

Energy Performance And Cost Analysis; A Prototype Sustainable Retail Building Vs. A Conventional Retail Building

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ABSTRACT: When operating a business, overhead costs are a significant expenditure that must be overcome in order to generate a profit. It is especially difficult for a retail business to make a profit in the first few years because clientele have to be established, operating procedures need to be standardized, and there is often a large amount of debt associated with purchasing and maintaining the buildings that contain the operation. This is a major financial endeavor for the initial startup costs, and there will be various life costs to operate the building comfortably and attractively both for employees and customers. Reducing operation and maintenance costs are a major goal of any commercial entity. Energy efficient or high performance buildings in addition to generating energy cost savings, improves worker's productivity which in turn reduces overall costs. Because energy costs are a major overhead burden on the operation of a company, any innovations that cut down on energy costs will reduce this liability and therefore make the company more profitable. Although, the productivity gains are factored rarely into financial return on investment, much of the studies on this subject indicate that the productivity gains of a more energy efficient building are significant. Our focus on this paper is to investigate the performance costs of a typical retail store of 20th century compared to that of a high performance prototype green building and the return period of investment.

KEYWORDS: Energy Costs, High Performance, Productivity, Sustainability

I. INTRODUCTION

The construction industry is a constantly changing field, as new materials and systems are becoming more popular and replacing the old methods of construction. Designs that incorporate high levels of thermal insulation, whole building air tightness, high performance windows, passive solar design techniques and energy saving technologies will create buildings that are more energy efficient and comfortable [12].

The criteria that satisfied society for development of the earth fifty years ago is not sufficient for the modern generation, and today's construction will not be acceptable fifty years from now. The priorities have changed from comfortable and enjoyable living for the current inhabitants to the same for our descendants as well. The changing trends in construction of new buildings are beginning to reflect this shift. Designers are choosing to use materials from renewable resources wherever possible instead of limited resources. The buildings today are planned to be disassembled at the end of their useful life instead of demolished, so that building materials can be reused or recycled instead of wasted and left to decompose. The sustainability trend is not only applicable to the environment, but to society as well. Engineers are also considering location of buildings relative to the amount of travel time to reduce the amount of automobile use. Storm water control, sewage treatment, and water use are important aspects in the development phase of building plans to minimize pollution and conserve water. Building designs that show environmental initiative are gaining appreciation with society and people are more likely to use those buildings. Many sustainability plans are meant to bring back the connection between humans and the earth that is missing from modern

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urban life. However, perhaps the most compelling reason for owners to choose options that are environmentally friendly is the economic benefit that can result from energy savings.

II. RELATED WORKS

We conducted a review of current literature on high performance buildings and their cost savings over the conventional buildings. These include the heating, cooling, and other means of energy saving; sustainable and LEED certified buildings. The methodology for energy analysis, calculations, and data sources are all from ASHRAE Fundamentals Handbook or other texts with the same sources. There is an abundance of literature available in the areas of energy analysis and energy savings in buildings in general and some in commercial buildings as well. Our specific topic on the suggested protocol for a typical retail store benefited from the general subjects on high Performance buildings. There are also several related papers we looked in for this paper.

Sam C M Hui [4] investigated the techniques for building analysis and experiment with the actual system to make a physical model using computer simulation techniques. This study was helpful in terms of the methodology and process of performance analysis.

Gary M Newsham et.al [6], compared and analysed the information supplied by the New Buildings Institute and the US Green Buildings Council on measured energy use data from 100 LEED-certified commercial and institutional buildings. In addition they examined energy use by LEED certification level and by energy-related credits achieved in the certification process. The results were that at a societal level, green buildings can contribute substantial energy savings, but further work needs to be done to define green building rating schemes to ensure more consistent success at the individual building level.

B.J Huang, et.al [3], proposed a study to understand the performance of an integrated photovoltaic and thermal solar system (IPVTS) as compared to a conventional solar water heater and to demonstrate the idea of an IPVTS design. They concluded that; the performance of a PV/T collector can be improved if the heat-collecting plate, the PV cells and the glass cover are directly packed together to form a glazed collector. Furthermore, the manufacturing cost of the PV/T collector and the system cost of the IPVTS can also be reduced. The overall results indicate that the idea of IPVTS is economically feasible as well.

Ibrahim Dincer [2], looked into the methods and applications of thermal energy storage (TES) assessment systems in buildings. Afterward, he discussed the various technical aspects and criteria for thermal energy storage systems and applications with energy saving techniques and environmental impacts of these systems. He then demonstrated how his method of energy analysis provides a more realistic and meaningful assessment than the conventional energy analysis of the efficiency and performance of a thermal energy storage system.

III.SUSTAINABLE OPPORTUNITY

There are many different methods a building designer can choose from to use natural energy rather than rely on utility provided power. The easiest and least expensive way to use natural energy is to orient the building to maximize sunshine into a building for lighting and heating. There are many different arrangements of building materials and installations that focus on the absorption of solar light for buildings and how to manage the heat that comes with it. Another way to use the sun's energy is to use solar panels, which directly generate direct current electricity. This can be transformed immediately for building use or stored in battery form to supply some of the building's electricity requirements. Another common way to use natural energy that is more useful in rural settings is wind power, which uses a turbine to generate electrical power. There are a few different ways to conserve water usage in a building system which include rainwater harvesting and grey water reuse.

The most important component of a building's electricity and energy demand is heating; which either requires burning fossil fuels inside the building to provide heat, or using electricity from the power grid. Both of these methods contribute to pollution and are more expensive than the alternative. Alternative energy systems are experiencing a rise in popularity, and the energy savings pay for the initial investment of the system. New construction that uses these

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systems has an advantage environmentally, socially, and economically over buildings that rely solely on fossil fuel combustion for energy and heat. The following investigation will determine the ultimate benefits of the green building technologies on the overhead costs and profit margin of the new retail store, as well as the added environmental and social factors involved.

IV. ENERGY PERFORMANCE ANALYSIS FOR PROPOSAL

Green buildings are becoming more popular in the 21st century, as building owners and designers recognize not only the economic benefit, but a reduction in environmental corruption and social benefits as well. The objective of this exploration is to discover the differences between typical retail stores built in the 20th century and a prototype for new stores with green building technologies. First we will explore the characteristics of the typical store and those of the prototype design. There are many areas in sustainability for the prototype retail store to improve upon the existing building's performance. Two major topics of concentration for comparison are the methods of heating the buildings and the insulation values of the exterior assemblies. This contributes to a difference in heating demand between the two designs and a difference in the price for the amount of heat needed. Also, on site power generated by photovoltaic panels will reduce the dependence of the prototype buildings on utility provided power. Other ways to improve the sustainability of the building include orientation for passive heating and lighting, water efficiency, and site selection. We will concentrate on all of these elements, and determine the economic benefits and how long it will take to overcome the extra price of the emerging technologies. We will also discover the added benefits of sustainable design and the possibilities of LEED certification for our prototype project.

V. HEATING METHOD AND INSULATION DIFFERENCES

The standard heating method for a retail store is a forced air furnace system, while the prototype building will use a geothermal heat pump system. The forced air system is popular in mid-sized buildings such as ours due to the low installation cost. A typical furnace in a light commercial application will use a well maintained induced draft furnace with a seasonal efficiency of about 80%, and the furnace burns number two fuel oil, which provides 140,000 Btu per gallon burned [13]. This efficiency refers to the amount of heat generated that is actually used compared the total amount generated. A geothermal building energy system takes advantage of the fact that the earth is a very good source of embodied heat. Water can be circulated through the ground to absorb the heat from the earth or shed unwanted heat from the building. No fuel is necessary to power this system, as electric energy pumps the water underground and back through the building. These systems require a backup system of typical electrical resistance heating for a total system efficiency of 250% [14].

Another method to reduce energy loads is to improve the insulation value of the assemblies. This is important in both the heating and cooling seasons, because the heat needs to be kept inside during the winter and outside during the summer. The typical building uses moderate insulation in the walls and roof, and poor insulation in the windows. Improving these assemblies will keep more heat from transmitting through. A proposed skylight and additional windows, which benefit the building in many different ways, can also contribute to better insulation. A major innovation in window technology for insulation values is the use of aerogel within the two window panes, which works extremely well to block air transmission for the building [21]. If aerogel is used on all the windows, the resistance to heat loss will be extremely higher than that of standard double glass windows.

We will assume the national average retail store size of 8,000 square feet and 14 feet high with no basement [9], and dimensions of 80 feet wide by 100 feet long. These dimensions will remain the same for the typical store and the prototype. Both also use the same concrete slab on ground floor system, identical doors, and each building faces west when looking at the front elevation. At this front elevation, both designs have the lower ten feet covered by a show window, except the area covered by the four front entrance doors. The typical building uses a steel stud and brick veneer wall assembly, while the prototype uses wood studs and concrete masonry units for the exterior walls. The brick veneer is indicated by the closely spaced lines, and the prototype building elevations would look identical except the masonry lines would be spaced farther apart to indicate concrete masonry units. The typical design would have only brick veneer for the north and south elevations, while the prototype uses concrete masonry and includes twenty four foot by four foot windows on the south elevation, as indicated by The original design has polyisocyanurate and perlite

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insulation between the concrete deck and the built-up roof, while the prototype design uses extruded polystyrene. The typical store uses double glass with a half inch air space for the show window, while the prototype design uses aerogel filled double glass for the show window, south facing windows, and 1,000 square foot skylight.

VI. HEATING LOAD ANALYSIS

The first thing we will analyse is the annual cost to heat the typical building using a forced air system compared to the cost for the prototype building using the geothermal system. Because the heating season contributes to the most discrepancy in the energy costs for buildings, we will concentrate only on the heating season. Before we can compare the heating costs, we must determine the total heating load for each building. The heating load can be estimated by considering the heating demand based on the climate, ideal indoor conditions; and heat loss due to transmission, ventilation, and infiltration. We must determine the average heat loss from each building design per degree Fahrenheit difference between inside and outside temperature over the period of a day. Then, the heat loss calculations begin by examining the insulation values of the entire assembly, which will show us the total heat loss due to transmission. An R value is a common scale used to describe insulation or resistance to transmission; and it is the inverse of the U value, which represents the heat transmission factor of a material or assembly [19]. In the following two charts (chart 1 for conventional buildings and chart 2 for the proposed prototype building) for transmission losses, the R values are converted to U values for the purpose of the heat loss calculation. The units for the U value are Btu per square foot, per degree, per hour [6]. To derive the transmission losses in Btu per hour for each individual assembly, the transmission values are multiplied by their respective area and the design temperature difference between the two sides of the assembly. The design temperature is the temperature between the desired indoor temperature and a temperature the climate allows to fall below during .4% of the year. If the desired indoor temperature during the heating season is 68° and the extreme temperature value in our location is 13°, the design temperature difference is 55° [18].

1. TRANSMISSION LOSSES FOR TYPICAL BUILDING:

Assembly	R-value ((ft ² hr°F)/Btu)	U-value (Btu/(ft ² hr°F))	Area (ft ²)	Design Temperature Difference (°F)	Heat Loss (Btu/hr)
Walls	11	.091	4,078	55	20,410
Roof	14	.071	8,000	55	31,240
Show Window	2.0	.500	716	55	19,690
Glass Doors	.9	1.111	84	55	5,130
Steel Doors	2.1	.476	42	55	1,100
Overhead Door	5.6	.179	120	55	1,180
Total			13,040		78,750

2. TRANSMISSION LOSSES FOR PROTOTYPE BUILDING

Assembly	R-value ((ft ² hr°F)/Btu)	U-value (Btu/(ft ² hr°F))	Area (ft ²)	Design Temperature Difference (°F)	Heat Loss (Btu/hr)
Walls	25.5	.039	3,758	55	8,060
Roof	31.5	.032	7,000	55	12,320
Aerogel Glass	20	.050	2,036	55	5,600
Glass Doors	.9	1.111	84	55	5,130
Steel Doors	2.1	.476	42	55	1,100
Overhead Door	5.6	.179	120	55	1,180
Total			13,040		33,390

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VII. INFILTRATION AND VENTILATION LOSSES

Now that we know the heat loss through transmission for each building by performing the calculations shown in the preceding chart, we need to find the heat loss through infiltration and ventilation to find the total heat loss of each building. The infiltration and ventilation rates are the same for both designs. An assumed air change rate of .5 means that half of the entire volume of air within the building will be replaced by infiltration every hour [8]. Because our building's volume is 112,000 cubic feet and half of that amount of air changes per hour, the rate we consider is 56,000 cubic feet per hour. The heat capacity of air is .018 Btu per cubic foot per degree Fahrenheit, and the design temperature difference is 55°, so the heat loss due to infiltration is 55,440 Btu per hour. A retail store requires .3 cubic feet per minute of ventilation per square foot of building area, which results in ventilation requirements of 2,400 cubic feet per minute, or 144,000 cubic feet per hour [8]. Using the heat capacity of air, the design temperature difference, and the required air change of ventilation per hour, we find a heating loss due to ventilation of 142,560 Btu per hour. Our total heating load from transmission, infiltration, and ventilation for the original building is 276,750 Btu per hour, which is the same as 6,642,000 Btu per day. In order to find the total amount of heat needed during the entire heating season, we multiply this heat load per day by the amount of heating degree days per year, and then divide by the design temperature difference. In a moderate climate such as ours, there are about 5,000 degree days, and dividing by the design temperature difference of 55° derives a total of 90.9 days considered for heating [16].

When we multiply the heating load per day by total heating days per year, we find that the total heat necessary to generate is 603,757,800 Btu annually. We will find out the cost of fuel that needs to be burned by the furnace to generate this amount of heat, considering the efficiency of the furnace. For the prototype building; the total heating load is 231,390 Btu per hour, 5,553,360 Btu per day, or 504,800,424 Btu annually. We will determine the cost of electricity needed to operate the geothermal system considering its efficiency.

VIII. ANNUAL HEATING COST DIFFERENCES

At this point we know how much heat will need to be produced in order to keep the ideal operating conditions of the both the typical and prototype retail store. Once we find the cost of the fuel used to operate the furnace for heat in the conventional application, we will compare it to the cost needed to operate the geothermal system. With an efficiency of 80%, 112,000 Btu will be used per gallon, so 5,391 gallons are required for the heating season of 603,757,800 Btu. At a typical price of \$3 per gallon, this is an annual cost of about \$16,172 [10]. To find the cost of heating the prototype building, we must convert 504,800,424 Btu to kilowatt hours at an equivalence of 3,413 Btu per kilowatt hour. The system produces 147,905 kilowatt hours of energy per heating season, and with the 250% efficiency, this requires about 59,162 kilowatt hours of energy. At a cost of 10 cents per kilowatt hour, this amounts to an annual cost of \$5,916 [11]. The annual savings in heating cost due to improved insulation and the more efficient heating system amount to just over \$10,000.

VIII. PAYBACK PERIOD FOR IMPROVED INSULATION AND GEOTHERMAL HEATING SYSTEM

Now that we know the difference in cost related only to the heating demand of each building, we must determine the annual operating costs not related to the necessary energy. If we use annual maintenance rates for a geothermal heat pump system compared to a system with a rooftop unit using natural gas heating and direct expansion cooling, we find that the annual maintenance cost for geothermal heat pumps is considerably lower than the alternative. With 2% yearly inflation, current annual rates for maintenance of the rooftop units are about \$.40 per square foot, and for the geothermal heat pump about \$.17 per square foot. For our 8,000 square foot building, the annual maintenance cost is \$3,200 for the rooftop system, and \$1,360. The annual energy and maintenance savings together amount to about \$12,100. The installation costs of the rooftop system are currently \$9.20 per square foot, and for the geothermal system \$12.80 per square foot. Therefore, the additional first cost of the geothermal system for our 8,000 square foot building would be \$28,800 [17]. We must add to this the added cost of the better insulating materials in order to find the total cost to overcome. The difference in installation cost of the two designs is not very important to our

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investigation due to the common availability of the labour and materials, with the exception of the aerogel. Aerogel commonly costs around \$5 per square foot, and the total price for 2,036 square feet of windows with aerogel would be \$10,180. The total cost of innovative technology for the prototype building is around \$39,000 for the geothermal heat pump system and aerogel. With \$12,100 in annual savings from the geothermal system, the payback period for the sustainable technology is just over three years

IX.PHOTOVOLTAIC PANELS

There are other strategies to reduce energy usage that can also help the company financially. Next we move on to the concept of solar powered energy. Like the geothermal system, solar powered energy has a high installation cost, but provides direct power to the building, thereby reducing reliance on the utility provided electric energy. With 20% solar insolation efficiency, 2,000 square feet of photovoltaic solar panels on the roof will provide about 167 kilowatt hours per day, which is approximately equivalent to a 7 kilowatt system [15]. A supply of about 60,833 kilowatt hours per year contributes to savings of \$6,083 annually from the cost of utility provided electricity. The cost of photovoltaic panels has dropped dramatically in recent years, to a typical price of less than \$1 per watt of output. If we assume a cost of \$1 per watt, the cost of our panel system will be about \$7,000, which suggests a return period of just over one year. Due to the rising popularity and corresponding price reduction, the solar panels are a very effective way to cut energy costs. All clean solar energy is beneficial to the environment because it harnesses natural energy with no pollution rather than the alternative methods of artificial and highly polluting processes. The store will also experience more popularity because society is becoming very receptive and encouraging of clean energy and especially on site energy production.

X.PASSIVE DESIGN IMPROVEMENTS

Another major innovation the store designers focus on is architectural design of the building. The construction of exterior walls, openings, and the roof are significant areas for green building innovations in several ways. One design strategy that is particularly important is building orientation, because the sun is the most vital source of energy used on earth. The original building design includes a show window; however this suits the purpose of advertising more than taking advantage of solar heat gains and day lighting. If a skylight is included in the roof, the lighting demand will decrease dramatically during sunny days while the sun is overhead. Also no windows are included in the other exterior walls of the original design. Orienting some windows towards the south will allow sunlight into the building and help reduce lighting loads during the daytime. Additionally, sunlight will provide heat for the building during the winter months, and this can help reduce the heating demand farther.

The prototype core and shell design that incorporates both improved insulation and passive design techniques is beneficial to both the environment and society in several ways. The United States Green Building Council offers a special LEED certification for core and shell design, and this project could definitely be considered for this [12]. If it is achieved, a LEED certification for Core and Shell design will attract people to the building. In a way, LEED certification is an advertisement for companies to show that they are keeping up with the sustainability trend. The store will see more business, which helps to stimulate local economy and increase morale among the community. Practically, the innovations to the building exterior will reduce energy consumption for heating, cooling, and lighting. This typically reduces the fossil fuels consumed, and in the case of our building it conserves electricity. The reliance on utility provided power is decreased, so there will be more available for the rest of the community. Also, unique design will inherently draw customers to the building to see the technology, enjoy the day-lighting, and have a more enjoyable experience. The relationship between the owners and the customers will become stronger as community members will prefer to use a sustainable building instead of an older and less efficient building.

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IX. WATER EFFICIENCY IMPROVEMENTS

Another green building strategy the owners want to consider is water efficiency. A reduction in water utility costs results from efficient use of water because less water is necessary to supply the building. The water demand for our building comes from the restroom that is available to the public and minor amounts of water needed for cleaning. By using low flow fixtures and dual flush water closets, and employing other conservation strategies, we can significantly reduce the water demand in the building. This water usage reduction is most beneficial to the local environment, because precious potable water is conserved, and there is less waste water to process. Our retail store uses a minimum amount of landscaping, but the little that is needed can be captured from rainwater and stored.

The concept of rainwater control is an important concept for sustainability that does not contribute directly to an economic advantage for the business, but it is very important for the environment. A green roof is a possibility for our store, because there remains a large amount of roof area despite the solar panels and skylights included in the design. This will keep the rainwater from dripping across the streets and carrying chemicals into local waterways. Also, it adds to the beauty of the scenery to make up for the unattractive nature of the solar panels. Because the retail store is located in an urban setting, bio-swailes and outside landscaping are less important, so the vegetated roof is an outstanding option. Another strategy the designers could use to limit water pollution is the use of pervious materials in parking areas and walkways so that rainfall stays on the site.

X. SITE SELECTION AND LEED CREDIT BENEFITS

The urban location of the retail store will provide mostly social benefits to the community, but also some environmental benefits. If the store is located in a district that is well developed with the existing infrastructure, both employees and customers can use mass transportation to access the facility. Also, if there are many different common types of businesses in the area, citizens will be more likely to use the nearby business in order to travel less. In city settings, people are more likely to walk or ride a bike to get to their destination, which boosts morale and helps provide exercise. The retail store's location as a whole will help the environment because the pollution associated with transportation will be reduced.

Although the design strategies are mostly concentrated on energy efficiency through the geothermal system and core and shell improvements, a general LEED certification is possible for the building if it uses many of these mentioned techniques, which will make the project eligible for credits that may add up to certification [5]. Now an analysis can be performed to see how well a building that uses these strategies measures up to the LEED standards. We will assume that the project meets all the prerequisites in order to achieve credits toward certification. Because the store is located in a busy environment, the site selection credit will be satisfied. The population in the area for the proposed store will meet the criteria for development density and therefore the five credits can be earned. Also, the ready access to public transportation qualifies our building for six credits for alternative transportation. The two parking capacity credits will be earned because no new parking spaces need to be established in the busy city setting. The green roof and pervious materials outside the building qualify the project for the credit for storm water design quantity control. This adds up to a total of 15 credits in the site selection category. For water efficiency, the retail store is able to earn 4 credits for a 40% reduction in water usage due to the low flow fixtures and dual flush toilets. Up to 19 credits can be earned for up to 48% total energy performance improvement over a baseline established by ANSI/ASHRAE/IESNA Standard 90.1-2007. The calculations for energy performance are derived from computer programs, so we will assume a 30% energy improvement for ten credit points for energy performance improvement. The geothermal and photovoltaic systems provide enough energy efficiency to account for at least 30% improvement. Also, the percentage of on-site renewable energy due to this system should exceed 13% to qualify for all seven credit points for that category. Construction waste management practices during the project should allow two credits to be earned for 75% recycled or salvaged content. With good construction management policies, two credits can be earned for an indoor air quality management plan during construction and before occupancy. These credits mentioned are enough to qualify for a basic LEED certification for new construction. This shows that LEED certification is very possible if green building practices are adhered to and a serious attempt is made to qualify for credits. There are more credits that could possibly

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be earned even if the previous credits were overestimated, so it is likely that our prototype retail store would qualify for standard LEED certification

XI. DISCUSSION AND FINAL NOTES

The replacement of a fuel fired furnace by a geothermal system with back up electric resistance is the most important green building strategy in this design. The entire heating costs with a geothermal system are about half the price of the costs with the furnace, if the cost of electricity remains at 10 cents and the cost of a gallon of fuel oil remains at \$3. The cost of fuel is historically subject to much more dramatic prices changed than the cost of electricity, so the geothermal heat pump will likely remain the cheaper option. The geothermal system is not beneficial for the company only for the economic factor, but because the store will gain respect for reducing pollution and installing a clean energy processing system. This will lead to more business for the store and more income, which will farther accelerate the success of the store. There will be more customers than is typical for a newly constructed retail store, which will decrease the time needed to pay for the costs of construction and other start-up costs.

We have determined that an improved core and shell design offers many benefits to the prototype building. An innovate design with skylights and southern facing windows will offer day-lighting to the building, reducing the amount of artificial light needed inside. Also, the heat from the sun provides natural heat during the winter season, which reduces the load on the heating equipment. Employees and customers will each enjoy using a building with a natural light source that connects the people with the natural world. The other major benefit of a new exterior wall and roof assembly is an improved insulation factor. Although ventilation is responsible for more heat loss than transmission, the reduction in transmission will keep heat inside the building during the winter and outside during the summer. Although we did not focus on the cooling season, the same facts apply that less hot air will transmit through into the building and the cooling load will decrease. The choice to use heavily insulated assemblies, especially the experimental aerogel in the window assemblies, will help the reputation of the company by showing it is up to date with sustainability trends and technologies.

Many other strategies have been mentioned for consideration by the design team, and the most promising is the solar panel technology. Photovoltaic panels do not have high efficiency at this point in the technology development, but in the coming years higher efficiency panels will become more common and less expensive. Also, the amount of roof area on the building will support much more than 2,000 square feet of photovoltaic panels, so there are a lot of decisions to make about size and efficiency of the installation. Ultimately, the more solar energy is saved, the less the building will need to rely on utility power, enjoying instead clean energy cultivated on site. The savings from solar technology will increase in the coming years, so it will slowly become standard that buildings have these installations on the roof of the building.

With these major design ideas, the company will be satisfied with the economic advantage of these sustainable trends. However, incorporating some more common strategies will help the reputation of the company, especially when it may lead to LEED certification, which recognizes building designs that incorporate many green building practices. There are simple improvements to the building design that can reduce water usage, harvest rainwater, and prevent storm water runoff from the site. It is advantageous for the store to be located in a busy area, because easy credit points can be earned for simply being in a populated area. Good construction and quality management practices can also earn the project much needed points toward the basic certification.

We have discovered the potential benefits for the retail chain to attempt a green building project for a new store by applying many sustainable design practices. The initial cost for implementing a project with innovative designs will be higher than the contemporary building design that has been used at all the company's other locations. For this reason, it is necessary that the company be well established to have enough investment capital to take on a more expensive project. Any new construction will be a significant financial expenditure for the owner, but there is also a risk factor for owners to endorse new practices. The economic benefits of using alternative energy will not be realized until the retail store makes enough profit to pay for the entire cost of construction. It normally takes several years for a company to begin making a profit at a new location. Eventually store income rises above overhead costs, employee

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wages, and the cost of goods sold. A successful company makes enough income that a failure of one store location does not destroy the finances. A risk is necessary whenever opening a new location, especially when the design is a prototype and has not actually been proven for performance. However, if the company sells a reasonable amount of merchandise it is unlikely that total overhead costs will exceed the income.

If this building design is a success in creating a more profitable operation, the company will likely continue in the route of sustainable buildings. The expansion of sustainable practices will encourage the company to perform their job well; both because it will be more enjoyable to work, and because the employees recognize the benefits of green practices. In fact, other similar companies will be influenced to follow the trend started by our company, which will help to spread the understanding of sustainability in buildings. The world is beginning to realize that the practices that have been made common in the past hundred years are seriously harming the standard of living for the next several hundred years. The sources of fossil fuel are becoming depleted, and it has been projected that at this rate of consumption it will all disappear within the next couple centuries. Because it is a non-renewable resource that takes millions of years to form, we cannot replace this precious resource. There are situations that require fossil fuels, and we need to ensure there will always be a reserve for future generations.

Recently, researchers and builders have discovered many ways to improve conservation of fuel, especially with automobile transportation. Hybrid vehicles are becoming more popular, and gasoline for cars is now mixed with small amounts of ethanol and alternate fuel that is renewable. Also, we are learning how to cultivate the sun's energy more effectively, using strategies such as passive design, photovoltaic panels, and geothermal embodied energy. As technology improves, especially in the case of solar panels, we will be able to enjoy higher efficiency solar energy that will become less and less expensive. It will take many years before the majority of automobiles use alternative energy and solar panels are widespread on most buildings, but at least positive steps have been made.

The green building movement is very influential for society to recognize that the environment is not invincible and is being harmed by human activities. Studying the fundamentals of sustainable building, students learn a lot about how the world's air, water, and ground are being polluted. Heavy industrial practices are a major contribution to air pollution, and arguably deplete the protective ozone layer in the atmosphere. Humans have been wasting the precious resource of water by consuming too much potable water and discharging it all to be treated, when water can be used for many purposes in buildings before it must be discharged to the sewer. The earth's resources are being depleted and natural existing habitats are being destroyed in order to support new human development. Recyclable content is being discarded at an alarming rate, destroying the earth's beauty with landfills. The construction industry is becoming the leader in sustainability not only with buildings but with a comprehensive view of the natural earth. We realize by studying green buildings that human construction is responsible for most of the degradation on earth that occurs.

There is a critical shortage of potable water in many areas of the world, and the construction methods used control how much of this is wasted and sent to the long process of waste water treatment. Building and infrastructure construction in recent times allows a lot of pollution in the waterways because rainfall is directed into streets where it travels to local waterways, having collected dangerous chemicals expelled by automobiles. Many building materials can be saved for reuse or to contribute to new materials, however these materials end up in landfills every day. Waste management practices are very important during construction to keep the earth clean. On site renewable energy is important to include in new buildings to reduce the drain on power plants that cause more pollution. All of these improvements are now becoming popular, and it appears that the world population has finally realized that the time has come to usher in the environmental revolution.

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- [17] Wujek page 96 "For tight, energy-efficient construction, the ACH is between .41 and .59"
- [18] Wujek, page 870, the location used was Silver Hill Maryland from Table 25.8.
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- [20] The location used for this investigation is Salisbury, Maryland in Table 4.6.
- [21] Source: Wujek page 113 <http://en.wikipedia.org/wiki/Aerogel>, Aerogel is a synthetic material derived from a gel to a solid that has extremely low density. Its low thermal conductivity makes it an excellent insulating material.