cassedy 2000). Many of the water-conserving benefits of passive design via landscaping are listed in the “Environmentally-Friendly Urban Landscaping” section.

Green Roofs

Green roofs are lightweight, engineered roofing systems that protect the integrity of the roof and provide many benefits for stormwater management and energy efficiency. The “Stormwater Management

Systems" section describes green roofs and the benefits for stormwater management. Below are additional benefits for energy efficiency (Eisenman 2004).

Benefits of Green Roofs

- Reduced heating due to fewer fluctuations in roof temperature and insulating properties of vegetation
- Reduced cooling costs due to fewer fluctuations in roof temperature and heat loss due to evaporation in the summer
- Increased property value
- Extension of the life of the roof membrane because of protection from intense ultraviolet radiation and continued expansion and contraction due to fluctuating temperatures
- Noise insulation

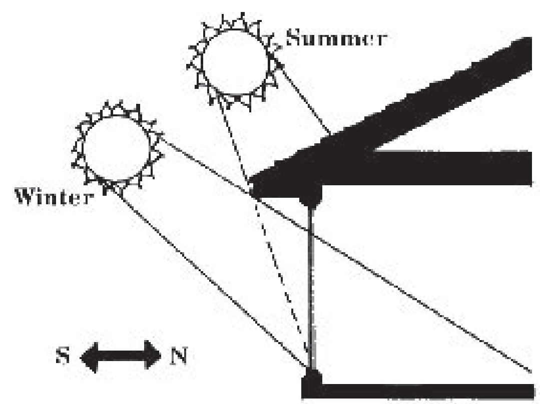


Figure 3.2. A diagram showing the beneficial use of an overhang to maximize passive solar design (Northeast Sustainable Energy Association 2000).

- Storm-water retention
- Improved air quality
- Habitat and biodiversity

Passive Solar Design

When sunlight strikes a building, the building materials can reflect, transmit, or absorb the solar radiation. Passive solar design maximizes the amount of solar energy absorbed and uses it to heat and light buildings. It is important to stress the need for high quality insulation when planning a passive solar design. There are three main considerations in passive solar design: building orientation, overhangs and shading, and thermal mass.

Building Orientation

There are several basic parameters for building orientation that are incorporated in any passive solar design. The site where the building will be located must have access to the sun, especially between 9 am and 3 pm, during the heating season, and there should be no more than 20 percent blockage along the sun's path (City of Austin's Green Building Program 2004). A long, thin building with one of the longer sides facing south and most of the windows on the southern wall will allow for maximum solar exposure during the winter months, providing both heat and light. An open floor plan placing the rooms requiring

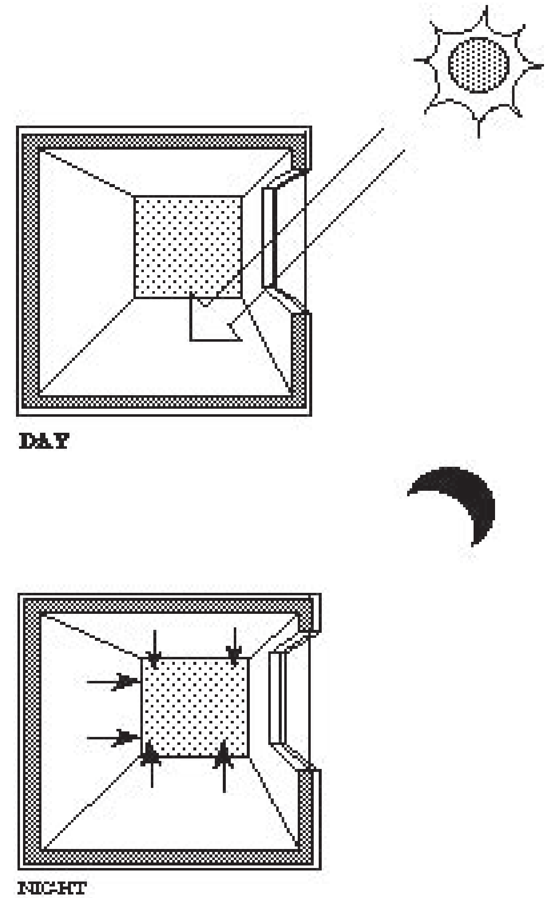


Figure 3.3. An illustration demonstrating direct gain thermal mass (City of Austin's Green Building Program 1994).

the most light and heat along the south face of the building optimizes passive system operation. Garages, storage rooms, and other such spaces can act as thermal buffers when located on the east and west side of a building (Consumer Energy Center

2004).

Windows and Shading

As previously stated, windows should have high R values, be tightly-fitted, and should be operable to allow for better temperature control. South windows should be shaded by overhangs or awnings. The shade provided should prevent direct sunlight in the summer months but allow maximum sunlight penetration into the building in the winter months, as shown in Figure 3.2. Deciduous trees provide optimal shading for the east and west sides of the building. During warmer months, the shading provided by the canopies of leaves and the transpiration of trees will contribute to the cooling needs of the building. However, the trees do not block the sun in the winter (Geller 2003). Shade trees appropriate for northeastern Wisconsin can be found on the list of native species in the "Environmentally-Friendly Urban Landscaping" section.

Thermal Mass

To truly optimize the benefits of the heat provided by the sun, a passive solar design incorporates thermal mass, materials with a high capacity for absorbing and storing heat (New Mexico Solar Energy Association 1998). Brick, concrete masonry, concrete slab, tile, adobe, and water are all materials that can be incorporated into a design as floors, interior walls, or fireplaces. Because of the high heat capacity of these materials, the heat absorbed from the solar radiation during the day is slowly released into the surrounding area at night. This allows a passive solar house to continue using the energy from the sun for heat long after the sun has set.

The two main designs for thermal mass placement are direct gain and indirect gain (Northeast Sustainable Building Association 2000). In a direct gain design (Figure 3.3), the thermal mass is incorporated inside the building and absorbs heat when the sunlight comes through the windows. In an indirect gain design (Figure 3.4), the thermal mass is located on the outer wall. A layer of glazing allows transmittance of light but reduces the amount of heat radiated back out away from the building. The thermal energy is absorbed during the day and then radiated into the building at night.

Benefits of Passive Solar Design

- Design is incorporated into building and lot design, so there is little or no upfront cost beyond the cost of the building
- Provides 30%-60% savings in heating and cooling needs
- No maintenance is required
- Benefits continue throughout the life of the house

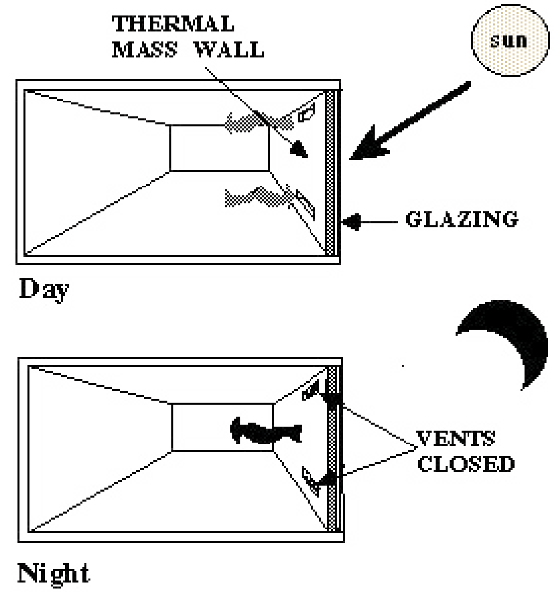


Figure 3.4. An illustration demonstrating indirect gain thermal mass (City of Austin's Green Building Program 1994).

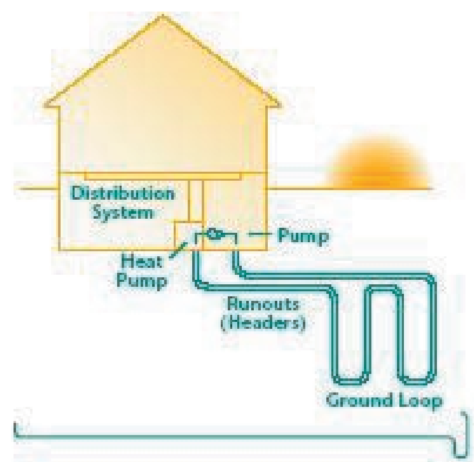


Figure 3.5. A diagram of a geothermal heat pump system (Natural Resources Canada 2002).

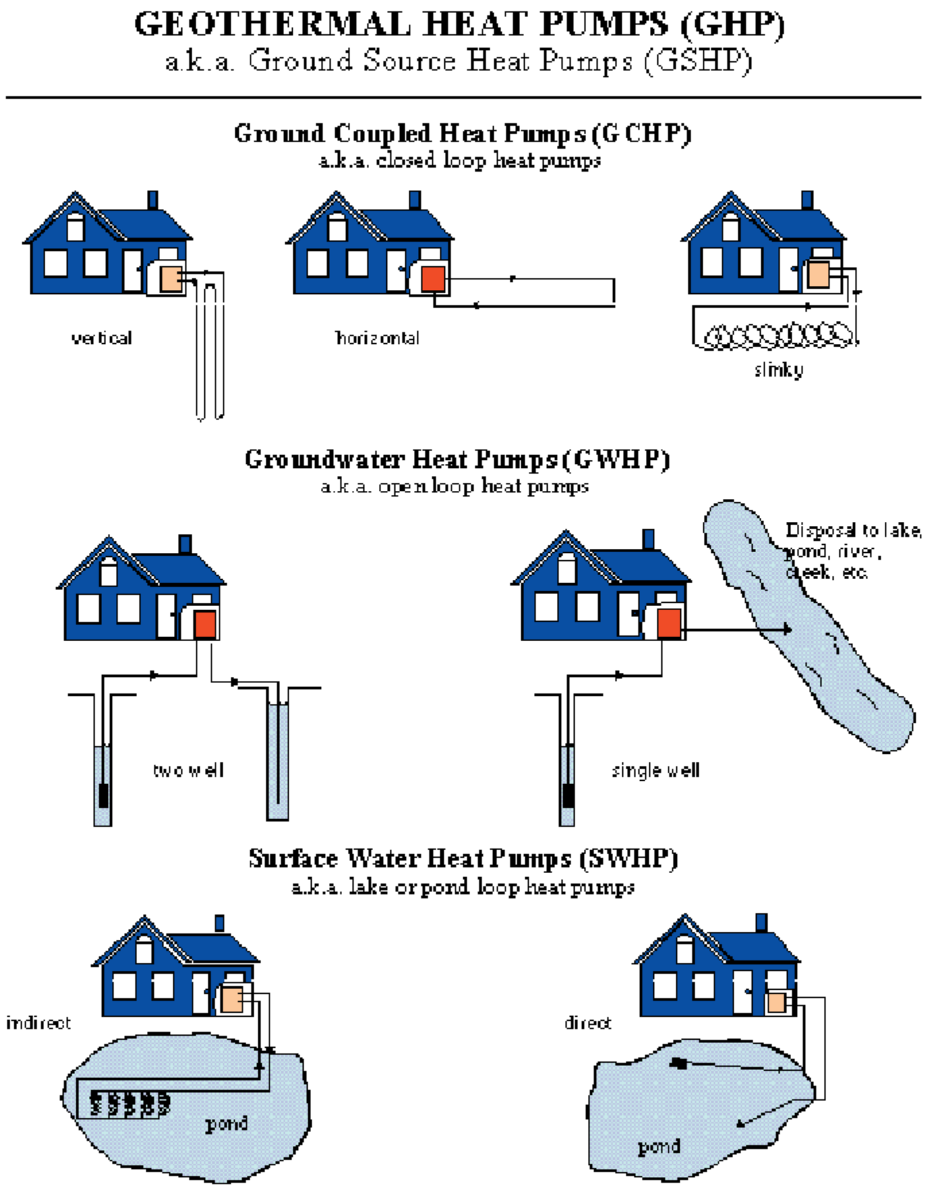


Figure 3.6. Examples of the different types of geothermal heat pumps (Rafferty 2001).

Active Design Alternatives

There are many practical design alternatives beyond standard building components that can greatly increase resource efficiency. Geothermal heat pump systems and solar hot water heaters are proven alternatives that can be readily incorporated into residential and commercial buildings in northeast Wisconsin. Though not detailed in this assessment, photovoltaic systems, biomass combustors, wind turbines, fuel cells, and other applications can be used to help offset some energy generation costs.

Geothermal Heat Pump Systems

The majority of the United States has nearly constant shallow ground temperature between 50°F and 60°F. Geothermal heat pump systems take advantage of the fact that the ground is cooler than the air above it in the summer and warmer than the air above it in the winter. In the summer excess heat is removed from indoor air and pumped into the ground, and in the winter thermal energy is gained from the ground and transferred into the building.

A diagram of a geothermal heat pump is shown in Figure 3.5. The heat exchanger (labeled “ground loop” in the diagram”) is the means by which the thermal energy is transferred to and from the ground. There are several different possible designs for a heat exchanger, including ground coupled, groundwater, and surface water heat pumps, as shown in the second diagram (Figure 3.6). (Cane, et al. 1998)

The optimal type of geothermal system is site specific. There are many contractors with the experience necessary to design and install an efficient, cost-effective system. A list can be found in Appendix C.

Benefits of a Geothermal Heat Pump System

- Highly efficient, for every unit of electricity used, four units of heating energy are produced
- Can also be used to aid in hot water heating
- 30-70% more efficient than ordinary heating and air conditioning systems
- Maintenance and service costs are significantly lower than conventional HVAC systems

Solar Hot Water Heaters

Hot water is the largest component of residential energy costs after heating and cooling (Cassedy 2000). A solar domestic water heating system that is well designed will provide 50-80% of hot water needs, depending on the building's geographical location and the time of year (City of Austin's Green Building Program 1994). Commercial buildings can achieve even greater benefits from solar water heating than residential if production of hot water is a major operating cost.

In solar water heating systems, thermal energy from the sun is transferred directly to water through a simple design (Figure 3.7). The solar collectors are dark and readily conduct heat. When sunlight hits the collectors, the temperature of the collector is quickly elevated. When the collector sensor registers higher temperatures within the collector, a fluid, usually a water/anti-freeze mixture in colder climates, is circulated through a closed loop system, passing through the solar collectors. Heat in the collectors is transferred to the fluid. The heated fluid then circulates through a heat exchanger, and thermal energy is transferred to water, producing hot water (Cassedy 2000). The system is installed with an auxiliary water heater to meet 100 percent of a building's hot water demands.

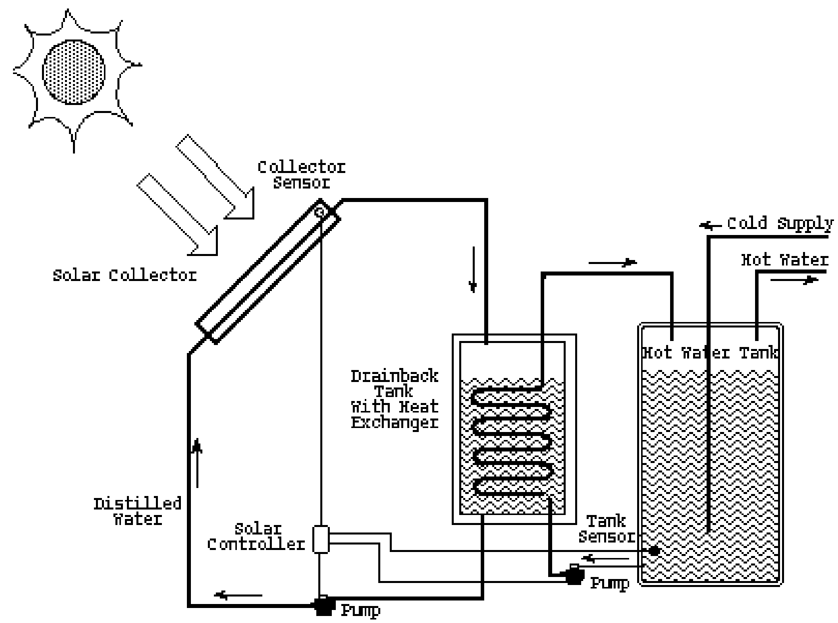


Figure 3.7. A schematic of a solar water heating system (City of Austin's Green Building Program 1994).

Benefits of Solar Hot Water Heaters

- Direct savings from lower energy costs
- System payback within 4-8 years
- Decreased air pollution from offset of fossil fuel use
- New systems are aesthetically pleasing and generally look like skylights when installed correctly
- Systems are automated and require little maintenance

Heating and Cooling Systems

Once a thermal layer (Figure 3.1) is

solidified and all efficiency measures have been included in building plans, the next course of action should be to examine the heating and cooling systems. Energy efficient models, which are generally less expensive and produce less pollution, such as an efficient HVAC system, can yield a payback time of roughly 5-20 years. In subsequent years instead of replacing the HVAC system, it can be tuned by professionals with an expected payback time of 1-3 years.

As more of the techniques presented above are incorporated into a building, an HVAC system can be sized smaller than in a conventional building. Each level of design, insulation/windows, passive design, and active design, reduces the heating and cooling loads for the HVAC system and allows for the installation of a smaller system to meet the same level of thermal comfort. Reducing the size of the HVAC system reduces the cost of the system and the cost of installation.

Incentive Programs

Given the economic costs involved with implementing new, more efficient technologies, several countries have tried to develop programs to encourage citizens to be mindful of their energy use (Cassedy 2000). In the United States, the federal government and several state governments have tried to encourage citizens to conserve energy through various programs (Energy Star, Seattle Energy Smart Services, and Wisconsin Focus on Energy). Providing incentives that entice developers to construct buildings that are energy, water, and resource efficient and environmentally sound creates the foundation for a competitive, efficient-building market.

Low-rate mortgages, rebates for appliances, and discounts from utilities are examples of incentive programs. Resources for incentive programs are provided in Appendix C.

Residential Case Studies

Successful and well thought out designs have the ability to cut utility bills in half (Rocky Mountain Institute 2004). The following section provides some case studies highlighting various aspects of energy efficiency in homes and expected paybacks. The studies are summarized in Table 3.2.

Table 3.2. Residential energy efficiency case studies.

Case Study	Methods	Cost	Annual Savings	Payback
Bircher Home	Daylighting, Solar Hot Water Heater, Photovoltaic Stems	$9,900 Minus 30-50% Rebates	$800 Utilities	Approx. 6 years
Esperanza del Sol Development	Passive Solar, Specialized Geothermal HVAC System	$1,250 Minus $1,000 saved (special HVAC)	$300 on Uilities $2000 on Utilities	Less than a year
Traugott Terrace Apartments	Following LEEDS Standards	Homes are similar to conventional home.	$9000 on Water Usage	Up to 10 years

Bircher Home
DePere, WI

The Bircher house was developed as a demonstration project to show the viability of photovoltaic systems (cost of $6000.00) and solar hot water heater (cost of $3900.00) in cold weather climates like Wisconsin (Wisconsin Focus On Energy 2004). Much of the cost of the systems was offset by grants from various organizations. The home is 2,700 square feet (sq. ft.) and was completed in 1999 at a cost of approximately $100 per sq. ft. This house also includes design concepts, such as daylighting, to take advantage of sunlight for illumination rather than light bulbs, and a masonry fireplace, to utilize the concept of thermal mass to keep the home warm during cold, Wisconsin winters. In addition, the Birchers have bought energy efficient appliances and an efficient, natural gas HVAC unit. The solar hot water heater supplies approximately 60 percent of the hot water needs. Annual electrical and natural gas usage amounts to $2,175 which is 40 percent less than for similar size homes with inefficient building envelopes and technologies. The Bircher home saves approximately $800 annually.

Esperanza del Sol Development “Hope of the Sun”
Dallas, TX

Esperanza del Sol is a housing development that highlights passive solar heating and cooling construction techniques (Water Furnace International, Inc. 2004). These homes are approximately 1273 sq. ft. each and incorporate design concepts which attempt to use approximately 60 percent less energy than a comparable home using conventional design techniques. A conventional home design translates into the homeowner spending approximately $600 annually. The Esperanza homeowner will spend approximately $300. The Esperanza homes also utilize 1.5 ton, geothermal HVAC systems, which cost $1000 less than a conventional HVAC 2.5 ton unit needed to heat and cool a comparable sized home without energy efficient designs. The $1,000 savings all but offsets the cost the $1,250 for constructing these energy efficient homes.

Traugott Terrace
Seattle, WA

Traugott Terrace is a 50 unit Belltown apartment building for low-income residents (Seattle Channel 2004). This project used many green-building practices to become the first affordable housing project in the United States to receive Leadership in Energy & Environmental Design (LEED) certification from the U.S. Green Building Council. In addition, the City of Seattle presented the project with the SeaGreen Award in recognition of the developer’s effort to create the first affordable housing project in Seattle built under the City’s new sustainable building guidebook, SeaGreen: Greening Seattle’s Affordable Housing, produced by the City’s Office of Housing. Sustainable strategies at Traugott Terrace include: energy-saving building envelope and windows, a heat-recovery ventilator, and fluorescent lighting. Low-flow plumbing fixtures reduce water use by 33 percent and save $9,000 a year. An energy-efficient, gearless-traction elevator (in lieu of a hydraulic elevator) is expected to save $2,000 a year in energy costs. The Energy Star™ rated roof coating is light colored, reducing solar absorbency and minimizing the urban heat island effect. Recycled materials were incorporated in the carpet, gypsum board, ceiling tile, insulation, steel siding, structural steel, and concrete. The contractor recycled over 75 percent of construction waste.

Commercial Case Studies

Implementation of efficient methods in commercial buildings offers a wide range

Table 3.3. Commercial energy efficiency case studies.

Case Study	Methods	Cost	Annual Savings	Payback
Bare Bones Furniture	Improved lighting	$16,240	$500 maintenance $4000 energy costs	4 years
Watertown Unified School District	Gas-electric cooling system	$170,000 Minus $128,000 of incentives	$14,000 energy costs	5 years
Clearview Elementary School	Daylighting, Passive solar heating, Geothermal heating and cooling, Improved building envelope	$150,000 more than standard school with same student capacity	$18,000 energy costs	9 years

of possibilities: substitution of better quality lighting, installation of improved heating and cooling systems, and use of synergy in the overall design of the building to maximize the potential of various options. Higher levels of energy efficiency can potentially lead to higher installation and maintenance costs. To provide reassurance of the economic and environmental viability of improved, efficient practices, the following various case studies of new and renovated buildings are presented. Table 3.3 summarizes the methods, implementation costs, anticipated annual savings, and estimated payback time of these studies.

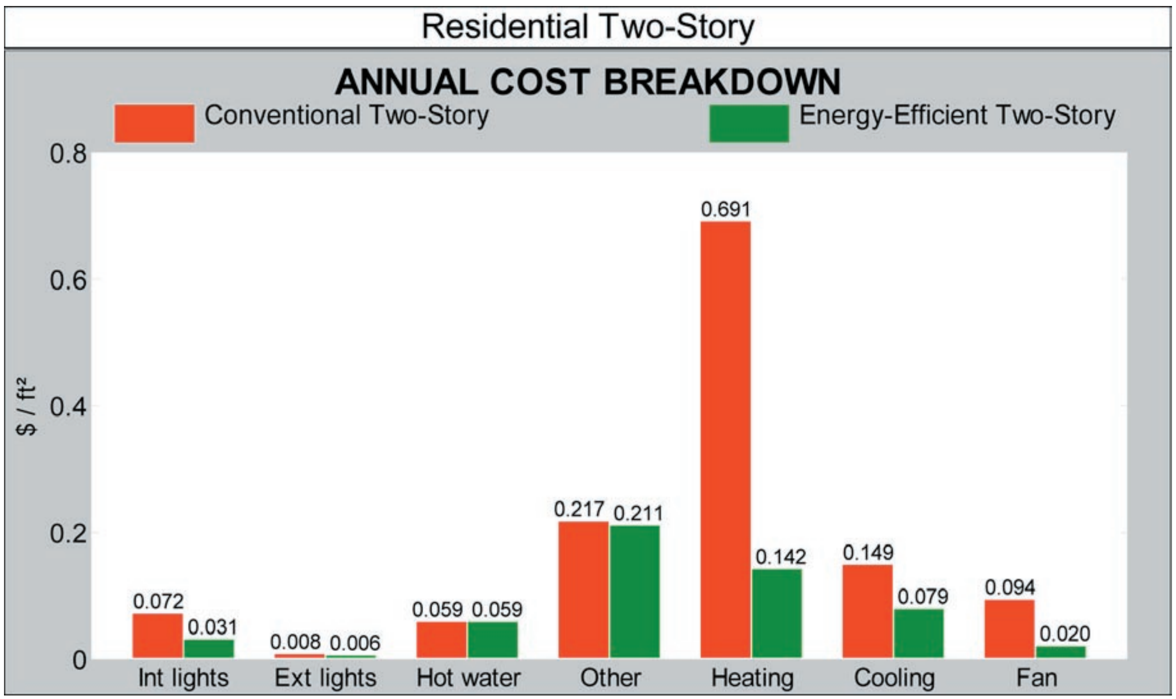


Figure 3.8. Energy 10 cost comparison of a 2,000 square foot conventional vs. energy-efficient residential two-story home.

Bare Bones Furniture
Glen Falls, New York

In renovating their store location, the proprietors of Bare Bones Furniture desired to replace lighting that was not only inefficient, but caused their merchandise to appear unnatural (New York Energy Smart 2004). Old, unshielded T-12 cool white lamps were substituted with industrial, hooded fluorescent fixtures and 23-watt compact fluorescent bulbs. The cost of the new instillation was $16,240. The new bulbs last twice as long as previous bulbs and require less energy for the same amount of light, reducing annual maintenance costs by $500 and lowering the annual electricity cost by $4,000. The estimated payback for this renovation is four years

Watertown Unified School District
Watertown, Wisconsin

A new school was constructed with a hybrid gas-electric cooling system that reduces use of electricity during peak hours (Energy Center of Wisconsin 2004). This system lowered operating costs by $14,000 per year. Installation costs were $336,000, nearly twice that of a standard electric cooling system. The school's utility provided $128,000 of incentives, with which the project achieves payback in five years.

Clearview Elementary School
Hanover, Pennsylvania

Clearview Elementary combines energy-efficient electric lighting with architectural design that maximizes daylighting to lower lighting demands (U.S. Green Building Council 2004). The passive solar design is also used in combination with a geothermal system to provide warmth in winter. In summer, the geothermal system assists with cooling. Additionally, an improved building envelope was installed with highly insulating walls and windows to reduce the need for heating and cooling. The overall costs were 2.15 percent higher than similar schools within Pennsylvania. However due to a 40 percent reduction in energy use, and a 30 percent reduction in water use, the school district can expect payback in under nine years.

Economic Comparisons Through Computer Models

There are a wide variety of software packages available to model different design considerations and their implications and cost savings potential. Version 1.3 of Energy 10 (build date November 19, 1999), developed by the National Renewable Energy Lab in cooperation with the Department of Energy, was used to model several common situations to demonstrate major areas of potential energy and financial savings, utilizing some of the design considerations discussed earlier in the section.

Base assumptions for each of the models in this section include:

- Climate Type: Midwest
- HVAC: Direct Vent Cooling System with Gas Heating
- Electric Rate: 8 cents per kWhr
- Natural Gas Rate: 60 cents per therm.

Other assumptions used are summarized in Appendix E.

The results of the two-story simulation, as illustrated in Figure 3.8, are that the biggest potential savings is in the area of heating. Based on the utility rates above, an annual energy-cost savings of nearly $1,500 could be realized if all the assumed, design criteria were implemented.

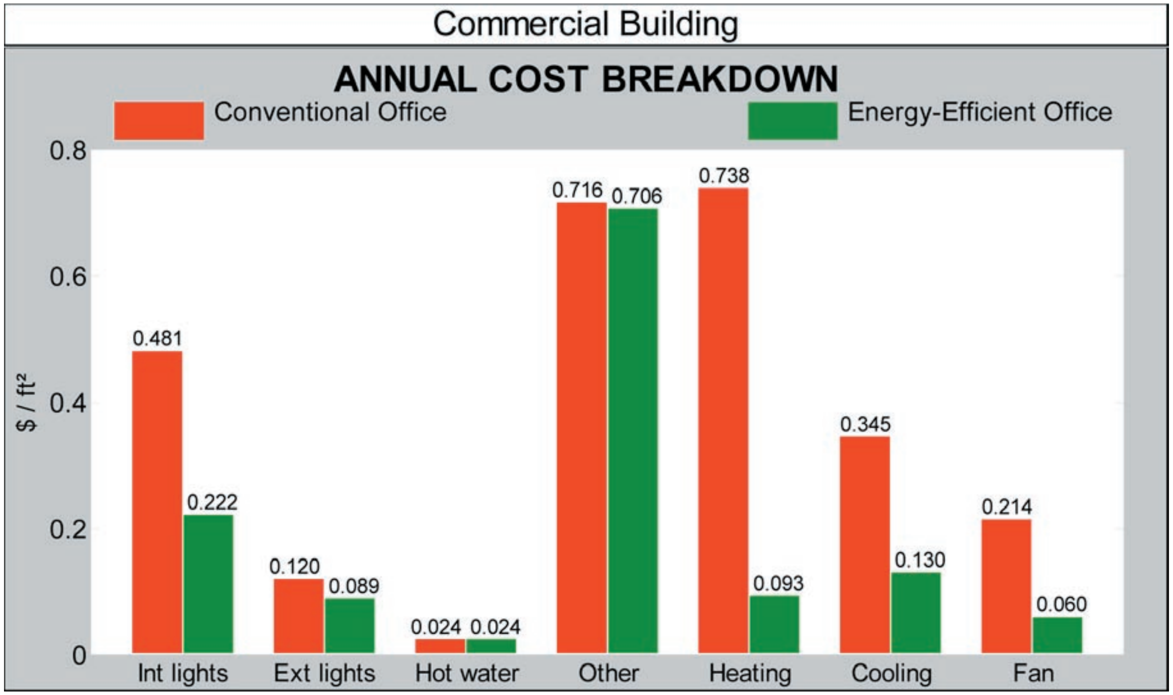


Figure 3.9 Energy 10 cost comparison of a 10,000 square foot, three-story conventional vs. energy-efficient office building.

To illustrate a commercial application of this computer model, a three-story, 10,000 sq. ft. office building was simulated. The results, depicted in Figure 3.9, show that the potential savings in heating costs can be even greater than in the residential case. In addition, this type of commercial building can also derive significant cost savings in the interior and exterior lighting categories. This savings is primarily due to considerations of daylighting in the initial building design.

Sustainable Building Methods

Sustainable Building Recommendations

The following recommendations are suggested to implement sustainable building practices in the Joint Planning Area:

- Use a whole-building design approach to maximize resource-efficiency benefits through synergy.
- Incorporate as many options from LEED and GBH standards as possible.
- Carefully plan construction and site design to preserve as much natural vegetation as possible.
- Install high-quality insulation and double-pane, low e windows.
- Invest in energy-efficient and water-conserving appliances, plumbing fixtures, machinery, and office equipment.
- Use a green roof or light-colored roofing materials.
- Carefully orient buildings to maximize the southern exposure.
- Position the majority of windows on the south wall of buildings.
- Shade windows to prevent direct sunlight in the summer while maximizing direct sunlight in the winter.
- Use floor plans that have main areas on the south side, areas that are infrequently used on the north side, and garages and store rooms on the east and west ends of the building.
- Plant native, deciduous, shade trees on the east and west ends of the building.
- Include thermal mass in buildings that will be used at night.
- Incorporate a solar hot water heater in building design.
- Carefully design HVAC systems.
    - Each efficiency technique included in the design will lessen the heating and cooling load for the system.
    - Consider the use of a geothermal heat pump as part of the HVAC system, decreasing energy and maintenance costs.

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