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Project Advisor's Approval Signatures:

Joseph M. Fehribach

Laura J. Menides

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Integrating Sustainability into Upkeep Courses

An Interactive Qualifying Project Report
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science

By:

Matthew C. Currid

Laurie L. Kenney

Matthew A. Shapiro

Michael A. Bertini

Approved:
Professor Joseph Fehribach, Major Advisor
Professor Laura Menides, Co-Advisor

Abstract

Upkeep, a nonprofit organization located in London, teaches professionals in the housing field about repairing of homes. This project incorporates information on environmental sustainability into the Upkeep curriculum. By surveying Upkeep's course attendees, performing library research on environmental sustainability, visiting sustainable developments, and interviewing experts; we were able to incorporate five informative, and practical, study packs regarding environmentally sustainability into Upkeep's courses.

Statement of Authorship

This project was contributed to equally by all the members of the team. First drafts and technical aspects of the body were given to Matthew Shapiro, and Michael Bertini. Final revision of the body was supervised by Matthew Currid. All appendices were split up between the members. The final revision of the appendices was supervised by Laurie Kenney.

Executive Summary

This Interactive Qualifying Project was sponsored by Upkeep, a nonprofit organisation located in London, England. Upkeep provides educational courses to those involved in the housing industry. These courses are designed to teach proper maintenance of dwellings, covering issues from basic building construction to electrical wiring. At the start of the project, Upkeep had little information specifically focusing on sustainability. Sustainability is a topic of growing importance, and recognition, throughout the world. Therefore, the goal of this IQP is to integrate sustainability into Upkeep's existing courses. Five courses, in particular, are most amenable to discussing sustainability: Basic Building Construction; Plumbing, Wastes, and Drains; Heating and Electricity; Inspecting Property; and Condensation, Damp, and Decay.

The incorporation of sustainable development into common practice has been a gradual process in the United Kingdom. The concept of reducing pollution from housing initially began in the mid-twentieth century. The path was paved by laws mandating specific requirements for energy conservation and environmental standards. Since this time, there have been numerous laws, both within the UK and throughout the world, that require a more sustainable environment. Reports such as *Our common Future*, by Prime Minister Brutland of Norway, and the UN's *Agenda 21,* call for action towards a more sustainable lifestyle around the world. The broader concepts from these reports

can be applied as practical options that every homeowner can implement towards a more sustainable home.

The central purpose of this project is to incorporate information on environmental sustainability into the Upkeep curriculum. To complete this task, we used four research methods: surveying Upkeep's course attendees, performing library research on environmental sustainability, visiting sustainable developments, and interviewing experts on sustainability. The result of this work is five study packs which are an informative, and practical, incorporation of sustainable practices of home maintenance into Upkeep's courses.

We have to two ultimate goals in completing this project. First, we hope to promote sustainable practices in a manner such that course attendees will take the information from Upkeep's courses, and apply the principles in dwellings that they build or maintain. The more course attendees reached by this information, the more likely sustainability will be incorporated into dwellings. Secondly, we hope to encourage course attendees to look further into sustainability. We have provided web resources and case studies for the class attendees to research further the issue and possibly discuss it with other homeowners. Sustainability is a worldwide issue—the contribution of excessive pollutants affects us all; and it is important for each homeowner to take part in actively addressing this issue.

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Introduction

The incorporation of sustainable development into common practice has been a slow but productive process in the United Kingdom. The importance of reducing pollution from homes became a real issue in the mid-twentieth century, after the Great Smog of 1953, which left thousands dead. From this tragedy came the Clean Air Act of 1956, which mandated specific regulations on energy conservation and environmental consideration. It was a crucial step towards a more environmentally friendly future for the United Kingdom (Liverpool City Council). There have been many laws since this time that strive towards environmentally friendly practices throughout the world. These environmental laws, and actions, eventually focused more on striving towards a sustainable environment, rather than just a healthy environment. At present, sustainability has developed from a concept into an important scientific study and practice.

Sustainability is a broad, yet complex, topic. It addresses three areas: the environment, society, and the economy (Sustainable Washington). Due to the large amount of information on the topic, this project focuses on the most practical aspects to maximize the number of homeowners who will benefit. The study material provides environmentally sound, as well as, cost-effective methods to assist with the environmentally sustainable effort. Every homeowner faces the challenge of finding the best way to surmount the difficulties in achieving a more sustainable home. The goal of

this project is to present a relative “win win” situation for the individual regarding cost and environmental assistance.

Everyone on Earth is affected by unsustainable dwellings. For example, average rainfall in the United Kingdom has sparked great concern. There has been a continual increase in the severity of precipitation. This precipitation may be the product of many centuries of pollution (Townsend). These adverse weather changes may be an effect of the environmental impact of modern society; wastefulness and inefficient consumption are not environmentally sustainable practices. The effort to improve the environment and to implement a sustainable lifestyle depends on individuals making changes in their homes. Factors such as: lack of interest, conflicting statistics, and large upfront costs, however, make for inaction (National Energy Foundation). The central problem is that information is spread out, spans all skill levels, and requires additional time to search several sources. There is a plethora of information and research available on the internet, in libraries, and scholastic journals. The main goal of this project was to better educate the public through concise, and understandable, facts designed to encourage all to help in achieving environmental sustainability. We hope to provide as much useful information within more concise informational packets.

We worked in conjunction with a non-profit organisation, called Upkeep, to achieve the goal of integrating sustainability into its existing courses. Lead by Annette McGill, Upkeep works to find solutions to building maintenance issues, and communicates

these solutions through effective educational mediums (Upkeep Website). Started in 1979, Upkeep reaches nearly 1200 homeowners each year through educational classes, while many others visit their website (McGill, Personal Communication). Upkeep was first located in Hampton Court Palace, and then moved to South London University. Finally it moved to its current location in the Building Centre in 2004. Upkeep educates everyone, from first time homeowners, to professional carpenters through educational classes. The courses are taught by certified instructors. A hands-on museum display is also utilized as one of the teaching tools by these instructors. One aspect of the educational program, which makes Upkeep unique, is the extensive hands-on resources. This includes museum displays, which are currently being rearranged. Upkeep has taken clear steps to incorporate sustainability into its educational courses and eventually into the museum.

The main objective of this project was to help reduce the aforementioned problem. By upgrading the existing Upkeep educational program to incorporate sustainable maintenance options for homeowners; this goal was achieved. Upkeep was largely focused, at the beginning of our work with them, on the construction of new homes; this project added information on how to sustainably maintain existing homes. London is the main concentration of population served by Upkeep. In its residential sector, "64% of the homes were built before 1964" (McGill, Personal Communication). The deterioration of these buildings results in a need for constant repair with regular monetary spending. Larger, one-time, repairs could directly assist the cause of sustainability. An example of

this would be providing a more efficient method of heating, or using better quality insulation. However this larger, upfront, cost may be a deterrent to these sorts of repairs. In the short term, the financial aspect of upgrading towards sustainability may seem overbearing to the average homeowner. However, with new grants being offered by the government, the savings over time make up for the cost incurred on the outset of the project (World Energy Council). Beyond the simple monetary savings are the benefits that these investments provide towards a healthier environment and a better long-term solution for all.

There are several private, and government, organisations working towards the cause of environmental sustainability through education. One problem that has developed within these organisations is the overall lack of trust of information that is presented (McGill, Personal Communication). The public is provided much conflicting information, and this causes difficulty making informed decisions. For example, when looking in three different sources for the amount of greenhouse gasses contributed by homes, to global warming, one will find at least three different answers (McGill, Personal Communication). In order to continue the move towards environmental sustainability, we identified issues with practical, sustainable solutions and provided information on how to put them into practice.

We worked directly with the existing Upkeep curriculum to design additional educational tools to be presented to students of the five most relevant Upkeep courses. These tools

were designed by first learning about the target audience. Surveys were designed to learn about knowledge, and interest, levels of those who would be exposed to the educational tools. From this new understanding of the audience, the team researched the topics of sustainability which were determined to be most effective in motivating the audience towards a common goal of sustainability in the home. We researched and produced a list of organisations which are relevant to the cause of sustainability. We also produced a list of manufacturers who make relevant materials which assist in the sustainable effort. Finally, we created a list of key organizations offering funding in the pursuit of a more sustainable country.

Background

2.1 Rationale for Project

Our liaison and Chief Director of Upkeep, Ms. Annette McGill, specifically requested the focus of this project be directed towards existing dwellings. We included information which applies to a wide-range audience; from homeowners and flat renters to landlords. In order to promote these sustainable practices on a practical and approachable level; we identify areas where environmental sustainability can be achieved in concert with financial viability. To properly approach this project, we researched the topic of sustainability, laws and regulations, and current case studies.

2.2 Definition of Sustainability

> *Sustainability is the [emerging] doctrine that economic growth and development must take place, and be maintained over time, within the limits set by ecology in the broadest sense--by the interrelations of human beings and their works, and the biosphere... It follows that environmental protection and economic development are complementary rather than antagonistic processes.*
> (Ruckelshaus)

In addition to the Ruckelshaus definition, sustainability is a three-fold concept involving environmental, social, and economic aspects. To fully understand the concept of

sustainability, all three of these areas should be considered. As demonstrated in the Venn diagram in Figure 1, one must strive towards all three aspects to be truly sustainable. In completing this project, we strived towards this goal of sustainability, through promoting environmental sustainability in dwellings.

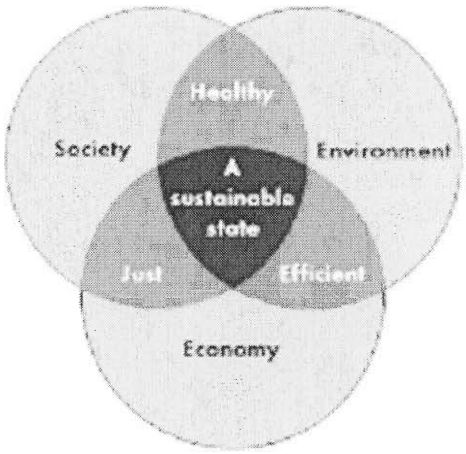


Figure 1

1997 Progress Report of the President's Council on Sustainable Development

The following excerpt from the *1997 Progress Report of the President's Council on Sustainable Development* offers further clarification of this point:

> *One of the greatest strides the Council made over the past four years was to reach a common understanding about the compatibility of economic growth, environmental stewardship, and social equity. As the Council defined its principles and goals and discussed the conditions that would be necessary to achieve them, it became clear that economic progress and environmental protection must go hand in hand. As stated in the Council's first report, "some things must grow - jobs, productivity, wages, profits, capital and savings, information, knowledge, education - and others - pollution, waste, poverty, energy and material use per unit of output - must not.*

2.2.1 Environmental Sustainability

The main area of focus for our project was the environmental portion of sustainability. In particular, we focused on sustainable housing maintenance practices. To gain a greater understanding of environmental sustainability, the Virtual Journal of Environmental Sustainability lists the following as the main aspects of the sustainability:

1 Resources management and recycling
2 Solid waste management including recycling resources
3 Water supply and wastewater treatment and reuse
4 Ecological sanitation
5 Green technology
6 Management of the air, water and soil quality
7 Global and regional environment
8 Policy regulations and institutional issues
9 Environmental systems approach
10 Life cycle assessment
11 Humans and environmental risk assessment

Each of these is a topic within the larger concept of environmental sustainability. The ultimate goal is to increase the efficiency of natural resource usage, in addition to decreasing pollutants caused by human beings. Instead of a downward spiral towards environmental negligence, humans must work towards sustaining the environment in a healthy cycle (Virtual Journal of Environmental Sustainability).

2.3 History of Sustainable Development

2.3.1 Application

The introduction of sustainable development is by no means a recent concept. There have been supporters of environmental living since pollution was recognised as a significant concern. At present there are numerous laws and regulation throughout the world that strive towards environmentally sustainable practices. These actions began in the second half of the 20th century, in response to the destruction caused by changes in human behavior. Before the industrial revolution, methods of transportation and communication were minimal, and usage of electricity was nonexistent. Instead of using energy sources which caused pollution; windmills, waterwheels and other natural sources of energy provided the necessary power for manufacturing. With the industrial revolution, beginning in the 18th century, there was an exponential increase in the energy consumption and pollution output of society. The use and transportation of natural resources also increased significantly, as environmental resources such as coal, trees, and metal ore were used to supply energy. With the industrial revolution came large buildings and factories that expelled great amounts of waste, something unheard of before this time. Large numbers of people moved into these industrialized cities to make a living, and life continued in this fashion up until the latter part of the twentieth century, when scientists and naturalists recognised pollution and health problems. (Sustainable Development: A History of Sustainable Development).

A movement for change swept the planet during the 1960's. People became more conscious of the environmental problems that were arising. The introduction of the "hippie lifestyle" came into existence during this era. This group of people decided to change from living a traditional lifestyle to one that was more natural. They adopted certain ideologies, clothes, and diets in an effort to promote a more natural existence. This new age mindset was expressed through several books, such as Alicia Bay Laurel's "Living on the Earth." In this environmental work, Bay demonstrates ways in which one can live with nature, emphasizing sustainable practices and communal living. Also, Rachel Carson's "Silent Spring" (1964) manifested a direct correlation between pollutant human behavior and environmental destruction. Memorable phrases such as "think globally, act locally" and "you are what you eat" further accelerated the spread of this innovation (Earth Consciousness).

In 1970, the first Earth Day celebration took place in San Francisco. This day is celebrated on the Spring Equinox, where both day and night are of equivalent length. This equivalency in nature is used to symbolize a balance that people need to obtain with the earth. The belief held by this celebration is that; "All individuals and institutions have a mutual responsibility to act as 'Trustees of Earth', seeking the choices in ecology, economics and ethics that will eliminate pollution, poverty and violence, foster peaceful progress, awaken the wonder of life, and realize the best potential for the future of the human adventure" (International Earth Day, World Energy Council).

Celebrations such as these act as reminders that one must take care of the earth in balance, rather than consume and destroy.

2.3.2 Policy

The nations of the world are at various stages of incorporating sustainability into everyday practice. Nations such as Norway and Sweden stand out as countries doing much to become more sustainable nations. They have numerous government organisations, laws and regulations, and website resources concerning the topic of sustainability. England and the United States both show sustainable successes and progress. Yet, many nations are lacking in the effort to become sustainable. Various economic and social reasons contribute to this lack of effort. In response to the general lack of effort; there have been several conferences, both international and nation-specific, during the last thirty years that push for sustainable integration throughout the world.

Conferences on sustainability began in the 1970's, with the 1972 United Nations Conference on the Human Environment, in Stockholm. This conference was focused on the outcome of an attempt towards preservation, and improvement, of the human environment. The first principle in the document fully displays this attitude:

> *Man has the fundamental right to freedom, equality and adequate conditions of life, in an environment of a quality that permits a life of dignity and well-being,*

> *and he bears a solemn responsibility to protect and improve the environment for present and future generations.*

A fundamental landmark in the progression of sustainable practices was the Bruntland Report, officially entitled *Our Common Future*. In 1987, Mrs. Gro Harlem Bruntland, the Prime Minister of Norway, for whom the document is named, chaired the World Commission of Environment and Development. The report brought the specific concepts of sustainability to international attention. Two years later, this document led to, through discussion by the UN in General Assembly, and the passing of Resolution 44/228 December 1989, the development of the UN Conference on Environment and Development (United Nations Conference on Environment and Development, 44/228). The UK Government displayed their faith, and support, in sustainability by writing a strategy, entitled *Sustaining Our Common Future,* for implementing sustainability. The UN created its first comprehensive strategy, called *This Common Inheritance*. This publication used ideas formulated by the UK.

Yet another important movement towards sustainability was the Earth Summit of 1992. Officially named the "UN Conference of Environment and Development", it was composed of almost 180 countries. The three major accomplishments of this meeting were; the Rio Declaration of Environment and Development, Agenda 21, and the UN Commission of Sustainable Development. The Rio Declaration was a set of twenty-seven principles supporting sustainable development. It was also written as a follow up to the 1972 conference (Rio Declaration on Environment and Development). Agenda 21

was a plan for the global development of sustainability involving international, national, and local organizations. Chapter seven of this document is titled "Promoting Sustainable Human Settlement Development," and covers providing everyone with shelter, industry, and energy use (Agenda 21). The Commission of Sustainable Development was developed to ensure that the UN Conference on Environment and Development was continued, to follow the implementation of Agenda 21, and to follow the "progress towards broad global sustainable development objectives" (Commission on Sustainable Development).

Two years later, in response to Agenda 21, the UK became one of the first countries to create an environmental sustainability strategy. The plan was entitled *Sustainable Development: The UK Strategy*; these practices were further pushed with the victory of the Labour Party in 1997. The party proclaimed intentions to create a new environmentally sustainable strategy. There were also changes made to Articles 2 and 6 of the Treaty of Amsterdam, which increased the sense of community in Europe. These changes were crucial to the implementation of sustainability into law and practice.

Sustainability was further incorporated into the public sector of the UK, in 1998, when *Opportunities for Change* was published to increase awareness. These documents provide a good explanation of how sustainable practices will affect the UK population, and make improvements to their respective communities. A year later, the government

published yet another strategy, *A better quality of life- A strategy for sustainable development for the UK.* This was accompanied by *Quality of life counts - Indicators for a strategy for sustainable development for the United Kingdom: a baseline assessment.* Both of these documents show the increase in the level of commitment of the UK to change. In 2001, *Achieving a better quality of life* was published as a progress report of the sustainable development change made in the UK. (Sustainable Development, Our Common Future)

2.4 Current Policy

2.4.1 Regional Development Agencies

The Regional Development Agencies Act 1998 took effect 1 April 1999 and created eight regional agencies, each of which is a non-departmental government body, charged with promoting economic development within their region. A ninth agency was created as the London Development Agency in July 2000, following the creation of its parent organization, the Greater London Authority.

In addition to their economic agendas, these regional agencies are to implement sustainable ideals in their planning. They take into account both the current, and future, needs of local and regional communities, as well as environmental considerations, in working toward economic growth.

The 1998 RDA Act requires each agency to develop strategic visions for their region, in compliance with specific statutory and non-statutory guidelines. The goal in creating the agencies was to ensure that those involved in economic decision-making work efficiently together.

2.4.2 Greater London Authority

Parliament passed the Greater London Authority Act in 1999, which created the Greater London Authority and its four functional bodies. Additionally, the Act granted the Secretary of State the power to create secondary legislation, better known as statutory instruments. In practice, the Secretary has the authority to set rules, regulations and policies regarding the specific sections of the Greater London Authority Act 1999.

2.4.3 Modernising Government

Published in 1999, the *Modernising Government* White Paper formally dedicated the government "to produce and deliver an integrated system of impact and appraisal tools in support of sustainable development covering impacts on business, the environment, health and the needs of particular groups in society" (Modernising Government, 1999). This led to the creation of a new mandatory appraisal for new proposals; it was named the Regulatory Impact Appraisal. The RIA incorporates sustainability considerations into its analysis; requiring policy-makers to identify the environmental, economic and social costs and benefits of their proposals (Modernising Government, 1999).

2.5 Topics in Sustainable Development and Case Studies

2.5.1 Holles House

A prime example of sustainable development in the UK took place in Lambeth, South London, in a block of houses called the Holles House (Sustainable Development: The UK's Approach). This project, undertaken by Anne Thorn Architects Partnership, repaired the houses on a sustainable agenda, so that there was a 40-50% reduction in energy demand. In addition, a reduced Carbon Dioxide emission of approximately 200 kg CO_2 equivalent per flat per year was achieved. This was accomplished through insulation of walls, as well as the installation of new windows. In addition to energy conservation concerns, the partnership addressed the lighting and safety concerns of the residents. This project not only saved energy resources, but also improved the quality of life for the residents. We used this case study as a cynosure of sustainable development for residential homes in the UK.

2.5.2 Millennium Integer House

The Millennium Integer House, located at the Building Research Establishment in Watford, England, was designed to be both intelligent, and green. Built in 1998 to exemplify the state-of-the-art; it features all the conveniences of the typical modern home, as well as technology that was cutting-edge at the time. All of the materials used

in the construction were donated. It served as a testament to the technical viability of the project.

Photovoltaic panels on the roof provide a source of clean electricity, while an evacuated-tube heating system supplies all of the necessary hot water. A large glass-enclosed conservatory on the southern face of the house harnesses sunlight to provide heat during the daytime. For heating on extra cold winter days, and through the nights, a heat pump system extracts warmth from 50 meters underground. This method of heating requires minimal energy and CO_2 production; the heat itself is provided by the earth, and the only energy expenditure is the running of the heat pump. By placing the bedrooms on the ground level behind windbreaks, where heating requirements would be less than the rest of the house, overnight energy usage was lowered further. Grey-water recycling is another key feature of the home; 35% of home water consumption is flushing the toilet, which is a waste of drinking-quality water. Wastewater from the showers, baths, and sinks is collected in large tanks beneath the home, and is then used for flushing the toilets. The annual water consumption of a home, with grey-water recycling, is drastically lower than a home without.

Although the Millennium Integer House was not constructed for habitation, it serves as a model home, and template, for organisations seeking to build ecologically sound housing. It demonstrates available design options that allow for decreased CO_2 emissions, while raising the standard of living.

2.5.3 London Borough of Greenwich

A sector of the Greenwich Council, the Sustainability division, is making great strides in providing solar power water heating for their existing properties. Alterations began in 1994 as a means of providing affordable energy costs to homeowners, as well as thermal comfort. Since then, Greenwich has developed a "Local Public Service Agreement (LPSA)" in an effort to give a focus on how they will accomplish this goal. In 2002, they received an Unsupported Credit from the Government in the amount of £500,000 to fulfill the following requirements:

- Improve the energy rating on 150 Miscellaneous Acquired Properties by 11 points on average
- Reduce carbon dioxide emissions by an average of 20%
- Reduce fuel costs by an average of 20%

2.5.4 Beddington Zero Energy Development (BedZED)

BedZED is located in Beddington, Sutton. It is the first large scale "carbon neutral" establishment. BedZED was constructed to demonstrate that homes can be built to operate completely on renewable resources, creating all energy onsite. BedZED was designed through the teamwork of Bill Dunster, architect, and BioRegional; and is being developed by the Peabody Trust. BedZED has incorporated many concepts of

sustainability into their housing developments. The primary combined heat and power system for the development is controlled by wood-chip technology. Essentially recycled wood is chipped down and burnt. The gases released from the chips form the power source. Since the carbon released back into the atmosphere is from a living organism, which requires the same amount to grow again, it is not considered an addition in carbon emission. To complete the power required for everyday living, BedZED uses photovoltaic cells. They are arranged within the window structure of the apartments to provide for a more aesthetically pleasing alternative to solar panels mounted elsewhere. All of BedZED's solar cells are placed on the southern face, as well, to maximize solar exposure. All of the office space is located opposite because electronics put out heat, so it is not as important to have the sun shining into that area. To save on water usage, grey-water recycling is incorporated into the scheme. W ater used to bath and wash dishes is run into a holding tank. From there it is pumped up through a filtering system. That same water is then pumped back into the home for use in flushing of toilets. Since flushing toilets accounts for 35% of water usage, grey-water recycling saves a considerable amount of water. Ventilation is of large concern within UK dwellings; and the amount of air that must circulate is regulated to half the air mass within the home per half hour. This is accomplished without the use of pumps or fans, in BedZED. Large wind cowls are placed on the roof, which u tilizes wind power, to keep air ventilating within the home. Heat from exiting air is also transferred to incoming air, again without pumps, to save on heating energy. Perhaps the most integral aspect of BedZED is its use of "heavy-weight" construction. A combination of brick, building blocks, and a

300mm width of environmentally safe insulation, provides for an extraordinary resistance to change in outside temperature. A minimal amount of heat is needed in the winter, and the same is true for air conditioning in the summer. This "heavy-weight" construction is the environmentally friendly alternative to the cheaper timber frame construction, which is referred to as "light-weight" construction.

2.6 Topics in Environmental Problems and the United Kingdom

2.6.1 Present Environmental Situation

The Department for Environment, Food, and Rural Affairs, in the UK, has produced an informative, and easy-to-use, website concerning where the air pollution comes from, and its particular effects on the environment, and the health of people (The Virtual Journal of Environmental Sustainability). These pollutants come from three main sources: vehicles, energy generation, and heating. While the subject of vehicles is a separate topic, energy generation and heating are directly related to residential housing in the UK. Some examples taken from the source are: sulfur dioxide, and nitrogen oxides, which contribute to air pollution and acidification; carbon dioxide, carbon monoxide, and ozone, which deplete the ozone layer and increase the temperature; and many other pollutants which may affect local plants, animals, weather patterns, and the health of human beings. If a stronger personal connection can be made between

individuals and the problem of pollution, there is a stronger chance that they will assist in the fight against it.

2.6.2 Issues of Global Warming

The issue of global warming has been an ongoing debate during the last century. The sun's heat passes through the atmosphere and is then trapped here by green house gases, such as water vapor, and carbon dioxide. Without this phenomenon the temperature on Earth would be considerably lower. With an increase in the carbon dioxide levels in the atmosphere there is an increase in the greenhouse effect, thus warming the planet. This concept is displayed in Figure 2.

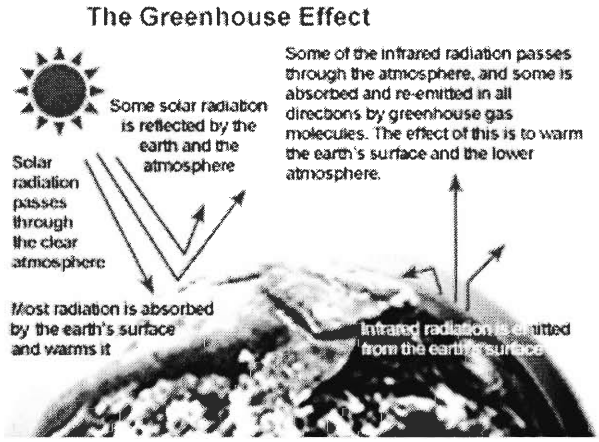


Figure 2

http://www.epa.gov/globalwarming/kids/images/earth.jpg

The contradiction to this issue is that the increase in average temperature is a natural cycle of the planet. Some see global warming as a positive issue because it holds off

the onset of the next fluctuation in temperature towards another "Ice Age". Dr Benny Peiser, of Liverpool John Moores University, was quoted in saying "Instead of driving us to the brink of environmental disaster, human intervention and technological progress will be seen as vital activities that have unintentionally delayed the onset of a catastrophic Ice Age." (Austin)

Although the future is unknown, some hypotheses claim that the effects of this temperature increase are already changing natural cycles. The amount of snowfall and glacial ice has decreased while the sea levels have risen several inches. With all of this information, it becomes quite difficult to determine what statistics to believe and which statistics should be disregarded (U.S. Environmental Protection Agency).

2.6.3 Local UK Environmental Issues

Some experts say the effects of humans can clearly be seen in the UK. One example is the potential extinction of the Cockney Sparrow. "The national sparrow population is reported to be 673,000, a 57 percent drop since 1979", according to Robyn Dixon. The majority of the population has disappeared from large cities, particularly London. "Birds are indicators of the quality of life. Is the house sparrow, the modern equivalent of the miners' canary, telling us something nasty is going on in our cities?" asked Keith Noble (Dixon, Robyn). Although the exact cause of their endangerment remains unknown, many speculate it is due to increasing pollution and changes in temperature. Sustainable building can help reduce pollution levels, thereby helping to preserve our

feathered friends. This example brings the larger statistics to an everyday level, on which residents can relate, and may be more inclined to act upon. Lastly, in addition to the sparrow extinction issue, there exist other environmental issues, including extraordinary amounts of precipitation, and occurrences of smog, which people may readily identify with.

2.6.4 Environmental Impacts of households in the UK

Environmental impacts of households: 1970-2001

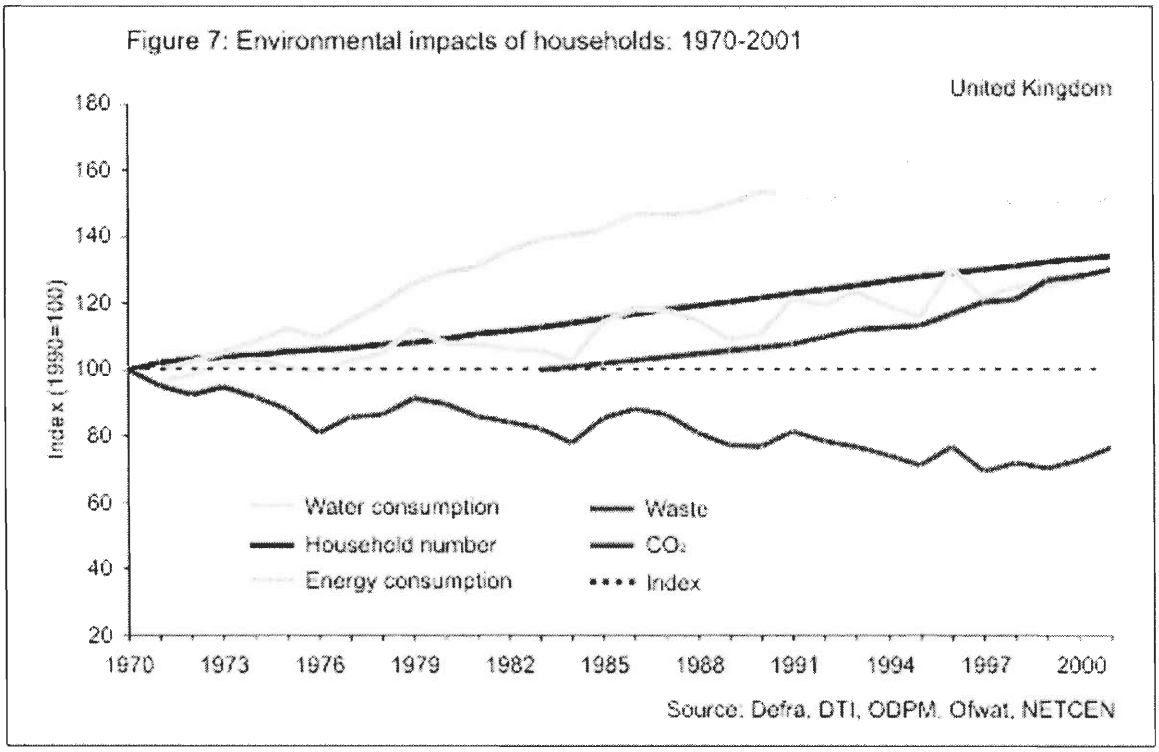


Figure 3

From figures provided by Defra, for residential homes in the UK, one finds an increasing trend in water consumption, number of households, waste, and energy consumption. The only category that one finds a decreasing trend is in the production of carbon

dioxide. Yet, this is due to an increasing usage of gas to supply heat to homes, as opposed to the formerly used coal. If all of these figures continue in the same manner, the demand of natural resources will climb to incredible heights. One purpose of sustainable development is to stop this upward trend and minimize the dependency on these resources, so as to save the environment.

According to Christopher Dow, three of the UK's major recessions occurred after 1970. These three recessions are: 1973-75, 1979-82, and 1989-93. It is true that during these times, energy consumption decreases in UK households. As the graph shows, as soon as these recessions were over, the energy consumption increased once again. This leads one to intuit that recessions are linked to decrease in energy consumption. We believe a significant goal would be to keep energy consumption at a lower number, especially when leaving a period of depression. It seems as though it might be more difficult to convince others to keep energy consumption low when the economy is booming.

2.6.5 Sustainability in the Home

There are many ways in which humans can help the environment by making changes within their homes and lifestyles. Yet, people must be motivated to make such changes. Homeowners typically ask pragmatic questions such as: "Why improve energy efficiency in dwellings? Why strive towards sustainability? How can I become more sustainable without spending a lot of money?" These are the questions that were

answered through additions to the Upkeep classes. We organized the concerns of homeowners into four categories of rationalization:

(1) Environment- you can help strive towards a healthier future

(2) Money- you can reduce your bills

(3) Health- you can avoid unnecessary illnesses

(4) Standard of living- you can live a comfortable lifestyle

These four topics are the simplest way to separate the concerns of homeowners. The weight of each of these can vary according to the homeowner. For example, a person who cares for environment, but does not have significant funds to update the home, would be concerned about the money aspect. On the other hand, someone who just has a baby might be more concerned for the standard of living aspect-the quality of life for future generations. All of these issues are substantially covered in the course materials; therefore, most homeowners' concerns should be covered in our defense of striving towards sustainability.

2.6.6 Present and Future Value

Most homeowners are concerned about monetary expenses when updating their home, to become more sustainable. One particular concept concerning sustainable investment practices is the notion of present and future value. As stated in the Investment FAQ, "Future value is simply the sum to which a dollar amount invested today will grow given some appreciation rate. To compute the future value of a sum invested today, the formula for interest that is compounded monthly is:

fv = principal * [(1 + rrate/12) ** (12 * termy)]

fv = future value

principal = dollar value you have now

termy = term, in years

rrate = annual rate of return in decimal (i.e., use .05 for 5%)

Note that the symbol '**' is used to denote exponentiation (2 ** 3 = 8)."

This economic concept makes for a great monetary argument for homeowners to turn to particular sustainable practices. For example, this present and future value could be applied to a new heating system that is installed. Instead of simply telling homeowners that they will possibly save money; we can show them in an economic and scientific manner how they will save money. It helps transform the nebulous concepts of saving money to a more concrete equation. This equation could be applied to almost any

capital investment made to improve the quality of a house. Additional engineering equations also come into play, such as, heat transfer and thermo fluid calculations. However, these may become too in depth for the goal of this report. In combining these types of economic equations on savings, in addition to environmental savings, we hope to convince Upkeep's audience to use sustainable practices.

The information collected in the background section is essential to our understanding of sustainability. Before we added information within the Upkeep course additions, we needed an understanding of the past, present, and potential future of sustainability. Once we completed the background, we had adequate means to implement the methods of approach section.

Methodology of Approach

The methods used to complete this project were derived from our understanding of the problem statement, in conjunction with recommendations from our liaison, and information gathered from "The Craft of Research" by Booth. From the outset, we hoped to accomplish four main research objectives: to acquire information from a sampling of Upkeep's course attendees, compile practical information for the packet additions, visit sustainable homes, and acquire practical advice related to our project from experts in the field. In researching the possible ways to complete these tasks, we narrowed our methodology to the following four approaches: conducting surveys, performing library research, interviewing experts, and examining case studies. Here, we present them in greater detail.

3.1 Survey

We first determined the various backgrounds and concerns of Upkeep's course audiences regarding the topics of environmental issues and sustainability. We designed the survey to gather the following information:

- Thoughts and beliefs towards global warming and environment
- Uses of sustainable practices and limitations thereof in course attendee's own home

- The sustainable practice undertaken by attendee's organisations
- Limitations to becoming more sustainable
- Helpful topics to be added to course materials

Two different surveys were implemented. Firstly, "Class Surveys" were distributed within Upkeep's training courses to class attendees. Another "e-mail Survey" was sent to various Upkeep contacts via e-mail.

-- For a more detailed examination of the surveys, see Appendix C and Appendix D, respectively.

We believed that the information gathered by these surveys was instrumental in providing the majority of quantitative data. We designed our survey with multiple-choice questions, which we formulated into statistical data to be used in presentations, and on the Upkeep website. The surveys also contained open-ended questions for further qualitative information, such as company names, contact information, and additional information pertaining to sustainability. The amount of time required to complete our survey was an important consideration in choosing this research option. The Upkeep course attendees spent at least six and a half hours in class during the day. It would have been unreasonable to ask them to stay longer. The quality and quantity of survey responses also may have suffered if we had done so.

Additionally, the average Upkeep class size was approximately 18 people, and performing interviews with each person individually would have required an inordinate amount of time. Focus groups, which typically consist of seven participants or less, would have demanded too much time on the part of the class attendees. The amount of space available for these undertakings was also limited as there was only one conference room available. Time and space were limited for both the class participants and ourselves, therefore a 5-minute survey distributed during the day was the most practical option to obtain our results.

The quantitative data provided from the surveys was entered into an Excel spreadsheet upon completion. The information from the "Course Survey" was compiled using statistical analysis to determine the groups and areas that we needed to address, while the "e-mail Survey" statistics were calculated automatically with an HTML program. The results of these surveys are described in greater detail in the "Results and Analysis" section.

3.2 Library Research

Another central objective of this project was researching environmental sustainability and its incorporation into domestic buildings. This objective was accomplished mainly through library research. We found the most relevant information within government websites, organisation and commercial websites on sustainability, and various texts

provided by Upkeep. These sources provided the foundation of the information that we incorporated into the course materials. There was no problem finding enough information on the topic of environmental sustainability; the greater effort was narrowing down the information within the packets to only the most important and relevant information to the course materials.

3.3 Analysis of Case Studies

Another important aspect of our research was visiting sustainable homes within the greater London area. We visited three locations which provided somewhat of a sustainable timeline for our research. Past attempts at sustainability, some of which have since become obsolete were displayed at the Millennium Integer House located at the BRE. The London Borough of Greenwich is undergoing dramatic changes to attempt to incorporate sustainability into its 150 properties. This gave us a look at what is currently going on in the United Kingdom regarding environmental sustainability. Finally, BedZED displayed to us the future of environmental sustainability with state-of-the-art technologies. Visiting these sites provided us with ample amounts of data to include in the course packets, in addition to "hands-on" experience.

3.3.1 Millennium Integer House

The Millennium Integer House was constructed with the most up-to-date technologies available in 1998. This case study represents our "sustainable past". The Integer House

is equipped with several sustainable technologies. One of these technologies is geo-thermal heating, which extracts heat from 50 meters within the earth, as opposed to generating it from energy sources that produce carbon emissions. However, with the concept and understanding of sustainability changing so frequently, this idea is rapidly becoming obsolete. Many, including Bill Dunster (BedZED architect), believe geo-thermal heating to be an unsustainable practice. The concept of using existing heat is sustainable; however, the energy it takes to operate pumps to make the heat usable is not. The Integer House does contain some up-to-date sustainable practices, however. These include, but are not limited to, solar water heating and grey-water recycling. These two technologies are still at the forefront of sustainability. One of the concepts that was initially included in the construction of the Integer House, but was later found to be impractical, was the use of wind power. Wind power requires many precise considerations, such as: proper landscape, adequate average wind speeds, and proper angular calculations; so many that it is not feasible for the average homeowner. Wind power has already proven itself practical, but this is when used in specific global areas, and with large numbers of windmills working together to produce energy. Despite the initial importance of Integer House in displaying the concept of sustainability within a dwelling, an increased amount of research taking place in environmental efficiency has pushed it from the cutting-edge. The Integer House has given way to newer, more up-to-date models of sustainable building practices.

3.3.2 London Borough of Greenwich

Visiting Greenwich was a great resource for information on solar energy. We were able to visit a house built in the 19th century that had solar water heating retrofitted on the roof. Additionally, we were able to speak to the resident of this home to acquire information regarding their level of satisfaction. This experience differed from our previous case studies in that this was new technology on an older dwelling. The homeowner was quite satisfied with the appearance, cost savings, and ease of use. Since Greenwich installed these panels at no cost to the homeowner, their installation proved incredibly beneficial. The only predicted potential problem with this solar water heater installation will be maintenance-related, after a number of years.

Ample information for the Upkeep sustainability supplement "Electricity and Heating" was gathered through this case study. Also, our contacts at this site provided numerous other informational sources to examine, such as the "Solar for London" project, as well as other developments within Greenwich.

3.3.3 Beddington Zero Energy Development (BedZED)

The Beddington Zero Energy Development (BedZED) was a case study into what the future may hold. The technologies and ideas implemented within BedZED are far ahead of mainstream implementation. There is state-of-the-art technology used in each of the areas in which sustainable practices were incorporated. It is so advanced, in fact, that it overshot the primary goal of the architect, Bill Dunster. His original goal was to set a

precedent that could be adapted and followed by the building community. However, so much money and radical thought went into the project that its ideals were never embraced by the building community. Regardless, BedZED still represents that which can be achieved in the future. Producing zero net carbon emissions, as well as having numerous other environmentally friendly aspects, it stands as a testament to the practicality of environmentally sustainable housing. The technologies used at BedZED were state-of-the-art, allowing us to observe potential downsides to them. For example, the woodchip technology used to provide combined heat and power for the development depended solely on the reliability of one machine, which was designed to burn the chips and convert the heat into electricity. At BedZED this machine has proved itself to be less than reliable. Being at the forefront of technology also meant that the BedZED installation needed to invest a good deal of time and patience in harnessing the full potential of this system.

BedZED also used grey-water recycling. However, the way in which they laid out the plumbing for this system required large amounts of pumping power to raise the recycled water to the surface for use. Although the process effectively recycled the grey-water, the energy required for pumping did not provide for optimum energy efficiency. One positive aspect of this implementation was the attitude of the development's inhabitants. As with any new design, the user acceptance level is always a concern. Although this building concept had not yet been widely accepted by building professionals, the residential population of the development accepted it with ease.

3.4 Expert Interviews

The last methodological approach taken was an interview with an expert. We will conduct an interview with Peter Smith, a Professor Emeritus of Leeds Metropolitan University, who has written numerous books on the practical implementation of sustainability in housing areas that pertain to our project. From this interview we hope to gain information, and to gauge the viability of the information we have already collected. We will also be providing Peter Smith with the drafts of the additions to the course materials to obtain feedback and advice.

Not until each of these four steps was completed did the sustainability supplements approach their full potential. Each method was instrumental in the process of refining, supplementing, or deleting the information that we had already gathered. We feel as though the end results of our efforts and the central project objective—to add information on sustainability into Upkeep's educational material—was completed to satisfaction. It is our hope that the information included in the packets will be read many Upkeep class attendees throughout Upkeep's existence.

Results

We had certain expectations upon undertaking our research as to what the results would be likely be. As a matter of pre-thought, we projected some statistics from the surveys, and also believed certain materials to be environmentally friendly. As we received surveys back from attendees, we found some of our projections to be accurate and others to be off mark. Additionally, we found a great deal of practical information from our library research that was not originally thought to be useful. A more in-depth look into our results is covered in the following paragraphs of this section.

4.1 Survey Summary

In studying the "Class Surveys" and "E-mail Surveys" we learned some important facts. Firstly, an overwhelming 76% of attendees believed that the way humans are using natural resources is changing the global climate. Only 9.8% of those surveyed believed humans did not have an effect; that left the remainder unsure. In the second question, the team was happy to find out that over 84% of respondents felt in some way concerned about global warming. 34% of respondents voiced that they are "very concerned". When asked whether people thought dwellings contributed to global warming, it was assumed by the team that the response would weight to the negative. However, the survey shows that an overwhelming 73% believed that dwellings did contribute to global warming. Without a single response of "no", that left the rest of the

sample “unsure”. This is important because it indicates peoples’ awareness of the need for sustainable housing. These results, in conjunction with recent media reports on climate change, exemplify a general awareness of the issue.

When asked who should take responsibility for changing the current environmental situation, the survey split. Of the respondents, 33% said “government”, and 39% said “everyone” should be responsible. This leaves the remainder split among various other answers. However, only 12% stated that “individuals” should take responsibility for global climate change. This is interesting because when asked what, if at all, you do to aid in helping the environment, 80% said “yes they do”. Of those 80%, 39% recycle. This is a very individual act. Clearly people may not feel as if it is completely their responsibility to save the environment, but there is an existing effort to assist. Perhaps most crucial to this IQP were questions 9B and 9C. In which these questions ask why the respondent has been unable to assist in the sustainable effort. Or, if they have, what was the greatest issue holding them back from doing it earlier. We found that of those who had not yet assisted in the effort, 63% indicated it was a problem of money. Of those who had helped, 38% said money. Those that had helped also indicated with a 33% response rate that time was an issue. Of those who had not yet helped, 55% indicated that confusing info was to blame. These bits of info told us many things. First, we needed to simplify the information so it was easy to understand, and therefore, more likely to be acted upon. Secondly, we needed to show reasons why these practices could save people money. Changing your home to fit the sustainable effort is costly at

first; however, one of the goals of the IQP is to show people that over time it can save money. When asked whether people would like information on global warming in their lesson packets they responded with 76% “yes”, and 1% “no”. This indicates, at least, a willingness to learn about the topic which is essential to reaching our audience.

Finally, people were asked what they would like to see most in the informational packets to assist them in their learning. This was essential to the project, as the team needed to learn how best to communicate to the target audience. About half stated they would like graphs to assist with information, and websites with further information so they could do further research. About a third of people indicated they would like information directly on global warming, and suppliers of applicable resources. These were all taken into consideration when creating the final copies of the study packets.

4.2 Interviews

In addition to the surveys, interviews with course participants resulted in a better understanding of general attitude towards some questions in the surveys. For example, many participants had a “don’t fix it if it isn’t broken” attitude towards certain aspects of their homes. This led us to take money into greater consideration, in addition to focusing on smaller sustainable improvement options. Instead of immediately promoting the purchase of a new heating system, we would promote smaller ways to conserve heat, and after that, to consider a more sustainable heating system when the time comes.

Others felt a sense of helplessness because their dwelling was owned by a landlord. For this reason, we provide information in the study packs that can help save on the electricity and heating bills and water conservation, while helping the environment.

These results are the outcome of a seven week time period. If the same methods were implemented for a longer period of time, we would expect similar results. However, if environmental of housing laws are passed, we understand the results could deviate from our collected results.

4.3 Study Packs

The final product produced was five supplements to add to the end of the existing study packs. These supplements varied in length from one paragraph (Condensation, Damp, and Decay), to thirteen pages (Basic Building Construction). They each contain sustainable practices pertaining to the topic of the existing course material. Each was broken into sections covering topics of interest as indicated by the audience through our survey.

4.3.1 Introduction

The beginning of a supplement introduces the reader to the connection between the individual course material and the sustainable effort. Also included in this introduction is

a definition of “global warming” and “sustainability”, to provide the reader with the basic knowledge to understand what they will be reading suggestions about. We included an introduction with each supplement, as opposed to jumping right into sustainable practices, because many respondents to the survey indicated they were not happy with the amount of information regarding sustainability. By introducing the reader directly to the concept of sustainability and global warming we are allowing the reader the opportunity to better understand the points we attempt to convey further along in the supplement.

4.3.2 Sustainable Options

The body of a sustainability supplement covers a varying degree of options that can be used to achieve a more-sustainable dwelling. These options are broken into two main categories. Firstly, we included the “simple methods” section. This section encompasses options that are low in cost and require little alteration to the existing building. Each supplement includes options that pertain directly to that study section. For example, tap aerators, which limit water flow, are included in “Plumbing, Wastes and Drains”, whereas insulating a water heater was included in “Domestic Electrical and Heating I”. Some sections did not include simple options, as there were no possible options that fit into the study material. An example of this was the “Basic Building Construction” section. This section deals primarily with the construction of a home and

all sustainable options pertaining to this section would fall into the second options category.

The second options section contained "advanced options". These included more expensive options that included more drastic changes are made to the dwelling to accommodate for them. Again each section varied including options that pertained to the specific course material. An example of a "Basic Building and Construction" option was replacing insulation and/or windows to better insulate the dwellings.

4.3.3 Conclusion

In conclusion, to each supplement we included cost-savings tips. This in-depth look at cost was in direct response to the large number of survey respondents who indicated "cost" as a deterrent to applying environmentally sustainable practices. By illustrating the present and future costs of certain options we can further inform the readers of approximately what they can expect to spend. The cost-saving tips are meant to display the connection between helping the environment, and saving money over time. Further information regarding cost of individual options and there technologies were included previously throughout each supplement.

Finally, in response to respondents concern of "information" and the inability to understand it all, we included sources which are informative yet concise. This will allow

readers to access easily understandable information for readers to further research the topics of our supplements if they so choose.

Conclusion

Upon arrival to the UK we were pleasantly surprised to see the extensive effort by both the English government, and its civilians to assist the sustainable effort.

The team was able to come up with substantial informational packets for five of Upkeep's courses. The sixth course, Condensation, Damp & Decay, already included a significant amount of information pertaining to sustainability. However, we added some background material, as well as a small bit of additional information to reinforce the message of sustainability.

A combination of surveys, professional interviews, and case studies gave us the basis for what we would include in our packets. Not only were we able to study the best information to include, but the way in which we displayed it to the audience was also carefully thought out. The most informative element of our audience research was the survey which was handed out to participants of the courses. These surveys allowed us to see what people were interested in, and how we could most effectively convey the information to them. Through interviews with professionals, namely Annette McGill and Peter Smith, we were able to decide what material was most relevant. We learned that some approaches to sustainability are great to use and very cost effective. However, some are not practical for homes. Finally, using case studies, we were able to see the ideas we highlighted in the study packs being implemented by housing organizations in

the real world. Our team visited two sites in particular; the Building Research Establishment (BRE) and Beddington Z (BedZED). The BRE contains a dwelling known as the Millennium Integer House (intelligent and green) was designed in 1998 to incorporate intelligent technologies and energy saving technologies into a three bedroom dwelling. BedZED is a zero emission dwelling. It is able to produce all of its needed energy completely independent of the grid. These two establishments gave us a chance to see just how practical the information we are putting out to others is. We used images of these two locations within the study packs to display a real sense of what the sustainable effort can provide.

We distributed a survey to the participants of Upkeep courses, to ascertain specifically which areas of sustainability they are most interested in. More than three-quarters of the respondents believe that our current use of natural resources is the primary cause of global climate change. However, only 73% percent of respondents feel that dwellings directly contribute to climate change; we received no responses indicating that dwellings are in fact not responsible. This showed us that our packets must, in addition to providing options for sustainable home maintenance, include information on the magnitude of impact homes have.

Responses as to who is responsible for this change were fairly ambiguous, with only 12% feeling that individuals should take responsibility for climate change. As there are many ways in which individuals can make a difference, it was important for us to take

this general feeling of disconnection from potential solutions into account. Our study packs had to be tailored to show the value of each individual working towards environmental sustainability.

The financial aspect of home maintenance also had an important part in the creation of the study packs, as cost was a common concern according to our survey results. Thus, we aimed to include information both on up-front and long-term costs in the study packs.

Recommendations

We found that surveying was the most effective way to research our target audience. Doing individual interviews was not time effective. It also was not possible to develop focus groups given the nature of our audience. Using surveys was the quickest and most straightforward method to gather information in a manner which we could derive useful information. By controlling the response we could effectively develop statistical data.

After handing out two different copies of the survey we realized there are still some things that could have been added to the survey for a more in depth look at our target audience. One possible question could have been the age of the participant. The gender also could have been asked. These two questions could have given us an idea of whether different age groups/genders viewed the environment in different ways. Surveys are a difficult thing to build. However, we found that although it is a good idea to find out as much as you can, and you may find yourself constantly wishing to expand on your survey, you should build one that best displays what you are looking at and nothing more. This is because, although it would be nice to show as many things as possible regarding your topic, you only have a certain amount of time. It is more important to explain what you need, in detail, then to briefly describe many topics that don't directly deal with your goals.

It is a good idea to go out and experience, if possible, the real-life impacts of what you are researching. By going to see different organizations such as BedZED and the BRE, our team was able to get a grasp on what our research was attempting to accomplish. That really helps with focusing on, and realizing, your efforts. It is easy to get tunnel vision on your project. However, when you get a chance to see how the results are applied in the physical realm you can refocus on what you are really trying to work towards.

We found that it was easiest for us to break up the project into tasks. Since we had much writing for the actually project we had double the writing as some of the more technical teams. The most effective way we found to handle this situation is to break up the primary writing assignments and share the revising. Each team member would write an entire section and the rest of the team would work to revise it. This method was applied to both the IQP paper, and the study packs we created for Upkeep.

With the growing interest of sustainability, combined with the technological changes taking place that directly affect the effort towards it; it may be in the interest of Upkeep to update these packets as new developments arise. It would be possible, in the future, for other WPI teams to further assist Upkeep in remaining up to date in the areas of sustainability.

Works Cited

Austin, Suzy. "Saved from Ice Age- by school runs" Metro. 24/1/2005.

Bruntland, G (ed) (1987). Our Common Future: The World Commission on Environment and Development, Oxford: Oxford University Press.

Centre of Alternative Technology in Wales. Dec 2004. <http://www.cat.org.uk/>

Clean Air Acts UK. Dec 2004.
<http://www.ace.mmu.ac.uk/eae/Air_Quality/Older/Clean_Air_Acts.html>

The Department for Environment, Food, and Rural Affairs (Defra) in the UK. Air Quality and Air Pollution. Nov 2004.
<http://www.defra.gov.uk/environment/statistics/airqual/aqmainap.htm>

Dixon, Robyn, LA Times. <http://www.ecology.com/ecology-news-links/2002/articles/7-2002/7-12-02/sparrows.htm>

Interface Sustainability. Dec 2004.
<http://www.interfacesustainability.com/social.html>

Jones, Laura. "Alternative Building for the Future." Illumin. Vol. 5, Issue 4. 12 March 2003. Dec 2004 <http://illumin.usc.edu/article.php?articleID=113>

Laurel, Alicia Bay. "Living on the Earth"
http://www.hippiemuseum.org/earth2.html

London Borough of Barking and Dagenham. *Sustainable Development: A History of Sustainable Development*. Retrieved November 17, 2004. http://www.barking-dagenham.gov.uk/6-living/envir-protect/sustainable-dev/sustain-dev-history1.html

McGill, Annette. Personal Communication. Nov 2004- Dec 2004.

Encyclopedia of the Environment. Manchester Metropolitan University, 2000.
http://www.ace.mmu.ac.uk/eae/Air_Quality/Older/Great_London_Smog.html

Modernising Government. 4 November - Dec 2004.
http://www.cabinetoffice.gov.uk/moderngov/?url=moderngov/whtpaper/

National Energy Foundation. 31 July 2003 - Dec 2004.

<http://www.natenergy.org.uk/insulat.htm>

RIO DECLARATION ON ENVIRONMENT AND DEVELOPMENT, <http://www.un.org/documents/ga/conf151/aconf15126-1annex1.htm>

Ruckelshaus, William, "Towards a Sustainable World", *Scientific American*, September 1989, p. 115

Sustainable Development: The UK's Approach. Sustainable Development Case Studies: Holles House. Dec 2004. <http://www.sustainable-development.gov.uk/casestudies/22.htm>

United Nations Conference on Environment and Development, *Our Common Future* (44/228). <http://www.un.org/documents/ga/res/44/ares44-228.htm
UN Department of Economic and Social Affairs: Division for Sustainable Development. Agenda 21. 24 Mar 2003. Dec 2004
<http://www.un.org/esa/sustdev/documents/agenda21/english/agenda21toc.htm#pre>

UN Department of Economic and Social Affairs: Division for Sustainable Development. Commission on Sustainable Development First Implementation Cycle 2004-2005. Nov 2004 <http://www.un.org/esa/sustdev/csd/csd13/csd13.htm>

United Nations Environment Programme."Declaration of the United Nations Conference on the Human Environment" Dec 2004.
<http://www.unep.org/Documents/Default.asp?DocumentID=97&ArticleID=1503>

United Nations Conference on Environment and Development, *Our Common Future* (44/228). <http://www.un.org/documents/ga/res/44/ares44-228.htm>

United States Environmental Protection Agency, *Global Warming*.
<http://yosemite.epa.gov/oar/globalwarming.nsf/content/Climate.html>

United States. Us President's Council on Sustainable Development.*1997 Progress Report of the President's Council on Sustainable Development*. Washington DC, January 1997. pdf.wri.org/ncsd_usa.pdf

The Virtual Journal of Environmental Sustainability. Dec 2004.
<http://www1.elsevier.com/homepage/san/vj/sustainability/index.html>

Washington State Department of Ecology. Sustainable Washington: Guiding Principles of Sustainability. Dec 2004.
<http://www.ecy.wa.gov/sustainability/principles.htm>

Wood, Andy."The Guide to Communal Living in Britain". Diggers and Dreamers Dec 2004 <http://www.diggersanddreamers.org.uk/Articles/199001.htm>

World Energy Council. Living in One World: The History of Sustainability. <http://www.worldenergy.org/wec-geis/publications/reports/liow/the_concerns/sustainability.asp>

Appendix A: Upkeep Background

Upkeep is a small educational charity situated in central London. Its goal is to educate the public about proper building maintenance and repair, particularly those who are responsible for care of houses and apartments.

To achieve this Upkeep works in several ways. Upkeep offers courses and seminars on a wide range of topics, from introductory courses for beginners up to highly technical classes for professionals. Additionally, Upkeep maintains a museum of scale reproductions of housing elements, and shows in detail the common problems which afflict them. The Upkeep website (http://www.upkeep.org.uk) contains information for homeowners, offering advice on what signs of trouble to look for and how to obtain remedy.

In order to promote sustainable development Upkeep would like to incorporate new information into their museum and programs. In addition to being confused and distrustful of environmental information the public also has the belief that there is not much they can affordably do; it is in finding solutions to these stumbling blocks that Upkeep has requested our assistance.

The Charities Facilities Management Group was founded in 2001 and is coordinated by Annette McGill, the director of Upkeep. Open to those who work for a volunteer organization, the Group currently has more than 100 members. The Group promotes the sharing of knowledge and experience between volunteer organizations, with the goal being to assist organizations in improving their facilities management.

At the present time the Charities Facilities Management Group is drafting a model policy of sustainable development for charities to adopt. The hope is that organizations will formally adopt policies of sustainability and promote those goals not only within their own structure but also to those they serve.

Upkeep was established in 1979 with support from a large group of professional and industrial bodies, which now form its Governing Council. In accordance with regulations Upkeep has a Board of Trustees and is Registered Charity Number 277351.

An independent body, continuous funding is not provided to Upkeep by the government or any other sponsor. Upkeep's income is principally from charging for the classes they offer, while video sales and museum admissions provide additional funds.

Appendix B: Definition of Interactive Qualifying Project

The Interactive Qualifying Project at Worcester Polytechnic Institute presents a challenge for students to combine societal issues with science and technology in order to solve a problem. The goal of the project is to teach students that the science and engineering disciplines can be used for the betterment of society. We come together in teams, from all different majors, to combine our skills to solve a socially centered problem in conjunction with a sponsor. The IQP exemplifies the WPI project program education, in addition to fulfilling the ABET criteria that call for an "understanding of professional and ethical responsibility". The IQP is essential for off-campus opportunities, as social problems exist around the world that demands the integration of science and technology for a resolution.

Our IQP with Upkeep falls under Division 44: Urban and Environmental Planning. Projects listed under this division cover a wide range of area. According to the WPI Undergraduate Catalog, the following are some topics that may be covered:

(1) Environmental Analysis—such as the investigation of the "quality of life" or the impact resulting from physical alterations of the environment
(2) Resource Management programs
(3) Redevelopment and renewal of city neighborhoods
(4) Fiscal analysis and program impacts

There is a great need for environmental improvements around the world. The problem of human pollution will continue to the point of destruction, unless changes are made to

live a more unobtrusive lifestyle. We will use our research and knowledge of technology, science, and the law in order to help promote sustainable practices within the Upkeep Organisation. We hope to present the most effective information to Upkeep's audience so that they will partake in sustainable practices within their homes, so as to help conserve energy and reduce pollutants—to help improve the environment. Our ultimate goal is for others to adopt the practice of displaying sustainable information to the public, so that people around the world may partake in environmentally sustainable practices. It is through the implementation of these goals that the IQP makes an impact for the social betterment of the world.

Appendix C: Interview with Professor Malcolm Fitzpatrick

Interview with Professor Malcolm Fitzpatrick

12/10/04

By Michael Bertini
Matthew Shapiro
For Team Upkeep

The following is the correspondents we had with Professor Fitzpatrick, a Civil and Environmental Engineering Professor at WPI. We conducted the interview at 12:30 PM in Kaven Hall, WPI, Worcester, Massachusetts.

Matt: "We are completing an IQP in London next term with a non-profit organization called Upkeep, which contains museum displays on housing. Upkeep wants us to add information to the museum displays on aspects of sustainable housing. You have been recommended to us by our advisors, so we came to ask you some questions concerning sources and your own practical experience with sustainability."

Prof. Fitzpatrick: "I'd recommend checking out the LEED Rating System on saving energy—they have some great resources. Basically, the question that should be asked is "how much for what?" How much can you ask people to do and for what cause do you want them to do it."

"Some inexpensive alternatives to saving heat and energy are:

- using ropes of putty around windows, which loose a large portion of heat.
- Fasten plexiglass to the outside of windows
- Take into consideration furniture and carpets, as they release poisonous chemicals and gases and should have some airflow. Also, insulation contains dangerous formaldehyde
- Stopping drafts is important, wool carpets and wool drapes help insulate very well

"Any other information that you need?"

Matt: "Can you speak more about heat and fuel sources and maybe point out more sources that we could examine?"

Prof. Fitzpatrick: "Well, you could look at "Green Building News"—it contains a lot of information on sustainable and environmentally friendly housing. A lot of times, hot air heating systems are a great alternative that run at 80-90% efficiency. You can burn wood and cardboard and non-toxic items that effectively distribute heat and burn safely. This way, you can get rid of your trash waste and become more self-sustainable. WPI is awful when it comes to sustainability. If you look at the building here, there are drafts, poor insulation, loss of heat through ceilings and windows…it's a shame nobody makes any changes."

"Wool rugs and radiant heating systems can also be very useful when saving heat. The point here is to save heat to become less dependent on fossil fuels. I understand most people run on gas or oil, but there are some great alternatives that need to be implemented"

Matt: "Thank you very much, Prof. Fitzpatrick. Are there any other helpful directions you can lead us in?"

Fitzpatrick: "I'd like to see a copy of the proposal when it's done. It seems like a great venture to undertake. Just remember to show people why they would want to do it. The book you have there [Eco-refurbishment] is a great source. Just go with it. Good luck!"

Matt: "Thank you very much for your time."

Appendix D: Domestic Electrical and Heating Installation

Sustainability

Introduction

Conserving the natural resources of our planet has become an increasingly important part of our future. As the effects of human activities begin to show themselves through weather and temperature changes we must make changes and try to limit our effects on natural cycles. This is the concept of environmental sustainability; working towards protecting natural resources for future generations. Individuals should also take part in this movement through making small changes in their homes and behaviours.

One of the major areas in dwellings concerning sustainable practices is energy conservation. Heating and electricity are the two major sources of energy consumption and are primarily produced by the burning of fossil fuels. Minimizing the consumption of these natural resources and incorporating more renewable forms of energy, such as solar energy, will reduce the impact of humans on the Earth. The following information contains steps one can take to conserve electricity and heating in dwellings.

Primary Steps

The biggest, but also one of the simplest steps is to reduce the amount of electricity used in the home. Not only will this save money, it will also save the resources used to create electricity.

Electricity

Tips

- Energy saving light bulbs
- Use "A" Rated appliances
- Turn off lights and appliances when not in use
- Fill washing machines and dishwashers to capacity and use economy option
- Consider Economy Seven

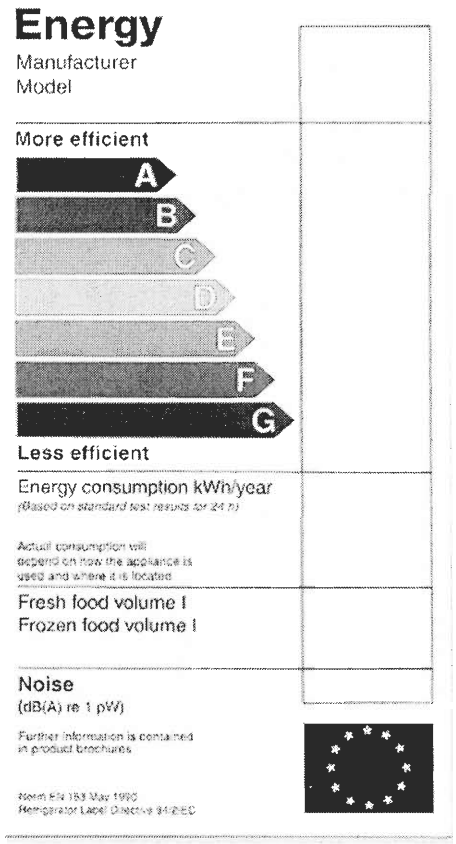
Energy Saving Light Bulbs

Energy-saving light bulbs are a simple and affordable method of conserving energy. This is a relatively established concept, so the prices are reasonable and the options are plentiful. According to the Energy Saving Trust the cost for energy-saving bulbs is initially higher, but will more than pay for themselves. The average energy-saving bulb costs £5 but within a year can save up to £7,

depending on length and frequency of bulb usages. Although some energy-saving bulbs take longer to attain full brightness, the overall energy consumption is decreased.

"A" Rated Appliances

There are multiple appliances on the market with EU Energy labels. When replacing an electric appliance, look for an "A" rating of efficiency. These appliances will be the most efficient in lowering energy consumption, saving you money on energy bills. One setback is that "A" rate appliances do tend to be more expensive than lower ratings.



EU Energy "A" Label

Energy Efficiency Recommended Logo

The Energy Saving Trust provides people with tips to reduce they bills this includes information on which appliances are the most efficient. It is similar to the "A" ratings. These parts are tested and backed by the government to meet or exceed energy efficiency standards.

Energy Efficiency Recommended Logo

Economy Seven

Economy Seven is a tariff that allows a homeowner the option of paying less for electricity during the night compared to the day. If you work during the day, this tariff can be a useful device to save money. The time when electricity costs the most will be when you are at home and not using as much. Only some electrical companies make use of this tariff. It is important to know if your provider offers this and whether this option coincides with your lifestyle. To find out if this alternative is available to you to call your local electrical provider or go to[3].

Heating

In addition to electrical appliances, heating systems consume a large amount of energy in the dwelling. About 60% of energy consumption in the dwelling goes to heating. This means that heat conservation is essential to saving resources and money on your bill.

Tips

- Have heating system
- inspected regularly
- Reduce hot water temperature and consumption
    - Taking shorter showers
    - Only running the dishwasher or washing machine with full loads

Each of these steps can reduce the heating bill from 5% to 10%. Additionally, these energy and money saving tips cost nothing, with the exception of heating maintenance.

Boilers

It is important to replace your boiler as it becomes older. Typically, it is recommended that a boiler should be replaced with a modern, more efficient option every 15 years. Spending money on a new boiler might seem like a big

expenditure, but a newer model boiler and will reduce energy consumption and the heating bill.

Combi-boiler

One type of boiler that is very efficient for people with low hot water demands are combi-boilers. They are currently the most commonly used system. They are cheaper than other conventional ways because they do not require a loft tank.

Advanced Steps

If the environmental aspect of sustainability is of great interest, then there are some further steps that could be taken to update a dwelling.

Solar Energy

There are two systems of solar energy that can be incorporated into the home

- Solar Water Heating System
- Photovoltaic Cells

Each of these deals with different areas of energy usage in the home.

Solar Water Heating Systems

Installing solar panels has become more accessible in the last few decades. Solar panels are 90% less expensive than they were in the 1970's, as well as much more efficient.[5]

The panels are installed on the roof tops of buildings with as much southward facing area as possible. This guarantees the greatest amount of heat absorbed. It is also important to make sure that there is a minimal amount of shading near the panels, so that the most amount of energy can be absorbed. When adding a solar panel to a roof it is required that there is enough room in the loft for the added water tank and that the pitch of the roof is correct.

The benefits of incorporating solar energy into a home are numerous. The charity, Solar for London, has a published booklet about solar energy that contains the following information[4]:

- A typical solar water heating system in the UK provides 50% to 70% of annual domestic hot water requirements
- It costs around £2,400 to install solar panels, before grant funding for an average 3-4 person home
- A 3-4 person household would on average have a 3-4 m2 solar panel installed

- There are numerous governmental subsides for solar panels

Photovoltaic Cells

These cells convert sunlight directly into electricity. These are typically located on the buildings and they will often double as building materials replacing walls, atrium roofs, windows and roof tiles and shingles. There are three different types that are applicable to homes in the UK. The cost of Photovoltaic cells can range up to an average £9,000, although the cost changes with the market.

Solar Shingles

The option of solar shingles is a good one for the UK climate because they can generate electricity even on a cloudy day. They are also lightweight and easy to install because they can double as roofing shingles.

Sunslates

These cells resemble roof tiles and can be installed in the same. Sunslates are also capable of producing electricity in the UK climate.

Sunstation

This system can easily be installed in one day and comes in multiple sizes.

Vale House Association

The Vale Housing Association is an example of an organization that not only strives to provide affordable heating to residents, but also strives to reduce heat loss and CO_2 emissions from its property[6]. This is a great resource to browse for information concerning heat saving tips.

Borough of Greenwich

This group has been working for the past decade to incorporate new efficient ways for heating homes. Currently they are working to fixed 150 properties with solar water heating systems with assistance from Solar for London charity. The goal of this project is do reduce the cost of hot water by 70%.

Cost

Clear Skies is an organisation offering information on grants for installing renewable forms of energy. This organization is managed by BRE and funded by DTI. They organise grants for homeowners and communities. The amount of money awarded depends on the project. Grants are offered for several energy sources[1]:

- Solar thermal
- Wind turbines
- Small scale hydro turbines
- Ground source heat pumps
- Room heaters/stoves with automated wood pellet feed
- Wood fuelled boiler systems

The grants for households range from £400 to £5000 while communities can receive up to £10,000.

More Information

1. Clear Skies- This site provides information for both households and communities on the issue of manufactures, installers, and many other areas.
http://www.clearskies.org

2. Energy Saving Trust- organisation that provides information on conserving energy in the home
http://www.est.org.uk/myhome/generating/types/solarpv

3. UK Power- provides ideas and tips for decreases your energy bills
www.ukpower.co.uk

4. Solar for London- A non-profit organisation that works with several boroughs to financially assist to bring solar water heating systems into homes.
www.solarforlondon.org

5. BBC Article on solar panels by Kate McGeown
http://news.bbc.co.uk/1/hi/uk/1434478.stm

6. Vale Housing Affordable Warmth Strategy
http://www.vale-housing.co.uk/whoarewe/environmental/affordable_warmth/affordable_warmth.html

Appendix E: Inspecting a Property I

Introduction

It is now predicted that the global temperature will rise by six degrees centigrade within the next twenty years. This global warming is caused directly by the steadily increasing amount of carbon dioxide emitted into the atmosphere. The goal of the environmental sustainable effort is to lessen the impact of humans on the environment; most specifically, to lessen the amount of excess carbon dioxide released into the environment. It has been determined that automobiles are not the only cause of net carbon dioxide release; dwellings also play a large role in this environmental hazard. The environmental sustainability of a dwelling is affected by two main areas: taking precautions to use environmentally friendly materials within the dwelling, and trying to adopt environmentally friendly practices.

This section looks at the different methods by which a dwelling may be assessed for energy efficiency. Understanding how buildings are assessed for energy efficiency will increasingly be a useful skill as the government pushes forward new measures to increase environmental sustainability within the UK. By the end of this section you should understand what you could do to make a dwelling more sustainable; as well as understand some of the things inspectors would look for in a home.

Government Assistance

The decision of whether or not to construct an environmentally sound and sustainable dwelling is no longer becoming an option. In the year 2000 the government made a commitment to bring all houses to a "decent rating" (the term "decent" will be discussed later in the section) within the next ten years. "The UK Government is putting in place strategies that will aim to reduce greenhouse gas emissions, particularly carbon dioxide." (sapratings.com). The government has passed Part L1 of the Building Regulations, which came into effect in April 2002. These amendments require the calculation of a Standard Assessment Procedure (SAP) rating both for all new dwellings, and any dwelling undergoing material change. The requirements also necessitate that the rating is displayed in the property upon completion.[1]

Who uses Energy Ratings?

Energy standards ratings are used by three types of people. The first group is of those building and/or adding onto an existing home. The second is homeowners who are changing heating elements and/or changing the glazing on their windows. Finally, the third group consists of Building Control Inspectors to insure that new and changing homes conform to current regulations.[1]

Decent Homes

The standard for social housing in the UK is known as the "Decent Homes" standard. This standard is applied to all social housing within England. For a landlord to meet the decent home standard he/she must reach four requirements.

- The dwelling must provides adequate heating
- The dwelling is in a reasonable state of repair
- The dwelling has adequately modern facilities
- The dwelling must meet minimum housing standards

There are two essential elements that every decent home must abide by when dealing with the issue of heating. First, they must provide adequate heating within the dwelling. Adequate heating is fulfilled by any gas/oil/LPG/solid fuel programmable system or electric storage heater. Secondly they must provide effective insulation. Different requirements exist for insulation depending on the heating system in place. For gas/oil programmable heating the dwelling requires cavity wall insulation or, at least, 50mm of loft insulation. For other heating systems cavity wall insulation and, at least, 200 mm of loft insulation is required.[6]

To find out more detailed information on the previous topics please see the "Energy Saving Trust" internet link at the end of the document.

Different types of Grading Scales

There are several different energy-rating services which can be used to assess domestic buildings for their energy efficiency. In this pack we will discuss four of the most commonly used services and each of their individual focuses.

- SAP Rating
- NHER Rating
- CI Rating
- Ecohomes

SAP Ratings

Currently the government standard is the **Standard Assessment Procedure (SAP)**. The SAP is a grading system used to measure the general energy

efficiency of a dwelling. This assessment rates a house from 1 to 120, with the higher numbers indicating a greater efficiency.
SAP was first introduced in 1998. Since this time it has undergone reconstruction to incorporate government changes. New legislation stipulates that SAP evaluations be required on both new homes, and those undergoing significant structural changes. The purpose of the rating is to enable the UK government to keep statistics on the environmental impacts of dwellings within the country. Housing Associations and/or Councils which own stock must submit average ratings to the government for recording. Currently the typical SAP rating for the average UK home is about 45. In comparison, a new home built according to Part L regulations is between 80 and 100.[1]
NHER Rating

In addition to SAP ratings, one can acquire a **National Home Energy Rating (NHER)**. Of all assessments, the NHER is the most accurate when describing the energy efficiency of a dwelling. It is also the most difficult to derive and is only done by experts in the field. The NHER rating is not required. However, if you were attempting to create a sustainable home, these ratings will give you a more detailed evaluation. The scale is from 1 to 10 with 10 being the most efficient. The NHER takes into account local factors when assessing a home. Where you live, climate, and weather patterns, can play a large part in evaluating your environmental efficiency. The NHER rating takes these factors into account whereas the SAP does not. The NHER rating also considers, in more detail than the SAP, the cost of heating a space, in addition to cooking, lighting, and electricity.[3]

CI Rating

The **Carbon Index Rating (CI)** determines how much carbon dioxide your dwelling emits into the environment. The CI grading scale also operates on a 1 to 10 scale with 10 being the best. A Carbon Index rating can only be done on a new dwelling during construction. The rating does not apply to existing buildings. The CI rating is concerned with the type of fuel required for space and water heating within the dwellings. Proper insulation is the key to a good CI rating.[4]

Ecohomes

Ecohomes is an assessment based on the rating known as the **Building Research Establishment Environmental Assessment Method (BREEAM)**. This rating operates on a credit system. A dwelling receives credits based on environmental impact, concern for wildlife, and resource usage. These credits are added up to get a rating of pass, good, very good, or excellent. The Ecohomes grading scale is applicable to all newly constructed homes. Since 2003, housing associations within England having only required a “pass” rating. However, that requirement will soon change to a “good” rating, with a recommendation of “very good”.[7]

How to Calculate an SAP Rating

Currently, an unofficial SAP rating can be derived by anyone using a calculator and a grading sheet that is readily available. Although without proper training will not be completely accurate, nor will it be officially recognized, it can be performed to give an estimate on a dwelling's sustainability.[1&2]
- For information on how to do an SAP rating and the worksheet see the "SAP" link at the end of this document.

The **Building Research Establishment (BRE)** offers a service, which approves software to be used to derive a more accurate SAP rating. To attain an "authorised, quality assured" rating, one must go through an authorised organization. There are only three in the UK; NES (operating the NHER scheme), Elmhurst Energy and MVM Consultants. These three organizations operate under the **Federation of Authorised Energy Rating Organisations (FAERO)**.[7]

- *For information on the Federation of Authorised Energy Rating Organisations see the "FAERO" link at the end of this document.*

You should not be concerned about how to make these assessments. However, it benefits you to know what the different assessments contain, as well as background information on grading. With the government emphasis on encouraging energy efficiency, and the introduction of new inspection regimes, this section is designed to display information to you on the future of home building.

What you can do to improve your home's energy efficiency

This information may seem a little overwhelming at first; but there are many simple things that can be done with little change to the dwelling. For example, home temperature is a factor. Lowering the temperature when you are sleeping, or not in the home, will improve the energy efficiency rating of the dwelling. Water conservation is also considered in the SAP rating. Installing aerators on your taps, and using toilets and showers that regulate the flow rate of water will increase the score. Also, preventing hot water taps to drip and/or leaking will help.

More advanced steps require some change to the dwelling. Changes may include new appliances. Using appliances with energy ratings of "A" or "B" help use less electricity to run. This will cut down on the amount of fossil fuel required to produce the energy and increase the environmental friendliness of the dwelling. There are many different kinds of insulation one can use in the dwelling. It is most important to use effective insulation to not leak heat from the home. The more heat that is wasted the more energy it will take to replace it. Using insulation that does not include ozone-depleting substances is also important. A

double-glazing window for better insulation is also a good way to improve the score.

The importance of higher SAP scores will become more apparent as the government continues the drive towards a more sustainable UK.

Home Information Packs

With the introduction of the concept of “Home Information Packs”, sellers will be held responsible for reporting the condition of their home to prospective buyers. The government is proposing that the Home Information Packs will include detailed information on the environmental friendliness and energy efficiency of the property. This assessment is likely to be based on the system of SAP ratings discussed earlier.
Assuring that a home is up to government standards now could save much hassle in the future.[8]

More Information

1. SAP Ratings-Provides information on the energy efficiency ratings of homes

www.sapratings.com

2. SAP2005-Information on the proposed revisions for SAP ratings available through the Building Research Establishment (BRE)

http://projects.bre.co.uk/sap2005/

3. National Home Energy Rating (NHER)- This scheme of home energy efficiency professionals provides information, software, and consulting on saving energy

http://www.nher.co.uk/index.shtml

4. Carbon Index- describes Part L using the SAP ratings to determine the carbon index of a building

http://www.squ1.com/part-l/carb-index.html

5. Federation of Authorised Energy Rating Organisations (FAERO) – this organisation works to promote the use of SAP ratings

http://www.nher.co.uk/e5x1.shtml

6. Energy Saving Trust- organisation that provides information on conserving energy in the home

http://www.est.org.uk/myhome/generating/types/solarpv

7. Ecohomes of the BRE provides information and sheets for the BREEAM scale.

http://products.bre.co.uk/breeam/ecohomes.html

8. Home Information Packs- article from the Office of the Deputy Prime Minister (ODPM) explain the home information packs\

http://www.odpm.gov.uk/pns/DisplayPN.cgi?pn_id=2004_0281

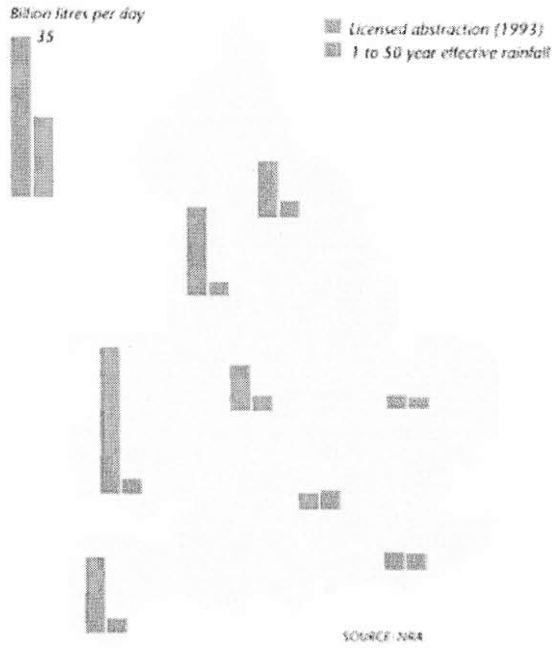
Appendix F: Plumbing, Wastes, and Drains

Introduction

Water is one of our most important natural resources, and our management of it must be guided by sustainable principles. While the present supply may appear to be in abundance, climate change and other environmental and social factors may put the supply under ever-increasing demand. To assure an adequate supply with which to meet the needs of the future, we must begin conserving water in the present.

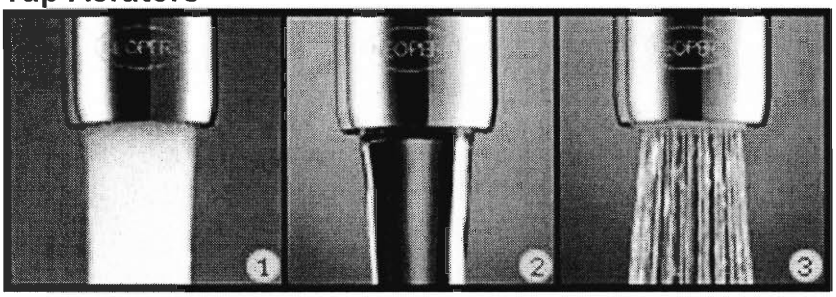
There are several areas of Plumbing, Waste and Drains in which environmentally sustainable concepts can be applied. In some areas these will result in monetary savings, while others will cost approximately the same as their non-environmentally sustainable counterparts.

Rainfall vs. Water Consumption



Preliminary Steps

Tap Aerators



Aerated flow (2) Laminar flow (3) Spray flow

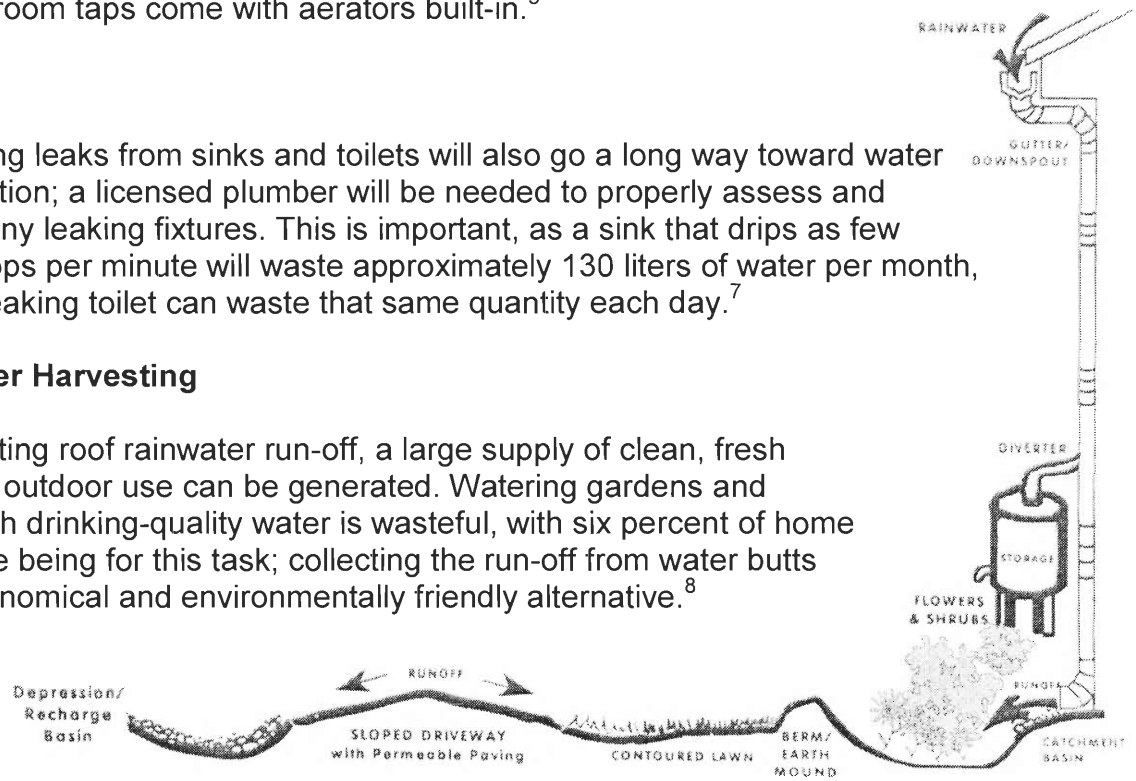
One highly effective and simple method of conserving water is through the use of tap aerators. These small devices, which thread onto the end of the tap, are readily available. They operate by disrupting the flow of water slightly and introducing air into the stream. This aeration enhances the flow of water and reduces the amount of water needed for many common tasks, such as washings your hands. Flow is reduced, without sacrificing water pressure. Tap aerators come in many styles, depending on the design of your tap. Most modern kitchen and bathroom taps come with aerators built-in.[3]

Leaks

Eliminating leaks from sinks and toilets will also go a long way toward water conservation; a licensed plumber will be needed to properly assess and Correct any leaking fixtures. This is important, as a sink that drips as few as 10 drops per minute will waste approximately 130 liters of water per month, while a leaking toilet can waste that same quantity each day.[7]

Rainwater Harvesting

By collecting roof rainwater run-off, a large supply of clean, fresh water for outdoor use can be generated. Watering gardens and lawns with drinking-quality water is wasteful, with six percent of home water use being for this task; collecting the run-off from water butts is an economical and environmentally friendly alternative.[8]



Rainwater run-off collected from roof; effective contouring allowing for good driveway drainage.

Plumbing Insulation

Heating and hot water generation account for 82% of each home's annual carbon dioxide emissions. Properly insulating your hot water cylinder and piping will reduce heat loss by up to 75%, amounting to significant fuel savings. The hot water storage cylinder should be insulated with a minimum of 100mm of insulation, to assure adequate heat retention. Materials such as mineral wool work well, provided they are kept dry. In addition, placing the boiler and water cylinder inside of an enclosure will decrease air circulation, and thus heat loss, further helping to increase efficiency.[4]

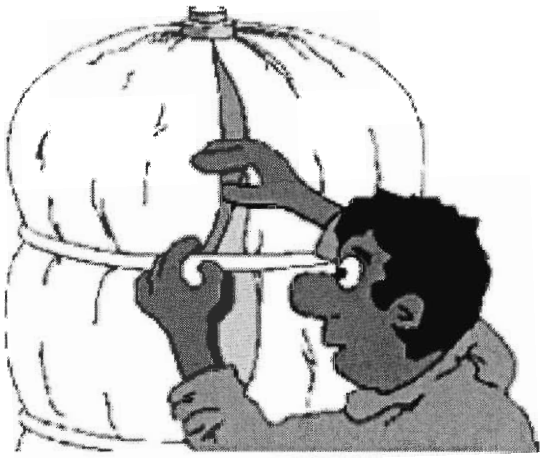


Illustration of hot water cylinder insulation

Advanced Steps

Grey Water Recycling

One way to effectively cut home water consumption by one-third is Grey Water Recycling. Grey water – the water from showers, baths, and lavatory sinks – is dirty, but still well suited to being used for other tasks. Most commonly, grey water is reused to flush toilets; more elaborate installations allow for its use in gardening as well. Toilets account for over one-third of home water consumption, and by reusing grey water for this purpose there is a significant reduction in water consumption. The table below illustrates this point, showing that fully two-thirds of wastewater from the home is suitable for reuse.

Waste and Grey Water Produced in the Home

Source	**Total Wastewater Generated**		**Total Grey Water Generated**	
	% Total	***Litres per day***	***% Total***	***Litres per day***
Toilet	35	205.1	-	-
Sink	8	46.88	7	46.88
Bath/shower	20	117.2	48	117.2
Kitchen	15	87.9	11	87.9
Laundry	12	70.32	34	70.32
Dishwasher	4	23.44	-	-
Outdoors	6	35.16	-	-
Total	100	586	100	322.3

To install a grey water system into an existing home several modifications must be made. Plumbing from the lavatory sinks, showers and baths must be run to a holding tank. A filter must also be fitted, to remove any particulate matter from the grey water. Then a pump is needed, to provide water pressure to supply the toilets.[1]

Rainwater Drainage

One important and often overlooked area, where sustainability applies, is drainage. It is important to assure that drainage surrounding dwellings is adequate, as pooling water caused by insufficient drainage can lead to flooding and damage. Walkways and driveways can be made of pervious materials, such as crushed stone and gravel. These will promote drainage of rainwater into the subsoil, reducing or eliminating the amount of run-off.[8]

Low Flow Toilets

Toilets that have multiple flush levels are available. These toilets allow you to select the quantity of water needed for the flush. Although, these toilets are more

popular in Scandinavian countries and legally required in the United States since the early 1990's, the technology has made it way to the UK.[5]

PVC Piping

Polyvinyl Chloride pipes are commonly used in housing construction today. PVC pipes are manufactured through processes that greatly contribute to greenhouse gas emissions and are very high-energy. Also, when PVC piping is removed from a home it must be sent to a landfill, as it is not a recyclable material. PVC piping in a landfill leaches dioxins and lead into the soil; these chemicals have proven to be extremely potent carcinogens and are considered a significant human health hazard. PVC piping is responsible for 28% of lead in domestic landfills.

For newly constructed homes, there are alternatives available, which, unlike PVC, are recyclable and are manufactured via low-energy processes that do not significantly contribute to global warming. It is probably best, however, that existing PVC piping be left in place, since little if anything is gained by its rapid removal.[6]

More Information

1. Grey Water- This article explains grey water recycling
http://www.sydneywater.com.au/SavingWater/GreyWater/

2. Insulation- information on insulation, including water heater tank and pipe insulation
http://www.hullcc.gov.uk/energymanagement/insulation.php

3. Tap aerators- Information on savings and installation
http://www.sydneywater.com.au/SavingWater/InYourHome/TapAerators.cfm

4. Insulation- information on water heater insulation
http://www.easington.gov.uk/services/energy/hotwatertankinsulation.asp

5. Water saving devices- other low cost devices for saving water
http://www.greenbuildingstore.co.uk/water-saving.php?PHPSESSID=fb2a26004a9402fca42181e039d8185b

6. PVC-explanations of the hazards of polyvinyl
http://www.besafenet.com/pvc.htm

7. Eastern Municipal Water District- Water Saving Tips
http://www.emwd.org/conservation/home_water.html

8. Sustainable Building Sourcebook- provides information and suppliers for sustainable building
http://www.greenbuilder.com/sourcebook/

Appendix G: Basic Building Construction

Introduction

Environmental sustainability is a phrase gaining popularity because of the current focus on environmental issues. It promotes alternatives and changes that will conserve resources for future generations. For example, reducing the amount of electricity used in your home everyday by turning off unused lights decreases the amount of fuel that is burned.

Currently, global warming is a concern for many people because long term consequences are unknown. It is caused by the increase of levels of green house gases, such as carbon dioxide. These carbon emissions are produced by burning of fossil fuels by humans. The effects of an increase in average global temperature can already be seen. The changes in weather patterns, such as the greater severity in storms, are causing flooding. Taking measures to improve the environmentally friendly performance of your home may seem like a daunting task but it is one of high value. Making sustainable changes will reduce carbon emissions and minimizes the progression of these problems.[21]

Within the area of basic building construction, the biggest concern is that the materials are environmentally sustainable and used to realistically conserve the greatest amount of energy. For example, using insulation and cladding may reduce heat loss by up to seventy percent.[20]

The benefits of sustainability are both personal but also global:

Personal Benefits-

- Lower heating bills
- Increased thermal comfort
- Decreased drafts
- Control of moisture
- Increased acoustic control
- Increased safety

Global Benefits-

- Reduced emissions from burning of fuel
- Conservation of natural resources

Basic Building Construction is divided into three sections:

- Foundations
- Walls
- Roofs

Each of these sections includes information on:

- Thermal Protection
- Building Materials

Thermal Protection

Reducing the amount of heat that is lost from a dwelling through the walls and roof will decrease the amount of fuel needed to hear the building. This will in turn decrease the emissions from the fuel and save the homeowner money by lowering bills.

"A properly insulated home or building can significantly reduce the amount of energy used by effectively maintaining a desired temperature without the need to exert more energy. A well-insulated household can save approximately [£415] per household for heating/cooling costs.[1] These savings provide benefit not only to the customer but also to the environment."

Green and Clean Report, Alliance to Save Energy, April 2001 (Savings may vary.)

Within each section of the home, there are different types of thermal protection that can be added to either the interior or exterior (see chart below).

Location of Thermal Shielding

	Interior	**Exterior**
Foundation	Insulation	
Walls	Dry lining & insulation	Cladding
Roof	Insulation	Cladding

Exterior Cladding

Walls

To reduce heat loss through the exterior walls of a building, install cladding. Over cladding added to a building is composed of a rigid insulation board and a waterproofing material to protect the building from the weather.[11]

Mineral Finishes: contain cement
- Dry Dash (also pebble or spar dash)
- Scrape Texture Renders
- Plain Float Renders
- Wet Cast (also harling or roughcast)

Synthetic Finishes: based with acrylic, silicone or magnesium silicate resins
- Masonry Paint
- Flexible Textured Finish

Aggregate Textured Finishes

Panel Finishes: only for ventilated rain screen systems
- Preformed Panels- glass fibre
- Profiled Metal Sheets-aluminium or steel
- Cassette Panels-aluminium

Natural Alternatives:
- Terracotta
- Stone
- Timber

Roof

There are several options for roof cladding. The following chart displays these options and information that is important in making a sustainable decision.

Environmental Criteria for Selection of Roofing Materials

	Embodied energy (MJ/m^2)	Weight (kg/m^2)	Life (years)	Material resources	Recyclability	Overall rating comparably
Timber shingles	Very low	Low	50	Renewable	Fair	1 (best)
Natural slates	130-160	20-30	100+	150	Very good	2
Aluminium (recycled)	30-90	<10	100+		Good	3
Concrete tiles	40-90	40-90	30-100	Abundant	Good	4
Clay tiles	270-430	40-60	30-100	Abundant	Good	5
Coated steel	180-290	7	30	230	Fair	6
Asphalt shingles	285	Low	20-30	75	Poor	7
Aluminium (virgin)	550-920	<10	100+	260	Good	8 (worst)

source- http://www.newbuilder.co.uk/archive/sustainable_roofing.asp **asked permission 16-02-05**

The slate and concrete tiles are rather durable, but they are very heavy. If they have to be transported great distances, they will require a lot of energy. Metal roofing materials are made from recycled materials and can be recycled. Another benefit is that they are lightweight and durable. The asphalt shingles can be recycled into surface aggregate, but they have a shorter life span than other options. The material that is considered the most sustainable is timber. It is a renewable resource that can readily be produced; it is also lightweight and has a reasonably long lifespan.[3]

Green Roofs

BedZED green roof with wind funnels
http://www.greenroofs.com/archives/sg_jan-mar04.htm

Adding a green roof onto a building can have several positive outcomes such as:

- Improved air quality
- Decreased rainwater runoff
- Increased greenery in urban areas
- Improved energy efficiency of building

Depending on the desire of the building owners and the capabilities of the building there are different degrees of green roofs. An "intensive" green roof has at least a foot of soil for the plants and can weigh between 80-150 lbs/ft^2. The smaller version is an "extensive" green roof. These are up at ten times lighter and require much less soil. The extensive roof, however, cannot be used as a recreational area whereas an intensive roof can.[1]

The Peabody's Trust BedZED development has a green roof. It was planted with sedum, also known as stonecrops. They are a basic ground cover that is self-generating, drought resistant and capable of withstanding extremes of climate. This green roof has the ability to absorb up to 50% of even a severe downpour. This assists in the control of rainwater so that guttering does not over flow causes structural damage.[1]

Interior Insulation

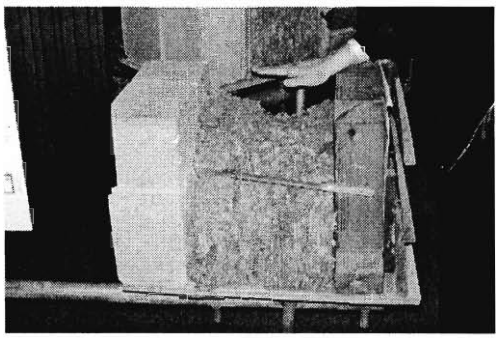
There are two categories of insulation:
Man Made Types
Natural Alternatives

Man Made types of Insulation[4]

Mineral Wool

Mineral wood is made from sand. It is one of the most common types of insulation; however, it does pose a health threat because it contains formaldehyde and can cause irritation.

Rock wool



Wall with Insulation from BedZED development

This type of insulation is made from recycled steel slag. It performs well and is fire resistant, but causes irritation because it is composed of fibres.

Rigid Foam

This type of insulation is found in all three section of the home, but is used mainly in the foundation. There are three different materials that can be used- Expanded polystyrene (EPS), Extruded polystyrene (XPS) and polyisocyanurate.

EPS- Also called beadboard is the most sustainable option of the three.

XPS- This material is more expensive and destructive to the ozone, but also greater value insulation.

Polyisocyanurate- Being the most destructive to the environment of the three types of rigid foam this material also can loose its ability within a few years.

Polyurethane

Containing formaldehyde this material does have health hazards.

Natural Insulation Materials

Cellulose

This material is made from recycled newspapers and cardboard. It is easy to install and has no health or irritant issues, however, it does need to be kept dry.[8]

Example- Warmcel100

Wool

Natural sheep's wool can be used in homes to adequately insulate. This material resists fire and has a long life span of fifty years.[8]

Example- Thermafleece or Nu-Wool

Flax

This material can be used in all of the areas of a building, but can only be used in an environment that is ventilated because is treated with boron and polyester.[20]

Hemp

Mixed with lime this material has proven to be good insulator. This is a relatively expensive form of insulating, however, and thus proves impractical.[16]

Other

Cotton, Straw and Clay

Another way to look at the information is to consider what form of insulation you want to use: blankets, blown, rigid, or loose fill.

Types of Interior Insulation

Form	Method of Installation	Where Applicable	Advantages
Blankets: Batts or Rolls Mineral wool Rock wool Cellulose Wool	Fitted between studs, joists and beams	All unfinished walls, floors and ceilings	Suited for standard stud and joist spacing
Loose-Fill (blown-in) or Spray-applied Rock wool Mineral wool Polyurethane foam No natural alternative available	Blown into place or spray applied by special equipment	Enclosed existing wall cavities or open new wall cavities Unfinished attic floors and hard to reach places	Commonly used insulation for retrofits (adding insulation to existing finished areas) Good for irregularly shaped areas and around obstructions
Rigid Insulation Extruded polystyrene foam (XPS) Expanded polystyrene foam (EPS) Polyurethane foam Polyisocyanurate foam Cellulose Wool	Interior applications: Must be covered with 1/2-inch gypsum board or other building-code approved material for fire safety Exterior applications: Must be covered with weather-proof facing	Basement walls Exterior walls under finishing Unvented low slope roofs	High insulating value for relatively little thickness Can block thermal short circuits when installed continuously over frames or joists.

Building Materials

There are several materials that should be avoided for construction if possible, however, if these items are already included in the building, they should only be replaced if there is damage or health concerns.

Material Summaries

Timber

To be sustainable the Forestry Stewardship Council (FSC) must certify it. This cost difference between this and other options are usually minimal, less than 5%.[6]

Concrete & cement

The production of these materials uses large amounts of water and energy. This puts a high demand on water and can lower the pH of the wastewater, possibly harming the environment. Parts of this product can be recycled and used as aggregate.[7]

Future Materials-

There are currently new types of cement that are being produced that can absorb carbon emissions and other pollutants. Magnesium carbonate based 'eco-cement' requires half as much energy to produce and reabsorbs the amount of carbon emissions it took to produce while drying. There are also paving slabs being produced in Japan containing titanium dioxide, a pollutant absorbing material. It is estimated that these slabs have removed up to 90% of the nitrogen oxides, which create smog.[20]

Brick

Similar to concrete this material is recyclable, but has a very high energy cost to produce. Using recycled bricks conserves energy and resources and can provide an antiqued appearance.[7]

Glass

When used in windows it is important to think about glazing. Double-glazing, which is two layers of glass separated by a space, is a means of decreasing the amount of heat lost through in windows.[8]

Slate

The most sustainable option for roofing is timber tiles, but the second choice is natural slate. Since it is produced naturally within the earth there is no energy cost for production. It does, however, take energy to transport, and quarry the slate. This causes environmental damage.[3]

Hemp

The Suffolk Housing Society introduced hemp as a building material with the construction of two hemp houses; there have been several follow up constructions. They are cheaper to heat, build and less waste during construction, but cost approximately ten percent more.[16]

Paint, stain, varnish, adhesive

Most of these products contain chemicals that can be dangerous to individuals and the environment as a whole. When using them make sure there is adequate ventilation and try to buy products that are low in volatile organic compounds (VOC's). You may find, however, that these products are more expensive.[20]

The chart below provides information on which materials should be avoided due to their damaging qualities.

Harmful Materials

Materials to be Allowed	Why	Alternative
Non-certified timber	Loss of forests and Biodiversity	Certified Timber
Polyurethane & Polystryrene	Formaldehyde, high energy product	Mineral Wool, Cellulose
Concrete	High energy product	Certified Timber

Determining sustainability

Ecopoints

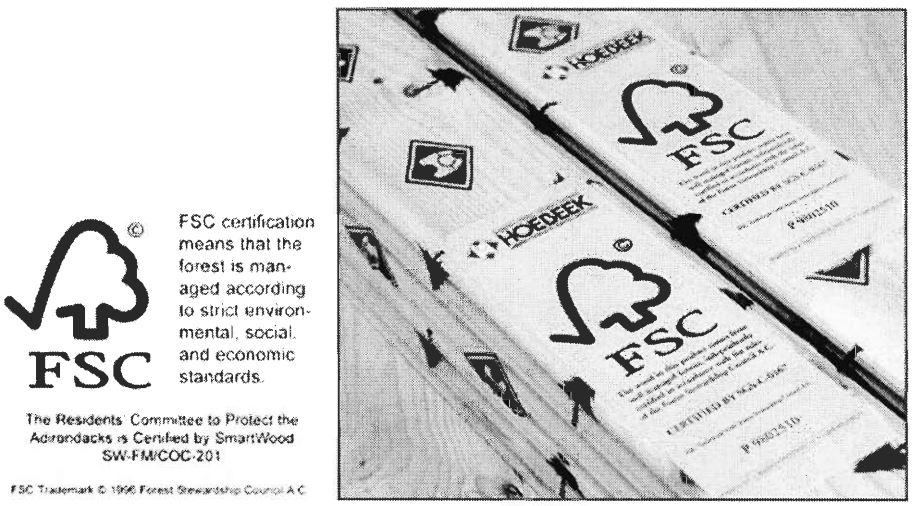
One way of measuring the sustainability of a product is the Ecopoints system. Materials are scored for the impact they have in each of the following areas:

- Climate change
- Fossil fuel depletion
- Ozone depletion
- Freight transport
- Human toxicity to air
- Human toxicity to water
- Waste disposal
- Water extraction
- Acid deposition
- Ecotoxicity
- Eutrophication
- Summer smog
- Minerals extraction

The higher the score is the greater the impact, and the damage to the environment.[17]

Federal Stewardship Certification

Federal Stewardship Certification (FSC) is focused only on ensuring the sustainability of sources of timber. Other guides that provide reliable information are the *The Good Wood Guide*, National Green Specification, and the Construction Resources.[18]



Label found on sustainable timber

Recycled Materials

The Architectural Salvage Index run by Hutton and Rostron provides information on:

Building materials: bricks, slates, tiles, stone and timber
Internal features: panelling, flooring, fireplaces, stairs, windows, doors and central heating systems.
External features: a range of garden features and furniture
Complete structures: barns, conservatories and pergolas.[20]

The Faber Maunsell's Sustainable Development Group and Ecological Development built the Ecoconstruction Database. This is a very useful source in determining recyclable material products, manufacturing emissions, and ordering and installing recycled materials.[13]

The Construction Industry Research and Information Association (CIRIA) promotes the use of reusable building materials through the education on how to use recycled materials.[12]

More Information

Articles

Green Roof
http://www.greenroofs.com/

Article on certification to grantee green insulation information
http://www.rsimag.com/rsi/article/articleDetail.jsp?id=124236

Information on sustainable roofing materials
http://www.newbuilder.co.uk/archive/sustainable_roofing.asp

This article provides environmental information on man-made types of insulation
http://www.motherearthnews.com/rec/hb/2053/

Organisations

CAT- The Centre for Alternative Technology provides classes and other services to people looking for green alternatives.
http://www.cat.org/uk

Lambeth Housing- Recommended Materials for Sustainable Construction- This is a reference that provides alternatives to conventional building materials
http://www.lambeth.gov.uk/intradoc/groups/public/documents/policydocument/005155.pdf

Sustainable Building Source Book- this online source provides information, suppliers, and installers of several sustainable materials.
http://www.greenbuilder.com/sourcebook/

Product Suppliers

Green Building Store- Providing an online source to purchase materials and valuable information on sustainable issues.
http://www.greenbuildingstore.co.uk

BRE- For the largest bookstore on this subject visit the Building Resource Establishment bookshop.
http://www.brebookshop.com

Green Choices- Provides product information and suppliers on areas from cleaning products to renewable energy including suppliers.
http://www.greenchoices.com

Insulated Render & Cladding Association (INCA)- This organisation represents suppliers and installers of insulation and cladding, but also provides a lot of good information.
http://www.inca-ltd.org.uk/

Recycled Materials Providers

Construction Industry Research and Information Association- Guidance on the use of recycled materials
http://www.ciria.org.uk

Faber Maunsell's Sustainable Development Group and Ecological Development- Information and sources on recyclable materials.
http://www.ecoconstruction.org

Architectural Salvage Index- Recycles materials from demolished or renovated buildings.
http://www.handr.co.uk/salvage_home.html

Information on hemp home projects

BRE-
http://projects.bre.co.uk/hemphomes/

Suffolk Housing
http://www.suffolkhousing.org/pages/press2b.html

Sustainability Certification

BRE-Information on Ecopoints as a system for accrediting sustainable materials
http://www.bre.co.uk/pdf/076.pdf

Federal Stewardship Certification- Determining the source of timber to determine if it's sustainable.
http://www.fsc-uk.info

National Green Specification- Determining the source of timber to determine if it's sustainable.
http://www.greenspc.org.uk

Books

This book shows large scale architectural options followed by pros and cons of each and case studies.

Smith, Peter F. 2001. **Architecture in a Climate of Change: A Guide to Sustainable Design.** Architectural Press, Oxford.
ISBN: 0 7506 5346 9

This book was written for the homeowner with several sustainable options to incorporate into their home.

Smith, Peter F. 2004. **Eco-Refurbishment: A Guide to Saving and Producing Energy in the Home.** Architectural Press, Oxford.
ISBN: 0 7506 5973 4

Appendix H: Condensation, Damp, and Decay

Sustainability

The effect we have on our environment is becoming continually harder to deny; every day we deal with the results of climate change. Levels of carbon emissions around the world are ever-increasing; with the result being a predicted [temp] increase in average temperature over the next 50 years. If this trend is ignored, and no one assumes responsibility for decreasing mankind's contribution to the greenhouse effect, the potential for ecological disaster is great. Already, negative repercussions of climate change are being seen; rainfall in the United Kingdom has increased in severity, while the London Fog is little more than a memory.

Home repair and maintenance is an often-overlooked area in which environmentally sustainable principles can be used to help reduce home carbon emissions. Within Condensation, Damp and Decay there are several areas in which the environment may be taken into consideration. Damp can cause great amounts of damage in a relatively short period of time, and controlling it is crucial. Letting repairs go unmade will allow damage to increase exponentially, raising both the capital and environmental costs.

The windows, insulation and other building materials used in construction should be evaluated not only by price, but also by their environmental ratings as established by an independent organization. Cleaning chemicals must also be considered; the most popular options, such as bleach, are far from the most ecologically sound. "Eco-wares" products, which carry neither the environmental nor health risks of traditionally cleaners, should be considered.

More information

Green Building Store- Provides information on sustainable alternative materials
http://www.greenbuildingstore.co.uk

Ecopoints- Provides the sustainability rating of building materials
http://www.bre.co.uk/pdf/076.pdf