SAFE + GREEN = SMART

SMART HOSPITALS TOOLKIT

Pan American Health Organization

World Health Organization
REGIONAL OFFICE FOR THE Americas

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

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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, mitigate their impact on the environment and 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. The image below defines what is meant by smart. It illustrates that improvements in safety, or an 'A' score on the Hospital Safety Index, result in a safe facility. A score of more than 70% on the Green Checklist equals a green facility. The graphic presents safe and green factors to consider and when these are combined, help to create a sustainable smart facility.

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.

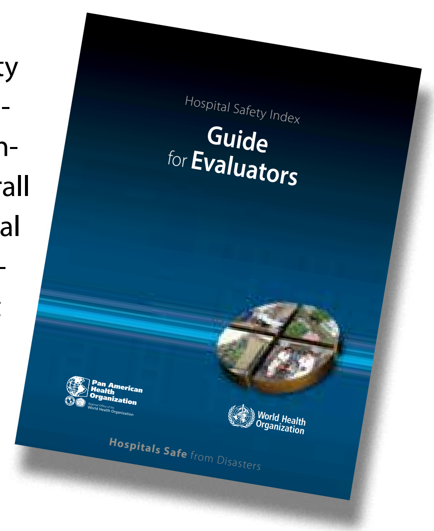
USING THE SMART HOSPITALS TOOLKIT

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 lessen 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.



In the Caribbean, however, there are many small and medium-sized health facilities that form part of the health network. 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 Guide (see Section 3).

SECTION TWO: The Baseline Assessment Tool (BAT)

The Baseline Assessment Tool (BAT) is used to collect baseline information to guide decisions regarding retrofitting health facilities. It complements the Hospital Safety Index and the Green Checklist. It compiles detailed information about the facility, which is needed to prepare the Scope of Work. The tool requires specialized skills, such as those of an electrical and structural engineer and the use of specialized equipment. Data collection focuses on energy and water consumption; indoor environmental quality (IEQ); building components; an occupant survey; and land use (local zoning regulations).

SECTION THREE: The Green Guide

The Green Checklist indicates improvements that hospitals and health facilities in the Caribbean can make to minimize their contributions to 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: References

A list of additional resources to consult.

SECTION FIVE: Annexes

Refer to the Table of Contents for a list of annexes. Annexes are available on the Smart Hospitals website at: www.paho.org/disasters/smarthospitals.

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 the facility faces and the safety needs that must be addressed.

STEP 2
- Apply the **Green Checklist** and determine if the green requirements have been met (a score greater than 70%).
- **Output**: Determination of what can be achieved and what is most feasible, based on available resources.

STEP 3
- Apply the **Baseline Assessment Tool**.
- **Output**: Baseline information that helps set priorities and determine the level of 'greening' to be achieved. This information also serves as the basis for developing the scopes of work and cost-efficiency analysis.

STEP 4
- Prepare Scopes of Work; tender documents.

STEP 5
- Identify and recruit qualified contractors to undertake proposed work.

STEP 6
- Evaluate the process and the lessons learned and monitor water and energy use.

STEP 7
- Develop maintenance plan for the facility and a monitoring and evaluation tool to ensure sustainability of the interventions.

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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 probability that a hospital or health facility will continue to function 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.

Safe Hospitals Checklist: First, an Evaluation Team uses the standardized Safe Hospitals Checklist to assess the level of safety in 145 areas of the hospital. This is applicable to large hospitals only. 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.

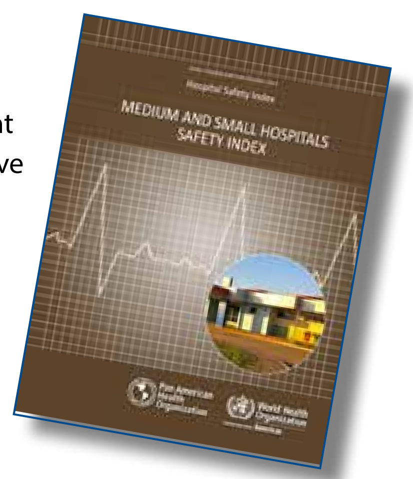
Guide for Evaluators: The Guide for Evaluators provides guidance and standardized criteria for evaluating the components of a health facility individually and as part of the health services network. A multidisciplinary team of Evaluators, which can include engineers, architects, health staff, hospital 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. Download the Guide for Evaluators at http://bit.ly/1e64EAZ.

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. Download the form at http://bit.ly/1g37pY3.

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.) ....
....
....

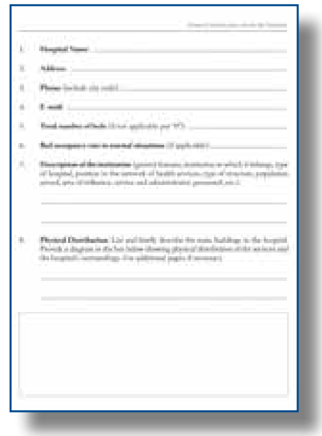
Medium and Small Hospitals: Safety Index



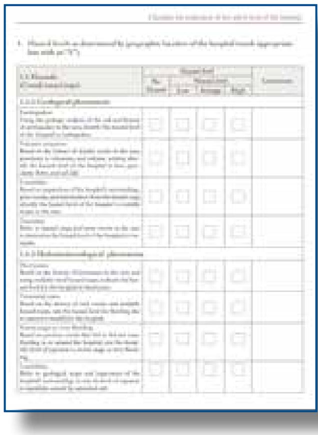
Health facilities that make up a country's health network have different functions. Therefore, achieving an optimal level of safety can be progressive in nature and undertaken differently than in larger hospitals.

This tool, which assesses 94 areas of the health facility, 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; pediatric internal medicine and general surgery) and, for the most part, have 20 beds or less.

Click on the appropriate link below to consult or download information about applying the Safety Index to medium and small hospitals and the forms that can be used to calculate your facility's safety score:



General Information about the Hospital: The hospital itself, and preferably the Hospital Disaster Committee, will complete this form. Download this form at: http://bit.ly/2jQT49x.



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. Download these forms at http://bit.ly/2jrEtD6.

Intervention Plan: The matrix summarizes the evaluation's results and helps to plan solutions. Download this form at: http://bit.ly/2kMW7Ou.

Download the complete publication *Medium and Small Hospitals: Safety Index* at: http://bit.ly/2bNH9Ed.

Section II
THE GREEN GUIDE

The Smart Hospitals Toolkit helps existing hospitals identify and implement low-cost adaptation measures. 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 operations of the facility, it is essential to identify low-cost (often non-structural) measures that can be easily implemented to reduce consumption.

The **Green Checklist**, developed as part of the Smart Toolkit, can be used in conjunction with planned renovation projects, which are ideal opportunity to introduce feasible 'smart' measures. It is also suitable for application to new health facility construction to help guide planning and development. The Baseline Assessment Tool (BAT) is used in conjunction with the Green Checklist to gather detailed information related to water and energy use data, indoor environmental quality, architectural and non-structural features, so that feasible upgrades can be identified and to guide development of the Scope of Works. Additionally, information contained in the BAT can be compared with after-retrofit conditions to highlight improvements. Structural deficiencies are dealt with separately.

The Checklist is comprised of a series of questions divided into the categories: Water, Energy, Atmosphere, Indoor Environmental Quality, Hazardous Materials, Pharmaceuticals, Food Services, Solid and Infections Waste Management. How to score each question and what is meant by 'critical standards' is explained in the Green Checklist Field Guide. Consult the **Green Checklist** at the end of this guide or download it at http://bit.ly/2jZSHY6. Download the **Field Guide for the Application of the Green Checklist** at http://bit.ly/2kufhLU.

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, and in some cases, desalinization. Including a rainwater capturing system in your health facility is pivotal to reducing potable water use, in conjunction with conservation efforts, upgrading faucets and installing efficient water-saving devices/equipment/appliances. 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

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

Recommended Action Points

Water Use Reduction

- Develop a water conservation plan. See resources for links to templates and other guidance documents.
- 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). 'Low-flow/low volume/efficient' refers to faucets, showerheads and other devices that use less water than older models. These items are usually certified by a third-party and labeled accordingly.
- Devise an education program for staff, patients and visitors, informing them of the need to conserve water. Highlight the fact that your facility uses captured rainwater for all non-potable uses 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 the Hospital Safety Index for further guidance.
- Refer to the Smart Hospitals 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 a flood-prone area.

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 using the effluent from your septic system or sewage treatment system 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

- Toolbox on Rainwater Harvesting in the Caribbean: http://www.caribbeanrainwaterharvestingtoolbox.com.
- Global Water Partnership - Caribbean: http://www.gwp.org/en/gwp-caribbean/.
- U.S. Environmental Protection Agency Water Sense Program: https://www3.epa.gov/watersense/.
- Preparing a Water Conservation Plan: http://extension.unh.edu/resources/files/Resource001227_Rep1568.pdf.
- Best Practices in Water Conservation: https://practicegreenhealth.org/topics/energy-water-and-climate/water/best-practices-water-conservation.
- Healthy Hospitals Healthy People Healthy Planet-Addressing Climate Change in Health Care Settings: http://www.who.int/globalchange/publications/climatefootprint_report.pdf.

Energy

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 great deal 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 emissions and reduced demand. However, simply switching to more efficient light bulbs is not enough. Energy conservation must be an overarching goal. Having an energy conservation plan will help to reduce energy use. The Resources section provides a link to a template for an energy conservation plan. If your country has not yet phased out the use of incandescent light bulbs, replacing them with energy-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 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. 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. Backup generators remain important to help ensure functionality.

Recommended Action Points

Renewable Energy

- Develop an energy conservation plan, as this is the most cost-efficient way to reduce energy use.
- Consider installing solar hot water heaters instead of 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. The use of regionally manufactured units is recommended.
- Use solar exterior motion-activated lighting where applicable.
- Install a rooftop or ground-mounted 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.) Avoid shading from trees and other buildings; adding Micro Inverters can increase energy harvesting where shading is inevitable. Roof assessment can be guided by the Hospital Safety Index. Also note that in countries where there is a volcanic risk, 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. PV system should have adequate air gap on the underside. If it heats up, it becomes less efficient. System can serve to insulate the building (roof insulation).
- If space, location, wind speed, 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. Assess environmental impact such as noise pollution and the mortality rate of birds and bats.

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. LEDs are becoming cheaper and have shown to be a better investment in the long run.
- 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.

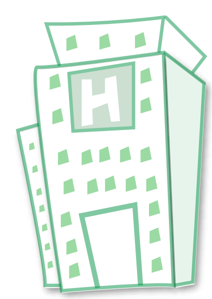
  Note: LED technology has improved in the past years, however it has generally not surpassed linear fluorescent (T8s T5s) in terms of performance at the colour temperatures required for indoor applications. High colour temperatures such as 5,000K and 6,000K definitely are very efficient, but contain too much blue light for most indoor health care applications; the blue light spectrum is eliminated by 4000k. 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. LEDs generally last for 50,000 hours, are very durable and can replace most bulb types. When making significant changes, consult an engineer or lighting designer to ensure appropriate lighting levels will be provided after the retrofit program is completed.
- 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). If the roof is in poor condition, consider installing a new roof over the existing one with an air gap between the two. This is an excellent form of insulation.

Control of Lighting Systems

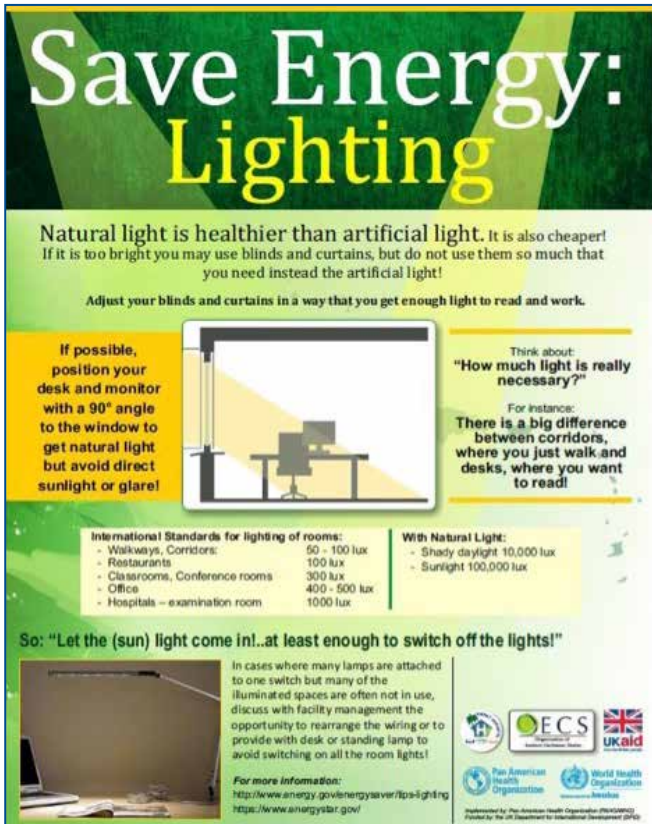
- Utilize as much daylight as possible, while minimizing direct sunlight.
- If feasible, use shade trees or shading devices on the exterior to prevent direct sunlight from entering the building.

  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. Include switches to separate lighting in large rooms, so certain areas can be switched off.

    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.



Refer to the diagram below provided by the Organization of Eastern Caribbean States (OECS) for additional guidance.



Resources

- United States Environmental Protection Agency and Department of Energy, Energy Star Program Product Guide: http://1.usa.gov/ZSaUbl.
- 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.

Atmosphere

Overview

The atmosphere plays a very important role in our daily lives and is a layer of gases surrounding the planet that protects us from ultraviolet radiation and keeps the Earth at reasonable temperatures. Both animals and plants are able to use the gases located in the lower levels of the atmosphere to maintain life. It became a major topic of discussion when a hole was discovered in the ozone layer several decades ago. Global action ensued and the Montreal

Protocol was ratified in an effort to curb the growth of the 'hole' through the reduction of chlorofluorocarbons and other substances being released in the atmosphere. The efforts have been successful and the 'hole' is recovering. However, several of the substances that contribute to the depletion of the Ozone layer also contribute to climate change as illustrated in the table below.

Implementation Strategies

Ensure that all equipment and machinery that use refrigerants are of the highest quality and are properly maintained.

Recommended Action Points

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

Ozone Depleting (ODP) and Global Warming Potential (GWP) of Refrigerants			
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.

> **Remember**
>
> - Ensure that your equipment is properly maintained and serviced.

Resources

- United States Environmental Protection Agency Ozone Layer Protection-Science: http://www.epa.gov/ozone/science/ods/index.html.

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.

Implementation Strategies

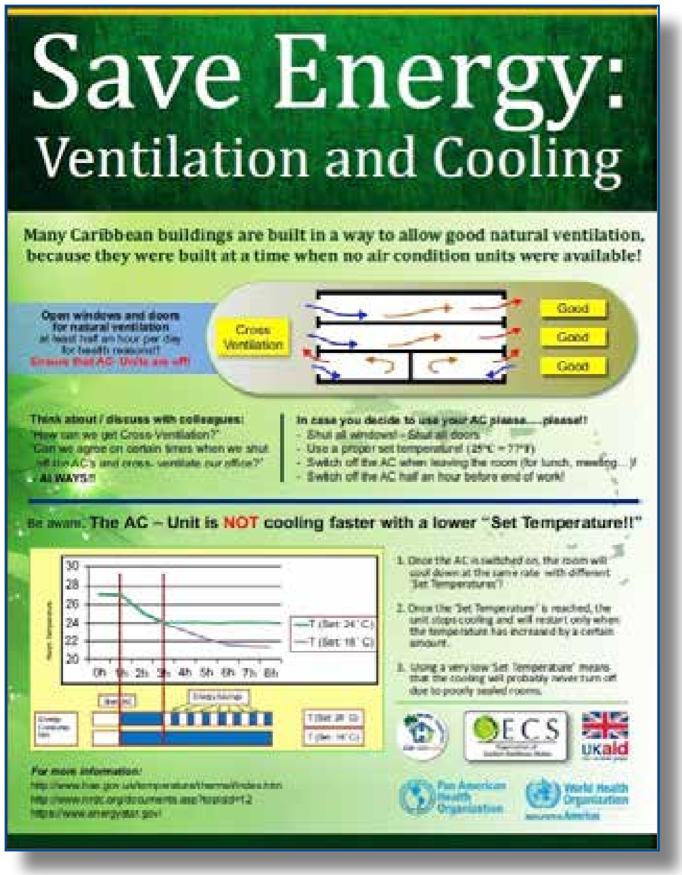
Mechanical ventilation equipment such as fans and air conditioning units can improve IEQ; however, making use of natural winds is more energy efficient. Operable windows and doors and their locations throughout a structure are key to natural ventilation.

Recommended Action Points

Environmental Tobacco Control

- Clearly indicate that your facility is a smoke-free environment.

  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 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. Refer to the diagram below provided by the OECS for further guidance.

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.

Hazardous Materials

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

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.

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 mercury should be treated as hazardous. Incinerating or disposing of mercury-containing items in landfills is not recommended.

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

- Go Mercury-Free: https://noharm-uscanada.org/issues/us-canada/go-mercury-free.
- Mercury in Health Care: https://noharm-global.org/issues/global/mercury-health-care.
- Green Guide for Health Care, Technical Briefs: http://www.gghc.org/tools.technical.php.
- United States Environmental Protection Agency- Integrated Pest Management (IPM) Principles: https://www.epa.gov/managing-pests-schools/introduction-integrated-pest-management.
- University of Minnesota-Radcliffe's IPM World Textbook: http://ipmworld.umn.edu/.
- United States Environmental Protection Agency- PestWise An EPA Partnership Program: https://www3.epa.gov/pestwise/index.html.
- Beyond Pesticides-Healthy Hospitals Controlling Pests Without Harmful Pesticides: http://www.beyondpesticides.org/hospitals/Healthy_Hospitals_Report.pdf.

Pharmaceuticals

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. 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

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 are 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. Consult the Green Guide for Health Care (GGHC) in the Resources section.
- To the extent possible, work with national or regional organizations/agencies to research and order safer alternatives, such as products that contain no mercury or PBTs. Procure products with less packaging, especially if they contain hazardous chemicals or components, as the packaging could be considered hazardous as well.
  Although not all of the following are applicable to the Caribbean setting, GGHC (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.

- To minimize pharmaceutical waste, rotate pharmaceuticals that are close to the expiration date back into high-use areas such as crash carts or the pharmacy.
- Ensure all pharmaceutical samples are logged into the facility, and only accept those samples with an expiration date 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).

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.

Resources

- 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/.
- Healthcare Environmental Resource Center; Sterilants and Disinfectants in Healthcare Facilities: http://www.hercenter.org/hazmat/steril.cfm.
- World Health Organization (WHO), Hand hygiene guideline: http://www.who.int/patientsafety/events/05/HH_en.pdf.
- Practice Greenhealth: Chemicals: https://practicegreenhealth.org/topics/chemicals.
- Green Guide for Health Care Technical Briefs: Pharmaceutical Management Technical Brief: http://www.gghc.org/tools.technical.php.

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 man-made 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, such as plastic, Styrofoam, and bottled water. In the absence of a recycling program, plastic from food services and bottled water will likely end up in a landfill or be incinerated. Paper products used in food services, such as napkins, consume natural resources and generate additional waste. Paper products from 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. Food waste can also be donated to local farmers.

Dishwashers should use hot water from solar water heaters. Additionally, cooking with gas is much more carbon efficient than electric stoves.

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

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 that litter the environment, are 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 leftover 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 determine 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 can take advantage of the food waste generated by health care facilities, restaurants, schools and other institutions.

Resources

- Practice Greenhealth, Sustainable Food: https://practicegreenhealth.org/topics/healthier-food.
- Prevention Institute, Cultivating Common Ground: Linking Health and Sustainable Agriculture: http://noharm.org/lib/downloads/food/Cultivating_Common_Ground.pdf.

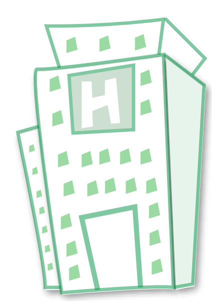
Solid Waste Management

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.

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.
- *Green Guide for Health Care* (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. *Green Guide for Health Care* (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, *Green Guide for Health Care* (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.

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.

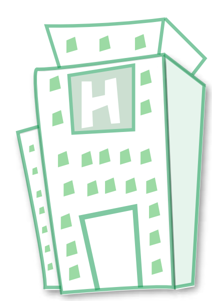
Regulated Medical Waste Reduction

- 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. • Pressurized steam is introduced at a minimum of 121°C. • Waste is exposed to the steam.	20 kg/hr to 3000 kg/hr; smaller units are available	$30,000 to 200,000; small units cost about $100

Alternative Health Care Waste Management Treatment Technologies				
Type of technology	**Description**	**General operating process**	**Range of capacities**	**Approximate capital cost in USD**
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. • A vacuum is used to remove air. • Pressurized steam is introduced at a minimum of 121°C. • Waste is exposed to the steam. • Steam is removed as condensate. • Waste is removed and processed in a shredder if desired. • 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. • A vacuum is used to remove air. • Pressurized steam is introduced at a minimum of 121°C. • Waste is exposed to the steam. • Two or more cycles of vacuum and steam injection are used. • Steam is removed as condensate. • Waste is removed and processed in a shredder if desired.	21 kg/hr to 84 kg/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. • A vacuum is used to remove air. • Steam is introduced at about 147°C. • Internal drum rotates causing waste containers to break and mix. • Steam is removed as condensate and waste is cooled. • Waste is removed and processed in a grinder.	90 kg/hr to 2000 kg/hr	$380,000 to 900,000
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. • Steam is injected in the outer jacket until the inner chamber is heated to 132°C. • Internal mixing arm breaks the waste containers and mixes the waste. • Steam is removed as condensate. • Waste is removed and processed in a shredder.	20 kg/hr to 1000 kg/hr	$70,000 to 550,000

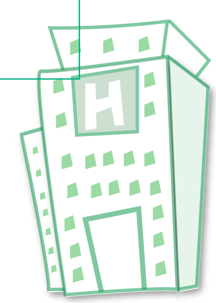


Alternative Health Care Waste Management Treatment Technologies

Type of technology	Description	General operating process	Range of capacities	Approximate capital cost in USD
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. • Steam is introduced at 132°C to 138°C. • Waste is shredded internally and exposed to steam. Steam is removed as condensate. • Waste is cooled. • Waste is removed.	40 kg/hr to 200 kg/hr	$190,000 to 470,000
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. • Steam and hot water are introduced. • Waste slurry is re-circulated through the grinder and held at 138°C. • Cold water is injected and the slurry is passed through a liquid separator to filter out the waste. • 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. • Waste passes through an internal auger where it is exposed to steam. • The dehydrator at the end of the auger removes excess liquid. • 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. • An optional second shredder at the end of the auger shreds the waste into a smaller size. • The waste is discharged into a container.	100 kg/hr to 250 kg/hr	$600,000 and higher
Small-scale microwave treatment	Technology consists of a treatment chamber and one or more microwave generators.	• Waste is placed inside the treatment chamber. • Water or steam is added. • Waste is exposed to microwave energy that generates heat inside the chamber. • Waste is removed and shredded if desired.	450 kg/hr to 2700 kg/hr	$12,000 to 85,000

Alternative Health Care Waste Management Treatment Technologies				
Type of technology	**Description**	**General operating process**	**Range of capacities**	**Approximate capital cost in USD**
Electro-thermal deactivation	Technology consists of size-reduction equipment, a conveyor and a high-voltage radio-frequency generator.	• Waste is placed on a conveyor. • Waste passes through a shredder. • Shredded waster is sprayed with water, compacted and then exposed to low-frequency radio waves which heat the waste. • 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. • Waste passes through a treatment section where it is exposed to an electron beam at doses that destroy pathogens. • 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. • Heated air at 177°C is circulated through the waste fir a prescribed time. • 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. • Sodium or potassium hydroxide solution is added to the vessel. • Steam or heated oil is circulated outside the jacket. • Waste is exposed to heated alkali solution for several hours until the digestion is complete. • Wastewater is neutralized if desired and discharged to the sewer or solidified and used as fertilizer. • Solid waste residue are discarded or used as soil conditioner.	14 kg to 4500 kg per cycle	$30,000 to 900,000 and higher
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. • A chemical disinfectant is mixed with waste (e.g., calcium chloride, calcium hydroxide, peracetic acid or ozone). • 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).



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.

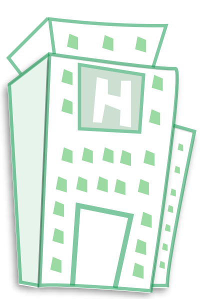
Resources

- Sustainability Roadmap for Hospitals - Waste: http://www.sustainabilityroadmap.org/topics/waste.shtml#.Vyuku4-cGM8.
- Practice Greenhealth - Less Waste: https://practicegreenhealth.org/topics/less-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/.
- 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— Purchasing Goals: https://noharm-uscanada.org/issues/us-canada/purchasing-goals.
- 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.

The **Green Checklist**, developed for this Toolkit, adapts existing green building rating systems to the Caribbean context, ensuring that it covers both the building itself and the facility's operations. 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 in the next page or download the form at: bit.ly/2jZSHY6.

Consult or download the **Field Guide for Application of the Green Checklist** at: http://bit.ly/2kufhLU.



Green Checklist

Name of Facility:		Assessment Date:	
Name of Assessors:			
Brief Summary of Green Assessment:			

INSTRUCTIONS: INSERT THE NUMBER "1" INTO THE ANSWER CELL FOR EACH QUESTION TO CALCULATE THE GREEN SCORE. INSERT COMMENTS.

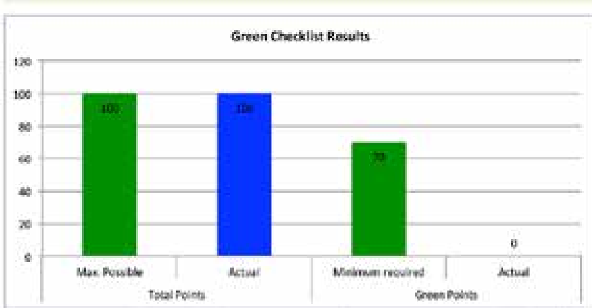
Cells highlighted in Yellow are critical standard questions, which must be met by the facility in order for it to be certified as Green.

Theme	Title	#	Question/Intent	Answer NA	Answer YES	Answer NO	Comments	Question Weight	Score achieved	Contribution To Total Points	Institutional type (Referral Hospital, District Healthcare, Poly Clinic; Health Center; Nursing Home; Psychiatric Hospital) RH	DH	PC	HC	NH	PH	Critical Standard
1. Water	1.1 Water Conservation Planning	1	Does the facility implement a water conservation plan? (please provide copy of plan)					1	0	1	X	X	X	X	X	X	X
			Is plan updated regularly?					1	0	1	X	X	X	X	X	X	
		2	Do you educate and involve staff in water conservation?					2	0	2	X	X	X	X	X	X	
		3	Do you have water meters throughout the facility (please provide meter readings)					2	0	2	X	X	X	X	X	X	X
		4	Are drawings available that show all water using sources (bathrooms, sinks, washing machines, HVAC, cooling, sterilizers)? Please provide copies to evaluators.					2	0	2	X	X	X	X	X	X	
	1.2 Water Efficiency	5	Are low-volume water fixtures installed throughout the facility?					3	0	3	X	X	X	X	X	X	X
		6	Do you actively detect leaks...					1	0	1	X	X	X	X	X	X	
			and repair them immediately?					1	0	1	X	X	X	X	X	X	
		7	Does the facility use water efficient washing machines and dishwashers?					2	0	2	X	X	X	X	X	X	
		8	Do you use water efficient sterilizers?					2	0	2	X	X	X	X	X	X	X
		9	Do you recycle steam condensate?					2	0	2	X						
		10	Do you have a rainwater catchment system?					2	0	2	X	X	X	X	X	X	X
			Does it include anti-mosquito breeding measures?					1	0	1	X	X	X	X	X	X	X
		11	Is vehicular fleet washed only when necessary?					1	0	1	X	X	X	X	X	X	
		12	Do maintenance personnel sweep instead of hosing down driveways, sidewalks and parking lots?					2	0	2	X	X	X	X	X	X	
		13	Do you practice water-efficient landscaping (Xeriscaping)?					2	0	2	X	X	X	X	X	X	
	1.3 Wastewater	14	Is used water treated and reclaimed?					2	0	2	X	X	X	X	X	X	
							POINTS ACHIEVED IN SECTION 1 =	0									
			Maximum Points Achievable in Section 1 (includes referral Hospitals) = 29. ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =					29									
2. Energy	2.1 Energy Audit	15	Does the facility implement an energy conservation plan? (please provide a copy of the plan)					3	0	3	X	X	X	X	X	X	X
			Is plan updated regularly?					1	0	1							
		16	Has an energy audit been carried out in the past 5 years? If so, please provide a copy to the evaluators					4	0	4	X	X	X	X	X	X	X
	2.2 Renewable Energy	17	Do you use solar voltaic panels or other type of renewable energy such as wind?					4	0	4	X	X	X	X	X	X	
		18	Do you use solar water heaters?					4	0	4	X	X	X	X	X	X	X
	2.3 Energy Efficiency	19	Do you use low energy lighting systems (LED)?					3	0	3	X	X	X	X	X	X	
		20	Do you use high energy efficient HVAC systems and inverter type AC Split systems?					3	0	3	X	X	X	X	X	X	
		21	Are equipment and appliances energy-efficient rated (US/EU standards)?					3	0	3	X	X	X	X	X	X	
		22	Do you utilize daylight to ensure adequate lighting in work areas while eliminating direct sunlight?					3	0	3	X	X	X	X	X	X	
		23	Does the facility have light sensors and occupancy sensors in staff and patient areas?					2	0	2	X	X	X	X	X	X	
							POINTS ACHIEVED IN SECTION 2 =	0									
			Maximum Points Achievable in Section 2 (includes referral Hospitals) = 30. ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =					30									
3. Atmosphere	3.1 Refrigerants	24	Have you replaced (or phased out) any devices that contain chlorofluorocarbons (CFC)?					3	0	3	X	X	X	X	X	X	
		25	Is your equipment serviced by a professional at least annually to reduce leakage/release into the atmosphere?					3	0	3	X	X	X	X	X	X	
							POINTS ACHIEVED IN SECTION 3 =	0									
			Maximum Points Achievable in Section 3 (includes referral Hospitals) = 6. ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =					6									

Green Checklist (cont.)

4. Indoor Environmental Quality	4.1 Tobacco Smoke	26	Is the facility a smoke free environment and clearly indicated as such?					2	0	2	X	X	X	X	X	X	X
	4.2 Ventilation	27	Is there adequate ventilation (windows and doors) that takes full advantage of the prevailing North-East Trade Winds?					3	0	3	X	X	X	X	X	X	
		28	Is air quality (Temperature and humidity) assessed regularly? Please provide report/results to the evaluators.					2	0	2	X	X	X	X	X	X	
	4.3 Dust/Particulate Control	29	Are entryway grills or mats able to capture dirt and particulates brought in from outside the facility?					1	0	1	X	X	X	X	X	X	
POINTS ACHIEVED IN SECTION 4 =								0									
Maximum Points Achievable in Section 3 (includes referral Hospitals) = 8. **ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =**								8									

Theme	Title		Question/Intent	Answer			Comments	Question Weight	Score achieved	Contribution To Total Points	Institutional type (Referral Hospital, District Healthcare, Poly Clinic; Health Center; Nursing Home; Psychiatric Hospital)						Critical Standard
				NA	YES	NO					RH	DH	PC	HC	NH	PH	
5. Hazardous Materials	5.1 Mercury Elimination	30	Have you replaced or phased out mercury-containing medical devices, substances and reagents?					3	0	3	X	X	X	X	X	X	X
	5.2 Pest Control	31	Does the facility apply an integrated Pest Management program, with minimal use and safe application of hazardous chemicals applied by a trained professional on a regular basis? Please provide report/visit log to evaluators					2	0	2	X	X	X	X	X	X	
POINTS ACHIEVED IN SECTION 5 =								0									
Maximum Points Achievable in Section 5 (includes referral Hospitals) = 5. **ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =**								5									
6. Pharmaceuticals	6.1 Pharmaceutical Minimization	32	Does the facility have established procedures for procuring,					1	0	1	X	X	X	X	X	X	X
			storing,					1	0	1	X	X	X	X	X	X	
			dispensing,					1	0	1	X	X	X	X	X	X	
			and proper disposal of pharmaceuticals?					1	0	1	X	X	X	X	X	X	
POINTS ACHIEVED IN SECTION 6 =								0									
Maximum Points Achievable in Section 6 (includes referral Hospitals) = 4. **ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =**								4									
7. Food Services	7.1 Local/Regional Foods	33	Do you procure food from local sources?					3	0	3	X	X	X	X	X	X	X
		34	Have you established ways to reduce food waste?					3	0	3	X	X	X	X	X	X	
POINTS ACHIEVED IN SECTION 7 =								0									
Maximum Points Achievable in Section 7 (includes referral Hospitals) = 6. **ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =**								6									
8 Solid and Infectious Waste Managment	8.1 Waste Minimization	35	Do you practice waste minimization at source including pharmaceuticals?					3	0	3	X	X	X	X	X	X	
	8.2 Infections Waste	36	Have you procedures and established practices to separate medical from non medical waste?					3	0	3	X	X	X	X	X	X	X
	8.3 Reduce, Reuse, Recycle	37	Do you use biodegradable products like paper, cardboard and plant-based products instead of plastics and Styrofoam?					3	0	3	X	X	X	X	X	X	
		38	Do you recycle wastes, including plastic; composting biodegradables; donating food waste to farmers?					3	0	3	X	X	X	X	X	X	
POINTS ACHIEVED IN SECTION 8 =								0									
Maximum Points Achievable in Section 8 (includes referral Hospitals) = 12. **ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =**								12									
TOTAL MAXIMUM POINTS AVAILABLE = 100. **ACTUAL TOTAL MAXIMUM POINTS BASED ON APPLICABLE QUESTIONS =**								100									
TOTAL POINTS ACHIEVED								**0**									
Facility can only be certified GREEN if all critical criteria have been met. Have all critical standards been met:								**NO, some standards not met, Facility is not GREEN**									
MINIMUM TOTAL POINTS NEEDED FOR CERTIFICATION (MINIMUM = 70%) =								70									
ACTUAL % RATING ACHIEVED FOR THIS FACILITY = Totatl Actual Points Achieved / Actual Total Maximum Points =								**0%**									



Section III

BASELINE ASSESSMENT TOOL

Overview

The Baseline Assessment Tool (BAT) is designed to collect baseline information to guide a health facility's decision-making process with regard to retrofitting. It complements the Hospital Safety Index and the Green Guide. It also compiles detailed information needed to prepare the Scope of Work documents. This process requires a level of skill and use of specialized equipment.

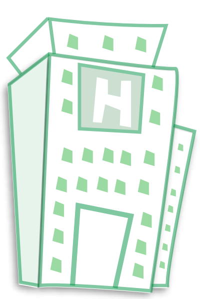
The BAT collects data on a facility's energy and water consumption; the indoor environmental quality; the building's components; the satisfaction of its occupants; and local zoning regulations. To this end, health facilities may use the following forms to collect this data:

1. Building/Property Components (Audit)
2. Energy Conservation (Audit)
3. Water Conservation (Audit)
4. Indoor Environmental Quality (IEQ)
5. Occupant Survey
6. Land Use

1. Building/Property Components (Audit)

General Building Information
Name of facility:
Location:
Property block/parcel No.
Size of property:
Building orientation:
Building floor area:
No. of stories/floors:
No. of parking spaces: Visitors ____________ Workers__________
Building capacity: No. of beds ____________
No. of employees: Full-time ___________ Part-time ______________
Year constructed:
Type of building construction:
Type of roof construction:
PAHO Hospital Safety Index (HSI) applied: Yes ❑ No ❑
If yes, is the report available?
Note any past damage to the facility:

The Building Component Audit is used to produce a complete inventory of a building (including equipment) and is used to identify deficiencies and determine the scope of work required for retrofitting. Areas to be examined include the structure, walls and roof, security and a review of safety issues.



Below is the form that can be used to capture critical data on various aspects of the building. The Building/Property Component Audit is grouped into three categories of components: exterior and interior building elements and safety/code compliance.

Following the form is an explanation of these components.

Component	Systems	Quantity/Square Area	Issues (Condition)	Additional Comments
Exterior Building Elements	Foundation/structure			
	Exterior walls			
	Roof system/drainage			
	Windows			
	Doors			
Interior Building Elements	Ceiling			
	Interior walls			
	Doors			
	Floors			
Safety Elements	Means of exit			
	Fire control			
	Fire alarm			
	Emergency lighting			
	Fire resistance			
	Provisions for handicap/accessibility			
	Perimeter fencing/security			

Building Audit Guide

Exterior Building Elements

Foundation/structure

- In addition to applying the Hospital Safety Index, assess the foundation, columns, beams or structural walls for any signs of failure or distress, such as settling, subsidence, severe cracking or crushing. Document the findings. For reference purposes, photograph the areas of damage.

Exterior walls

- In addition to applying the Hospital Safety Index, inspect the exterior wall surfaces (inside and outside) for any signs of water intrusion, surface cracks or separation issues. Be sure to photograph the area of damage for reference.

Roof system /drainage

- In addition to applying the Hospital Safety Index, inspect the roof system, flashing, downspouts, gutters and all their connection points. Make note of any damage to the roofing membrane, displaced flashing, leaks and any visible cracks on flat concrete roof sections. In addition, document the condition of all drains and culverts, especially at invert locations where water enters from surface and/or roof run-off.

Windows

- Make note of all window types, size (width × height), quantity, condition and any thermal characteristics. It is important to document the existing window height from the finished floor level.

Doors

- Make note of all exterior door types, size (width × height), quantity, condition and direction of swing (left-hand or right-hand). Also document any issues affecting the operation of doors, including hinges, jambs, locking devices and any failure of emergency devices (crash bar mechanisms).

Interior Building Elements

Ceiling

- Inspect the condition of ceilings for any deficiencies or problems, including soiling or discoloration due to water damage, or any cracks if it is an exposed concrete slab. It is important to document if the ceiling contains any hazardous materials (asbestos) or other unsafe conditions. Note if the ceiling is a drop/suspended ceiling and take its overall dimensions (length × width) for retrofitting purposes.

Interior Wall

- In addition to applying the Hospital Safety Index, document the condition of all interior walls and their connections to each other.

Interior Doors

- Make note of all exterior door types, size (width × height), quantity, condition and direction of swing (left-hand or right-hand). It is important to note if the doors are fire-resistant and document any issues affecting the operation of the door, including its hinges, jambs and locking devices.

Flooring

- In addition to applying the Hospital Safety Index, it is important to document the condition of the building's flooring and any slipping or tripping hazards. Note the type of flooring, its location and corresponding square footage (length × width) for retrofitting purposes.

Safety/Code Compliance

Means of Exit

- Verify and document if all exit doors are easy to open; if equipped with panic bar locks; and are visible with well-lighted exit signage above doors. Exits and exit access corridors should be well lighted (all areas of the building should have at least two exits). The width of exit doors, staircases (in buildings of two or more stories) should be wide enough for evacuation and comply with local building codes.

Fire Control

- In addition to applying the Hospital Safety Index, document the availability, quantity and condition of all portable chemical fire extinguishers and fire hoses, noting their locations throughout the building. If available, verify if they have been checked by the local fire department and are annually inspected and certified. It is important that special extinguishing systems (halon or CO_2) are considered for hazardous areas of the facility, such as electrical rooms, and that fire separation walls exist for shafts and corridors.

Fire Alarm

- In addition to applying the Hospital Safety Index, document the availability, quantity and condition of all smoke detectors and if any fire alarm system exists. Ideally, the building will be equipped with a fire alarm system, connected to emergency backup power, and have smoke detectors that are connected to a permanent and visible central fire alarm panel. The system should also be connected to the local fire department system (if applicable). A voice communication system, with a sound alarm, should be integrated into the system. If a sprinkler system exists, the system should have a hydraulic-operated alarm bell, actuated by the flow of sprinkler water.

Emergency Lighting

- Verify and document the availability, quantity and condition of all emergency lighting. Be sure to test the units and verify if they meet local and international standards. The equipment should be free from dust, rust and provide adequate illumination in large areas such as corridors and exits.

Fire Resistance

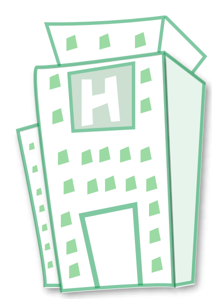
- Concrete constructed buildings provide some level of fire resistance. However, if the facility contains timber columns, walls and metal stud walls present, verify if the walls are covered with gypsum board (all sides). Also check stairs to determine if they are concrete or made of fire-proofed steel. Note: one-hour-rated fire separation walls for one-story buildings and two-hour-rated for two-story buildings. Read more about these standards from the International Code Council's Fire Resistance-Rated Construction, http://bit.ly/292AgMj.

Accessibility

- In addition to applying the Hospital Safety Index, document if the facility meets the standards for accessibility ramps for the physically disabled. It is important that all levels of the building are accessible. All doorways and corridors should be of an adequate width and all bathrooms and showers should be equipped with grab bars and other ADA certified equipment.

Perimeter Fencing/Security

- In addition to applying the Hospital Safety Index, assess the condition and integrity



of the perimeter fencing, gates and all connections. It is essential that the facility maintains a level of security and control of pedestrian and vehicular traffic entering the facility and compound. If security systems are present, document their condition and any improvements that can be made to the system.

2. Energy Conservation (Audit)

The health sector will benefit from cost-effective solutions to address the rising cost of energy and the health implications of energy use. Once a facility has developed an energy baseline by tracking and measuring energy use, it can begin to zero in on key areas of inefficiency and review potential energy reduction strategies, with an eye toward what will work, given the hospital's financial resources. Improving energy efficiency will reduce energy costs, greenhouse gas emissions and pollution associated with the burning of fossil fuels. While various professionals can complete other aspects of the BAT, a qualified electrical engineer is best suited to conduct an energy audit.

To perform an energy audit, data on the following should be collected:

a) Energy consumption (at least two years of data from electric bills)
b) Renewable energy
c) Standby generator
d) Lighting
e) Air conditioning equipment
f) Refrigeration
g) Medical equipment
h) Washers and dryers
i) Water heater
j) Miscellaneous electrical loads

	Electricity Consumption						
	Month	Days in period	Usage kWh	Fuel surcharge	Cost per kWh	Monthly cost	Remarks
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 per kWh	Monthly cost	Remarks
YEAR 2	January						
	February						
	March						
	April						
	May						
	June						
	July						
	August						
	September						
	October						
	November						
	December						

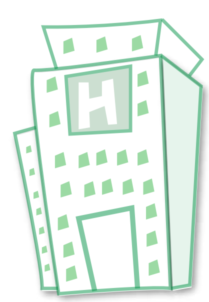
Fixed Charges:

VAT:

Consumption Range (kWh)	Cost Per Unit

Renewable Energy				
Type of technology	Grid-tied/off grid	Size of battery bank	Size of system (kW)	Annual power production (kWh)

Standby Generator			
Brand / Model	Power rating (kW)	Power rating (kVA)	Power factor



Lighting

Fluorescent tubes

Location and remarks	Bulb length	Base type	Ballast (electronic/ magnetic)	Number of fixtures	Number of bulbs in fixture	Power (W)	Hours per week

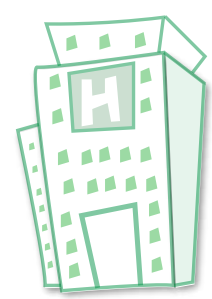
LED tubes

Location and remarks	Bulb length	Base type	Number of fixtures	Number of bulbs in fixture	Wattage	Hours per week

Compact fluorescent lamps (CFL)				
Location and remarks	Base type	Quantity	Wattage	Hours per week

LED lamps				
Location and remarks	Type	Quantity	Wattage	Hours per week

Incandescent bulb				
Location and remarks	Type	Quantity	Wattage	Hours per week



Halogen lamp				
Location and remarks	Type	Quantity	Wattage	Hours per week

High pressure sodium (HPS) lamps				
Location and remarks	Type	Quantity	Wattage	Hours per week

Air Conditioning												
Cooling Capacity												
Location and remarks	Quantity	Type	Model	Thermostat setting (Celsius / Fahrenheit)	Tonnage	British thermal units (BTU)	Power (W)	Refrigerant	EER	SEER	ESEER	Hours per week

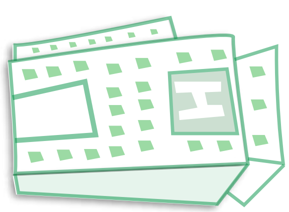
NOTES

Model: AC Brand / Model - Can be used to determine capacity and power if it is not shown on the unit

EER: Energy-efficiency ratio

SEER: Seasonal energy-efficiency ratio

ESEER: European seasonal energy-efficiency ratio



Refrigeration									
Location and remarks	Quantity	Model	Capacity cu. ft	Voltage (V)	Amps (A)	Power (W)	Temperature setting (hi/med/low)	Refrigerant	Year

Medical Equipment					
Equipment name	Model	Voltage (V)	Amps (A)	Power (W)	Hours per week

Washers and Dryers					
Equipment name	Model	Voltage (V)	Amps (A)	Power (W)	Hours per week

Water Heater										
Location and remarks	Quantity	Type	Tank / tankless	Model	Capacity (gal.)	Gallons per minute (GPM)	Voltage (V)	Amps (A)	Power (W)	Energy factor (EF)

Miscellaneous Electric Loads							
Location and remarks	Quantity	Name of appliance	Model	Voltage (V)	Amps (A)	Power (W)	Hours per week

3. Water Conservation (Audit)

The water conservation audit is designed to help analyze the health facility's water use. Certain items may not apply to all facilities.

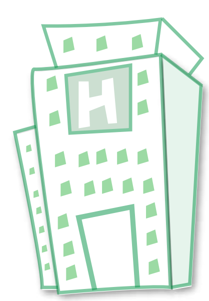
Background	
Local water provider:	
Where does your water come from?	
Number of buildings at facility:	Size of buildings (area):
Area of grounds:	Number of employees per shift:
Number of shifts per day:	
Average number of visitors/occupants per day (if applicable):	
Water pressure at your facility: ___________ (psi) *(Often reducing water pressure by a mere 10-15% can reduce water consumption significantly without affecting activities. Water pressure that is too high can result in leaks.)*	

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?

Utility/Consumption Data			
Water meter/s (utility meters)			
Meter #	**Meter size**	**Area served**	**Annual consumption**

	Monthly Water Use					
	Month	**Days in Period**	**Usage**	**Surcharge**	**Cost**	**Notes**
YEAR 1	January					
	February					
	March					
	April					
	May					
	June					
	July					
	August					
	September					
	October					
	November					
	December					



Monthly Water Use						
	Month	**Days in Period**	**Usage**	**Surcharge**	**Cost**	**Notes**
YEAR 2	January					
	February					
	March					
	April					
	May					
	June					
	July					
	August					
	September					
	October					
	November					
	December					

Water Consumption	
Number of restrooms:	Number of toilets (total):
Note: Many fixtures have the average flow rate printed on the fixture itself, along with the make and model. If you cannot find this printed information, consult your maintenance staff or facility manager.	

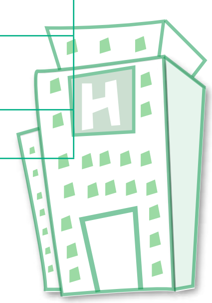
Toilets/Urinals			
(Type of toilets/urinals and average water consumption in gallons per flush (gpf)): *Note: Most toilets are either gravity flush; flush valve/flushometer/tankless; or pressurized tank types.*			
Toilet type:	Number:	Average gpf:	Condition:
Toilet type:	Number:	Average gpf:	Condition:
Urinal model:	Number:	Average gpf:	Condition:
Are toilets equipped with toilet dams or low-flow flapper valves?		Yes ❑	No ❑
Do flush valve (tankless) toilets have water-saving diaphragms?		Yes ❑	No ❑
Are toilets equipped with automatic water-flushing systems?		Yes ❑	No ❑
If so, what is the timing cycle?			
Are the sensors/timers coordinated with regular work hours?		Yes ❑	No ❑
Total water consumption per workday from toilet flushes: ____________. *(Assuming each employee/occupant uses the bathroom 4 x per workday)*			

Restroom Faucets			
Number of restroom faucets (total):	Faucet flow rate:	Condition:	
Are faucets equipped with aerators?		Yes ❑	No ❑
Are faucets equipped with automatic or metered shutoff mechanisms?		Yes ❑	No ❑

Showers		
Number of showers (total): ___________	Showerhead flow rate: ___________	gpm Condition: ___________

Fountains		
No. of drinking fountains: ___________	Fountain flow: ___________	gpm Condition: ___________
Are fountains ❑ air-cooled or ❑ water-cooled?		

Kitchens/Cafeterias			
Number of kitchen/cafeteria areas: ___________	Number of kitchen sinks/ faucets: ___________	Faucet flow rate: ___________	gpm Condition: ___________
Are kitchen faucets equipped with aerators?		Yes ❑	No ❑
Do refrigerators use water coolant systems?		Yes ❑	No ❑
Are refrigerators equipped with icemakers?		Yes ❑	No ❑
Are icemakers:		Water-cooled ❑	Air-cooled ❑
Do refrigerators provide drinking water?		Yes ❑	No ❑
Do kitchens use:	Garbage disposal ❑	Composting ❑	Neither ❑
Is there a dishwasher?		Yes ❑	No ❑
Number of dishwashers: ______ Make/model: ______________________			
Average number of loads per day: ___________		Water consumption per load: ___________	
Are dishes pre-washed?		Yes ❑	No ❑
Is potable water used for pre-washing dishes?		Yes ❑	No ❑
Is dishwasher wastewater reused?		Yes ❑	No ❑
Does the flow of water to the garbage disposal stop when the disposal motor stops? *(Many disposals have two water-supply lines, one to the bowl and one to the grinding chamber. Check both.)*		Yes ❑	No ❑
Are there grease traps available at the facility? How often is it maintained? ________________________ Make/model: _______________________ Condition: _________________________		Yes ❑	No ❑
Number of ice machines: _____ Are ice machines:		Water-cooled ❑	Air-cooled ❑
Are kitchen floors hosed clean? How often? ___________		Yes ❑	No ❑
Are hoses equipped with high-pressure, water efficient nozzles?		Yes ❑	No ❑
Are linens washed on-site? How often? ___________		Yes ❑	No ❑



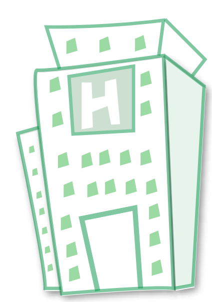
Laboratory Consumption				
Number of laboratories (total in facility): __________	Number of kitchen sinks/ faucets: __________	Faucet flow rate: __________		gpm Condition: __________
Are faucets equipped with aerators?		Yes ❑		No ❑
List lab equipment that uses water in any way:				
Equipment	**Amount used**	**Closed-loop?**		**Potable or Reused?**
		Yes ❑	No ❑	
		Yes ❑	No ❑	
		Yes ❑	No ❑	
		Yes ❑	No ❑	
Describe lab procedures/clean-up practices that consume water:				
Are procedures and clean-up practices posted in the lab?		Yes ❑		No ❑

Mechanical Consumption			
Number of water heater(s): _____ Size: ____________ Condition: ____			
Are water softeners in use? Number: ______ Condition:________________________		Yes ❑	No ❑
Is softener regeneration automated?		Yes ❑	No ❑
If automatic regeneration, is it initiated by?	Time ❑	Meter ❑	Sensor ❑
Is resin cleaner used?		Yes ❑	No ❑
Are drink machines in vending areas?		Water-cooled ❑	Air-cooled ❑
Are cooling towers in use at your facility? Number: ________ *(For each cooling tower, approximately how much make-up water is needed or used to replace water lost to blow-down, evaporation, and other process inefficiencies. Check settings for level of total dissolved solids (TDS) at blow-down and frequency.)*		Yes ❑	No ❑
Are boilers used at your facility? Number: _____ Condition: ________ *(For each boiler, approximately how much make-up water is needed or used to replace water lost to blow-down, evaporation, and other process inefficiencies. Check settings for level of total dissolved solids (TDS) at blow-down and frequency.)*		Yes ❑	No ❑
Are water-cooled air compressors used?		Yes ❑	No ❑
Are water-cooled pumps used?		Yes ❑	No ❑
List any other machines that use non-contact cooling water:		Yes ❑	No ❑

Heating, Ventilating and Air Conditioning (HVAC) Consumption		
What type of HVAC system do you have?:		
Does your HVAC system have condensate collection and/or re-use?	Yes ☐	No ☐
Is your HVAC system always on?	Yes ☐	No ☐
Is your HVAC system?	Water-cooled ☐	Air-cooled ☐
If water-cooled, is your system	Open-loop ☐	Closed-loop ☐

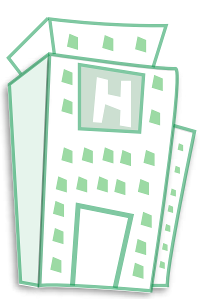
Cleaning Use		
Motor Pool: Number of vehicles: ______ Where are they washed? ______________ How frequently? ____________		
Number of watercraft: ______ Where are they washed? ______________ How frequently? ____________		
Does your HVAC system have condensate collection and/or re-use?	Yes ☐	No ☐
Is your HVAC system always on?	Yes ☐	No ☐
Is your HVAC system?	Water-cooled ☐	Air-cooled ☐
If water-cooled, is your system?	Open-loop ☐	Closed-loop ☐

Janitorial Use			
Is the janitorial staff aware of water conservation efforts?		Yes ☐	No ☐
Are there areas that janitors mop? Where: ____ Area mopped (ft^2): ____________ How often? __________________		Yes ☐	No ☐
Are hoses used?		Yes ☐	No ☐
Are dry-clean (rather than wet-clean) practices and procedures in place? (i.e. sweep instead of hosing, scrape before spraying, etc.)		Yes ☐	No ☐
List other janitorial practices that consume water:			
Task	**Where**	**How often**	**Average water used**



Landscape Consumption			
Does your landscape use mulch?		Yes ☐	No ☐
Does your facility have an irrigation system? Type: ___________________ Where does the system irrigate? _______________________ How often? ______________		Yes ☐	No ☐
Does your system have a rain gauge?		Yes ☐	No ☐
Does your system have manual override controls?		Yes ☐	No ☐
Are hoses used for irrigation?		Yes ☐	No ☐
Are hoses equipped with fine-spray/high-pressure/water-efficient nozzles?		Yes ☐	No ☐
Does your facility have any pools or fountains? Number: _______ When are fountains running? ___________ Typical water consumption? _________		Yes ☐	No ☐
Do fountains use recycled water?		Yes ☐	No ☐
Are they part of a closed-loop system?		Yes ☐	No ☐
Are paved areas?	Swept clean ☐	Blown cleaned ☐	Hosed ☐

Maintenance		
Are faucets, pipes and plumbing checked regularly for leaks? How often? ______________	Yes ☐	No ☐
Is there regularly scheduled preventive maintenance in your facility?	Yes ☐	No ☐
Is maintenance documented with standard records or inspection logs?	Yes ☐	No ☐
If you contract with a maintenance company: How quickly does maintenance staff respond and repair leaks?	Yes ☐	No ☐
If you control your own maintenance program: How do you handle reporting and repair of leaks?		
How quickly are leaks usually repaired?		



4. Indoor Environmental Quality (IEQ)

Indoor environmental quality (IEQ) refers to the quality of a building's interior environment in relation to the health and wellbeing of its occupants. IEQ is determined by many factors, including lighting, air quality, and ventilation and humidity/damp conditions.

Some existing health facilities have poor indoor environmental and/or air quality (IEQ/IAQ). IEQ encompasses thermal comfort, humidity, ventilation, lighting and noise levels. An ideal indoor environment in terms of occupants' health, comfort, safety and satisfaction is an important consideration when assessing indoor environmental quality.

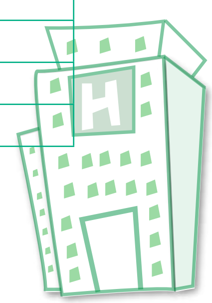
Lighting Levels

The outdoor light level is approximately 10,000 lux on a clear day. Inside the building, in areas closest to windows, the light level may be reduced to approximately 1,000 lux. In some places in the interior of a hospital, it may be as low as 25-50 lux. Additional lighting equipment is often necessary to compensate for the low levels.

Previously, it was common to perform normal activities with light levels in the range 100-300 lux for normal activities. Today light levels in the range 500-1000 lux—depending on the activity—are much more common. For precision and detailed work, required light levels may even approach 1500-2000 lux.

The table below is guidance for recommended light levels in different work spaces.

Hospitals		
Area–Activities	**Type of work**	**Recommended lux – (minimum lux)**
Doctors' offices	(General lighting)	150
Doctors' offices	(Working table)	1000 – (500)
Waiting areas		150
Bathrooms	(General)	200 – (100)
	(Mirror)	400 – (200)
Library		500 – (250)
First aid ward	(Localized)	1000 – (500)
	(General)	20,000 – (10,000)
Corridors - staircases		150
Kitchen		500 – (250)
Laboratory	(Research areas)	500 – (250)
Laboratory	(Working table)	1000 – (500)
Operating room	(General)	1000 – (500)
	(Working table)	40,000 – (20,000)
	(X-ray ward) adjustable lighting	0 – 100 – (0-50)
Dentistry	(General)	500 – (250)
	(Chair)	10,000 – (5000)



Hospitals		
Area–Activities	**Type of work**	**Recommended lux – (minimum lux)**
Maternity ward	(Delivery bed)	10000 – (5000)
	(Deliver area) general	500 – (250)
	(Infant and waiting area)	200 – (100)
Patient rooms	(General)	150
	(Localized lighting: beds)	500 – (250)

Humidity Levels

Correct humidity levels are essential to patient health, staff comfort and prevention of electrostatic damage to medical equipment. The medical industry's goal is to treat the injured or ill in a safe and comfortable environment. Hospital staff must also have a comfortable environment, so they are at their best in order to perform proper diagnosis and treatment.

Hospitals also have various rooms with various purposes. They range from waiting rooms to intensive care units, X-ray facilities and surgery rooms. These types of rooms all require a degree of air quality that includes specific requirements for humidity. Deviations from the mid-range of relative humidity (RH) of 40-60% can reduce air quality by causing an increased growth of bacteria, airborne infection, sore eyes, sore throat, increased static and dust, and premature coagulation.

Hospitals are recommended to keep humidity levels as follows:

Hospitals		
Hospital area	**Temperature (F/C)**	**Recommended humidity**
Operating, cystoscopic and/or fracture Rooms	72°F /22°C	50 %RH
Patient rooms	75°F / 24°C	45 %RH
Intensive care unit	75°F / 24°C	40 %RH
Administrative and service areas	75°F/ 24°C	40 %RH

Carbon Dioxide (CO_2 Levels)

Since people exhale carbon dioxide (CO_2) at predictable levels, its content in the air may be a significant indication of air quality. A measure of CO_2 indicates the amount of fresh air supply; 15 cfm[1] ventilation rate per occupant corresponds to 1000 ppm CO_2 and 20 cfm ventilation rate per occupant corresponds to 800 ppm CO_2.

Standard levels of carbon dioxide (CO_2) (recommended in ASHRAE[2] standard 62-1989) are as follows:

- Classrooms and conference rooms: 15 cfm per occupant
- Office space and restaurants: 20 cfm per occupant
- Hospitals: 25 cfm per occupant

1. cfm: cubic feet per minute. ppm: parts per million.
2. American Society of Heating, Refrigerating and Air-Conditioning Engineers.

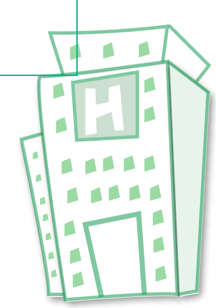
The referenced CO_2 levels are as follows:

- 350- 450 ppm: background (normal) outdoor air level
- Less than 600 ppm: acceptable levels
- 600- 1,000 ppm: complaints of stiffness and odors
- 1,000 ppm: ASHRAE and OSHA standards (CO_2 concentration at this level should not exceed 1,000 ppm)
- 1,000-2,000 ppm: level associated with complaints of drowsiness and poor air.
- 2,000-5,000 ppm: level associated with headaches, sleepiness, and stagnant, stale and stuffy air. Adverse health effects expected.
- Greater than 5,000 ppm: exposure may lead to serious oxygen deprivation resulting in permanent brain damage, coma and even death.

5. Occupants Survey

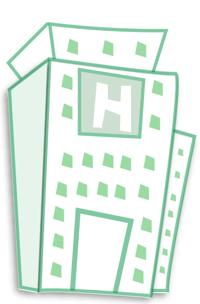
Occupant surveys are highly effective as a way to judge the current performance of a building. After all, the occupants are the people who spend the most time in the building. An occupant survey will highlight any day-to-day building performance that falls below tenants' expectations and can also highlight thermal comfort, noise, glare, transport and other operational issues. To be effective, the audit will be carried out in a highly structured manner so that the results can allow comparison with a well-established, benchmarked database of criteria.

Patient/Staff Occupancy Satisfaction Survey					
Question	**Responses**				
Please identify your relationship to the facility:	Employee ❑	Patient ❑	Visitor ❑	Other ❑ Specify: ____________	
Do you understand the concept of "greening" buildings?	Yes ❑	No ❑	Not sure ❑		
Which of the following renewable energy sources do you know about?	Solar ❑	Wind ❑	Geothermal ❑	Bio energy ❑	None ❑
Do you give consideration to energy and water conservation in your normal functions?	Yes ❑	No ❑	Not sure ❑		
On average, how much time do you spend at the facility in one week?	<40 hrs ❑	>40 hrs ❑	Not sure ❑		
How do you get to the facility?	Walk ❑	Private vehicle ❑	Public transport ❑	Other ❑ ______________	
Approximately how many miles is the drive to work/ facility?	<5 miles ❑	Between 5-9 miles ❑	More than 10 miles ❑	Not sure ❑	



Patient/Staff Occupancy Satisfaction Survey

Question	Responses						
If you use a vehicle or public transport to get to the facility, please provide some details about the vehicle.	Make	Model	Year	Not sure ❑			
How satisfied are you with lighting?	Very satisfied ❑	Moderately satisfied ❑	Not satisfied ❑				
Does the lighting affect you ability to function normally?	Yes ❑	No ❑	Not sure ❑				
Can you point out specific problems with the lighting?	Glare ❑	Reflections ❑	Direct sunlight ❑	Faulty fixtures ❑	Other ❑ ___________		
Overall, does the air quality enhance or interfere with your ability function normally?	Enhance ❑	Interfere ❑	Not sure ❑				
How satisfied are you with the air quality (i.e. stuffy/stale air, odour) at the facility?	Very satisfied ❑	Moderately satisfied ❑	Not satisfied ❑				
Does direct sunlight enter any of the windows and doors?	Yes ❑	No ❑	Not sure ❑				
Does the temperature of the facility affect your ability to function normally?	Yes ❑	No ❑	Not sure ❑				
Does the ventilation (movement of air) affect your ability to function normally?	Yes ❑	No ❑	Not sure ❑				
In your opinion, is the building strong/safe?	Yes ❑	No ❑	Not sure ❑				
Would you feel comfortable in the building during a tropical storm or hurricane?	Yes ❑	No ❑	Not sure ❑				
What improvements would you like to see to the building?	Better lighting ❑	Operable windows ❑	Operable doors ❑	Air conditioning ❑	Reliable electricity ❑	Reliable water supply ❑	Other ❑ ________



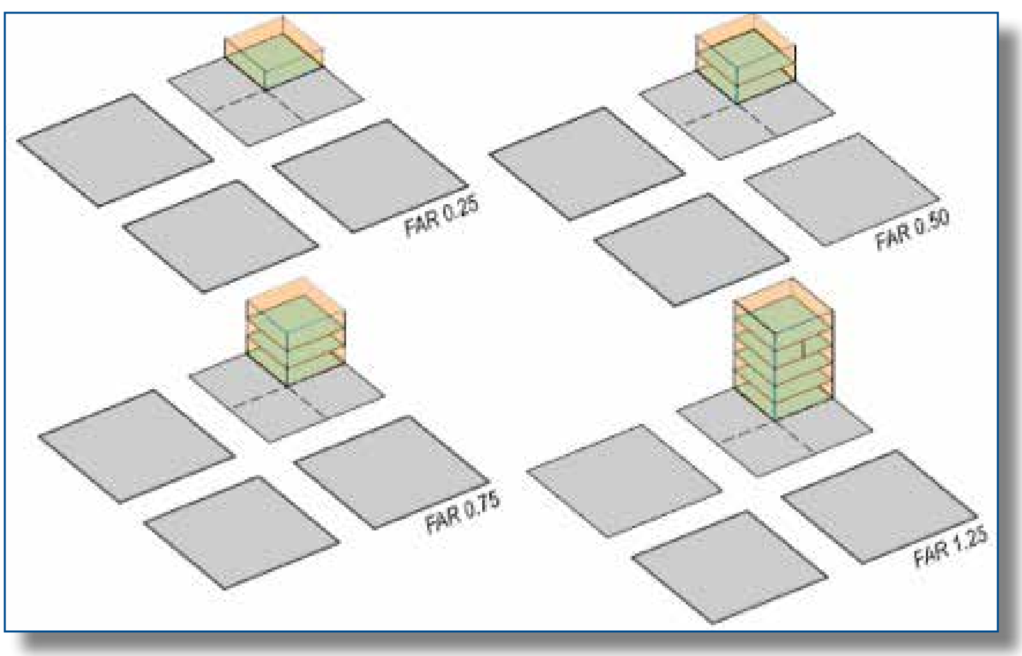
The following information is required to assess if conditions in the health facility are contributing to illness, absenteeism or a high turnover rate. These questions may be revisited once the project has been completed and workers have had a chance to use the facility for some time in order to determine if the changes had an impact on working conditions and indoor environmental quality (lighting, air quality, dampness, etc.).

In an effort to calculate the health facility's carbon footprint, questions related to the procurement of food are included below.

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 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?		

6. Floor Area Ratios

Another key issue to be assessed is whether the allowable gross floor area on the particular site has increased since the building was first constructed. This section of the Baseline Assessment Tool relates to zoning densities, which are set by individual countries. The questions in the form below are targeted to calculate floor area ratios (FAR). See the following example.



Zoning and density often change over time to allow for smart growth and to address socioeconomic trends. If the available GFA has increased, a health facility may explore adding on to existing buildings in coordination with projects to upgrade the facility. In some cases, in which allowable GFA has increased significantly, there may even be a business case to tear down and rebuild rather than retrofit.

With regard to the table below, a plot is defined as the land area, measured in square meters or square feet, to the boundary of the site.

Description of Project	Results	Notes
No. of buildings on plot		
Maximum allowable height of buildings		
Plot area		
Building area		*This is the footprint size of the building on the plot, from a bird's-eye view.*
Total floor area		*For example, in a two-story building, add the area for each floor to find the total floor area (ground floor plus first floor, plus second floor, etc.*
Site coverage* (e.g., % of plots covered by buildings) [B/A × 100]		*Calculation is expressed as a percentage. From the calculation, the percentage could show that a building occupies over 13% of the entire land area, which is low, and thus has potential and space for expansion. Refer to country zoning laws and guides.*
Plot ratio** (divide total floor area expressed in ratio e.g. 1:07) [1:C/A]		*In BVI, for example, a ratio below 1:0.7 is allowable. Other countries vary. Refer to country zoning laws and guides.*

*Site coverage refers to the building area (area occupied from a bird's-eye view) divided by the plot (site) area. New development cannot exceed a certain percentage of available area, which is why this information is important.

**Plot ratio is the total floor area (ground floor, 1st floor, etc.) divided by the plot (site) area.

The following equipment is required to perform a basic assessment of your health facility:

1. Portable indoor air quality CO_2 meter/Data logger
2. Voltage tester – AC power meter panel energy monitor
3. Light meter
4. Electricity usage monitor
5. Ballast checker (electronic or magnetic)
6. Digital high-current probe

Section IV

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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 gives guidance for engineers and architects. More detail is given for structural and civil engineers, rather than for architects, mechanical, or electrical engineers, due to the fact that this Annex refers 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 of this Annex 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.

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.

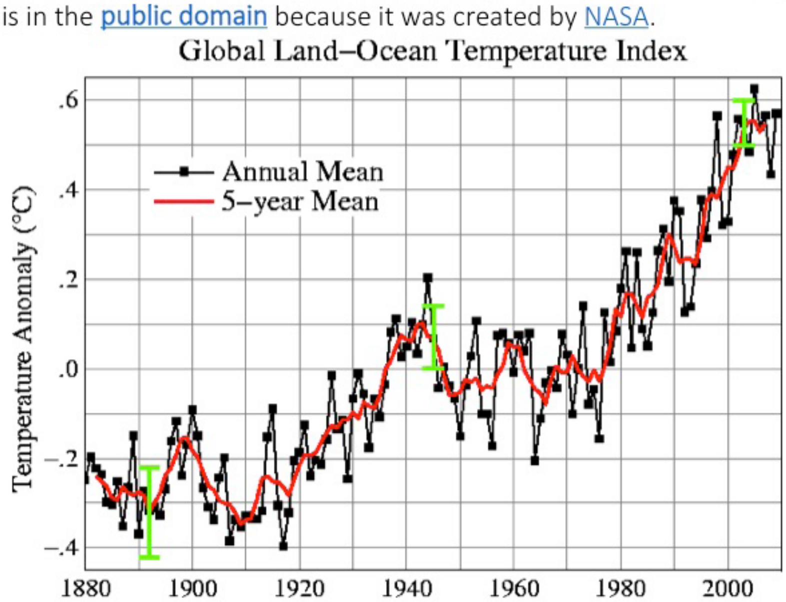
Instead of design based largely on past experience, architects and engineers must now factor predicted climate change scenarios into their concepts and calculations. Spatial layout, structural frame and foundations have relatively long life spans and will be affected by changes in climate. Other components, 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.

This graph depicts temperature anomalies from meteorological stations, showing both annual means and a five-year mean from 1880-2010. Temperatures show a clear upward trend since the 1970s. **Credits:** This file is in the public domain because it was created by NASA.



Temperature rise scenarios

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. Use lower level windows on the windward side and higher level windows on the leeward side. Maximize airflow. Do not place windows opposite each other. 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. Limit the amount of direct sunlight impacting east and west facades. 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. 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. Covered entry spaces, protected from rain and shaded, but otherwise open: protect the walls and inner spaces from direct sunlight. 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. Choose bright colours in the external finishes. 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. 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. 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. 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 1 m 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 . Measures for preventing rising damp and for waterproofing of the walls below ground.	Buoyant forces on the basement. 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.

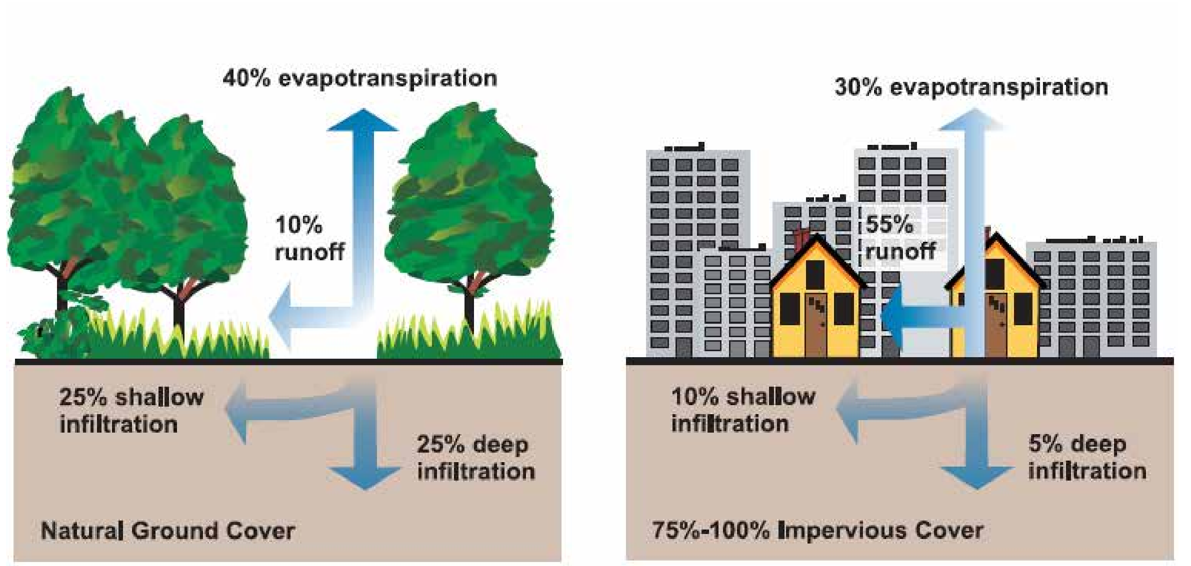
The stability of slopes and embankments can be affected by very dry or very wet weather conditions. Periods of dry weather will decimate the plant cover on many slopes. This can contribute to soil erosion and make the slope more vulnerable to landslide when rains do occur.

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.

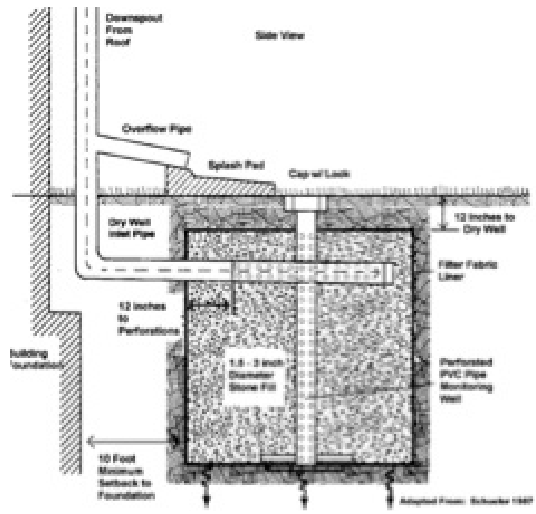
Inland flood damage is mainly due to inadequate capacity of drainage facilities during periods of excessive rainfall. The external works associated with buildings for public occupancy must be carefully designed with climate change parameters in mind.

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] 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. Caution: exercise care with waterproofing and drainage. 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. 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. 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

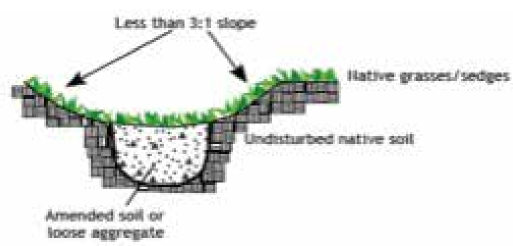
Typical Green Roof[13]



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 collec-tion 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 Hurricane Gustav. The

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

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

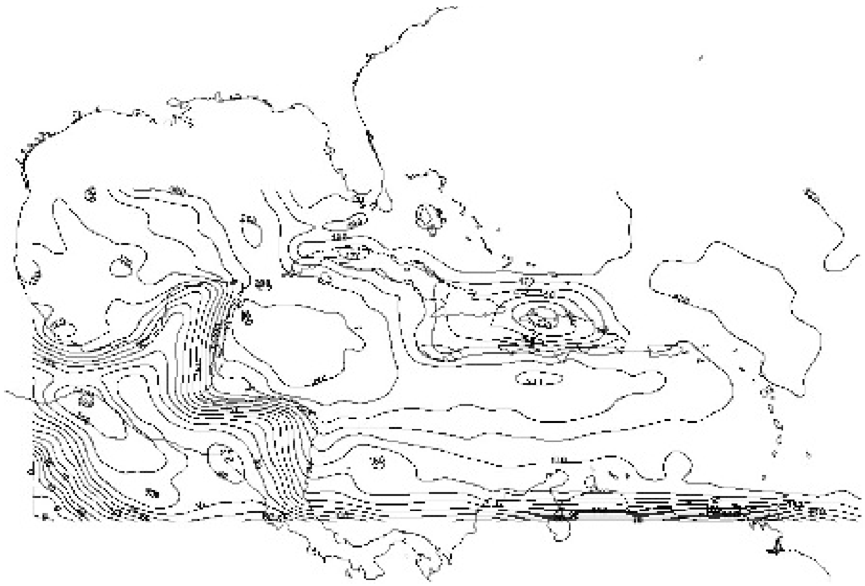
For conventional buildings[19] the proposed Caribbean standard[20] will adopt 700-year return period wind speeds and for important buildings[21] such as hospitals the 1,700-year return period wind speeds will be adopted. (These return periods provide "ultimate" or failure wind speeds.)

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.

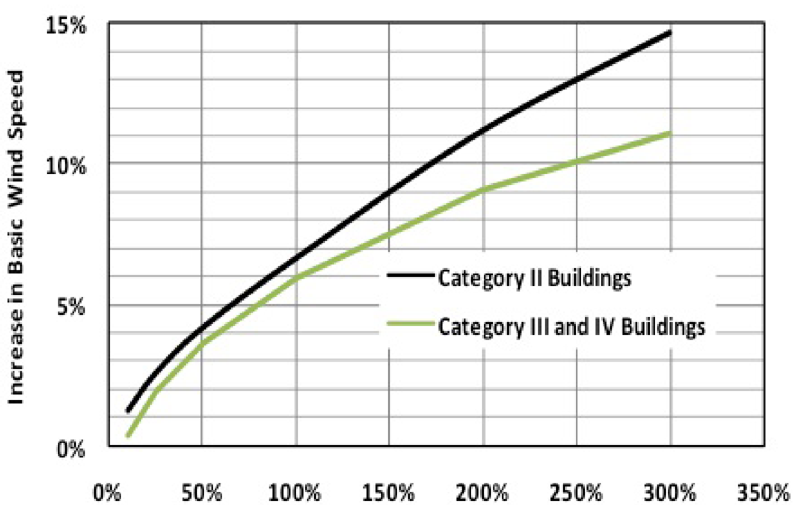
19. Category II in the American Society of Civil Engineers standard ASCE 7.
20. Based on the American Society of Civil Engineers standard ASCE 7.
21. Categories III and IV in the American Society of Civil Engineers standard ASCE 7.
22. Saffir-Simpson scale for hurricanes, not to be confused with the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



Increase in annual frequency of Category 4 and 5 hurricanes

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 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.

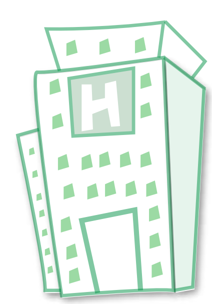
Alternative ways to achieve a sustainable outcome	Detail
Focus on whole life costs rather than only on the initial cost.	Using a standard such as EN ISO 14040 series for life cycle assessment can achieve a sustainable building project.
Adopt a rating system and attempt to gain "points" by following the 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 (ECO_2) 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 $kgCO_2e$ released due to the embodied energy plus any process emissions, such as the CO_2 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 assembly of

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.

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.

Re-use of previously occupied sites

Consulting Engineers Partnership Ltd.

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

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. 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. Design concept determines the level of natural lighting: building shape, orientation, façade openings, maximum depth between opposing facades, placement and transparency of partitions 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 suitable strength,

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.

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.

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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).

Annex 2

A MODEL POLICY FOR SMART HEALTH FACILITIES

Foreword

The Caribbean is a highly hazard-prone region. Hurricanes Gilbert, Ivan and Tomas are stark reminders of how the direct and indirect impact of weather-related disasters can significantly disrupt access to health services and the sector's ability to provide care. However, today it also is becoming increasingly clear that the health sector itself is one of many contributors to the impact of climate change, making it imperative to step up efforts to reduce the environmental footprint and increase the resiliency of its health facilities.

The SMART Health Facilities Initiative is an important step in this direction. The Pan American Health Organization (PAHO) is spearheading this initiative in an effort to ensure that health facilities in the Caribbean are both safe and green.

While there is broad support for the principles of smart health facilities, there are very few actual policies at the national level that call for a shift away from the traditional disaster response model to one that proactively seeks to minimize the health impact of a disaster through climate adaptation, mitigation and preparedness. This publication aims to guide the health sector in developing a policy on SMART health facilities, a policy that forms an integral part of the health agenda of PAHO's Member States; is backed up by earmarked resources in the national budget; and counts on commited leadership at the highest level of government.

We encourage health authorities throughout the Caribbean to begin the process of developing a policy on SMART health facilities, seeking to strike a balance between safety and an environmentally-sustainable setting, thereby reaching for the goal of health facilities that are climate-smart and disaster-resilient, that protect the lives of patients and staff and that continue to function when they are most needed.

Section I: Defining the Problem

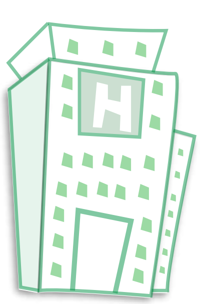
The Vulnerability of Health Facilities to Natural Hazards

According to data provided by PAHO/WHO Member States, 67% of their health facilities are located in disaster risk areas. In the last decade, nearly 24 million people in the Americas lost health care for months, and sometimes years, due to the damage directly related to disasters. On average, a hospital out of service in the Region leaves approximately 200,000 people without health care and the loss of emergency services during disasters sharply reduces the chance to save lives.[1] Many countries in the Caribbean have only one referral hospital.

The vulnerability of health facilities in disaster situations cannot be underestimated. There is a widely held expectation that health facilities are prepared to deal with emergency situations. However, the impact of past earthquakes and hurricanes in the Americas has proven that hospitals and other health facilities are indeed vulnerable. Many have been left unable to function and provide not only emergency services but also routine medical care and public health services. During the San Fernando, California earthquake of 1971, for instance, four hospitals were damaged so severely that they were no longer operational, at the time they were most needed. The majority of deaths occurred in two of the hospitals that collapsed. It was an ironic feature of that earthquake that the most hazardous place to be in San Fernando was in a hospital![2] In the 1985 earthquake in Mexico, 5,826 hospital beds were lost either to the direct impact of the quake or because of the need to evacuate the three largest health institutions in Mexico City—the Social Security Institute's National Medical Center, the Hospital General and the Hospital Juarez. Most striking were the collapse of the obstetric complex (six floors) and the medical residences (eight floors) of the Hospital General and the collapse of the 12-story central tower of the Hospital Juarez. Many patients as well as doctors and nurses, who were among the nation's best prepared to respond to mass casualties, lost their lives.

> The loss of a health care facility is more than a medical issue. It is a larger public health issue, a social and political issue, and an economic issue.
>
> Source: *Safe Hospitals: A Collective Responsibility, a Global Measure of Disaster Reduction*. Pan American Health Organization. Date? 2005?

In addition to the need to build new and retrofit existing health facilities so that they are structurally sound, there is growing recognition of the need to reduce the non-structural vulnerability of existing facilities. This is particularly true in hospitals, where between 85-90% of the facility's value resides in architectural finishes, mechanical and electrical systems and the equipment and supplies contained in the building.[3] A building's non-structural elements include architectural elements (such as ceilings, windows and doors), medical and laboratory equipment, and lifelines (mechanical, electrical and plumbing). Considerations related to the equipment and lifelines focus on their location and whether they are anchored properly. The reinforcement of non-structural elements can significantly reduce hurricane-related risks for the health facility and its occupants.



1. Pan American Health Organization, Progress Report on National and Regional Health Disaster Preparedness and Response, http://www.paho.org/english/gov/cd/CD47-inf4-e.pdf.
2. Pan American Health Organization, Disaster Mitigation Guidelines for Hospitals and Other Health Care Facilities in the Caribbean. http://www.preventionweb.net/files/1948_VL206305.pdf. Accessed on March 7 2013.
3. Pan American Health Organization, Principles of Disaster Mitigation in Health Facilities (Washington, D.C., 2000). http://www1.paho.org/english/ped/mitigation3.pdf.

The Vulnerability of Health Facilities to Climate Change and Variability

Health facilities in the Caribbean are vulnerable to climate change and variability. Climate-related hazards create risks that disrupt the delivery of health services. Extreme weather events (such as storms, floods, drought, etc.) create emergency situations that damage infrastructure, compromising access to critical resources (e.g., food and water) and the safety of patients, visitors and staff. The effects of climate change can increase the risk of some infectious diseases (vector-, water- and food-borne, new and emerging) and worsen air quality.

Climate Change and Reducing Disaster Risk

Climate change considerations can be integrated with disaster risk reduction (DRR) in cities. DRR efforts—already familiar to many—may be used as a platform from which to develop climate change adaptation plans. In practical terms, disaster risk reduction and climate adaptation can be integrated in many instances, although cities should also consider incremental or gradual changes in climate that affect government operations or community life in less immediate and visible ways than conventional disasters.

Source: *Guide to Climate Change Adaptation in Cities*. World Bank, 2011.

Rising sea levels, together with coastal erosion and saltwater intrusion, increase the intensity of tropical storms and hurricanes and disrupt rainfall patterns and the freshwater supply, representing a significant threat to countries in the Caribbean. The anticipated negative health impacts of climate change include worsening of sanitary conditions due to a limited water supply during droughts or contamination of water supplies as a result of floods—conditions that favour the spread of water and vector-borne diseases like malaria, dengue and diarrheal diseases, as well as heat stress in vulnerable groups (such as the elderly).

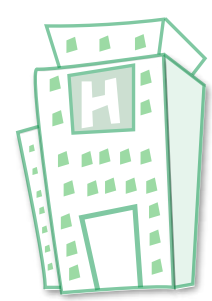
Protecting Health from the Impact of Climate Change

PAHO/WHO has committed to support the efforts of Member States to:

- launch campaigns to raise awareness about climate change.
- reduce the health sector's carbon footprint.
- assess vulnerability to climate change and develop adaptation options based on these assessments.
- prepare health professionals to implement effective adaptation interventions.

Source: Pan American Health Organization. Resolution CD51.R15. 51st Directing Council. 2011. Online at http://bit.ly/17mRMrG.

When health facilities are destroyed or damaged by climate-related disasters, their ability to provide emergency care to victims and ongoing health care for their communities is very limited. It is, however, noteworthy that national and regional climate change policies in the Caribbean have not articulated a suite of responses to the impact of climate change and climate variability on health facilities. Most, if not all, of these policies focus on the impact of climate change on diseases. The Caribbean Regional Framework for Achieving Development Resilient to Climate Change, for instance, only seeks to disseminate information and promote the adop-



tion of practices to prevent and/or reduce exposure to vector-borne diseases resulting from increased temperatures, extreme rainfall and flooding.

As climate variability and climate change are becoming increasingly observable and as science points to an increase in the number of hazard-related events in the Caribbean, it makes good sense to protect these critical facilities at the levels of life protection; investment protection; and operational protection.

Damage to Health Facilities from Disasters

A report prepared by the UN Economic Commission for Latin America and the Caribbean estimates that the Region lost more than US$ 3.12 billion in one 15-year period due to damage to health infrastructure. Indirect losses are estimated to be significantly higher when measuring the increases in health care costs for the millions that have been left without health services for a prolonged period of time.[4]

In the Caribbean, hurricanes have severely damaged hospitals in Dominica, Jamaica, Montserrat, and St. Kitts. Hurricane Gilbert prompted the evacuation of some hospitals in Jamaica in 1988. There are also many examples of Caribbean hospitals and other health facilities that were flooded because they were located in vulnerable areas and/or poorly maintained. Table 1 summarizes the damage caused by Hurricane Tomas to health facilities in St. Lucia.

Table 1: Impact of Hurricane Tomas (2010) on health facilities in Saint Lucia

Region	Population served	% of total population served	Description of damage to facilities	Cost of damage (in USD)
Gros Islet	13,033	8	Damage to the roof of the small operating theatre in Gros Islet Polyclinic.	2,950
Dennery	13,351	8	Unable to function and out of commission. There was damage to the roof and flooding.	4,914,818
Micoud	15,758	10	The interior of the Micoud Health Centre was flooded.	3,460
Vieux Fort	27,092	17	Although the health facility continued to function, as a result of flooding there was no running water for several days, due to a lack of water storage facilities. The fence of the Laborie Health Centre was damaged.	30,000
Soufriere	19,034	12	Soufriere Hospital suffered damage because of a badly leaking roof. Damage to the road infrastructure made access to the facility nearly impossible. Etang Health Centre was badly damaged due to a leaking roof.	314,352 91,352
Anse La Raye	19,957	7	Jachmel Health Centre – damage to the roof.	76,352

4. UN/ECLAC, Economic Impact of Natural Disasters in Health Infrastructure, Report to the International Conference on Vulnerability Reduction in Health Facilities. (Mexico, 1996).

Region	Population served	% of total population served	Description of damage to facilities	Cost of damage (in USD)
Castries	52,788	33	The paediatric ward of the Victoria Hospital suffered damage due to leaking water. The X-Ray department was heavily flooded. The Mental Wellness Centre was blocked by a fallen wall. The Entrepot Health Centre suffered damage to its roof.	192,000
TOTAL				**US$5,642,257**

Source: UNECLAC. Saint Lucia: *Macro socio-economic and environmental assessment of the damage and losses caused by Hurricane Tomas: a geo-environmental disaster; towards resilience*. http://bit.ly/1c0rgDN.

Grenada's Richmond Home for the Elderly

In 2004 Hurricane Ivan badly damaged Grenada's Richmond Home for the Elderly, which also accommodates psychiatric patients. The entire roof of the three-story main building collapsed (the top floor had housed female patients). When this occurred, the Richmond Home had approximately 100 residents, but over the course of the next six months, some 30 residents died. Although one death was the direct result of collapsing structures during the storm, most of the deaths came about as a result of the increased stress faced by the elderly living in unsanitary cramped conditions following what must have been a traumatic event.

Ten months later, Hurricane Emily (a category 1 event) struck Grenada, causing significant damage to the temporary roof that was installed after Hurricane Ivan. When Emily struck, not all of the damage from Hurricane Ivan had been repaired. In particular, the nurses' quarters had not been returned to full use, and the repairs that had been made, were emergency repairs and not intended to withstand future hurricane events.

At this point, there was general agreement that future repairs and retrofitting should aim to meet standards for a geriatric home to retain its functionality for the medium term (5-10 years). These standards should also be suitable for the long-term alternative use of the facility for other institutional purposes after the geriatric home is relocated to a more suitable site.

Source: Pan American Health Organization. http://bit.ly/1flS2Gn. Accessed on May 13 2013.

The Cost of Damage to Health Facilities in the Caribbean

During the past several decades there has been a major increase in the costs of natural disasters across the globe. This is reflected in the huge jump from US$53.6 billion in losses in the 1950's to US$620.6 billion between 2000 and 2008.[5] This global upward trend in losses is no different from what has occurred in the Caribbean, which has also seen a similar pattern in losses from disasters.

For Caribbean countries, the impact of natural hazards is particularly pronounced, given the size of the countries and their GDP. For the purpose of comparison, Hurricane Katrina, which is often used as a benchmark for a significant catastrophic event, accounted for less than a 1% of the

5. Kunreuther, Michel-Kerjan et al. *At War with the Weather: Managing Large-Scale Risks in a New Era of Catastrophes*. (Cambridge, Massachusetts: MIT Press, 2009).

U.S. GDP. On the other hand, Hurricane Ivan (2004) resulted in more than a 200% loss to the GDP of the Cayman Islands and Grenada. It has become clear that beyond the immediate and tragic loss of life, catastrophic events can also unleash a set of circumstances that hinder a government's ability to effectively finance its immediate recovery and longer-term redevelopment processes. This impact has a further reverberating effect on the wider economy of the country, whilst also exacerbating the level of poverty among survivors.

Governments are often challenged with the task of financing post-disaster recovery efforts. Whilst dealing with the fiscal demands of relief operations, such as ensuring the availability of emergency assistance and sourcing funding for shelter, food and medical attention for displaced persons, governments also must contend, simultaneously, with the challenge of mobilising sufficient resources to undertake the medium- to long-term recovery and reconstruction process. This can include tasks that range from clearing debris to restoring critical services. The above expectations are often precariously balanced with the need for governments to subsidise the reconstruction of private assets such as the homes of displaced low-income families, all of which must be accomplished in an environment of dramatically declining revenue.

The Cost of the 2010 Earthquake in Haiti

Damage to all social sectors: US$553.3 million
Damage to the health sector: US$273.7 million
Damage to 49.4% of the social sector.

Thirty of Haiti's 49 hospitals were damaged and the health care system's ability to provide services was permanently affected. During the first eight days following the earthquake, there was no local blood supply available. The buildings housing Haiti's National Centre for Transfusions and the National Blood Safety Program had been destroyed.

Costs Related to Climate Change and Variability

Health facilities use a great deal of energy because of how they are run and the large number of people that use them. In fact, hospitals expend about double the amount of energy per square foot as office buildings. Therefore, health facilities have a significant carbon footprint.[6]

Not only are utility costs high, the resources used to pay for energy consumption could be put to better use to improve health services. In the U.S., it is estimated that health care organisations spend nearly $8.8 billion[7] on energy each year to meet patient needs. Every dollar a non-profit health organisation saves on energy has an impact on operating margins: it is equivalent to increasing revenues by $20 in hospitals or $10 in medical offices.

The cost of energy in the Caribbean is among the most expensive in the world: in 2006 it cost between US$0.24-0.37 per kilowatt hour as compared with US$0.08 per kilowatt hour in the U.S.[8] In the face of this reality, Table 2 describes the challenges faced in Guyana.

6. A carbon footprint is the amount of carbon dioxide created from everyday activities. Carbon dioxide, the most plentiful greenhouse gas, 'traps' the sun's heat and contributes to global climate change.
7. U.S. Energy Information Administration. *Commercial Buildings Energy Consumption Survey*. 2003. Adjusted for inflation to 2008 dollars.
8. Cleantech. *Huge renewable energy potential - but funding and regulatory obstacles*, http://bit.ly/15Pi1EN. Accessed on May 2013.

Table 2: Categorization of Energy Supply in Health Facilities in Guyana

Category	Description	Examples	Typical Loads	Challenges
I. Grid-connected	Connected to the national grid (or similar large grid). Usually a large load.	GPHC, New Amsterdam, Linden, Blood Bank, Reference Lab, Warehouse.	• air conditioning • full service lab • refrigerators • x-ray machine	• Expensive ($0.25-$0.30 per kilowatt hour • Power quality issues • Reliability problems
II. Quasi-Grid	Connected to IPP, or locally-operated grid. Medium loads.	Mahdia and other similar interior district and regional hospitals.	• small laboratory • lighting • radio, computer • refrigerators	• Expensive (more than $3 per kilowatt hour) • Very poor power quality • Not available 24 hours a day
III. No-Grid	No grid electricity available. Remote facilities. Small loads.	Hinterland health clinics and NGO offices.	• lighting • radio • vaccine refrigerator	• Generators are expensive • PV systems have not been sustainable

Source: USAID (2007) Powering Health: Improving energy services at health facilities in Guyana.

Health facilities will achieve multiple gains by integrating disaster risk reduction with low carbon energy use, adaptation and environmental protection. Investing in these efforts has financial and social benefits, including behavioural changes, in addition to those related to health. In light of these issues, PAHO/WHO is working towards the goal of health facilities that are not only safe but also 'green.'

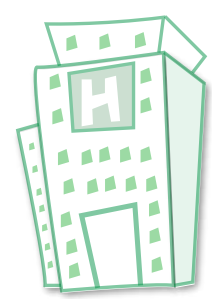
Progress is Being Made

For more than a decade, PAHO/WHO's disaster program has been working to address the safety of health facilities and to promote comprehensive mitigation policies so that losses, such as those experienced at the site of the Juárez Hospital in Mexico and in a host of Caribbean countries, would not occur again.

One of the most widely used tools to achieve this end is the Hospital Safety Index, developed through a lengthy process of dialogue, testing and revision, initially by the Pan American Health Organization's Disaster Mitigation Advisory Group (DiMAG) and later with input from other specialists in Latin America and the Caribbean. The Hospital Safety Index assesses the likelihood that a hospital can remain functional during disaster situations.

When the Hospital Safety Index was used to assess hospitals and health facilities region-wide, one-third of the assessed facilities had a safety score that revealed potential risks for patients, hospital staff, and the facility's ability to function during and after a disaster. 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.

In the Caribbean, the Hospital Safety Index was applied in 45 hospitals and 59 small facilities in St. Kitts and Nevis, Grenada, Montserrat, Saint Vincent and the Grenadines, Anguilla, Dominica and Barbados. Based on the results and recommendations from the evaluation team,



15 facilities have begun to make needed improvements. Preliminary results from the application of the Hospital Safety Index in Bolivia, Ecuador, and Peru suggest that non-structural factors such as architectural features, basic installations, and equipment contribute more to vulnerability than structural factors. The results also point to the importance of having a legal framework for action to reduce vulnerability.[9] The best argument for demonstrating that it is possible to have safe hospitals in the Caribbean is that a few of the countries, with greater vision than actual resources, are actually accomplishing this.

Hospital Safety Index at a Glance

- A rapid, reliable and low-cost diagnostic tool.
- Easy to apply by a trained team of engineers, architects and health professionals.
- Results take into account the safety level of structural, nonstructural and functional components.
- 145 items or areas are assessed.
- Health facilities fall into one of three safety categories: High, Average and Low.

Source: PAHO (2013). http://safehospitals.info/.

The SMART Hospitals Initiative in the Caribbean builds on the Hospital Safety Index, and aims to bridge the gap between environmental performance or climate-proofing and hazard resilience and disaster risk reduction in health facilities. However, the best design criteria for safe hospitals are not always the most beneficial for climate adaptation and mitigation and therefore, it is necessary to develop higher design and construction standards for new hospitals, incorporating lower energy and water use to help withstand expected climate variability and change. Energy efficiency must be combined with disaster resiliency. Countries need to be smart about what is useful, needed and cost effective.

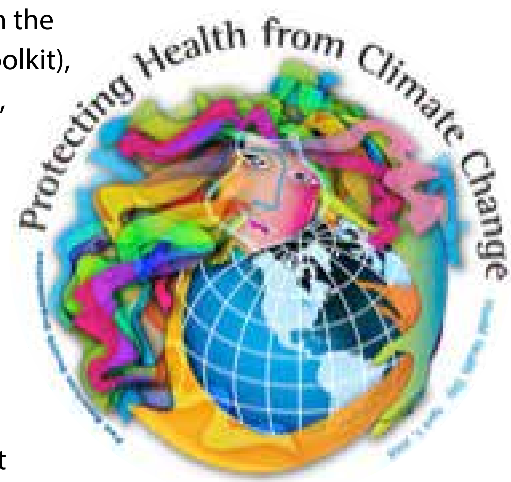
In this context, the construction of safe, disaster-resilient health facilities must take into account the risk of climate change and climate variability and the need for a reduced environmental footprint, with the ultimate goal not only of protecting the lives of patients, staff and other occupants, but also of ensuring that such facilities continue to operate after a disaster. Fortunately, the knowledge of how to build safe hospitals not only exists, but also is readily available.

9. Pan American Health Organization, "New PAHO Tool Measures Hospital Safety," *Disasters: Preparedness and Mitigation in the Americas* (December 2008), http://bit.ly/15sqTTt. Accessed on August 21 2013.

Section II: The Conceptual Framework of the Smart Health Facilities Policy

The policy on SMART Health Facilities builds on established principles and priorities that governments in the Caribbean are using to improve the resilience of these facilities. Most of the plans, values and guidelines fall under the umbrella of the regional Safe Hospitals Initiative, which was endorsed by the Ministers of Health of Latin America and the Caribbean at the 27th Pan American Sanitary Conference in 2007. A number of complementary initiatives is underway to strengthen the goal of disaster-resilient hospitals:

- The PAHO/European Commission (ECHO) initiative 'Caribbean Health Services Resilient to the Impact of Emergencies and Disasters,' which aims to improve the capacity of health services to respond to emergencies. One of the expected results is that all large- and medium-size health facilities in the Caribbean are safer.
- PAHO/WHO and the UN Environment Programme (UNEP) have developed a tool to assess vulnerability and climate adaptation. It provides guidance on conducting assessments of current and future vulnerability and health risks stemming from climate change and policies and programmes that can increase resilience, taking into account the multiple determinants of climate-sensitive health outcomes.
- The SMART Health Care Facility Initiative, which builds on the Caribbean Hospital Safety Index (see SMART Hospitals Toolkit), bridges the gap between environmental performance, climate-proofing, hazard resistance and disaster risk reduction in health facilities. (A higher standard of design and construction as well as energy and water use and service delivery capacity will be established to help withstand expected climate variability and change.) The intended impact of the Smart Health Facility Initiative is to build and/or retrofit climate-smart and disaster-resilient health facilities in the Caribbean. Under this initiative, PAHO is developing a cost-benefit framework to determine the feasibility of making a health facility 'smart.' Two demonstration projects are underway at the Georgetown Hospital in St. Vincent and the Grenadines and the Pogson Medical Centre St. Kitts and Nevis. Both demonstration projects aim to establish an integrated approach to health facility design, featuring both environmentally green and disaster-resilient institutions. The projects' four main target areas include:



World Health Day 2008

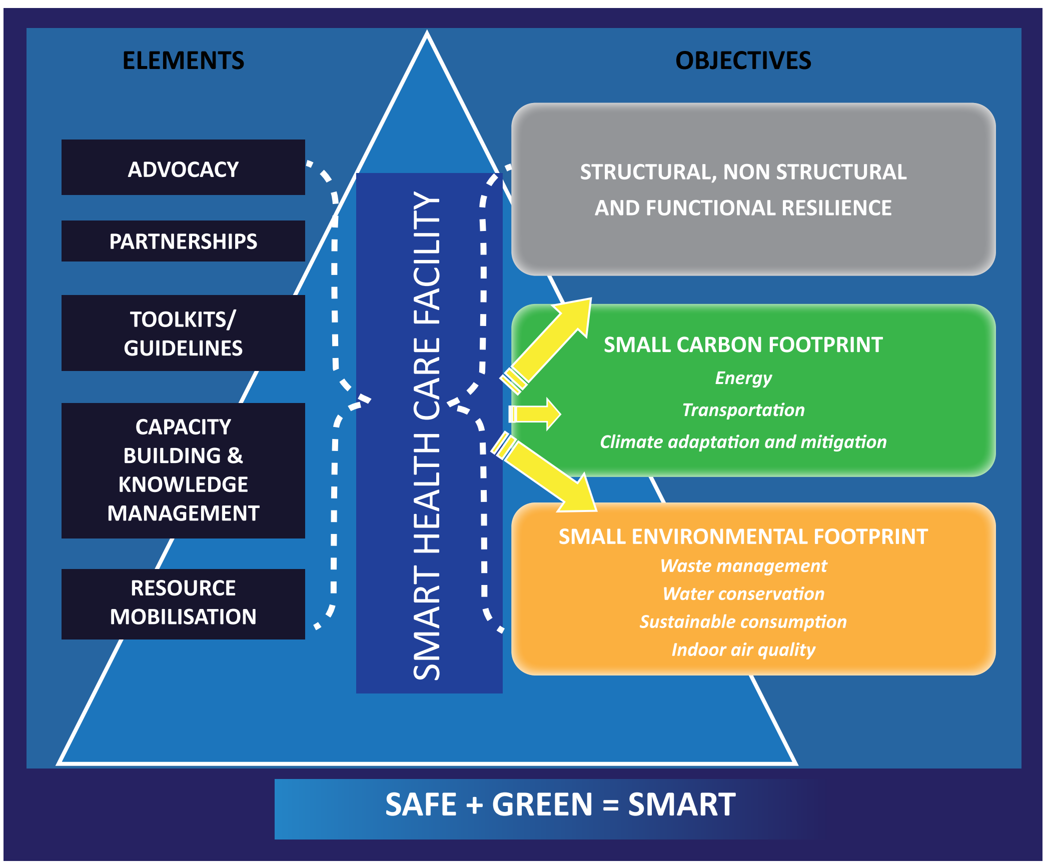
  1. Preparation of an Annex on SMART Health Facilities to accompany national building standards and codes for new facilities.
  2. Development of the 'SMART Hospitals Toolkit' to guide implementation of measures to adapt to climate change and mitigate the impact of disasters in existing health facilities.
  3. Enhancing national capacity to deliver climate-smart health facilities by conducting training workshops and providing advice and support to strengthen policies.

4. Carrying out demonstration projects of SMART health facilities

In the long run, the SMART Health Facilities Initiative is expected to yield benefits, including: cost savings on health, utility bills and travel expenditure; reduced greenhouse gas (GHG) emissions; improved air quality; reduced transmissions of airborne infections and aggravation of respiratory conditions; increased productivity; improved staff and patient satisfaction; improved physical access to hospitals and improved access to safe water. The results of the cited demonstration projects will help define a methodology to guide countries on how to conduct a Cost-Benefit Analysis, which is part of the Toolkit under development.

The conceptual framework of the policy on SMART Health Facilities is built around three principal objectives as shown in Figure 1.

Figure 1: A Conceptual Framework for the SMART Health Facilities Policy



The SMART framework is described as follows:

- A SAFE health facility is structurally, non-structurally and functionally able to withstand the impact of all types of natural hazards and mitigate the impacts associated with climate change and variability.
- A GREEN health facility has a small carbon footprint (through energy efficient operations) and an equally small environmental footprint (through sustainable and sound environmental management practices such as proper waste management; reduced red bag (medical) waste;

increased recycling; water conservation; reduced use of materials that may have toxic effects (PVC, cleaning materials, heavy metals in electronics, pesticides, batteries); green landscaping to reduce water use and manage storm water more sustainably; etc.

- A SMART health facility (safe and green) will protect the lives and health of patients and health workers; has taken measures to reduce the damage to hospital infrastructure and equipment as well as the surrounding environment; continues to function as part of the health network, providing services under emergency conditions; uses scarce resources more efficiently, thereby generating cost savings; and improves strategies to adjust to and cope better with future hazards and climate change.

This framework represents a seamless set of activities and interventions—from preparedness to mitigation; planning to prediction; and response to recovery—all directed towards achieving disaster resilience; adapting to climate change; reducing the carbon footprint; and improving environmental sustainability. Through this ongoing process, Caribbean health facilities, in collaboration with governments and civil society, can plan for and reduce the impact of:

a) **Disasters** - Appropriate actions at all points in the process will lead to greater prevention, mitigation, and climate adaptation measures and strengthen the role of the health facilities' disaster risk management committees.
b) The **environmental footprint** – Appropriate environmentally sound actions include the greening of operations,[11] climate proofing and instituting best practices such as the use of less-toxic personal care (fragrance free, for example) and clinical products; removing metals (mercury, lead, cadmium) from pharmaceuticals; etc.
c) The **carbon footprint** – Actions include energy-efficient equipment and energy conservation, through proper building design, etc.

As noted in Figure 1, this framework will be delivered through: advocacy; partnerships; toolkits and guidelines; training; and resource mobilisation. Chapter 3 on developing a policy on SMART Health Facilities provides more in-depth information about these elements and how they will help to achieve the policy's objectives.

Figure 2 represents the operationalization of the policy on SMART Health Facilities.

11. For example: water conservation; less toxic environmental services and maintenance products (e.g. paints, sealants, finishes; green cleaning chemicals; enhanced recycling programs; lawn and garden care; pest control; and greening of transportation (e.g., post "No Idling" signs at emergency room entrance and loading dock, offer priority parking for car pooling.

Figure 2 - Operationalising the Smart Health Facility Policy

The SMART Health Facilities Initiative represents a paradigm shift—away from the traditional disaster response model to one that proactively seeks to minimize the health impact of a disaster through climate adaptation, mitigation measures (including climate-proofing and reduction of the environmental footprint) and preparedness. Consequently, it is essential that this health policy is incorporated into the Member State's political agenda; that it is backed by earmarked resources in the national budget; and that it has the leadership and support of the highest levels of government.

Section III: A Model for Developing a Policy on Smart Health Facilities

Purpose of the Policy

The policy on SMART Health Facilities provides a platform for integrating initiatives currently underway that seek to make facilities SAFE (structural and non-structural resilience to disasters) and GREEN (a small environmental footprint).

Committing to the following will contribute to making Caribbean health facilities 'SMART':

- Becoming resilient to the risks related to climate change and variability and natural hazards.
- Proper management of critical resources (e.g., pharmaceuticals, food, transportation, medical supplies and equipment) based on climate change considerations.
- Committing to sustainable environmental practices such as water and energy conservation, promoting active transportation, and local food procurement.
- Engaging in ongoing communication, education and awareness to bring about behavioural changes.

Becoming SMART

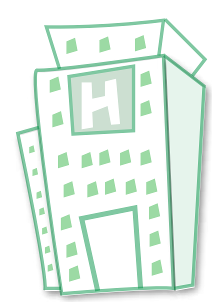
A SMART health facility commits to sustainable practices such as water and energy conservation, active transportation that is environmentally friendly and helps reduce greenhouse gas emissions, and local food procurement. By investing in these areas, health care facilities can reduce operating costs and increase resilience in the community.

Policy Guidelines

The following parameters will guide development of the SMART Health Facilities Policy:

- The policy will be implemented within the framework of existing PAHO and Ministry of Health work programmes.
- The policy does not require renegotiations or amendments to existing strategic partnerships that national Ministries of Health and/or PAHO have with public and private sector agencies, other civil society organisations, and regional and international organisations.
- Although the policy may generate new funding requirements, Ministries may consider reallocating existing sectoral budgets and identifying new funding sources.
- The policy will contribute to the national government's priorities and directives in disaster risk reduction, adaptation to climate change, and sustainable environmental management.
- The policy will have a cost-neutral impact on households.
- The policy will help safeguard health facilities, which are important assets of a country's critical infrastructure, and ultimately contribute to national security.
- The policy may be submitted to the PAHO Directing Council for endorsement.

The SMART Health Facilities Policy is based on a number of PAHO/WHO initiatives taking place nationally, regionally and internationally. Importantly, the policy advances the building of safe and green health facilities; the use of technical guidelines and toolkits that have been tested regionally and internationally; and the application of knowledge and information through advocacy and training for sound decision making.



Components of the Policy on SMART Health Facilities

The policy statement comprises a vision statement, the purpose and the objective. The impact outcome of this policy will be the sustainable development of the Caribbean health sector.

The components of the policy include:

> ### Vision
>
> Enhance health gains from sustainable development investments and decisions in health care.
>
> ### Policy Goal
>
> To ensure that everyone receives safe, effective, high quality health care in structurally and non-structurally safe and green health care facilities.
>
> ### Policy Objective
>
> To build SMART health care facilities that are resilient to disasters and climate change and which are climate resilient and environmentally friendly.

The SMART Health Facilities Policy:

- Is only as effective as the degree to which other areas and sectors, such as operations and maintenance, disaster management organizations, planning, finance, public services and architecture and engineering, are involved in determining the vulnerability of health facilities and addressing these concerns.
- Must adhere, in design and construction, to building codes, fire safety guidelines and other risk-reduction measures.
- Must reduce the non-structural and functional vulnerability of existing facilities through greening and energy-efficient strategies.
- Must enact legislation and earmark financial resources to renovate and retrofit the most critical facilities to increase protection levels and safeguard the health workforce, patients and their families in these facilities.

In consideration of the limited resources available to the health sector in the Caribbean, the long-term costs of mitigating the structural and non-structural vulnerability of health facilities will far outweigh the short-term investment, helping to ensure health facilities continue to function in disaster situations and sustain limited losses of health assets. The use of appropriate energy-efficient and other green technologies and processes can further reduce these costs.

Figure 3 maps the development of a SMART Health Facilities Policy.

> ### Commitment of the Health Sector
>
> The health sector will ensure that its practices, the products it consumes, and the buildings it operates do not harm human health and the environment and are resilient to climate change and hazard events.

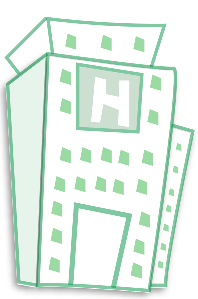
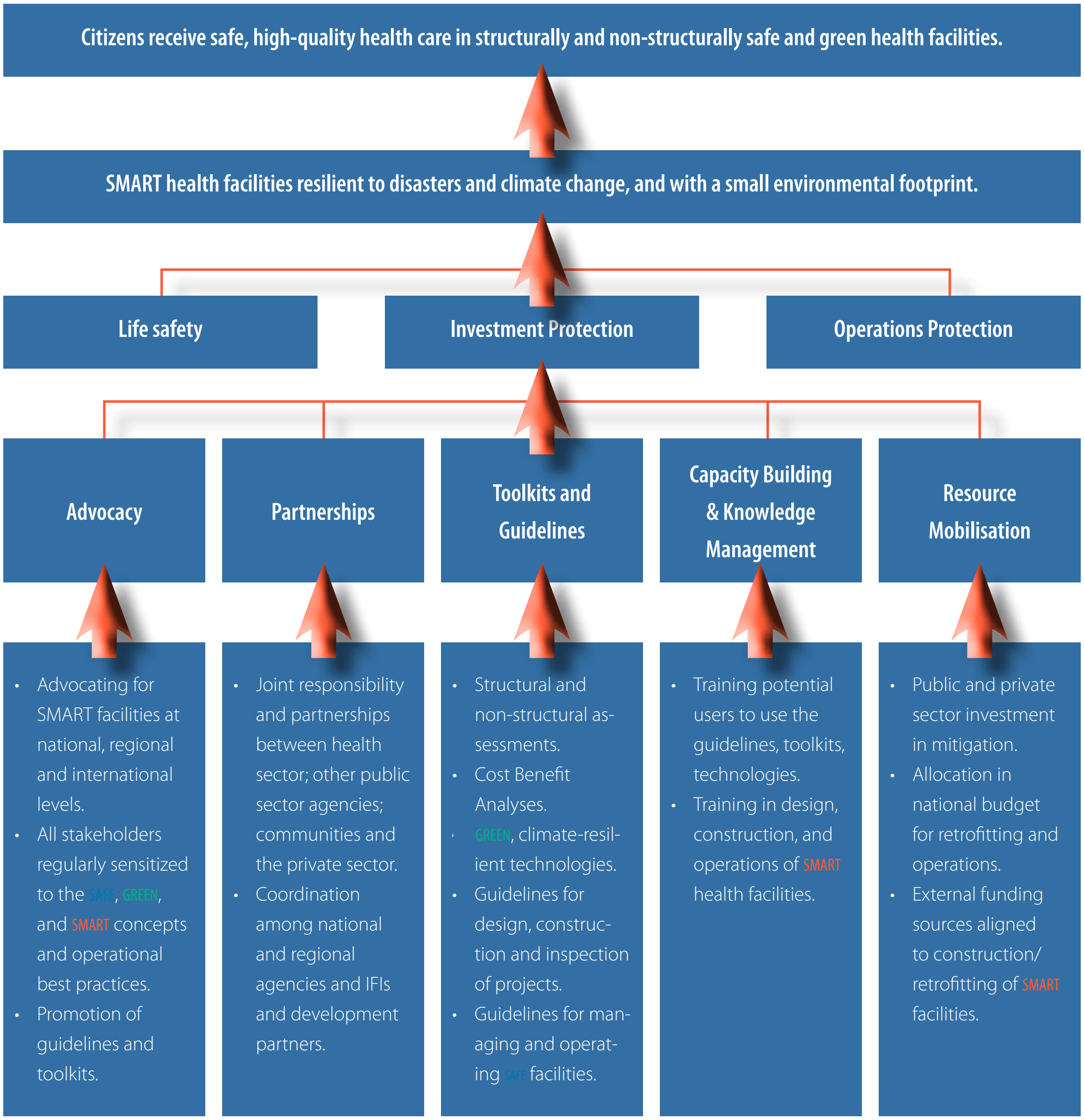


Figure 3: Mapping the SMART Health Care Facility Policy



The Policy's objectives will be achieved through:

a. **Advocacy** – all stakeholders in the health sector, including: policy makers; other public sector agencies; communities; and the private sector are regularly sensitised to the SAFE, GREEN and SMART concepts and operational best practices and over time, become satisfied users of the facilities.

b. **Partnerships** – a SMART health facility is the joint responsibility and outcome of partnerships between the health sector; disaster management offices; other public sector agencies (e.g. planning and public works; environment and sustainable development, etc.); communities in which health facilities are located and the nation in general; the private sector (contractors, engineers, other service providers); and bilateral agencies providing sources of funding.

c. **Toolkits and guidelines** – PAHO has developed a comprehensive suite of tools and guidelines for use by health administrators, technical advisors and other professionals whose responsibilities include the management, design, construction and inspection of health facility projects. National health authorities, planners, and funding institutions must use these guidelines and tools when developing projects for the construction of new health facilities or the retrofitting of existing facilities.

d. **Capacity building and knowledge management** – Just as all stakeholders should be regularly reminded of the need for SMART health facilities, training must be provided regularly to the potential users of the guidelines and tools. Potential targets for training include, among others:

   i. Initiators of health facility construction projects:
      - Public sector (Ministry of Health, Health Services Authorities etc.)
      - Private sector
      - Civil society
      - Municipal governments
      - Ministries of Finance

   ii. Executors and supervisors of health facility construction projects:
      - Ministry of Health; Ministry of Works; Ministry of Finance
      - Government offices or independent agencies in charge of enforcing building standards
      - Subcontractors entrusted with hospital management
      - Subcontractors entrusted with the management, quality control, design and/or execution of the project
      - Private sector

   iii. Financing bodies in charge of funding health facility construction projects:
      - Government
      - Public sector bodies that have identified the need for new facilities
      - Ministry of Health, in tandem with the Ministry of Finance
      - International sources: development banks and bilateral and multi-lateral donors
      - Nongovernmental organizations
      - The private sector (including private banking)

e. **Resource Mobilisation** - The main challenge to mobilising resources for SMART Health Facilities lies in convincing countries of the importance of incorporating prevention and mitigation measures during the allocation of resources for infrastructure investments. One reason is the belief that these measures will significantly increase the cost of the initial investment, thereby affecting eventual profits or health budgets. This reticence on the part of governments and the private sector alike is aggravated when financial resources are scarce or expensive, forcing mitigation projects down the list of priorities. In fact, just the opposite is true: protecting the costly investment demands high safety and performance standards.

   The cost of mitigation measures that increase the structural integrity of a health facility will increase total construction costs by no more than 1-2 percent.[12] If the cost of the non-structural elements (which account for about 80 percent of the total cost of the facility) is added, the

12. Pan American Health Organization, Principles of Disaster Mitigation in Health Facilities, (Washington D.C., 2000). http://www1.paho.org/english/ped/mitigation3.pdf.

incorporation of mitigation measures into the construction of a new health facility accounts for less than 4 percent of the initial investment.[13]

The cost of preventive maintenance is not high if it is considered part of the normal operating budget of a facility.[14] Proper maintenance not only reduces the degradation of the health facility but can also ensure that public services such as water, gas, and electricity, and non-structural components such as detailing, roofs, doorways, etc., continue to function properly during an emergency.

Policy Strategy

The elements of the policy strategy include:

a. Assessing existing hospitals and health facilities in terms of structural, non-structural and functional vulnerability.
b. Advocating for construction of new hospitals or health facilities that can withstand any emergency or disaster.
c. Planning for renovations and retrofitting of existing facilities to ensure their resilience, safety and continuous operations in times of emergency and disaster.
d. Introducing green and climate-resilient technologies and methods that reduce the environmental and carbon footprint, with immediate health and economic benefits.
e. Sensiting all stakeholders, including civil society, to the social and economic significance of safe and green health facilities.

'Greening' Strategies for a SMART Health Facility

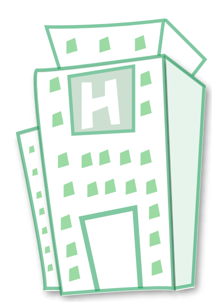
- **Energy efficiency:** Reduce hospital energy consumption and costs through efficiency and conservation measures.
- **Green building design:** Build hospitals that are responsive to local climate conditions and optimized for reduced energy and resource demands.
- **Alternative energy generation:** Produce and/or consume clean, renewable energy onsite to ensure reliable and resilient operation.
- **Transportation:** Patient and community use of public transport; site health facilites to minimize the need for staff and patient transportation.
- **Food:** Provide sustainably grown local food for staff and patients.
- **Waste:** Reduce, reuse, recycle, and compost; employ alternatives to waste incineration.
- **Water:** Conserve water; avoid bottled water when safe alternatives exist.

Implementing the Policy

Implementing the SMART Health Facilities Policy will require, above all, political and financial commitment. It also requires that the Ministries of Health take leadership, by:

a. Assigning a specific entity in each Ministry of Health to develop a disaster risk reduction programme.

13. Pan American Health Organization, Report to the International Conference on Vulnerability Reduction in Health Facilities. (Mexico, 1996).
14. Pan American Health Organization, A World Safe from Natural Disasters: The Journey of Latin America and the Caribbean. (Washington, D.C., 1994). www.paho.org/English/Ped/ws-chapter6.pdf. Accessed on July 27 2013.



b. Including a sub-programme on SMART Health Facilities as part the risk reduction programme.
c. Expanding the mandate of the 'Safe Hospitals' Committee, under the coordination of the Ministry's Disaster Coordinator, to become a SMART Committee.
d. Actively supporting a campaign on SMART Health Facilities:
    i. Involving a variety of partners including (a) stakeholders within and beyond the health sector; (b) national and international financial institutions and (c) other key contributors.
    ii. Sharing and implementing best practices on practical and significant progress towards the SMART Health Facilities Initiative at the country level.
    iii. Encouraging assessment of disaster vulnerability in existing health facilities to develop long-term plans.
d. Ensuring that financing is available to implement, at a minimum, the priority recommendations identified following application of the Hospital Safety Index.
e. Encouraging external agencies that finance the construction of new health facilities to incorporate the principles set out in this policy.
f. Encouraging Ministries of Finance and Public Works to ensure that the cost of a Check Consultant[15] is incorporated into the tender documents.
g. Collaborating with other public and private sector agencies to introduce green and climate-resilient technologies and methods to achieve immediate health and economic benefits in the heath sector.
h. Inserting this policy into other relevant national policies and strategies and, where appropriate, ensuring that it is incorporated into the government's legislative agenda.

At the regional and international level, PAHO will champion the strategy with agencies such as the Caribbean Community Climate Change Centre; the Caribbean Disaster Emergency Management Agency (CDEMA); the Caribbean Community (CARICOM); the Organization of Eastern Caribbean States (OECS); the Caribbean Development Bank; the World Bank; and the Inter-American Development Bank.

The objectives and elements of the Policy on SMART Health Facilities are applicable beyond the health sector. These objectives and elements can be used to make other critical infrastructure, such as schools and tourism plants, 'SMART'. Indeed, the Government of the British Virgin Islands has already applied the tools and guidelines to the educational sector and discussions are now underway to use these same building blocks in the tourism sector and communities.

Monitoring, Evaluation and Reporting

PAHO is currently developing a Toolkit to help achieve SMART health facilities. The guidance document comprises a number of tools that include:

15. A Check Consultant provides an independent technical inspection of plans, calculations, building requirements and all associated works related to planning a new hospital or critical facility. A highly qualified person or team, completely independent of the builders, must perform the inspection. This will improve the detection of errors. The Check Consultant acts as support and does not replace the Contractor's project manager. The Check Consultant(s) in charge of the technical inspection of the project must be engineers or other professionals who have proven experience, broader than that of the project manager, in each of the areas to be monitored. Funding for the Check Consultant should come from the financier of the planned facility. The Check Consultant acts on behalf of the client of the Health Facility (eg., the Ministry of Health) and not the contracting authority and/or the project management.

1. The Hospital Safety Index[16]

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. An Evaluation Team uses a standardized Checklist to assess the level of safety in 145 areas of the hospital. The 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. Periodic application of the Hospital Safety Index can be used to monitor and evaluate the extent to which the health facility is safe.

2. Baseline Assessment Tool (BAT)

The Baseline Assessment Tool was designed to achieve cost savings by reducing the consumption of good and supplies, saving on energy and water costs, increasing efficiency of operations, using resources efficiently, creating favorable working conditions, generating community goodwill, avoiding future liability problems and educating the users of health facilities about the value of caring for the environment.

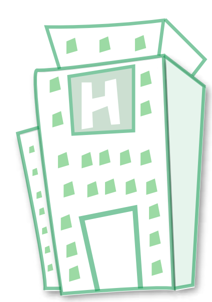
The BAT includes criteria for selecting an appropriate health facility that can be made 'smarter.' This is followed by a Patient/Occupant Satisfaction Survey to determine the satisfaction of patients and staff with: a) the general building; b) air quality; c) ventilation; d) acoustics; and e) lighting. Another section covers the baseline information required to conduct the assessment. The areas covered in the checklist include: energy; water; condition of the property; waste; indoor environmental quality; fire safety and egress; accessibility; and gross floor area. The BAT can be applied periodically to gauge the health facility's progress towards becoming 'smarter.'

3. The GREEN Checklist and Discussion Guide

The GREEN Checklist provides an indication of improvements that Caribbean hospitals and health facilities can make in their daily operations to reduce their environmental and carbon footprint. The Green Checklist identifies areas that can conserve resources, cut costs, increase efficiency in operations and reduce a hospital's carbon emissions.

The GREEN checklist can be used regularly to monitor the impact of the improvements that have been made towards becoming SMART. For example, after introducing energy-efficient measures and technologies, the Energy Audit can be used on an annual basis to determine changes in the how the facility consumes electricity. Similarly, a Water Audit is first performed to deter-

16. The Hospital Safety Index for Small and Medium-Sized Health Facilities, has been adapted for the Caribbean.



mine quantity and patterns of potable water use in the facility. After putting water saving measures in place, the same audit can then be used periodically to determine if water conservation measures have made a difference.

4. Cost-Benefit Analysis

The Cost-Benefit Analysis (CBA) framework is an economic tool used to support decision making, since it provides greater understanding of the impact of alternative courses of action in terms of costs and benefits. It involves comparing the value of SMART Hospital interventions and is designed to assess whether the advantages (benefits) of the project exceed the disadvantages (costs).

A simple monitoring and evaluation framework can be developed, based on the periodic use of these tools. The reporting framework must be reflected and incorporated into ongoing disaster management reporting at the national and regional levels, through the:

- Annual Reports of the National Disaster Organisations; Ministries of Health; Pan American Health Organization;
- Reports on the protection of critical infrastructure and the impact of climate change; reports to CDEMA Caribbean Disaster Management Conference.

Conclusion

Health care facilities in the Caribbean represent a great social value to communities, offering an essential sense of security. Although the social, political and economic justification for maintaining a health facility's ability to function in the aftermath of disasters is strong enough, there is an even stronger justification within the health sector itself. The cost of running hospitals in the Caribbean represents approximately 70% of the budget of the Ministries of Health, with most of the money going to salaries.[17] In remote areas and in small island nations, frequently there is only one facility of this type; if it is not functioning, this represents a 100% loss. Every day the health sector invests large sums of money in building, remodeling or expanding its health infrastructure.

> Health centers in the Cayman Islands were virtually undamaged by Hurricane Ivan's strong winds, torrential rains and storm surge. The behavior of retrofitted facilities in actual disasters, such as the East Point Clinic, confirms that this approach is technically and politically feasible and effective in saving lives and reducing the disruption of essential services. Most of the disruption in retrofitted facilities was due to nonstructural damage and unnecessary evacuation.

When the status of the vulnerability of the health sector to disasters was reviewed in 2004[18] in Nicaragua and Trinidad and Tobago, reports pointed to the fact that low and middle-income countries have demonstrated, through pilot projects, that it is possible to significantly reduce vulnerability to disasters, making health facilities safe, with existing technical and financial resources.

The same is true when it comes to SMART health facilities. For the most part, technical and financial considerations are not standing in the way. Making significant advances towards SMART health facilities will require committed support from other sectors, a strong political commitment and higher international visibility.

The opportunity to draw attention to the importance of incorporating disaster mitigation climate adaptation measures to contribute to the sustainability of these investments cannot be let pass. Countries are encouraged to recognise the importance of formulating a national SMART Health Facilities Policy and incorporating this policy into the national Health Disaster Management Policy.

> Reducing the vulnerability of Caribbean health care facilities is a goal we can achieve.

17. Pan American Health Organization, Report on reducing the impact of disasters in health facilities, (Washington, D.C., 2004). http://www1.paho.org/english/gov/cd/CD45-27-e.pdf.
18. Ibid.

Acronyms

GDP	Gross Domestic Product
UNECLAC	United Nations Economic Commission for Latin America and the Caribbean
USD	United States Dollars
PAHO	Pan American Health Organization
WHO	World Health Organization
USAID	United States Agency for International Development
ECHO	European Commission for Humanitarian Aid and Civil Protection
GHG	Greenhouse gasses
CARICOM	Caribbean Community
OECS	Organisation of Eastern Caribbean States
CDB	Caribbean Development Bank
IADB	Inter American Development Bank
UK	United Kingdom

Glossary

Disaster

A serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources.

Disaster Management

A systematic process that includes planning, organization, management, and control of all disaster-related activities. Disaster management is achieved through prevention, mitigation, preparedness, response, rehabilitation, and reconstruction activities.

Disaster Risk Management

The systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards.

Disaster Risk Reduction

The concept and practice of reducing disaster risks through systematic efforts to analyse and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.

Emergency

The affected community generally has the resources to respond to an emergency.

Hazard

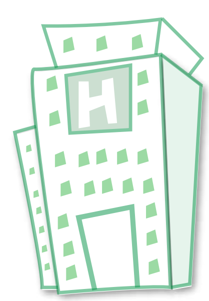
A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Mitigation

Activities that aim to lessen the likelihood of damage resulting from hazards. Mitigation of damage is achieved by reducing the hazards, vulnerability, or both. In general, one cannot mitigate natural hazards such as earthquakes and hurricanes.

National Disaster Organisation (NDO)

The NDO in this document refers to the national organizational structure of agencies linked for the purpose of attending to the legal, institutional and operational aspects of disaster preven-



tion and mitigation, preparedness and response and recovery and rehabilitation. The NDO is generally headed by the Governor, Prime Minister or Head of government in the respective country.

Non-structural elements

Elements that do not form part of the support system of the structure. These include architectural elements (such as cladding, interior partitions, ceilings), equipment (such as industrial, medical, and laboratory equipment and furnishings), and systems that are essential for the facility's operation (such as power system, water distribution and drainage, heating and cooling systems, staircases, etc.).

Preparedness

Actions and measures taken to increase the capacity to effectively anticipate, respond to, and recover from damage caused by adverse events. Preparedness is achieved by developing disaster response plans, training concerned personnel, and establishing necessary resources to carry out response activities.

Prevention

Actions aimed at avoiding damage as a consequence of adverse phenomena. Prevention is achieved by eliminating the hazard, the vulnerability, or both.

Public Awareness

The extent of common knowledge about disaster risks, the factors that lead to disasters and the actions that can be taken individually and collectively to reduce exposure and vulnerability to hazards.

Reconstruction

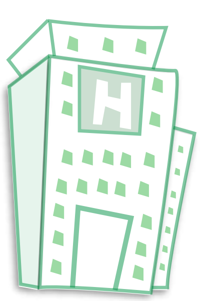
Complete repair of physical, social, and economic damage to a level of safety that is higher than existed prior to an event. Reconstruction incorporates disaster risk reduction measures when restoring damaged infrastructure, systems, and services.

Rehabilitation

Provisional or temporary restoration of essential services (lifelines) in a community affected by a disaster. Rehabilitation is achieved by providing services at pre-disaster levels.

Relationship between risk, hazard, and vulnerability

Risk is the result of the interaction of hazard and vulnerability. This is a dynamic and complex relationship that changes according to the probability of an adverse event occurring at a given time and place with a given magnitude, intensity, and duration, and the predisposition of people, infrastructure, services and goods to be affected by said phenomenon. This relationship can be expressed in the formula $R = H \times V$, where R is risk, H is hazard, and V is vulnerability.



Response

The provision of emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected.

Risk

Probability of social, environmental, and economic damage occurring in a specific community and in a given period of time with a magnitude, intensity, cost, and duration determined by the interaction between hazard and vulnerability.

SAFE Hospital

A health services facility that remains accessible, is able to function at full capacity, and can depend on its own infrastructure during and after an adverse event.

Structural components

Supporting or load bearing elements of a building, including the columns, beams, load bearing walls, foundations, slabs, etc.

Vulnerability

The risk factor for a person, object, or system exposed to a hazard. This corresponds to the predisposition or level of susceptibility to damage resulting from that hazard.

Annex 3

GREEN CHECKLIST AND FIELD GUIDE

Green Checklist

Name of Facility:		Assessment Date:	
Name of Assessors:			
Brief Summary of Green Assessment:			

INSTRUCTIONS: INSERT THE NUMBER "1" INTO THE ANSWER CELL FOR EACH QUESTION TO CALCULATE THE GREEN SCORE. INSERT COMMENTS.

Cells highlighted in Yellow are critical standard questions, which must be met by the facility in order for it to be certified as Green.

Theme	Title		Question/Intent	Answer			Comments	Question Weight	Score achieved	Contribution To Total Points	Institutional type (Referral Hospital, District Healthcare, Poly Clinic, Health Center, Nursing Home, Psychiatric Hospital)						Critical Standard
				NA	YES	NO					RH	DH	PC	HC	NH	PH	
1. Water	1.1 Water Conservation Planning	1	Does the facility implement a water conservation plan? (please provide copy of plan)					1	0	1	X	X	X	X	X	X	X
			Is plan updated regularly?					1	0	1	X	X	X	X	X	X	
		2	Do you educate and involve staff in water conservation?					2	0	2	X	X	X	X	X	X	
		3	Do you have water meters throughout the facility (please provide meter readings)					2	0	2	X	X	X	X	X	X	X
		4	Are drawings available that show all water using sources (bathrooms, sinks, washing machines, HVAC, cooling, sterilizers)? Please provide copies to evaluators.					2	0	2	X	X	X	X	X	X	
	1.2 Water Efficiency	5	Are low-volume water fixtures installed throughout the facility?					3	0	3	X	X	X	X	X	X	X
		6	Do you actively detect leaks...					1	0	1	X	X	X	X	X	X	
			and repair them immediately?					1	0	1	X	X	X	X	X	X	
		7	Does the facility use water efficient washing machines and dishwashers?					2	0	2	X	X	X	X	X	X	
		8	Do you use water efficient sterilizers?					2	0	2	X	X	X	X	X	X	X
		9	Do you recycle steam condensate?					2	0	2	X						
		10	Do you have a rainwater catchment system?					2	0	2	X	X	X	X	X	X	X
			Does it include anti-mosquito breeding measures?					1	0	1	X	X	X	X	X	X	X
		11	Is vehicular fleet washed only when necessary?					1	0	1	X	X	X	X	X	X	
		12	Do maintenance personnel sweep instead of hosing down driveways, sidewalks and parking lots?					2	0	2	X	X	X	X	X	X	
		13	Do you practice water-efficient landscaping (Xeriscaping)?					2	0	2	X	X	X	X	X	X	
	1.3 Wastewater	14	Is used water treated and reclaimed?					2	0	2	X	X	X	X	X	X	
POINTS ACHIEVED IN SECTION 1 =								0									
Maximum Points Achievable in Section 1 (includes referral Hospitals) = 29. **ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =**								29									

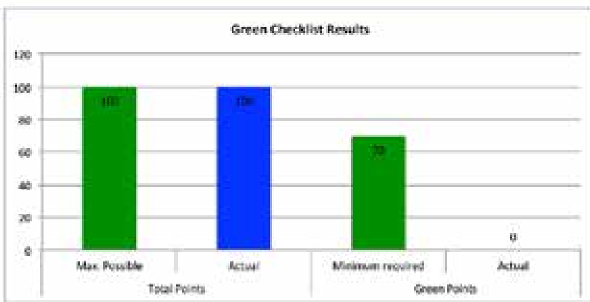
Green Checklist (cont.)

Theme	Title	#	Question/Intent	Answer: NA	Answer: YES	Answer: NO	Comments	Question Weight	Score achieved	Contribution To Total Points	Institutional type (Referral Hospital, District Healthcare, Poly Clinic; Health Center; Nursing Home; Psychiatric Hospital): RH	DH	PC	HC	NH	PH	Critical Standard
2. Energy	2.1 Energy Audit	15	Does the facility implement an energy conservation plan? (please provide a copy of the plan)					3	0	3	X	X	X	X	X	X	X
			Is plan updated regularly?					1	0	1							
		16	Has an energy audit been carried out in the past 5 years? If so, please provide a copy to the evaluators					4	0	4	X	X	X	X	X	X	X
	2.2 Renewable Energy	17	Do you use solar voltaic panels or other type of renewable energy such as wind?					4	0	4	X	X	X	X	X	X	
		18	Do you use solar water heaters?					4	0	4	X	X	X	X	X	X	X
	2.3 Energy Efficiency	19	Do you use low energy lighting systems (LED)?					3	0	3	X	X	X	X	X	X	
		20	Do you use high energy efficient HVAC systems and Inverter type AC Split systems?					3	0	3	X	X	X	X	X	X	
		21	Are equipment and appliances energy-efficient rated (US/EU standards)?					3	0	3	X	X	X	X	X	X	
		22	Do you utilize daylight to ensure adequate lighting in work areas while eliminating direct sunlight?					3	0	3	X	X	X	X	X	X	
		23	Does the facility have light sensors and occupancy sensors in staff and patient areas?					2	0	2	X	X	X	X	X	X	
			POINTS ACHIEVED IN SECTION 2 =					0									
			Maximum Points Achievable in Section 2 (includes referral Hospitals) = 30. ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =					30									
3. Atmosphere	3.1 Refrigerants	24	Have you replaced (or phased out) any devices that contain chlorofluorocarbons (CFC)?					3	0	3	X	X	X	X	X	X	
		25	Is your equipment serviced by a professional at least annually to reduce leakage/release into the atmosphere?					3	0	3	X	X	X	X	X	X	
			POINTS ACHIEVED IN SECTION 3 =					0									
			Maximum Points Achievable in Section 3 (includes referral Hospitals) = 6. ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =					6									
4. Indoor Environmental Quality	4.1 Tobacco Smoke	26	Is the facility a smoke free environment and clearly indicated as such?					2	0	2	X	X	X	X	X	X	X
	4.2 Ventilation	27	Is there adequate ventilation (windows and doors) that takes full advantage of the prevailing North-East Trade Winds?					3	0	3	X	X	X	X	X	X	
		28	Is air quality (Temperature and humidity) assessed regularly? Please provide report/results to the evaluators.					2	0	2	X	X	X	X	X	X	
	4.3 Dust/Particulate Control	29	Are entryway grills or mats able to capture dirt and particulates brought in from outside the facility?					1	0	1	X	X	X	X	X	X	
			POINTS ACHIEVED IN SECTION 4 =					0									
			Maximum Points Achievable in Section 3 (includes referral Hospitals) = 8. ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =					8									
Theme	Title		Question/Intent	Answer: NA	Answer: YES	Answer: NO	Comments	Question Weight	Score achieved	Contribution To Total Points	Institutional type (Referral Hospital, District Healthcare, Poly Clinic; Health Center; Nursing Home; Psychiatric Hospital): RH	DH	PC	HC	NH	PH	Critical Standard
5. Hazardous Materials	5.1 Mercury Elimination	30	Have you replaced or phased out mercury-containing medical devices, substances and reagents?					3	0	3	X	X	X	X	X	X	X
	5.2 Pest Control	31	Does the facility apply an Integrated Pest Management program, with minimal use and safe application of hazardous chemicals applied by a trained professional on a regular basis? Please provide report/visit log to evaluators					2	0	2	X	X	X	X	X	X	
			POINTS ACHIEVED IN SECTION 5 =					0									
			Maximum Points Achievable in Section 5 (includes referral Hospitals) = 5. ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =					5									
6. Pharmaceuticals	6.1 Pharmaceutical Minimization	32	Does the facility have established procedures for procuring,					1	0	1	X	X	X	X	X	X	X
			storing,					1	0	1	X	X	X	X	X	X	
			dispensing,					1	0	1	X	X	X	X	X	X	
			and proper disposal of pharmaceuticals?					1	0	1	X	X	X	X	X	X	
			POINTS ACHIEVED IN SECTION 6 =					0									
			Maximum Points Achievable in Section 6 (includes referral Hospitals) = 4. ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =					4									
7. Food Services	7.1 Local/Regional Foods	33	Do you procure food from local sources?					3	0	3	X	X	X	X	X	X	X
		34	Have you established ways to reduce food waste?					3	0	3	X	X	X	X	X	X	
			POINTS ACHIEVED IN SECTION 7 =					0									
			Maximum Points Achievable in Section 7 (includes referral Hospitals) = 6. ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =					6									

Green Checklist (cont.)

8 Solid and Infectious Waste Managment	8.1 Waste Minimization	35	Do you practice waste minimization at source including pharmaceuticals?					3	0	3	X	X	X	X	X	X	
	8.2 Infectious Waste	36	Have you procedures and established practices to separate medical from non medical waste?					3	0	3	X	X	X	X	X	X	X
	8.3 Reduce, Reuse, Recycle	37	Do you use biodegradable products like paper, cardboard and plant-based products instead of plastics and Styrofoam?					3	0	3	X	X	X	X	X	X	
		38	Do you recycle wastes, including plastic; composting biodegradables; donating food waste to farmers?					3	0	3	X	X	X	X	X	X	

POINTS ACHIEVED IN SECTION 8 =	0
Maximum Points Achievable in Section 8 (includes referral Hospitals) = 12. **ACTUAL TOTAL POINTS BASED ON APPLICABLE QUESTIONS =**	**12**
TOTAL MAXIMUM POINTS AVAILABLE = 100. **ACTUAL TOTAL MAXIMUM POINTS BASED ON APPLICABLE QUESTIONS =**	100
TOTAL POINTS ACHIEVED	**0**
Facility can only be certified GREEN if all critical criteria have been met. Have all critical standards been met:	**NO, some standards not met, Facility is not GREEN**
MINIMUM TOTAL POINTS NEEDED FOR CERTIFICATION (MINIMUM = 70%) =	70
ACTUAL % RATING ACHIEVED FOR THIS FACILITY = Total Actual Points Achieved / Actual Total Maximum Points =	**0%**



Field Guide for Application of the Green Checklist

The Smart Hospitals Toolkit helps existing hospitals identify and implement low-cost adaptation measures. 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 operations of the facility, it is essential to identify low-cost (often non-structural) measures that can be easily implemented to reduce consumption.

The Green Checklist developed as part of the SMART Toolkit outlines feasible areas and applies to planned renovation projects, which are an ideal opportunity to introduce 'smart' measures. It is also suitable for application to new health facility construction to help guide planning and development. The Baseline Assessment Tool (BAT) is used in conjunction with the Green Checklist to gather detailed information related to water and energy use data, indoor environmental quality, architectural and non-structural features, so that feasible upgrades can be identified and to guide development of the Scope of Works. Additionally, information contained in the BAT can be compared with after-retrofit conditions to highlight improvements. Structural deficiencies are dealt with separately.

The Green Guide contains a Green Checklist, comprised of a series of questions divided into the categories: Water, Energy, Atmosphere, Indoor Environmental Quality, Hazardous Materials, Pharmaceuticals, Food Services, Solid and Infections Waste Management. The answer to each question—'Yes', 'No', or 'Not Applicable' (N/A)—is assigned a weight. Points are awarded to 'Yes' answers only and there are no partial points. If the answer to a question is unknown, a 'No' should be recorded. A maximum score is 98 points for medium and small facilities; for referral hospitals, the maximum score is 100 points.

Questions that are not applicable should not be included in the Maximum Points Achievable tally. Certification is calculated based on the Maximum Points Achievable and the points obtained; i.e. questions that do not apply to the facility should be excluded from the Maximum Points Achievable.

Critical standards are highlighted in yellow throughout the Checklist and marked with an 'X' in the last column. Critical standards must be met in order for a healthcare facility to be certified/recognized as 'green'. If any of these critical standards are not met the facility cannot be certified. The weighting is as follows:

- A total of 69 to 79 points (70-80%) are required for 'C' certification/rating;
- A total of 80 to 89 points (81-90%) are required for 'B' certification/rating;
- A total of 90 to 98 points (91-100%) (100 for Referral Hospitals) are required for 'A' certification/rating.

The type of facility that the questions apply to include: Referral Hospital (RH); District Healthcare (DH); PolyClinic (PC); Health Center (HC); Nursing Home (NH); and Psychiatric Hospital PH). These are also indicated with an 'X'.

The following table provides a brief explanation/clarification for some of the questions in the checklist.

Theme	Question #	Explanation/Clarification
Water	1	A Water Conservation Plan is a written document that describes the existing conditions at the facility as it pertains to water use, sets goals for water use reduction and provides details on how the goals are to be achieved. A program for monitoring water usage reduction after the plan is implemented is also included. Refer to Section 1 of the Discussion Guide for links to templates, etc.
	2	An important part of reducing water use is to educate staff and patients/residents and visitors. This can be achieved through posters in the facility, reminders posted on bathroom walls, next to faucets, in kitchens, etc
	3	In order to determine water usage and to assess the improvements made by upgrades it is important that a functional meter or meters are installed at the facility. If there are multiple meters to different buildings on the compound please gather information for all for at least 2 years.
	4	Overall site plans are necessary; upgrades cannot be made without site plans. Site drawings showing the location of water using features will be very useful.
	5	Low volume water fixtures are generally newer and labeled as such. They include low volume shower heads, low volume and dual flush toilets; flow controlled faucets, motion-activated faucets, touch-activated faucets, etc.
	6	Regular inspections of plumbing lines, fixtures and faucets can detect leaks as well as comparing waters bills. Once a leak is detected, is it repaired within a day or two at the most.
	7	Efficient appliances are widely available and are labeled as such. Water and energy efficient front loaders recommended.
	8	Steam condensate is generated by cooling towers used in large cooling systems. Condensate can be reused for other applications.
	12	Hosing down driveways, parking lots, etc. wastes water; however, there is a trade off as sweeping can raise dust; it is anticipated that maintenance personnel will exercise some discretion when sweeping on a windy day.
	13	Xeriscaping is a landscaping technique that utilizes local plants species that are adapted to the climatic conditions and which require little or no water/irrigation.
	14	Effluent from sewage treatment systems or septic tanks can be reused for irrigation.

Theme	Question #	Explanation/Clarification
Energy	15	An Energy Conservation Plan is a written document that describes the existing conditions at the facility as it pertains to energy use, sets goals for reduced consumption and provides details on how the goals are to be achieved. A program for monitoring usage after the plan is implemented should also be included to monitor progress. Refer to Section 2 of the Discussion Guide for links to templates, etc.
	19	Low energy lighting systems consists of LED bulbs which are the most efficient bulbs available o the market currently.
	20	Efficient HVAC and air conditioning units have Energy Efficiency Ratios (EER) or Seasonal Energy Efficiency Ratios (SEER) of 13 or higher. Only newer units will have this rating and it may be in manuals and other documents and not on the unit itself.
	21	Energy efficient appliances and equipment are generally labeled to US or European standards. Only newer units will be rated.
	22	Utilizing daylight will lessen or eliminate the need for lighting during the day time. Windows, door, skylights and other architectural features such as light shelves can help light get further into a facility. It is important that light is allowed into a building not direct sunlight.
Atmosphere	24 & 25	Chlorofluorocarbons, used in the past in refrigerants, are known to damage the ozone layer. There manufacture has since been phased out and replaced with other substances; however, some of these substances are known to contribute significantly to the greenhouse gas effect. A list of refrigerants and their global warming potential (GWP) and ozone depleting potential (ODP) is provided in Section 3 of the Discussion Guide. It is recommended that a trained professional service all equipment that utilizes refrigerants to minimize leakage.
Indoor Environmental Quality	27 & 28	The Carbon Dioxide, temperature and humidity of a facility are important as it relates to worker and patient comfort. Making use of natural ventilation will help reduce the need for mechanical ventilation such as fans and air conditioning units.
Hazardous Materials	30	Mercury is a hazardous substance and devices such as older blood pressure monitors and thermometers need to be phased out. Additionally, fluorescent light bulbs contain mercury and should never be handled without gloves when they break.
	31	Integrated Pest Management eliminates the food source of pests as a means of control and utilizes as little chemicals as possible. Trained professionals are utilized.
Pharmaceuticals	32	Disposal is an important issue that needs to be addressed. Pharmaceuticals should not be disposed of in landfills or dumped down drains. Collecting and returning to manufacturer would be ideal.
Local/Regional Foods	33	Local food refers to meats, vegetables, provisions, legumes, spices, fruits, etc.
	34	Ways to reduce food waste include working with a meal plan.
Solid and Infectious Waste Management	35	Waste minimization includes double-sided printing, not ordering too much so that some material expires and has to be disposed, ordering supplies such as paper in bulk to reduce packaging, etc.
		If composting organic waste s not appropriate or allowed, donating discarded food to farmers is an excellent way of reducing solid waste generation.

Annex 4

COST-EFFECTIVENESS ANALYSIS: Users' Guide for Applying the Retrofitting Economic Support Tool (REST)

Introduction

To aid the decision-making process about which healthcare facilities to retrofit, the Department of Health Policy and Management at Florida International University has developed a Retrofitting Economic Support Tool (REST). REST is designed to provide a simple and easy-to-interpret cost-effectiveness analysis (CEA) to support decision-making in retrofitting healthcare facilities to meet consensus SMART standards. REST is not designed to be used as a stand-alone program evaluation tool. The REST tool is an Annex of the Smart Hospitals Toolkit (2016), developed by the Pan American Health Organization.

How to use the REST report to support decisions

The REST report presents:

- a CEA graph to identify the healthcare facilities that are more cost-effective to retrofit.
- a CEA table summarizing the source of costs, savings and Quality-Adjusted Life Years (QALYs) for each healthcare facility.

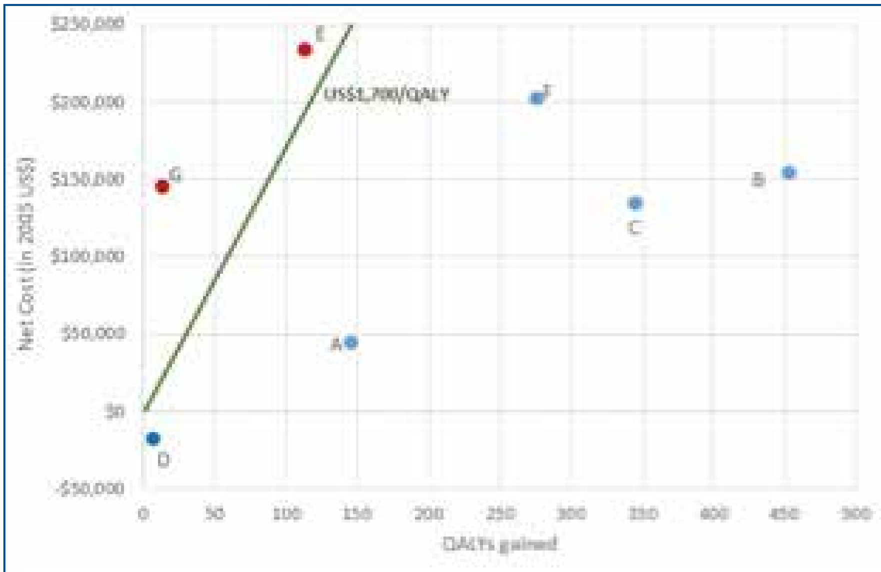
See samples of the graph and table below.

Definition of Key Terms

- ***Smart Healthcare Facility:*** A healthcare facility is considered SMART when it has structural and operational designs that improves safety and makes the facility more energy efficient and green compliant. The SMART initiative is broad and covers facility upgrades that make buildings and operations more safety-resilient and environmentally-friendly.
- ***Quality-Adjusted Life Year (QALY):*** This is a utility measure of health status that combines quantity and quality of life over a period of a year. A QALY equal to 1 is equivalent to one year of life in perfect health. A QALY lower than 1 implies either a quantity of life lower than a year or a quality of life less than perfect health, or a combination of both. QALYs can be zero (death) or even negative when there is extreme suffering (quality of life considered worse than death).
- ***Benefits:*** This measures the lives and injuries avoided (in quality-adjusted life years) during the considered disasters after retrofitting. Total benefit over a 20-year period is calculated using a 3% annual discount rate. Notice that benefit estimates in the table do not include benefits due to other reasons, such as the savings defined in the bullet point below.
- ***Savings:*** This measures expected annual savings (in dollars) due to reduced building damage from the considered disasters and reduced energy and water consumption after retrofitting. The savings due to reduced building damage from the disasters incorporate (1) the savings given a disaster and, (2) the probability of that disaster. The savings may appear small if the likelihood of that hazard event is small. The total savings over a 20-year period is calculated using a 3% annual discount rate.
- ***Costs:*** This measures all retrofitting costs (in dollars) spent to improve the facility's safety and to make the facility more 'green.' Costs of items that have no impact on either safety or green improvement are excluded.
- ***Net Costs:*** This equals the total costs minus the total savings (not including lives or injuries avoided). A negative net cost means the savings due to retrofitting are greater than what it costs, which is a favorable outcome. Facilities with negative net costs are always recommended.
- ***Cost-Effectiveness Analysis (CEA):*** This assesses the net costs and QALYs saved when a healthcare facility is retrofitted versus not retrofitted.
- ***Incremental Cost-Effectiveness Ratio (ICER):*** This measures the net costs paid for one QALY gained. It equals the net costs divided by total QALYs (or benefits defined above). The higher the number is, the greater the cost per QALY.
- ***Return on Investment (ROI):*** This measures the return in dollars per $1 invested. It equals the total savings divided by the total costs. Since the savings, as defined above, do not include lives or injuries avoided, likewise the ROI estimates do not include lives or injuries avoided. Facilities with an ROI greater than 1, meaning every $1 invested results in more than $1 in return, are always preferred. Their net costs, in this case, would also be negative. Retrofitting facilities with an ROI less than 1 would generate a loss in monetary terms.
- ***Gross Domestic Product (GDP) Threshold:*** The GDP threshold represents the value of one year of production of an average healthy person as measured by the per capita GDP. This threshold represents the amount one would like to pay for one QALY gained.

The box defines key terms that are important for understanding the REST report.

Sample Cost-Effectiveness Graph



This graph presents QALYs gained on the x-axis and net costs (US$) on the y-axis. We recommend considering the following principles when making decisions.

1. **Retrofitting projects that produce savings (negative net costs) are always recommended.** For facilities whose net costs are negative (below the x-axis in the figure above) we recommend retrofitting. For example, facility D has a net negative cost (savings) as shown in the graph.
2. **Facilities that do not meet a country's threshold for the net economic value per QALY (GDP threshold) should not be retrofitted.** In the CEA graph, a green line has been inserted to represent the threshold. A GDP threshold is country-specific. Facilities to the left of the GDP threshold (represented with red dots) are not recommended. In the graph, these are facilities E and G. The facilities to the right of the GDP threshold (represented with blue dots) could be considered for selection (facilities A, B, C, D and F). If the budget allows, all facilities to the right of the GDP threshold could be retrofitted. Typically, budgets constrain our choices and therefore we suggest applying a third principle.
3. **With competing investment decisions, choose retrofitting facilities that are more cost-effective relative to alternative projects.** Among retrofitting projects with the same cost, those that produce more QALYs will be preferred. Among those that produce the same QALYs, those that cost less will be preferred. As shown in the CEA graph, retrofitting facility C is more cost-effective than retrofitting facility F because it produces more QALYs at a lower cost. Based on this criteria, retrofitting facilities D, A, C and B would be cost-effective.

Sample Cost-Effectiveness Table

The REST generates a table that summarizes cost-effectiveness metrics of the facilities under consideration. A sample output table is presented below. We draw particular attention to the last two rows of the table, where facilities are ranked based on their ROI and ICER.

If we look at ICER, facility D is also the most preferred one. Because facility D's costs are less than savings, it has negative ICER. It means we do not pay but actually save $2,621.33 for every QALY gained, which is always favorable. All other facilities have positive ICERs, which are much more common than negative ones. Facility A is the second most favorable facility, since it costs less than the rest of the facilities for each QALY gained. The least favorable facility is facility G because it has the highest costs ($11,147.23) for one QALY gained.

If we look at the ROI among the seven facilities, facility D has the highest ROI. For every dollar spent, facility D has $1.22 as a return, due to savings from making the facility more 'safe and green.' All other facilities have returns of less than $1. Facility A has the second highest ROI ($0.65 return per $1 spent). The least favorable is facility G, with the lowest ROI ($0.07) among all facilities.

The following considerations are important for users of the following sample cost-effectiveness table.

- The annual estimate of benefits does not include the safety benefits due to cyclones, since the impact of cyclones on injuries and deaths are negligible compared to earthquakes.
- The costs of items that have no impact on safety improvement are not included in the cost estimates.
- The ROI estimates include savings measured by dollars but not benefits on lives or injuries avoided. The estimates mean the return in dollars per $1 investment.

Sample Cost-Effectiveness Table

Hospital Name	A	B	C	D	E	F	G
BENEFITS measured by dollars ($)							
Annual estimates							
Safety - Earthquake	$213.4	$111.7	$178.3	$213.0	$301.7	$318.8	$235.5
Safety - Cyclone	$221.4	$17.5	$119.0	$234.0	$56.6	$78.8	$38.1
Green - Energy	$4,230.0	$900.0	$1,500.0	$5,400.0	$3,600.0	$2,200.0	$100.0
Green - Water	$938.9	$1,095.4	$859.1	$408.4	$700.7	$131.4	$8.3
Total per year	$5,603.8	$2,124.6	$2,656.5	$6,255.4	$4,659.1	$2,729.0	$382.0
TOTAL over 20 years	**$83,370.0**	**$31,609.0**	**$39,521.5**	**$93,065.0**	**$69,315.1**	**$40,600.9**	**$5,682.7**
BENEFITS measured by QALYs							
Annual estimates							
Safety - Earthquake	9.7	30.4	23.2	0.4	7.6	18.5	0.9
Total per year	9.7	30.4	23.2	0.4	7.6	18.5	0.9
TOTAL over 20 years	**$145.0**	**$452.7**	**$345.2**	**$6.5**	**$112.4**	**$275.9**	**$13.0**
COSTS measured by dollars ($)							
Safety - w/ impact	$66,000.0	$122,000.0	$121,000.0	$53,600.0	$102,500.0	$149,000.0	$127,500.0
Green - Energy	$32,200.0	$19,200.0	$19,900.0	$12,400.0	$187,500.0	$80,700.0	$9,600.0
Green - Water	$30,000.0	$45,000.0	$33,000.0	$10,000.0	$13,500.0	$13,000.0	$14,000.0
TOTAL costs	**$128,200.0**	**$186,200.0**	**$173,900.0**	**$76,000.0**	**$303,500.0**	**$242,700.0**	**$151,100.0**
COST-BENEFIT							

Hospital Name	A	B	C	D	E	F	G
Return on Investment	**$0.65**	**$0.17**	**$0.23**	**$1.22**	**$0.23**	**$0.17**	**$0.04**
Ranking	**2**	**5**	**4**	**1**	**3**	**6**	**7**
Incremental cost-effectiveness ratio	**$309.22**	**$341.47**	**$389.33**	**-$2,621.33**	**$2,084.27**	**$732.64**	**$11,147.23**
Ranking	**2**	**3**	**4**	**1**	**6**	**5**	**7**

What input is required to produce the REST report?

REST is built on an Excel file. Final users **must** complete two input forms:

1. Safety component
2. Green component

Both forms are provided as Appendices I and II. They also available as an online survey at: http://goo.gl/5BsHsl.

Safety component

The information provided in the safety component form (Appendix I) can be divided into two types of data: general information about the facility and information from the Hospital Safety Index (HSI), both pre- and post-retrofitting.

Facility Information. Much of the facility information can be obtained from existing reports such as Selection Criteria and Smart Report (PAHO, 2016). Other information may need to be collected additionally by facility staff. Construction classes are based on Table 3A of HAZUS Earthquake Model Technical Manual (HAZUS MR4, 2014). Users must identify the construction class of the healthcare facility and the construction classes of buildings in the surrounding area. Users need to observe the buildings in the neighborhood and choose the type that best represents the average type of buildings.

HSI Pre- and Post-Retrofitting Information. The pre-retrofitting scores can be copied from HSI reports. The HSI post-retrofitting scores are specified by the users, based on recommended retrofitting works. For a particular retrofitting work, users must find the closest item in the HSI and modify the score from the pre-retrofitting level (low, average, or high) to the desired level (average or high). In addition, a projected cost associated with this retrofitting work needs to be provided in the column next to the post-retrofitting scores.

Appendix I provides an example of a completed Safety Component information form.

Green Component

The information provided in the green component form (Appendix II) can be divided into 4 types: general information; energy improvement; water consumption; and the cost of green improvements.

General Information. Most information can be obtained from the Green Checklist, the Baseline Assessment Tool (BAT) and the Smart Report. Facility staff may need to collect additional information.

Green Savings. Baseline information on energy and water consumption as well as itemized retrofitting recommendations are available from the BAT, the Smart Report and projected retrofitting costs, or by consulting facility personnel.

Cost of Green Improvements. A list of each recommended retrofitting works and projected costs is required. Preliminary cost files should be available from PAHO.

Appendix II provides an example of a completed Green Component information form.

What is behind the REST report?

The REST report is based on a cost-effectiveness model that estimates savings in dollars and QALYs associated with retrofitting to be safe and green. The model incorporates safety and green savings independently.

For the safety component, REST considers the short-term surge of demand for health services caused by a disaster, and the mid-term impact of the disaster on the facility's capacity. The map below illustrates the approach, using a fictitious healthcare facility in a coastal area.

- **Reduction in facility's capacity.** Geographic location and characteristics of the facility are obtained to estimate the exposure of the facility to a hazard and its vulnerability, based on potential structural and non-structural damage (HAZUS MR4, 2014; CIMNE, 2013). Structural elements are part of the building's load-bearing system (e.g., columns, beams, walls, floors, slabs, etc.). Non-structural elements are those systems that are necessary for building operations (e.g., architectural components, equipment, etc.).
- **Surge in demand.** The geographic location of the facility's catchment area is identified and building characteristics in the area are obtained to estimate the exposure of the catchment area and its vulnerability to a hazard. Expected injuries requiring medical attention are estimated.

For the green component, REST considers the efficiency gains in water and energy consumption caused by the replacement or addition of green equipment (Fortier, et al., 2015). Other environmental benefits, for example the result of waste management and air quality improvements, are not considered in REST.

The REST benefit estimation involves three steps:

1. Estimating the vulnerability of the facility and economic losses under the risks of disaster.
2. Estimating the savings in water and energy consumption.
3. Combining the cost and benefit estimates to produce decision support information such as return-on-investment and incremental cost-effectiveness ratios.

REST compares future gains (with and without retrofitting) with the investment cost of retrofitting, over a 20-year time period (after the retrofitting is completed). After retrofitting, healthcare facilities may be able to treat an increased flow of patients during disasters. The change in the number of patients served during an emergency period (immediately after disaster) and reconstruction period (post-recovery after disaster) is measured in QALYs saved. The current version of the REST includes QALYs saved associated with earthquakes only. QALYs saved associated with cyclones were excluded because of the low mortality associated with this type of hazard (Goklany, 2009). Future versions of the REST will incorporate cyclones and additional hazards with available information in the region. Savings due to reduced energy and water use after retrofitting are measured in dollars.

The REST cost estimation includes the total cost of labor, materials and equipment used for the facilities to reach specific safe and green standards. The standards to be reached are determined by stakeholders and can be inferred from recommended retrofitting work indicated in the Smart Report and attendant cost estimates. Costs that have no impact on improving safety or saving water and energy are not included. For example, the cost of painting is not included because it has little impact on either the building's resilience or water and energy savings.

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HAZUS MR4 (2014). Earthquake Model Technical Manual. Available at: http://www.fema.gov/media-library/assets/documents/16606.

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PAHO (2016). Smart Hospitals Toolkit. Available at: http://www.paho.org/disasters/smarthospitals.

Goklany, Indur M. (2009). Deaths and death rates from extreme weather events: 1900-2008. Global Trends 13: 14.

Appendix I: Safety Component

General Information	Sample Answers
Hospital Name	Facility A
Address	Street A, city B
Country	C
Latitude	12.132554
Longitude	-61.652548
Construction Class (select one type)	URML
Number of stories	1
Gross floor area (square feet)	5500
Height to roof (m)	4.6
Number of beds	47
Replacement value	9400000
Building construction class in surrounding areas (select one type)	URML
Average number of stories in surrounding areas	2
Average height to roof (m) in surrounding areas	6.1
GDP per capita	$7,890.51
Patient consultations per day	1200
Hospital admissions per day	10
Number of staff	41
Catchment population	30500

Hospital Safety Index (HSI) pre- and post-retrofitting

	Pre-retrofitting HSI			Post-retrofitting HSI			Cost (US $)
Facility name: A	**Low**	**Average**	**High**	**Low**	**Average**	**High**	
HSI score	x					x	30,000

Appendix II: Green Component

General Information	Sample Answers
Facility name	Facility A
Facility type	Inpatient Hospital
Number of beds	47
Number of exam/consulting rooms	5
Total daily operating hours	24
Operating days per week	7
Annual patient-days	1,200 per month
Gross floor area of the facility	5,500
Unit	sq. ft.
Admissions, assessments and out-patient department(s)	yes
Restaurants, cafeteria, eating spaces, or kitchen	YES
Laundry	YES
Laboratory testing	NO
Emergency department	YES
Operating theaters (incl. maternity operating theaters)	yes
Radiotherapy unit and radiotherapy support spaces	NO
Chemotherapy unit and chemotherapy support spaces	NO
Adult inpatient wards (incl. maternity) - private bedrooms (single bed per room)	NO
Adult inpatient wards (incl. maternity) - shared bedrooms (4 beds per room typical)	YES
Critical care unit	NO
Maternity antenatal facilities	NO
Maternity neonatal	NO
Imaging suites	YES
Was the building constructed after 1980?	NO
What year was the building was constructed?	1950
Building construction type	CONCRETE
Do any of the windows open and close in the patient rooms (operable windows)?	YES
Is the facility cooled with any of the following?	AC
What types of energy are directly consumed in your facility?	ELECTRICITY
Do you have meters on-site that measure the electricity usage for all buildings at your facility?	YES
Do you have meters on-site that measure the natural gas usage for all buildings at your facility?	NO
Do you generate energy at your facility using renewable energy sources?	NO
Do you have an on-site generator?	YES
Do you know how much you spent on energy in the past 12 months?	YES
Energy cost for previous 12 months	44,000
Unit	EC$
Electricity - Amount used in previous 12 months	54,400
Unit	kWh
Electricity - Cost for previous 12 months	44,000

General Information	Sample Answers
Unit	EC$
Natural Gas - Amount used in previous 12 months	X
Unit	X
Natural Gas - Cost for previous 12 months	X
Oil - Amount used in previous 12 months	X
Oil - Cost for previous 12 months	X
Diesel - Amount used in previous 12 months	
Diesel - Cost for previous 12 months	

Energy improvement

General Information	Sample Answers
Facility name	Facility A
Group A - Windows	
Install low solar gain window films	X
Replace windows and frames with double-paned low-e, thermally broken, vinyl-framed windows, with high visible light transmittance	
Install automated louver shading systems on all sun-exposed windows	
Install exterior window shading	X
Perform blower testing and sealing of envelope	
Group B - Roof	
Add a reflective roof covering	X
Install green roof	
Group C - Air	
Install screw air compressors	
Reduce compressed air losses	
Group D – Building systems	
Upgrade and optimize building control systems (HVAC, lighting, service hot water)	
Install occupancy sensor devices for workstation power control	
Perform re-commissioning on building systems (HVAC, service hot water, envelope)	
Group E – Electric components	
Install static power factor correction (capacitors)	X
Install dynamic voltage optimization	
Replace electrical transformers with right-sized, higher efficiency models	
Group F – Electrical equipment	
Replace cafeteria appliances with ENERGY STAR models	
Specify medical equipment that has low standby mode electrical use, and equipment that can be powered down or off when not in use	
Group G – Laundry equipment	
Install drain water heat recovery on washing machines and clothes dryer heat recovery system	

General Information	Sample Answers
Reclaim laundry water	
Group H – Other equipment	
Install high efficiency drive belts	
Install VSDs on chilled-water and hot water pumps	
Replace oversized, inefficient fans and motors with right-sized NEMA premium efficiency motors	
Install VSDs for demand control of kitchen hood exhaust fans	
Group L - Other equipment	
Install solar hot water pre-heat	
Install photovoltaic system for electricity generation	
Add a reflective roof covering	
Group M - Other equipment	
Add insulation to steam/hot water pipes	X
Install solar hot water pre-heat	
Install instantaneous domestic water heaters	
Install low flow shower heads	
Install low flow sink aerators	
Additional EEMs -	
Replace exit signs using incandescent lamps with LED exit signs	
Replace T12 fluorescent lamps and older T8 lamps and magnetic ballasts with high-efficiency T8 lamps and instant-start electronic ballasts	
Replace incandescent lamps with CFLs	
Install more efficient exterior lighting for facades and parking lots	
Install occupancy sensors for lighting in rooms that are used intermittently	
Install lighting timers in rooms that are used intermittently and for very short intervals	
Install photosensors and dimming ballasts to dim lights when daylighting is sufficient	
Install bi-level or dimming control for nighttime setback in corridors and at nurses' stations, with upgraded task lighting	
Use lighting controls that first switch power to 80%, with 100% requiring manual up-switching for examination rooms, nurses' stations, and other areas	
Install LED lighting for all patient rooms, examination rooms, and operating rooms	
Install wind turbine system for electricity generation	X

Water consumption

General Information	Sample Answers
Facility name	facility A
Baseline usage (gal)	100
$ per gal	0.75

Cost of green improvements

Retrofitting Items	Cost (US $)
Water tanks	10000
Faucets and fixtures	5000
Improve plumbing	40000
Water filters	3000
TOTAL COST	**58000**

Annex 5

WATER CONSERVATION PLAN

Policy Statement

It is the policy of [_____INSERT FACILITY NAME_____] to conserve water and to take all appropriate steps in doing so. The administrator(s) and staff of this facility recognize that water is of utmost importance to the health of patients, staff and the country as a whole and pledge to do their part to conserve water at the facility.

It is the duty of each member of staff to become familiar with the water conservation policy and to co-operate with administration and the administrative officer(s). All members of staff are expected to comply with the recommendations herein.

As part of the policy ensure that:

- Employees are educated about the importance and benefits of water conservation.
- Signs are installed in restrooms, offices, laundry rooms, cafeterias, etc., that encourage water conservation.
- An employee is assigned evaluate water conservation opportunities and effectiveness.

General Facility and Water Use Information

Name of the Facility:	
Location:	
Contact information:	Telephone: Email:
Areas served:	
Year constructed:	
Number of buildings on compound:	
Building capacity: No. of beds	
Average number of visitors/occupants per day (if applicable): __________	
No. of employees:	Full-time: ___________ Part-time: ___________
Number of shifts per day:	
Local water provider:	

Name of the Facility:		
Water service		
Are there any underground cisterns onsite?	Yes ❑	No ❑
If yes, what is the capacity? (L×W×D) × 7.48	Gallons: __________	
Are there any storage tanks onsite?	Yes ❑	No ❑
If yes, what is the capacity? (L×W×D) × 7.48	Gallons: __________	
How are the storage tanks/ cisterns filled	Rainwater ❑ Portable ❑	
Is the water being treated before use?	Yes ❑	No ❑
If yes, how is this being done?		
Sewage treatment		
Type of sewage system:	Underground septic tank ❑ Treatment Plant ❑ Public Sewer ❑	
What is the capacity? (L×W×D) × 7.48	Gallons: __________	

Utility/Consumption Data

Number(s) for water meter(s) located at the facility, the areas they serve and the annual water consumption are shown in the table below. *(Please provide data as indicated below. Add additional lines as appropriate/needed. Delete text once data is inserted into table.)*

Water Meter Data		
Meter number	**Areas served**	**Annual water consumption**

In order to determine what progress is being made due of conservation efforts, monthly water usage has to be recorded. *(To establish a baseline, set your baseline year and gather water usage data fill-in the table below. Fill-in monthly water data as bills are received. Add a column for cost if desired. Please keep in mind that potable water costs may change and may not accurately reflect savings. Delete text once data is inserted into table.)*

Month/Year (Baseline)	Water Usage (gal)	Month/Year (Year 1)	Water Usage	Month/Year (Year 2)	Water Usage	Month/Year (Year 3)	Water Usage
Jan		Jan		Jan		Jan	
Feb		Feb		Feb		Feb	
Mar		Mar		Mar		Mar	
Apr		Apr		Apr		Apr	
May		May		May		May	
Jun		Jun		Jun		Jun	

Month/Year (Baseline)	Water Usage (gal)	Month/Year (Year 1)	Water Usage	Month/Year (Year 2)	Water Usage	Month/Year (Year 3)	Water Usage
Jul		**Jul**		**Jul**		**Jul**	
Aug		**Aug**		**Aug**		**Aug**	
Sep		**Sep**		**Sep**		**Sep**	
Oct		**Oct**		**Oct**		**Oct**	
Nov		**Nov**		**Nov**		**Nov**	
Dec		**Dec**		**Dec**		**Dec**	

Water Conservation Efforts

Hospitals and medical facilities instituting water-saving measures can see reduced operating cost. To reduce water consumption whether in an office, medical facility or commercial/industrial setting, consider the three-step process below. Foremost, employees must understand how their job affects water use in their work environment. Solicit ideas from those most involved with the daily operations and activities of the facility. Make conserving water part of their job by having them identify where water is used, whether in bathrooms or kitchens, etc. Once the areas of water consumption have been determined, engage staff to help implement conservation measures.

- Educate and involve staff on water conservation,
- Locate all water using sources (bathrooms, wash sinks, hoses, dish machines, HVAC, cooling water, etc.) in facility; and
- Identify and implement water conservation options.

In line with the policy above, some activities for reducing water use are outlined below. *(Please indicate if the activities are planned, ongoing or completed in the table and insert appropriate comments. Add additional lines for other upgrades/activities/changes that affect water use. Please note that some of the activities in the table above apply only to large hospitals. If they do not apply to your facility, kindly remove from the list. (Delete this text once activities are identified/listed.)*

Reduction Measure Implemented				Comments
Complete a water use audit. Medical methods, processes and equipment are constantly upgrading, thus changing the need for water in some areas.				
Create and/or implement a comprehensive water conservation plan.				
Track facility's water usage and costs using a tracking tool/spreadsheet. Compare the results to the same month of the previous year. This will help to identify leaks as they occur, as well as monitor your conservation efforts.				
Evaluate daily routines of staff (i.e. patient showering, cleanup, scrubbing and hand-washing) and encourage efficient practices and procedures regarding water use.				
Provide signage urging water conservation.				
Operations equipment				
Install or maintain a closed cooling system for process water.				
Install or maintain a condensate recovery system.				
Install or maintain flow-reducing technology for faucets (motion sensors, aerators).				
Install or maintain low-flow fixtures for toilets.				
Install spring-loaded valves or timers of all non-clinical faucets.				

Reduction Measure Implemented	Comments			
Install or maintain low-flow fixtures for showers.				
Install toilet tank water displacement devices, such as toilet dams, bags, or weighted bottles.				
Retrofit flushometer (tank-less) toilets with water-savings diaphragms, which save one gallon (20 percent) per flush.				
Replace toilets with low-volume models. Toilets can use as much as 4.5 gallons per flush, while low volume toilets use only 1.6 gallons per flush. An average savings of more than 7 percent of a hospital's total water use was possible through this one water conservation action.				
Capture rainwater and use for non-potable uses such as toilet flushing. (A filtration system will allow this water to be used for potable uses such as drinking and cooking.)				
Set urinals with programmable automatic flush valves to a water saving mode that flushes the urinal after more than one use.				
Install or maintain water efficient kitchen equipment: dishwashers.				
Install or maintain water efficient kitchen equipment: food disposal.				
Consider using water-efficient ice machines.				
Install automatic valves on film processing equipment to stop water flow when equipment is not in use.				
Use temperature control valves.				
Recycle brine from reverse osmosis, or filter backwash, for cooling.				
Replace lab aspirators with a central vacuum system.				
Install or maintain a closed cooling system for process water.				
Operations - Indoors				
Check the water supply system for leaks, and turn off unnecessary flows.				
Repair leaks! A leaking toilet can waste more than 50 gallons of water each day, and a dripping faucet or showerhead can waste up to 1,000 gallons per week.				
Shut off the water supply to equipment and areas that are unused.				
Discontinue water circulation pumping in areas not in use.				
Read water meters monthly. Compare the results to the same month of the previous year.				
Check the water system pressure. Where system pressure is higher than 60 psi, install pressure-reducing valves.				
Adjust boiler and cooling tower blowdown rate to maintain total dissolved solids (TDS) at levels recommended by manufacturers' specifications.				
Return steam condensate to the boiler for reuse.				
Consider using ozone as a cooling tower treatment to reduce water used for make-up.				
Shut off water-cooled air conditioning units when not needed, or replace water-cooled equipment with air-cooled systems.				
Overhaul faulty steam traps on sterilizers.				
Turn off the continuous flow used to wash the drain trays of the coffee/milk/soda beverage island. Clean thoroughly as needed.				
Adjust ice machines to dispense less ice if ice is being wasted.				
Reuse the rinse water from the dishwasher as flush water in garbage disposal units.				
Investigate a rinsewater reclamation system to reuse rinsewater for wash cycle.				
Consider installing a washwater and rinsewater treatment and reclamation system.				

Reduction Measure Implemented	Comments			
Shut off the water supply to equipment and areas that are unused.				
Discontinue water circulation pumping in areas not in use.				
Check the pressure. Where system pressure is higher than 60 psi, install pressure-reducing valves.				
Operations - Outdoors				
Use rainwater and/or grey water in landscaping.				
Use xeriscaping (water efficient landscaping).				
Apply water, fertilizer, or pesticides to your landscape only when needed. Look for signs of wilt before watering established plants.				
Water early in the morning or in the evening when wind and evaporation are lowest.				
Install an automatic rain shut-off device on sprinkler systems.				
Consider using low-volume irrigation, such as a drip system.				
Avoid runoff! Make sure sprinklers are directing water to landscape areas, and not to parking lots, sidewalks, or other paved areas.				
Adjust the irrigation schedule for seasonal changes.				
Consider using drought-tolerant, low-maintenance plants.				
Be sure all hoses have shut-off nozzles.				
Use a broom, rather than a hose, to clear sidewalks, driveways, loading docks and parking lots.				
Wash vehicles only when needed.				
Investigate the availability of reclaimed water for irrigation and other approved uses.				
Cleaning				
Use microfiber materials in equipment for facility cleaning (mops, cloths).				
Use full loads in sanitizers, dishwashers, sterilizers and laundry washing machines, consistent with infection control requirements.				
Instruct cleaning crews to use water efficiently for mopping.				
Switch from "wet" carpet cleaning methods, such as steam, to "dry," powder methods.				
Change window cleaning schedule from "periodic" to "as required."				
Turn dishwashers off when dishes are not being processed.				
Overhaul faulty steam traps on sterilizers.				

Please note that some of the activities in the table above apply only to large hospitals. If they do not apply to your facility, kindly remove from the list.

Staff Engagement in Energy Efficiency

Plan of Action (Add or delete as needed)	Comments
Turn of faucets when not in use.	Change in behavior is important to conservation.
Monitor for leaks.	
Post flyers to remind staff and visitors to conserve water.	These can serve as reminders. Replace when faded or worn.

Education of Staff, Patients and Visitors

This plan will not be successful without the cooperation of staff, patients and visitors; therefore, some level of education will be required. Ensure that staff is familiar with the aim of the plan and its contents. Post flyers in strategic places to remind staff, patients and visitors of the policy and goal of the facility to conserve water. Highlight any upgrades/retrofits that aid with water conservation as well as achievements.

Download the ***Water Conservation Plan*** template at http://bit.ly/2kEZkAf.

Download a sample poster at http://bit.ly/2lLSQT8.

SAFE + GREEN = SMART

Annex 6

Energy Conservation Plan

Policy Statement

It is the policy of _Insert Facility Name__ to conserve energy and to take all appropriate steps in doing so. The administrator(s) and staff of this facility recognize that energy is of utmost importance to the health of patients, staff and the country as a whole and pledge to do their part to conserve energy at the facility.

It is the duty of each member of staff to become familiar with the energy conservation policy and to co-operate with administration and the administrative officer(s). All members of staff are expected to comply with the recommendations herein.

As part of the policy ensure that:

- Employees are educated about the importance and benefits of energy conservation.
- Employees are educated about the energy conservation measures implemented in the facility
- Signs are installed in restrooms, offices, laundry rooms, cafeterias, etc that encourage energy conservation.
- An employee is assigned evaluate energy conservation opportunities and effectiveness.
- Employees follow the procedures listed below to conserve energy

General Information

Name of the Facility:	
Location:	
Contact information:	Telephone: Email:
Areas served:	
Year constructed:	
Number of buildings on compound:	
Building capacity: No. of beds	
Average number of visitors/occupants per day (if applicable): ___________	___ consultations per month at clinic. ___ admissions per month to hospital.
No. of employees:	Full-time: ____________ Part-time: ____________
Number of shifts per day:	

Utility/Consumption Data

In order to determine what progress is being made by conservation efforts, monthly energy usage has to be recorded. Energy consumption data prior to the retrofit are included for reference. *Add a column for cost if desired*.

Month/ Year (before retrofit)	Energy Usage (gal)	Month/Year (Year 1)	Energy Usage	Month/Year (Year 2)	Energy Usage	Month/Year (Year 3)	Energy Usage
Jan/15		Jan/16		Jan		Jan	
Feb/15		Feb/16		Feb		Feb	
Mar/15		Mar/16		Mar		Mar	
Apr/15		Apr/16		Apr		Apr	
May/15		May/16		May		May	
Jun/15		Jun/16		Jun		Jun	
Jul/15		Jul/16		Jul		Jul	
Aug/15		Aug/16		Aug		Aug	
Sep/15		Sep/16		Sep		Sep	
Oct/15		Oct/16		Oct		Oct	
Nov/15		Nov/16		Nov		Nov	
Dec/15		Dec/16		Dec		Dec	

Energy Conservation Efforts

Hospitals and medical facilities instituting energy-saving measures can see reduced operating cost. To reduce energy consumption whether in an office, medical facility or commercial/industrial setting, consider the three-step process below. Foremost, employees must understand how their job affects energy use in their work environment. Solicit ideas from those most involved with the daily operations and activities of the facility. Make conserving energy part of their job by having them identify how the electrical consumption is distributed. Once the areas of energy consumption have been determined, engage staff to help implement conservation measures.

- Educate and involve staff with energy conservation measures already implemented in the facility
- Identify all energy consuming appliances (washers, air conditioners, medical equipment, lamps, etc.) in facility; and
- Implement action plan (behavioral changes, scheduled maintenance, monitoring and logging)

Energy Measures Implemented (add and delete measures as needed)	Comments
Energy audit.	
Implementation of a comprehensive energy conservation plan.	
Signage urging energy conservation.	
Installation of a photovoltaic system (PV).	
Installation of solar water heaters.	
Installation of energy efficient lamps (LEDs).	
Installation of occupancy sensors.	
Installation of photocell switches for exterior lighting.	
Tinting windows in air conditioned rooms.	
Upgrade air conditioning units to more efficient and environmentally friendly units.	

Electrical Consumption at the (INSERT NAME OF FACILITY) can be divided in to the following categories:

_% Lighting – LED fixtures.

_% Air Conditioning – inverter split units.

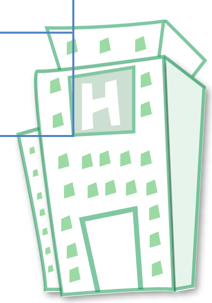
_% Refrigeration – refrigerators.

_% Medical equipment – autoclaves, dental chair and compressor.

_% Miscellaneous loads – computers, fans, washing machine, microwave, kettle.

Staff Engagement in Energy Efficiency

Plan of Action (add and delete measures as needed)	Comments
Turn off all non-essential electrical equipment overnight such as computer, printers.	Savings can be made by eliminating the use of equipment that consumes power while not in use.
Eliminate the use of transformers.	
Use natural ventilation as much as possible.	Windows were modified during the retrofit to increase ventilation throughout the facility.
Close blinds, curtains, doors and windows when air conditioning units are on. Recommended temperature 25o Celsius.	This reduces the amount of hot air that needs to be removed by the air conditioning unit.
Turn off lights that are not in use and use natural lighting as much as possible.	Although LEDs are more efficient than fluorescent lighting even more savings can be made with behavioral changes.
Track facility's energy usage and costs using a tracking tool/ spreadsheet.	Compare the results to the same month of the previous year to monitor conservation efforts.
Evaluate daily routines of staff and patients that involve the use of energy and encourage efficient practices and procedures regarding energy use.	



Plan of Action (add and delete measures as needed)	Comments
Air conditioning units should be serviced regularly.	This is important to maintain the efficiency of the unit.
Clean diffusers in lamps regularly.	This is important to maintain adequate lighting levels.
An energy audit should be conducted and the conservation plan updated when equipment is added to the facility.	

Education of Staff, Patients and Visitors

This plan will not be successful without the cooperation of staff, patients and visitors; therefore, some level of education will be required. Ensure that staff is familiar with the aim of the plan and its contents. Post flyers in strategic places to remind staff, patients and visitors of the policy and goal of the facility to conserve energy. Highlight any upgrades/retrofits that aid with energy conservation as well as achievements.

Download the ***Energy Conservation Plan*** template at: http://bit.ly/2kPTJce.

Download sample posters at http://bit.ly/2kjtOXs.

Pan American Health Organization

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