SAFE + GREEN = SMART

# SMART HOSPITALS TOOLKIT

A practical guide for hospital administrators, health disaster coordinators, health facility designers, engineers and maintenance staff to achieve Smart Health Facilities by conserving resources, cutting costs, increasing efficiency in operations and reducing carbon emissions


Pan American Health Organization

World Health Organization
Regional Office for the Americas

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# INTRODUCTION

The Caribbean region is prone to a wide variety of natural hazards such as earthquakes, tropical storms and hurricanes. The impact of climate change, which causes rising sea levels and coastal erosion and disrupts rainfall patterns and the supply of fresh water, is expected to further compound these threats.

This reality poses a significant threat to health facilities in the Caribbean. When 38 hospitals in the English-speaking Caribbean were assessed, 82% fell into Category B (measures are required in the short term to reduce losses) and 18% fell into Category C (urgent measures are required to protect the life of patients and staff). Weaknesses in both functional and non-structural issues (e.g. risk of damage to roofs, water and gas supplies, etc.) tended to be the predominant cause of increased vulnerability. Forty percent of the assessed facilities took some measures to improve their safety score.

At the same time, health care facilities are also leading consumers of energy, with a large environmental footprint. Energy prices in the Caribbean are among the highest in the world. This money could be put to better use to improve health services. A resilient health sector is vital to the functioning of society in the face of natural and manmade disasters. Health care facilities are 'smart' when they link their structural and operational safety with green interventions, at a reasonable cost-to-benefit ratio.

A SMART (safe and green) health facility:

a) Protects the lives of patients and health workers;
b) Reduces damage to the hospital infrastructure and equipment as well as the surrounding environment;
c) Continues to function as part of the health network, providing services under emergency conditions to those affected by a disaster;
d) Uses scarce resources more efficiently, thereby generating cost savings;
e) Improves their strategies to adjust to and cope better with future hazards and climate change.

This Toolkit is comprised of previously developed instruments such as the Hospital Safety Index, which many countries are using to help ensure that new or existing health facilities are built or retrofitted in such a way that they are resilient to the effects of natural and manmade hazards. The Green Checklist and other accompanying tools support the Safe Hospitals Initiative and will guide health officials and hospital administrators in achieving Smart health care facilities.

Experience in the Caribbean has shown that even low and middle-income countries can improve the safety of their health facilities, provided that, at a minimum, there is political commitment and multi-sector participation. Building upon this experience, this Toolkit will aid health care facilities to incorporate 'climate-smart' standards. Mitigation strategies are also recommended to integrate environmental performance and disaster resilience in health care facility planning.

## GREEN + SAFE = SMART

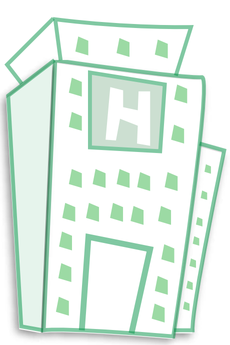
To achieve 'SMART' (safe + green) hospitals, one has to make both buildings and operations more resilient, to mitigate their impact on the environment and to reduce pollution. There are several 'win-win' ways to accomplish this, which, in the process, also save costs, reduce greenhouse gas emissions, and achieve adaptation, risk reduction and development benefits. These include:

- Improving the structural safety of health care facilities;
- Reducing energy and water use;
- Boosting energy security with low carbon, renewable sources;
- Improving air quality and reducing harmful emissions;
- Strengthening disease surveillance and control;
- Equipping structures with efficient and environmentally friendly appliances and fixtures.

Other measures, such as the use of eco-friendly flooring, paints, furniture and furnishings will further contribute to increased sustainability and risk reduction. Health facilities that 'green' their operations by using less paper, recycling, generating less and properly disposing of waste (solid and otherwise) and pharmaceuticals, using environmentally-benign chemicals, and more locally and sustainably produced food will also improve 'smartness.'

The 'Smart' Hospitals Initiative builds on the Guidelines for the Evaluation of Small and Medium-sized Health Facilities, the Caribbean version of the Hospital Safety Index, the centerpiece of PAHO/WHO's disaster risk reduction programme, which is now a global tool.



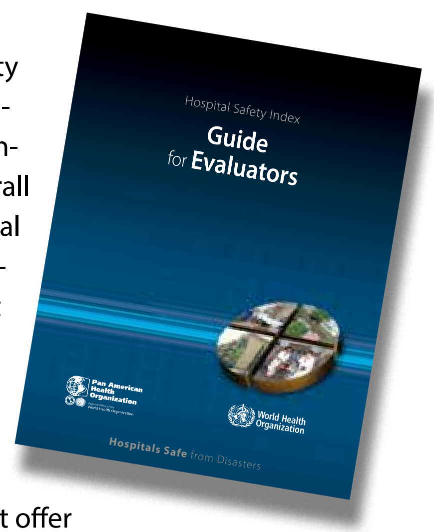


# USING THE SMART HOSPITALS TOOLKIT

The Pan American Health Organization, under the DFID-funded SMART Hospitals Initiative, developed this comprehensive Toolkit. It provides guidance on achieving a balance between safety and an environmentally-friendly setting in health care facilities in the Caribbean, thus contributing to the goal of climate-smart and disaster-resilient hospitals – a balance that is achieved by targeting interventions that lessens the vulnerability of health facilities to natural hazards and the potential effects of climate change, while reducing their carbon footprint as well.

The Toolkit was designed for hospital administrators, health disaster coordinators, health facility designers, engineers and maintenance personnel associated with the overall management and operations of health care facilities in the Caribbean. It incorporates climate-smart and safety standards for health facilities. Several strategic and guidance documents, previously developed by PAHO to reduce vulnerability in health care facilities, have been incorporated into the Toolkit, making it more comprehensive in assessing both green and safe components. This Smart Hospitals Toolkit includes the following sections:

## SECTION ONE: The Hospital Safety Index




The Hospital Safety Index is a tool that helps to determine the probability that a hospital or health facility will continue to function in emergency situations, based on structural, non-structural and functional factors. By determining a hospital's safety score, countries and decision makers will have an overall idea of its ability to respond to major emergencies and disasters. The Hospital Safety Index does not replace costly and detailed vulnerability studies. However, because it is relatively inexpensive and easy to apply, it is an important first step toward prioritizing a country's investment in hospital safety.

The Hospital Safety Index takes an in-depth look at health facilities and is best suited for hospitals with more than 200 beds. In the Caribbean, however, there are many small and medium-sized health facilities that form part of the health network. Among these are primary care facilities that offer certain specialized services (obstetrics and gynecology; pediatrics; internal medicine; and general surgery) and often have 20 beds or less. These facilities may use the Hospital Safety Index for Small and Medium-Sized Health Facilities, which has been adapted for the Caribbean.

In order to achieve a Smart Health Facility, this tool must be applied along with the Green Checklist (see Section 3).

## SECTION TWO: The Baseline Assessment Tool (BAT)

The Baseline Assessment Tool was designed to guide facilities to focus interventions on those areas that would cut costs through reduced consumption of good and supplies, energy and water savings, increased efficiency of operations, efficient use of resources, creation of favorable working conditions, generation of community goodwill, avoidance of future liability problems and education of the users of health facilities about the value of caring for the environment.

The first section of the BAT includes basic screening criteria for selecting an appropriate health care facility that can be made 'smarter.' It must be pointed out, however, that in specific cases, investment in 'smartening' an existing hospital may not be worthwhile, as the cost of a reduction in the carbon footprint may not be justified nor represent a sound return on investment. If a facility is deemed eligible, the next step is a Patient/Occupant Satisfaction Survey. By determining the satisfaction of patients and staff with: a) the general building; b) air quality; c) ventilation; d) acoustics; and e) lighting, key areas for action to improve productivity and well-being are identified.

The third section of the BAT covers the baseline information required to evaluate the facility under consideration and conduct a more quantitative assessment. The areas covered include: energy; water; condition of the property; waste; indoor environmental quality; fire safety and egress; accessibility; and gross floor area.

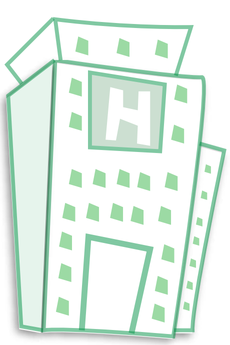
Due to economic constraints, not all measures may be feasible to implement. The BAT, together with the Green Checklist, will help set priorities for greening, which you combine with the priorities from the Hospital Safety Index. Cost benefit analysis is then applied to aid decision-making for implementation.

## SECTION THREE: The Green Checklist and Discussion Guide

The Green Checklist provides an indication of improvements that hospitals and health facilities in the Caribbean can make in their daily operations that will help minimize or stop potential impact from climate change. It is not meant to replace the Hospital Safety Index, but rather to work in tandem with it to achieve a Smart Health Facility. The Green Checklist identifies areas that can conserve resources, cut costs, increase efficiency in operations and reduce a hospital's carbon emissions.

The Checklist is accompanied by a detailed description of each category, implementation strategies, recommended action points and links to other resources that provide additional information.





## SECTION FOUR: Cost-Benefit Analysis

## SECTION FIVE: Bibliography

This section contains a list of additional resources to consult.

## SECTION SIX: Training Aids

Powerpoint presentations have been included to assist in training others to utilize the information contained in the Toolkit.

To achieve a smart health care facility, priority interventions must be applied that link safety with greening and with associated cost benefits. The chart below illustrates the recommended steps that should be taken to achieve smart health care facilities.

## SECTION SEVEN: Lessons Learned from the Smart Hospital Initiative

**A STEP-BY-STEP GUIDE TO USING THE TOOLKIT**

**Step 1**-Apply the **Hospital Safety Index**, based on the size of the facility.
**Output**: Determination of the extent of the risk facing the health facility and the safety needs that must be addressed.

**Step 2**-Apply the **Baseline Assessment Tool**
**Output**: Baseline information helps set priorities and determine the level of 'greening' to be achieved, and serves as the basis for application of the Green Checklist and the Cost-Benefit Analysis.

**Step 3**-Apply the **Green Checklist**
**Output**: Determination of what can be achieved and what is most feasible, based on available resources.

**Step 4**-Verify the results of the Green Checklist against the findings of the BAT and the Hospital Safety Index.
**Output**: Setting of realistic goals. Plan of Action to make the health facility more 'green.'

**Step 5**-Apply the final steps of the **Cost-Benefit Methodology** (including initial input from the BAT).
**Output**: Confirmation that it is appropriate to move forward.

**Step 6**-Prepare bill of quantities and scope of work.

**Step 7**-If funding is available, initiate processes to identify and recruit qualified contractors to undertake proposed work.

**Step 8**-Evaluate the process and the lessons learned.

## Section I

# THE HOSPITAL SAFETY INDEX

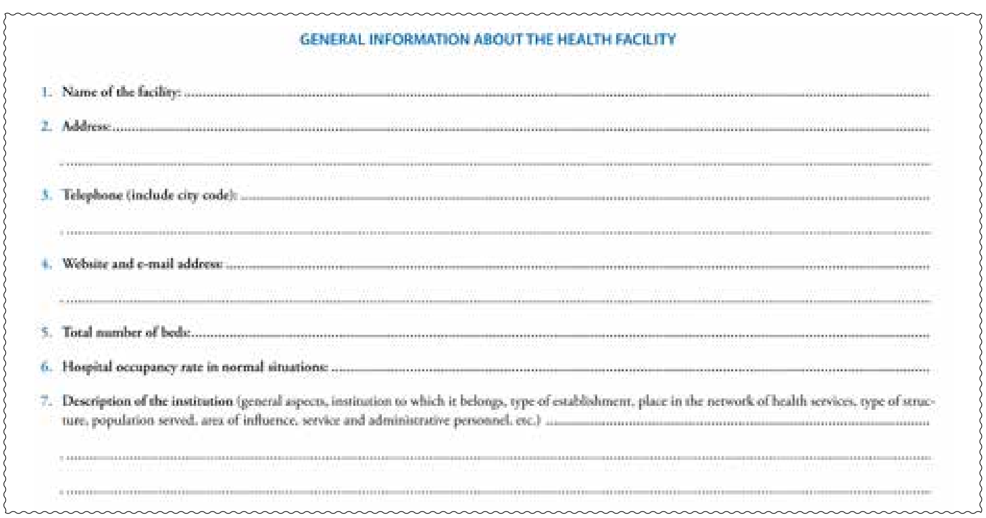
The Hospital Safety Index, a tool developed by the Pan American Health Organization and a group of Caribbean and Latin American experts, is being widely used by health authorities to gauge the overall level of safety of a hospital or health facility in emergency situations.

The Hospital Safety Index helps health facilities to assess their safety and avoid becoming a casualty of disasters by providing a snapshot of the probability that a hospital or health facility will continue to function in emergency situations, based on structural, non-structural and functional factors, including the environment and the health services network to which it belongs.

By determining a hospital's Safety Index or score, countries and decision makers will have an overall idea of its ability to respond to major emergencies and disasters. The Hospital Safety Index does not replace costly and detailed vulnerability studies. However, because it is relatively inexpensive and easy to apply, it is an important first step toward prioritizing a country's investments in hospital safety.

There are a number of steps to calculating a health facility's Safety Index.

**General information about the health facility:** The hospital's disaster committee should complete this form prior to the evaluation. It includes information on a health facility's level of complexity, the population it serves, specialty care and other available services, and health staff. Below is a short extract from this form. Click here to print this form.


GENERAL INFORMATION ABOUT THE HEALTH FACILITY

1. Name of the facility: ..........
2. Address: ..........
3. Telephone (include city code): ..........
4. Website and e-mail address: ..........
5. Total number of beds: ..........
6. Hospital occupancy rate in normal situations: ..........
7. Description of the institution (general aspects, institution to which it belongs, type of establishment, place in the network of health services, type of structure, population served, area of influence, service and administrative personnel, etc.) ..........

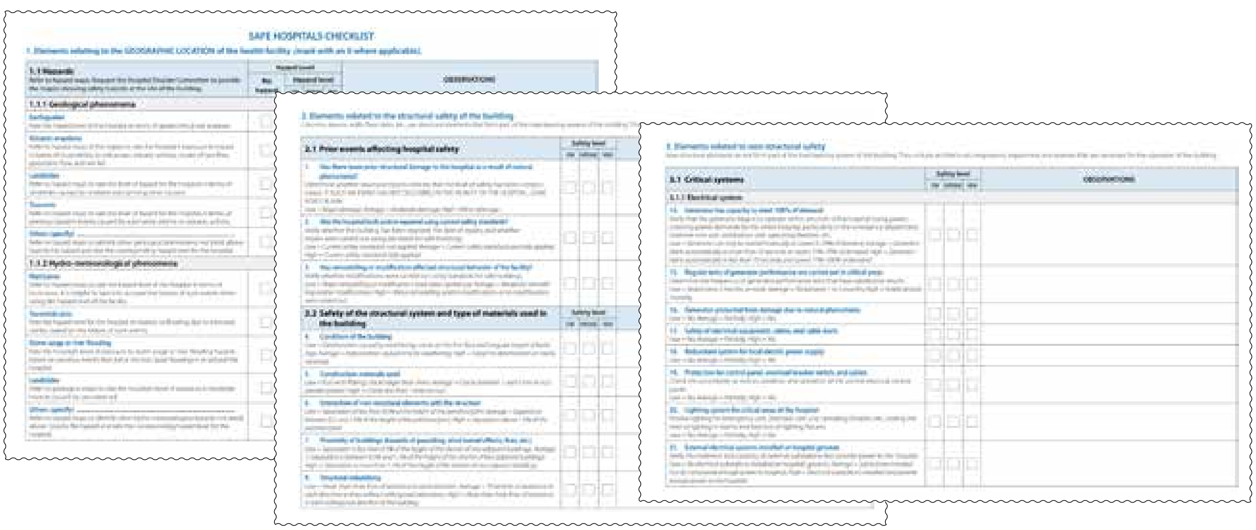
**Safe Hospitals Checklist:** The trained team of Evaluators then uses the Safe Hospitals Checklist to assess the level of safety of 145 areas of the health facility, grouped by location, structural, non-structural and functional components. Once the Checklist has been completed, the Evaluation Team collectively validates the scores and enters them into a scoring calculator, which weighs each variable according to its relative importance to a hospital's ability to withstand a disaster and continue functioning. The safety score is calculated automatically.

The final Safety Index score places a health facility into one of three **categories of safety**, helping authorities determine which facilities most urgently need interventions:

- **Category A** is for facilities deemed able to protect the life of their occupants and likely to continue functioning in disaster situations.
- **Category B** is assigned to facilities that can resist a disaster but in which equipment and critical services are at risk.
- **Category C** designates a health facility where the lives and safety of occupants are deemed at risk during disasters.

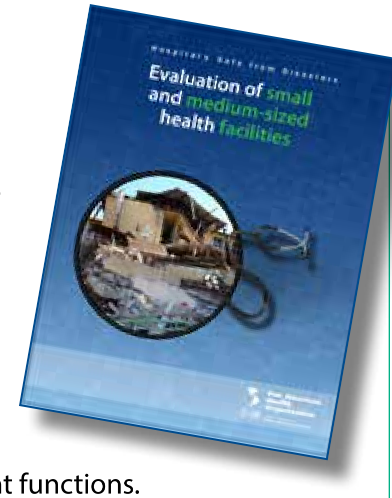
Calculating the safety score allows health facilities to establish maintenance and monitoring routines and look at actions to improve safety in the medium term. This quick overview will give countries and decision makers a starting point for establishing priorities and reducing risk and vulnerability in health care facilities.

Below is a short extract from several areas of the form. Click here to print or photocopy additional copies of these forms.




**Guide for Evaluators:** The Guide for Evaluators provides guidance and standardized criteria for evaluating the components of a health facility individually and as part of the health services network. A multidisciplinary team of Evaluators, which can include engineers, architects, health staff, hospital directors and others who have undergone previous training, uses the Guide. The Guide explains the methodology and rationale for the Hospital Safety Index as well as how to calculate and interpret the health facility's safety score. Click here to view or download the Guide for Evaluators.

## Evaluation of Small and Medium-Sized Health Facilities

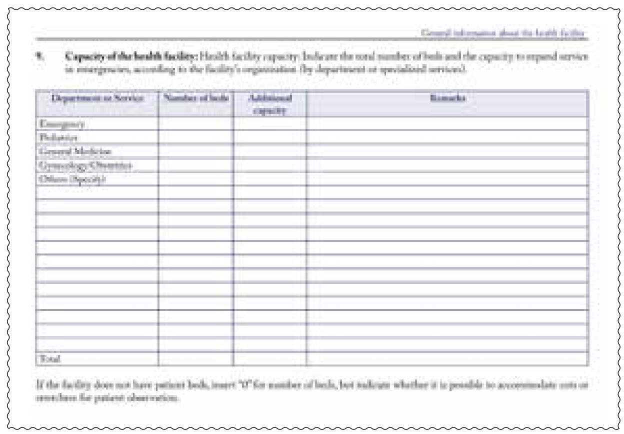



This tool uses the same methodology as Hospital Safety Index and has been adapted to the Caribbean. It aims to improve the safety and response capacity of smaller health facilities in emergency situations. In this guide, smaller facilities are defined as those of low complexity, which together with major hospitals, make up the health network. These include primary care facilities that offer certain specialized services (obstetrics and gynecology; pediatrics internal medicine and general surgery) and often have 20 beds or less.

Health facilities that belong to a country's health network have different functions. Therefore, achieving an optimal level of safety can be progressive in nature and undertaken in a different manner than with larger hospitals.

Click on the appropriate link below to consult or download information about the Evaluation of Small and Medium-Sized Health Facilities and the forms to calculate your facility's safety score:

**Background Information and Guidelines:** This comprehensive reference guide discusses the components of the Evaluation of Small and Medium-Sized Health Facilities and offers guidance on points to consider (structural, non-structural and functional aspects of the facility) as one completes the Safe Hospitals Checklist. Download this material.

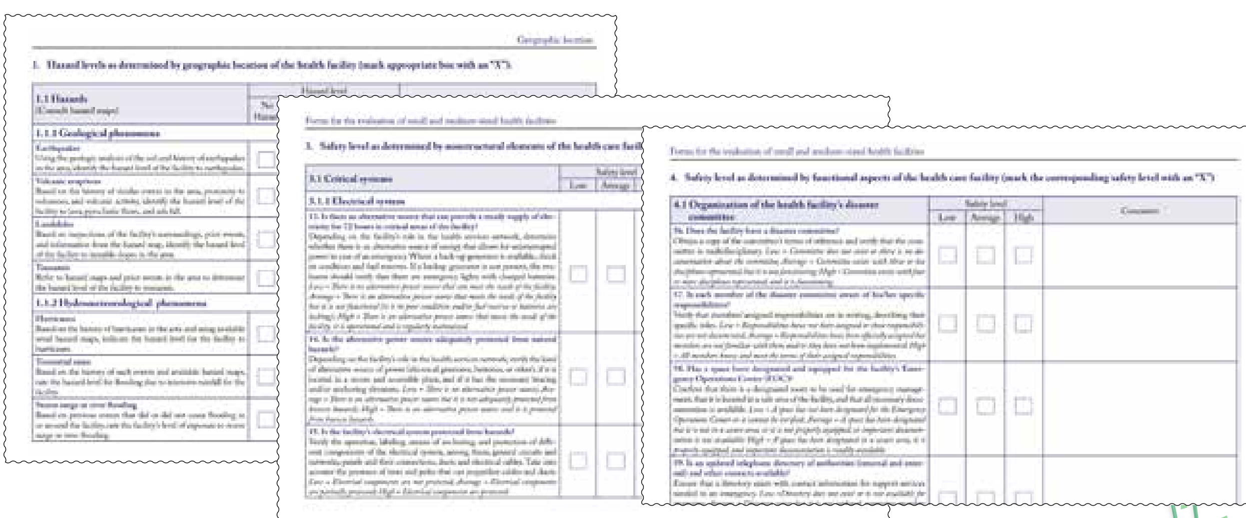


9. **Capacity of the health facility:** Health facility capacity. Indicate the total number of beds and the capacity to expand service in emergencies, according to the facility's organization (by department or specialized services).

| Department or Service | Number of beds | Additional capacity | Remarks |
|---|---|---|---|
| Emergency | | | |
| Pediatrics | | | |
| General Medicine | | | |
| Gynecology/Obstetrics | | | |
| Others (Specify) | | | |
| Total | | | |

If the facility does not have patient beds, insert "0" for number of beds, but indicate whether it is possible to accommodate cots or stretchers for patient observation.

**Safe Hospitals Checklist for Small and Medium-Sized Facilities:** The evaluation team leader will distribute a copy of the Checklist to each evaluator. The team is comprised of specialists in a variety of technical areas, who will complete the corresponding section the Checklist according to their area of expertise. Below is a short extract from several areas of the form. Click here to download these forms.



**Intervention Plan:** The matrix summarizes the evaluation's results and helps to plan solutions. Click here to download this form.

Intervention plan to improve the level of safety

**Name of facility:**.......................................................................................................

**Location of facility:** ..................................................................................................

**Date of evaluation:** ....................................................................................................

| Elements evaluated | | | Problems | Actions | Priorities* | Comments |
|---|---|---|---|---|---|---|
| Structural elements | | | | | | |
| Nonstructural elements | Essential services | Electrical system | | | | |
| | | Telecommunications system | | | | |
| | | Water supply system | | | | |
| | | Fuel storage | | | | |
| | | Medical gases | | | | |
| | | Sewage system | | | | |
| | | Storm drainage | | | | |
| | Heating, ventilation, air conditioning, hot water | | | | | |
| | Furniture and fittings, office equipment, and storage | | | | | |

Download the complete publication Evaluation of Small and Medium-Sized Health Facilities.

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## Section II

# BASELINE ASSESSMENT TOOL

## Overview

A health facility's age; physical condition; quality of construction; structural, non-structural and mechanical integrity; and compliance with current building, fire and electrical codes are important factors to consider in the audit of any facility. The **Smart Hospital Baseline Assessment Tool** (BAT) helps to assess these factors by collecting reliable and detailed information on the building's performance and operations and how it measures up against current code, regulatory requirements and zoning regulations.

The information drawn from the assessment covers the building's operating systems; capital improvement requirements and history; energy and water usage; waste generation; Indoor Environmental Quality (IEQ); occupant satisfaction; facility management; security, overall design and architectural features; and any signs of physical deterioration. The assessment also examines building codes, fire safety, accessibility, and health and safety. This information is needed to 'smarten' the facility—making it environmentally friendly, safe and disaster-resilient—and to prioritize measures to reduce energy and water consumption, waste generation and undertake a cost-benefit analysis of the proposed interventions.

The Baseline Assessment Tool is comprised of the following sections:

1. **Criteria for selecting a health care facility for green retrofitting**.
2. **Patient/Administrator Occupant Satisfaction Survey** – examines such factors as lighting, temperature, glare, ventilation and perception of the building's safety during natural disasters. It highlights areas of concern that should be addressed during the project design and decision making process.
3. **Required baseline information** to properly evaluate the health facility. Information useful for calculating the carbon footprint of the structure is also included.
4. **Evaluation of property condition** – evaluates the suitability of a structure for retrofitting: evaluation of the structure, doors, windows, flooring, structural defects, air conditioning systems or equipment, items of deferred maintenance and building code violations.

The information/schematics/site plans, energy and water usage data and all other information required to complete this assessment will help evaluators decide which structure is suitable for 'smartening'/green retrofitting. For the evaluation to be as comprehensive as possible, every effort should be made to gather as much of this information as possible prior to making decisions.

## 1. Criteria for Selecting a Health Care Facility for 'Smartening'

Before examining the criteria for selecting a health facility, it is important to ascertain buy-in from the Ministry of Health, the National Disaster Office, the director of the health facility and other governmental departments/agencies if the green retrofitting or 'smartening' is to be successful. If an in-patient facility is envisaged (10 beds), then the Hospital Safety Index for small and medium-sized hospitals should be applied first and recommendations for improving safety in the face of natural hazards such as hurricanes and earthquakes should be put in place.

### Initial Screening

The following areas should be assessed prior to any decision to green retrofit or 'smarten' a health facility:

- **Roof:** The roof must be strong enough to withstand the additional weight of solar panels and solar water heaters (to maximize electricity production, solar panels should face south to southwest).
- **Catchment population:** The facility should serve a minimum catchment population of 5,000 persons.
- **Number of beds:** The facility should have at least 10 beds.
- **Building condition:** The age, structural, and mechanical integrity of the building must be taken into consideration, as they will help to determine if renovation will be possible and economically feasible and may impact the degree to which changes can be made.
- **Electricity:** how much of the facility's consumption of electricity comes from non-renewable sources?
- **Potable water:** How much of the facility's water consumption comes captured rainwater?
- **Operations:** Does the facility operate at least 40 hours per week?
- **Electrical equipment and devices:** are cooling and refrigeration systems and other devices Energy Star or other efficiency program rated?
- Does the facility have minimum staff requirements of at least:
  - 1 full time medical doctor
  - 2 assistant medical doctors
  - 1 nurse per 5 patients
  - Midwives
  - Technicians

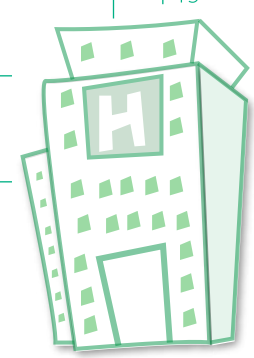
## 2. Patient/Staff Occupancy Satisfaction Survey

Once a facility has been selected, apply the Occupant Satisfaction Survey to determine the satisfaction of patients and staff with: a) the general building; b) air quality; c) ventilation; d) acoustics; and e) lighting. Occupant surveys are an effective means of judging the current performance of a building. After all, the occupants are the ones who spend the most time in the building. The occupant survey will highlight day-to-day building performance areas that fall below expectations and which may affect productivity and well-being. To be effective, the audit should be carried out in a highly structured and visible manner so that the results can be compared over time and used to determine if issues were addressed appropriately and progress made.

View the Patient/Staff Occupancy Satisfaction Survey or [download the Survey form here](#).

**Patient/Staff Occupancy Satisfaction Survey**

| Question | Responses | | | |
|---|---|---|---|---|
| Please identify your relationship to the facility | Employee ❑ | Patient ❑ | Visitor ❑ | |
| Do you understand the concept of "greening" buildings? | Yes ❑ | No ❑ | | |
| Which of the following renewable energy sources do you know about? | Solar ❑ | Wind ❑ | Geothermal ❑ | Bio Energy ❑ |
| Do you give consideration to energy and water conservation at work? | Yes ❑ | No ❑ | | |
| On average, how much time do you spend at work? | <40 hrs ❑ | >40 hrs ❑ | | |
| How do you get to work or to the facility? | Walk ❑ | Private Vehicle ❑ | Public Transport ❑ | |
| Approximately how many miles is the drive to work/facility? | | | | |
| Please provide details about the vehicle you use to get to and from work/facility | Make | Model | Year | |
| How satisfied are you with lighting? | Poor ❑ | Moderate ❑ | Good ❑ | |
| Does the lighting affect you ability to work? | Yes ❑ | No ❑ | | |
| Can you point out specific problems with the lighting? | Glare ❑ | Reflections ❑ | Direct Sunlight ❑ | Faulty Fixtures ❑ |
| Overall, does the air quality enhance or interfere with your ability to get your job done? | Enhance ❑ | Interfere ❑ | | |
| How satisfied are you with the air quality (i.e. stuffy/stale air, odor) at your workplace? | Poor ❑ | Moderate ❑ | Good ❑ | |
| Does direct sunlight enter any of the windows and doors? | Yes ❑ | No ❑ | | |



| Patient/Staff Occupancy Satisfaction Survey | | | | | | |
|---|---|---|---|---|---|---|
| **Question** | **Responses** | | | | | |
| Does the temperature of your workplace affect your ability to work? | Yes ❑ | | | No ❑ | | |
| Does the ventilation (movement of air) affect your ability to work? | Yes ❑ | | | No ❑ | | |
| In your opinion is the building strong? | Yes ❑ | | | No ❑ | | |
| Would you feel comfortable in the building during a tropical storm or hurricane? | Yes ❑ | | | No ❑ | | |
| What improvements would you like to see to the building? | Better Lighting ❑ | Operable Windows ❑ | Operable Doors ❑ | Air Conditioning ❑ | Reliable Electricity ❑ | Reliable Water Supply ❑ |

## 3. Baseline Information Requisition Checklist

In order to properly evaluate the facility under consideration, it is important to gather and compile specific details. The information collected will be used for comparison, will be entered into tables provided elsewhere and used for calculations. As much information as possible as indicated in this table should be gathered.

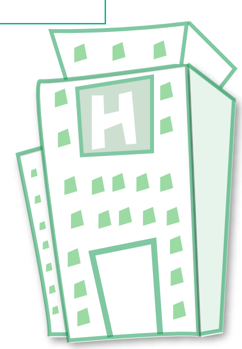
### Required Documents/Information

Consult the list of information and documents required to complete the Baseline Assessment in the following section. Click on this link to download copies of this form.

| Name of Facility | | |
|---|---|---|
| **Document** | **Date Received** | **Comments** |
| **A. As-Built Plans and Specifications** | | |
| 1. Survey drawings | | |
| 2. Site plans | | |
| 3. Structural plans | | |
| 4. Architectural plans | | |
| 5. Mechanical plans | | |
| 6. Electrical plans | | |
| **B. Building Maintenance History** | | |
| 1. Age of building | | |
| 2. Maintenance records of all equipment | | |
| 3. Copy of maintenance plan (if any) | | |
| 4. Maintenance records on standby generators (if any) | | |

| Name of Facility | | |
|---|---|---|
| **Document** | **Date Received** | **Comments** |
| 5. Record of vehicles associated with the facility | | |
| 6. Documentation of damage/repairs to: | | |
| a. Façade repairs/restoration | | |
| b. Roof | | |
| c. Plumbing | | |
| d. Electrical | | |
| e. Heating | | |
| f. Air conditioning | | |
| g. Elevators | | |
| h. Safety alarm system | | |
| i. Water catchment/cistern | | |
| **C. Building Consumption** | | |
| 1. Copy of electrical bills for 3 years | | |
| 2. Copy of water bills for 3 years | | |
| 3. Information on waste collection costs for 3 years | | |
| 4. Information on disposal of hazardous waste | | |
| 5. Information on materials recycled incinerator | | |
| **D. Miscellaneous Information** | | |
| 1. Environmental impact assessment | | |
| 2. Tenant complaint log | | |
| 3. Property ownership details | | |
| 4. Property ownership details for adjoining properties | | |
| 5. Geographical information for area served | | |
| 6. Building capacity (fulltime and part-time), patients visited and number of beds | | |
| 7. Information of local labour costs | | |
| 8. Information on local construction costs | | |
| 9. Information on procedures on duty free concessions for construction materials and equipment | | |
| 10. Copy of building code | | |
| 11. Copy of labour code | | |
| 12. Copy of fire code (if any) | | |
| 13. Copy of town and country planning acts | | |
| 14. Copy of health and safety plan (if any) | | |
| 15. Copy of evacuation plan and maps (if any) | | |

The following administrative/facility management questionnaire helps to determine if conditions at the facility are contributing to illness, absenteeism or a high turnover rate. These questions may be revisited once the project is complete and workers have had a



chance to use the facility for some time to determine if the changes made had any impact on work conditions and indoor environmental quality (lighting, ventilation, temperature).

Additionally, in an effort to calculate the greenness of the facility, questions related to food procurement are included below. Click on this link to download a copy of this form.

| | | |
|---|---|---|
| How many employees are assigned to the facility? | | |
| Over the past year, has /have any employee(s) resigned from a post at this facility; if so, how many? | | |
| On average, how many days are employees absent from work excluding vacation time? | | |
| Has any occupant ever lodged a complaint about the facility, such as leaky faucets, faulty light fixtures, inoperable windows and doors, etc.? | Yes ❑ | No ❑ |
| Has any employee ever lodged a complaint related to temperature? | Yes ❑ | No ❑ |
| Is food prepared at the facility? | Yes ❑ | No ❑ |
| Is food generally delivered from a central location/warehouse? | Yes ❑ | No ❑ |
| Approximately how much food is consumed /prepared at the facility? | | |
| Is any locally available food used at the facility? | Yes ❑ | No ❑ |
| If yes, is food acquired from the surrounding communities? | Yes ❑ | No ❑ |
| Approximately how much of the food prepared at the facility is locally grown? | | |
| Approximately how much of the food prepared at the facility is imported? | | |

## Energy Audit

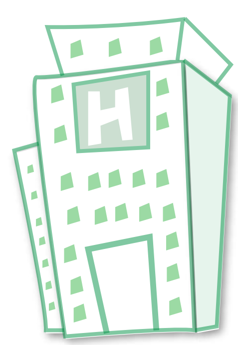
An energy audit will determine how much electricity is being consumed by the facility. The audit should include electricity and gas usage and information about any and all electrical devices and equipment and other sources that consume energy. A review of energy bills for three years, as noted in the information requisition checklist, will determine monthly electricity usage and any abnormal variations in consumption. It will help determine the size of required renewable energy systems (PV), if any are to be installed. It can also be used to show reductions in energy use once upgrades are undertaken or a PV system installed.

Consult the Energy Audit forms below. Click on this link to download copies of these forms.

| | Electricity Consumption | | | | | |
|---|---|---|---|---|---|---|
| | Month | Days in Period | Usage kWh | Fuel Surcharge | Cost | Notes |
| YEAR 1 | January | | | | | |
| | February | | | | | |
| | March | | | | | |
| | April | | | | | |
| | May | | | | | |
| | June | | | | | |
| | July | | | | | |
| | August | | | | | |
| | September | | | | | |
| | October | | | | | |
| | November | | | | | |
| | December | | | | | |

| | Electricity Consumption | | | | | |
|---|---|---|---|---|---|---|
| | Month | Days in Period | Usage kWh | Fuel Surcharge | Cost | Notes |
| YEAR 2 | January | | | | | |
| | February | | | | | |
| | March | | | | | |
| | April | | | | | |
| | May | | | | | |
| | June | | | | | |
| | July | | | | | |
| | August | | | | | |
| | September | | | | | |
| | October | | | | | |
| | November | | | | | |
| | December | | | | | |





**Electricity Consumption**

**YEAR 3**

| Month | Days in Period | Usage kWh | Fuel Surcharge | Cost | Notes |
|---|---|---|---|---|---|
| January | | | | | |
| February | | | | | |
| March | | | | | |
| April | | | | | |
| May | | | | | |
| June | | | | | |
| July | | | | | |
| August | | | | | |
| September | | | | | |
| October | | | | | |
| November | | | | | |
| December | | | | | |

**Fixture and Equipment Classification**

**Air Conditioning**

| Quantity | Type | Make | Size (BTU) | Comments |
|---|---|---|---|---|
| | | | | |
| | | | | |
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| | | | | |
| | | | | |
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**Emergency Generator**

| Model | Rating | Fuel Type | Capacity | Age | Condition | Notes |
|---|---|---|---|---|---|---|
| | | | | | | |
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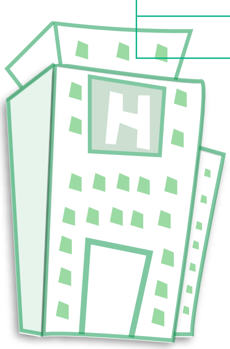

| Refrigerator/Freezeer | | | | | | |
|---|---|---|---|---|---|---|
| Model | Rating | Size | Quantity | Age | Condition | Notes |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

| Stand Fans/Ceiling Fans | | | | |
|---|---|---|---|---|
| Model | Quantity | Age | Rating | Condition |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| Television | | | | |
|---|---|---|---|---|
| Model | Size | Age | Rating | Condition |
| | | | | |
| | | | | |
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| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

| Washers | | | | | |
|---|---|---|---|---|---|
| Model | Capacity | Top/Front Load | Age | Condition | Notes |
| | | | | | |
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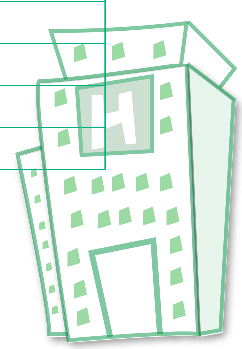

| Dryers | | | | | |
|---|---|---|---|---|---|
| Model | Electric | Gas | Age | Condition | Notes |
| | | | | | |
| | | | | | |
| | | | | | |

| Medical Equipment | | | | | |
|---|---|---|---|---|---|
| Type | Capacity | Top/Front Load | Age | Condition | Notes |
| | | | | | |
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| Stove/Ovens | | | | | | |
|---|---|---|---|---|---|---|
| Model | Electric | Gas | Age | Rating | Quantity | Condition |
| | | | | | | |
| | | | | | | |
| | | | | | | |

| Light Bulbs | | | | | | |
|---|---|---|---|---|---|---|
| Location | Fixture Type | | Bulb Type | Quantity | Rating | Notes |
| | Wall | Ceiling | | | | |
| | | | | | | |
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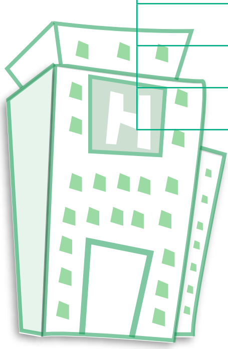


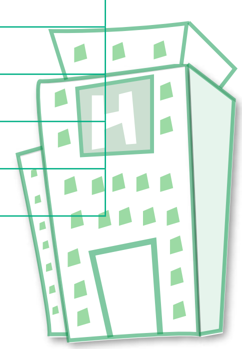
## Water Audit

A water audit is performed to help determine how much potable water the facility is using. A review of water bills may also determine abnormal variations in consumption. It is important that all water-using devices (i.e. faucets, dishwashers, washers, sinks, toilets, urinals, water coolers and showers) are catalogued and reviewed. If flow rates are available, they should be included as well. The information collected will be used to help determine where and how to reduce the use of potable water.

Consult the Water Audit forms in following section. [Click on this link to download copies of these forms].

| | Water Consumption | | | | | |
|---|---|---|---|---|---|---|
| | Month | Days in Period | Water Usage | Surcharge | Cost | Notes |
| YEAR 1 | January | | | | | |
| | February | | | | | |
| | March | | | | | |
| | April | | | | | |
| | May | | | | | |
| | June | | | | | |
| | July | | | | | |
| | August | | | | | |
| | September | | | | | |
| | October | | | | | |
| | November | | | | | |
| | December | | | | | |

| | Water Consumption | | | | | |
|---|---|---|---|---|---|---|
| | Month | Days in Period | Water Usage | Surcharge | Cost | Notes |
| YEAR 2 | January | | | | | |
| | February | | | | | |
| | March | | | | | |
| | April | | | | | |
| | May | | | | | |
| | June | | | | | |
| | July | | | | | |
| | August | | | | | |
| | September | | | | | |
| | October | | | | | |
| | November | | | | | |
| | December | | | | | |



## Water Consumption

**YEAR 3**

| Month | Days in Period | Water Usage | Surcharge | Cost | Notes |
|---|---|---|---|---|---|
| January | | | | | |
| February | | | | | |
| March | | | | | |
| April | | | | | |
| May | | | | | |
| June | | | | | |
| July | | | | | |
| August | | | | | |
| September | | | | | |
| October | | | | | |
| November | | | | | |
| December | | | | | |

## Water Catchment/Treatment

| | | |
|---|---|---|
| Are there underground cisterns onsite? | Yes ❑ | No ❑ |
| If yes, what is the capacity? *(LxWxD)x 7.48* | Gallons: | |
| Are there water storage tanks/cisterns onsite? | Yes ❑ | No ❑ |
| If yes, what is the capacity? *(LxWxD)x 7.48* | Gallons: | |
| How is the tank filled? | Rainwater ❑ | Potable water ❑ |
| Is the water being treated before use? | Yes ❑ | No ❑ |
| If yes, how is this being done? | | |
| Are the grounds irrigated? | Yes ❑ | No ❑ |
| If yes, how often? | | |
| If yes, for how long? | | |

## Sewage Treatment

| |
|---|
| Type of sewage system: Underground septic tank ❑ Treatment plant ❑ Public sewer ❑ |
| What is the capacity? (LxWxD)x 7.48 Gallons: _______________ |
| No. of buildings served? |

## Water Fixture Classification

### Toilets/Urinals

| Quantity | Model | Flow Rate (GPF) | Location | Condition |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

### Showers

| Quantity | Grab Bars | | Location | Condition | Notes |
|---|---|---|---|---|---|
| | Yes | No | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

### Sink Faucets

| Quantity | Type | Aerated | | Location | Condition | Notes |
|---|---|---|---|---|---|---|
| | | Yes | No | | | |
| | | | | | | |
| | | | | | | |
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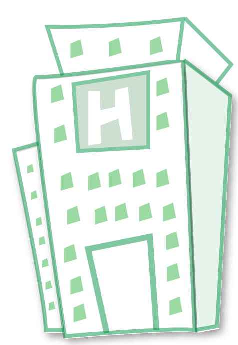
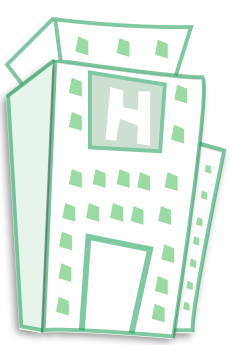


| Hot Water Heaters | | | | | | |
|---|---|---|---|---|---|---|
| Model | Quantity | Capacity | Rating | Type | Age | Condition |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | | | | | | |

## 4. Property Condition Evaluation (Click on this link to download copies of the form)

| General Building Information |
|---|
| Name of facility: |
| Location: |
| Property block/parcel no. |
| Size of Property: |
| Building Orientation: |
| Building Floor Area: |
| No. of floors: |
| No. of parking spaces: Visitors ____________ Workers__________ |
| Building Capacity: - No. of Beds ____________ Facility Capture Population : ____________ |
| No. of Employees: Full-time ___________ Part-time ______________ |
| Year Constructed: |
| Type of Building Construction: |
| Type of roof construction: |
| PAHO/WHO Hospital Safety Index Applied: Yes ❑ No ❑ |
| If yes, is the report available? |





## Building Condition Audit

A condition audit is used to determine the current condition and expected remaining economic life of the building's components. This instrument will produce a complete inventory of a building (including equipment) and identify deficiencies. Areas to be examined will include the structure, walls and roof, mechanical, electrical and IT systems, hazardous materials (asbestos, lead, etc.), security and safety.

Consult the Condition Audit forms below. [Click on this link to download copies of the forms](#).

| Building Condition-Primary | | | |
|---|---|---|---|
| **Primary Building Elements** | **Scoring Range** | **Score** | **Comments** |
| Foundation/structure | 0-10 | | |
| Exterior walls | 0-5 | | |
| Roof system | 0-6 | | |
| Windows/doors | 0-2 | | |
| Trim/finishes | 0-2 | | |
| **Primary Score** | | | |

| Building Condition-Interiors | | | |
|---|---|---|---|
| **Interior Elements** | **Scoring Range** | **Score** | **Comments** |
| Ceilings | 0-6 | | |
| Interior walls/doors | 0-8 | | |
| Floors | 0-8 | | |
| Fixed furniture equipment | 0-3 | | |
| **Interior Score** | | | |

| Building Condition-Systems | | | |
|---|---|---|---|
| **Systems** | **Scoring Range** | **Score** | **Comments** |
| Ventilation | 1-4 | | |
| Plumbing | 1-4 | | |
| Electrical | 1-6 | | |
| Lighting | 1-5 | | |
| Drainage and guttering | 1-6 | | |
| **System Score** | | | |

Add the scores from tables A, B, C, and D. Compare the total score to the ranges provided below to determine the overall condition of your building.

| Condition Audit Area | Score |
|---|---|
| **Table A: Primary score** | |
| **Table B: Interior score** | |
| **Table C: System score** | |
| **Table D: Code score** | |
| **TOTAL** | |

**Score Conversion:**

| Score | Overall Condition |
|---|---|
| 80-100 | The overall building condition is good to excellent |
| 60-80 | Building is generally suitable. Minor improvements are needed |
| 40-60 | Building has suitable characteristics, but requires specific upgrades |
| 20-40 | Building has serious deficiencies |
| Under 20 | Building is unsuitable for intended use |

| Flooring Condition | | | | |
|---|---|---|---|---|
| **Flooring** | | | | |
| **Type of Finish** | **Coverage (SF)** | **Condition** | **Location** | **Notes** |
| | | | | |
| | | | | |
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| Window Condition | | | | | |
|---|---|---|---|---|---|
| **Windows** | | | | | |
| **Qty** | **Size (wxd)** | **Type** | **Condition** | **Location** | **Notes/Recommendations** |
| | | | | | |
| | | | | | |
| | | | | | |
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| Door Condition | | | | | |
|---|---|---|---|---|---|
| **Doors** | | | | | |
| **Qty** | **Size (wxd)** | **Type** | **Condition** | **Location** | **Notes/Recommendations** |
| | | | | | |
| | | | | | |
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## Waste Audit

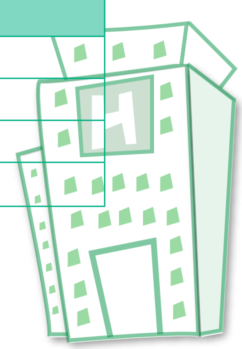
The waste audit will determine the total amount of waste generated by the facility and its operations. It will also identify how much of this is being recycled, composted and/or sent to incineration/landfill. This results of the waste audit will help identify opportunities to implement or increase recycling and/or composting and minimize the amount of waste that is incinerated or sent to landfills.

Consult the Waste Audit forms in following section. [Click on this link to download copies of these forms].

| Recycled Waste | | | | | | |
|---|---|---|---|---|---|---|
| Where is waste disposed of? | | | | | | |
| Is waste deposited in landfills or incinerated? | | | | | | |
| Is hazardous waste (biological and medical) separated from the waste stream? | | | | | Yes ❑ | No ❑ |
| How is the hazardous waste (biological and medical) disposed? | | | | | | |
| Is any of the waste recycled? | | | | | Yes ❑ | No ❑ |
| Is any of the waste composted? | | | | | Yes ❑ | No ❑ |
| **Waste Material** | | | | | | |
| **Materials** | **Location** | **Recycled** | | **Disposal Lbs/ Week** | **Disposal Tons/Yr** | **Notes** |
| | | **Yes** | **No** | | | |
| Computer paper | | | | | | |
| Ledger paper | | | | | | |
| Mixed paper | | | | | | |
| Corrugated | | | | | | |
| Newspaper | | | | | | |
| Magazines | | | | | | |
| Glass containers | | | | | | |
| Aluminum cans | | | | | | |
| Steel cans | | | | | | |
| Scrap metals | | | | | | |
| Plastics | | | | | | |
| Pallets | | | | | | |
| Batteries | | | | | | |
| Other | | | | | | |
| **TOTALS** | | | | | | |
| **Collection Cost** | | | | | | |
| **Date of Collection** | **% Filled** | **Pickup Cost** | **Type** | **Size** | **# of Collections per Month** | **Monthly Cost** |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| **TOTALS** | | | | | | |







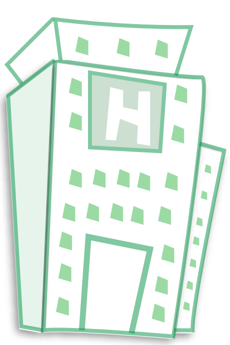
## Inventory Usage Report

The Inventory Usage Report shows how inventory or items were used over a certain time period. Consult the Inventory Usage Report forms below. Click on this link to download copies of these forms.

| Item | Material purchased/used (lbs) | | | | | | | | | | | | Total Qty Used | Cost | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year 1 | | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | | | |
| Paper | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Glass | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Aluminum | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Metals | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Plastics | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

| Item | Material purchased/used (lbs) | | | | | | | | | | | | Total Qty Used | Cost | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year 2 | | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | | | |
| Paper | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Glass | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Aluminum | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Metals | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Plastics | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |





| Item | Material purchased/used (lbs) | | | | | | | | | | | | Total Qty Used | Cost | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Year 3 | | | | | | | | | | | | | | |
| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | | | |
| Paper | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Glass | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Aluminum | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Metals | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Plastics | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |
| Other | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | |

## Indoor Environmental Quality

Many existing buildings have poor indoor environmental and/or air quality (IEQ/IAQ). IEQ takes into account thermal comfort, air quality and lighting and noise levels. These areas should be examined to find out if issues or concerns exist within the interior of the facility and with staff, patients and visitors, pointing to improvements that can be made as appropriate. Specialized equipment may be necessary to obtain some of the information in this section. Consult the IEQ forms below or click on this link to download copies of these forms.

| Date of Assessment: | Yes | No | Notes |
|---|---|---|---|
| **Exterior: Ground Level** | | | |
| Are outdoor air intakes unobstructed? | | | |
| Are pollutant sources such as buses and other vehicles clear of outdoor air intakes? | | | |
| Is air entering outdoor intakes (i.e. unit ventilators are on)? | | | |
| Is there evidence of bird/animal nests or droppings near outdoor air intakes? | | | |
| Are garbage dumpsters located near doors, windows or outdoor air intakes? | | | |
| Are potential sources of air contaminant (i.e. factories, hazardous waste sites, etc.) near the facility? | | | |
| Are cracks visible in the exterior walls? | | | |
| Is the building apron/landscape sloped away from the foundation? | | | |
| Are all gutters and downspouts installed to carry water away from the foundation? | | | |

| | | | |
|---|---|---|---|
| Do sprinklers dump water near the building, spray water onto the building or into outdoor air intakes? | | | |
| Are clean walk-off mats placed at every exterior entrance? | | | |
| **Exterior: Roof Level** | **Yes** | **No** | **Notes** |
| Is there evidence of water ponding or pooling? | | | |
| Are air handling units on and drawing air into outdoor air intakes? | | | |
| Are outdoor air intakes and dampers open? | | | |
| Is there evidence of bird nests or droppings near outdoor air intakes? | | | |
| Are plumbing stacks at least 10 feet away from outdoor air intakes? | | | |
| Are there any exhaust air outlets within 10 feet of outdoor air intakes? | | | |
| Are exhaust fans operating and is air flowing out? | | | |
| **Air Conditioning Systems** | **Yes** | **No** | **Notes** |
| Are air conditioning condenser units elevated above ground? | | | |
| Are new filters needed? | | | |
| Do filters fit properly in their tracks in a manner to prevent air bypassing of filter media? | | | |
| Are filters installed in proper direction for airflow? | | | |
| Are condensate pans clean (i.e. no rust, sludge, bio film or other debris)? | | | |
| Do condensate pans drain properly (i.e. no standing water or rust)? | | | |
| Are cooling coils clean? | | | |
| Are other components of the air handling unit clean (i.e. mixing chambers, fan blades, ducts etc.)? | | | |
| Are mechanical rooms and air mixing chambers used to store trash, chemicals, supplies, etc.? | | | |
| If applicable, is return air drawn into ceiling plenum? | | | |
| If unit ventilator, is it used to store supplies, books, plants, etc. or otherwise obstructed? | | | |
| Is there a regular cleaning and preventative maintenance plan in place? | | | |
| **Housekeeping** | **Yes** | **No** | **Notes** |
| Are walk-off mats present at all entrances? | | | |
| Does the facility use high efficiency vacuum filters? | | | |
| Are carpets/floors cleaned regularly? | | | |

| Environmental Sampling | | |
|---|---|---|
| Carbon Dioxide, Temperature, and Relative Humidity Measurements | | |
| Time | Location | PPM, F Degrees, and Percent RH |
| | | |
| | | |
| | | |
| | | |
| | | |
| Mercury Vapor Measurements | | |
| Time | Location | Micrograms per cubic meter |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |
| | | |

## Fire Safety and Egress

Existing buildings, especially older ones, often are no longer compliant with the latest safety requirements. Therefore, upgrading may address any non-compliance issues, which can range from minor (i.e., adding fire extinguishers) to large-scale interventions (i.e. adding stairs or sprinkler systems). Depending on the extent of the upgrade, it may be that only new work to an existing building must comply with the current Fire Code. Projects that involve a major upgrade may require the entire building to be brought up to current regulations. Understanding the level of work required to meet current fire and safety regulations is a key first step, since it may define design constraints for the building.

Consult the Fire Safety and Egress forms below or click on this link to download copies of these forms.

| Areas to be Assessed | Yes | No | Notes |
|---|---|---|---|
| **Fire Extinguishers** | | | |
| A fire extinguisher is within 75 feet of every area and within 50 feet of potentially hazardous areas, such as the kitchen or a workshop. | | | |
| Fire extinguishers are checked annually by a licensed service contractor. | | | |
| Fire extinguishers are not hung higher than five feet from the floor to the top of the extinguisher. | | | |

| Exits | Yes | No | Notes |
|---|---|---|---|
| At least two exits are available from every area. | | | |
| Exits are accessible without using a key. | | | |
| Exits are marked with illuminated exit signs that are working. | | | |
| Storage, furniture, trash, etc. are not located in corridors or stairways. | | | |
| Fire doors to stairways and storage rooms can close and latch automatically. | | | |
| Fire doors are not blocked open *(fire doors can only stay open normally if smoke detectors, connected to automatically-releasing door holders, are installed).* | | | |
| The walls and corridor ceilings and stairs are solid. Any holes or other damage has been repaired. | | | |
| Exits are not hidden by draperies, furniture, etc. | | | |
| Exit doors open outwardly. | | | |
| Corridor doors are solid (20-minute rated) and have automatic door closers, unless there are approved smoke detectors in the corridors. | | | |
| **Fire Alarms** | **Yes** | **No** | **Notes** |
| Building is equipped with a functioning fire alarm system. | | | |
| Each bell or horn, manual alarm station and smoke or heat detector is functioning. | | | |
| The alarm stations are red, and are not covered or blocked by furniture, posters, drapes, etc. | | | |
| Smoke detectors are in every room used for sleeping and in the corridors and stairs. | | | |
| The fire alarm can be heard throughout the building. | | | |
| **Walls/Ceilings/Floors** | **Yes** | **No** | **Notes** |
| The interior finish of corridors, stairways, foyers, lobbies and any other exits are rated Class A or B. This means that paneling, ceiling tile, carpets, decorations, etc. in these areas is fire retardant. | | | |
| The interior finish of all other areas is rated Class A, B or C. This allows a more flammable finish, but still prohibits very flammable finishes, such as some wood paneling, paper, some fabrics, etc. | | | |
| The use of highly flammable decorations is prohibited. | | | |
| **Maintenance** | **Yes** | **No** | **Notes** |
| Every required safety device *(fire alarms, exit lights, fire doors, etc.)* is functioning and maintained in good repair. | | | |
| **Fire Protection Systems** | **Yes** | **No** | **Notes** |
| Sprinkler systems are located in most storage areas, and turned on at all times | | | |

| | | | |
|---|---|---|---|
| Extinguisher systems protect the kitchen exhaust hood and deep fryers, griddles, and stovetops. These are inspected and serviced every six months. | | | |
| **Storage** | **Yes** | **No** | **Notes** |
| Flammable liquids *(paints, etc.)* are limited to that needed for routine maintenance and are stored in approved storage rooms. Approved storage rooms are separated from the rest of the building by one-hour fire rated construction and have a sprinkler system. | | | |
| Gasoline is prohibited from the building, including that used in the tanks of cycles, mopeds, lawnmowers, and storage cans. | | | |
| Combustible storage *(furniture, luggage, paper supplies, lumber, tires, etc.)* is held in approved storage rooms. | | | |
| **Housekeeping** | **Yes** | **No** | **Notes** |
| Accumulations of combustible debris that could block an exit or could easily be set on fire are prohibited. | | | |
| Are walk-off mats present at all entrances? | | | |
| **Fire Drill** | **Yes** | **No** | **Notes** |
| Evacuation routes and procedures are posted in each room/ common area. | | | |
| Fire drills are conducted every quarter and witnessed by a fire officer. | | | |
| Emergency contact information, in the event of an emergency, is posted. | | | |
| **Fire Escapes** | **Yes** | **No** | **Notes** |
| Railing or gates are secured and in place (no open drops). | | | |
| Exits are easily opened from the inside without a key or special devices. | | | |
| **Fire Lanes** | **Yes** | **No** | **Notes** |
| Fire lanes are marked with signs or painted curbs. Vehicles are prohibited from parking in these areas, as they block rescue ladder trucks from getting ladders to windows. | | | |

## Accessibility

Buildings must be accessible for disabled persons. Many buildings may not be compliant with the current accessibility requirements and may require additional ramps, lifts, guardrails, toilets or other changes to the current building. Conduct a building review to assess what retrofitting works are required. If extensive work is required, this could present design constraints for the building.

Consult the Accessibility forms below or click on this link to download copies of these forms.

| Areas to be Assessed | Yes | No | Notes |
|---|---|---|---|
| **Building Exterior** | | | |
| Is there a drop-off point close to the main entrance? | | | |
| Are there any designated accessible parking spaces near your building? | | | |
| Is the outside of the building well lit? | | | |
| Are there any other barriers to the approach of your building? (i.e. uneven pavement, narrow path, kerb) | | | |
| Are your main entrance points clearly marked? | | | |
| What is the most accessible entrance for wheelchair users? | | | |
| Is access to the building on level ground?<br>• Is there a permanent ramp?<br>• Do you have portable ramps if required? | | | |
| Are there any steps into your building?<br>• Do the steps have handrails? | | | |
| Can a mobility-impaired person enter your building unaided?<br>• Are your main entry doors wide enough for easy wheel-chair access?<br>• Can they accommodate wide electric wheelchairs?<br>• Are the doors easy to open? | | | |
| What assistance or alternative service can you offer someone who is unable to enter your building? | | | |
| **Reception and Customer Service Areas** | **Yes** | **No** | **Notes** |
| Is signage clear? | | | |
| Are stairs or a lift required to access your services?<br>• Do steps have handrails?<br>• Are the lift locations clearly signed?<br>• Can wheelchair users use the lift without assistance? | | | |
| Can someone with mobility impairment access your services without assistance?<br>• Are information/payment counters low enough for a wheelchair user to access? | | | |
| Can someone with a visual impairment access your services without assistance? | | | |
| Can someone with a hearing impairment access your services without assistance?<br>• Does the building have an induction loop for individuals with hearing loss?<br>• Do you have access to interpreter services if needed? | | | |
| Does the reception area have space for someone to sit down if needed? | | | |
| Do you provide toilets for customers?<br>• Are there grab bars?<br>• Would a wheelchair user be able to use the toilet without assistance? | | | |

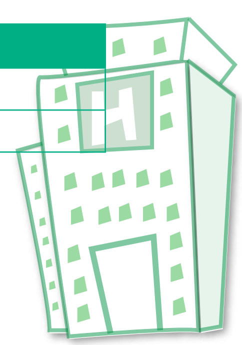
| Printed and Electronic Material | Yes | No | Notes |
|---|---|---|---|
| Do you offer materials in any of the following formats?<br>• Large print<br>• Easy-to-read format<br>• Audio recording<br>• Braille | | | |
| Does your website offer alternative reading formats? | | | |
| Do you use pictures or diagrams to illustrate complex concepts? | | | |
| Do you have a template for producing accessible printed materials within your organisation? | | | |
| Do you know how to modify accessibility options on your computer?<br>• Font type<br>• Font size<br>• Voice output<br>• Internet options | | | |
| **Staff Awareness** | **Yes** | **No** | **Notes** |
| Have you or any of your staff participated in disability awareness training? | | | |
| Are staff members aware of the role of the access officer? | | | |
| Are key staff members aware of accessibility standards? | | | |
| Is anyone in your office trained in using sighted guide techniques? | | | |
| Is there a written policy on accessibility of goods and services? | | | |
| Do staff members know where to go for additional information or support? | | | |
| Is disability awareness included in induction training for new staff? | | | |

## Availability of Gross Floor Area (GFA)

Another key issue to be assessed is whether the allowable GFA of the particular site has increased since the building was first constructed. Zoning and density often change over time to allow for smart growth and to address socioeconomic trends. If current benchmarks now allow for more GFA, adding to an existing building could be explored, in coordination with upgrading works. In some cases, if allowable GFA has increased significantly, there could even be a business case to tear down and rebuild rather than retrofit.

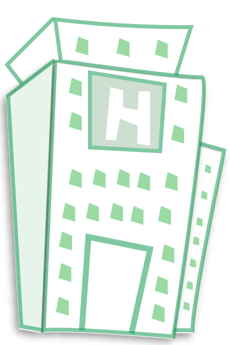
Consult the GFA form below or click on this link to download copies of this form.

| Description of Project | Results | Notes |
|---|---|---|
| No. of buildings on plot | | |
| Maximum height of buildings | | |



| Description of Project | Results | Notes |
|---|---|---|
| No. of plot(s) | | |
| (A) Plot area | | |
| (B) Building area | | |
| (c) Total floor area | | |
| Site Coverage (e.g. % of plots covered by building [B/A x 100] | | |
| Plot ratio (divide total floor area expressed in ratio e.g. 1:07) [1:C/A] | | |





## Section III

# THE GREEN CHECKLIST AND DISCUSSION GUIDE

Hospitals use the greatest proportion of energy during daily operations, when energy needs for heating water, lighting and telecommunications are most acute. Studies suggest that between 70 and 80% of greenhouse gas emissions (GHG) are released during this period. Because of the high level of carbon impact associated with the operational phase, it is essential to identify low-cost (often non-structural) measures that can be easily implemented. The Smart Hospitals Toolkit helps existing hospitals identify and implement low-cost adaptation measures.

Several green building rating systems exist: LEED (developed by the United States Green Building Council) and BREEAM (United Kingdom BRE Environmental Assessment Method) are two of the more well-known certification systems. Recognizing that health facilities require special attention due to the nature of their operations and services (often with strict regulatory requirements, 24/7 operations, and specific programmatic demands), LEED joined forces with the Green Guide for Health Care, a self-certifying toolkit that sets forth special requirements for hospitals and similar institutions, to create the rating system LEED for Health Care, which maintains close alignment to LEED for New Construction.

The Green Checklist developed for this Toolkit has adapted existing green building rating systems to the Caribbean context, ensuring that it covers both the building itself and the facility's operations. Achieving certification under existing green building rating systems will be difficult in the Caribbean, due to the systems' strict requirements, the absence of Caribbean environmental policies, as well as the cost and technical capacity available in the region. The Green Checklist outlines feasible areas and applies to planned renovation projects, which are an ideal opportunity to introduce 'smart' measures.

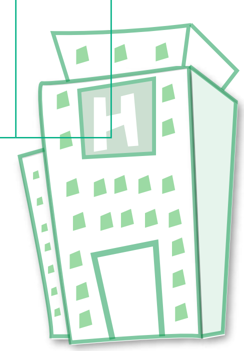
Consult the Green Checklist below or download the form through this link.

| SMART HOSPITALS INITIATIVE<br>GREEN HOSPITALS CHECKLIST | | | | | |
|---|---|---|---|---|---|
| CATEGORY | TITLE | INTENT | ACHIEVABILITY | | |
| | | | Yes | Planned | No |
| Renovations | | | | | |
| Water | Water Use Reduction | • Are you able to monitor water usage throughout your facility?<br>• Have you added a rainwater capture system?<br>• Are faucets and plumbing water efficient (e.g. low-flow faucets; dual flush toilets, etc.)?<br>• Does your facility have an educational program that highlights the need to conserve and use water efficiently? | | | |
| | Water-efficient Landscaping (no potable water used) | • Have you captured rainwater and installed a drip irrigation system for landscaped areas?<br>• Do you have space to install an aerobic sewage treatment system so that the effluent can be used for irrigation?<br>• Have you utilized local, drought-resistant species and mulch plantings? | | | |
| Energy and Atmosphere | Renewable Energy: On-site Generation | • Do you have an energy conservation plan?<br>• Has the facility's roof been assessed to ensure that it can accommodate a PV system and/or a solar hot water heater?<br>• Does your roof face south/southwest to allow for maximum solar exposure?<br>• Is your rooftop energy system secure against natural hazards? | | | |
| | Efficient Equipment/ Fixtures/Appliances | • Have you conducted an energy audit?<br>• Do you have an energy conservation plan?<br>• Are equipment and appliances energy-efficient rated (US/EU standards)?<br>• Have you replaced your light bulbs and electrical devices with more efficient models/ types? | | | |
| | Refrigerant Management | • Do you know what type of refrigerant your devices/appliances use?<br>• Have you phased out any devices that contain chlorofluorocarbons (CFC) and replaced them with devices that contain/ use refrigerants that have a reduced global warming potential (GWP) or less potent ozone depleting substances?<br>• Is your equipment serviced by a professional to reduce leakage /release into the atmosphere? | | | |
| Materials and Resources | Management of Construction Waste | • Does your construction company or public works department have a construction waste management plan? | | | |

| SMART HOSPITALS INITIATIVE<br>GREEN HOSPITALS CHECKLIST | | | | | |
|---|---|---|---|---|---|
| CATEGORY | TITLE | INTENT | ACHIEVABILITY | | |
| | | | Yes | Planned | No |
| | Sustainable Materials | • Have you ensured that the building materials/products utilized are rapidly renewable or have recycled content? | | | |
| | Mercury Elimination | • Have you replaced bulbs containing mercury?<br>• Have you phased out mercury-containing medical devices? | | | |
| | Eliminate Use of Persistent Bioaccumulative and Toxic Chemicals (PBTs) | • Can you avoid using building materials/products that contain Persistent Bioaccumulative and Toxic Chemicals (PBTs)? | | | |
| | Furniture and Medical Furnishings | • Have you procured furniture/furnishings that use wood from managed forests or that contain no PBTs, PVC, heavy metals or other harmful chemicals? | | | |
| Indoor Environmental Quality | Environmental Tobacco Smoke Control | • Is there a national no-smoking policy or can you establish a facility policy? | | | |
| | Natural Ventilation | • Have you checked that all windows are operable so that you can take full advantage of prevailing North-East Trade Winds? | | | |
| | Low-Emitting Materials | • Have you procured materials, furnishings, paints, sealants, adhesives, etc. with no or reduced amounts of Persistent Bioaccumulative and Toxic chemicals Volatile Organic Compounds (VOCs), Semi-volatile Organic Compounds (SVOCs), Halogenated Fire Retardants (HFR), heavy metals, phthalates, perfluorochemicals (PFCs) and other chemicals?<br>• Have you checked labels, ingredient lists, and material safety data sheets for hazardous components or requested these from suppliers?<br>• Have you issued specifications for composite wood products that contain no urea-formaldehyde resins?<br>• Have you procured paints without antimicrobial ingredients and metal products that are pre-painted?<br>• Do you avoid cleaning/sterilizing substances that contain volatile components such as Volatile Organic Compounds (VOCs), Semi-volatile Organic Compounds (SVOCs) and other harmful chemicals? | | | |





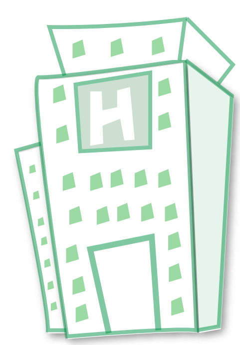


| SMART HOSPITALS INITIATIVE<br>GREEN HOSPITALS CHECKLIST | | | | | |
|---|---|---|---|---|---|
| CATEGORY | TITLE | INTENT | ACHIEVABILITY | | |
| | | | Yes | Planned | No |
| | Chemical and Pollutant Source Control | • Have you provided an entryway system, grills or mats that can capture dirt and particulates brought in from outside the facility?<br>• Can you procure equipment that is efficient and uses less hazardous chemicals?<br>• Have you labeled and properly stored all chemicals as per manufacturer's recommendations?<br>• Do you use natural cleaning products wherever and whenever possible?<br>• Have you ensured that pesticides and other chemicals used on the exterior of the facility are applied safely by a trained professional?<br>• Do you use local landscape plants/shrubs?<br>• Is there an incinerator onsite? If not, is there an alternative for waste disposal? | | | |
| | Controllability of Systems: Lighting | • Do you utilize daylight while eliminating direct sunlight?<br>• Have you used shade trees or shading devices on the exterior to eliminate direct sunlight from the building?<br>• Have you installed lighting controls such as light sensors and occupancy sensors in staff and patient areas?<br>• Have you provided individual lighting controls to enable adjustments to suit individual patient while limiting disturbance in multiple-patient areas? | | | |
| | Daylight and Views | • Have you added light shelves to reflect light further into the interior? | | | |
| **Operations** | | | | | |
| Chemical Management | Chemical Management Policy | • Has a national chemical management policy that aims to reduce the purchase and use of hazardous chemicals been developed? | | | |
| | Community Contaminant Reduction: Leaks and Spills | • Have you documented the purchase, delivery, storage and use of all hazardous chemicals and substances stored onsite?<br>• Have you provided secondary containment and security for substances stored outdoors, above ground or underground?<br>• Have you educated staff on proper handling and storage of chemicals and the proper procedures for spills/leaks? | | | |

| SMART HOSPITALS INITIATIVE<br>GREEN HOSPITALS CHECKLIST | | | | | |
|---|---|---|---|---|---|
| CATEGORY | TITLE | INTENT | ACHIEVABILITY | | |
| | | | Yes | Planned | No |
| | Indoor Chemical Contaminant Reduction: Hand Hygiene Products, Sterilization and High Level Disinfection | • Has a national policy been developed that prohibits the disposal of chemicals down drains?<br>• Have you phased out the use of Ethylene Oxide and high level disinfectants (glutaraldehyde and other hazardous substances) and replaced them with safer alternatives?<br>• Have you ensured that all sterilizing and disinfecting appliances are top-of-the-line and efficient?<br>• Have you replaced manual disinfection with automatic machine washers/disinfectors? | | | |
| | Pharmaceutical Minimization, Management and Disposal | • Have you created a policy that establishes procedures for procuring, storing, dispensing and proper disposal of all pharmaceuticals?<br>• Have you ensured that pharmaceuticals are ordered on an as-needed basis to minimize expiration and that expired/unused pharmaceuticals are properly disposed of?<br>• Have you ensured that safer alternatives, such as products that contain no Mercury or PBTs, are ordered? | | | |
| Solid Waste Management | Solid Waste Land Disposal | • Have you established a policy and guidelines to achieve zero waste and aligned your operations and procurement with this goal in mind?<br>• Have you minimized the sources of waste?<br>• Have you properly segregated waste at all times and stored it in a secured location until disposal?<br>• Have you ensured that the solid waste facility that accepts waste from your facility is well managed? | | | |



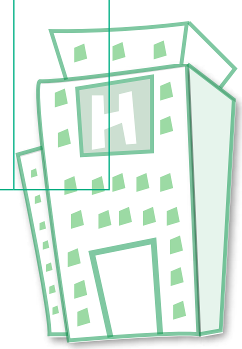




**SMART HOSPITALS INITIATIVE**
**GREEN HOSPITALS CHECKLIST**

| CATEGORY | TITLE | INTENT | ACHIEVABILITY | | |
|---|---|---|---|---|---|
| | | | Yes | Planned | No |
| | Solid Waste and Material Management: Waste Prevention and Reduction | • Have you made waste reduction a goal and ensured that all of your purchases—from high-end machinery and equipment to food and office supplies—are aligned with this goal?<br>• Have you streamlined and computerized procedures, printing on both sides of paper and purchased paper that contains recycled content?<br>• Have you procured or leased photocopiers and printers that are capable of printing on both sides?<br>• Have you made arrangements to ensure that biodegradable waste such as paper, cardboard, plant-based waste and food waste can be composted on-site, in the community or at a municipal or commercial facility? | | | |
| | Regulated Medical Waste Reduction | • Have you established a waste management policy that seeks to reduce overall waste generation, ensures that all waste generated is properly segregated and stored and ensures that staff is aware of and trained in the requirements of the waste plan?<br>• Do you avoid mixing infectious and other medical waste with regular garbage?<br>• Have you ensured that plastics, anything containing PVC, batteries, mercury-containing products and materials treated with flame retardants are not incinerated along with other medical waste and that an effort is made to reduce the purchase, use and disposal of these materials?<br>• Do you purchase supplies that use fewer raw materials and that generate less waste and are recyclable?<br>• Have you considered using alternative medical waste treatment technologies in an effort to reduce the volume of waste that is incinerated or disposed of in landfills? | | | |

| SMART HOSPITALS INITIATIVE<br>GREEN HOSPITALS CHECKLIST | | | | | |
|---|---|---|---|---|---|
| **CATEGORY** | **TITLE** | **INTENT** | **ACHIEVABILITY** | | |
| | | | **Yes** | **Planned** | **No** |
| Environmental Services | Environmentally Preferable Cleaning: Products, Materials and Equipment | • Do you procure cleaning products and materials that are environmentally benign or that are less toxic than other products and that still maintain the high level of cleanliness required in the facility?<br>• Have you ensured that disposable paper products, like paper and hand wiping towels, contain recycled content?<br>• Do you prohibit products that are manufactured with carcinogens, mutagens and teratogens; aerosols; asthma-causing agents, respiratory irritants, benzene-based solvents, very acidic or alkaline products; anti-microbial hand soaps; persistent, bioaccumulative and toxic chemicals (PBTs); and products requiring disposal as hazardous waste? | | | |
| | Integrated Pest Management | • Have you or the agency responsible for maintaining your facility developed and implemented an Integrated Pest Management program? | | | |
| Food Services | Sustainable Food Policy and Plan | • Have you developed a sustainable food policy and plan that seeks to make the procurement of food and food services in general more sustainable?<br>• Do you encourage farmers to shift from fertilizer and chemical-dependent farming to practices that are more closely aligned with natural processes? | | | |
| | Local, Sustainably Produced Food Purchasing | • Have you implemented a sustainable food plan and increased the procurement of locally and regionally sustainably produced foods? | | | |
| | Reusable and non-reusable Products: Food Service Ware, Non-Food Service Ware and Bottled Water Elimination | • Do you eliminate the use of disposable products (plastic, paper, styrofoam) in food services?<br>• Do you reduce the use of non-food service paper products such as paper towels and napkins?<br>• Have you eliminated or reduced the use of bottled water for patients? | | | |
| | Food Waste Reduction, Donation and Composting | • Have you examined ways to reduce food waste?<br>• Have you considered donating food that remains at the end of daily operations to food banks, churches and other community groups? | | | |



| SMART HOSPITALS INITIATIVE<br>GREEN HOSPITALS CHECKLIST | | | | | |
|---|---|---|---|---|---|
| **CATEGORY** | **TITLE** | **INTENT** | **ACHIEVABILITY** | | |
| | | | **Yes** | **Planned** | **No** |
| Environmentally Preferable Purchasing | Mercury Reduction | • Have you prepared a plan to phase out or replace items that contain mercury such as medical devices and light bulbs? | | | |
| | Electronics Purchasing and End of Life Management | • Have you ensured that electronic equipment is not disposed of in landfills or incinerated? | | | |
| | Solid Waste Reduction in Purchasing | • Have you ensured that your purchases are in line with the overarching goal to reduce solid waste generation and disposal? | | | |
| | Toxic Chemical Reduction in Purchasing | • Have you prepared a comprehensive list of materials, products and supplies that contain harmful chemicals and considered how they will be replaced or phased out?<br>• Have you investigated suitable, safer building materials if renovations or alternations are planned? | | | |

# Green Checklist
# Discussion Guide

## Renovations

### Water

#### Overview

One of the key benchmarks of environmental sustainability is the use of potable water. Reducing the amount of potable water used not only conserves water and saves money but also reduces emissions associated with pumping and treatment. Including a rainwater capturing system in your health facility is pivotal to reducing potable water use. Captured rainwater from roofs can be used to flush toilets, irrigate landscaping, and for other non-potable uses. Given the changing rainfall patterns, it is prudent for health facilities to consider the installation of cisterns and other rainwater capturing devices/features. These must be constructed/installed in compliance with building codes and regulations to ensure their safety against natural hazards (see the Guide for Evaluation of Small and Medium-Sized Facilities in Section 1).

#### Implementation Strategies

Reduced water use is a key step in making your health facility smart. Begin by determining baseline water usage, examining water bills for at least the three previous years. Refer to the Smart Hospital Baseline Assessment Tool (BAT) in Section 2 for a water audit worksheet.

#### Recommended Action Points

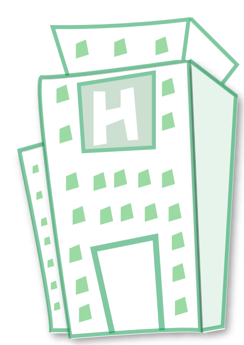
#### Water Use Reduction

- Add a rainwater capture system and access and upgrade plumbing to allow captured rainwater to be used for non-potable uses.

  *Note:* Consider installing a filtration and treatment system. Install a first flush diverter, as recommended by the Caribbean Environmental Health Institute (refer to the Resources at the end of this section for the link).
- Outfit your facility with high-efficiency plumbing fixtures, low-flow faucets, dual-flush toilets, motion-activated faucets or other innovative technologies to maximize water savings, regardless of whether or not rainwater is used in these faucets (refer to Resources section for the link to the U.S. EPA Water Sense Program/Products).
- Devise an education program for staff, patients and visitors, informing them of the need to conserve water. Highlight the fact that captured rainwater is used for all non-potable uses in your facility and point out the high-efficiency devices/appliances/fixtures.







### Things to Remember

- Have your roof inspected by an engineer to ensure that it can support the weight of a solar water heater.
- Have a licensed plumber inspect your plumbing, faucets and water-using devices.
- Consult Hospital Safety Index for further guidance.
- Refer to the Smart Hospital Baseline Assessment Tool (BAT) in Section 2 for a water audit worksheet.
- If you plan to install a cistern, ensure that it is not located in an area prone to flooding.

### Water Efficient Landscaping

- Install a rainwater capture system and use for irrigation, if needed.
- Use local, drought-tolerant species in your landscaping, as they are adapted to soil, temperature and water availability and will require less, if any, irrigation and maintenance.
- Consider installing an aerobic/oxygenated sewage treatment system where effluents can be used for irrigation.
- Use drip irrigation, as it is more efficient and delivers water where it is needed.
- Mulch landscape plantings to help retain moisture around the root system.
- Design your landscaping to include rain gardens that utilize storm water runoff generated from your roof or hardscape/impervious surfaces.

### Resources

- Rainwater Harvesting in the Caribbean: http://www.cehi.org.lc/Rain/index.html; http://cehi.org.lc/Rain/docs.html.
- A Toolbox on Rainwater Harvesting In the Caribbean: http://bit.ly/13H03kQ.
- Global Water Partnership - Caribbean: http://www.gwp.org/en/gwp-caribbean/.
- United States of America Environmental Protection Agency Water Sense Program: http://www.epa.gov/watersense.

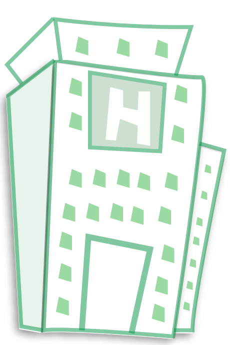
## Energy and Atmosphere

### Overview

Energy and the way it is used is the most significant contributor to climate change. Energy conservation and utilizing renewable energy will be significant factors in making your health facility 'smarter.' In the health sector, energy is consumed by lighting, large and small specialized equipment and devices, appliances and transportation. Although large specialized pieces of equipment are integral to the health sector, they consume a lot of energy. Significant savings can be achieved by ensuring that all electronic equipment, devices, appliances and fixtures are certified and labeled as energy efficient under American and European labeling system.

Changing from incandescent or other inefficient lights bulbs to more energy-efficient options can result in cost savings and reduced energy usage which results in reduced emis-





sions and reduced demand.  However, simply switching to more efficient light bulbs is not enough. Energy conservation must be an overarching goal. If your country has not yet phased out the use of incandescent light bulbs, replacing them with efficient bulbs, consult the U.N. Environment Programme's *en.lighten* initiative (http://www.enlighten-initiative.org/).

### Implementation Strategies

Establish baseline energy usage by examining electricity bills or usage information from your utility company for at least the three previous years. Refer to the Smart Hospital Baseline Assessment Tool (BAT) for the energy audit worksheet.

Photovoltaic (PV) systems capture energy from the sun and convert it into electricity, thereby reducing energy generated via fossil fuels. Consult with your utility company to determine any policies and safeguards regarding the installation of a PV system. For safety reasons, a grid-connected PV system will not be operational when the grid is offline Therefore, although going completely off-grid is possible, the cost of purchasing and maintaining the batteries that store the energy from the PV system will be significant. Improved battery technology may make this option more feasible in the near future.

### Recommended Action Points

#### Renewable Energy

- Develop an energy conservation plan, as this is the most cost-efficient way to reduce energy use.
- Install a rooftop or on-site PV system to offset as much of your electricity use as possible.

  *Note:* Ensure that you have sufficient space on your roof, that the roof can support the weight of the system, is secure against natural hazards and that the roof faces the south/southwest to allow for maximum solar exposure.  (Panels can be tilted if required.) Roof assessment can be guided by the Hospital Safety Index.  Also note that in countries where there is a volcanic hazard, panels can be affixed to the walls of the structure or on hip roofs that are designed to allow the ash to fall off during a volcanic event. All systems must be properly secured to withstand the natural hazards that affect the Caribbean.
- If space, location, prevailing wind direction and building codes allow, consider installing wind turbines in addition to or along with a PV system.

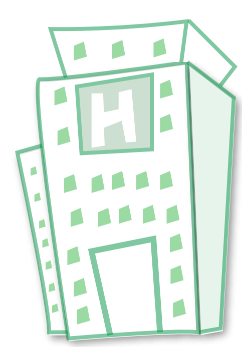
  *Note:* Ensure that your turbine is designed to automatically shut off during periods of strong winds typically associated with tropical storms and hurricanes that affect the region. Also ensure that your turbine is securely erected.
- Consider installing solar hot water heaters instead of or to supplement electrical heaters.

  *Note:* Roof assessments can be guided by the Hospital Safety Index.  Any roof-mounted solar hot water heaters must be properly secured to withstand natural hazards that affect the Caribbean.

#### Efficient Equipment/Fixtures/Devices and Features

- Replace incandescent light bulbs or other inefficient bulbs with fluorescent bulbs with electronic ballasts or LED bulbs, if suitable for the application.



*Note:* LEDs are the most efficient light bulbs available on the market today but may not be suitable for all areas in a health facility. They last much longer, use less electricity and contain no mercury; however, they cost more.

- Replace existing magnetic ballasts (some of which may contain PCBs) with electronic ballasts.
- Replace T12 technology with retrofit LED or T8 or T5 fluorescent technology to suit the application.

  *Note:* Ensure that the energy replacement provides the lighting performance and quality that is required by the application. When making significant changes, consult an engineer or lighting designer to ensure appropriate lighting levels will be provided after the retrofit program is completed.

  LED technology has improved in the past years, however it has generally not surpassed linear fluorescent (T8s T5s) in terms of performance at the colour temperatures required for indoor applications. High K values such as 5,000K and 6,000K definitely are very efficient, but contain too much blue light for most indoor health care applications. LED colour temperatures in the 3,000K-3,500K range are generally comparable to fluorescent lamp outputs if considering high quality LED products from reputable vendors. One of the challenges in operation is heat and dissipation of the heat. Installing in tight ceiling spaces which may be subject to high ambient temperatures could impact projected product life and should be taken into consideration.
- Upgrade/replace your equipment, be it medical or office equipment, with energy efficient models. (See Resources section below for link to the U.S. EPA Energy Star Program/Products)
- Buy equipment that is made for your energy system to avoid using transformers, as they waste energy.
- Insulate your roof to reduce heat transfer into the facility and paint it a light colour such as grey or white (if surrounding uses will not be impacted by glare).

### Refrigerant Management

- Ensure that all refrigerant-containing equipment and appliances do not use CFCs and plan to phase-out/upgrade existing equipment that contains CFCs. Weigh carefully refrigerant options, as some chemicals that do not contribute to ozone depletion contribute significantly to global warning. Opt to buy equipment that uses refrigerants that contain less potent ozone-depleting substances (ODSs) and with reduced global warming potentials (GWPs).
- Have trained professionals service your refrigerant-containing equipment on a regular basis in an effort to reduce leakage/release into the atmosphere.
- Procure equipment with increased equipment life and reduced refrigerant charge.
- Do not install fire suppression systems that contain ozone-depleting substances (CFCs, HCFCs or Halons).

| Ozone Depleting (ODP) and Global Warming Potential (GWP) of Refrigerants | | | |
|---|---|---|---|
| **Refrigerant** | **ODP** | **GWP** | **Common Building Application** |
| **Chlorofluorocarbons** | | | |
| CFC-11 | 1.0 | 4,680 | Centrifugal chillers |
| CFC-12 | 1.0 | 10,720 | Refrigerators, chillers |
| CFC-114 | 0.94 | 9,800 | Centrifugal chillers, |
| CFC-400 | 0.605 | 7,900 | Centrifugal chillers, humidifiers |
| CFC-502 | 0.221 | 4,600 | Low-temperature refrigeration |
| **Hydrochlorofluorocarbons** | | | |
| HCFC 22 | 0.04 | 1,780 | Air-conditioning, chillers |
| HCFC-123 | 0.02 | 76 | CFC-11 replacement |
| **Hydrofluorocarbons** | | | |
| HFC-23 | ~0 | 12,240 | Ultra-low-temperature refrigeration |
| HFC-134a | ~0 | 1,320 | CFC-12 or HCFC-22 replacement |
| HFC-245fa | ~0 | 1.020 | Insulation agent, centrifugal chillers |
| HFC-404A | ~0 | 3,900 | Low-temperature refrigeration |
| HFC-407C | ~0 | 1,700 | HCFC-22 replacement |
| HFC-410A | ~0 | 1,890 | Air conditioning |
| HFC-507A | ~0 | 3,900 | Low-temperature refrigeration |
| **Natural Refrigerants** | | | |
| Carbon Dioxide ($CO_2$) | 0 | 1.0 | |
| Ammonia | 0 | 0 | |
| Propane | 0 | 3.0 | |

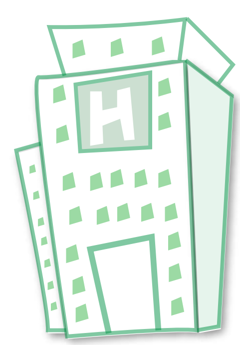
Source: Green Guide for Health Care: Best Practices for Creating High Performance Healing Environments, January 2007.

### Things to Remember

- Have your roof inspected by a structural engineer to ensure that it can support the weight of a PV system and/or a solar water heater.
- Check with your utility company to determine policies and regulations regarding PV systems
- Consult the Hospital Safety Index for further guidance.
- Refer to the Smart Hospital Baseline Assessment Tool (BAT) in Section 2 for an energy audit worksheet.

## Resources

- United States Environmental Protection Agency and Department of Energy, Energy Star Program Product Guide: http://1.usa.gov/ZSaUbl.
- United States Environmental Protection Agency Ozone Layer Protection-Science: http://www.epa.gov/ozone/science/ods/index.html.



## Materials and Resources

### Overview

The selection of materials and resources used during construction or renovations, as well as the interior furnishings and furniture, offers a significant opportunity to reduce your carbon footprint and overall environmental impact and make your facility 'smart' and 'green.' Utilizing rapidly renewable wood and products that contain recycled components helps to protect virgin resources and reduces the impact of extraction, transportation and processing.

Debris from construction or renovation activities can be significant. Most of the waste likely ends up in a landfill or incinerator, where is can contribute to environmental degradation. However, proper construction management can eliminate some of the waste generated or redirect certain items to organizations, groups and individuals.

Toxic chemicals that can be found in building products and materials are of concern. Mercury, for instance, is known to be harmful to humans, especially to developing fetuses. It is also one of several chemicals cited as persistent bioaccumulative and toxic chemicals (PBTs). With no program in place for handling mercury-containing waste, it is likely that these products would be incinerated or placed in landfills, where they can pollute soil and water. Burning mercury releases it into the atmosphere. Health Care Without Harm (HCWH) and the World Health Organization are working to eliminate mercury from the health sector and find safer alternatives. Other PBTs specifically addressed include dioxins, cadmium and lead, all of which are known to be harmful to human health and are found in building products.

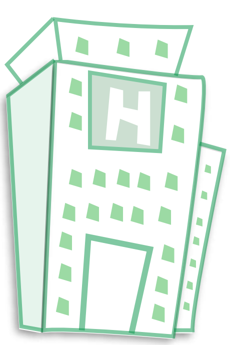
### Implementation Strategies

Procurement choices impact your indoor environmental quality and the environmental, so consider the components of your building materials, furniture and furnishings. Construction debris, furniture, furnishings and other material that are incinerated release greenhouse gases and other pollutants and chemicals into the atmosphere. The ash that remains after incineration is hazardous waste and should be properly handled and disposed of. When this material is disposed of in landfills, it can lead to land and water pollution and the release of gases into the atmosphere.

### Recommended Action Points

#### Management of Construction Waste

- Practice proper construction management to reduce waste. Consider donating usable construction waste and materials such as doors, windows, faucets, etc. to organizations, groups and community members who could use the materials.



#### Sustainable Materials

- When selecting materials, ensure that you specify materials that are rapidly renewable, originate from sustainably managed forests, contain recycled content, or are themselves recyclable to the extent possible. Also consider using materials that were salvaged from renovation or construction projects.

*Note:* Ensure that salvaged materials are suitable for re-use in a health care setting.

### Mercury Elimination

- Specify and install low-mercury fluorescent lamps or LED light bulbs that contain no mercury. Keep in mind that fluorescent and LED light bulbs use less energy.

  *Note:* Mercury is released into the atmosphere when mercury-containing bulbs are broken. Handle with care, ensuring that the area is well ventilated and they are properly disposed of. Disposing mercury-containing bulbs in landfills may result in land contamination. Likewise, incineration releases methlymercury into the atmosphere.

### Elimination of Persistent Bioaccumulative and Toxic Chemicals (PBTs)

- Avoid the use of building materials that contain PBTs or whose production or incineration results in the release of these substances into the atmosphere.

  *Note:* (Lent, 2007) provides the following table of chlorinated plastics to avoid in building materials and to avoid burning:

| | |
|---|---|
| Chlorinated polyethylene (CPE also brand name Tyrin) | Used in buildings primarily as an additive to PVC in windows, pipes and cables. |
| Chlorinated polyvinyl chloride (CPVC) | Primarily used for hot water pipes. |
| Chlorosulfonated polyethylene (CSPE, also known by the brand name Hypalon) | Used in buildings primarily for single ply roofing membranes, geomembranes and other coated fabrics. |
| Polychloroprene (CR or chloroprene rubber, also known by the brand name Neoprene) | Used in adhesives, gaskets, hot tar flashings, expansion joint filler, geomembranes and coatings. |
| Polyvinyl chloride (PVC) | By far the largest bulk of chlorinated plastics found in building materials. PVC is used in piping, roof membranes, window frames, siding, carpet backing, resilient flooring, ceiling tiles, window treatments, wall coverings and wall protection. |

Green Guide for Health Care Technical Brief *PBT Elimination from Building Materials* (Lent, 2007, p. 5) also notes the uses of some PBTs containing materials and alternatives.

### Lead

Lead is used in solder, roofing, gutter and flashing products, radiation shielding, and batteries and as a stabilizer in PVC products. In the past, it was used in paints and pipes and is considered a hazard in older buildings and demolition projects.

- Specify 100% lead-free solders. (Note that solders marketed as 'lead-free' can still legally contain >0.2% lead.)
- Avoid terne and copper roofing, flashing and gutter products.
- A major use of lead in PVC products is in the insulation jacketing for wiring. Specify lead-free jacketing where available. (Also note that Teflon®-jacketing should be avoided).
- Green Seal certified paints are assured to be free of cadmium and lead.

### Cadmium

Cadmium is used in paints, coatings, and batteries and as a stabilizer in PVC products.

While lead has been largely eliminated from paints, cadmium remains a widely used pigment.

- Green Seal certified paints are assured to be free of cadmium and lead.
- Review material MSDS sheets if concerned that a material may contain cadmium.

The Green Guide for Health Care (hCare, 2007) asks to "[c]onsider materials that are not manufactured with chlorine or other halogens. Options include (but are not limited to) TPO, EPDM, and FPO [thermoplastic polyolefin, ethylene propylene diene monomer, flexible polyolefin] for roof membranes; natural linoleum, rubber, or alternate polymers for flooring and surfacing; natural fibers, polyethylene, polyester and paint for wall covering; polyethylene for wiring; wood, fiberglass, [high density polyethylene] HDPE, and aluminum with thermal breaks for windows; and, copper, cast iron, steel, concrete, clay, polypropylene and HDPE for piping."

### Furniture and Medical Furnishings

- Procure furniture and furnishing that are sourced from managed forests or are free of heavy metals, PVC, PBTs and other harmful chemicals. The following table lists building products, components and materials to avoid, suggesting safer alternatives:

| Product/Material | Avoid | Use |
|---|---|---|
| Roof Membrane | Lead, Cadmium, chlorine, halogens, heavy metals, fire retardants, chlorinated polyethylene (CPE also known by the brand name Tyrin), chlorinated polyvinyl chloride(CPVC), chlorosulfonated polyethylene (CSPE, also known by the brand name Hypalon, polychloroprene (CR or chloroprene rubber, also known by the brand name Neoprene), polyvinyl chloride (PVC), Teflon | Thermoplastic polyolefin, ethylene propylene diene monomer, flexible polyolefin |
| Flooring/Surfacing | | Natural linoleum, rubber, or alternate polymers |
| Wall Coverings | | Natural fibers, polyethylene, polyester and paint |
| Paint | | Green Seal or similarly certified paints. |
| Wiring | | Polyethylene |
| Windows | | Wood, fiberglass, HDPE, and aluminum with thermal breaks |
| Piping | | Copper, cast iron, steel, concrete, clay, polypropylene and HDPE, lead-free solder |

### Resources

- Articles, case studies, etc. on green building products:
  http://www.buildinggreen.com/
  http://www.mercuryfreehealth care.org/
  http://noharm.org/all_regions/issues/toxins/mercury/
- Sustainable Hospitals – Alternatives to mercury-containing equipment: http://www.sustainablehospitals.org.
- Green Guide for Health Care, Technical Briefs: http://www.gghc.org/tools.technical.php.

## Indoor Environmental Quality

### Overview

Indoor Environmental Quality (IEQ) is important in health facilities because it can negatively impact the health of staff, patients and visitors. IEQ is related to ventilation, which is related to building design, window placement, prevailing winds, and energy use (in cases where mechanical ventilation is used). Many factors impact indoor air quality: building products, furnishings, furniture, paint, floor coverings, sealants, adhesives, varnishing, equipment, mold and other biological agents, cleaning products, tobacco smoke, chemicals, etc. Without proper ventilation, the levels of gases, chemicals and particulates can be higher indoors than outside.

Of importance to IEQ are the products and materials used on and in the building's interior and the chemicals they contain. Proper ventilation or choosing safer alternatives can significantly reduce indoor pollution.

## Implementation Strategies

When choosing products and materials for your structure, consider the components, who uses the facility and may potentially be exposed, if there is adequate ventilation to move gases, particulate matter and pollutants out of the structure and if safer alternatives are available on the market.

## Recommended Action Points

### Environmental Tobacco Control

- Establish a policy that prohibits smoking in the facility.

  *Note:* A government regulation may need to be enacted that prohibits smoking in public facilities. If a smoking area is designated, make sure it is at least 50 feet from the facility to reduce the impact of smoke on patients, staff and visitors and to prevent interior surfaces from absorbing the smoke. Ensure that the smoking area is downwind and away from main entrances/exits, windows, air conditioning units and air intakes.

### Natural Ventilation

- Ensure that all windows are operable to take full advantage of prevailing breezes.

  *Note:* Despite the energy savings and reduced environmental impact, it may not be practical to use natural ventilation at all times. Therefore, buildings should be constructed with mechanical and natural ventilation in mind. Certain areas of the hospital must be mechanically ventilated, while natural ventilation is appropriate for other areas of the hospital and could be coupled with ceiling/destratification fans to improve occupant comfort (without having to actually reduce the ambient temperature of a space).

A properly maintained mechanical ventilation system will likely provide better air quality than outdoor air, as the filtering process will remove a number of particulates, etc.

### Low Emitting Materials

- Specify materials that contain no or reduced amounts of Persistent Bioaccumulative and Toxic chemicals (PBTs), Volatile Organic Compounds (VOCs), Semi-volatile Organic Compounds (SVOCs), Halogenated Fire Retardants (HFR), heavy metals, phthalates, perfluorochemicals (PFCs) and other chemicals that can pose harm to installers, staff, patients and visitors.

*Note:* If possible, allow the building to air out properly after products that contain the chemicals noted above have been installed or applied.

- Specify composite wood products that contain no urea-formaldehyde resins.
- Avoid using furniture that contains foam, as it is likely treated with a variety of flame-retardants. Use furniture with mesh instead.
- Avoid paints with antimicrobial ingredients and, if possible, specify metal products that are pre-painted.
- Avoid cleaning/sterilizing substances that contain volatile components. Use dry-applied substances instead of wet-applied chemicals.

> **Things to Do**
>
> - Encourage regional paint manufacturers to have their products Green Seal or GREENGUARD certified.

### Chemical and Pollutant Source Control

- Provide an entryway system, grills or mats to capture dirt and particulates brought in from the exterior; clean these often.
- Specify equipment that is efficient and that uses less hazardous materials.
- Correctly label and properly store all chemicals as per manufacturer's recommendations.
- Use natural cleaning products wherever and whenever possible and ensure that they are not highly scented. Use dry-applied products instead of sprays.

  *Note:* Ensure that products provide the level of disinfection needed in the facility.
- Ensure that pesticides and other chemicals used on the exterior of the facility are applied safely by a trained professional and that only the amounts required are used.
- Do not use landscape plants or shrubs that will require synthetic inputs, instead use local, hardy, resistant species.
- Do not incinerate waste onsite.

  *Note:* If onsite waste incineration cannot be avoided, locate the incinerator downwind from facility and ensure that there are no air intakes nearby.

### Control of Lighting Systems: Lighting

- Utilize as much daylight as possible, while minimizing direct sunlight.
- If feasible, use shade trees or shading devices on the exterior to prevent direct sunlight from entering the building.

  *Note:* Shading devices could also serve as hurricane shutters.
- Use lighting controls such as light sensors and occupancy sensors for staff and patient areas.
  - Provide individual lighting controls to enable adjustments to suit individual patient needs and preferences and to limit disturbance in multiple-patient areas.

    Note: It is important that energy-efficient light bulbs are used in combination with lighting controls to achieve maximum cost savings.
  - Consider using light shelves to reflect light further into the interior.

### Resources

- Unites States Environmental Agency: Indoor Air Pollution: An Introduction for Health Professionals: http://www.epa.gov/iaq/pubs/hpguide.html.
- Whole Building Design Guide: Natural Ventilation: http://www.wbdg.org/resources/naturalventilation.php.
- GREENGUARD Environmental Institute was founded in 2001 and seeks to protect human health and quality of life by improving indoor air quality and reducing chemical exposure. The GREENGUARD Certification Program helps manufacturers create, and buyers identify, interior products and materials that have low chemical emissions, improving the quality of the air in which the products are used. http://www.greenguard.org/en/index.aspx.
- GreenSeal, developed in 1989, as an independent non-profit organization dedicated to safeguarding the environment and transforming the marketplace by promoting the manufacture, purchase, and use of environmentally responsible products and services. http://www.greenseal.org/.
- The Green Label and Green Label Plus testing programs, overseen by independent labs, are designed for architects, builders, specifiers and facility managers who want assurances that carpet and adhesive products meet the most stringent criteria for low chemical emissions and help improve indoor air quality. Currently, carpet, cushion and adhesives as well as vacuum cleaners are tested in these programs. http://www.carpet-rug.org/about-cri/cri-signature-programs.cfm.
- Whole Building Design Guide: Energy Efficient Lighting: http://www.wbdg.org/resources/efficientlighting.php.
- Whole Building Design Guide: Electric Lighting Controls: http://www.wbdg.org/resources/electriclighting.php.

# Operations

## Chemical Management

### Overview

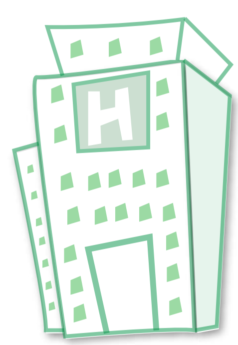
Chemicals are prevalent in the health sector. They are used in building maintenance, infection control and in the overall provision of health care to patients. Some components of the pharmaceuticals, products and devices used are considered to be harmful and toxic.

Chemicals and fuels in or around the health care facility should be used with caution to prevent contamination and reduce exposure to staff, patients, visitors and the surrounding community. It is not safe to dispose of liquid waste that contains cleaning or disinfection agents down drains and this method of disposal is not recommended under any circumstances. Antibacterial/antimicrobial products and sterilization and disinfecting chemicals also are commonly used in the health sector. However, the effects of some of these chemicals on living organisms are coming to light. The effects of exposure to these agents needs more study, but they should raise concern.

Pharmaceuticals minimization, management and disposal is also of concern because medicine intended for human use may have completely unexpected and unwanted effects







on other organisms, so proper management and disposal are required. Neither disposal in landfills nor incineration is appropriate for pharmaceuticals because of the potential for land, air and water contamination. Pharmaceuticals should never be disposed of down drains.

### Implementation Strategies

Chemical management in a health care setting should be a priority, given the potential negative ecological and human impact. Every effort should be made to ensure that all chemicals and pharmaceuticals are used and disposed of properly.

### Recommended Action Points

#### Chemical Management Policy

- Develop a chemical management policy that aims to reduce the use of hazardous chemicals by purchasing less hazardous/toxic and more environmentally-benign alternatives. Ensure that the policy addresses purchasing, receiving, transporting, storage, handling and use of chemicals. Emphasize that discharges of cleaning and other chemicals down drains or into the septic or sewer system is prohibited unless specifically stated as an appropriate disposal method by the manufacturer, suppliers or the safety instructions included with the product.

  *Note:* Pay special attention to areas of the health facility such as laboratories, dental offices, building system operations, environmental services, food services, and diagnostic and treatment areas, where hazardous materials/substances may be used or generated. Some chemicals to watch for include solvents and disinfectants, soaps, chlorine, radioactive substance and gluteraldehyde.

  If the facility is mechanically ventilated, chemicals should be stored in areas with a negative pressure to that of surrounding areas and the exhaust air from these spaces should not be mixed with the incoming fresh air supply. This mitigates the potential transmission of odours throughout the building and exposure from the re-introduction of those exhausted from the building.

#### Community Contaminant Reduction: Leaks and Spills

- Properly document the purchase, delivery, storage and use of all hazardous chemicals and substances stored onsite. This will assist with leak detection.
- Provide secondary containment and security for substances stored outdoors, above ground or underground to further ensure against leaks and spills.
- Educate staff on proper handling and storage of chemicals and the proper spill/leaks procedures.

#### Indoor Chemical Containment Reduction: Hand Hygiene Products, Sterilization and High-Level Disinfection

- Ensure that a policy exists that prohibits the disposal of chemicals down drains and that training for staff is included.
- Phase out the use of Ethylene Oxide and the high-level disinfectant (HDL) glutaraldehyde and other hazardous substances and replace with safer alternatives.

*Note:* Alternatives to Ethylene Oxide include other low temperature sterilization methods such as vaporized hydrogen peroxide, hydrogen peroxide-gas plasma, liquid peracetic acid, and ozone.

- Purchase non-hazardous chemicals and/or determine opportunities to reduce highly hazardous materials.
- Ensure that all sterilizing and disinfecting appliances are top-of-the-line and efficient in an effort to reduce the use and disposal of chemicals.
- Replace manual disinfection with automatic machine washers/disinfectors to minimize staff exposure to liquid disinfectants.

### Pharmaceutical Minimization, Management and Disposal

- Establish procedures for procuring, storing, dispensing and proper disposal of all pharmaceuticals. Be sure to emphasize that pharmaceuticals are not to be disposed of down drains or into septic or sewer systems.
- Ensure that pharmaceuticals are ordered on an as-needed basis to minimize expiration and disposal of unused portions. Investigate whether or not suppliers/manufacturers will be willing to take back un-dispensed and/or expired pharmaceuticals.
- Ensure that expired/unused pharmaceuticals are properly disposed of. Disposal in landfills is not appropriate, as chemicals can contaminate soil and groundwater. Incineration also releases chemicals into the atmosphere and the residue from burning may be considered hazardous waste. See GGHC recommendations in the Resources section.
- Work with national or regional organizations/agencies to research and order safer alternatives, such as products that contain no mercury or PBTs, to the extent possible. Procure products with less packaging, especially if they contain hazardous chemicals/components, as the packaging could be considered hazardous as well.

  Although not all of the following are applicable to the Caribbean setting, GGHC (Care G. G., 2008, pp. 8-26) recommends these measures to minimize the generation of pharmaceutical waste:
  - Improve inventory control processes.
  - Reduce the number of pharmaceuticals dispensed and returned that cannot be re-prescribed.
  - Substitute less toxic pharmaceuticals or mechanical methods for products containing toxic substances such as persistent bioaccumulative toxic chemicals (PBTs).
  - Minimize packaging and container weight of pharmaceutical products and formulations.
  - Minimize personal protective equipment waste. Mix chemicals in batches, minimize spills, and institute regular staff training.
  - Institute best management practices for the handling and disposal of pharmaceuticals that act as teratogens, mutagens, carcinogens, endocrine disruptors, reproductive and developmental toxicants or pose a threat to ecosystem health.

    *Note:* Until new technologies have been developed and legalized, the best management practice for disposal of non-regulated pharmaceuticals is incineration with regulated medical waste. As a result, facilities should actively minimize pharmaceutical waste wherever possible.

- Utilize stock rotation strategies to rotate pharmaceuticals close to the expiration date back into high use areas such as crash carts or the pharmacy as a means of minimizing pharmaceutical waste.
- Ensure all pharmaceutical samples are logged into the facility, and only allow those samples with an expiration of one year or longer.
- Discontinue disposal of all pharmaceuticals in sewers where possible and advocate updating state regulations to prohibit this practice.
- Examine all non-hazardous pharmaceutical waste and segregate it into dedicated containers for disposal.
- Avoid uncontrolled disposal of mercury-containing drugs, diagnostic agents (e.g., Thiomersal®), disinfectants (e.g., Merbromin®, Mercurochrome® and Nitromersol®), and diuretic agents (e.g., mercurophyllin).

### Things to Remember

- Ensure that lab equipment functions properly and works efficiently in respect to the chemicals required and that plans are in place to upgrade inefficient/outdated equipment.
- Include an education component in the policy, as it is important that all members of staff are aware of usage, storage and handling requirements and proper disposal practices.
- Encourage and work with your government to develop a national pharmaceutical management and disposal policy.

## Resources

- Material Safety Data Sheets: http://www.msds.com/.
- Centers for Disease Control and Prevention: Guideline for Disinfection and Sterilization in Health Care Facilities, 2008: http://www.cdc.gov/hicpac/Disinfection_Sterilization/toc.html.
- Centers for Disease Control and Prevention: Hand Hygiene in Health Care Settings: http://www.cdc.gov/handhygiene/.
- Health care Environmental Resource Center: http://www.hercenter.org/hazmat/steril.cfm.
- Practice Greenhealth: Sterilants and Disinfectants: http://practicegreenhealth.org/topics/chemicals/sterilants-disinfectants.
- World Health Organization (WHO), Hand hygiene guideline: http://www.who.int/patientsafety/events/05/HH_en.pdf.
- Sustainable Hospital Project, "List of Mercury-free Alternatives in the Lab." http://www.sustainablehospitals.org/cgi-bin/DB_Report.cgi?px=W&rpt=Cat&id=18.
- Labs for the 21st Century, http://www.labs21century.gov.
  - Practice Greenhealth: Chemicals: http://practicegreenhealth.org/topics/chemicals.
  - Green Guide for Health Care Technical Briefs: Pharmaceutical Management Technical Brief: http://www.gghc.org/tools.technical.php.
  - Practice Greenhealth: Pharmaceutical Waste http://practicegreenhealth.org/topics/waste/waste-categories-types/pharmaceutical-waste.

## Solid Waste Management

### Overview

Health care facilities generate large amounts of waste, most of which is regular, solid waste that can be handled and disposed of normally. All waste should be separated at the point of origin in properly labeled containers that can be sealed to avoid pests; waste should be stored in a secure location and transported to a secure disposal or incineration site.

Because of space constraints, incineration is likely the disposal method of choice in the Caribbean region, but there are serious issues associated with burning waste. (Harm, Waste Management) "[i]n many developing world hospitals, all of this trash is mixed together and burned in low tech, highly polluting incinerators, or in the open with no controls whatsoever. It is now well established that incinerating medical waste produces large amounts of dioxin, mercury and other pollutants. These end up in the air, where they can be transported thousands of miles to contaminate the global environment, or in the ash, which is frequently dumped without thought for the load of persistent toxins that it carries." The World Health Organization (2012) recommends the following for the incineration of medical waste:

- Good practices in incinerator design, construction, operation (e.g., pre-heating and not overloading the incinerator, incinerating only at temperatures above 800°C), maintenance and lowest emissions;
- The use of waste segregation and waste minimization practices to restrict incineration to appropriate infectious wastes;
- Availability of good practices and tools, including dimensional construction plans, clear operational guidelines, etc.;
- Correction of current deficiencies in operator training and management support, which lead to poor operation of incinerators;
- Materials containing chlorine such as polyvinyl chloride products (e.g., some blood bags, IV bags, IV tubes, etc.) or heavy metals such as mercury (e.g., broken thermometers) should never be incinerated.

### Implementation Strategies

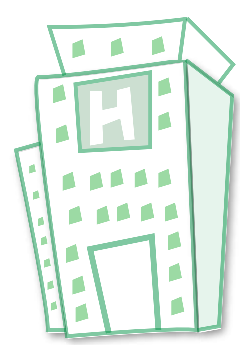
Any efforts to manage waste should include efforts to reduce overall waste. Waste minimization practices can be achieved through training, policy changes and procurement practices. Phasing out and computerizing forms along with double-sided printing will reduce paper waste. Importantly, minimizing the amount of waste that is disposed of also depends on a national recycling program. Paper, plastic, metal and glass can all be recycled and turned into useful products.

### Recommended Action Points

#### **Solid Waste Land Disposal**

- Reduce sources of waste as much as possible.





- Establish a policy and guidelines to achieve zero waste through composting and/or recycling and align your operations and procurement with this goal in mind.

  *Note:* The policy should include requirements and guidelines for composting organic, non-infectious waste and recycling.
- Keep waste properly segregated at all times and stored in a secure location until it is collected for disposal.
- Ensure that the solid waste facility that accepts your facility's waste is well-managed, thereby reducing the potential for soil and groundwater contamination. It may be necessary to work with the government so that landfills are adequately constructed, lined, secure and safely operated.
- Biological waste should be disposed as recommended by national regulations.

### Solid Waste and Material Management: Waste Prevention and Reduction

- Make waste reduction a goal and ensure that all of your purchases—from high-end machinery and equipment to food and office supplies—are aligned with this goal.
- Streamline and computerize procedures so that less paper waste is generated and if, possible, buy paper that contains recycled content and print on both sides. Procure or lease photocopiers and printers that are capable of printing on both sides.
- Biodegradable waste, such as paper, cardboard, plant-based waste and food waste, can be composted on-site, in the community or at a municipal or commercial facility.

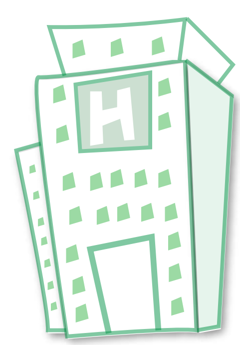
### Regulated Medical Waste Reduction

- Establish a policy that seeks to reduce overall waste generation, ensures that all medical waste is properly segregated at the point of origin into properly labeled receptacles, i.e. avoid mixing infectious and other medical waste with general garbage; ensure that staff is aware of and trained in the requirements of the waste plan.
- Ensure that plastics, anything containing PVC, batteries, mercury-containing products and materials treated with flame retardants are not incinerated along with other medical waste, as they release toxic and carcinogenic compounds into the air when incinerated. Additionally, the ash that remains when these materials are burnt is hazardous itself. Put policies in place to reduce the purchase, use and disposal of these materials.
- Consider using alternative medical waste treatment technologies in an effort to reduce the volume of waste that is incinerated or disposed of in landfills. The following table provides a brief description, the capacities and approximate costs in $US of some the alternative waste treatment technologies.

| Alternative Health Care Waste Management Treatment Technologies | | | | |
|---|---|---|---|---|
| **Type of Technology** | **Description** | **General operating process** | **Range of capacities** | **Approximate capital cost in USD** |
| Standard gravity-fed autoclave | Technology consists of a pressure vessel, typically cylindrical or rectangular, with or without steam jacket and designed to withstand elevated pressures. Steam is introduced by gravity displacement | • Waste is placed inside the autoclave.<br>• Pressurized steam is introduced at a minimum of 121°C.<br>• Waste is exposed to the steam.<br>• Waste | 20 kg/hr to 3000 kg/hr; smaller units are available | $30,000 to 200,000; small units cost about $100 |
| Standard prevacuum autoclave | Technology consists of a pressure vessel, typically cylindrical or rectangular, with or without outer steam jacket and designed to withstand elevated pressures. A vacuum is used to remove air and then steam is introduced. | • Waste is placed inside the autoclave.<br>• A vacuum is used to remove air.<br>• Pressurized steam is introduced at a minimum of 121°C.<br>• Waste is exposed to the steam.<br>• Steam is removed as condensate.<br>• Waste is removed and processed in a shredder if desired.<br>• Some technologies compact the waste. | 15 kg/hr to 1000 kg/hr | $30,000 to 500,000 |
| Pulse-Vacuum autoclave | Technology consists of a pressure vessel, typically cylindrical or rectangular with or without outer steam jacket and designed to withstand elevated pressures. Two or more cycles of vacuum and steam injection are used. | • Waste is placed inside the autoclave.<br>• A vacuum is used to remove air.<br>• Pressurized steam is introduced at a minimum of 121°C.<br>• Waste is exposed to the steam.<br>• Two or more cycles of vacuum and steam injection are used.<br>• Steam is removed as condensate.<br>• Waste is removed and processed in a shredder if desired. | 21 kg/hr to 84kg/hr | $120,000 to 240,000 |
| Rotating autoclave | Technology consists of a cylindrical pressure vessel with an internal rotating drum lined with sharp vanes and designed to withstand elevated pressures | • Waste is placed in the rotating autoclave.<br>• A vacuum is used to remove air.<br>• Steam is introduced at about 147°C.<br>• Internal drum rotates causing waste containers to break and mix.<br>• Steam is removed as condensate and waste is cooled.<br>• Waste is removed and processed in a grinder. | 90 kg/hr to 2000 kg/hr | $380,000 to 900,000 |





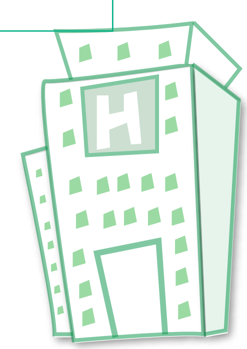


| Alternative Health Care Waste Management Treatment Technologies | | | | |
|---|---|---|---|---|
| **Type of Technology** | **Description** | **General operating process** | **Range of capacities** | **Approximate capital cost in USD** |
| Hydroclave | Technology consists of a cylindrical pressure vessel with an outer steam jacket and an internal mixing drum arm, designed to withstand elevated pressures | • Waste is placed in the hydroclave.<br>• Steam is injected in the outer jacket until the inner chamber is heated to 1320C.<br>• Internal mixing arm breaks the waste containers and mixes the waste.<br>• Steam is removed as condensate.<br>• Waste is removed and processed in a shredder. | 20 kg/hr to 1000 kg/hr | $70,000 to 550,000 |
| Steam treatment with internal shredding | Technology consists of a cylindrical or hemispherical pressure vessel with an internal shredder and other steam jacket. Some systems are designed on mobile units | • Waste is placed in the vessel.<br>• Steam is introduced at 1320C to 1380C.<br>• Waste is shredded internally and exposed to steam. Steam is removed as condensate<br>• Waste is cooled.<br>• Waste is removed | 40 kg/hr to 200 kg/hr | $190,000 to 470,00 |
| Steam cleaning with continuous internal maceration | Technology consists of a rectangular container with a treatment vessel connected to a pump-grinder and liquid separator. | • Waste is placed in the vessel.<br>• Steam and hot water are introduced.<br>• Waste slurry is re-circulated through the grinder and held at 1380C.<br>• Cold water is injected and the slurry is passed through a liquid separator to filter out the waste.<br>• Waste solids are captured in disposable bags. | 68 kg/hr | $200,000 |
| Semi-continuous steam treatment | Technology consists of a hopper, shredder, rotating auger, dehydrator and discharge section. | • Waste is automatically dumped into a sealed hopper.<br>• Waste passes through an internal auger where it is exposed to steam.<br>• The dehydrator at the end of the auger removes excess liquid.<br>• The waste is discharged into a container. | 140 kg/hr to 1800 kg/hr | $300,000 to 1,800,000 |
| Large-scale microwave treatment | Technology consists of hopper, shredder, rotating auger, microwave generators, holding tank, secondary auger and shredder. | • Waste is automatically dumped into a sealed hopper. Waste passes through an internal shredder and a horizontally inclined rotating auger where it is exposed to steam and microwave energy.<br>• An optional second shredder at the end of the auger shreds the waste into a smaller size.<br>• The waste is discharged into a container. | 100 kg/hr to 250 kg/hr | 600,000 and higher |

| Alternative Health Care Waste Management Treatment Technologies | | | | |
|---|---|---|---|---|
| **Type of Technology** | **Description** | **General operating process** | **Range of capacities** | **Approximate capital cost in USD** |
| Small-scale microwave treatment | Technology consists of a treatment chamber and one or more microwave generators. | • Waste is placed inside the treatment chamber.<br>• Water or steam is added.<br>• Waste is exposed to microwave energy that generates heat inside the chamber.<br>• Waste is removed and shredded if desired. | 450 kg.hr to 2700 kg/hr | $12,000 to 85,000 |
| Electro-thermal deactivation | Technology consists of size-reduction equipment, a conveyor and a high-voltage radio-frequency generator. | • Waste is placed on a conveyor.<br>• Waste passes through a shredder.<br>• Shredded waster is sprayed with water, compacted and then exposed to low-frequency radio waves which heat the waste.<br>• Waste is discharged. | 450 kg/hr to 2700 kg/hr | Not available |
| Electron bean irradiation | Technology generally consists of a conveyor, beam accelerator and shielding | • Waste is placed on a conveyor.<br>• Waste passes through a treatment section where it is exposed to an electron beam at doses that destroy pathogens.<br>• Waste is discharged and passed through a shredder. | 180 kg/hr to 250 kg/hr | $500,000 to 1,500,000 |
| Dry heat treatment | Technology generally consists of a treatment chamber, resistance heater and fan to re-circulate hot air. | • Waste is placed in the treatment chamber.<br>• Heated air at 1770C is circulated through the waste fir a prescribed time.<br>• Waste is cooled and then disposed. | 0.15 kg/hr | $5000 |
| Alkaline hydrolysis or alkaline digestion | Technology consists of a cylindrical pressure vessel with an outer jacket and an internal spry assembly or mixer, a heat source, alkali solution, load sells, pump and piping controls. The technology is designed for digesting tissues, organs, body parts and animal carcasses. | • Waste is placed in the pressure vessel.<br>• Sodium or potassium hydroxide solution is added to the vessel.<br>• Steam or heated oil is circulated outside the jacket.<br>• Waste is exposed to heated alkali solution for several hours until the digestion is complete.<br>• Wastewater is neutralized if desired and discharged to the sewer or solidified and used as fertilizer.<br>• Solid waste residue are discarded or used as soil conditioner. | 14 kg to 4500 kg per cycle | $30,000 to 900,000 And higher |







| Alternative Health Care Waste Management Treatment Technologies | | | | |
|---|---|---|---|---|
| **Type of Technology** | **Description** | **General operating process** | **Range of capacities** | **Approximate capital cost in USD** |
| Chemical disinfection technologies | Technologies typically consist of a treatment chamber and internal shredder and mixer, and some use of a solid-liquid separator. | Waste is passed through an internal shredder.<br>A chemical disinfectant is mixed with waste (e.g., calcium chloride, calcium hydroxide, peracetic acid or ozone).<br>Some technologies discharge the waste disinfectant; some remove and reuse the disinfectant solution; and others neutralize and residual disinfectant. | 20 kg/hr to 1000 kg/hr | $30,000 to 400,000 And higher |

Source: UNDP-GEF Global Healthcare Waste Project (see link in References section).

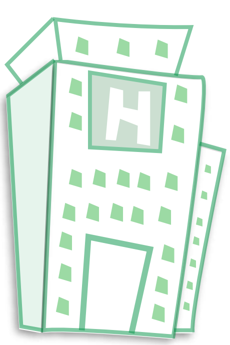
### Things to Remember

It will be difficult to reduce the amount of waste generated if there is no recycling or composting program in place. Metals, plastic, glass and paper can all be recycled, but there has to be a national policy that mandates such. Despite the fact that recycling may be difficult for small nations to undertake, several islands may be able to join together to make it feasible. Work with the government to formulate regulations that call for recycling and composting. The resulting compost can be used in the community or sold locally. Biodegradable waste that ends up in a landfill or incinerator adds to greenhouse gas emissions and serves no useful purpose. As compost, it can enrich soil and reduce the need for artificial inputs, some of which are harmful to the environment.

## Resources

- The Zero Waste Alliance: http://www.zerowaste.org/.
- Sustainability Roadmap for Hospitals - A Guide to Achieving your Sustainability Goals: Waste: http://www.sustainabilityroadmap.org/topics/waste.shtml.
- Practice Greenhealth - Waste: http://practicegreenhealth.org/topics/waste.
- UN/GEF Global Health care Waste Project: Alternative Health-care Waste Management treatment technologies: http://www.gefmedwaste.org/downloads/ALTERNATIVE%20HEALTH-CARE%20WASTE%20MANAGEMENT%20TREATMENT%20TECHNOLOGIES.pdf.
- Best Environmental Practices and Alternative Technologies for Medical Waste Management: http://noharm.org/lib/downloads/waste/MedWaste_Mgmt_Developing_World.pdf.
  - World Health Organization: Safe management of wastes from health care activities: http://www.who.int/water_sanitation_health/medicalwaste/wastemanag/en/.





## Environmental Services

### Overview

Maintaining a clean environment in and out of health care facilities is important to control infections and pests. It is also important to limit exposure of staff, patients and visitors to chemicals that could irritate, trigger medical conditions or cause serious harm. Attention needs to be paid to the components of cleaning agents, pest management chemicals and all other substances used inside and outside the facility. If products currently used contain toxic components, they should be phased out and safer alternatives found. Cleaning products should be environmentally benign or less toxic or harmful than products being used and still provide the high level of cleanliness required in the facility. Also, janitorial paper products should be evaluated for recycled content and to ensure that they do not contain harmful components.

Chemicals used to control pests indoors and outdoors can potentially affect staff, patients, visitors and applicators. Integrated Pest Management (IPM) is a concept of pest management that seeks to reduce the use of harmful chemicals, target specific pests, increase the use of safer alternatives and techniques and limit exposure of applicators, humans and other organisms to harmful substances. It is a proactive approach with the premise that if the food and habitat are not provided for the pests, they will look elsewhere. In addition, if chemicals have to be applied as a last resort, then the least hazardous chemical is applied in the lowest possible concentration and by trained personnel.

### Implementation Strategies

All aspects of a health care facility's operations come into play with regards to the overall 'greening' of the facility. Cleaning and pest control is especially important because they usually involve the use of chemicals that are respiratory irritants, toxic and harmful.

### Recommended Action Points

#### Environmentally Preferable Cleaning: Products, Materials and Equipment

- Establish an environmentally preferable purchasing program and ensure that procurement of cleaning and other janitorial products supports the program.
- Procure cleaning products and materials that are environmentally benign or that are less toxic than other products while still maintaining the high level of cleanliness required in the facility.
- Ensure that disposable paper products, such as paper and hand wiping towels, contain recycled content.
- Prohibit "products that are manufactured with carcinogens, mutagens and teratogens; aerosols; asthma-causing agents (asthmagens), respiratory irritants, and chemicals that aggravate existing respiratory conditions; neurotoxins; endocrine modifiers; benzene-based solvents, butoxyethanol, chlorinated organic solvents, and paradichlorobenzene; very acidic or alkaline products; anti-microbial agents in hand soaps for patients and visitors; persistent, bioaccumulative and toxic chemicals (PBTs); and products requiring disposal as hazardous waste," and "[u]se combination cleaner/disinfectants and dyes judiciously and only as necessary or where appropriate." GGHC (Care G. G., 2008, pp. 10-11).

### Integrated Pest Management

- Develop an IPM program or request that the agency responsible for maintaining your facility develops one that incorporates the following principles and practices, as noted by Practice Greenhealth (Greenhealth, 2012):
  - Design, construct, and maintain buildings to be as pest resistant as possible.
  - Ensure that roof parapets and caps are sealed, any other devices on roofs, such as traps or bait stations, are placed at documented locations and regularly checked, and nets for bird/pigeon activity are checked on a regular basis.
  - Eliminate cracks and holes to keep pests out. Lightly dust gaps between walls and other voids with boric acid before closing them up.
  - Inspect the grounds around buildings and fill burrows with pea gravel. Keep vegetation at least 12 inches from building perimeter.
  - Ensure that devices such as bait stations placed in outside areas are locked, secured, clean, and in good working order. Rodents do not like dusty and unclean bait stations.
  - Use physical barriers to block pest entry and movement (such as door sweeps, screens at air intakes, doors, and windows).
  - Train staff on proper management of food and drinks outside of the cafeteria or dining areas.

### Resources

- Green Seal: http://www.greenseal.org.
- Environmental Choice CCD-113 for Drain or Grease Traps Additives: http://www.ecologo.org.
- United States Environmental Protection Agency- Integrated Pest Management (IPM) Principles: http://www.epa.gov/pesticides/factsheets/ipm.htm.
- University of Minnesota-Radcliffe's IPM World Textbook: http://ipmworld.umn.edu/.
- United States Environmental Protection Agency- PestWise An EPA Partnership Program: http://www.epa.gov/pesp/publications/index.html.
- Beyond Pesticides-Healthy Hospitals Controlling Pests Without Harmful Pesticides: http://www.beyondpesticides.org/hospitals/Healthy_Hospitals_Report.pdf.

## Food Services

### Overview

Agriculture and food systems have a significant impact on the environment and on human health. Large inputs of energy and chemicals lead to degradation of soil, water and other natural resources. The use of energy releases pollution into the atmosphere and contributes to climate change. Planting, reaping, transportation, processing, packaging, shipping and the use of manmade inputs make the global farming system unsustainable. With livestock, the system is similarly unsustainable because most animal food is processed using energy, some animals are housed in controlled environments and the animals themselves contribute greenhouses gases to the atmosphere and pollute other resources as well.

In an effort to achieve an environmentally-friendly food system, health facilities must strive to eliminate the use of disposable food containers and bottled water. If no national recycling program is in place, plastic from food services and bottled water will likely end up in a landfill or incinerated. Paper products such as napkins are often used in food services, but they consume natural resources and generate additional waste. Paper products with recycled content offer a better, more sustainable option. Additionally, food waste can be removed from the waste stream and composted on-site, in the community or in a municipal or commercial facility. Compost can be reused in farms and add to the overall sustainability of the agriculture sector.

## Implementation Strategies

In an effort to make health facilities and the overall health sector more sustainable, changes must be made to how food services are provided and to ensuring that the food acquired has been produced in an environmentally safe and sustainable manner. The Caribbean is a net importer of food. In order for this change to occur, agriculture must be improved locally and regionally. Governments will need to get involved, as this requires national effort. Health care systems have large purchasing power and can use that leverage to advocate for local change.

## Recommended Action Points

### Sustainable Food Policy and Plan

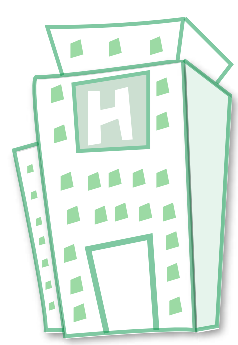
- Develop a sustainable food policy and plan that seeks to make the procurement of food and food services in general more sustainable. Include plans to seek local and regionally produced, sustainable food products over products imported from farther away and eliminate disposable food service ware like plastic and paper plates, cups, cutlery, etc.  Encourage local farmers to shift from fertilizer and chemical-dependent farming to practices that are more closely aligned with natural processes.

### Local, Sustainably Produced Food Purchasing

- Implement a sustainable food plan and increase the procurement of locally and regionally produced foods.
    - *Note:* In collaboration with the Ministry of Agriculture, encourage local farmers to shift to agriculture that relies less on manmade inputs.

### Reusable and Non-Reusable Products: Food Service Items, Non-Food Service Items and Bottled Water Elimination

- Eliminate the use of disposable products in food services. If there is a need for disposable products, use biodegradable/compostable food service wares available on the market.
- Reduce the use of non-food service paper products such as paper towels and napkins or use efficient dispensing systems to control the amount of these products used.  Seek out products made from recycled/natural fibers.
- Eliminate or reduce the use of bottled water for patients. If there is no national recycling program in place, work with the government to institute a program.  A recycling program will significantly reduce the amount of plastic bottles and other items



tossed about, disposed of in landfills or incinerated. The concerns related to burning plastics were discussed earlier.

### Food Waste Reduction, Donation and Composting

- Examine ways to reduce food waste. GGHC (Care G. G., 2008, pp. 11-30) recommends "programmatic innovations such as 'room service,' 'meals on demand,' 'just-in-time' food preparation, etc.
- If there is a cafeteria or other food facility located in the hospital, consider donating food that remains at the end of daily operations to food banks, churches and other community groups rather than disposing of it.
- Join with the community and staff to start an organic garden onsite, if space permits. Use organic refuse from food services to create a compost pile and reuse material in the garden. If space does not allow for a garden, a simple compost pile may be possible. Donate compost to community members.

  *Note:* Commercial composters are available on the market that can turn discarded food into compost. Coordinate with waste management companies or authorities to establish if such a device can feasibly be used. Keep in mind that the compost can be sold locally or regionally. A national food composting initiative that includes health care facilities, restaurants, schools and other institutional uses that generate food waste can be incorporated into the program.

### Resources

- Practice Greenhealth, Sustainable Food: http://practicegreenhealth.org/topics/sustainable-food.
- Health Care Without Harm, Healthy Food Global Overview: http://noharm.org/all_regions/issues/food/.
- Prevention Institute, Cultivating Common Ground: Linking Health and Sustainable Agriculture: http://noharm.org/lib/downloads/food/Cultivating_Common_Ground.pdf.

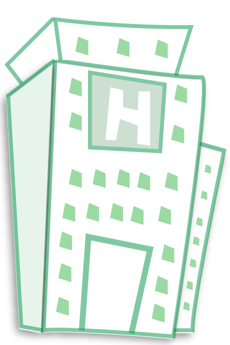
## Environmentally-Preferable Purchasing

### Overview

There is no doubt that the products, pharmaceuticals, equipment, fixtures, food, and cleaning and other general supplies purchased for or by health facilities have a significant impact on the facilities' carbon footprint. Unused or expired pharmaceuticals, chemicals disposed of in an irresponsible manner, and packaging and other materials add to the waste stream and contribute to environmental degradation. Environmentally conscious purchasing decisions can, therefore, significantly improve sustainability. Keep in mind that, the farther away the source of the goods/products/materials, the greater their carbon footprint. Therefore, a facility that strives to make its operations more sustainable will make purchasing decisions with this goal in mind.

The global movement Health Care without Harm notes that products purchased with the environment in mind should:





- Be less toxic
- Be minimally polluting
- Be more energy efficient
- Be safer and healthier for patients, workers, and the environment
- Contain higher recycled content
- Have less packaging
- Be fragrance-free

## Implementation Strategies

Procurement practices need to be aligned to an overarching commitment to sustainability for a health facility or the health sector. Make every effort to reduce the amount of solid waste generated and purchase products that are environmentally benign.

## Recommended Action Points

### Mercury Reduction

- Prepare a plan to phase out or replace items that contain mercury.

  *Note:* Include in the plan how the items that are to be replaced/phased out are to be disposed of. Mercury is hazardous and anything that contains it should be treated as hazardous. Incinerating or disposing of mercury-containing items in landfills is not recommended.

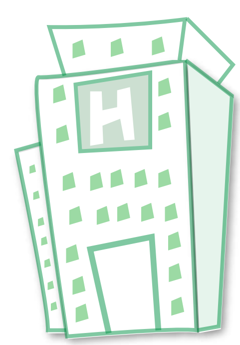
### Electronics Purchasing and End-of-Life Management

- Ensure that electronic equipment does not end up in landfills and incinerators where it can negatively impact the environment.

  *Note:* Proper recycling and redirecting equipment to appropriate markets for reuse will eliminate much of the materials in electronic equipment from being wasted. This saves natural resources, reduces energy use, has less of an impact on climate change and improves sustainability.

  GGHC (Care G. G., 2008, pp. 12-38 - 12-39) recommends the following for managing electronics and electronic waste:
  - Reduce generation of electronic waste by leasing equipment, purchasing refurbished electronic equipment, upgrading equipment instead of taking it out of service and/or participating in a buy-back program.
  - Give preference to products registered with programs such as EPEAT, which requires all registered products to offer take-back and recycling options.
  - Give preference to products that are available with extended warranties and parts for five years.
  - Collect all electronics for responsible management (recycling), including but not limited to: cell phones, pagers, walkie-talkies, hand-helds, televisions, fax machines, copiers, monitoring equipment, medical equipment.





- If donating retired equipment, ensure that it is mercury free, in working condition, and has all parts necessary to be of use in other locations where extra parts and servicing might not be available.

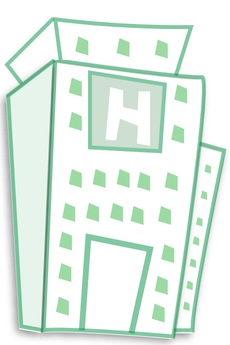
### Solid Waste Reduction in Purchasing

- Ensure that your purchases are in line with the overarching goal to reduce solid waste generation and disposal. GGHC (Care G. G., 2008, pp. 12-10 - 12-11) recommends the following to reduce solid waste generation through environmentally preferable purchasing:
  - Collaborate with group purchasing organizations (GPO) and manufacturers to identify opportunities to reduce waste in their product or service offerings.
  - Require take back of shipping crates and pallets in contract language with manufacturers and/or distributors.
  - Require take back or leasing programs for televisions, copiers, computers, telephones and medical equipment in contract language with manufacturers and/or distributors.
  - Institute a paper prevention initiative, including review of all printed reports and opportunities for distribution sharing and printing of departmental-specific pages only. Purchase or lease printers, scanners and copiers with automatic double-sided copying capabilities.
  - Review purchasing policies and establish high-percentage post-consumer recycled content and increased recyclability in product or packaging if not in place. For example, request recycled paper packaging instead of foam plastic packaging and containers made from plastics #1 and #2, to increase potential for recycling when a reusable option is unavailable.
  - Review packaging and shipping materials to identify materials used and reduction opportunities.
  - Establish a program to divert furniture and supplies from the waste stream through donation, refurbishment or recycling.
  - Research regional recycling and reuse markets to maximize waste reduction opportunities.

  To further reduce solid waste generation, GGHC (Care G. G., 2008, pp. 12-10 - 12-11) also points out that consideration should be given to using reusable alternatives for the following:
  - Toters for material delivery from receiving/storeroom to user areas.
  - Linens, including underpads (chux), pillows, isolation gowns, barrier protection, surgical drapes, stainless sterilization containers (versus blue wrap), lab coats and linen bags.
  - Mattresses—eliminate disposable 'eggcrate' foam mattresses.
  - Shipping containers for regulated medical waste removal.
  - Sharps containers for sharps management.
  - Medical devices, including instruments.







### Toxic Chemical Reduction in Purchasing

- Prepare a comprehensive list of materials, products and supplies that contain chemicals of interest and how they will be replaced or phased out. Keep in mind that disposing of materials in landfills or incinerating might not be the most ecologically sensitive method.

Many items may be able to be recycled. Work with manufacturers, local, regional or international agencies, organizations or authorities to have items properly disposed of or preferably recycled. For items that are to be replaced or phased out, identify safer alternatives.

- Investigate suitable, safer building materials, as many contain toxic chemicals if renovations or alternations are planned.

### Things to Remember

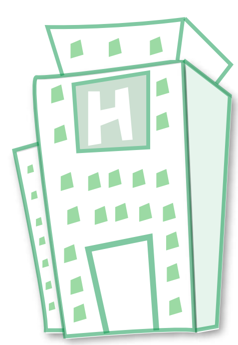
- Prepare a comprehensive list of mercury-containing items and suitable alternatives that do not contain mercury.
- Work with manufacturers, local, regional or international agencies, organizations or authorities to have items properly disposed of or preferably recycled.

## Resources

- Mercury-Free Health Care: http://www.mercuryfreehealthcare.org/.
- Health Care without Harm—Mercury Issues: http://noharm.org/all_regions/issues/toxins/mercury/.
- Sustainable Hospitals – Alternatives to mercury-containing equipment: http://www.sustainablehospitals.org.
- EPEAT® (the definitive global registry for greener electronics) http://www.epeat.net/.
- How to Buy Better Computers: Going Beyond EPEAT. http://noharm.org/lib/downloads/electronics/How_Buy_Better_Comp.pdf.
- Health Care Without Harm—Green Purchasing: http://noharm.org/global/issues/purchasing/.
- Practice Greenhealth: Environmentally Preferable Purchasing: http://practicegreenhealth.org/topics/epp.
- Health Care Without Harm—Safer Chemicals Tools and Resources: http://noharm.org/global/issues/chemicals/resources.php.







## Section IV

# COST-BENEFIT ANALYSIS METHODOLOGY

The purpose of the cost benefit analysis (CBA) is to help decision makers make informed choices on whether to invest in Smarting of health facilities, which are designed not only to increase the resilience of the facility to the impact of hazards, whose effects have been exacerbated due to climate change, but to also implement climate mitigation measures through a reduction of the energy and water consumption thus making the health facility more efficient.

### Definitions by UNISDR (UN Office for Disaster Risk Reduction)

**Hazard:** "A potentially damaging physical event, phenomenon, or human activity that may cause loss of live or injury, property damage, social and economic disruption or environmental degradation"

**Climate Change:** "Encompasses all forms of climatic inconstancy regardless of their statistical nature or physical causes. It may result from such factors as solar activity, long-period changes in the Earth's orbital elements, natural internal processes or the climatic system, or anthropogenic forcing."

**Vulnerability:** "The condition determined by physical, social, economic and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards"

**Resilience:**

- Reduced failure probabilities
- Reduced consequences from failure
- Reduced time to recovery

The cost benefit analysis process estimates the benefits and costs of an investment for two reasons:

1. To determine if the project is viable; if it is a good investment
2. To compare one project investment with other competing projects, to determine which is more feasible.

It allows decision makers to appraise projects in a consistent and comparable manner.

Conducting a CBA can be an expensive and cumbersome undertaking, depending on the range of input data used to determine a project's costs and benefits. Hence, these are recommended for use in projects where the potential costs of the project(s) are significant enough to justify the allocation of resources to forecast, measure and evaluate anticipated benefits, costs and impacts.

## Input Data Requirements

Certain assumptions and decisions need to be made to determine some of the input data and there are definite questions that will be raised.

It is important to ensure that the assumptions and methodological approach are consistent for the various projects being compared. Some of the questions that may be asked are:

1. What baseline will the benefits of the project(s) be estimated?
2. What is the chronological and spatial extent of project impact(s)?
3. Which specific elements of the project / activities are most relevant to the CBA?

## Discount Rate

The value of money or goods in the present is viewed as higher than the expected value of goods and financial returns in the future. The further a potential benefit or cost is in the future, the less its value. This concept is made tangible by a process called discounting. This is where a discount rate is applied to anticipated costs and benefits of a project over the duration or 'life span' of the project to convert the value of a return in the future into today's value. Hence, for instance, the returns of a multi-year project are usually referred to as discounted returns.

The lower the discount rate sometimes referred to as interest rate, the higher the return value of the project's future costs and benefits. Conversely, the higher the discount/ interest rates the lower the future return value will be.

The selection of the appropriate discount rate is important to ensure that future project returns are not being over- or under-estimated in today's value.

## Types of Cost Benefit Analysis

There are different types or methods of analysis to determine the economic efficiency of a project. The types that will be covered in this section are:

1. Benefit Cost Ratio (BCR)
2. Incremental Cost Benefit Ratio
3. Net Present Value (NPV)
4. The Payback Period

## Benefit Cost Ratio (BCR)

This is the ratio of project benefits versus project costs. It involves summing the total discounted benefits for a project over its entire duration/life span and dividing it over the total discounted costs of the project.

$$BCR = \frac{[\Sigma B_i / (1+d)^i]}{[\Sigma C_i / (1+d)^i]} \text{ summed over } 1 = 0 \text{ to n years}$$

Where:

Bi = the project's benefit in year i, where i = 0 to n years

Ci = the project's costs in year i, where i = 0 to n years

n = the total number of years for the project duration/ life span

d = the discount rate

The simple steps in this methodology are:

1. Determine the discounted benefits for each year of the project
2. Determine the discounted costs for each year of the project
3. Sum the total discounted benefits for the entire project duration
4. Sum the total discounted costs for the entire project duration
5. Divide the total discounted benefits over the total discounted costs

### Understanding the results of BCR

| BCR < 1.0 | BCR = 1.0 | BCR > 1.0 |
|---|---|---|
| In economic terms, the costs exceed the benefits. Solely on this criterion, the project should not proceed. | Costs equal the benefits, which means the project should be allowed to proceed, but with little viability. | The benefits exceed the costs, and the project should be allowed to proceed. |

This method does not give a result of the projected total gains or losses of one project compared with another project. This can be done using the incremental BCR methodology.

## Incremental Benefit Cost Ratio

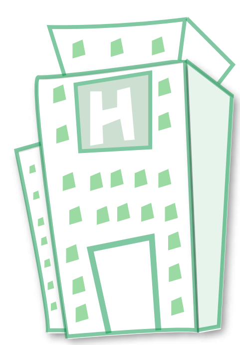
This method helps to determine the margin by which a project is more beneficial or costly than another project. It is used to compare alternative options to help determine which is more feasible over the other(s).

The steps in this methodology are:

1. List the projects from the least costly to the most expensive in ascending order.







2. Take the least costly project and compare it to the second cheapest option by subtracting the total discounted benefits for each project and dividing this by the difference in the total discounted costs for each project.

$$\text{Incremental BCR} = (\Sigma B_1 - \Sigma B_2) / (\Sigma C_1 - \Sigma C_2)$$

Where:

ΣB1 = total benefits for project '1'

ΣC1 = total costs for project '1'

3. If the incremental BCR obtained is higher than the target incremental BCR, then discard the lower-cost option (project 1 in this case) and use the higher-cost option (project 2) to compare with the next project on the ascending cost list.
4. If the incremental BCR obtained is lower than the target incremental BCR, then discard the higher-cost option (project 2 in this case) and use the lower-cost option (project 1) to compare with the next project on the ascending cost list.
5. Repeat these steps (2-4) until all of the project options have been analysed.
6. The project which has the highest cost and an incremental BCR equal to or greater than the target incremental BCR.

## Net Present Value

This method considers the difference between the total discounted benefits minus the total discounted costs, which gives the Net Present Value of a project. Projects with positive net benefits are considered to be viable and a project with a higher NPV as compared with another project with a lower NPV is measured to be less lucrative. In other words, the higher the NPV, the greater the calculated benefits of the project.

$$\text{BCR} = [\Sigma B_i / (1+d)^i] - [\Sigma C_i / (1+d)^i] \text{ summed over } 1 = 0 \text{ to } n \text{ years}$$

Where:

Bi = the project's benefit in year i, where i = 0 to n years

Ci = the project's costs in year i, where i = 0 to n years

n = the total number of years for the project duration/ life span

d = the discount rate

## Payback Period

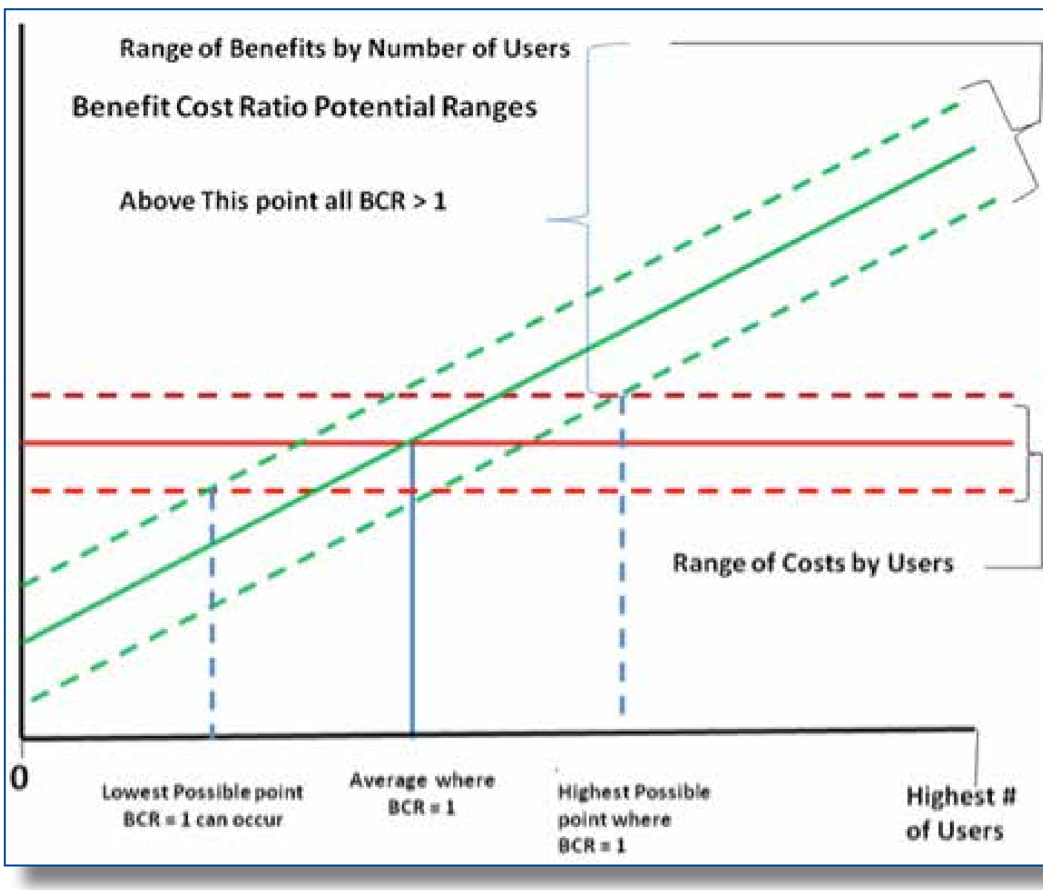
This is the time period required for the total discounted costs of a project to be surpassed by the total discounted benefits. This can be easily done, say in excel, by calculating the cumulative discounted benefits and cumulative discounted costs of a project for each consecutive year of a project. The year that the cumulative benefits exceed the cumulative costs is the payback period year of the project. In other words, the year following the project payback period will see net profits or benefits to the project.

## Sensitivity Analysis

The calculated benefits and costs of a project may vary depending on differing assumptions about the input data and methodology applied in the cost benefit analysis. The range of potential outcomes for differing inputs can be gauged using a sensitivity analysis.

A sensitivity analysis is also useful to determine the potential where the net benefits of the project will not be positive, as highlighted in the Figure below.

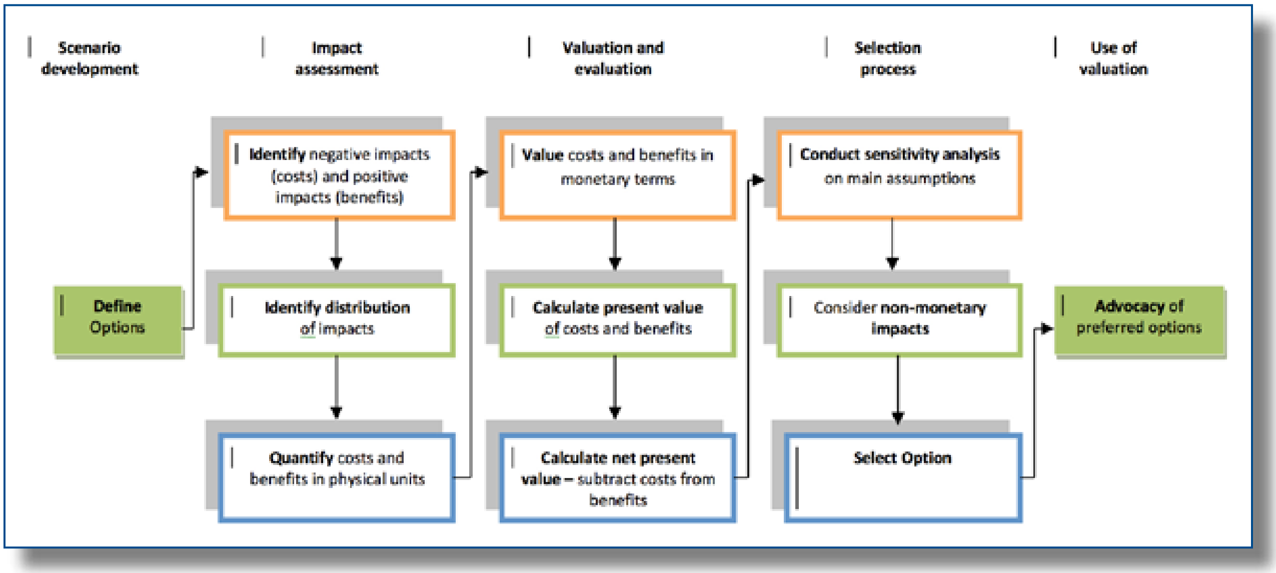
For example some projects calculated benefits and costs may be affected by how the project is scheduled, determining an appropriate project life span, the geographic scale of the impacts of the project and knowing what discount rate to select.




**Sensitivity analysis of projects for range of potential costs and benefits**

## Methodology Used in the CBA of the Demonstration Projects

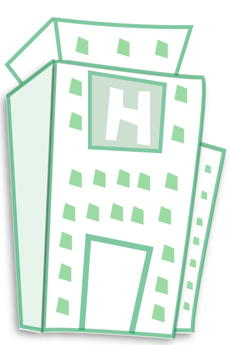
The main steps performed by economist, Dr Mark Bynoe, in the CBA for the demonstration projects are presented in the next Figure, showing how these steps fit with the overall framework of analysis advocated in the toolkit. These steps are described in detail below:




**Methodological Steps Followed in the Cost Benefit Analysis for the SMART Health Care Facility**

1. Define options. The first step in the CBA was to identify the alternative options to be considered. The options under consideration were specific to the particular problem and context, but under other circumstances may have included investments, projects, policies, and development plans. It was important to have a clear and detailed description of what each option was as detailed in the following section.
2. Identify costs and benefits. We then identified all negative impacts (costs) and positive impacts (benefits) related to each option under consideration. If known, it is useful to describe the geographical and temporal boundaries of the analysis, i.e. the area and number of years over which costs and benefits are expected to accrue. In our analysis, the entire Island was seen as being the beneficiary and the project was projected to have a life of 20 years.
3. Identify the distribution of impacts. Costs and benefits of alternative options will not be distributed evenly over the various individuals and groups that are impacted by the project. The distribution of costs and benefits (and the potential need for compensation) therefore becomes an important determinant of whether the project was acceptable and desirable.
4. Quantify costs and benefits in physical units. Each cost and benefit was then quantified in relevant physical units for each year in which those benefits and costs occur. We utilized the excel spreadsheet for our analysis.
5. Value costs and benefits in monetary units. Each cost and benefit was then quantified in monetary units for each year in which it occurs.





6. Calculate present values. Calculating present value (PV) involved discounting values that occur in future years. Present value costs and benefits were then summed across years to obtain the total present value costs and benefits.
7. Calculate the net present value (NPV). The net present value (NPV) of each option.
8. Calculate the benefit cost ratio (BCR) and internal rate of return (IRR). The results of a CBA can also be represented by two other indicators of a project's worth (in addition to NPV). These are the benefit cost ratio (BCR) and the internal rate of return (IRR). The IRR is the discount rate at which a project's NPV becomes zero. If the IRR exceeds the discount rate, the project generates returns in excess of other investments in the economy, and can be considered worthwhile.
9. Conduct sensitivity analysis. Information on the monetary values of costs and benefits of alternative options will often not be known with absolute certainty. Uncertainty over the values or assumptions included in the analysis leads to the results also being uncertain. One such area is the discount factor applied. We therefore varied this, among other things, to test the sensitivity of our analysis.
10. Select option. Based on the information generated on the NPV of each option, the sensitivity of the results, the distribution of impacts, and additional non-monetary information, a decision maker can select the most preferred option.
11. Use the results. The results of the CBA can then be used in various ways to influence a decision over a policy or project.

## Summary of the Economic Analysis of Smarting of Georgetown Hospital, St Vincent

The cost benefit analysis (CBA) for the Georgetown Hospital in St Vincent, conducted by economist, Dr Mark Bynoe, was done for the scope of works of the retrofitting project. This included improving the condition to better withstand the impact of natural hazards including the effects of climate change.

Two options were considered in the cost benefit analysis: Do Nothing and Retrofitting for Smarting the facility. The costs and benefits associated with each option are shown in Tables 1 and 2. The comparisons indicate that the Do Nothing option would not provide any benefits to the medical facility.

**Table 1 - Comparison of Costs and Benefits for the 'Do Nothing' option**

| Options | Costs/Issues | Benefits |
|---|---|---|
| Do nothing | • Continued dilapidation of the hospital; hinders its efficient operations.<br>• Leaking roof.<br>• Fading, peeling and moss/mold growth on exterior walls.<br>• Water damaged and worn floor finishes.<br>• Inefficient ventilation, hot water systems, cooling systems and water catchment.<br>• Inadequate water storage capacity and lack of water treatment.<br>• Lack of fire/smoke alarms, emergency lighting, exit signage maps, fire extinguishers and handicap accessibility.<br>• Insufficient provision of shelter from the elements.<br>• Vulnerability to wind uplift and hurricane events.<br>• Water damage to wooden beams and supporting posts.<br>• Insufficient lighting of the ambulance area.<br>• No public restroom facility for visitors.<br>• Outdated power supply system and non-operational emergency power supply.<br>• Current building codes do not adequately address resilience to climate change and climate variability to meet the 'Hospitals Safe from disasters'. | ZERO BENEFITS |

**Table 2 - Costs and Benefits associated with the retrofitting option**

| Options | Costs/Issues | Benefits |
|---|---|---|
| Retrofitting (Smart Hospital) | • Capital cost of designing and retrofitting the hospital.<br>• Incremental maintenance cost. | • Revised hospital design that can withstand greater natural hazards intensities.<br>• Minimized vulnerability to wind uplift of the roof and improved structural integrity of the hospital.<br>• Improved healthcare, reduced mortality and other social spill-off benefits.<br>• Eradicate leaking roof.<br>• Improved roof bearing capacity such that it could accept the solar panels for the proposed Photo Voltaic (PV) system.<br>• Improved hospital ventilation, security, safety, hygiene, accessibility, conservation, lighting, sanitation, aesthetics and morale.<br>• Reduced energy demand generally and from the national grid, and improved efficiency in the use and production of electricity.<br>• Enhanced hospital compliance to safety and risk reduction and staff awareness and development.<br>• The provision of a baseline from the project from which replication and policy recommendations can be drawn for incorporation into the building codes of St. Vincent and the Grenadines and the wider Caribbean. |

Table 3 below highlights the actual cost breakdown for the retrofitting works, which were donor funded and treated as a sunk cost for the CBA study.

The total cost of various elements of the works at the Georgetown Hospital is illustrated below in $US. The majority of the funds were used to upgrade the electrical system and provide an alternative source of energy in the PV system.

**Table 3 – Capital investment costs of retrofitting works at the health facility**

| # | Georgetown Hospital: Item Description | Cost (US$) |
|---|---|---|
| 1 | Preliminaries | 8,866.67 |
| 2 | Roof Renovations | 38,996.11 |
| 3 | Windows | 20,747.04 |
| 4 | Doors | 28,531.63 |
| 5 | Plumbing and Sanitary Fixtures | 24,877.78 |
| 6 | Electrical Works (Light and Power) | 52,951.85 |
| 7 | Electrical Works (Emergency Power Supply) | 20,583.33 |
| 8 | Electrical Works (Alternative Power Supply) | 34,374.07 |
| 9 | Mechanical works | 16,373.70 |
| 10 | Interior Furnishings | 7,461.85 |
| 11 | Wall Finishes | 8,893.33 |
| 12 | Floor Finishes | 11,583.70 |
| 13 | Ceiling Finishes | 8,918.15 |
| 14 | Code Compliance | 11,614.07 |
| 16 | External Works | 3,024.44 |
| 17 | New Main Entrance Covering | 3,007.78 |
| **Total Value Added Tax (VAT) 15%** | | 45,120.83 |
| **Grand Total Cost (including contingencies)** | | **345,926.35** |

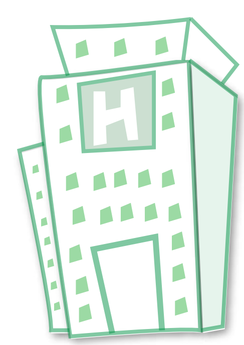
Costs associated with the planned preventative maintenance programme for the health facility, for the life span of the project – 20 years, was also included as the future incremental maintenance costs of the project. Some of the expenses that were considered in the analysis are as follows:

- Building inspections
- Roof checks and maintenance
- Sanitation and safety checks
- Painting of the facility
- Administrative monitoring
- Insurance for the facility
- Labour costs associated with operating the facility
- Contingency for unforeseen or unplanned expenses

The findings of the cost benefit analysis were such that, if the 'Do Nothing' option was continued, then the health facility would be at increased risk to the impact of natural hazards; with the continued deterioration of the facility, estimated at 5% annually for tangible







and non-tangible assets. In the short-term there is medium risk that as the facility continues to deteriorate it will become more vulnerable to climate change and climate variability. The risk increases to high if no improvements are made in the medium to long-term.

**Table 4 - Risk of the 'Do Nothing' option**

| Risk to Hospital Tangible and Non-Tangible Assets | | | |
|---|---|---|---|
| Risk of deteriorate and increase vulnerable to climate variability and climate change | Do Nothing | | |
| | Short-term | Medium-term | Long-term |
| Low | | | |
| Medium | x | | |
| High | | x | x |

## Financial Analysis

The two main benefits included in the cost benefit analysis were:

1. Savings due to efficient utilization of water, estimated at 10% of the current consumption.
2. Saving due to efficient energy usage, estimated at 10% of the current consumption.
3. Savings from the energy supply of the PV system, to the order of about 40%.
4. Savings in the ambulance operating between Georgetown and Kingstown.

It should be noted that reductions in energy use consumption were verified for one month following the completion of the retrofitting project and this was found to be 64% savings, which is significantly higher than the estimated 40% used in the analysis.

The water usage was not verified due to a faulty water meter that has since been changed.

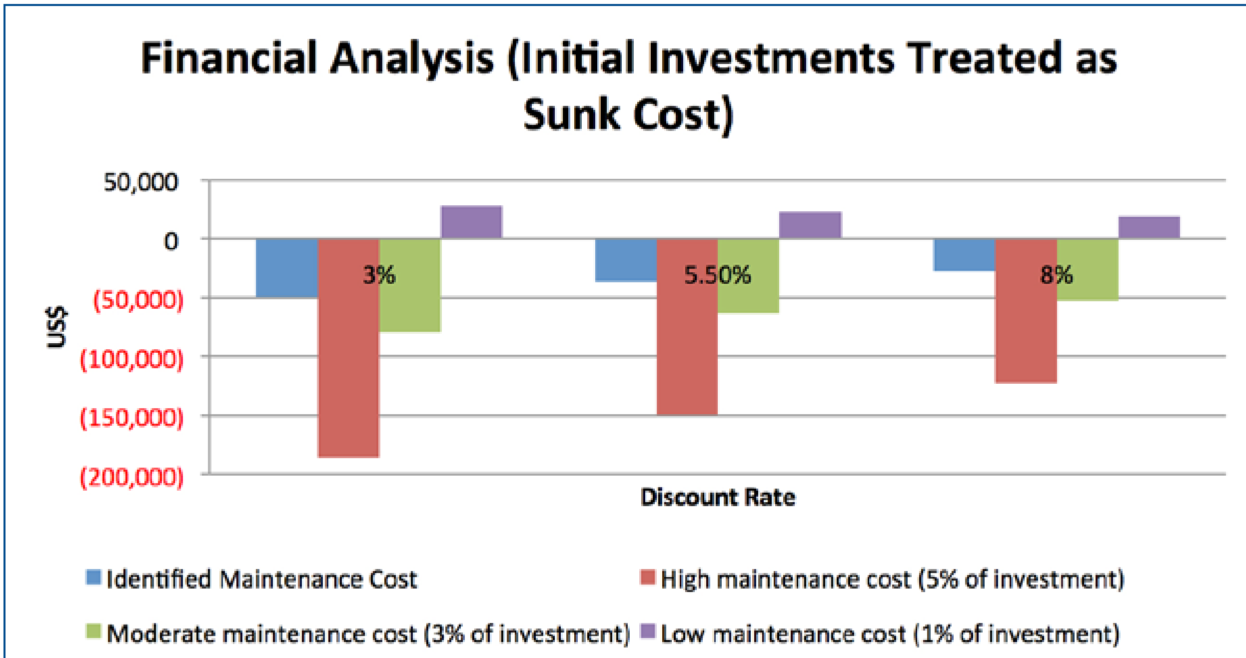
### Discount Rate

The Caribbean Community Climate Change Centre (CCCCC) estimated benchmarks for the Social Rate of Time Preference (SRTP)[1] for selected Caribbean Countries. Discount rates of 3%, 5.5% and 8% were used in this analysis. CCCCC estimated that the SRTP for St. Kitts and Nevis is 3.58%; however, sensitivity analyses suggest it could range from 3% to 8%.

### Net Present Value of the Retrofitting Project based on Annual Maintenance Costs

The Net Present Value (NPV) of the project for 20 years, treating the initial investment as a Sunk Cost, since this was donor funded by DFID, indicated the project as being beneficial in terms of savings for maintenance percentages at 0%, 1% and 3%, but not at 5%.

1. The social discount rate can be defined at a rate at which a people is willing to forgo consumption now in order to derive benefits in the future. It is also the rate at which funds are diverted from one alternative to another, i.e. the cost/benefit to society for investing in this project.



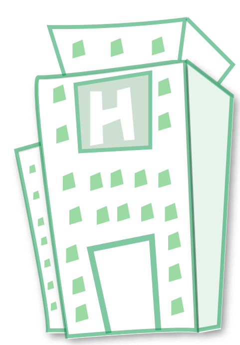

**Net Present Value (NPV) based on varying % annual maintenance costs of the initial investment for 20 years**

Note, PAHO recommends a planned preventative maintenance cost for health facilities at about 4% per annum of the current value of the building/ facility.[2]

## Ability to Pay and Willingness to Pay

A willingness and ability to pay survey[3] was used to estimate the utility derived from retrofitting the health facility. Despite majority of the respondents suggesting that they are satisfied with the current health service, when asked about their major concerns about the current health care provided, the following suite of responses followed:

- The Hospital facilities needs urgent upgrading;
- There are inadequate supplies at the hospital;
- The facilities at the hospital are poorly kept and maintained;
- There is a lack of specialist care and the hospital is losing nurses and qualified health professionals;
- There is a lack of privacy with medical records and professionalism is lacking in handling clients;
- The Georgetown hospital should be improved to provide hospital care for persons on the windward side of island;
- Better distribution of medical staff is needed to ensure the availability of doctors at rural hospitals such as Georgetown.
- Key healthcare services are in Kingstown. Travels to Kingstown are too far and exhausting for sick people;



2. Design Manuals for Health Facilities in the Caribbean, PAHO – by Tony Gibbs.
3. See Annex 2 for results of the Willingness and Ability to pay survey.

- Cost of healthcare is high;
- Accessibility to a doctor is sometimes a problem;
- Improved supplies, upgraded facilities and improved security needed for the hospital ;
- Accessibility to an ambulance is an issue.

It was found that the average willingness to pay for health services was US$56 and the average ability to pay was US$60.[4]

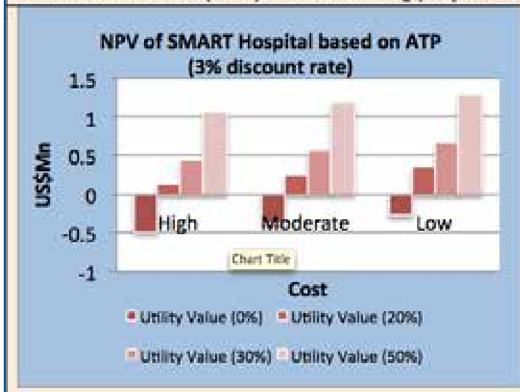
Economic Analysis based on ability to pay (ATP) and willingness to pay (WTP) over the range of discount rates are shown in the following graphs.

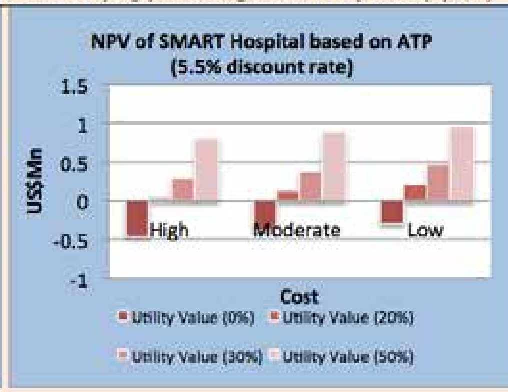
**Table 5 - Range of percentages of ATP and WTP considered in Economic Analysis**

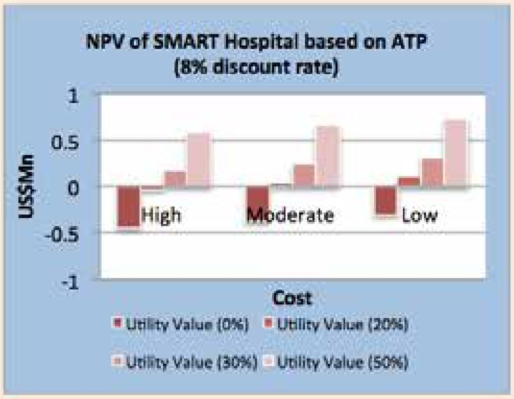
| Percentage | WTP (US$) | ATP (US$) |
|---|---|---|
| 0% | 0.0 | 0.0 |
| 20% | 12 | 11.2 |
| 30% | 18 | 16.8 |
| 40% | 30 | 28 |

4. The average presented here is the 5% trimmed mean.

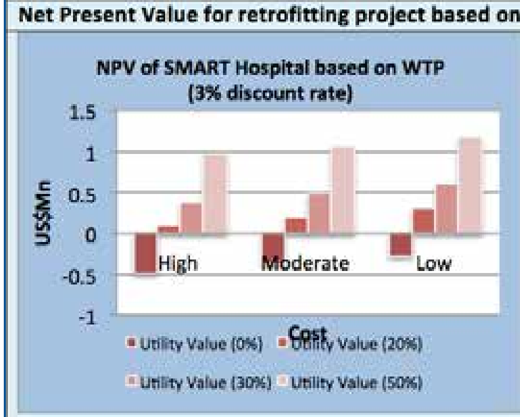
**Net Present Value (NPV) for retrofitting project based on varying percentages of Ability to Pay (ATP)**

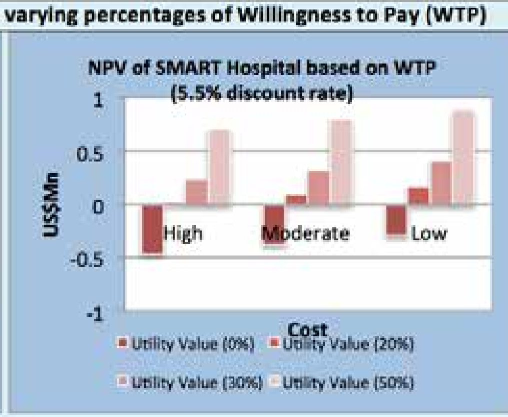


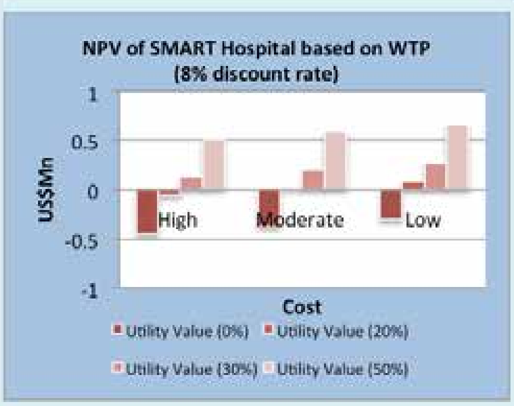




**Net Present Value for retrofitting project based on varying percentages of Willingness to Pay (WTP)**



## Conclusions and Recommendations

Retrofitting the Georgetown hospital is more favorable than the 'do nothing' option. 'Do nothing' in the medium to long term puts the hospital's assets, tangible and non-tangible, at a high risk of greater deterioration and increased vulnerability to climate variability and climate change. Contrary, retrofitting the hospital in the short-term is the better option as it will result in a facility that is user and staff friendly with better ventilation, security, hygiene, accessibility, conservation, lighting, sanitation and aesthetics.

However, the identified revenue streams from retrofitting the hospital in the form of savings from the efficiency utilization of water, savings from rainwater harvested, savings from the efficiency in energy usage and installation of renewable energy will only sustain the project financially over 20 years if the maintenance cost is less than or equal to about 1% of the capital expenditure. It is therefore imperative that the cost of maintenance and operation is minimized and other sources of revenue schemes are identified to financially support the project over its lifespan.

From an economic, social and environmental perspective the project is desirable and it becomes even more desirable if the community (users and staff) derives significant utility from seeing the hospital retrofitted which includes improved ventilation, security, safety, hygiene, accessibility, conservation, lighting, health, sanitation, aesthetics and morale. Furthermore, this project presents a guideline of practices for St. Vincent and Grenadines that other public buildings, schools, hotels and other private building could adhere to.

## Summary of the Economic Analysis of Smarting of Pogson Medical Centre, St Kitts

The cost benefit analysis (CBA) for the Pogson Medical Centre, conducted by economist, Dr Mark Bynoe, was done for the original scope of works of the retrofitting project. However, due to financial constraints, the scope of works was later modified and reduced to fit within the allowable budget. Hence, the results presented here represent the theoretical economic analysis had the overall scope been completed.

Two options were considered in the cost benefit analysis: Do Nothing and Retrofitting for Smarting the facility. The costs and benefits associated with each option are shown in Tables 1 and 2. The comparisons indicate that the Do Nothing option would not provide any benefits to the medical facility.

**Table 1 - Comparison of Costs and Benefits for the 'Do Nothing' option**

| Options | Costs/Issues | Benefits |
|---|---|---|
| Do nothing | • The continued disrepair of the medical facility, which hinders its efficient operations.<br>• The roof is prone to leaks under high wind conditions and there is a risk of the roof cracking, main entry roof vulnerable to wind uplift and hurricane events.<br>• Some windows require winder mechanism replacement or repair, the X-ray room window requires proper lining to prevent radiation exposure.<br>• The Emergency exits require improved security features and emergency panic bar mechanisms, the X-ray room door us not adequately lead lined to minimize radiation exposure.<br>• Selected bathroom fixtures require replacement while others have minor damages in need of repairs.<br>• Light fixtures (receptacles, switches, lights) need replacement, ballast units need to be replaced with 60 hz units, breakers trip when multiple appliances and equipment are in use at the same time, battery supply is faulty, diesel storage tank not properly anchored to foundation, electrical meter should be relocated, properly sheltered and mounted outside the generator housing, no existing alternate power supply.<br>• Lack of ventilation, cooling units not working or susceptible to flood damages.<br>• Inadequate water storage capacity and nonexistent water treatment systems.<br>• Shelving units that store medical supplies and files are not properly secured.<br>• Fading, peeling and moss/mold growth on the exterior walls and ceiling tiles.<br>• Inadequate emergency exits signage, emergency fire equipment are faulty and/or damaged, nonexistent emergency lights, illegible fire extinguisher instructions.<br>• Staircases and handicap ramps are exposed to the elements, surface are slippery when wet.<br>• Drains require demarcation to differentiate between storm vs. sewer manholes, pipes need to be flushed, landscaping to prevent water runoff.<br>• Incomplete wastewater treatment system.<br>• A substandard building code. | ZERO BENEFITS |

### Table 2 - Costs and Benefits associated with the retrofitting option

| Options | Costs/Issues | Benefits |
|---|---|---|
| Retrofitting (Smart Hospital) | • Capital cost of designing and retrofitting the medical facility.<br>• Incremental maintenance cost. | • Revised hospital design that can endure greater hurricane intensities. Minimized vulnerability to wind uplift of the roof and improved structural integrity of the hospital.<br>• Improved health facilities and services, mortality and other social spill-off benefits.<br>• Resolved roof leaking issues.<br>• Improved Hospital ventilation, security, safety, hygiene, accessibility, wastage, lighting, healthier, sanitary, aesthetics, and staff morale.<br>• Reduce energy demand and improve efficiency / conservation use and provide reliable production of electricity.<br>• Enhanced hospital conformity to safety and risk reduction and staff awareness and development.<br>• Improve the drainage of the landscape around the facility and eliminate any potential flooding of the facility.<br>• Properly treat and reuse all the sewerage water from the facilities and circulate the treated water through a drip irrigation system into surrounding environs.<br>• Minimize the overflow and pumping of sewerage and eliminate the exposure of sewerage water flowing through open drains.<br>• The project serves as a baseline from which replication and policy recommendations can be drawn for incorporation into the building codes of St. Kitts and Nevis and in the wider Caribbean. |

Table 2 below highlights the actual cost breakdown for the retrofitting works, which were donor funded and treated as a sunk cost for the CBA study.

The total cost of various elements of the works at the Pogson Hospital is illustrated below in $US. The majority of the funds were used to upgrade the electrical system and mechanical works with the aims of reducing the current consumption of the facility and also reduce its carbon footprint.

### Table 3 – Capital investment Costs of retrofitting works at the health facility

| Items | Description | Cost (US$) |
|---|---|---|
| 1 | Preliminaries | 26,473.06 |
| 2 | Roof Renovations | 18,531.14 |
| 3 | Windows | 3,088.52 |
| 4 | Doors | 33,799.28 |
| 5 | Plumbing and Sanitary Fixtures | 14,339.58 |
| 6 | Electrical Works (Light and Power) | 40,283.18 |
| 7 | Electrical Works (Emergency Power Supply) | 7,280.09 |
| 8 | Mechanical works | 36,091.61 |
| 9 | Interior Furnishings | 1,103.04 |
| 10 | Wall Finishes | 3,750.35 |
| 11 | Ceiling Finishes | 4,480.37 |
| 12 | Code Compliance | 9,526.29 |
| 13 | External Works | 409.13 |
| **Total** | | **188,155.65** |

Costs associated with the planned preventative maintenance programme for the health facility, for the life span of the project – 20 years, was also included as the future incremental maintenance costs of the project. Some of the expenses that were considered in the analysis are as follows:

- Building inspections
- Roof checks and maintenance
- Sanitation and safety checks
- Painting of the facility
- Administrative monitoring
- Insurance for the facility
- Labour costs associated with operating the facility
- Contingency for unforeseen or unplanned expenses

The findings of the cost benefit analysis were such that, if the 'Do Nothing' option was selected, then the health facility would be at increased risk to the impact of natural hazards; with the continued deterioration of the facility, estimated at 5% annually. In the short-term there is medium risk that as the facility continues to deteriorate it will become more vulnerable to climate change and climate variability. The risk increases to high if no improvements are made in the medium to long-term.

**Table 4 - Risk of the 'Do Nothing' option**

| Risk to Hospital Tangible and Non-Tangible Assets | | | |
|---|---|---|---|
| Risk of deteriorate and increase vulnerable to climate variability and climate change | Do Nothing | | |
| | Short-term | Medium-term | Long-term |
| Low | | | |
| Medium | x | | |
| High | | x | x |

## Financial Analysis

The two main benefits included in the cost benefit analysis were:

1. Savings due to efficient utilization of water, estimated at 20% of the current consumption.
2. Saving due to efficient energy usage, estimated at 10% of the current consumption.

It should be noted that reductions in energy use and water consumption had not been verified at the time of this report, as the retrofit works were completed on January 20, 2014 the time period until the end of the project did not allow for this data collection.

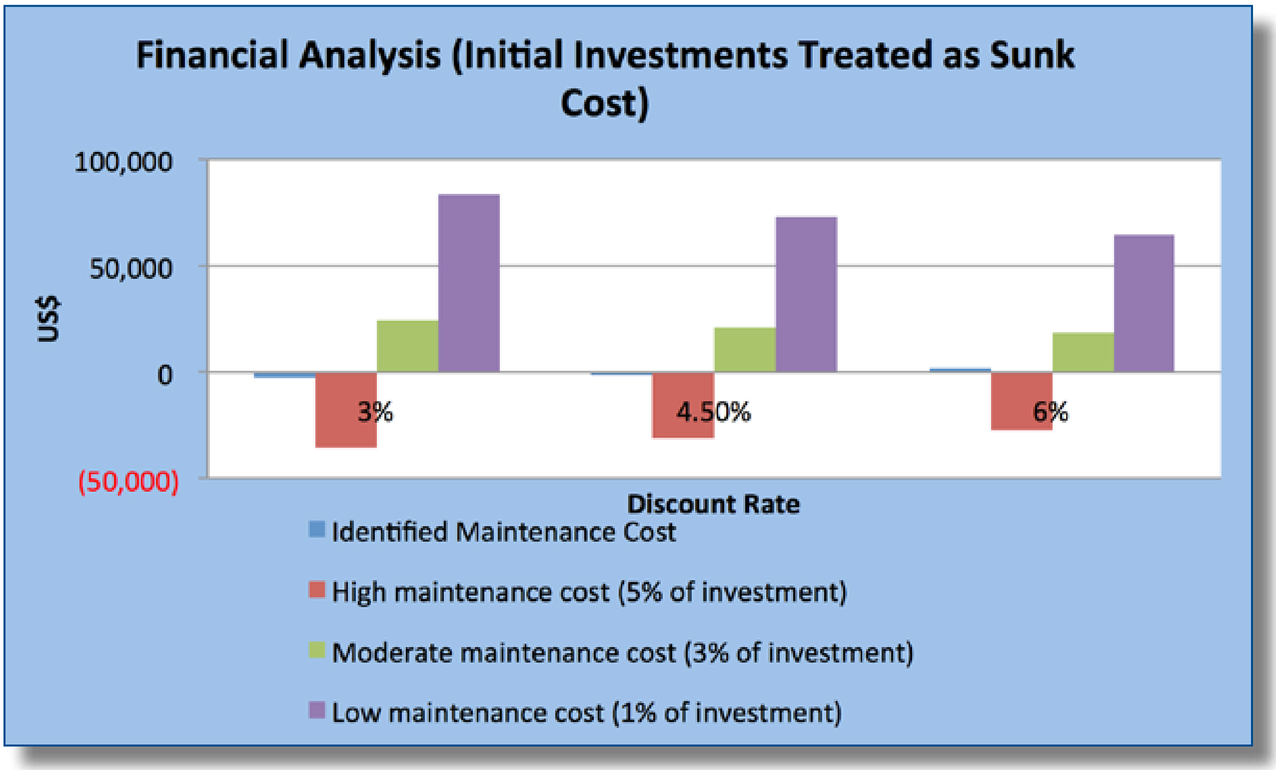
### Discount Rate

The Caribbean Community Climate Change Centre (CCCCC) estimated benchmarks for the Social Rate of Time Preference (SRTP) for selected Caribbean Countries.[5] Discount rates of 3%, 4.5% and 6% were used in this analysis. CCCCC estimated that the SRTP for St. Kitts and Nevis is 5.61%; however, sensitivity analyses suggest it could range from 3% to 6%.

5. The social discount rate can be defined at a rate at which a people is willing to forgo consumption now in order to derive benefits in the future. It is also the rate at which funds are diverted from one alternative to another, i.e. the cost/benefit to society for investing in this project.

## Net Present Value of the Retrofitting Project based on Annual Maintenance Costs

The Net Present Value (NPV) of the project for 20 years, treating the initial investment as a Sunk Cost, since this was donor funded by DFID, indicated the project as being beneficial in terms of savings for maintenance percentages at 0%, 1% and 3%, but not at 5%.




**Net Present Value (NPV) based on varying % annual maintenance costs of the initial investment**

Note, PAHO recommends a planned preventative maintenance cost for health facilities at about 4% per annum of the current value of the building/ facility.[6]

## Ability to Pay and Willingness to Pay

A willingness and ability to pay survey[7] was used to estimate the utility derived from retrofitting the health facility. Despite majority of the respondents suggesting that they are satisfied with the current health service, when asked about their major concerns about the current health care provided, the following suite of responses followed:

- Deteriorating structure, hospital facilities needs upgrading;
- There are inadequate medical supplies at the facility;
  - There is a lack of specialist care and the facility is in need of more trained and qualified health professionals;
  - There is a lack of privacy with medical records;

6. Design Manuals for Health Facilities in the Caribbean, PAHO – by Tony Gibbs.
7. See Annex 2 for results of the Willingness and Ability to pay survey.

- Need for trained staff;
- The Pogson Medical Centre should be improved to provide hospital care long term admissions/treatments;
- Persons from the Sandy Point Area are transported to JNF Hospital in the Capital if they require long periods of monitoring;
- Better distribution of medical staff is needed to ensure the availability of doctors at rural hospitals ;
- Cost of healthcare and medication is high;
- Waiting time to receive service is too long.

It was found that the average willingness to pay for health services was US$19.67 and the average ability to pay was US$20.01.[8]

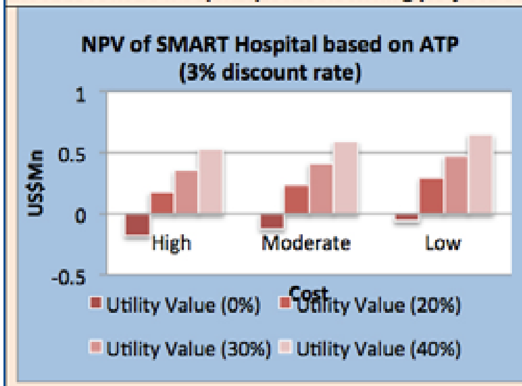
Economic Analysis based on ability to pay (ATP) and willingness to pay (WTP) over the range of discount rates are shown in the following graphs.

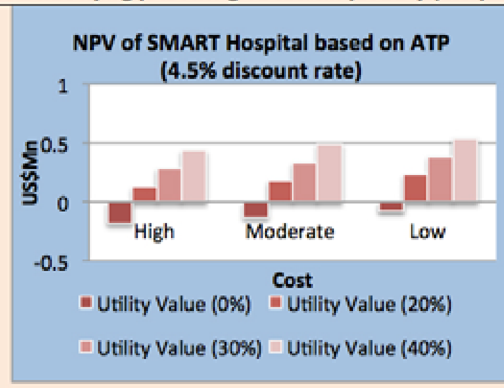
**Table 5 - Range of percentages of ATP and WTP considered in Economic Analysis**

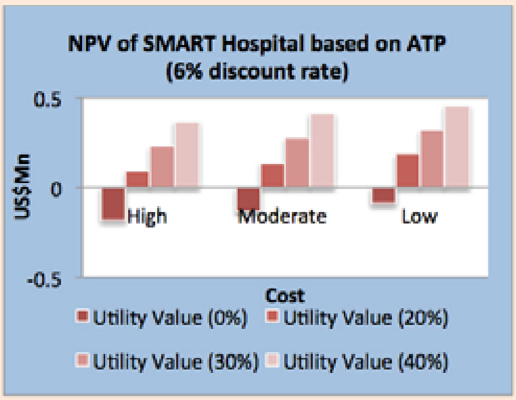
| Percentage | WTP (US$) | ATP (US$) |
|---|---|---|
| 0% | 0.0 | 0.0 |
| 20% | 3.9 | 4.0 |
| 30% | 5.9 | 6.0 |
| 40% | 7.8 | 8.0 |

8. The average presented here is the 5% trimmed mean.

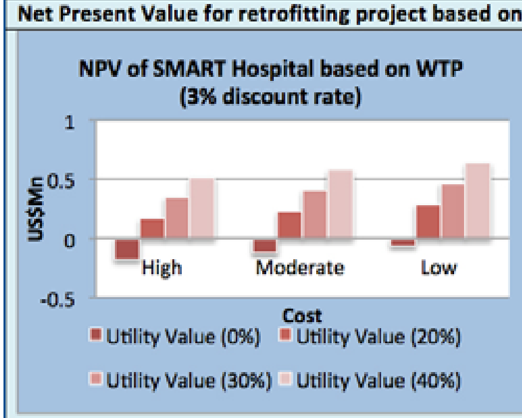
Net Present Value (NPV) for retrofitting project based on varying percentages of Ability to Pay (ATP)

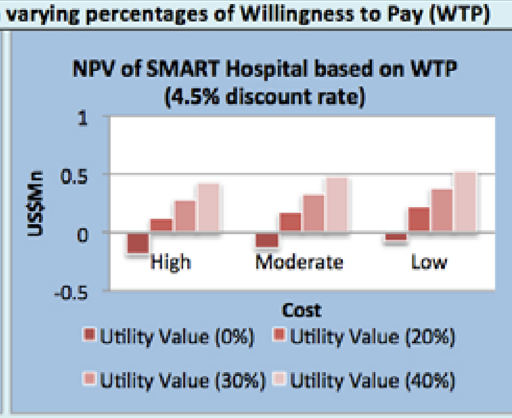


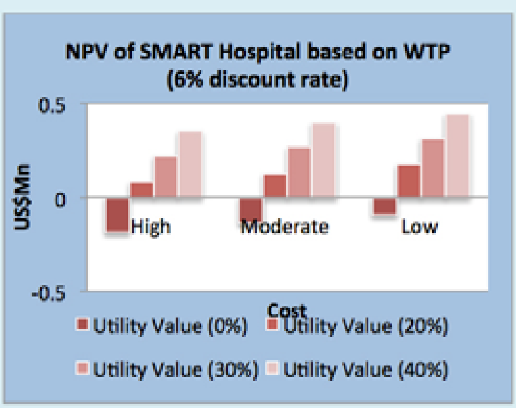




Net Present Value for retrofitting project based on varying percentages of Willingness to Pay (WTP)



## Conclusions and Recommendations

- In the analysis provided above, a variety of discount rates and differing assumptions were used to reach the conclusions drawn below. In such a case, where actual data may not be readily available, the estimations tended to take the conservative route, only entering those benefits that are known, while over-estimating the costs.
- With the currently identified revenue streams in the form of savings from efficient usage of water and energy, the project was found to be financially sustainable since the capital investment was treated as a sunk cost, which was due to funding from UK Department for International Development. Also, the project was found to be feasible when the operation maintenance was a maximum of about 3-4% of initial investment. However, it is imperative that maintenance costs in minimized and other sources of revenue schemes are identified to financially support the project over its lifespan.
- The above findings also point to a fundamental issue that keeps occurring in environmental economics literature. It is evident that for adaptation projects of this nature to succeed, and given the limited fiscal space within which many governments in Small Island Developing States (SIDS) operate, funding for these types of initiatives either have to be of a grant or on a concessional basis.
- From an economic, social and environmental perspective the project is desirable and it becomes even more desirable if the community (users and staff) derives significant utility from seeing the hospital retrofitted which includes improved ventilation, security, safety, hygiene, accessibility, wastage, lighting, health, sanitation, aesthetics and morale. This project presents a baseline project for St. Kitts and Nevis that other public buildings, schools and private building could adhere to.
- Of significant, are the benefits derived from savings on energy consumed and enhanced energy efficiency. St Kitts and Nevis has one of the highest energy costs in the region and this energy architecture makes most projects unsustainable. However, through building in energy efficiency criterion and utilizing a renewable energy source would allow the facility to be feasible. This is a significant lesson learnt for other such projects that may be undertaken.



**The full Cost Benefit Analysis reports are available at the Smart Hospitals website**

**http://bit.ly/1gcELQk**

SAFE + GREEN = SMART

## Section V

# BIBLIOGRAPHY


Care, G. G. (2008, December). Green Guide v2.2 Operations. Retrieved July 18, 2012, from Green Guide for Health are: http://www.gghc.org/tools.2.2.operations.php.

Care, G. G. (2008, December). Green Guide v2.2 Overview. Retrieved July 18, 2012, from Green Guide For Health Care: http://www.gghc.org/tools.2.2overview.php.

Caribsave. (2012). Retrieved July 26, 2012, from Caribsave.org: http://caribsave.org/assets/files/CCCRA%20Final%20Documents/FINAL%20Summary%20Document%20CCCRA%20-%20St.%20Vincent%20&%20the%20Grenadines.pdf.

Greenhealth, P. (2012). Integrated Pest Management. Retrieved November 24, 2012, from Practice Greenhealth: http://practicegreenhealth.org/topics/chemicals/integrated-pest-management.

Harm, H. C. (n.d.). Issues: Green Purchasing. Retrieved December 2, 2012, from Health Care Without Harm: http://noharm.org/all_regions/issues/purchasing/.

Harm, H. C. (n.d.). Waste Management. Retrieved November 21, 2012, from Health Care Without Harm: http://noharm.org/global/issues/waste/.

hCare, G. G. (2007, January). Green Guide v2.2 Design and Construction. Retrieved September 13, 2012, from Green Guide for Health Care: http://www.gghc.org/tools.2.2.design.php.

Lent, T. (2007, June 29). Technical Briefs. Retrieved October 2, 2012, from Green Guide For Health Care: http://www.gghc.org/tools.technical.php.

Organization, W. H. (2012). Health-care Waste Management. Retrieved November 20, 2012, from World Health Organization: http://www.who.int/mediacentre/factsheets/fs281/en/index.html.

## Section VI

# TRAINING AIDS

Click on the titles to open the training aids.

- Unit 1 – Introduction
- Unit 2 – Site Selection and Assessment
- Unit 3 – Sustainable Design and Construction of New Hospitals
- Unit 4 – Applying the Baseline Assessment Tool (BAT)
- Unit 5 – Green Checklist
- Unit 6 – Results and Lessons Learned from the Demonstration Project
- Unit 7 – Cost Benefit Analysis Methodology
- Unit 8 – A Model Policy for SMART Health Facilities

## Section VII

# LESSONS LEARNED FROM THE SMART HOSPITAL INITIATIVE

The SMART Hospital Project was an innovative project and the first of its kind to be implemented in the region. It sought to develop resilient and climate-adapted health care facilities in the Caribbean region through the application of interventions aimed at reducing the vulnerability of facilities and their impact on the environment. The project combined an existing and now globally-accepted tool, the Safe Hospital Index, and measures to improve sustainability. The project not only resulted in a valuable Toolkit for health care personnel, architect, engineers and others to apply but it demonstrated the application of measures to improve safety, reduce risk and also to 'green' health care facilities. Furthermore, as the facilities selected for retrofit were of different ages, one being more than 30 years old the other less than five (5) years old, the project further illustrated how impacts can be made and benefits gained from older and newer facilities. Given the innovative nature of the project and the ages of the facilities retrofitted, there were going to be issues encountered and lessons learned.

### For the Georgetown Hospital Lessons Learned Include:

- Provisions for future expansion on electrical components should be allowed within the facility e.g. electrical conduits.
- Electrical wiring for both 110 and 220v should be provided in critical areas within the hospital and raised well above the floor level. It should be noted that flooding at the Milton Cato Memorial Hospital in Kingstown, St. Vincent and the Grenadines in December 2013 affected electrical outlets.
- Ease of access, maintenance and cost of replacement of items must be considered when selecting components for retrofitting.
- Health facilities must establish maintenance agreements to prevent deterioration. Local or regional purchasing of equipment and supplies will help in this regard. Also, it is important to note that if no maintenance plan exists significant funds will go into retrofitting rather than focusing on Green and Safety improvements. Greater focus on maintenance is needed in these critical facilities
- Appreciate and incorporate the customs and traditions of the local authorities and to avoid any colours, logos or images with political connotations.

- It is critical to properly educate the community prior to commencement of works so that SMART concepts are more accepted by the public e.g. rain water harvesting. In the case of the Georgetown Hospital there was opposition from the community to the capture and storage of rainwater, so that element of the project was modified. All components are installed and just need to be connected should the need arise in the future or perceptions change.
- It is extremely important that there is strong community support and involvement of NGO's and community members. Unexpected benefits were realized with the Georgetown facility as community members were highly motivated by the works they were witnessing. For instance, community members offered to sand and repaint all of the hospital beds, a washing machine was donated and funds obtained from the catering at the re-opening ceremony were donated to the facility. The Health Planner for St. Vincent and the Grenadines indicated during the training workshop that a commitment has been made to source an ambulance for the hospital as well.
- The government allowed for the reuse of the dismantled structural components and distribution of some items to community members but under proper debris management plans for sorting, storage and transportation. This is in keeping with the waste reduction and reuse measurers included in the 'Green checklist' component of the project.

### For the Pogson Hospital Lessons Learned include:

- Projects of this nature should be well coordinated and reporting lines known by all.
- Maintenance programmes must be established to ensure that "SMART" status is maintained. The importance of maintenance was also highlighted previously.
- Identification of a maintenance officer to ensure that training is provided in the operation of the new systems and proper hand over of manuals is performed.
- Works undertaken should ensure that there are provisions for future expansion
- Constant dialogue between contractor and check consultant is essential. Lines of communication must be kept open for the duration of the project.

### General Lessons Learned:

- Clarity on tender process needed,
- Selection of a multi-skilled principal consultant to guide the variety of works needed and to engage in some of the actual works required to prepare the facility;
- Project teams should be comprised of individuals trained in architecture, engineering (various specialities) and green/sustainable building;
- Importance of Public Relations throughout implementation of the project;
    - Community empowerment activities;
    - Good risk analysis and mitigation measures for addressing delays and hazard impacts. should be included/addressed
    - Importance and need for a detailed scope of works to be developed and handover of manuals and as built drawings to ministry of health and maintenance personnel.

- Ensure the involvement of NDO's and other national level partners such as planning and building authorities, maintenance units/agencies, energy units and climate change focal points to allow for effective national level coordination and to ensure cross training for personnel.

## Annex 1

# SUSTAINABLE CONSTRUCTION: DESIGNING FOR THE FUTURE

**A practical guide for hospital administrators, health disaster co-ordinators, health facility designers, engineers, constructors and maintenance staff**

## 1. Introduction

### Scope and Format of the Guidelines

This section of the Toolkit deals gives guidance for engineers and architects. More detail is given for the structural and civil engineers, rather than for architects, mechanical, or electrical engineers because this Annex 1 constantly references sections of the International Code Council's 2012 Green Construction Code (2012 IgCC). Many issues related to architecture, mechanical and electrical engineering are dealt with in this code.

The focus is on sustainable construction of new health facilities and on identifying and counteracting the loads and adapting to the effects of climate change on structure and infrastructure.

This section considers two main issues:

1. Adaptation of structure and infrastructure to climate change related phenomena.
2. Mitigation of climate change through informed design and construction.

The section begins with definitions of key concepts used throughout the text. It continues with guidance on design for adaptation to climate change. The later sub-sections address mitigation of climate change through informed design and construction.

The annex should be used as a starting point, to be read in conjunction with other codes for the purpose of designing a green and a safe hospital in the Caribbean context. Constructors will find it serves as a guide to sustainable site practice and a source of information about sustainable design objectives. For health sector personnel, the guidelines summarise key issues that must be addressed during procurement of new hospitals.

The guidelines therefore provide general information and references which give more details.

The focus is on reducing direct contributions to, and counteracting the effects of, climate change. Other aspects of sustainable construction will not be dealt with, even though some of them may indirectly impact climate change.

Adaptation to climate change includes provision of measures to enhance the hospital's resistance to natural hazard forces that could result in disaster situations. Torrential rain, flooding and coastal hazards are addressed, but they are not specifically linked to tropical cyclones. Wind forces are treated separately.

The document refers specifically to new hospitals and while its principles can often be applied to other types of facilities, in some cases the advice is specific to the hospital context.

## Climate Change - Adaptation and Mitigation

Climate change refers to the change in global temperature caused via the greenhouse effect by the release of greenhouse gasses. Carbon dioxide ($CO_2$) emissions, referred to as 'carbon,' are major contributors to climate change and global warming. Volatile organic compounds such as methane and nitrous oxide also contribute to global warming, although indirectly, by chemical reactions which produce ozone. The global warming potential of these other greenhouse gasses is significant, but the quantity of emissions is lower. Their effect can be represented as a carbon-dioxide equivalent. Water vapour, also considered to be a greenhouse gas, contributes to rising temperatures. The effect is short lived and water vapour quantities cannot be readily controlled by man.

Definitions of other key terms are included in Chapter 2 of the Green Construction code.

Raised global temperature is expected to cause more extreme weather phenomena and rising sea levels. Torrential rain intensity is expected to increase in many places and periods of drought to become more severe. Climate change adaptation is necessary because some long-lived greenhouse gasses are already in the atmosphere. Global warming will continue for many years to come. Climate change mitigation is only aimed at reducing potential further change.

## Hospitals

Hospitals are the most complex of building types. Each hospital is comprised of a wide range of services and functional units. These include diagnostic and treatment functions, such as clinical laboratories, imaging, emergency rooms, and surgery; hospitality functions, such as food service and housekeeping; and the fundamental inpatient care or bed-related function. This diversity is reflected in the breadth and specificity of regulations, codes, and oversight that govern hospital construction and operations.

Each of the wide-ranging and constantly evolving functions of a hospital, including highly complicated mechanical, electrical, and telecommunications systems, requires specialized knowledge and expertise. No one person can reasonably have complete knowledge, which is why specialized consultants play an important role in hospital planning and design. Early consultation of all design team members is the best approach to achieving a sustainable outcome. Ideally, the design process incorporates direct input from the owner and from key hospital staff early on in the process.

The basic form of a hospital is, ideally, based on its functions:

- bed-related inpatient functions
- outpatient-related functions
- diagnostic and treatment functions
- administrative functions
- service functions (food, supply)
- research and teaching functions

In a large hospital, the form of the typical nursing unit, since it may be repeated many times, is a principal element of the overall configuration. Nursing units today tend to be more compact shapes than the elongated rectangles of the past. The trend is towards all private rooms.

A smart hospital is defined as a facility which is safe in the face of natural hazards, adapted to climate change phenomena and makes a contribution to the mitigation of climate change. It is a health facility that remains accessible and functioning at maximum capacity and in the same infrastructure, during and immediately following the impact of a natural hazard.

Hospitals come under Institutional Group occupancy classification I-2 in section 308 of the *International Building Code 2009*. Clinics and other health care facilities come under Business Group B in section 304.

### Future proofing of hospitals

Since medical needs and modes of treatment will continue to change, hospitals should be designed with changing needs and adaptability in view. This is essentially 'future proofing.' Hospitals should be designed on a modular system basis, with generic room sizes to the extent possible, so that they are adaptable. It is best to provide for vertical expansion[9] without disruption to the lower floors. The design should be open ended, with well-planned directions for future expansion, for instance, positioning 'soft spaces' such as administrative departments, adjacent to 'hard spaces' such as clinical laboratories.

Adaptable features should be targeted at specific realistic functional scenarios within the health sector.

## Role of the structural and civil engineer

The multidisciplinary team should be involved from the start of concept design to the final delivery of the new facility. Each team member has a particular specialism.

The architect conceptualizes the site layout and landscaping and determines the use of space within the building, specifying furniture and finishes. The civil and structural engineer deals with the design and specification of structure and infrastructure within a multi-disciplinary team. The mechanical and electrical engineer specifies the equipment and building services for the operation of the hospital facility.

> The design team decides the climate change impact of a new building at the start of a project because:
>
> - the choice of structural form, materials and finishes – all of which generate carbon dioxide emissions at the time of construction.
> - the choice of equipment and the nature of the building services – over the life of the building these components generate carbon dioxide emissions.

9. Preliminary designs by Architect, Civil Structural Mechanical and Electrical Engineers must be made for the whole of the proposed structure, as well as technical analyses to facilitate detailing of those parts of the building being constructed at the time.

## 2. Adaptation

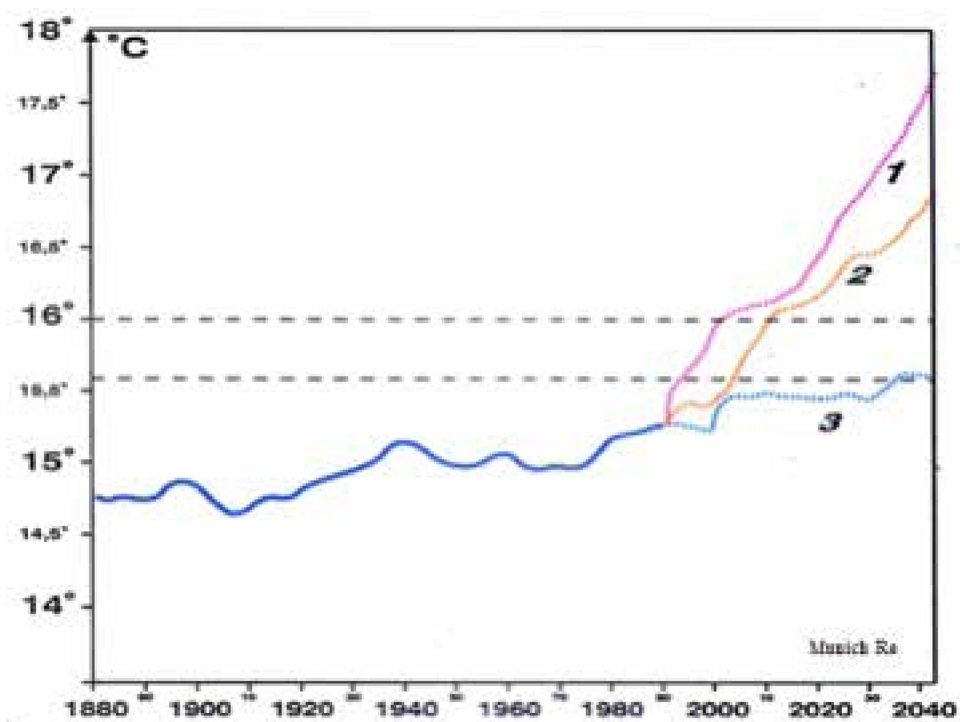
Both new and existing hospitals must respond to climate change. Suitable adaptation measures will depend on whether a new facility is to be built on a virgin site, or whether a new facility is to be created through re-use of an existing building or a site previously dedicated to another purpose. The architectural ideal is a timeless building concept.

Instead of design based largely on past experience, architects and engineers must now factor predicted climate change scenarios into their concepts and calculations. Spatial layout, structural frame and foundations have relatively long life spans and will be affected by changes in climate. Other components, such as cladding and façade, can be upgraded in line with climate change impacts because they are maintained / replaced more frequently.

> One adaptation strategy is to learn lessons from other locations where the climatic conditions are harsher, but similar to the ones predicted for the chosen locality.

### Adaptation to temperature rise

Rising temperature will affect the behaviour of materials, particularly those with high coefficients of thermal expansion.




**Temperature rise scenarios by Munich Re**

| Engineering design considerations | Why? |
|---|---|
| More movement at joints | Detailing interfaces between materials and joints with an allowance for greater temperature related movement than in the past. |
| Structural elements will expand and contract | Materials with high coefficients of thermal expansion will be susceptible to temperature changes. Allow for movement |
| Possible weakening of adhesives | Adhesives are heat-sensitive. Products such as glue-laminated timber will be adversely affected by rising temperatures. |

| For consideration in construction | Why? |
|---|---|
| Ventilate the temporary works | Methods of natural (or even forced) ventilation should be considered in scheduling the construction work so that the partially complete building does not provide an uncomfortable working environment. Refer to section 803.1.2.1 of the 2012 *IgCC* for guidance. |
| Limit temperature rise of concrete | Fresh concrete generates considerable heat of hydration as it develops strength and hardens. The temperature rise associated with this process must be controlled, and for large masses of concrete steps are taken to limit the temperature rise. The constraints on such concrete pours will become more onerous due to global warming. |

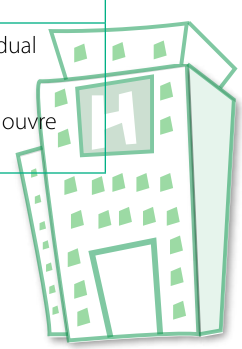
## Keeping the building cool

The Green Construction code section 605 on building envelope systems gives prescriptive advice on insulation, fenestration and shading. The code also gives a performance based specification – i.e. target outcomes.

Some architectural considerations, presented in the *Energy Efficiency Guidelines for Office Buildings in Tropical Climates* are relevant and are summarized below.

| Design features | Ways to enhance cooling |
|---|---|
| Façade openings | Encourage cross ventilation. Recommend at least 20% porosity[10] for facades perpendicular to the prevailing wind direction.<br>Use lower level windows on the windward side and higher level windows on the leeward side.<br>Maximize airflow. Do not place windows opposite each other.<br>Partitions must not interrupt air flow – place them parallel to the wind direction. |
| Orientation relative to the sun path | Avoid solar heat gain through glazed openings. Assess the sun path at the given latitude.<br>Limit the amount of direct sunlight impacting east and west facades.<br>Provide natural lighting through openings in the north façade, which receives low direct sunlight at Caribbean latitudes. |
| Separation between buildings | Allow breezes to circulate between adjacent buildings. (Allow for the venturi effect in determining wind loads.) |
| Sunshades | Sunscreens reduce solar heat gain. Specially designed sunshades can serve a dual purpose as hurricane shutters.<br>Consider horizontal shades / overhangs for north-south facades and vertical / louvre style shades for east-west facades. |

10. Porosity refers to the ratio: total area of wall openings divided by total wall area.



| Design features | Ways to enhance cooling |
|---|---|
| Shade trees | Plants provide natural shade. Added advantage is that they help percolation of rainwater into the soil. (The location of trees should take into account their potential to be a hazard in hurricanes.) |
| Transition spaces | Consider balconies, atria and porches with planned air flow patterns.<br>Covered entry spaces, protected from rain and shaded, but otherwise open: protect the walls and inner spaces from direct sunlight.<br>For hurricane resistance, roof design should not be continuous from such areas to the enclosed spaces. |
| Ceiling height | Higher ceilings allow warm air to rise away from the occupants. |
| Reflect direct sunlight | Choose pitch in relation to sun path for maximum reflection.<br>Choose bright colours in the external finishes.<br>Caution: this can worsen the urban heat island problem for neighbours. |
| Double Roof | In a double roof system the upper roof shades the lower and minimizes solar heating of the internal air space.<br>A ventilated roof with a gap between the covering and ceiling is similar. Protect opening from fauna, and exercise care with wind resistance. |
| Walls | Consider double walls, green walls, or wall insulation, especially for walls exposed to direct sunlight. |
| Glazing | Use double glazing with air gap, non-conducting frames, thermal bridge breaking frames to reduce solar heat gain.<br>Consider smaller glazed openings. |

## Adaptation to changes in the frequency of precipitation

Climate change can be expected to generate higher temperatures, longer periods of dry weather, and increased loss of moisture from trees located close to buildings. For structures on expansive clay, the result will be more frequent and severe subsidence.

### Subsidence

Subsidence is downward movement of a building foundation caused by loss of support underneath it. The ground has, in effect, moved away from under the building foundation, and often cracks develop in the superstructure as a result. One common cause of subsidence is drying out and shrinkage of clay sub-soil under the foundations during periods of dry weather. This clay contains minerals that give it expansive properties and make it moisture sensitive. Certain types of trees can draw moisture from deep underground (even up to 6m) and exacerbate the drying shrinkage of clay. In the presence of such trees the problem of subsidence is more acute.

| Solutions for new buildings | Explanation |
|---|---|
| Deep foundations | Subsidence typically affects shallow foundations such as strip footings or slabs on grade. Consider using deep foundations, such as mini piles, which are less affected by volume changes in clay soils. (Allow for the effect of volume change on skin friction.) |
| Ground improvement and root pruning | If trees are located nearby and contributing to the subsidence problem, their roots can be pruned or otherwise removed from the vicinity of the structure. |

During periods of wet weather, expansive clays will swell and cause heave of the foundations. Repeated wetting and drying can therefore cause undesirable cyclic movement of the building foundations. Problems due to subsidence are more common than problems due to heave or cyclic movement.

Development of cavities (swallow holes) in chalk soils also causes subsidence. This movement often takes place after heavy rain. The problems and remedies are similar to those described above for foundations on clay soils. (Potential sink holes should be investigated, for example using ground-penetrating radar.)

## Adaptation to more intense precipitation

Rainfall levels are constantly monitored by local meteorological offices. Based on the data collected intensity-duration-frequency (IDF) curves can be developed which will reflect changing trends in the distribution and intensity of rainfall. IDF curves are essential for rational storm-water drainage design. Climate change is expected to generate more intense rainstorms. General advice on storm-water management is given in section 403.

Areas of the building envelope to focus on are listed in section 507.

| Problem | Solutions | Consider also |
|---|---|---|
| Driving rain requires better waterproofing and shading of exposed facades | Recessed windows and doors, and separate hoods, rather than longer eaves projections which compromise wind resistance. | Careful detailing of glazing, joints, and openings, methods of fixing the façade and overlaps between panels, fixings and overlaps on roof sheeting.<br>Antifungal treatment of external finishes. |
| Large volume flow rate of storm water from the roof | Auxiliary down pipes to prevent problems due to blockage | Avoid large continuous roof areas in design concept |
| Flooding – providing structural solutions | Suspended ground floor elevated at least 1m above the predicted maximum flood levels. (A 'soft storey' could be created detrimental in earthquake.) | Superstructure well fixed to the supports so as to resist uplift of the structure by the water passing under it, or by other forces (e.g. earthquake) |
| | Piers, posts or columns embedded deeply enough to withstand undermining by flood waters | Floating structures built on raft foundations incorporating a buoyant layer of foam |
| | 'door dams', flood levees around the building and non-return drainage valves, as temporary measures | Fencing or a hedge that will not obstruct the passage of flood water or contribute to the debris carried by the flood. Avoid masonry boundary walls. |

### Effects of rising ground water

Rising ground water levels can result from infrastructure development and from increased precipitation. The latter is a direct climate change impact. The former is indirect, in that some flood defence infrastructure can have the effect of constricting the natural flow of ground water and causing local ground water levels to rise. Rising ground water can also result from sea level rise since the water table near the coast is directly affected by the sea.

| Problem | Solutions | Consider also |
|---|---|---|
| Rising groundwater affecting new and existing basements. | Drainage system for ground water .<br>Measures for preventing rising damp and for waterproofing of the walls below ground. | Buoyant forces on the basement.<br>Protected connections for timber joists supported on the basement walls. |
| Rising groundwater affecting slopes. | Improve drainage behind retaining walls, under embankments and at the toe of the slope. | Drought resistant plant cover to hold the soil. |
| Rising groundwater affecting buried pipes. | Anchor pipe against buoyant forces. | Subsidence of ground supporting pipes. Use flexible jointing and pipework. |

### Soils and slopes – why drainage is important

Ground conditions are generally made worse by rising ground water levels. The bearing capacity of granular soils (e.g. sandy soils) is reduced when they are submerged. The submerged soil can only support half of the load that it could support in the dry condition. This leads to foundation failures and slope failures when areas that were designed to be dry become submerged. A risk associated with climate change is the saturation of granular soils in areas where it was not anticipated.

The stability of slopes and embankments can be affected by very dry or very wet weather conditions. Periods of dry weather will decimate the plant cover on many slopes. This can contribute to soil erosion and make the slope more vulnerable to landslide when rains do occur.

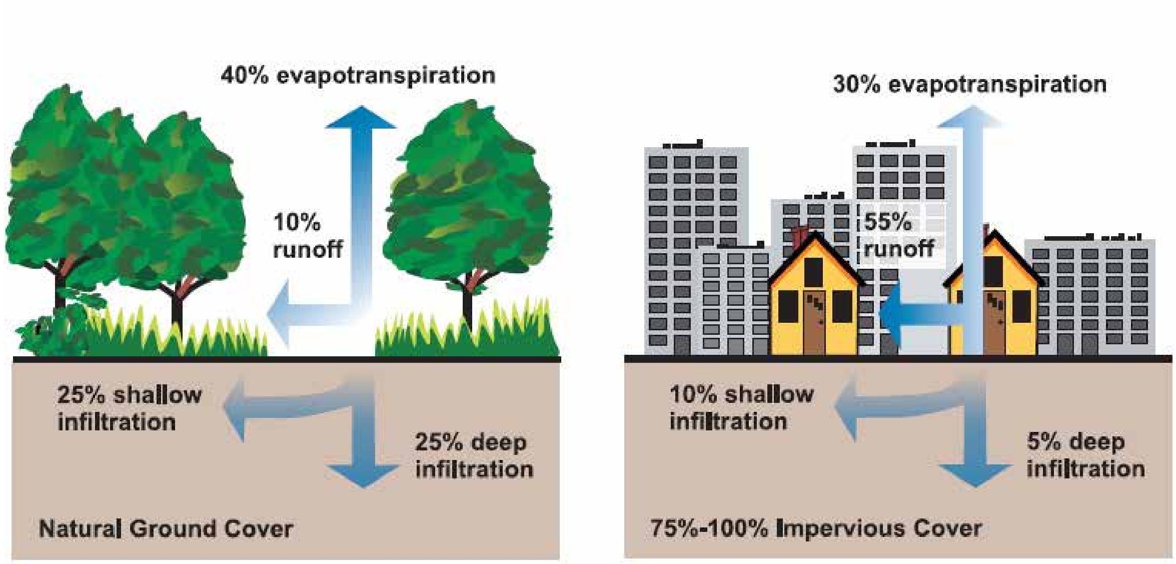
As soil pore water pressures increase, the effective stresses that contribute to slope stability are reduced. As a result slopes are more vulnerable to landslides. Increased pore pressures and ground water forces will also tend to de-stabilise existing retaining walls that are not designed to withstand them.

Earthquakes introduce a further complication. Certain granular soils in the presence of high pore water pressures can liquefy during earthquakes. The soil loses its ability to support load and this causes dramatic failures of foundations and structures. Rising ground water increases the liquefaction risk. In seismically active regions, the potential of climate change to increase the risk of liquefaction should be seriously considered in design or during retrofitting.



### Flooding – drainage solutions

A critical facility should not be built in a flood hazard area. However, with climate change, an area formerly free from flooding may become a flood hazard area. An adaptation strategy would be to anticipate this occurrence. Advice for developers in flood hazard areas is given in section 402.2 and design guidance for flood loads is given in the International Building Code 2009 section 1612.




Source: http://upload.wikimedia.org/wikipedia/commons/4/46/Natural_%26_impervious_cover_diagrams_EPA.jpg.

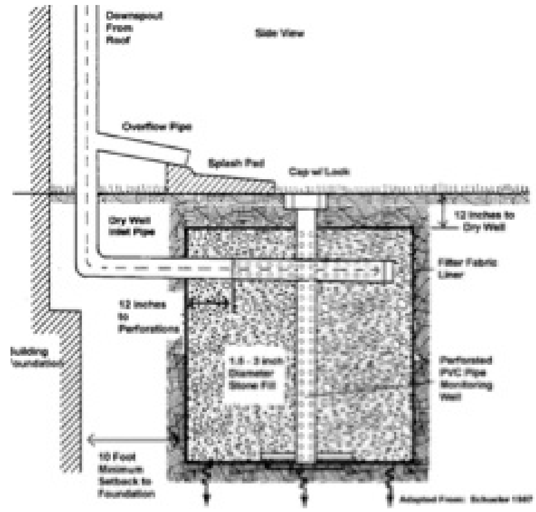
Inland flood damage is mainly due to inadequate capacity of drainage facilities during periods of excessive rainfall. The external works associated with buildings for public occupancy must be carefully designed with climate change parameters in mind.

| Stormwater quantity reduced | Measures to adopt |
|---|---|
| More green and blue[11] spaces | Maximise the unpaved areas to increase percolation, and use greener paving solutions such as "grass-crete".[12]<br>Refer to section 408. |
| Green roofs | Reduce rainfall runoff. They have the added benefit of providing thermal insulation and contributing to the capture of carbon from the atmosphere.<br>Caution: exercise care with waterproofing and drainage.<br>Notes on green roofs are given in section 408.3.2. |
| Planned storage and overflow | To reduce the load on the collection system, plan the direction of overflow and provide for storage in the system. Allow for blockage by debris. Allow for seasonal variation in flows. |
| Rainwater tanks, ponds or pools | Collection of the rainwater and controlled release reduces the load on the storm-drainage infrastructure during heavy downpours.<br>The rainwater collected can be used for irrigation during dry weather and for flushing toilets (or other applications permitting non-potable water). Refer to section 404 for advice on irrigation systems using non-potable water.<br>Guidance on the design of rainwater storage tanks and associated plumbing is given in section 707.11 "Rainwater catchment and collection systems". Reference is also made to the International Plumbing Code. |

11. Blue spaces are water features such as ponds, lakes or fountains.
12. Made of hollow concrete blocks containing soil and grass, providing a "green" surface for vehicles. Notes on porous paving are given in the *ANSI / ASHRAE / USGBC / IES* standard, section 5.3.2.1c).

| Stormwater quality improved | Measures to adopt |
|---|---|
| Soakaways and catch basins | Include pollutant removal mechanisms including petrol interceptors, silt traps, screens for debris |

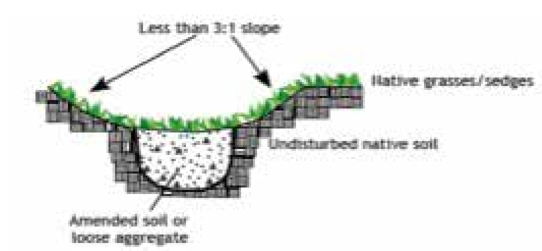

**Typical Green Roof**[13]




**This dry well is a form of soakaway**[14]

| Better quality and lesser quantity | Measures to adopt |
|---|---|
| Grass swales | Allow infiltration and provide greener spaces |
| French drains | Promote infiltration and storage of stormwater, reducing load on the collection system |
| Porous paving | Promotes infiltration and groundwater recharge. A common example in the Caribbean is grass-crete, mentioned earlier. |

**A Grass swale**[15]




**Cross-section of a Typical Infiltration Trench**[16]

13. Source: http://www.glwi.uwm.edu/research/genomics/ecoli/greenroof/benefits.php.
14. Source: http://www.seagrant.sunysb.edu/cprocesses/pdfs/BMPsForMarinas.htm.
15. Source: http://www.pbcgov.com/coextension/horticulture/neighborhoods/tips/_images/swale.jpg.
16. Source: http://www.anr.state.vt.us/dec//waterq/stormwater/htm/sw_InfiltrationTrenches.htm.

Installed permeable pavers[17]

Grass Paver system[18]

Besides improving storm-water quality and reducing the total volume of flow, the speed of flow should be retarded if possible.

Where vegetation is specified the species should be low maintenance, pest resistant, and indigenous. Avoid invasive varieties. Plants increase ambient humidity and should be placed in areas with good natural ventilation.

## Adaptation to changes in wind forces

### The wind hazard and long-term sustainability

The principal meteorological hazards in tropical and sub-tropical regions are high winds, rainfall, wind-driven waves and storm surge. The hazards of waves and storm surge are related to wind speeds. With increases in speeds it is reasonable to conclude that waves and storm surge will pose more intense threats in coming years. These threats will be further amplified by rising sea levels (addressed in the following section). Most of the economic activities of many tropical islands are located in coastal areas.

Reference is made to the Technology Strategy Board report *Design for Future Climate opportunities for adaptation in the built environment*. In it is mentioned the Association of British Insurers recommendation that design codes for buildings in the south east of the UK should incorporate increased wind speeds, although the document indicates that the effect of climate change on future wind loading is unclear.

### Climate change

Hurricane Catarina made landfall in the north of Brazil on 27 March 2004. This was the first hurricane ever recorded in the South Atlantic. Hurricane Ivan struck the island of Grenada on 07 September 2004 with peak gust winds of 135 mph (60 ms-1). According to the USA National Hurricane Centre Ivan was "... the most intense hurricane ever recorded so close to the equator in the North Atlantic". On 30 August 2008 a new world surface wind gust record for hurricanes was registered at the Paso Real de San Diego meteorological station in Pinar del Rio (Cuba) during Hur-

17. Source: http://www.enhancecompanies.com/idea_gallery/permeable_pavers.php.
18. Source: http://www.grassypavers.com/.

ricane Gustav. The Dines pressure tube anemometer recorded a gust of 211 mph (94 ms-1). Are these isolated incidents or portents of future climate?

In 2008 the World Bank funded a multi-faceted project of which one component was the investigation of the possible effects of climate change on wind speeds for structural design in the island of Saint Lucia in the Eastern Caribbean. The project was executed by the Caribbean Community Centre for Climate Change and the actual work was done by the International Code Council (a wholly USA organisation) using the services of Georgia Institute of Technology (principal researchers Judith Curry and Peter Webster), Applied Research Associates Inc (principal researcher Dr Peter J Vickery) and Tony Gibbs.

Hurricane activity in the North Atlantic (including the Caribbean) follows multi-decadal cycles. The current warm phase of the Atlantic multi-decadal oscillation is expected to extend to the year 2025. By that time it is expected that the sea-surface temperatures would have risen by 1o F (0.56o C). The region experiences historically more hurricanes, and more severe hurricanes, during warm phases of Atlantic multi-decadal oscillations.

The number of tropical cyclones in the North Atlantic has averaged 10 per year in the past 50 years and 14 per year in the past decade. This is projected to rise to 15-20 per year by 2025. The combination of greenhouse warming and natural cyclical variability of the climate will produce unprecedented tropical cyclone activity in the coming decades.

### Effects on Wind Speeds

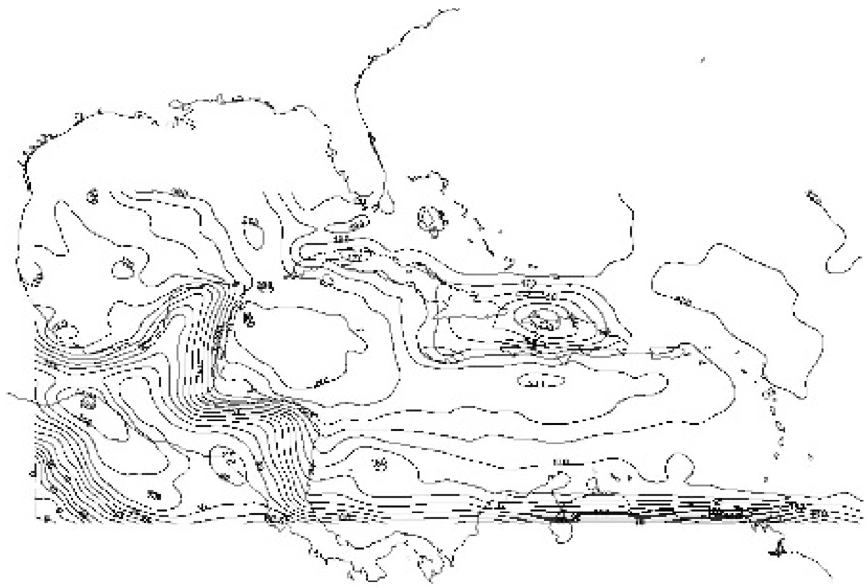
For conventional buildings[19] the proposed Caribbean standard[20] will adopt 700-year return period wind speeds and for important buildings[21] such as hospitals the 1,700-year return period wind speeds will be adopted. (These return periods provide "ultimate" or failure wind speeds.)

There could be an average of three to four Category 4 and 5 hurricanes[22] per year by 2025 in the North Atlantic. This represents a 210 to 280 percent (average 245%) increase in the number of Category 4 and 5 hurricanes compared to the long-term (1944-2007) average of 1.4 Category 4 and 5 hurricanes per year. If this turns out to be the case, the basic wind speeds for conventional buildings in Saint Lucia would be increased by about 12 to 14 percent (25 to 30 percent increase in forces), and the basic wind speeds for important buildings such as hospitals would be increased by about 10 percent (21 percent increase in forces).

Although the studies were carried out specifically for Saint Lucia, the results are probably valid for most of the Eastern Caribbean and are generally indicative of what is in store for much of the North Atlantic. This work carries an important message for all countries. Serious consideration should now be given to modifying wind speeds in other countries where national codes may be based on out-of-date wind speeds.

The website http://bit.ly/15pYrzg gives the 2008 Caribbean Basin wind hazard maps and an application document with guidance on using them. A sample hazard map showing the 1700 year return period wind speeds follows.

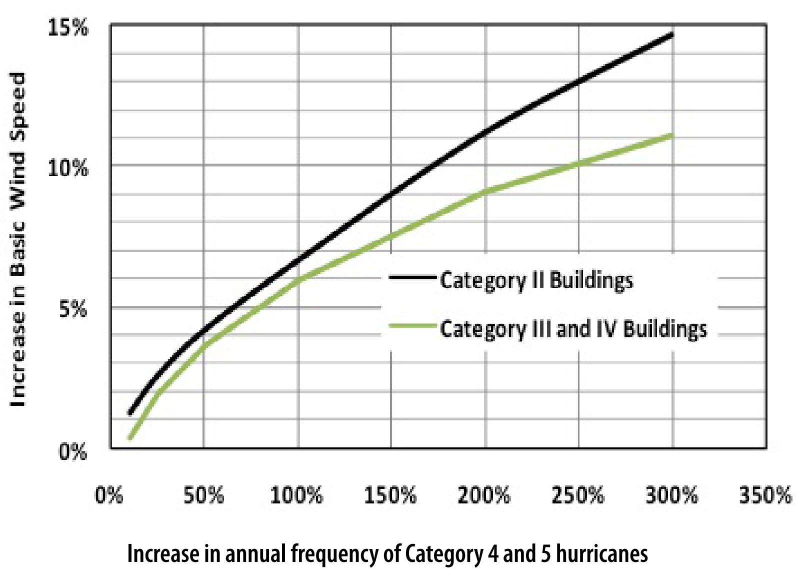
19. Category II in the American Society of Civil Engineers standard ASCE 7.
20. Based on the American Society of Civil Engineers standard ASCE 7.
21. Categories III and IV in the American Society of Civil Engineers standard ASCE 7.
22. Saffir-Simpson scale for hurricanes, not to be confused with the building Categories in ASCE 7.



**1700-year return-period marine wind speeds for Caribbean region.**

The combination of greenhouse warming and natural variability will produce unprecedented tropical cyclone activity in the coming decades. The graph that follows shows the percentage increase in basic wind speeds for St Lucia against the percentage increase in annual rates of category 4 and 5 hurricanes. It is applicable across the Eastern Caribbean.

> Designers of new facilities today should already be using the anticipated higher wind speeds in their work.
>
> The adaptation response to the expectation of higher wind speeds should be to use structural forms with better aerodynamic properties, for example steeply pitched roofs and regular plan layouts.



## Adaptation to rising sea levels

A critical facility should not be built near the coastline. However, with rising sea levels, areas formerly at some distance from the shoreline will be increasingly vulnerable. An adaptation strategy would be to anticipate this occurrence.

Non-elevated buildings close to the shoreline are most vulnerable to damage by wave energy. Flood damage in coastal areas is due to unusually high tides, storm surge,[23] and waves which can be up to seven metres high in extreme cases.

Carbon monoxide absorbed into sea water causes acidification, which damages the coral reefs. These reefs act offshore to break the force of incoming waves, and the sand formed by the breakdown of coral provides a buffer zone when it is deposited on-shore. Therefore, sea level rise will be compounded by loss of the coral reefs and reduced amounts of sand deposition.

Physical works along the coast afford direct, immediate protection against rising sea levels. Long-term measures to respond to climate change are indirect and involve changes to human activities based on planning initiatives.

### Solutions for new buildings

- Restrict the use of the ground floor to applications that do not impair the function of the building, e.g. car parking or non-essential administrative functions. Costly or essential equipment is placed on higher floors.
- Construct suspended ground floors, as mentioned in the flood mitigation section above.
- Construct the building on an embankment: raise the existing ground level before construction and protect the new, higher shoreline from erosion.

### Coastal defence structures

A range of coastal defence structures can provide suitable protection. They have to be designed for rising sea levels, higher wave energies and more intense storm surge than formerly. They also have to be designed so that the protection afforded to one location is not detrimental to a neighbouring location.

At present such works are not typically included in the scope of a new-build hospital project. However, with increasing awareness of the hazards affecting structures near the coast, some of these defence measures may become essential parts of the scope of works.

#### Hard shore protection

Hard shore protection creates a barrier between the sea and the structures built near the coast, aiming to fix the shoreline in its current location. Generally hard shore protection measures are more disruptive to natural ecosystems than the alternatives.

23. Small volcanic islands are not prone to severe storm surge which is a feature of areas with shallow bathymetry and long coastlines.

| Method | Description | Drawbacks |
|---|---|---|
| Sea walls | Solid, vertical structures - act as dikes to prevent coastal flooding and wave damage | They reflect the wave energy and as a result can be affected by scour / erosion at the base of the wall. Designs with sloped or curving sections can reduce this problem. |
| Revetments | Heavy stones are placed as armour on the slope, and these dissipate the wave energy. | Reflection of the waves causes erosion rather than deposition of sand at the toe of the slope. |
| Gabions | Enclosed baskets of aggregate can be placed on slopes to provide protection in locations where significant earthworks are difficult. | Not recommended for beaches. They have a very short lifespan, due to corrosion. |

### Protection of the coral reefs

Effluent from sewage treatment and storm-water is discharged to the sea. The point of discharge for effluent is often at the end of an outfall, whereas for storm-water, the point of discharge is often at the coastline. Both types of discharge can have an adverse effect on the coral reefs that protect the coastline. Many hospital facilities operate their own sewage treatment plants and are responsible for their stormwater drainage systems. Enhanced sewage treatment and filtration of stormwater can minimize the negative impact on the coral reefs. This adaptation measure is aimed at preserving and maximizing effectiveness of the buffer zone.

### Creating a buffer zone

The beach serves as a buffer zone absorbing wave energy and restricting encroachment of the sea.

| Method of creation | Effect |
|---|---|
| Beach nourishment | If no other steps are taken regular maintenance is needed to replenish the natural loss of sand over time. This would typically be a governmental responsibility. |
| Breakwater built parallel to the coastline | Serves to reduce wave energy and encourage deposition of sand along the coast. This will generally widen the beach in the sheltered area, although it may have an adverse effect on the width of the beach elsewhere. |
| Groynes and headlands at right angles to the coastline | Trap sand and create or widen a beach. The areas down-drift of the headland can be adversely affected unless measures are taken to ensure that deposition continues in these locations. |
| Sea grass beds | Can help to anchor the beaches in place |
| Coastal wetlands and mangroves | Slow down erosion and absorb flood waters. Wetland protection and development in wetland areas is discussed in section 402.4<br>These regions will naturally migrate inland if allowed to do so, because of sea level rise. For this to happen there must be a planned retreat of human activities landwards. |

### Planned retreat

One planning tool is the implementation of a set back for construction along the coast. Section 402.3 supports this principle, but does not give specific guidance. This is usually provided by the local regulating authority. Generally structures should be set back at least thirty metres from the shoreline. This set back is determined based on the encroachment of the sea due to climate change and also takes into account the heights of seasonal storm waves. Implementation of set backs is hampered by historical land use and limitations on the space between the coastline and the property boundary. In effect, an increasing set back over time constitutes a planned retreat landwards.

For essential facilities such as hospitals, planned retreat should be considered. The time scale for which provision is being made is critical. About 50-100years is the norm.

## Adaptation to changes in human activities

Communities are actively responding to climate change and adopting sustainable practices. One of the responses has been to reduce consumption of potable water.

### Design of sewers for low flow facilities

The volume of water used by sanitary ware has been declining, and this will in the long term reduce the efficiency of sewer systems. Gradients of gravity sewers were designed for a certain volume flow rate of liquid. When this is not achieved the system can be blocked by an accumulation of solids.

| Solution | Drawback |
|---|---|
| Vacuum drainage system | Power requirement to create the vacuum. |
| Combination of storm-water and sewage flows | Seasonal variation in storm-water flows and the increased risk of contamination of flood waters by sewage. |

# 3. Mitigation

There are new initiatives for mitigation of climate change involving capture of carbon out of the atmosphere and reflection of solar radiation causing global warming. This section of the guidelines looks at mitigation in the context of sustainable construction of new buildings and infrastructure.

Landscaping measures such as carbon capture by trees and plant life in ponds also contribute to mitigation. They were mentioned earlier in the adaptation context and will not be repeated here.

## Planning and procurement of sustainable construction

Procurement is the 'process which creates, manages and fulfils contracts relating to the provision of goods, services and engineering and construction works or disposals, or any combination thereof' (ISO 10845-1). Procurement is accordingly a key process in the delivery and maintenance of construction works, as organisations invariably require goods and services from other organisations.

Professional services are required to plan, budget, conduct condition assessments of existing elements, scope requirements in response to the owner or operator's brief, propose solutions, evaluate alternative solutions, develop the design for the selected solution, produce production information enabling construction and confirm that design intent is met during construction. Constructors, on the other hand, are required to construct works in accordance with stated requirements or to perform maintenance services.

With a performance specification, procurement is judged in terms of outcome. With a prescriptive specification, procurement is based on input requirements.

Developed countries tend to focus more on minimising the harmful effects of development on the local environment and the promotion of increased use of environmentally sound goods, building materials and construction technologies. Developing countries on the other hand tend to focus more on the alleviation and reduction of poverty, the establishing and strengthening of indigenous building industries and construction technologies that increase employment.

Sustainable procurement raises the following issues, among others:

- Usage of resources such as energy and water
- Choice of building materials, including local sourcing and use of recycled materials
- Choice of construction methods and resources
- Waste disposal
- Adaptability for changed usage and design for deconstruction
- Ease of maintenance and durability.

These issues may relate to different stages in the life cycle of construction works.

| Alternative ways to achieve a sustainable outcome | Detail |
|---|---|
| Focus on whole life costs rather than only on the initial cost. | Using a standard such as EN ISO 14040 series for life cycle assessment can achieve a sustainable building project. |
| Adopt a rating system and attempt to gain "points" by following the recommended sustainable practices. | Awareness among engineers can contribute even more sustainable outcomes because there are flaws in the rating systems such that they do not reward every sustainable decision. |
| Follow a model taken from a similar project (possibly overseas) | It may be necessary to adapt it to suit the local case |
| Innovate within a design team committed to sustainability and use databases and software available. | Databases will give information on the life cycle cost of materials in terms of energy or carbon. Carbon will be a design constraint and the specifications will be performance based rather than prescriptive, to allow the necessary flexibility. |

## Reducing embodied carbon

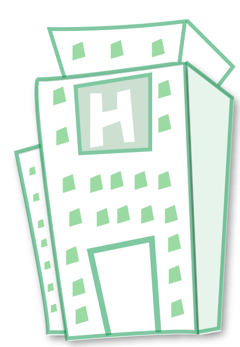
A building's carbon footprint describes its overall impact in terms of carbon-dioxide emissions. Estimating the carbon footprint over the life cycle of a building includes both the embodied carbon and the operational carbon.

**Embodied carbon** (ECO2) is associated with the construction of the building itself including the extraction and processing of materials, the manufacture of components, and the transportation of these items for their assembly on site.

**Operational carbon** rrefers to the emissions generated by occupation of the structure. In considering the balance between embodied and operational carbon, the (possibly conflicting) needs of both owners and users must be considered.







**Direct reduction in carbon** is achieved by cutting down on emissions of greenhouse gasses.

**Indirect reduction in carbon** is achieved by cutting back on the amount of new or recycled material used in construction, and maximising re-use or recycling (reducing waste) where feasible. The frequency of replacement of components also determines the carbon footprint, and this leads to an emphasis on life cycle assessment.

### Embodied carbon estimates and computations

The engineer's experience enables structural concepts to be developed to define form, layout and the principal materials which will be used. Structural engineers need quick and easy tools to compare different alternatives and the IStructE's *Short Guide to Embodied Carbon in Buildings* aims to provide these tools.  As the design develops more detailed carbon calculations are needed both to refine the design and develop specifications, as well as to claim credits on appropriate rating schemes. Data bases and handbooks with the relevant information are increasingly available and some relevant references are listed at the end of these guidelines.

**The embodied energy of a building** is the energy required to make, deliver, assemble and dispose of all of the materials used in its construction, refurbishment and demolition. It is usually expressed in Mega-joules (MJ) rather than kWh (3.6MJ = 1kWh).

**Embodied carbon** is the kgCO2e released due to the embodied energy plus any process emissions, such as the CO2 released by the chemical reaction when cement is produced.

Most data is quoted as "cradle to gate" and includes the carbon emissions associated with all stages of manufacture from extraction through processing until the component leaves the factory for the site.

A **life cycle inventory** is a data base for a range of materials and basic components, containing information such as the polluting emissions associated with the product. Materials manufacturers and suppliers have compiled these life cycle inventories.[24]

To quantify the embodied carbon of a building the engineer requires a database of individual material emissions (from the life cycle inventory) and quantities of these materials incorporated into the building. Each material quantity is multiplied by its unit impact and an allowance is made for site waste.

To allow for replacement, refurbishment or deconstruction the embodied carbon of initial construction is presently factored up by a percentage amount. More detailed guidance on this aspect of the calculations is to be furnished by future research.

Life cycle inventory data varies from country to country and depends on the individual manufacturing process. Therefore, the sources quoted should be used with caution, bearing in mind the characteristics of their country of origin.

One school of thought favours the concept of embodied energy as opposed to embodied carbon because in the long run, the sources of energy powering the production and

24. The University of Bath Inventory of Carbon and Energy is freely available and assembled from a range of published information and life cycle assessments. The European Commission's European Reference Life Cycle Database and the National Renewable Energy Laboratory's (US) Life Cycle Inventory Database are also freely available. A freely available calculation tool giving an approximate estimate of embodied carbon is the "Construction Carbon Calculator". The BRE Green guide to specification gives independent carbon figures for structural and architectural components, rather than basic materials.

assembly of components will be increasingly those that do not result in carbon emissions. Energy will continue to be a resource in limited supply for some time to come and therefore the goal of reducing embodied energy will remain current. However, this report will use the embodied carbon approach as a constant reminder that in order to mitigate climate change in the short term, carbon-dioxide emissions must be reduced.

Carbon is often given a 'price' so that it can be 'traded' and the value of reduced emissions can be estimated relative to other design constraints. International debate is centred on determining a 'fair price' for carbon.

> Preliminary indications are that there is little variation in embodied carbon for different forms of structure using the same basic structural grid. However, varying the structural layout itself can have a significant beneficial effect, as can the detailed design and specification, for example of the concrete mix.
>
> Engineers must choose a structural scheme to suit the building constraints and optimise the quantity of materials used. Such optimisation must provide for future alterations to the building, e.g. increases in live loads.

**A bus workshop converted into a police station in St Peter, Barbados**

## Re-use of previously occupied sites

There are often opportunities to reuse previously occupied building sites. This allows the re-use of the existing infrastructure to the site and facilitates connections to existing utilities, even if new infrastructure is created.  From a sustainability viewpoint it is usually preferable to developing a green-field site. The decision may also involve the re-use of sub structure (foundations).

The remediation of land contaminated by previous industrial and commercial uses reduces risks to the environment and human health, and relieves pressure to develop green-field sites. On-site containment of pollutants can also remove the need to excavate contaminated soil and transport the material to a hazardous waste landfill.[25]

25. Guidance on development of brownfield sites is given in the *ANSI / ASHRAE / USGBC / IES* standard, section 8.3.5 with notes on isolation of the building from pollutants in the soil.

Foundations, comprising a significant percentage of the embodied carbon of a building, are usually left in the ground on demolition. Particularly in areas where land space is limited, foundations should be designed with potential re-use in mind.[26]

## Design of a low carbon facility

Design team members with different specialisations impact the operational carbon of the facility. It is critical that the building is handed over to the owners with a complete package detailing its construction and operation. As in the first part of this annex, reference is made to relevant sections of the 2012 International Green Construction Code.

The tables below show how mitigation of climate change can be achieved by collaboration across disciplines.

| Energy loss via cooling system | Role of the design team in mitigation of climate change |
|---|---|
| Air leakage from the building envelope | Detailing the building envelope to minimize air leakage, for example by placing air curtains at open doors to maintain a temperature differential.<br>Seal around ductwork and penetrations in the building envelope. |
| Dissipation of waste heat | Specify ground source heat pumps. These operate on the principle that the ground can act as a sink for heat extracted from the building. Some advice is given in section 606.2.2.1. Unsuitable in regions with hot dry soils. |
| Operation in unoccupied spaces | Specify motion sensors, carbon dioxide concentration sensors and timers to trigger operation in areas not continually occupied. Refer to section 608. |

One recent innovation is the use of radiant ceiling panels to augment the forced ventilation system. These panels are maintained at a cool temperature and by contact with the ambient air, reduce its temperature. Energy savings can be realized due to the reduced load on the air-handling system. However, separate electrical de-humidifiers may be needed.

The cooling system, partitions and finishes should be free of gasses harmful to the ozone layer.[27] Section 606.7 gives guidelines for kitchen exhaust systems and section 606.8 for laboratory exhaust systems.

| Building services | Mitigation of climate change |
|---|---|
| Lighting | Maximize daylight within the constraints of site location, solar heat gain and ventilation requirements.<br>Design concept determines the level of natural lighting: building shape, orientation, façade openings, maximum depth between opposing facades, placement and transparency of partitions<br>Specify skylights or light-tubes when windows are not practicable. |
| Hot water supply | Specify solar hot water systems and systems for heating water using waste heat generated elsewhere in the building. |

26. One example is shown in the photos above, where the structural frame and its foundations were re-used in the new building. Another example is the conversion of the Vista Cinema into a Cave Shepherd retail outlet on the south coast of Barbados. In this case the existing pad foundations were strengthened and re-used to support the new structural frame.
27. Refer to the ANSI / ASHRAE / USGBC / IES standard, section 8.4.2.1.2 and 8.4.2.4.

Section 608 deals with the efficiency of electrical systems and section 609 relates to electrical appliances. Of particular relevance are elevators and food service equipment. The first part of section 702 addresses plumbing fixtures and equipment using water. Guidance on plumbing requirements for gray water systems is given in section 708, to be read in conjunction with sections 702, 706 and 709.

Provision of bicycle paths and facilities for cyclists is another design feature of a low carbon facility, as well as the provision of parking for high occupancy vehicles like buses. Section 407 addresses these issues as part of site planning.

Garbage rooms and waste collection areas should provide for sorting of solid waste for recycling purposes. Refer to section 504.

## Informed specification of materials

The net embodied carbon of a building can be improved by avoiding over-specification of materials and maximising the lifespan of materials already chosen. A number of options are available:

- Prevention - Design philosophy to avoid the excessive use of materials, e.g. using structural repetition.
- Reuse – Reuse of a component in an application of equal quality or value to the source e.g. a brick re-used as a brick.
- Recycle – Recovery and re-manufacture of a material into a component of equal quality to the source, e.g. structural steel melted and re-formed into structural steel.
- Energy recovery / other recovery – For example using waste materials as fuel or composting.

The role of the design team is to specify products and materials that meet sustainability and cost objectives. The constructor's role is to contribute additional value engineering and to arrange the on-site aspects of the procurement.

Responsible sourcing considers the full material life cycle and its impact on the surrounding communities, as well as the carbon footprint. The focus here is on the climate change impact of sourcing materials. The specifier/purchaser should be able to identify the source of key components and therefore the conditions under which the material was extracted or harvested. While it is important to know the origins of the components it is equally important to know that any 'added value' steps in the supply chain are equally committed to sustainability. Certification to environmental management systems and performance records can be checked to ascertain this.

Environmental guidelines to be followed in the construction phase should be included in the tender documents. Some examples are given below.

1. Specify materials, equipment based on performance to encourage innovation.
2. Use recycled materials.
3. Use local and regional materials as much as possible.
4. Use local labour and sub-contractors as far as possible.
5. Use rapidly renewable materials, e.g. sustainable site timber.
6. Select adhesives and wood products with volatile organic compound limits, e.g. wood products that do not contain urea-formaldehyde resin.
7. Use new materials with a low carbon footprint.

Refer also to section 505, which deals with material selection for construction.

### General comparison of structural materials from a sustainability point of view

| Disadvantages | Advantages |
|---|---|
| Steel is made using an energy intensive process and from non-renewable resources. | Steel is readily re-useable / recyclable. |
| Concrete is made using an energy intensive process and from non-renewable resource. | Concrete can give passive solar benefits. |
| Timber must be specified from an appropriate source to be renewable. Choice of disposal method is critical, with landfill being preferable to incineration. | Timber requires less energy to produce the equivalent load carrying member compared to steel / concrete elements. |

## Re-use of materials

Having responsibility for the design and specification of structural elements, the engineer should consider whether it is possible to reuse certain materials sourced from elsewhere.

Some elements that have been specified for reuse are listed below:

- Hot rolled steel sections, cold formed steel sections
- Structural timber, timber sheet products and carcassing
- Masonry
- Pre-cast concrete units
- Sheet piling
- Entire portal frame buildings
- Foundations

By reusing components and materials the structural engineer can reduce the embodied carbon of the structure, and possibly the financial cost, and gain advantages from a reduced demand on finite resources. The greatest challenges associated with re-use of structural components are the difficulties in removing them from their previous use unscathed and assurance of their properties in order to specify for reuse.

**Re-use of masonry** elements is specific to the local context in terms of the nature and durability of the bricks or blocks, as well as the methods of deconstruction and rebuilding of masonry walls.

## Recycling materials

Recycling materials depends on local availability, since long distance transport defeats the goal of reducing the carbon footprint.

**Recycled steel** is produced by an electric arc furnace or basic oxygen furnace.

**Concrete recycling** is achieved by crushing the element to produce secondary aggregate. Efforts to recycle concrete require balanced judgement, for example higher cement content is often used to compensate for the inclusion of recycled aggregates.

**Structural glass** at present cannot include recycled content, since impurities might compromise the strength of the finished product. However, glass can be crushed to provide sand sized aggregate for use in concrete.

### Cement replacement

The production of cement involves the conversion of calcium carbonate to calcium oxide with carbon dioxide as a by-product. The total embodied carbon is therefore the sum of that associated with the energy of manufacture plus that produced by the manufacturing process. Reducing Portland cement content significantly reduces the carbon footprint of a concrete element. By-products of certain industrial processes such as pulverized fuel ash are used.

Table A.6 in BS 8500-1:2006 provides details of the cement and combinations of cement alternatives recommended for selected exposure classes, life-span and nominal cover to reinforcement. However, S 8500-1:2006 does not provide specific guidance on the relative merits of cements and combinations in terms of their environmental impacts. To minimize embodied carbon the designer should chose options with low recommended minimum cement contents and permitted cement/combination types with the highest levels of Portland cement replacement.

### Strength class is lower

Using cement alternatives such as fly ash or granulated slag tends to reduce the strength class of the concrete. Although there will be savings in terms of embodied carbon, structural elements will be correspondingly larger. Therefore a balanced judgment is needed, looking at the overall structural form and the implications of using larger elements. Other considerations may make higher strength concrete more sustainable (e.g. a reduced floor to floor height is possible with the stronger concrete).

### Early strength development is hampered

For a given value of 28-day[28] strength, concrete containing additions such as fly ash and granulated slag will exhibit lower relative early age strengths than those containing Portland cement only. This is because concrete's early strength is dependent, primarily, on its Portland cement content.

This can hamper the program of works on site. To help reduce formwork striking times, for instance, technologies such as accelerating admixtures can be combined with earlier curing. Methods of monitoring the early age concrete strength are given in the references below.[29]

### Greater long-term strength development

In the long term, there is a significant strength development, so that designers should review the implications for points of restraint and potential cracking.

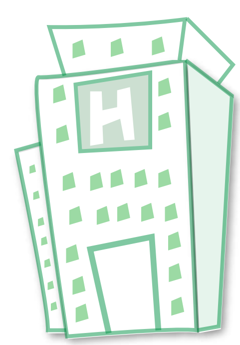
### Other performance criteria are affected

Almost all concrete properties are affected by the use of cement/combinations containing additions such as fly ash and granulated slag, particularly at high replacement levels. These include:

- Properties of fresh concrete: water demand, setting time, heat of hydration, rate and quantity of bleeding.







28. Although the long term strength is used in design calculations, the construction contract should specify short term strength (7-day instead of 28-day strength). This allows removal of defective concrete when it is least disruptive to the progress of the works.
29. (a) A Decision Making Tool for the Striking of Formwork to GGBS Concretes (a project report submitted for the award of diploma in Advanced Concrete Technology, The Institute of Concrete Technology), John Reddy, 2007.
(b) Formwork striking times of GGBS concrete: test and site results, C. A. Clear, Proceedings, Institution of Civil Engineers, Structures and Buildings, 1994, 104, Nov. 441-448.
(c) Formwork striking times – criteria, prediction and methods of assessment, CIRIA Report 136, TA Harrison, 1995.

- Properties of fresh concrete: water demand, setting time, heat of hydration, rate and quantity of bleeding.
- Durability.

As such, the cement/combination type requires consideration of a wide range of performance-related issues, including:

- execution of the work;
- end use of the concrete;
- curing conditions (e.g. heat treatment);
- dimensions of the structure (the heat development);
- environmental conditions to which the structure is to be exposed;
- potential reactivity of aggregate to the alkalis from the constituents.

Further guidance is available from the Concrete Society[30] and from material suppliers / trade associations.

### Aggregate replacement

Recycled and secondary aggregates are generally formed of crushed construction waste or by-products of industrial processes, but can also include some post-consumer waste products such as crushed bottle glass. Construction waste can be divided into potentially good quality material, essentially crushed concrete (RCA), and lower quality material that can include high proportions of crushed masonry (RA). Industry by-products can similarly be divided into high and lower performing materials.

BS 8500-1, for use by engineers specifying concrete, provides definitions for two types of recycled aggregate:

1. Recycled concrete aggregate (RCA) is aggregate principally comprising crushed concrete. It should only be used if it is locally available or would otherwise go to landfill.
2. Recycled aggregate (RA) is aggregate resulting from the reprocessing of inorganic material previously used in construction. This material can be a highly variable and is generally suitable only for use in low-grade concrete; it is not recommended for use in structural concrete.
3. Secondary aggregates (SA) are generally by-products of industrial processes which have not been previously used in construction. They can be divided into manufactured SA (including air-cooled blast furnace slag, sintered fly ash (Lytag) and crushed glass), and natural SA (including china clay stent coarse aggregate, slate waste, and china clay sand).

Strict composition limits for coarse recycled aggregates (RCA and RA) are provided in Table 2 of BS 8500-2 for contractors producing concrete. Recycled aggregates are generally only suitable to replace a limited proportion of the natural coarse aggregate and little, if any, of the sand fraction. Ground glass has been used to replace sand in concrete. Research and experience[31] may allow the currently accepted proportions to increase without compromising performance.



Other recycled aggregates include spent rail ballast and recycled asphalt although the latter may not be suitable for use in concrete. The aim is to utilize granular materials of a suit-

30. The use of GGBS and PFA in concrete. Technical report 40, The Concrete Society, 1991.
31. The Rex St Lucian Hotel was built in 1969 with coarse aggregates derived by crushing the concrete in a World War 2 amphibian aircraft ramp.

able strength, chemical stability and surface texture, rather than to dispose of them to landfill. Materials outside the scope of standards should be used with caution.

> If significant travel is involved or the cement content is significantly increased to compensate for using recycled aggregates there is little benefit to the carbon footprint of the final product. It is better to use RCA to replace primary aggregates where both the fine and the coarse portions are appropriate (e.g. as fill) rather than in structural concrete.

### Admixtures for concrete

Admixtures are defined as 'material added during the mixing process of concrete in a quantity not more than 5% by mass of the cement content of the concrete, to modify the properties of the mix in the fresh and /or hardened state'. They are generally in liquid form and act on the surface of particles in the mix, as opposed to "additions" such as GGBS, fly ash and limestone fines which are powders that can be added to produce blended cement or added at the ready-mix plant.

Depending upon the exposure condition and the cover, BS 8500 will define a minimum cement content, maximum water-cement ratio and possibly required strength to give the desired design life. The use of water-reducing or super-plasticizing admixtures enables a given strength and/or water cement ratio to be achieved with lower cement content (subject to achieving the minimum cement content).

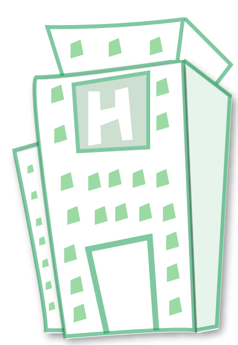
> Admixtures can reduce the embodied carbon of concrete, despite having relatively high embodied carbon themselves. This is because the dosages are so small they contribute less than 1% to the total embodied carbon of concrete while allowing other high carbon constituents to be reduced.

Under the environmental management standard, BS EN ISO 14001, constituents contributing less than 1% of the impacts can be ignored, and this would apply to most cases of admixture usage. This reduction in embodied carbon of the concrete can be achieved whilst maintaining and even enhancing its properties. In the hardened state admixtures can significantly improve the durability of the concrete to a range of aggressive environments, extending the service life of the elements concerned.

## Provision for future alterations

Future proofing refers to provision for changes in the building over its expected lifetime. Ease of separation of structure from the building envelope, services, and space plan is a core principle of simple, cost effective future-proofing.

Loose fit provides for the separation of the building elements according to their life-span. Thus a short life-span element does not compromise the life expectancy of other, more durable, components attached to it. Typically building services are expected to last



about 15-25 years; glazing, cladding and façade approximately 20-30 years; and structure and foundations in excess of 50 years.[32]

Provision for future flexibility in any structure is focused on changes to the use of the existing spaces. These will be reflected in dimensional alterations and possible increases in operational loads (live loads). There may also be special requirements associated with the installation of new equipment, i.e. new service openings and limitations on vibration levels. A summary list of the issues to be considered is given below:

- load
- span
- floor to ceiling height
- vibration and other service requirements
- separation of services, structure, and finishes ("loose fit")
- provision for exposing and altering the structure
- possibility for expansion/extension, especially in the vertical direction
- provision of voids for changes in circulation and services
- ease of maintenance and durability
- a timeless building envelope
- reconfiguration of the internal layout, e.g. adopting a modular plan.

Alterations to the building will be triggered by:

- Operational changes in line with technology and trends in health care, as noted in the earlier section on 'Hospitals'.
- Adaptations to climate change scenarios, as described in the first part of this guide.
- Deterioration of components and the need to replace them as they reach the end of their useful life.

A common method of providing future flexibility is through a blanket increased load allowance and provision of spare capacity in the structure. This additional structure 'in hand' does not always prove to be useful, since changes may affect critical bays that are already working at 100% capacity.

Provision for total future flexibility is not cost-effective, or effective in terms of carbon footprint. Balanced judgment is required. For example, if block work is to be used in non-loadbearing partitions some of these partitions could become loadbearing elements to minimize the total use of material. However, the addition of loadbearing walls makes the structure less flexible to alterations and is not normally in keeping with a 'future proofing' philosophy.

32. Many hospitals in the Caribbean and in most parts of the world are more than 50 years old.

In the case of a hospital, the potential future uses of the building are more limited than with many other commercial structures. Best practice shows that identifying future strategies for circulation, storage, zones with stringent performance requirements (such as vibration) and likely changes of use will result in a more effective solution than blanket provision for the maximum possible load.

Another example is the use of materials. Immediate savings can be realized by minimizing the use of materials. However, material reduction can hamper design for re-use and long life, because reducing materials can prevent use of optimized forms and restrict redundancy. Optimized forms are facilitated by modular design using standardized units that may not always be of the minimum required size. Redundancy provides a partial safety net against possible increases in loading and increases the flexibility of the structural design.

Inherent in future proofing is a certain level of uncertainty and risk.

### Design for deconstruction

The key issue in design for deconstruction (DfD) is ensuring that an element has value when no longer required in its planned setting. Design for deconstruction means considering the full lifecycle of the element and end of use scenarios during initial design. There is no point in careful disassembly of a structure to be followed by carbon intensive re-cycling or destruction.

For reasons of health and safety, slow and dangerous hand demolition methods should be avoided. When assessing the potential of a site for deconstruction, the following issues are relevant:

1. Ease of separation of the components and their quality and durability are important. Otherwise recycling, or other disposal options, will be the most cost effective.
2. Deconstruction will be commercially viable only if elements are available in sufficient quantity and do not require a great deal of re-processing.
3. Highly optimized structures with bespoke components and unusual connections have a limited market for re-use.
4. Fixings must be simple and of a mechanical nature to facilitate disassembly. A simple and clearly defined load path is also an asset.

In summary, the following may prove more successful than trying to plan for full and complete deconstruction of a conventional building structure.

- Provision of complete as-built documents to building owners at the time of handover. These give information about materials and construction sequence to be used by future designers.
- Modular construction with mechanical connections.
- Plan for re-use of compound elements, rather than single ones to allow selective demolition techniques such as pancaking.
- Plan for a combination of recycling and reuse.

## Informed construction methods and site practice

The environmental impact of extracting, processing and transporting construction materials, assembling them and dealing with the waste generated releases greenhouse gasses and produces toxic emissions. The mitigation of climate change through sustainable construction includes informed site practices.

Some goals to be achieved by environmentally aware contractors are listed below:

1. Energy efficient site accommodation.
2. Efficient use of construction plant, avoiding oversized machines and using appropriate levels of power for different applications.
3. Earlier connection to the grid.
4. Good practice energy management on site.
5. Fuel efficient driving for both freight delivery and waste disposal.
6. Efficient flow of materials so that freight vehicles are fully utilized.
7. Reducing the transport of waste and maximizing recycling.

During construction the day-day site management will determine the embodied carbon in the final product. Therefore sustainable construction techniques are an important part of mitigating climate change. Some suggestions for sustainable site management are given below.

1. Energy
    a. Use energy efficient lights and motion sensors to reduce energy usage during construction.
    b. Use renewable technology or green sources of energy to power site equipment and vehicles as far as possible.
    c. It may be possible to use waste heat generated on site.
    d. Monitor fuel consumption. Consider metering the use of fuels on site.
2. Water
    a. Minimize water use with low flow equipment. Both the treatment and distribution of mains water are carbon intensive.
    b. Use rainwater or grey water on site where possible.
3. Waste
    a. Collect and sort waste for recycling and re-use.
    b. Re-use formwork as much as possible.
    c. Select products with minimal packaging.
    d. Use a centralized facility to provide just in time deliveries and to reduce the waste stream on site.
    e. Deliver precut materials to site rather than cutting them on site, e.g. cut and bent rebar.
4. Carbon
    a. Monitor and set targets for the site carbon footprint. To this end, adopt a rating system (e.g. LEED green building rating) providing guidance on sustainable measures that can be adopted during construction.

Prefabrication is one means to reduce site generated waste and associated transport. This method of assembly should be considered. However, there are disadvantages. Components are made off site and the restricted tolerances can cause problems when they come to be fitted in place. Site measurements must be very accurate. Also, there is limited scope for making alterations to the component to suit unexpected conditions.

To minimize the earthworks component (and embodied energy) of the project, the new landscape should as far as possible use native soils and species, and disturb the local hydrology as little as possible. Maintaining vegetation and erosion control can preserve the plants that absorb carbon from the atmosphere. Control of pollution reduces the energy required for water treatment later on. Management of sediment in the runoff from site is dealt with in section 405, along with disposal of excavated materials and soils. One option is to export the soils to another site where they are required.

Also relevant is section 406 of the 2012 IgCC dealing with site waste and section 503 dealing with construction material management.[33]

Protection of air handling systems and ventilation openings is addressed in section 803.1.

## 4. Summary

The guidelines focused on the contribution of engineers and architects to the construction of safe hospitals that are climate change resilient and, by means of sustainable building practices, mitigate climate change. The principles are generally applicable to residential buildings and buildings for public occupancy.

33. The *ANSI / ASHRAE / USGBC / IES* standard includes construction waste management in section 9.3.1 and responsible sourcing in section 9.4. There is a performance based specification.

## References


*A short guide to embodied carbon in building structures*. London: IStructE, August 201.

*Adaptation Tool kit: sea level rise and coastal land use* by Jessica Grannis. Washington DC: Georgetown Climate Centre, October 201.

*Admixtures for sustainable concrete* by A. Minson and I. Berrie. The Structural Engineer Volume 91(1) Jan 2013 p.30-3.

*BS 8500-1, Concrete – Complementary British Standard to BS EN 206-1 – Part 1: Method of specifying and guidance for the specifier.* British Standards Institution, BSI 2006.

*BS 8500-2, Concrete – Complementary British Standard to BS EN 206-1 – Part 2: Specification for constituent materials and concrete*. British Standards Institution, BSI 2006.

*Basic principles of flood resistant housing for the Caribbean* by I.D.C. Imbert, Project Leader, Cyclone resistant housing project Trinidad: UWI, 1995.

*Building for a Sustainable future: construction without depletion.* London: IStructE, Nov 1999.

*Carbon: reducing the footprint of the construction process, an action plan to reduce carbon emissions,* prepared by Joan Ko on behalf of the strategic forum for construction and the carbon trust Report 006. July 2010.

*Cementitious materials*. Sustainability Briefing in The Structural Engineer Vol. 89(9) 3 May 2011 p. 21-22.

*Climate change and sea level rise in the San Francisco Bay area*, adapted from 'Climate change hits home' by Laura Tam. San Francisco Planning and Urban Research Association, January 2012.

*Design for deconstruction*. Sustainability briefing in The Structural Engineer Vol. 89(4) 15 Feb 2011 p.20-21.

*Design for future climate – opportunities for adaptation in the built environment* by Bill Gething. Technology Strategy Board.

*EN 12620:2002 + A1:2008 Aggregates for concrete*, European Committee for Standardization, CEN, 2008.

*Energy efficiency guidelines for office buildings in tropical climates*. European Commission & Organisation of American States. March 2013.

*Environment and Sustainability Health Technical memorandum 07-07: Sustainable health and social care buildings. Planning, design, construction and refurbishment*. Department of Health. London: The Stationery Office, Jan 2009.

*Environmental Impact of materials*. CIRIA Special publication 116 volume A, 1995.

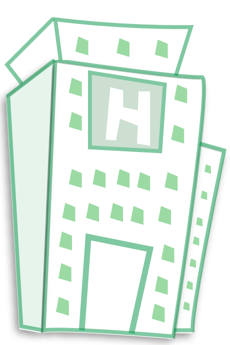
*Flood resistant design and construction*. ASCE Standard ASCE/SEI 24-05, 2006.

*Framework standard for the responsible sourcing of construction products*. BES 600:2008 issue 1. BRE, 2008.

*Future flexibility of buildings by Sarah Kaethner*. IStructE Sustainability panel briefing sheet SCP/12/06.

*Green construction handbook. A manual for clients and construction professionals research* by Ove Arup and Partners. A JT Design Build Publication, 1993.



*Guidance on adapting New Zealand's built environment for the impacts of climate change, Study report no. 130, Climate Change Adaptation* by Michael O Connell and Rachel Hargreaves. October 2004.

*Handbook of sustainable building: An Environmental Preference Method for Selection of Materials for Use in Construction and Refurbishment* by Annik, Boonstra, and Mak. Earthscan, 1996.

*Integrated Sustainable Design of Buildings* by Paul Appleby. London Washington: Earthscan, 2011.

*International Building Code* by the International Code Council. 2009.

*International Green Construction Code* by the International Code Council and American Society of Heating Refrigerating and Air-Conditioning Engineers (ASHRAE). Vitrium Systems Inc. 2012.

*International Energy Conservation Code* by the International Code Council. 2009.

*Low carbon construction innovation and growth team interim findings* by HM Government Department for Business, Innovation and Skills. Spring 2010.

*New construction and major renovation. Existing Buildings*. 3rd ed. US green building council reference guides, 2007.

*Putting embodied carbon and operating energy into perspective*. IStructE Sustainability panel briefing sheet SCP/11/47.

*Recycled and secondary aggregates in concrete*. Sustainability briefing in The Structural Engineer Vol. 88 (15/16) 3 Aug 2010 p.12-13.

*Refurbish or replace*, IStructE Sustainability panel briefing sheet SCP/11/05 Jan 2011.

*Responsible sourcing* by A Minson. IStructE Sustainability panel briefing sheet SCP/10/06 3rd draft.

*Shoreline and property protection options*. Coastal Zone Management Unit, Barbados. (web page accessed Feb 2013, www. coastal.gov.bb/).

*State of the art review for sustainable building design and innovation technologies* by William E Roper of George Mason University, Fairfax, Virginia.

*Standard for the Design of High-Performance Green Buildings except low rise residential buildings ANSI / ASHRAE / USGBC / IES Standard 189.1-2011* by ASHRAE and US Green Building Council. 2011.

*Sustainable buildings in practice. What the users think* by Baird and George. Oxford: Routledge, 2010.

*Sustainable construction methods and techniques*, working group interim report SCMT Interim Report 270703 – Contract B4-3050/2003/352567/SER/B4. July 2003.

*Sustainability guidelines for the structural engineer* by Kestner, Goupil and Lorenz editors. ASCE Structural Engineering Institute, 2010.

*Synopsis of assessment - Policy tools for local adaptation to sea level rise* by Barbara Lausche. Technical report #1419 Florida: Mote Marine Laboratory, October 2009.

*Tackling sustainability through procurement practices*. IStructE Sustainability panel briefing sheet SCP/12/08.

*The green guide to specification*, 4th ed. by Anderson, Shiers and Steel. BRE press Wiley Blackwell, 2009.

*The re-use of structural components and materials*. Sustainability briefing in The Structural Engineer 89(1) 4 Jan 2011 p. 15-16.

*The value of structural engineering to sustainable construction*. Final report by ARUP. London: IStructE, March 2012.

*Toolkit part 1, Guide to construction materials for carbon neutral developments*. UK: Bioregional. Lazarus, 2002.

## Historical Background on wind speeds

During the past 50 years the evolution of wind speeds for structural design in the Commonwealth Caribbean[34] is as follows:

- Early 1960s – CP3:Chapter V:Part 2:1952 (It did not address hurricane force winds).
- Mid to late 1960s – South Florida Building Code (The procedures were very elementary).
- 1970 – the first CCEO[35] standard (This followed the philosophy of the then yet-to-be-published CP3:Chapter V:Part 2:1972. The meteorological work was done by Harold C Shellard.[36])
- 1981 – Revision of the CCEO standard. (It has since been adopted as the Barbados standard BNS CP28. The meteorological work was done by Basil Rocheford.[37])
- 1985 – CUBiC[38]: Part-2:Section-2. (The meteorological work was done by Alan Davenport *et al*.[39])
- 2008 – Caribbean Basin Wind Hazard Study. (The principal researcher was Peter Vickery.[40])



34. The Commonwealth Caribbean consists of the 17 former (and current) British colonies in the Caribbean.
35. Council of Caribbean Engineering Organisations – an umbrella body for 12 national engineering associations.
36. Formerly of the UK Meteorological Office and attached to the Caribbean Meteorological Institute 1967-70.
37. Caribbean Meteorological Institute (now Caribbean Institute for Meteorology and Hydrology).
38. Caribbean Uniform Building Code.
39. Professor Alan G Davenport, Dr David Surry and Dr Peter Giorgiou (Boundary Layer Wind Tunnel Laboratory, University of Western Ontario).
40. P J Vickery and D Wadhera (Applied Research Associates, Inc).