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SUSTAINABLE CONSTRUCTION MINI-GUIDES

An Interactive Qualifying Project Report

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by

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Abstract

This project involved the development of a series of mini-guides on sustainable construction topics including solar energy, water conservation, and life cycle cost analysis. The London Borough of Merton wishes to provide such guidance to building professionals to encourage and enable green design in their design and construction practices. This assistance would help those involved in the construction profession to comply with the newly enacted Policy ST.1a: Sustainable Development in the Unitary Development Plan. The mini-guides were subjected to a multi-level, iterative process of review, feedback and revisions. The final mini-guides were presented to the Merton Council and represent the start to the Council's now expanding series of sustainable construction guidance materials.

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Executive Summary

The London Borough of Merton currently has and is expanding a wide range of policies and projects to promote sustainable development. The Merton Council desires more concentration on the issue of sustainable construction. While some general guidance is available for architects, developers, builders, and other construction professionals, more focused and detailed materials are thought to be necessary. The Borough has regulations that require only minimum standards to be applied to design schemes. Assistance and incentives are needed for construction professionals to go beyond these standards and the dominance of concentration on initial costs.

A greater concern for sustainable practices is needed among construction specialists. In order to encourage this, assistive materials were necessary. The main goal of this project was to research, design, and create mini-guides on sustainable construction specifically in the areas of solar energy, water conservation, and life cycle cost analysis. The guides were designed to aid building professionals in complying with sustainable development policies currently stated in Merton's Unitary Development Plan.

The Borough is currently involved in a European Union funded venture called the Asia Urbs Project, which encourages the networking of development projects to share knowledge and experience between Europe and Asia. One of the objectives of this project was to enhance the mini-guides with an international scope so that construction professionals engaged with the Asia Urbs Project could use them within their own developments.

This project sets the initial stage for the development of a series of guidance documents. At this phase, concentration was placed on solar energy, water conservation,

and life cycle cost analysis. A template was designed so that future projects can expand with more topics on sustainable construction practices.

In order to achieve these objectives, a series of steps were taken, the first of which was researching materials for the content and format of the mini-guides. This was followed by the initial development of the guides in draft form. The drafts were then subjected to an iterative process of review, feedback, and revision at three successive levels. The first level involved the project liaisons, which was then followed by internal Merton officials, primarily from the Development Control department. The final stage of this process consisted of analysis by external contacts, including green architect Bill Dunster from BedZED and contacts from Spain and India involved with the Asia Urbs Project. A questionnaire, with questions regarding the form, content, and effectiveness of the mini-guides, was given to each individual. The guides were modified based on the questionnaire responses after each feedback level. Once revisions were made to the mini-guides, the process moved into the next level.

After the liaisons reviewed the mini-guide drafts, they presented their feedback. Their suggestions included:

- Change the pictures on the covers to a graphic that corresponds to the topic
- Include the date of the mini-guide development on the cover
- Eliminate the booklet sized guide
- Switch the perspective of the life cycle cost analysis mini-guide and make connections to the solar energy and water conservation mini-guides
- Create a references section with citations throughout the text and indicate sources of the pictures and diagrams
- Make references to the householders guide and the standards of the EcoHomes assessment

The revisions were made and the mini-guides were distributed to the internal Merton officials. The Merton officials reviewed the mini-guides and submitted the completed questionnaire with their comments on the guides. The data from the feedback of the internal Merton officials was then reviewed. The results of the closed ended questions were presented using tables. These tools graphically displayed trends in the responses. The open ended questions allowed the officials to give other comments that were not covered in the closed ended questions. The questionnaire offered the following comments:

- The brochure was too wordy, with too many lengthy descriptions- particularly the solar energy brochure
- The content of the life cycle cost analysis mini-guides required information on the UDP.
- A "Local Suppliers and Contractors" section should be added to the solar energy and water conservation guides
- The guides would be very helpful in assisting construction professionals in complying with the UDP sustainability policies.

All Merton officials, who completed the questionnaire, rather the format, appearance, and organization of the brochure sized mini-guide and found it more user-friendly. The comments and suggestions were reviewed with the project liaisons and the mini-guides were amended accordingly.

The external feedback involved representatives of the Asia Urbs Project and BedZED. The mini-guides and questionnaires were sent via email. The contacts in India wanted to see more illustrations and diagrams explaining solar energy and water conservation techniques.

The main project objective of researching, designing, and creating mini-guides on sustainable construction practices, specifically in the areas of solar energy, water conservation, and life cycle cost analysis, was attained. Initially, three sized mini-guides for each area were created. After the iterative review process previously mentioned, the Merton Council was presented with six final mini-guides; a brochure and A4 size for each subject.

The project team has many recommendations based on the project results for future work in the area. The most efficient way for creating mini-guides is to start with the A4 size and work down to the brochure size. It is easier to start with a great deal of information rather than continuously having to find more material. More mini-guides can be developed in the following areas: ground works and site preparation, construction and demolition waste, building techniques and materials, energy efficient building design; including combined heat and power, ecology and landscaping, health and wellbeing, renewable energies, and environmental and social life cycle analysis.

The team also recommends not focusing the initial research solely on the internet. Valuable information for the life cycle cost analysis mini-guides was found in resources at the Royal Institute of British Architects (RIBA) Library. Future work should also explore the idea of developing a mini-guide based on the case method. Providing building professionals with case studies of sustainable designs may be an effective way to promote sustainable construction practices in Merton. Further feedback should be acquired from green architects to obtain their recommendations and comments on the mini-guides. In conclusion, the project consists of a pioneering effort from the London Borough of Merton in order to supply detailed guidance on sustainable construction practices so that professionals can include green design in future developments.

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1 Introduction

1.1 Sustainable Construction

The world now understands the necessity for environmental protection. Every year, resources are consumed at a rate higher than previous ones and pollution is weakening the environment. The increases in energy use and potable water consumption are now affecting the normal operation of the earth's natural activities. A need for sustainable development has come to the attention of the nations of the world. Steps have been taken to remedy the problem but there is still a need for further improvement.

One of the major areas of sustainable development is the construction sector. This includes the large and small scale, residential and commercial developments. Sustainable construction practice encourages the long-term view of construction aspects and promotes a new approach for architects, developers, planners, designers and end-users. It involves the reduction of the use of the earth's resources for building operations such as heating, cooling, lighting, and water use. The construction industry is one of the most important sectors in the world's economy. It is predicted that the industry employs around 50 percent of material resources, 40 percent of energy consumption and generates around 50 percent of waste (Anink et al, 1996). Sustainable construction practices address the following stages during the construction process: ground works, site preparation, water use conservation, building techniques, ecology, landscaping, health and well being, and demolition.

1.2 Current Situation in Merton

The London Borough of Merton has and is expanding a range of policies and projects to promote sustainable construction. General guidance is available for architects, developers, builders, and other construction professionals. However, the Borough has had regulations that require only conventional standards to be applied to design schemes. Assistance and incentives were needed for construction professionals to go beyond these standards and the dominance of concentration on initial costs. The recently adopted sustainable development policies can be found in Merton's Unitary Development Plan. The UDP helps "guide development in the Borough by setting out a framework of policies and proposals against which planning applications and development proposals will be assessed, and ways in which Merton's nature and historic built environment can be protected" (Merton's UDP 2000). In this plan, Policy ST.1a: Sustainable Development requires applicants for developments to submit a sustainable development statement detailing the plans for meeting sustainability within the design. Therefore, more focused and detailed materials are necessary for providing assistance to building professionals in meeting the terms stipulated in Policy ST.1a.

1.3 Sustainable Construction in the Boroughs of London

Sustainable construction is a major concern among the thirty-three Boroughs of Greater London. Some of them, such as Brent and Enfield, have taken steps to promote sustainable construction through the use of guides. Each borough has created a comprehensive guide that contains information in all areas of sustainable construction. The Borough of Merton has opted for a series of smaller guides with more detailed information in each aspect of sustainable construction.

1.4 Research Space

Sustainable construction demands from construction professionals greater attention to sustainable practices. In order to encourage this, assistive materials are needed so that architects, developers, builders and construction professionals can be thoroughly informed. Prior to the project, the London Borough of Merton did not have guidance resources suitable to the promotion of sustainable construction practices in their projects. These resources will also serve to inform the process by which developers can produce their sustainable development statements to comply with Policy ST.1a.

1.5 Project Goals

This section outlines the objectives of the project. The main goal of this project was to research, design, and create mini-guides to promote sustainable construction practices, specifically in the areas of solar energy, water use, and life cycle analysis, for building professionals in the London Borough of Merton. Another goal of the mini-guides was to make guidance available for construction professionals in creating the sustainable development statements that were required by the UDP. This project was the preliminary stage of Merton's mini-guide development, where a template was established for future expansion into other sustainable construction topics.

2 Background

This section provides the background necessary for the understanding and execution of the project. The main goal of this project was to research, design, and create a template for a mini-guide that can promote sustainable construction practices in the Borough of Merton. The template needs to be versatile so it can be used in other countries including those involved in the Asia Urbs Project, such as Spain and India.

This section starts by introducing the current situation locally and internationally, in the parts on the Unitary Development Plan and the Asia Urbs Project. Background material that was used for the mini-guide development is portrayed in the sections on Solar Energy, Water Use and Conservation, and Life Cycle Cost Analysis. The following section provides information on independent organizations currently involved with sustainable construction; including the Building Research Establishment and BedZED. These organizations were used both in the mini-guide development and feedback stages. The last section describes the methods used to define an actual mini-guide for this project.

2.1 The Unitary Development Plan (UDP)

According to Councillor Su Assinen, the Chair of the Environment Committee, the purpose of the Unitary Development Plan "is to provide guidance as to how changes to the Borough's physical environment should be directed and controlled, in the interests of meeting the needs of its residents"(Merton's UDP 1999). The plan outlines planning policies that construction professionals need to follow within their developments. The UDP is in accordance with national government policies. The revised plan of 2000, compared to that of 1999, focuses more on the idea of sustainability and its importance to the community. The Supplementary Planning Guidance Note on Sustainable Development, produced in October 2001, provided an outline on policies of sustainable development and how they could be implemented. The Council in turn required more detailed guidance to complement the SPG note. In depth guidance is therefore needed on how these policies can be implemented. The mini-guides that were produced set forth alternatives to current standards, to attain a sustainable development design.

2.2 Asia Urbs Project

This section explains the Asia Urbs Project and its significance to this project. "The European Commission developed a strategy for Asia which seeks to improve the mutual awareness and understanding between the European Union and Asia. More specifically, it aims to raise the profile of Europe in Asia, and enhance economic co-operation between the two continents"[http://europa.eu.int/comm/europeaid/projects /asia-urbs/index_en.html]. The Asia Urbs Project is one of the initiatives created to further this relationship. In order to meet this mutual plan, the project will promote "decentralized (city-to-city) cooperation between the two regions" [http://europa.eu.int/comm/europeaid/ projects/asia-urbs/index_en.html]. According to its website, the Asia Urbs Project has two major aims:

- To provide co-funding to local government partnerships to undertake urban development projects
- To encourage the networking of these projects to share knowledge and experience.

Our project has an international dimension because it meets the second aim of the Asia Urbs Project. The mini-guides were specifically designed to be used by construction professionals in Spain and India. Both the Institut Catala d'Energie, in Barcelona, Spain, and The Energy and Resources Institute, in Gurgaon, India, are interested in improving urban environments through the implementation of sustainable construction practices. The mini-guides provide guidance to apply sustainable construction in these countries.

2.3 Life Cycle Cost Analysis

The cost estimation is a very critical aspect in the building process. The determinations of costs for a building have been based mainly on initial capital costs. Life Cycle Cost Analysis is a way of achieving cost-effectiveness in a building development. Sustainable construction practice encourages the involvement of operating and maintenance costs in the price estimation of a construction project. The Life Cycle Cost approach promotes the connection between capital costs and operating costs when defining economic issues in a construction process [http://www.gamc.nsw.gov.au/tam2000/TAM-4-4.asp]. Life Cycle costing makes the latter possible by including acquisition, installation, operation, maintenance, refurbishment and demolition costs when estimating the cost of a building. In most construction processes, operation, maintenance, refurbishment and demolition costs are not part of the cost estimating phase. Maintenance and refurbishment costs can reach half of the cost of what was being invested in a building. In the United Kingdom such costs range from £8 to £20 billion every year and are not typically included in the initial cost picture [http://www.bsee.co.uk/news/fullstory.php/aid/1979/A_building_is_for_life_%97_not_just_for_building.html]. Life Cycle Costing requires a change of thinking in construction professionals so they can make developments sustainable while tending to every aspect of the design possible. These individuals should be looking for the most cost-effective solution which should involve design, building and operating stages over a complete life cycle.

There have been studies and analyses on how to apply the Life Cycle Costing method. These explanations try to quantify the theory behind this approach. In one of these studies, Life Cycle Costing is calculated in a very simple but meaningful way shown in the following equation:

$$LCC = I + R + E + W + OM\&R - S$$

Where:

I: initial investment cost

R: present value of Replacement costs

E: present value of energy costs

W: present value of water costs

OM&R: present value of operation, maintenance, and repair

S: present value of salvage (resale or residual) (Marshall 1995).

For example, considering sustainable design in a development may increase initial investment cost (I) but in the long run this decision will reduce significantly energy (E), water (W), operation, maintenance, and repair (OM&R) costs. The following section portrays the background information used to create the solar energy mini-guides.

2.4 Solar Energy

Energy use is one of the more important issues when considering sustainable construction. The use of energy generated from fossil fuels is dramatically increasing.

This rapid use of energy is depleting a limited resource and creating pollution that is leading to global warming. In the United Kingdom, energy used in buildings accounts for almost fifty percent of the present carbon dioxide emissions. This energy is used to provide heating, cooling, hot water, lighting, and power for appliances. Less energy will be used if the buildings are designed to be energy efficient (Brent Council Environmental Services [BCES], 2002). If architects employ these means for designing an energy efficient building, energy use declines.

The goal in designing an energy efficient building is to produce a structure that uses the minimum amount of energy to provide a comfortable living or working space. To reduce the amount of energy needed, the building design needs to minimize heat loss in the winter and heat gain in the summer. Natural lighting and ventilation should be used as much as possible. Maximizing the efficiency of the energy use in the building reduces the amount of fuel needed to supply these energy dependant services (BCES, 2002).

Using sustainable energy in a building design has many benefits. It promotes energy efficiency and conservation of limited resources. It also forces the use of renewable energy technologies. There may be a higher initial cost incurred, but over a long- term period these costs are offset by the reduced running costs over the lifetime of the building. When sustainable energy use is integrated into a building design, environmental impacts of energy generation are decreased (BCES, 2002). The next section on water use and conservation contains the material used to create the mini-guides.

2.5 Water Use and Conservation

The potable water supply in London is adequate but diminishing. London gets its drinkable water from groundwater and a river network (mainly the Thames River). During the 1960s, central London's groundwater table fell to 98m below sea level because industry was thriving. The groundwater table has since risen due to the North London Abstraction Recharge System (NLARS) that was developed in the 1990s. The system established a management and conservation measure to store treated water in the aquifer and guards against the depletion of reservoirs during periods of dryness. Dry weather and water shortages during the 1990s created awareness for reducing water usage (BCES, 2002). Water conservation practices help maintain and improve the limited groundwater supply.

As with energy, reducing the demand for water in buildings is necessary to attain sustainability. In commercial and domestic buildings, water demand can be reduced by as much as fifty percent when a variety of simple and innovative strategies are integrated into the design. Regulations have changed to incorporate water conservation. Toilets can use a maximum of 6 liters of water per flush. Waterless urinals are becoming increasingly implemented in developments. Faucet aerators in sinks and low-flow showerheads are also water saving options. Gray water from kitchen sinks can be used for toilet flushing, cooling towers, boiler makeup water, landscaping, or fire- fighting. Rainwater from roof drains can also be used for the same purposes as gray water. Water conservation is maximized and most cost effective when integrated into the initial design of a building. If architects have the information at hand in a mini-guide they will be educated on how to incorporate these conservation methods into a sustainable construction project (BCES, 2002). The next section provides information on several independent organizations immersed in sustainable construction practices throughout the United Kingdom.

2.6 Independent Organizations in Sustainable Construction

Several organizations in the United Kingdom, including the Building Research Establishment (BRE) and the Beddington Zero Emissions Development (BedZED), are working to promote sustainable construction.

2.6.1 Building Research Establishment

The Building Research Establishment (BRE) is an example of an independent institution involved with sustainable development. It consists of a consulting firm that performs research, commissioning and testing services for building projects. BRE applies the concepts involved in the Life Cycle Cost Analysis. The BRE has been considered to be a leading center of expertise in the area of sustainable construction and has been the research base for most sustainable construction projects in the United Kingdom. One of these projects is titled "Sustainable Construction – The Data" and its objective is:

> *To marshal key available data on the social, economical, environmental and resource implications of construction.* [http://projects.bre.co.uk/sustainable/SusConstructionData.pdf]

The project was performed in 1999 with close participation from BRE experts. BRE has also contributed a series of innovative tools to the context of sustainable construction. Some examples of these tools developed by BRE are CALIBRE and

SMARTWaste. Both of these initiatives measure the performance of the waste management processes within the construction site. (http://www.bre.co.uk/what.jsp) [http://www.bre.co.uk/services/BREEAM_and_EcoHomes.html].

2.6.1.1 BREEAM

BREEAM is the Building Research Establishment Environmental Assessment Method. BREEAM is a system for assessing the environmental performance of buildings. A trained building professional, licensed by the BRE, performs the assessments. BREEAM assesses a building's performance in management, energy use, health and well being, pollution, transport, land use, ecology, materials, and water. Credits are awarded for meeting or exceeding good practice. The credits are weighted to consider the importance of each issue with respect to the overall environmental impact of the building. The overall score then falls into a category of *pass, good, very good,* or *excellent.* A certificate is then issued by the BRE which can be used to promote the environmental credentials of the organization [www.bre.co.uk].

2.6.1.2 EcoHomes

EcoHomes is the homes version of BREEAM. EcoHomes assessments are carried out at the design stage by licensed assessors who are trained by the BRE. The developer enters information on the design into a workbook that is issued by the BRE. The assessor reviews the information, completes the workbook and determines the rating that the developer achieved. Issues assessed include energy, water, pollution, materials, transport, ecology and land use and health and well being. EcoHomes rates new and renovated homes with either *pass*, *good*, *very good* or *excellent*. EcoHomes can be used at any time during the design stage, but developers are encouraged to start at the earliest opportunity to maximize their benefits (www.bre.co.uk).

An EcoHomes assessment is optional for developers; however, it gives a credible label to houses and apartments. The developers are rewarded for good designs that improve environmental performance rather than focus on capital costs. The developers demonstrate their sustainability credentials to planning authorities, investors and customers. In designing these homes to be assessed by EcoHomes, developers reduce running cost for home owners, create healthy internal environments, and put themselves one step head of regulation (www.bre.co.uk). The next section provides information on the sustainable development, BedZED.

2.6.2 BedZED

The Beddington Zero Emissions Development (BedZED) a sustainable development in the London Borough of Sutton was used in the feedback stage of this project. Bill Dunster Architects (BDA) designed BedZED. The development incorporates zero-emissions, a sustainable transportation system, nearly 100% water recycling, and recycled/locally derived building materials. Bill Dunster was an external contact for this project. His feedback on the mini-guides was important because he is a green architect presently working to promote sustainable construction practices. The next section defines a mini-guide.

2.7 Mini-Guides

This section outlines the research involved in defining a mini-guide. Investigations were done in both the United States and the United Kingdom in major hardware/construction and DIY stores such as Lowe's, Home Depot, Wicks and

Homebase. After visiting and speaking with representatives at these locations, example guides were obtained. Of particular interest were those found in Lowe's and Wicks, which were defined as how-to guides. Each individual guide contained information pertaining to a wide range of construction and installation subjects and is structured in the form of a full open pamphlet. These were very useful in understanding the needs of this particular project, because there was a pamphlet for each subject. A full color booklet was also acquired from Lowe's, which had content similar to what was appropriate for this project's mini-guides. This booklet provided more detailed explanations of the information. Some sections that it included, and which were used in the mini-guides of this project, were terminology, products, and installation tips. The disadvantage that it posed was its size because it may be too large in dimensions to be considered a mini-guide. The material obtained from these stores provided guidance for determining the size and content required to create a successful mini-guide for this project.

3 Methods

The purpose of this section is to outline the proposed methods for answering the following research questions:

> **1) What is the best form (design and layout) for the mini-guides to communicate information effectively to those working in the construction process?**
>
> **2) What content is necessary for mini-guides on solar energy, water conservation, and life cycle cost analysis to be implemented by those working in the construction process?**

The methods are outlined in a chronological process of events. The initial phase of the methodology concentrated on research and collection of relevant content concerning each of the three areas of the mini-guides: life cycle cost analysis, solar energy, and water conservation. Once all this information was obtained, it was then condensed and organized into the three different types of guides. The types were brochure, booklet, and A4 sized structure. Once a set of draft mini-guides were produced, they were subjected to a multi-level feedback process. Based on comments and suggestions from those involved in this process, appropriate changes were made, and where required, additional information was added. A flow diagram of the methodology process is shown below in Figure 3.1.

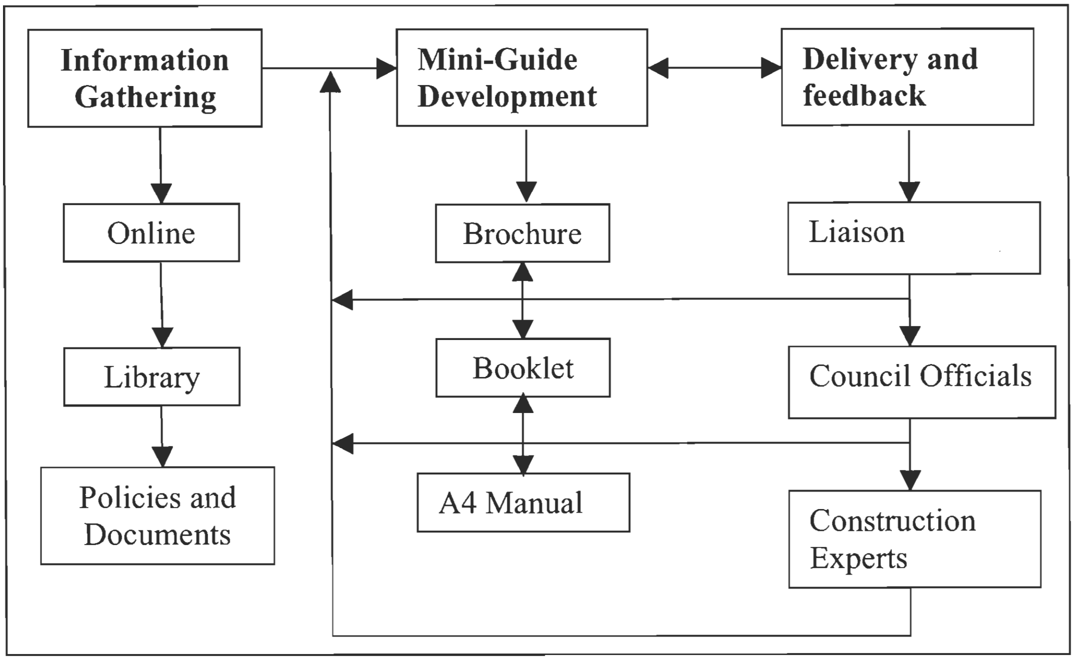


Figure 3.1: Methodology Process

3.1 Information Gathering

Our first steps were to collect the information that was currently scattered in different forms of media. This included a wide array of technical advice, contact information, and additional resources. With its advancement and popularity, the internet was the most likely choice for finding a majority of the data. Conventional methods such as library use also proved useful when online research did not have the capability of delivering what was needed.

3.1.1 Online Research

Various websites were found on the internet that presented information in the areas of solar energy and water conservation. Several agencies and organizations have published valuable material within their websites, which makes for easier access to documents. This form of media, however, was not useful for the area of life cycle cost analysis. In order to get to this information, the conventional method of library searching was used.

3.1.2 Libraries

Informative books and journals were found at the Royal Institute of British Architects (RIBA) Library, in which were found a variety of books and journals relating to the idea of life cycle analysis and more specifically life cycle cost analysis, material that was very helpful in obtaining information for the mini-guides.

3.1.3 Environmental Services Documents and Policies

Several documents were presented to the group that contributed useful material in each of the areas: solar energy, water conservation, and life cycle cost analysis. These documents include:

- Merton's Unitary Development Plan October 2001
- Enfield Guide on Sustainable Construction
- Brent Guide on Sustainable Construction
- Supplementary Planning Guidance (SPG) on Sustainable Development
- WPI IQP Project E-term 2002
- Global Report Initiative Sustainability Reporting Guidelines
- BRE sustainability checklist for developments
- Woking's Local Agenda 21 Newsletter
- Asia Urbs: Sustainable building design in Gurgaon: Strengthening capacities for planning and implementation (Draft)

3.2 Mini-guide Development

The mini-guides are intended to portray technical information and persuasive motivational narrative to those engaged in the construction enterprises and their clients. Templates were needed to explore the means for presenting this content in the most effective manner. We decided to create and test three candidate formats for the guides;

brochure, booklet, and A4 structure. These three options were selected based on initial research on past developments of mini-guides found in major home improvement stores in the United States and London. Each subject mini-guide would first be developed using one structure. The other two formats were then created based on this initial structure. The matrix below shows the order in which each was developed.

	Mini-Guide Development Sequence		
	Solar Energy	Life Cycle Cost Analysis	Water Conservation
Brochure	3	1	3
Booklet	2	2	1
A4 Manual	1	3	2

Table 3.1: Mini-guide Development Sequence

3.2.1 Brochure

The brochure mini-guide was developed using the Microsoft Word template "Brochure". This template consisted of a three-fold brochure that allows six faces of content in an A4 size paper. The purpose of the brochure mini-guide is to provide a first exposure to the subject being promoted. Given its promotional purpose, the content in the guide needed to be appealing and attention-getting for the target audience. Content needed to be concise and if possible organized in bulleted lists. The inclusion of graphs, tables, pictures and charts was thought to be essential for the success of a brochure mini-guide. In addition, in order to make the mini-guides attractive, different colors and pictures were used. The content of the brochure mini-guide addressed three different areas: why, how, and the further information contact list. The life cycle cost analysis guide was first developed in this form. An example of the brochure is shown in Figure 3.2 exposing three of the six available faces

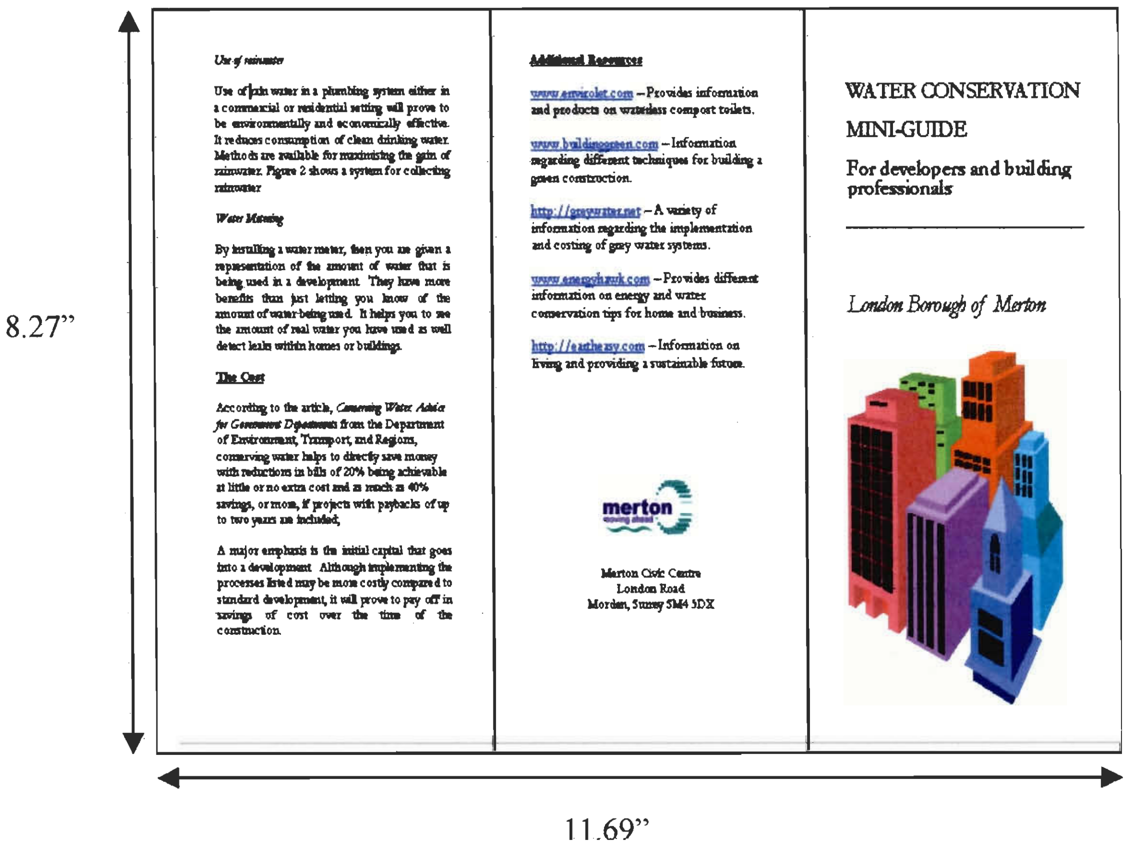
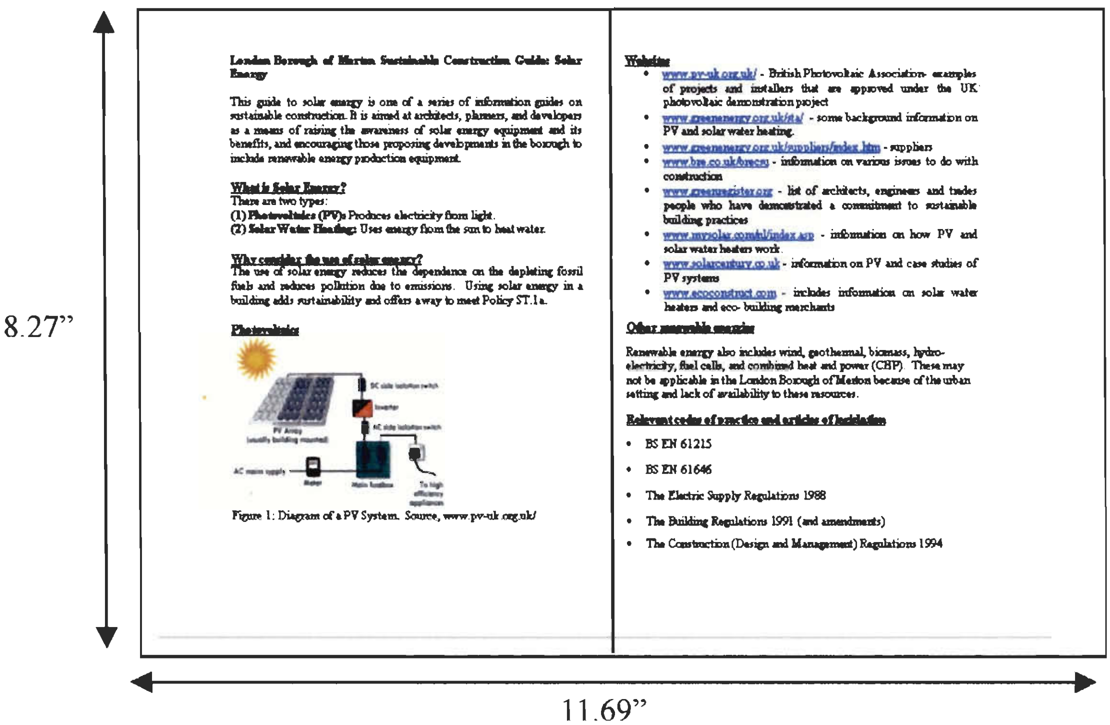


Figure 3.2: A brochure guide, showing three of the six available faces

3.2.2 Booklet

Compared to the brochure-sized guide, the booklet offers more space. The size is relatively larger and has the capacity to portray very detailed information. The dimensions are relative to an A4 sized paper, folded in half. With the assistance of Microsoft Word, this type of guide could be created by using a landscape page, and selected for two columns. The booklet-sized guide lacks the size constraint of the brochure guide. The guide can hold a variety of information, including a table of contents, a limited amount of technical information, and any additional applicable information. It also allows for graphical and pictorial presentations, space for which is limited in the brochure. An example of the booklet is shown in Figure 3.3 exposing two of the many possible surfaces.



London Borough of Merton Sustainable Construction Guide: Solar Energy

This guide to solar energy is one of a series of information guides on sustainable construction. It is aimed at architects, planners, and developers as a means of raising the awareness of solar energy equipment and its benefits, and encouraging those proposing developments in the borough to include renewable energy production equipment.

What is Solar Energy?
There are two types:
(1) **Photovoltaics (PV):** Produces electricity from light.
(2) **Solar Water Heating:** Uses energy from the sun to heat water.

Why consider the use of solar energy?
The use of solar energy reduces the dependence on the depleting fossil fuels and reduces pollution due to emissions. Using solar energy in a building adds sustainability and offers a way to meet Policy ST.1a.

Photovoltaics

Figure 1: Diagram of a PV System. Source, www.pv-uk.org.uk/

Websites
- www.pv-uk.org.uk/ - British Photovoltaic Association- examples of projects and installers that are approved under the UK photovoltaic demonstration project
- www.greenenergy.org.uk/sta/ - some background information on PV and solar water heating.
- www.greenenergy.org.uk/suppliers/index.htm - suppliers
- www.bre.co.uk/brecsu - information on various issues to do with construction
- www.greenregister.org - list of architects, engineers and trades people who have demonstrated a commitment to sustainable building practices
- www.mysolar.com/rl/index.asp - information on how PV and solar water heaters work.
- www.solarcentury.co.uk - information on PV and case studies of PV systems
- www.ecoconstruct.com - includes information on solar water heaters and eco- building merchants

Other renewable energies

Renewable energy also includes wind, geothermal, biomass, hydro-electricity, fuel cells, and combined heat and power (CHP). These may not be applicable in the London Borough of Merton because of the urban setting and lack of availability to these resources.

Relevant codes of practice and articles of legislation

- BS EN 61215
- BS EN 61646
- The Electric Supply Regulations 1988
- The Building Regulations 1991 (and amendments)
- The Construction (Design and Management) Regulations 1994

Figure 3.3: Booklet guide, showing two of many possible surfaces

3.2.3 A4 Manual mini-guide

The A4 Manual mini-guide was developed using the “Manual” template from Microsoft Word. The purpose of this type of mini-guide was to add more technical advice than the brochure and booklet sized guides could offer. Content in this mini-guide includes the majority of the material that was researched. A table of contents, case studies and a list of helpful contacts were also integrated into this guide. The A4 manual also allows more pictures, tables, charts and graphs than the brochure and booklet sized guides. An example of an A4 guide is shown in Figure 3.4.

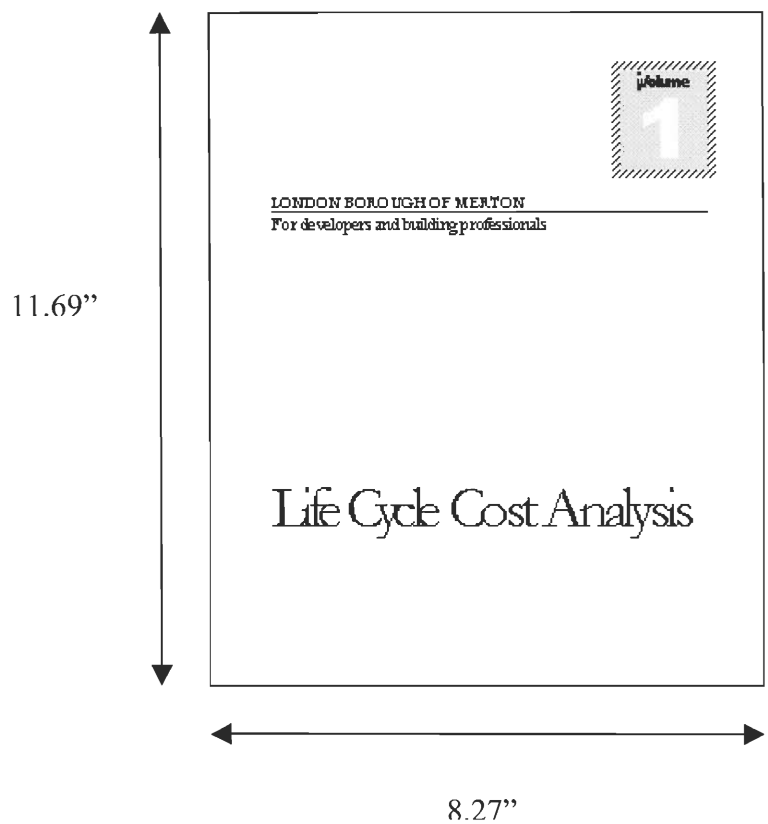


Figure 3.4: A4 guide, cover page

3.3 Feedback

Once the guides were developed in a draft form, they were subjected to a multi-level review process. The first form of feedback and subsequent revision came at the liaison level with the participation of Steve Cardis, Richard Ainsley, and Phil Ryder. Once these individuals critiqued the guides, the process moved outward to the internal council level. This group included development control officers, people who assess proposals for meeting sustainable development policies. In order to get a clearer understanding of the responses from this level, a questionnaire, with questions focusing on form, content, and effectiveness of each mini-guide, was created and presented to the officials. Further modifications were then made based on the questionnaire responses and written comments on the mini-guides. When the guides were well understood within the Council, the review of the guides moved into the realm of the external contacts. They were sent out to the construction professionals to obtain their analysis and comments. The guides were then modified once again. Figure 3.5 illustrates the three levels of feedback for the mini- guides.

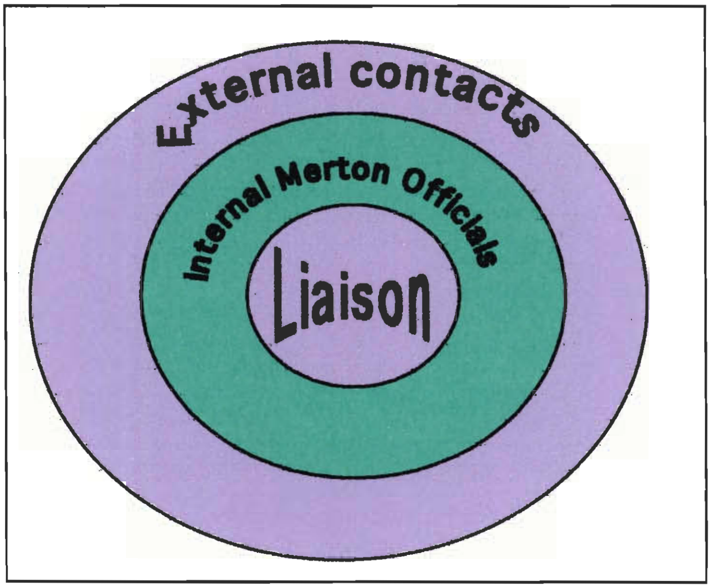


Figure 3.5: Feedback Levels

3.3.1 Liaison Feedback Level

The drafts of the mini-guide were first examined at the liaison level, which included Steve Cardis, Richard Ainsley, and Phil Ryder. Since these individuals directed the project, the guides had to meet their expectations in order to move on to the next stage in the process. Mr. Phil Ryder had produced a document called the householder's guide, which outlines environment and economic saving tips for home owners. His knowledge in this area can be of assistance when targeting residential developments. Since contact with the liaison was not a problem, it was possible to maintain a face-to-face discussion regarding the initial drafts.

3.3.2 Internal Council Feedback Level

The Council is the main body that assesses sustainability within developments. Since one of the goals of the mini-guides is to meet sustainable development policies within the Unitary Development Plan, the Council needs to be advised on the guidance provided to developers in order to meet these policies. Development Control Officers are the individuals that evaluate sustainability in developments. The mini-guides will assist these officers in understanding the sustainable practices currently available. A questionnaire was produced, for this level and beyond, to obtain concise analysis on the form, content, and effectiveness of each guide. A list of the names of these officials and their positions is shown in Appendix A. The questionnaire is shown in Appendix C.

3.3.3 External Feedback Level

The final level in this process was obtaining feedback from the external professionals. These include construction experts, green architects, and Asia Urbs participants. At this stage of the process, it is necessary to acquire the advice and criticism of the main users of the mini-guides, primarily developers and construction professionals. In addition, green architects are currently applying practices associated with sustainable construction; therefore the feedback that they provide will help in shaping the mini-guides for those surrounding the architect profession. In order to attain the international scope discussed earlier, Asia Urbs connections from Spain and India were presented with draft mini-guides for analysis. A list of these contacts is presented in Appendix A.

3.4 Schedule

This section details the schedule of events that took place from the time of data gathering, to the final stage of revisions.

- Weeks 1 and 2: Data Gathering and mini-guide development
- Week 3: Liaison feedback and preparing for internal feedback
- Weeks 4 and 5: Second stage of feedback from internal contacts, then necessary modifications
- Week 6: External feedback and final revisions made
- Week 7: Presentation and Final Report

4 Results – Final Mini-guides

The main outcome of this project was a series of mini-guides on sustainable construction practices in the areas of solar energy, water conservation, and life cycle cost analysis. The final products consisted of two types of guides: brochure and A4. The brochure will act as a promotional guide with an introduction to the topic being discussed, while the A4 guide compliments the brochure and goes more in-depth into the subject matter. Users can range from DIY specialists to Development Control Officers from Merton. The brochure was designed for those that possess limited knowledge in the subject; therefore it could be useful for clients of developers who do not have any understanding of the different technologies currently available. The A4 includes a wide range of technical information; as a result, they are aimed at those who are proficient in construction practices, such as developers, architects, and builders. The final mini-guides can be viewed in appendices E, F, and G.

5 Mini-guide Feedback Analysis

5.1 Liaison Feedback

The following are key comments identified by the project liaisons after their review of the mini-guides.

- General Comments for all guides
  - Add date of creation to front cover and choose cover graphics specific to respective topic of mini-guide
  - Eliminate booklet sized guide because it did not possess a special function like the other 2 sized guides
  - Add a section on the EcoHomes assessments- provide a list of the specific topics that the assessments cover to provide more guidance for building professionals
  - Add more references to the householders guide to create synergy among the Council's guidance

- Solar Energy Specific Comments
  - Adjust the length of the A4 guide by changing the formatting to include more information on one page
  - Remove the section on other renewable energies because more guide may be created on these topics

- Water Conservation Specific Comments
  - Change the hierarchy of information by first discussing water saving devices in the home, then rainwater usage, and finally grey water usage
  - Include devices for taps or faucets in the section on shower heads
  - Add sections on water efficient home appliances, such as washing machines and dishwashers, and drought resistant plants

- Life Cycle Cost Analysis Specific Comments
  - Modify the approach of the mini-guide by including a green dimension to the content of the guides.
  - Make links to the other two guides.
  - Focus on United Kingdom examples and cases.

5.2 Internal Merton Officials Feedback

5.2.1 Life Cycle Cost Analysis

At this level of feedback, four Council officials were chosen to review the two types of mini-guides on Life Cycle Cost Analysis. These individuals were: Ged Lawrenson, Lone Le Vay, Alec Johnson and Adrian Hewitt. Three of these four professionals contributed with responses to the questionnaires.

The following table summarizes the responses to the questionnaires pertaining to the A4 sized mini-guide on Life Cycle Cost Analysis:

Total Responses	SD	D	U	A	SA	
2	0	0	0	2	0	I learned a great deal of new information from the guide
2	0	0	0	0	2	The guide stimulated my interest in the subject
2	0	0	1	1	0	The information helped me professionally
2	0	1	0	1	0	There is enough technical advice contained within the guide
2	1	0	0	1	0	The guide would assist construction professionals in complying with the UDP sustainability policies in conjunction with the SPG
2	0	0	1	1	0	The guide is appropriately directed to building professionals
2	0	0	1	1	0	The guide was user friendly
2	0	0	0	1	1	The guide contained adequate visual aids
2	0	0	1	1	0	I liked the appearance of the guide
2	0	0	0	2	0	I liked the format of the guide
2	0	0	1	0	1	The guide communicated the information effectively
2	0	0	1	1	0	The information was well organized

Table 5.1: Questionnaire Result for LCCA A4

The following table summarizes the results of the questionnaires from those who responded to the LCCA Brochure mini-guide.

Total Responses	SD	D	U	A	SA	
2	0	0	1	1	0	I learned a great deal of new information from the guide
2	0	0	0	2	0	The guide stimulated my interest in the subject
2	0	0	1	1	0	The information helped me professionally
2	0	0	1	1	0	There is enough technical advice contained within the guide
2	0	0	0	2	0	The guide would assist construction professionals in complying with the UDP sustainability policies in conjunction with the SPG
2	0	0	1	1	0	The guide is appropriately directed to building professionals
2	0	0	0	2	0	The guide was user friendly
2	0	0	1	0	1	The guide contained adequate visual aids
2	0	0	0	1	1	I liked the appearance of the guide
2	0	0	0	1	1	I liked the format of the guide
2	0	0	0	2	0	The guide communicated the information effectively
2	0	0	0	2	0	The information was well organized

Table 5.2: Questionnaire Results for LCCA brochure

5.2.2 Solar Energy

At this level of feedback, seven Council officials were chosen to review the two types of mini-guides on Solar Energy. These individuals were: Rory Doyle, Adrian Hewitt, Cecily Herdman, Alec Johnson, Tim Cutts, Nick Smart,

The following table summarizes the results of the questionnaires from those who responded to the Solar Energy A4 Guide.

Total Responses	SD	D	U	A	SA	
5	0	1	0	3	1	I learned a great deal of new information from the guide
5	0	1	0	4	0	The guide stimulated my interest in the subject
5	0	1	1	3	0	The information helped me professionally
5	0	0	0	4	1	There is enough technical advice contained within the guide
5	0	1	1	1	2	The guide would assist construction professionals in complying with the UDP sustainability policies in conjunction with the SPG
5	0	0	1	2	2	The guide is appropriately directed to building professionals
5	0	0	0	2	3	The guide was user friendly
5	0	1	1	2	1	The guide contained adequate visual aids
5	0	0	1	3	1	I liked the appearance of the guide
5	0	0	0	3	2	I liked the format of the guide
5	0	0	0	4	1	The guide communicated the information effectively
5	0	0	0	4	1	The information was well organized

Table 5.3: Questionnaire Results for Solar Energy A4

The following table summarizes the results of the questionnaires from those who responded to the Solar Energy Brochure mini-guide.

Total Responses	SD	D	U	A	SA	
3	0	0	1	1	1	I learned a great deal of new information from the guide
3	0	1	0	2	0	The guide stimulated my interest in the subject
3	0	0	1	2	0	The information helped me professionally
3	0	0	0	1	2	There is enough technical advice contained within the guide
3	1	0	0	1	1	The guide would assist construction professionals in complying with the UDP sustainability policies in conjunction with the SPG
3	0	0	1	1	1	The guide is appropriately directed to building professionals
3	0	0	0	2	1	The guide was user friendly
3	0	0	1	2	0	The guide contained adequate visual aids
3	0	0	0	3	0	I liked the appearance of the guide
3	0	0	0	2	1	I liked the format of the guide
3	0	0	0	2	1	The guide communicated the information effectively
3	0	0	0	2	1	The information was well organized

Table 5.4: Questionnaire Results for Solar Energy Brochure

5.2.3 Water Conservation

At this level of feedback, four Council officials were chosen to review the two types of mini-guides on Water Conservation. These individuals were Adrian Hewitt, Cecily Herdman, and Valerie Mowah.

The following table summarizes the results of the questionnaires from those who responded to the Water Conservation A4 Guide.

Total Responses	SD	D	U	A	SA	
3	0	0	0	2	1	I learned a great deal of new information from the guide
3	0	0	1	1	1	The guide stimulated my interest in the subject
3	0	0	2	1	0	The information helped me professionally
3	0	0	0	3	0	There is enough technical advice contained within the guide
3	0	0	0	3	0	The guide would assist construction professionals in complying with the UDP sustainability policies in conjunction with the SPG
3	0	0	2	1	0	The guide is appropriately directed to building professionals
3	0	0	0	3	0	The guide was user friendly
3	0	0	1	2	0	The guide contained adequate visual aids
3	0	0	0	3	0	I liked the appearance of the guide
3	0	0	0	3	0	I liked the format of the guide
3	0	0	0	3	0	The guide communicated the information effectively
3	0	0	0	3	0	The information was well organized

Table 5.5: Questionnaire Results for Water Conservation A4 Guide

The following table summarizes the results of the questionnaires from those who responded to the Water Conservation Brochure.

Total Responses	SD	D	U	A	SA	
3	0	0	0	2	1	I learned a great deal of new information from the guide
3	0	0	0	3	0	The guide stimulated my interest in the subject
3	0	0	2	1	0	The information helped me professionally
3	0	0	0	3	0	There is enough technical advice contained within the guide
3	0	0	1	2	0	The guide would assist construction professionals in complying with the UDP sustainability policies in conjunction with the SPG
3	0	0	1	1	1	The guide is appropriately directed to building professionals
3	0	0	0	2	1	The guide was user friendly
3	0	0	1	1	1	The guide contained adequate visual aids
3	0	0	0	3	0	I liked the appearance of the guide
3	0	0	0	3	0	I liked the format of the guide
3	0	0	0	3	0	The guide communicated the information effectively
3	0	0	0	3	0	The information was well organized

Table 5.6: Questionnaire Results for Water Conservation Brochure

5.2.4 Overall Questionnaire Results

The following is a table that presents the percentages of the questions on the questionnaire that had responses of a 4 = somewhat agree and 5 = strongly agree.

	A4	**Brochure**
Solar Energy	79%	83%
Water Conservation	86%	81%
Life Cycle Cost Analysis	80%	73%

Table 5.7: Percent of responses that "Agree" and "Strongly Agree"

As you can see from table 5.7, the acceptance is high among the responses. The overall acceptance rate is about 80%. The next section will discuss the general comments from the responses on the open-ended questions contained in the questionnaire.

5.2.5 Open-ended Questions - Summary

The following are some of the common themes found on the four open-ended questions that were part of the questionnaire distributed among the internal Merton officials.

Solar Energy A4 mini-guide

- Good amount of technical information
- Include environmental and financial benefits
- Add section on local suppliers and contractors

Solar Energy brochure mini-guide

- Include section on running and maintenance costs
- Insert motivational elements

Water Conservation A4 mini-guide

- Add information pertaining to energy involved in purifying water
- Expand on climate change section
- Add section on local suppliers and contractors

Water Conservation brochure mini-guide

- Emphasis on the advantages of responding to the UDP policies

Life Cycle Cost Analysis A4 mini-guide

- Include introduction/foreword explaining the aim of the mini-guides
- Add UDP connection to the guide
- Add section on Embedded Energy
- Include more case studies in the Case Studies chapter.
- Address the payback periods

Life Cycle Cost Analysis brochure mini-guide

- Include a checklist on LCCA
- Include aspects such as use of raw materials, maintenance costs and environmental impacts of disposal.

5.3 External Contact's Feedback

Feedback from external contacts level was only received from individuals in The Energy and Resources Institute (TERI) in India. The comments can be viewed in Appendix D.

6. Conclusions and Recommendations

We achieved our main objective, which was to research, design, and create mini-guides on sustainable construction. Specifically the focus was on the areas of solar energy, water conservation, and life cycle cost analysis. The initial methodological strategy during the early phases of the project was a multi-level review process of the mini-guides.

As described earlier, the first level of the process involved feedback from our liaisons, followed by analysis from housing and planning officials in Merton. The final level in the three-level process was obtaining the perspectives of external contacts, such as green architects. Unfortunately, due to time constraints, this final stage could not be fully completed in the serial manner originally planned. However, instead of eliminating this final stage, it was modified. Both Merton officials and the external contacts reviewed the mini-guides concurrently. This was the alternative to having Merton officials review the mini-guides, making the necessary changes based on their feedback, and then sending the guides out to the external contacts for their review.

Fortunately the goal of attaining both green and international viewpoint on the issues was still achieved because contacts in Spain and India possessed the attributes to cover both areas. In the end, even with time as an adversary, the final product still proved to be very helpful in meeting the sustainability needs of Merton, based on the opinions of Merton officials and green architects.

Communication began with the international contacts in India and Spain, and with Bill Dunster from BedZED. Input and advise from green architects, such as these, is essential because they are professionals in the field who fully understand the advantages of, and methods for, implementing sustainable construction practices.

Our results showed that the A4-sized mini-guide was rich in detail and very informative. However, we do recommend that the mini-guides adopt more of a functional feature. In order to do this we suggest modeling a new type of mini-guide after the case method, which is based on the presentation of case studies. This will encourage the user to apply concepts described in the guides because it will present the actual histories of projects in which various sustainable construction practices have been used. We also propose taking a close look at the London Borough of Enfield guide because it utilizes this approach in the sustainable construction mini-guide prepared for its developers and building professionals.

Our next recommendation is based on information gathered on solar energy, life cycle cost analysis, and water conservation. We found it necessary to develop much more than a shallow grasp of the fundamental concepts of the topics being covered by the mini-guides. Another important suggestion, while in the information retrieval stage, is not to rely heavily on online sources, because not all the information is reputable. Although the Internet can be a magnificent research tool, there are other options that should be explored when researching sustainable construction practices. For example, we suggest looking at architectural journals and publications because they were very useful for attaining of the goals of the project. We also advocate visiting architecture institutions, such as the Royal Institute of British Architects or the American Institute of Architects for the purpose of obtaining information on sustainable construction practices.

Sustainable construction is a broad topic that is steadily gaining attention and adherents around the world. Our research revealed several topics that might be of interest to the Council for future mini-guide development. We suggest expanding the initial collection because our results showed that the mini-guide can be helpful and informative. In addition, we encourage further developments in the following areas: ground works and site preparations, construction and demolition waste, building techniques, sustainable building materials, energy efficient building design, renewable energy, ecology and landscaping, and health and wellbeing.

The London Borough of Merton is one of the thirty three boroughs in Greater London. Merton has taken the initiative to promote sustainable construction practices through the enactment of new policies. The mini-guides from this project provide the guidance needed to involve people with sustainability, and go beyond the minimum requirements. It is becoming more and more apparent that everyone needs to be concerned about the long-term effects of today's construction decisions on the communities of tomorrow.

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Muschett, F. D. (1997) Principles of Sustainable Development. Delray Beach, FL: St. Lucie Press.

Smith, M., Whitlegg, J. & Williams, N. (1998). Greening the Built Environment. London: Earthscan.

Marshall, H. E. & Petersen, S. R. (1995). Mechanical Estimating Guidebook. New York, NY: McGraw-Hill, Inc.

Appendix A – List of External Contacts

Sustainable Construction Contacts List; April 2003.

1. **Renewable Energy**

- Anthony Waddington; Creative Environmental Networks (CEN) anthony@cen.org.uk 020-8683-6652
- Joanne Wheeler. WWF. JWheeler@wwf.org.uk 01483-426444.
- Solar City London; Chris Dunham. Chrisd@solarcity.org.uk 020-7820-3151
- Green Register of Construction professionals. Info@greenregister.org 020-7820-3159.
- Energy Savings Trust; info@practicalhelp.org.uk 0870-241-2089.

2. **Water Conservation.**

- Simon Wyke; Environment Agency; simon.wyke@environment-agency.gov.uk 020-8305-4024.
- Diana Langdon re Climate Change at Kings College. Diana.langdon@kcl.ac.uk

3. **Life Cycle Analysis**

- See green architects below.
- Martin Hunt; Construction Industry Environmental Forum (CIRIA) martin.hunt@ciria.org.uk 020-7222-8891.
- Susheel Rao; BRE Sus Const Consultant. Raos@bre.co.uk 01923-664565.

4. **Asia Urbs**

- Grisha Domakowski; Institut Catala d'Energie (ICAEN) domakowski@hotmail.com 34-93 622 0500
- Mili at Teri India; milim@teri.res.in
- Ritu Kumar; Teri rep in London. Ritukumar@aol.com

5. **Green Architects/ Experts.**

- Bob Harris. (Green Arch)Earthdance Ltd and Richmond College. robert.harris3@tesco.net 020-8977-4763.
- Leigh Bowen Bedzed. Leigh@zedfactory.com 020-8404-1380.
- Bree Day Partnership (Tim Day and Damian Bree; Green Architects) design@architech.co.uk 020-8744-4440.

6. **Building Experts**

- Chris Twinn; Arups structural engineer. Chris.twinn@arup.com 020-7755-3411.
- Alan Crane; Rethinking Construction alan.crane@rethinkingconstruction.org.uk

7. Other Experts.

- Kate Theobald . Northumbria University; kate.theobald@freeuk.com 0191-227-3500
- Norman Beddington. Ecological Development. NB.ecodev@btinternet.com 020-7837-6308.
- Martin Shaw. TCPA. Policy@tcpa.org.uk 020-7930-8903.
- Mike Sammons at Greenwich mike.sammons@greenwich.gov.uk LA21 officer

Appendix B – Internal Merton Officials

Name	Department	Mini-Guide
Rory Doyle	Environmental Health Energy advice.	Solar
Adrian Hewitt	Sustainability Officer.	Solar, Water, LCCA
Cecily Herdman	Housing Officer.	Solar, Water
Ged Lawrenson	Plans and Projects	LCCA
Lone Le Vay	Plans and Projects	LCCA
Valerie Mowah	Plans and Projects	Water
Alec Johnson	Building Control	Solar, LCCA
John Hill	Development Control	Water
Tim Cutts	Development Control	Solar
Nick Smart	Business and Environmental Partnerships Unit	Solar
Trevor Macintosh	Building Control	Solar

Appendix C – Questionnaire

Questionnaire

Which topic are you evaluating?

a. Solar Energy b. Water Conservation c. Life Cycle Cost Analysis

Which sized guide are you evaluating?

a. Brochure b. A4

After reviewing each mini-guide please answer the following questions to the best of your ability and please feel free to write any comments on the guides:

1. Please circle the appropriate number for each question based on your opinion. 1=strongly disagree, 2=somewhat disagree, 3=Undecided, 4=somewhat agree, 5= strongly agree.

   a) I learned a great deal of new information from the guide. 1 2 3 4 5

   b) The guide stimulated my interest in the subject. 1 2 3 4 5

   c) The information helped me professionally. 1 2 3 4 5

   d) There is enough technical advice contained within the guide. 1 2 3 4 5

   e) The guide would assist construction professionals in complying with the UDP sustainability policies. 1 2 3 4 5

   f) The guide is appropriately directed to building professionals. 1 2 3 4 5

   g) The guide was user-friendly. 1 2 3 4 5

   h) The guide contained adequate visual aids. 1 2 3 4 5

   i) I liked the appearance of the guide. 1 2 3 4 5

   j) I liked the format of the guide 1 2 3 4 5

   k) The guide communicated the information effectively. 1 2 3 4 5

   l) The information was organized well. 1 2 3 4 5

2. In your opinion, what section(s) of the guide was/were most helpful. And what/which was/were least helpful? Why?

3. What information and/or sections could be added to make the guide better?

4. Would you change the sequence of sections? If yes, how?

5. Other comments and suggestions?

Thank you for taking the time to complete this evaluation.

Appendix D – TERI India Feedback

Principal Contact: Mili Majmudar

Comments on solar energy manual from TERI India - Shirish Garud

- Title "what is solar energy?" can be changed to "How solar energy is used"
- Use hyper links to units' definitions like kWp.
- Some more details about PV materials and attach bigger photographs so that it's easy to identify the panels of various types.
- Installed kW capacity and actual power generation relationship
- Thin film pv cell description starts with amorphous silicon and then says about other materials this can be confusing for common user (in India at least)
- Life of PV System – It may be better to explain the life cycles of each subsystem. For example – battery has life cycle of 4-5 years.
  Electronics – can last up to 10 – 15 years.
- Orientation
  - Tilt with horizontal may be added

SOLAR THERMAL SYSTEM

- Solar thermal system diagram can include the components names.
- Design guidelines for the thermal system designing.
- Hot water consumption norms for houses, commercial establishments etc. can be included in tabular form.
- Evacuated tubes are best suited for cloudy and foggy climate. This fact may be highlighted.
- Close up photograph of systems can be included.
- Requirement of ground area visa a vis solar collector area can be given in tabular form.

- Solar tank location is important in building suitability since the hot water tank load is much more and roof design to take this additional load is important. (This is more important in India where thermosyphon systems are used. I am Not clear about UK conditions)

Comments on Manual on water efficiency - K V Rajeshwari

- Available manufacturers/suppliers under different products in water saving techniques.
- Incorporation of pictures
- Though website addresses in each section may give the details of each product, certain overview and sample details can be given in the text itself.
- Detail on available sensors for urinals and taps.
- The landscaping section can also include low flow sprinklers and drip irrigation techniques.
- A section on best practices such as regular checking of water leakage, landscape
- Watering schedules etc.

Appendix E – Life Cycle Cost Analysis Guides

HOW DOES A LCC ANALYSIS WORK?

Steps in LCC ANALYSIS

The following steps need to be followed when conducting a LCC analysis of a green development:

1. Identify options
2. Establish assumptions
3. Estimate all project costs and their timing
4. Discount future costs to present value
5. Compute the LCC for each alternative
6. Identify alternative with the lowest LCC

HOW TO COMPUTE LCC?

$$LCC = I + R + E + W + OM\&R - S$$

I: initial Investment Cost

R: present value of Replacement Costs

E: present value of energy costs

W: present value of water costs

OM&R: present value of operation, maintenance, and repair

S: present value of salvage

ADDITIONAL RESOURCES:

The information on this brochure was obtained from the following sources:

http://www.gvrd.bc.ca/sustainability/GreenBuildConf2001/Workshop%202-Tim%20Spiegel.pdf

http://www.eed.state.ak.us/facilities/publications/LCCAHandbook1999.pdf

http://www.icfox.com/sg/useful_info/eng/LCC/Content.htm

http://www.eere.energy.gov/femp/resources/pdfs/lcc_guide_rev2.pdf

http://www.gamc.nsw.gov.au/tam2000/TAM-4-4.asp

http://www.bsee.co.uk/news/fullstory.php/aid/1979/A_building_is_for_life_%97_not_just_for_building.html

http://fire.nist.gov/bfrlpubs/build96/PDF/b96102.pdf

http://irc.nrc-cnrc.gc.ca/cbd/cbd212e.html

http://www.buildinggreen.com/features/lc/low_cost.cfm

http://www.wgba.org/html/green_building.html

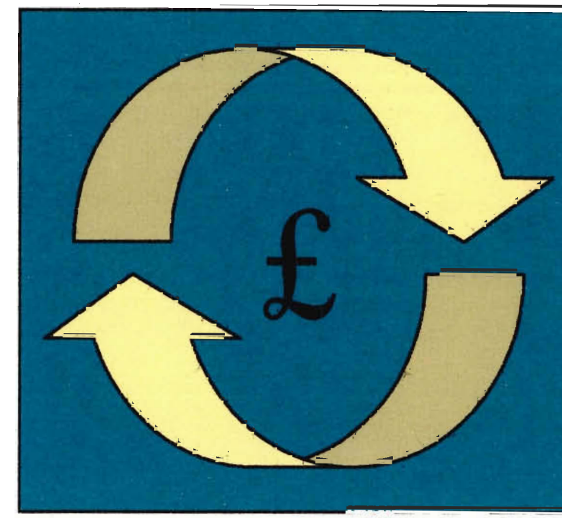
http://www.homeasta.org/pattern3.htm

merton moving ahead

LIFE CYCLE COST ANALYSIS

MINI-GUIDE

For developers and building professionals



London Borough of Merton

April 2003

LIFE CYCLE COST (LCC) ANALYSIS

The idea that environmental sustainable buildings improve the financial performance of a building may sound problematic and new to many building professionals. However, the business community is considering green building because it provides many economical advantages. The main benefit behind the application and the success of green buildings is the completion of cost effectiveness in a project. Cost-effectiveness is reached when construction professionals take into account the Life Cycle Cost Analysis in the design stage of the building developments. The Life Cycle Cost Analysis is a method of assessing cost effectiveness in sustainable buildings.

Source: alumweb.mit.edu/classes/ 1961/green.htm

INVESTMENT DECISIONS

The Life Cycle Cost Analysis is an approach that may allow the architect or building professional to make decisions such as:

- ✓ Accept or reject a project
- ✓ Achieve optimal efficiency
- ✓ Make optimal system selection

Some of these decisions described above appear in the context of energy conservation (See Solar Energy Guide). For instance, some of the following questions can be answered using a Life Cycle Cost Analysis:

1. What is the best energy conservation feature among various options such as: solar, wind, biomass, etc? For example conventional heating versus solar power.
2. How much investment is required in an energy conservation feature?
3. Are there any desirable combinations between different energy conservation features?

Life Cycle Cost Analysis also provides answers to which sustainable construction practice is the most feasible for a development in terms of water conservation. (See Water Conservation Mini-Guide) Some of these questions are:

1. What is the best water saving device to include in home or in commercial premises over the expected lifetime of the construction?
2. How much is required to save the most in water consumption looking at the long term?

RECOMMENDATIONS

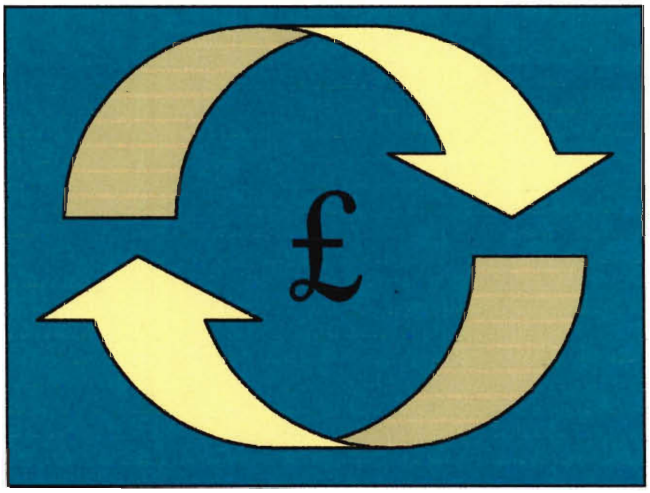
Selecting materials that cost the least at the time of purchase may load a householder with enormous operating, maintenance, repair, and disposal costs, and even health problems. The following are recommendations for building professionals and developers to consider sustainable design in their building developments:

- ✓ Products that are recyclable at the end of their useful life.
- ✓ Preference to locally and regionally produced equivalent products.
- ✓ Avoid products with components or constituents that are regulated as hazardous waste.
- ✓ Consider the expected lifetime and maintenance requirements of all products relative to alternative products.
- ✓ Select energy-efficient and water-efficient systems and appliances to reduce lifetime consumption. (See Solar Energy and Water Conservation Mini-Guides)

Volume 1

LONDON BOROUGH OF MERTON

For developers and building professionals



Life Cycle Cost Analysis

APRIL 2003

ENVIRONMENTAL SERVICES DEPARTMENT

Life Cycle Cost Analysis

merton moving ahead

Merton Civic Centre London Road,
Morden, Surrey SM4 5DX

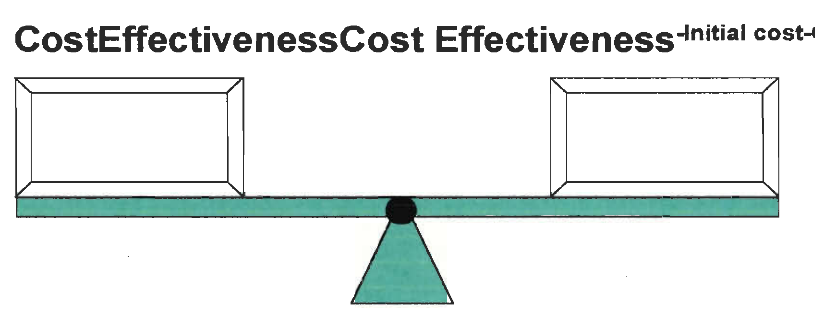
Table of Contents

Chapter 1

This guide is aimed at those directly related to the construction industry. Possible users are, but not limited to, developers, architects, builders, and surveyors. The guide will prove useful for these professionals in attaining sustainable development policies currently found in the London Borough of Merton's Unitary Development Plan (UDP). This guide on life cycle cost analysis is one of a series of information guides on sustainable construction. The purpose of this specific guide is to provide assistance on life cycle cost analysis in order for construction professionals and developers to consider sustainable practices in their designs and to comply with the UDP policies.

The guide will be specifically useful in considering **Policy ST.1a: Sustainable Development**, which states that "The Council will encourage development which is sustainable and resist development which substantially fail to follow the principles of sustainable development. In applying this policy, the Council will apply its sustainability checklist to assess whether development is sustainable. Where large development schemes are proposed developers should normally submit a sustainable development statement with the planning application". If developers are able to respond to the UDP policies then it will be easier for them to receive planning permission for their schemes. For more information on Merton's Unitary Development Plan, visit the London Borough of Merton website: www.merton.gov.uk.

The idea that green buildings improve the financial performance of a building may sound problematic and new to many building professionals. However, the business community is considering green building because it provides many economical advantages. The main benefit behind the application and the success of green buildings is the completion of cost effectiveness in a project. Cost-effectiveness is reached when construction professionals take into account the Life Cycle Cost Analysis in the design stage of the building developments.



Source:(http://www.ipk.ntnu.no/rams/notater/lcc.doc)

Figure 1. The picture illustrates the relationship between cost and effectiveness in a green building.

1. What is Life Cycle Cost Analysis?

The Life Cycle Cost Analysis is a method of assessing cost effectiveness in sustainable buildings. The following are three definitions of what the life cycle cost analysis is:

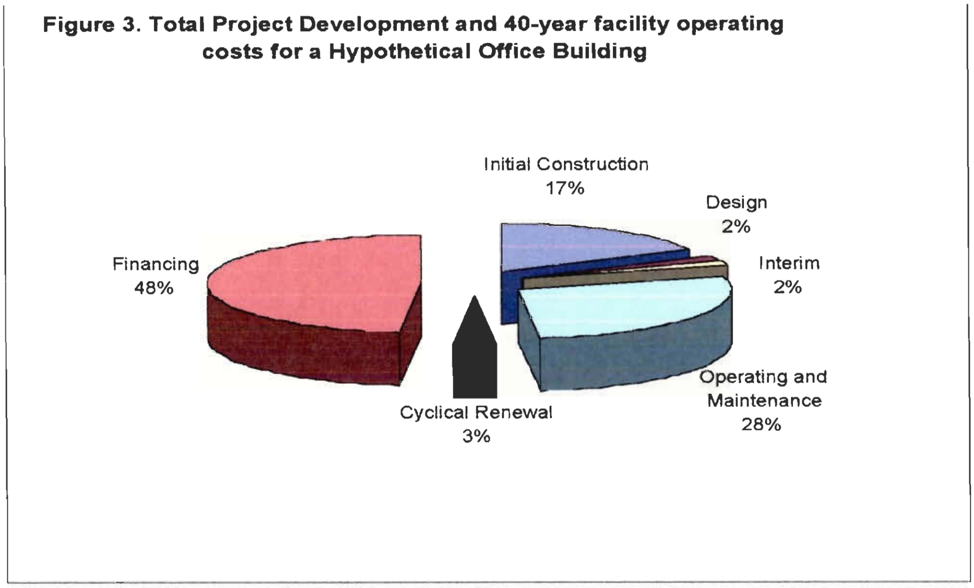
- The present value of the total cost of that asset over its operating life including initial capital cost, occupation costs, operating costs, and the cost or benefit of the eventual disposal of the asset at the end of its life. (RICS)
- A set of techniques for evaluating all relevant costs of acquiring and operating a project, asset, or product over time.[3]
- The sum of all discounted costs of acquiring, owning, operating, maintaining and disposing of a building project over a determined study period[5]

2. Why consider Life Cycle Analysis?

There are a number of reasons for developers and building professionals to consider Life Cycle Cost Analysis in the design stage of a building process. As mentioned before, Life Cycle Cost Analysis assess cost-effectiveness of a sustainable project. In addition, the method provides a number of economic benefits listed below:

- Operating Costs: it is possible to reduce building energy consumption by 20 to 30 percent. While in the 1970's energy costs were a major concern among architects and building professionals, the cost of water, operations personnel and maintenance has also been increasing at a rapid rate. Figure 3 shows the importance of operating and maintenance costs of a hypothetical office building over a 40-year period. An increase in energy efficiency will reduce energy costs over the lifetime of a development. The following example shows how operating and maintenance expenses are underestimated when designing a building and therefore the need for sustainable development in early stages of the construction process.[10]

> "The average school district spends over $50 a year to operate and maintain $1000 of plant; this means that over a span of less than 20 years these costs equal the cost of the plant itself". *American School and University magazine*



- All building costs have risen dramatically in the past years. Fewer owners and architects have been able to deal with the different costs incurred in a development. For instance, in the United Kingdom the *General Building Cost Index* rose 6.1% in the year to the 4th quarter of 2002. Figure 1 shows the upward trend of the index for the past 17 years. However, if building professionals incorporate sustainable design approaches like the Life Cycle Cost Analysis of a project the savings there will be able to save money and justify their development.[12]

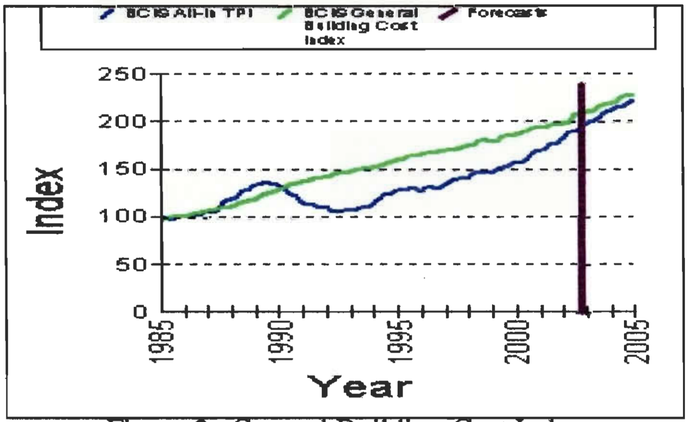


Figure 2. General Building Cost Index

- Over the past decades, there has been a growing interest from developers and building professionals to get involved in sustainable construction practices because it has provided advantages in social, economical and environmental aspects of a construction process. There is also special interest to get a better feel of the long-term costs of a building over its life cycle. In addition, special attention has been given lately to energy and water conservation issues that are key aspects of a green building.[12]

Chapter 2

1. How does the Life Cycle Cost Analysis works?

Buildings and structures influence the environment around them. They must be designed, built, operated and maintained in such way that they meet the varying demands of society. The energy a building consumes in its lifecycle has a far greater effect on the environment than the energy used in construction, and extracting the materials. Sustainable construction is about considering the long-term effects of design for the life of the building and its occupants. [8]

Life Cycle Cost Analysis examines each and every possible design alternatives by comparing the possible costs over the life span of the building. This offers the decision-makers a valuable tool to assess the sustainability of a development. A green building may cost more at the initial stage, but saving is attained through lower operating costs over the life of the building. The environmental building approach applies a project life cycle cost analysis to determine the appropriate initial expenditure. [5]

2. Steps in a Life Cycle Cost Analysis

The following are seven basic steps to follow when computing a Life Cycle Cost Analysis in a generic green building development. [7]

1) Identify options
2) Establish assumptions
3) Estimate all project costs and their timeframes
4) Discount future costs to present value
5) Compute the LCC for each option
6) Identify the option with the lowest Life Cycle Cost
7) Select the best option

3. Calculation of a Life Cycle Cost Analysis

There are several different ways of performing the calculation of a Life Cycle Cost Analysis. The Life Cycle Cost of a project can be computed by adding up the present values of each kind of costs and subtract the present values of any positive cash flows. That might sound a little confusing!

The following is a very simple method to calculate the life Cycle Cost of a building development. The formula is as follows:

$$LCC = I + R + E + W + OM\&R - S$$ [3]

Where:

I: initial investment cost

R: present value of Replacement costs

E: present value of energy costs

W: present value of water costs

OM&R: present value of operation, maintenance, and repair

S: present value of salvage (resale or residual)

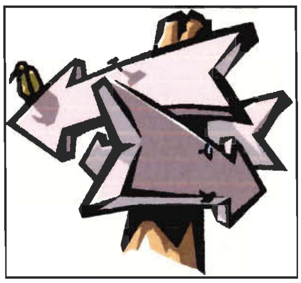
4. Assumptions Used in Life Cycle Cost Analysis

One of the most important factors when conducting a Life Cycle Cost Analysis is to mind the assumptions under the calculations. It is very important to define the assumptions as soon as the options are identified. The following is a checklist of the assumptions to keep in mind when using a Life Cycle Cost Analysis. Make sure your analysis has considered the following implications.

Assumptions Checklist[3]	
☑	Same discount rate
☑	Same study period
☑	Present value inputs
☑	Inflation rate
☑	Borrowing rates
☑	Energy Prices Rates

Chapter 3

1. Applications



The next section describes the different applications that the Life Cycle Cost Analysis provides within a sustainable building development. The basic application of the Life Cycle Cost Analysis is to evaluate design and investment decisions by identifying different approaches that will achieve the same goals over the lifetime of a building. The main applications of a Life Cycle Cost Analysis are investment decisions that are strictly related to sustainable construction practices specifically in the areas of water and energy conservation.

2.1 Investment Decisions

The Life Cycle Cost Analysis is an approach that may allow the architect or building professional to make decisions such as[3]:

- Accept or reject a project
- Achieve optimal efficiency
- Make optimal system selection

An example of these decisions described above appears in the context of energy conservation (See Solar Energy Guide)[8]. For instance, some of the following questions can be answered using a Life Cycle Cost Analysis:

1. What is the best energy conservation feature among various options such as: solar, wind, biomass, etc? For example conventional heating versus solar power.

2. How much investment is required in an energy conservation feature?

3. Are there any desirable combinations between different energy conservation features?

Another example where the Life Cycle Cost Analysis provides answers to which sustainable construction practices are the most feasible for a development is water conservation in a building design[8]. (See Water Conservation Mini-Guide) Some of these questions are:

1. What is the best water saving device to include in home or in commercial premises over the expected lifetime of the construction?

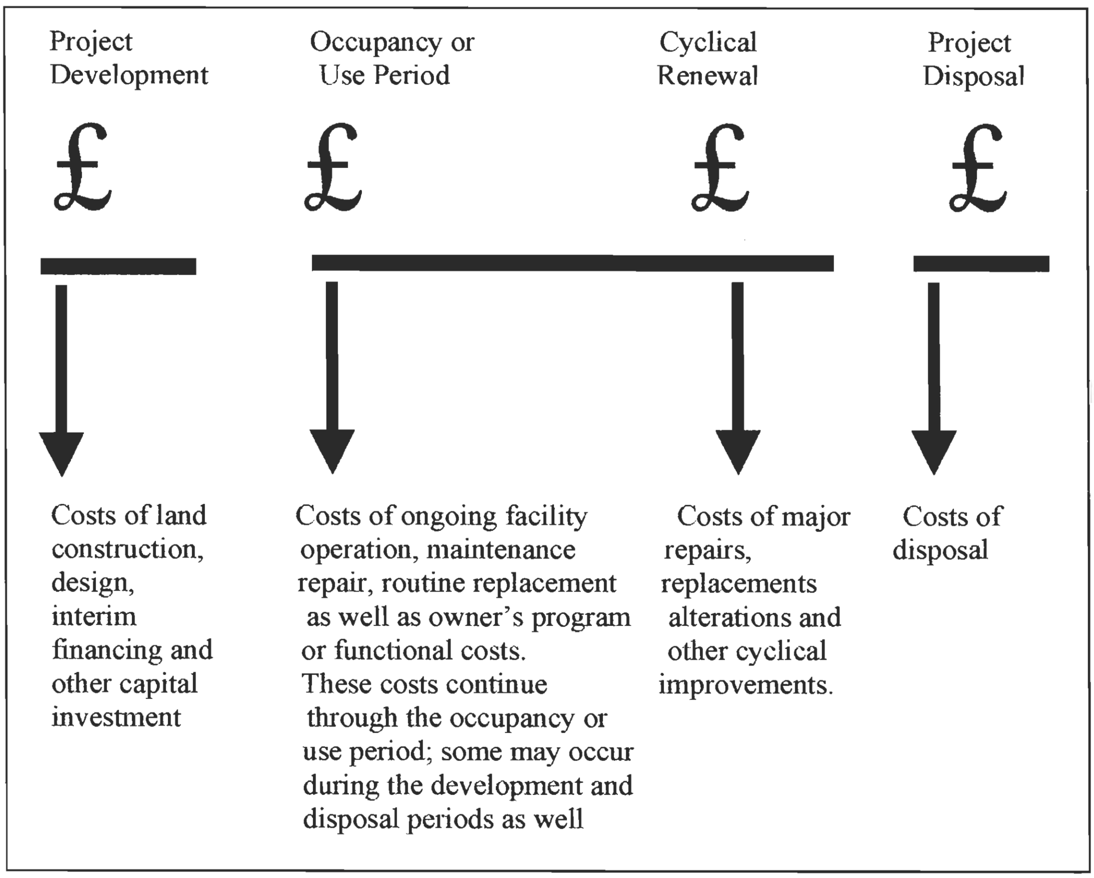
2. How much is required to save the most in water consumption looking at the long term?

2. Stages in a Life Cycle Cost Analysis

Throughout the guide, several costs and terms have been used that are part of the different stages of a green development. This section describes what each of the phases is and what costs are incurred in each of them.

There are different views about how many stages exist in a building development. For instance, Figure 3 portrays four different stages with the different costs and their importance on the analysis.

Figure 3. Stages and components of a Life Cycle Cost Analysis



Source: American Institute of Architects

In Figure 5, the Athena Institute suggests six different stages in a building development starting from the resource extraction until the disposal phase.

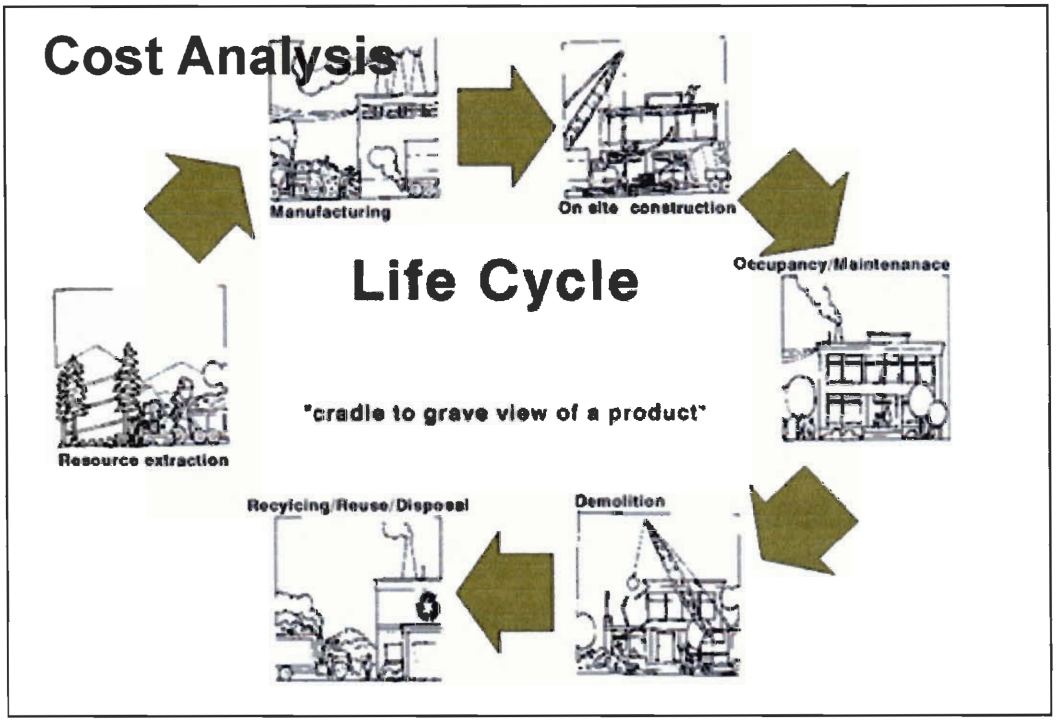


Figure 5: Life Cycle Cost Analysis from the Athena Institute, Canada

Source: Athena Institute

3. Recommendations

On a construction development, materials or systems that look like a bargain turn out not to be such a good deal over the long run. They might end up being negative for the owner or for the environment. Selecting materials that cost the least at the time of purchase may load a householder with enormous operating, maintenance, repair, and disposal costs, and even health problems. Some of these inexpensive products also affect negatively the environment, causing severe impacts such as pollution and energy employed in transportation and installation. Comparing the life-cycle costs of materials can be challenging, because there is no single repository of information on the complete life cycles of all types of building products. The following are recommendations for building professionals to include green design in their building developments[11]:

- Choose products that are recyclable at the end of their useful life.
- Give preference to locally- and regionally produced equivalent products.
- Avoid products with components or constituents that are regulated as hazardous waste.
- Consider the expected lifetime and maintenance requirements of all products relative to alternative products.

- Select energy-efficient and water-efficient systems and appliances to reduce lifetime consumption. (See Solar Energy and Water Conservation Mini-Guides)

Chapter 4

Additional Information

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3. http://www.icfox.com/sg/useful_info/eng/LCC/Content.htm
4. http://www.eere.energy.gov/femp/resources/pdfs/lcc_guide_rev2.pdf
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12. Life cycle cost analysis: a guide for architects. The American Institute of Architects. [Washington]: AIA, 1977.

2. Contacts in Merton

- Rory Doyle; Environmental Health Energy Advice
- Adrian Hewitt:; Sustainability Officer
- Cecily Herdman; Housing Officer
- Steve Cardis; Unitary Development Plan
- Phil Ryder; Wandle Strategy
- Richard Ainsley; Planning Officer

3. Case Studies: Life Cycle Analysis of a Residential Home in Michigan

Please refer to the following web site in order to find details on the following case study: The most relevant information on the Life Cycle Cost Analysis can be found on section 2.8 of the Methods chapter and on section 3.4 of the Results chapter.

- http://www.umich.edu/%7Enppcpub/research/lcahome/

Appendix F – Solar Energy Guides

Planning opportunities and constraints

One of the main considerations when installing a PV system is to assess whether planning permission is required. Government Guidance on photovoltaics is set out in PPG22 Annex on Photovoltaics.

Solar water heating systems are not specifically mentioned in Planning Policy Guidance Note PPG22 Annex. However, check with Merton's Development Control Section if you have any questions. Refer to www.merton.gov.uk for more information.

Grants

Grants are now available from the Government as part of the UK Photovoltaic Demonstration Programme. Applicants will need to fill out an application form from the Energy Savings Trust (see their website for more details www.est.org.uk/solar/). Grants range from between 40-65% of total cost of installation.

The grants currently available from the Government for solar power do not presently extend to those who want to include solar water heating on their buildings. However because there are cost savings each year from reduced use of gas supplies (or other fossil fuel) it means that the initial cost of installing the SWH would effectively be paid back over several years.

Further Information

- A4 guide to solar energy
- The Householder's Guide- Guide for householders to use sustainable features in their homes
- www.pv-uk.org.uk/ - British Photovoltaic Association- examples of projects and installers that are approved under the UK photovoltaic demonstration project
- www.greenenergy.org.uk/sta/ - some background information on PV and SWH
- www.greenenergy.org.uk/suppliers/index.htm - suppliers
- www.bre.co.uk/brecsu - information on various issues to do with construction
- www.greenregister.org - list of architects, engineers and trades people who have demonstrated a commitment to sustainable building practices
- www.mysolar.com/nl/index.asp - information on how PV and solar water heaters work.
- www.solarcentury.co.uk - information on PV and case studies of PV systems
- www.ecoconstruct.com - includes information on solar water heaters and eco-building merchants

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Merton Civic Centre

London Road

Morden, Surrey SM4 5DX

SOLAR ENERGY

MINI-GUIDE

For developers and building professionals

London Borough of Merton

April 2003

SOLAR ENERGY

Why consider the use of solar energy?

The use of solar energy reduces the dependence on the depleting fossil fuels and reduces pollution due to emissions. It also reduces global warming which leads to climate changes. Using solar energy in a building adds sustainability and offers a way to meet the Merton Council's planning policy ST.1a.

Merton Council is aiming to reduce the Borough's reliance on traditional energy sources, and requiring the inclusion of renewable energy in new developments is crucial to achieving this. Merton's new UDP Policy E13 requires all new industrial, warehousing, office and live/work developments over $1000m^2$ to include renewable energy production equipment to provide at least 10% of predicted energy requirements.

Solar energy technologies are simple and affordable methods for achieving a sustainable future for everyone. As global climate change threatens all our futures, we need to switch to clean, renewable forms of energy and electricity production.

What are the available techniques?

Photovoltaics

Photovoltaic (PV) technology involves using the free and inexhaustible energy from the sun to generate your own electricity.

A modern PV system consists of an array that is mounted to the building that collects the sun's energy. When daylight hits the PV cells in the array, it is converted to electricity.

Please refer to www.pv-uk.org.uk to learn more about the latest PV technologies.

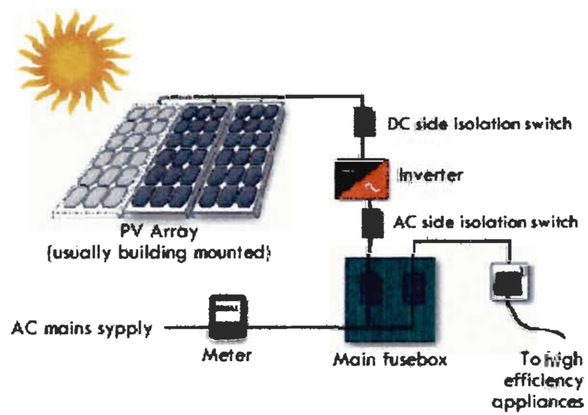

Figure 1: Diagram of a PV System. Source, http://www.pv-uk.org.uk/technology/configuration.html

Any house, offices, and commercial and industrial buildings are suitable for modern PV systems. The latest PV technologies come in a variety of colours, can be made to look like conventional roof tiles, and can be incorporated into building facades, canopies or sky lights.

Solar Heating

A solar water heating (SWH) system uses the sun to heat water in collectors mounted on a roof of some raised, south-facing area. The heated water is then stored in a tank, not unlike a conventional electric or gas water heater tank, and is used as hot water for washing, cooking, or in the central heating system, to provide heating for a building.

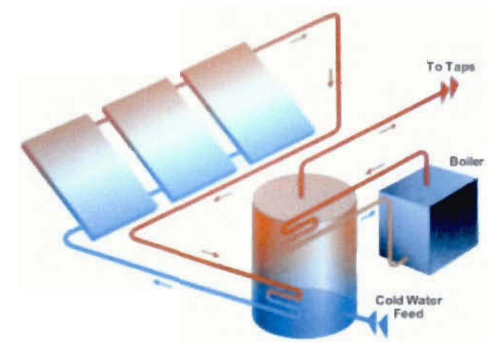

Figure 4: Typical set up for a solar water heating system in the UK. Source, http://www.greenenergy.org.uk/sta/solarenergy/index.htm

SWH systems are safe and virtually maintenance-free. Savings on hot water bills range from 50-70% and they have a payback of 10-20 years.

Modern SWH systems operate in a wide variety of climates. In addition to solar water heating being an environmentally sound choice (SWH systems reduce the amount of greenhouse gas emissions for heating your water when compared to conventional methods), they are very cost effective when compared to your monthly energy bill.

Volume

2

LONDON BOROUGH OF MERTON

For developers and building professionals

Solar Energy

APRIL 2003

ENVIRONMENTAL SERVICES DEPARTMENT

Solar Energy

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Table of Contents

Chapter

1

Introduction

1. Using this guide

This guide to solar energy is one of a series of information guides on sustainable construction. It is aimed at architects, planners, and developers as a means of raising the awareness of solar energy equipment and its benefits, and encouraging those proposing developments in the borough to include renewable energy production equipment.

2. How solar energy is used?

There are two types:
1. Photovoltaics (PV): Produces electricity from light
2. Solar Water Heating: Uses energy from the sun to heat water

3. Why consider the use of solar energy?

The use of solar energy reduces the dependence on the depleting fossil fuels and reduces pollution due to emissions. It also reduces global warming which leads to climate changes. Using solar energy in a building adds sustainability and offers a way to meet Policy ST.1a.

Merton Council is aiming to reduce the Borough's reliance on traditional energy sources, and requiring the inclusion of renewable energy in new developments is crucial to achieving this. Merton's new UDP Policy E13 requires all new industrial, warehousing, office and live/work developments over $1000m^2$ to include renewable energy production equipment to provide at least 10% of predicted energy requirements.

Chapter

2

Photovoltaics

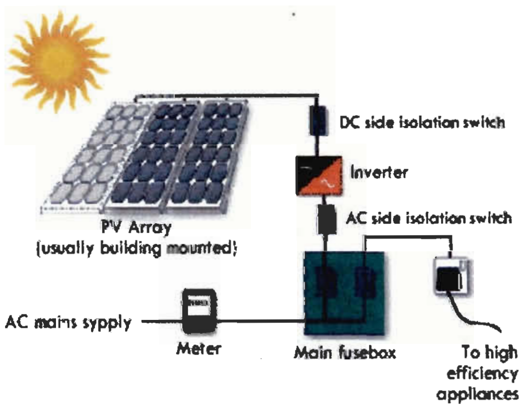


Figure 1: Diagram of a PV System. Source, http://www.pv-uk.org.uk/technology/configuration.html

1. How does it work?

PV cells have at least two layers of semiconductors: one positively and the other negatively charged. When light shines on the semi conductor, the electric field across the junction between the two layers causes electricity to flow – the greater the intensity of the light the greater the flow of electricity.

The electrical output from a single cell is small, so multiple cells are connected together and sealed usually behind glass to form a module (or panel). The module is the principle building block of a PV system, as many modules as possible can be linked together to achieve the desired electrical output.

When daylight hits the PV cells it is converted to electricity. The PV cells deliver DC electricity, and then an inverter converts this to AC so that the electricity can be used for household appliances. It is the then connected a main fusebox.

PV roofs generate electricity all day, so spare electricity goes to the grid. An extra meter can be fitted to show how much electricity is exported. Spare electricity is then sold to the electricity supplier. No electricity can be produced at night, so during the night electricity can be drawn from the grid (if the system is grid connected).[i]

2. Why use a PV System?

PV systems are low maintenance and as there are no moving parts energy production is silent. However the main reason for installing a PV system are the environmental benefits. Because the energy produced comes from the sun, this reduces the amount of fossil fuel burning energy that you need to power your building. Therefore Carbon Dioxide (CO_2) emissions are reduced.

3. How much energy do they produce?

A system with a PV array tilted towards the south would generate approximately 750kWh/year per kWp installed. A typical domestic system of 1.5 kW in the UK would produce around a third of the annual demand of an average family household (taking the average demand to be around 10 kWh per day).[ii]

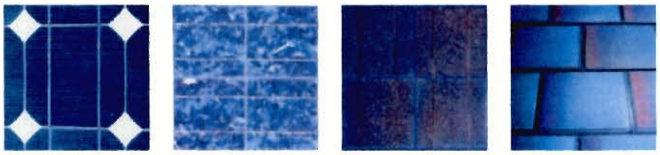
4. What types of systems are there?

- **Grid Connected**- This is the most popular for homes and businesses. The PV system is connected to the local electricity network allowing any excess solar electricity produced to be sold back to the utility or needed electricity to be dawn from the grid at night.
- **Grid Support**- The PV system is connected to the local electricity network and a back-up battery. Excess solar electricity produced after the battery is charged is sold back to the utility. This is ideal in areas of unreliable power supply.
- **Stand-alone photovoltaic systems/off-Grid**- Completely independent of the grid; the solar power is directly connected to a battery, which stores the electricity generated and acts as the main power supply.
- **Hybrid Systems**- Combines the solar power with another power source, such as biomass generator, wind turbine, or diesel generator. These systems can also be grid connected, grid support, or stand-alone.[iii]

see www.pv-uk.org.uk for more information

5. PV Materials

- **Monocrystalline PV**- The most efficient, but costs more than other photovoltaic (PV) technologies because of the complicated manufacturing process
- **Multicrystalline PV**- Cheaper, however, they tend to be slightly less efficient
- **Thick-film PV**- Efficient in poor light conditions and the most environmentally friendly. Silicon is deposited in a continuous process onto a base material giving a fine grained, sparkling appearance. Like all crystalline PV, this is encapsulated in a transparent insulating polymer with a tempered glass cover and usually bound into a strong aluminium frame.
- **Thin-film PV**- Made with amorphous silicon, which absorbs light more effectively than crystalline silicon, so the cells can be thinner. Amorphous silicon can be deposited on a wide range of substrates, both rigid and flexible, which makes it ideal for curved surfaces and "fold-away" modules. These cells are less efficient than crystalline based cells, but they are easier and cheaper to produce. A number of other 'thin-film PV' materials such as cadmium telluride (CdTe) and copper indium diselenide (CIS) are now being used for PV modules. The attraction of these technologies is that they can be manufactured by relatively inexpensive industrial processes, yet they typically offer higher module efficiencies than amorphous silicon.[iv]



(a) (b) (c) (d)

Figure 2: PV materials: (a) monocrystalline, (b) multicrystalline, (c) thick-film, and (d) thin- film. Source, http://www.pv-uk.org.uk/technology/types.html

6. What is the estimated lifetime of a PV system?

The PV systems should last 30 years or more. The first PV systems were installed about 20 years ago and are still producing electricity now.[v]

7. Is my building suitable for a PV system?

- Any house, offices, and commercial and industrial buildings
- PV cells come in a variety of colours, can be made to look like conventional roof tiles, and can be incorporated into building facades, canopies or sky lights

(a) (b) (c) (d)

Figure 3: Integrated PV: (a) building façade, (b) glass roof, (c) skylight window, (d) house roof Source, http://www.solarcentury.co.uk/content.jsp?sectno=1&subno=1

- For maximum output:
    - Due south orientation
    - 30- 40° roof tilt
    - Avoid shading of cells[vi]

8. Cost of PV Systems

As of April 2003, the British Photovoltaic Association states that a typical price for a grid connected, building integrated PV system is between £12 000 - £14 000 for a 2 kWp system for a house. Some installers offer all inclusive systems for between £6,700 - £8,600. This includes site survey, delivery, PV modules, installation, and connection to the mains. For a bespoke solution prices vary but are likely to be around £20,000. Refer to www.pv-uk.org.uk for cost saving tips.[vii]

Chapter

3

Solar Heating

Figure 4: A collector of a solar water heating system. Source, http://www.greenenergy.org.uk/sta/solarenergy/index.htm

1. How Does it Work?

A solar water heating (SWH) system uses the sun to heat water in collectors mounted on a roof or some raised, south-facing area. The heated water is then stored in a tank, not unlike a conventional electric or gas water heater tank, and is used as hot water for washing, cooking, etc or is used in the central heating system. As with PV systems, solar water heating systems can also be orientated to south, south east or south west. They need to be positioned at an angle of between 10-60°.

Solar water heating can operate in a wide variety of climates. In addition to solar water heating being an environmentally sound choice (SWH systems reduce the amount of greenhouse gas emissions for heating your water when compared to conventional methods), they can be quite cost effective when compared to your monthly energy bill.[viii]

2. Why use a SWH system?

The power from the sun is both free and renewable, which means that it is a clean alternative to heating water through conventional methods. Most central heating and hot water systems are powered by fossil fuel sources (usually gas), so by installing a SWH this would reduce the amount of fossil fuel used by the building, this in turn means that there would be less environmentally harmful emissions into the atmosphere (which are associated with global warming).

3. How much energy do they produce?

For a family of four, a well designed Active Solar Heating system should contribute between 1,500kWh and 2,000kWh, which will be equivalent to 40 to 50% of the household's water heating energy needs over a year. The value of this saving will depend on the type of energy displaced.[ix]

4. What types of systems are there?

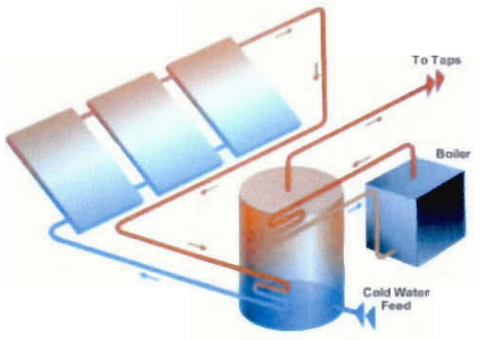


Figure 5: Typical set up for a solar water heating system in the UK. Source, http://www.greenenergy.org.uk/sta/solarenergy/index.htm

The type of system used will largely be dependent on the climate. There are several types of system available, however due to the UK climate, a typical system would include a collector of some description (situated on the roof) which is separate from the cylinder that feeds cold water into the collector. Once water is heated in the collector it returns to the cylinder. Where it is then either tapped off for hot water use (washing, cleaning etc) or goes into the boiler for use in the central heating system. Normally in the UK SWHs will include an auxiliary heating system (powered by natural gas or oil burner) to ensure a constant supply of hot water during winter or at times of low solar radiation. The UK climate also means that systems will include an anti- freeze, to ensure that the collector is not damaged during freezing weather. An electronic controller constantly compares the temperature of the solar collectors with the temperature of the water in the cylinder.

Whenever the collectors are hotter than the cylinder, the controller switches on the system's circulating pump. A mixture of antifreeze and water is then circulated through the collectors and the cylinder's heat exchanger, heating the cylinder in just the same way as a central heating boiler.[x]

5. What types of solar collectors are there?

The main part of any system is the solar collector, and this will have a big impact on the efficiency and cost of the system. The main types of solar collectors are:

- **Evacuated tubes**- A series of insulated glass heat tubes containing a vacuum. They are covered in a selective surface. More efficient that flat plate collectors, but more expensive.
- **Flat plate collectors**- Sheets of black metal that absorb the suns energy. The water is fed through the panel in pipes and picks up the heat from the metal. To withstand the UK climate, the pipes contain a non-toxic anti-freeze and the metal sheet is covered with glass or clean plastic.

- **Selective surfaced flat plate**- More efficient than a flat plate collector because of the selective surface that is good at absorbing energy but does not radiate much energy back to the atmosphere.
- **Non-selective surfaced flat plate**- Normally a black surface that both absorbs radiation and radiates heat back out.[xi]

see www.mysolar.com/nl/index.asp for more information

6. What is the estimated lifetime of a SWH system?

A good glass covered water heater can perform well for more than 20 years.[xii]

7. Is my building suitable for a SWH system?

A SWH system can be used with all buildings, commercial, residential etc. They can either retrofit or be designed into new development (it can often be cheaper to design in at the start). There are a range of products, some are designed to fit curved or low pitch roofs. This means that including a SWH does not have to compromise architectural flexibility. These types of SWH systems can be particularly suited to public or commercial buildings which require a different design solution to a domestic home. The SWH needs to be positioned in a shade free position as with PV, they can also be on a roof a wall or at ground level.

A typical installation in the UK has a panel of $3m^2$ to $4m^2$ with a storage tank of 150- 200L. However, the optimum size will depend on actual hot water use. This can be calculated using software to simulate system performance throughout the year. Some are as small as 1.5m.[xiii]

8. Cost of SWH systems

As of April 2003, the cost of installing a solar water system into existing households ranges from approximately £500-£1500 for a DIY system and to £2500-£4500 for a commercially installed system. These prices however, are dependent on the size of the system, type of collector, etc. DIY or new build system installations are cheaper, costs can also be reduced particularly in the case of large scale new building projects.[xiv]

Chapter 4

Grants

1. For PV Systems

Grants are now available from the Government as part of the UK Photovoltaic Demonstration Programme. These were introduced in May 2002 by DTI and £20m is available over the next three years. Applicants will need to fill out an application form from the Energy Savings Trust (see their website for more details www.est.org.uk/solar/). Grants range from between 40-65% of total cost of installation.[xv]

2. For SWH Systems

The grants currently available from the Government for solar power do not presently extend to those who want to include solar water heating on their buildings. However because there are cost savings each year from reduced use of gas supplies (or other fossil fuel) it means that the initial cost of installing the SWH would effectively be paid back over several years.

Chapter

5

Planning and constraints

1. For PV Systems

One of the main considerations when installing a PV system is to assess whether planning permission is required. Government Guidance on photovoltaics is set out in PPG22 Annex on Photovoltaics.

If a new building is proposed that includes a PV system, Merton Council will assess whether the PV has any visual impact on the amenity of the surrounding area. Where it is proposed to install PV on an existing building Merton's Development Control Section would assess whether the PV would be a material alteration of the external appearance of the building. If it is not considered to be a material alteration, planning permission will not be required. If it is considered to be a material consideration then planning permission will be required.

If it is proposed to install PV on a listed building, or on a structure in the curtilage of a listed building, it is likely that an application for listed building consent will be required. In conservation areas Merton Council have a duty to consider the potential impact on the character or appearance of the area.

If PV is proposed on a building close to a listed building or conservation area, its proximity to such an area or buildings may be a material consideration for the local planning authority in deciding the application. Merton Council will seek to strike a balance between the impact on the character of the area and the desire to promote sustainability. Where it is proposed to install PV they should where appropriate be located away from principal roof pitches and if possible should be set into the roof coverings to minimise projection beyond the existing roof slopes.

2. For SWH Systems

Solar water heating systems are not specifically mentioned in Planning Policy Guidance Note PPG22 Annex. However given that the two forms of solar energy use tend to have a similar effect on the appearance of a building it is likely that the planning considerations that are relevant to PV systems are likely to be relevant to SWH systems, however if there is any doubt you should check with Merton's Development Control Section.

Chapter 6

Additional Resources

1. Websites

The information in this guide came from the following sources. Please refer to them for more information.

- www.pv-uk.org.uk/ - British Photovoltaic Association- examples of projects and installers that are approved under the UK photovoltaic demonstration project
- www.greenenergy.org.uk/sta/ - some background information on PV and SWH.
- www.greenenergy.org.uk/suppliers/index.htm - suppliers
- www.bre.co.uk/brecsu - information on various issues to do with construction
- www.greenregister.org - list of architects, engineers and trades people who have demonstrated a commitment to sustainable building practices
- www.mysolar.com/nl/index.asp - information on how PV and solar water heaters work.
- www.solarcentury.co.uk - information on PV and case studies of PV systems
- www.ecoconstruct.com - includes information on solar water heaters and eco- building merchant

2. Case Studies

View www.pv-uk.org.uk/uk/projlist.html for a comprehensive list of PV building projects in the United Kingdom.

Refer to www.greenenergy.org.uk/sta/solarenergy/index.htm to see letters written by solar water heating systems.

3. EcoHomes

EcoHomes is the Building Research Establishment's (BRE) system for assessing the environmental performance of homes. EcoHomes assessments are carried out at the design stage by licensed assessors who are trained by the BRE. Listed below are issues that the BRE addresses in their assessments. They can be used as a guide for improving the energy use in a home.

- Carbon Dioxide Emissions- In an EcoHomes assessment, you get the most points for achieving CO_2 emissions of less than or equal to 10 kg/m^2/yr. Zero points are awarded for having CO_2 emissions of more than 60 kg/m^2/yr.

- Building envelope performance compared with building regulations- The most points are awarded for a 30% improvement; zero points for less than 10% improvement.

- Provision of a secure drying space

- Provision of eco-labeled white goods

- Provision of external lighting systems which are low energy

4. The Householders Guide

This is Merton's new guide for householders to apply sustainable features in their homes.

5. Relevant codes of practice and articles of legislation

- BS EN 61215
- BS EN 61646
- The Electric Supply Regulations 1988
- The Building Regulations 1991 (and amendments)
- The Construction (Design and Management) Regulations 1994

References

[i] http://www.pv-uk.org.uk/technology/whatispv.html

[ii] http://www.pv-uk.org.uk/technology/generation.html

[iii] http://www.pv-uk.org.uk/technology/applications.html

[iv] http://www.pv-uk.org.uk/technology/types.html

[v] http://www.pv-uk.org.uk/technology/configuration.html

[vi] http://www.pv-uk.org.uk/technology/installation.html

[vii] http://www.pv-uk.org.uk/technology/cost.html

[viii] http://www.mysolar.com/mysolar/heat/solarheat.asp

[ix] http://www.greenenergy.org.uk/sta/solarenergy/index.htm

[x] http://www.greenenergy.org.uk/sta/solarenergy/index.htm

[xi] http://www.greenenergy.org.uk/sta/solarenergy/index.htm

[xii] http://www.greenenergy.org.uk/sta/solarenergy/index.htm

[xiii] http://www.mysolar.com/mysolar/heat/yranswers.asp#q8

[xiv] http://www.greenenergy.org.uk/sta/solarenergy/index.htm

[xv] http://www.pv-uk.org.uk/technology/grant.html

Appendix G – Water Conservation Guides

Use of rainwater

Use of rain water in a plumbing system either in a commercial or residential setting will prove to be environmentally and economically effective. It reduces consumption of clean drinking water. Methods are available for maximising the gain of rainwater. The figure below shows a system for collecting rainwater.

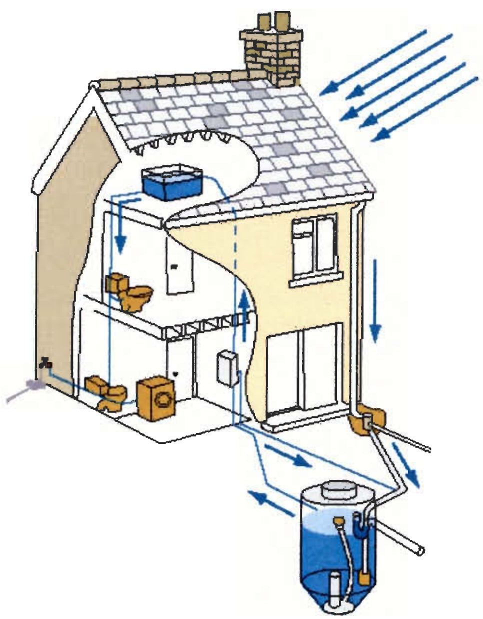


Figure 2: Rainwater collection for homes

Water Metering

By installing a water meter, then you are given a representation of the amount of water that is being used in a development. They have more benefits than just letting you know of the amount of water being used. It helps you to see the amount of real water you have used as well detect leaks within homes or buildings.

Further Information

A4 guide to water conservation – more information on these and further topics.

The Householder's Guide – Guide for householders to use sustainable features in their homes.

www.environment-agency.gov.uk – Provides range of information on water conservation techniques

www.envirolet.com – Provides information and products on waterless compost toilets.

www.buildinggreen.com – Information regarding different techniques for building a green construction.

http://greywater.net – A variety of information regarding the implementation and costing of grey water systems.

www.energyhawk.com – Provides different information on energy and water conservation tips for home and business.

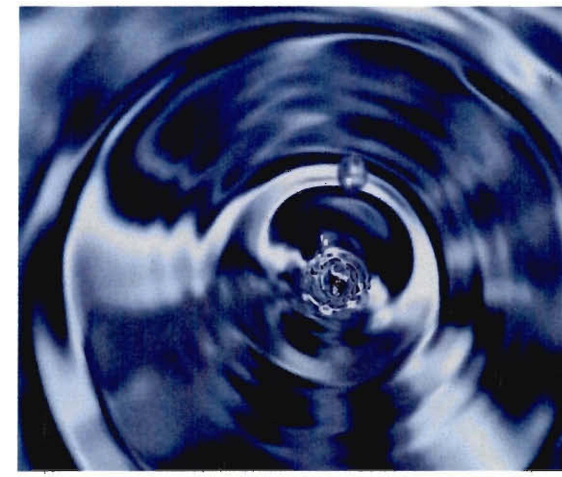
http://eartheasy.com – Information on living and providing a sustainable future.

Merton Civic Centre
London Road
merton moving ahead
Morden, Surrey SM4 5DX

WATER CONSERVATION

MINI-GUIDE

For developers and building professionals



London Borough of Merton

April 2003

WATER CONSERVATION

Why conserve water?

It is important to realise that the world's natural resources are gradually depleting. A major emphasis needs to be placed on water. There are devices available that can provide construction professionals with alternatives to today's standards. Merton's Unitary Development Plan lists policies which encourages sustainable construction designs within developments. Some relevant policies are:

- Policy BE.31: Sustainable Development
- Policy PE.6: Flooding
- Policy PE.7: Water Quality
- Policy PE.8: Capacity of Water Systems

General information regarding water conservation can be found in the Supplementary Planning Guide on Sustainable Development. These documents and more can be found at www.merton.gov.uk.

What are the available techniques?

There are different cost-effective devices available for people to install in homes or buildings in order to conserve water. The average family in the UK uses about 150 litres of water a day, which amounts to about 54,750 litres a year. There are several ways that new and old homes as well as commercial and large-scale developments can be fitted with water saving devices in order to reduce the usage.

Toilets and Urinals

Devices in the bathroom account for nearly half of a home's water consumption. Currently 9 litres (2 gallons) is the amount of water used in every flush in the UK. This can sum up to a large amount in an average sized home

Modern toilets are available that currently only use 6 litres (1.3 gallons) of water per flush.

Toilets where flushing is not necessary are also available. These are waterless compost toilets. Since nearly 50% of the water use comes from toilet flushing, it will dramatically cut the consumption. For more information on this please refer to the A4 guide.

For commercial and large-scale developments as well as where water supply is limited, waterless urinals should be considered.

Modern dual flush toilets give the user the option to flush using either 3 or 6 litres of water instead of the standard 9 litres.

Taps and Shower Heads

Tapmagic for homes can be installed which gives you the option of two different pressures for water flow.

For larger developments, spray, sensor, and timed turn-off taps will prevent loss of water and flooding.

A typical showerhead provides about 20 litres (4.5 gallons) of water per minute. If a person takes on average 7 minutes for a shower, it amounts to about 140 litres a day. There are alternative heads that can reduce this number. Substitutes are flow restrictors and aerators. More information can be found in the A4 guide and the householders guide.

Water Efficient Home Appliances

New washing machines and dishwasher are available that use water efficiently. Make sure that you integrate those machines with efficiency ratings.

Grey Water

For new developments you should consider the use of grey water for toilets and landscaping. Grey water is the liquid waste from domestic fixtures (not including toilets) such as baths, showers, hand basins and laundry facilities. This can be used for WC flushing and irrigation purposes (once filtered). The figure below shows how this can be done.

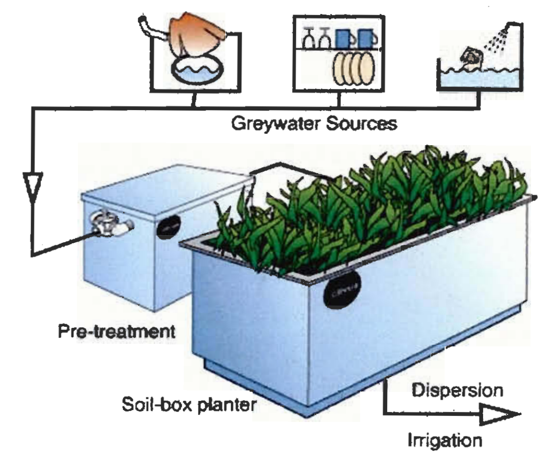


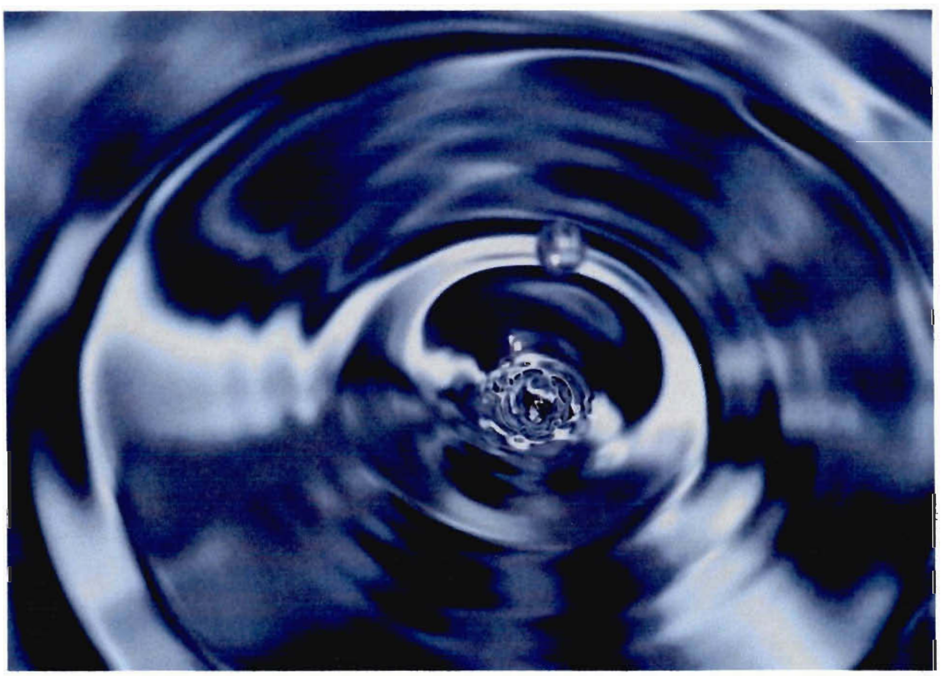
Figure 1: Greywater system for irrigation

Volume

3

LONDON BOROUGH OF MERTON

For developers and building professionals



Water Conservation

APRIL 2003

ENVIRONMENTAL SERVICES DEPARTMENTS

Water Conservation

Merton Civic Centre London Road,
Morden, Surrey SM4 5DX

Table of Contents

Chapter

1

1. How to use this Guide

This guide is aimed at those directly related to the construction industry. Possible users are, but not limited to, developers, architects, builders, and surveyors. The guide will help these professionals in attaining sustainable development policies currently found in the London Borough of Merton's Unitary Development Plan (UDP). This guide to water conservation is one of a series of information guides on sustainable construction. The purpose of this specific guide is to raise the awareness of water conservation techniques and their benefits to the user.

The guide will first discuss the reason why there needs to be a conscious effort in promoting water conservation. It will provide the user with ideas for reducing water consumption, for both commercial and residential developments, and the benefits that they would bring. It will then offer some information on the need for more conservation due to the climate change around the world. Links to case studies are also included so you can see how certain water saving techniques are being implemented in developments.

2. The need for Conservation

It is important to realise that the world's natural resources are gradually depleting. Water is one of the most fundamental natural resources and a major emphasis needs to be placed on conserving and protecting it. Water needs to be purified. This takes a lot of energy from fossil fuels, so water conservation will help reduce carbon emissions and energy bills.

It is also perceived that the UK has an abundant water supply due to rainfall. But the World Resources Institute have categorised the water sources in the UK as low. This is due to increased demand in lifestyles and changing rainfall patterns which have caused droughts in the past. There are different techniques available that can provide developers and construction professionals with water saving alternatives.

Merton's current Unitary Development Plan (UDP) encourages architects, developers, builders and other construction professionals to find ways to maximise water conservation. The policy that deals with this is **Policy BE.31: Sustainable Development**. In the justification it is stated that the Council is keen to see energy and water efficient features incorporated into the planning and design of development wherever practicable. Implementing these types of measures will help construction professionals meet current UDP policies. It will also prove useful in considering **Policy ST.1a: Sustainable Development**, which states that "The Council will encourage development which is sustainable and resist development which substantially fail to follow the principles of sustainable development. In applying this policy, the Council will apply its sustainability checklist to assess whether development is sustainable. Where large development schemes are proposed developers should normally submit a sustainable development statement with the planning application". If developers are able to respond to the UDP policies, then it will be easier to receive planning permission for purposed schemes.

3. The facts of water use

The table below shows the water use in a typical from 1997-1998.

England & Wales	Percentages (%)
Bath/shower/handbasin	28
WC flushing	35
Clothes washing	12
Dishwashing	4
Garden use and car washing	8
Other[1]	13
1 Includes kitchen taps, swimming pools, paddling pool, direct heating systems, general cleaning etc.	
Source: Environment Agency	

Table 1: Domestic Water use in Litres based on total of 150 litres per day
Source: Environment Agency

Chapter 2

Water Saving Techniques

1. Toilets and Urinals

Devices in the bathroom account for nearly half of the total consumption of water in a home. Currently 9 litres (2 gallons) is the amount of water used in every flush. This amounts to about 52 litres a day in an average home. You can reduce the water usage by implementing alternative methods for both the toilet and showerheads.

Toilets are available that currently only use 6 litres (1.3 gallons) of water per flush.

DUAL FLUSH TOILETS

Modern dual flush toilets are available with three-litre and six-litre flushes, which can save up to half the water used for WC flushing. Currently, regulations state that only new developments have the option of dual flush toilets. Based on a simple payback period, calculations for single family dwellings show that a £190 dual-flush toilet will have a payback period of approximately 8.5 years. A five-year payback period would be achieved (using the same criteria) if the cost of water was increased to £1.06 per m^3 or the cost of the toilet was reduced to £110.[i]

WATERLESS URINALS

For commercial developments as well as where water supply is limited, waterless urinals should be considered. A conventional urinal flushes periodically in order to remove urine and debris from the bowl. New Waterless Urinal Bowls are normally fitted to either new or existing plumbing. These types of designs generally incorporate a specially designed 'airlock' cartridge in the base of the urinal bowl. This is used in conjunction with barrier oil or other sealant liquid, allowing urine to pass through to the waste pipe but deterring malodour from returning to the room. The cartridges are generally designed to trap sediments and debris, and need periodic replacement - typically between 2 and 4 times per year depending on usage. The advantage of using this system is saving 65,000 litres of water per urinal. The quantity of water passing through waste treatment plants is reduced, and the natural resources required to process the water are saved. [ii]

WATERLESS TOILETS

Toilets where flushing is not necessary are also available. There are two types currently available: composting and incinerating. Composting toilets are toilet systems, which treat human waste by composting and dehydration to produce a useable end product that is a valuable soil additive.[iii] Incinerating toilets are self-contained units typically consisting of a traditional commode-style seat, which is connected to a holding tank and a gas-fired or electric heating system to incinerate waste products deposited in the holding tank. It produces a fine ash, which can easily be disposed of.[iv] More information can be found at http://www.nsfconsumer.org/environment/. Since one quarter of the water use comes from toilet flushing, it will dramatically cut the total consumption. For more information on this, go to www.compostingtoilet.org.

2. Taps and Shower Heads

A third of the water used in an office comes from the tap. By installing spray taps, it can reduce water from tap usage by about 80%. Sensor taps and timed turn-off taps prevent wastage and flooding. For home use, sprayers may not be feasible. A device called the Tapmagic can be fitted to most taps with a round outlet hole or standard metric thread, which reduces water flow from domestic taps.

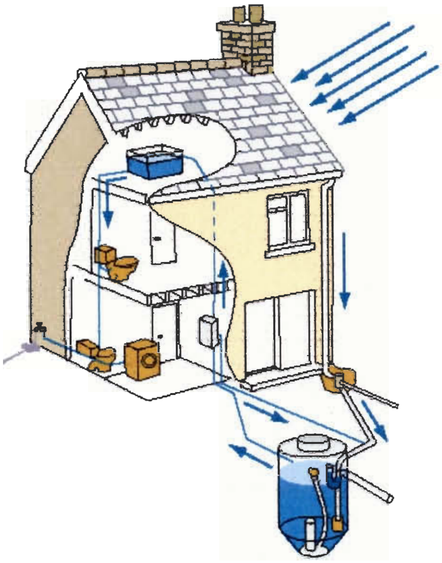
A quick shower uses a third of the water of a bath, but power showers can use more water than a bath in less than five minutes.[v] A typical showerhead provides about 20 litres (4.5 gallons) of water per minute. There are alternative heads that can reduce this number. Substitutes are flow restrictors and aerators. A flow restrictor just restricts the flow that goes through the showerhead. For information on flow restrictors go to www.energyhawk.com. An aerator mixes air into the water stream in a showerhead, which provides a steady and even flow (http://eartheasy.com). A low-flow showerhead:

- costs about £7-£13
- pays for itself in just a few months, and
- use no more than 2.5 gallons per minute at standard residential water pressure.

3. Rainwater Collection

Reuse of rain water in a plumbing system either in a commercial or residential setting proves to be environmentally and economically effective. It can reduce the use of clean drinking water for purposes that do not require clean drinking water. Rainwater falling on to the roof is collected via guttering into down pipes that link into a water butts and underground tanks.[vi] Before considering installation of this system you should exam the potential savings. It may not be economic to use in existing homes, but can be used in new developments. For a typical four-person home, a holding tank of $2m^3$ would suffice. Installation will be easier for new developments and buildings with downpipes at one end and a garage or cellar with a place for a low-cost tank. Other possibilities for this system include clothes washing and toilet flushing because the water is considered "soft". Figure 1 shows a system for rainwater collection for homes.

Figure 2.1: Rainwater reuse for homes



Source: Environment Agency

4. Grey Water Usage

In considering your developments, you should take into account including a grey water system. This system can be implemented in both residential and commercial settings. Grey water is the liquid waste from domestic fixtures (not including toilets) such as baths, showers, hand basins and laundry facilities.[vii] This is then used for other means, such as irrigation and WC flushing. A more in-depth discussion on the use and effectiveness of grey water can be found at http://greywater.net. A trial by the Environment Agency's National Water Demand Management Centre showed a range of water savings from about five percent to 36 percent for different trialists. Figure 2 shows a grey water system used for irrigation purposes.

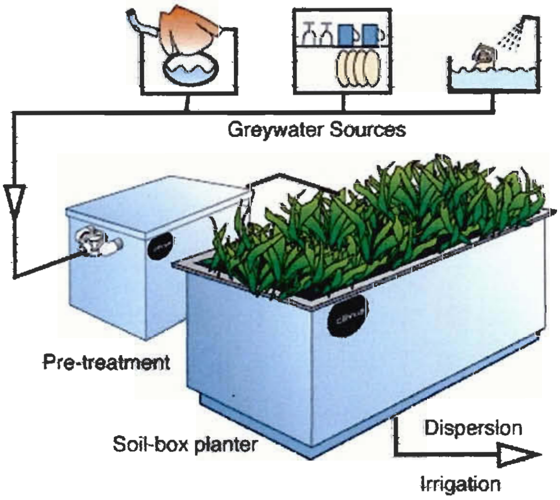


Figure 2.2: Grey Water System for Irrigation
source: http://greywater.net

Below is green water recycling system used in the Beddington Zero Emissions Development (BedZED). It integrates both grey water (foul water) and rain water systems discussed earlier.

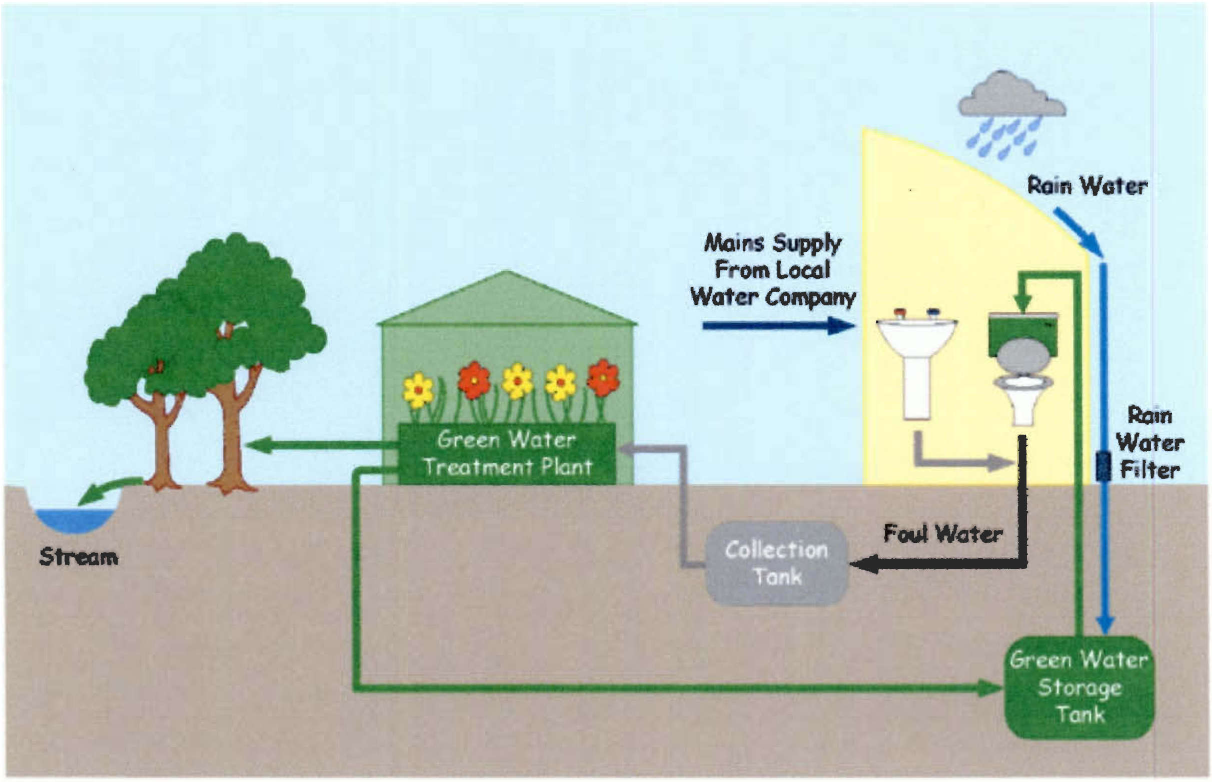


Figure 2.3: Green Water Recycling system

Source: http://www.enviro-logic.com

5. Use of water efficient domestic appliances – (if developer will provide these)

For home developments, appliances such as washing machines and dishwashers should be as efficient as possible. Current washing machine use accounts for about 12 percent of the water use at home, while the dishwasher accounts for about 4 percent. New washing machines use about half of the water that a ten-year-old machine uses. The new machines now use about 50 litres per wash. According to a study by *Which?* , a test on 13 dishwashers found that 7 use about 16 litres per cycle. The three graphs on the next page show water consumed and cost incurred through old and new washing machines and dishwashers.

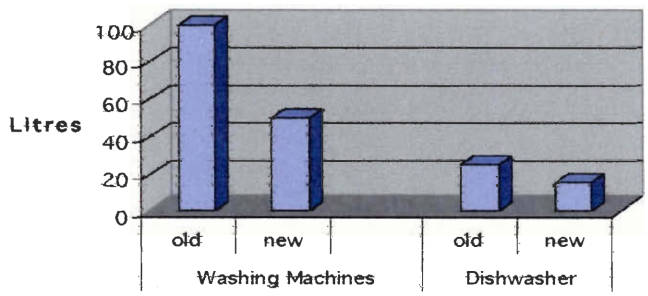


Figure 2.4: Litres per wash (full load)

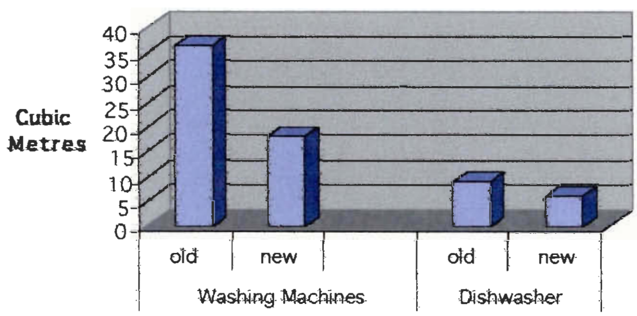


Figure 2.5: Annual Water use

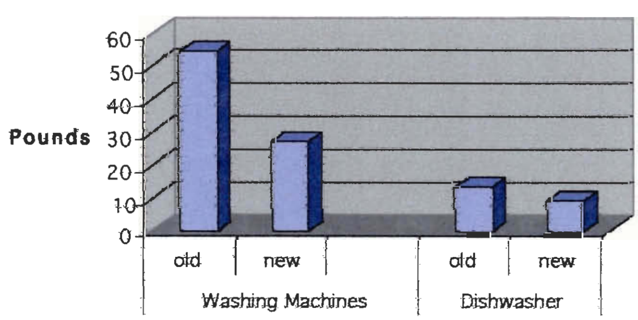


Figure 2.6: Annual water cost
Source: Environment Agency

6. Planting – Drought resistant plants

The average water use outside, including garden watering and car washing accounts for about 6 percent of annual domestic water consumption. On hot summer days, 50 percent or more of the water supply may be used for garden watering when supplies are more stressed.

Plan on using drought resistant plants, so less watering is needed. The following list shows plants that thrive in hot and dry conditions.

African lily	Lavender
Buddleia (butterfly bush)	Peruvian lily
Californian lilac	Pink
Californian poppy	Red-hot poker
Catmint	Rock rose
Daisy bush	Rosemary
Evening primrose	Straw daisy
Foxtail lily	Thyme
French honeysuckle	Tulip

Source: Environment Agency

7. Water Metering

By installing a water meter, then you will get a clear idea of the amount of water that is being used in a building. This has more benefits than just letting you know of the amount of water being used; it also helps you to detect leaks within homes or buildings. As of 1 April 2000, home developments had the right to a metered water supply. You can ask your water company to install a water meter free of charge. However, if it will be too difficult or cost too much to install a water meter, water companies have the right to charge. Currently all new large-scale developments are required to install water meters.

Chapter

3

Climate Change and Water Conservation

Construction professionals need to be aware of the changing climate of the world and it's response to the earth's natural resources. Its biggest impact would be the water supply.

According to the DEFRA's Climate Change Scenarios for the United Kingdom, April 2002, the UK's climate has changed within the past century with central England temperature rising as much as 1°C. Other factors they have noted relating to climate change are

- Hotter and drier summers will be more frequent
- cold winters will become increasingly rare
- Snowfall amounts will decrease throughout the UK
- Sea level has started to rise

With warmer and drier summers due to global warming, there will be an increase in the use of water. Areas such as gardens and agriculture will account for this rise in water use. Therefore, consideration needs to be placed on how to alleviate the need for this change.

For more information on climate change and water resources, go to www.environment-agency.gov.uk.

Chapter 4

Additional Resources

1. Additional Information

The Householders Guide – Merton's new guide for householders to apply sustainable features in their homes.

www.envirolet.com – Provides information and products on waterless compost toilets.

www.buildinggreen.com – Information regarding different techniques for building a green construction.

http://greywater.net – A variety of information regarding the implementation and costing of grey water systems.

www.energyhawk.com – Provides different information on energy and water conservation tips for home and business.

http://eartheasy.com – Information on living and providing a sustainable future.

http://www.environment-agency.gov.uk – The environment agency of Britain. Provides a wide range of literature on green efficiency.

2. Case Studies

For examples on how the systems above have been implemented, please see the Water Efficiency Awards found at www.environment-agency.gov.uk. The Water Efficiency Awards recognises those developments which have taken a positive step in applying water conserving techniques.

The BedZED project is also a good source for understanding how many of the techniques discussed in this guide are used. You can find more information about this development at www.bedzed.org.uk.

References

[i] http://www.cmhc-schl.gc.ca/publications/en/rh-pr/tech/02-124-e.html

[ii] http://www.ri-research.com/health/newsandt /Watrless/watrless.htm

[iii] http://www.compostingtoilet.org/explain.html

[iv] http://www.nsfconsumer.org/environment/ wastewater_incinerating.asp

[v] Environment Agency – Conserving water in buildings *10 Showers and baths.*

[vi] http://www.selenvironmental.com/stormwater /rainwater%20reuse.htm

[vii] www.geelongcity.vic.gov.au/media/news/1999/ news_99-37.htm