2010

BIB Eco Construction Guidebook

BIB Ecological Assessment Board

Better In Belize

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Foreword

Welcome to “Better in Belize” the most exciting place in the world. We have created this special space and development to address the needs of our generation and children’s future. The activities of the construction sector have been and continue to be a major source of environmental degradation, its impacts being felt over time and space. Its geographical spread and rapid growth rate impacts the present global ecosystem. Moreover, the long lives of the structures being built extend the impacts over several generations. This makes the construction sector an industry that requires immediate intervention. The dynamics of current ecological and economic systems and their collapse mandate a paradigm shift in development processes.

The evolving concept of eco-housing is a flexible, bottoms-up approach that could reverse these negative non-sustaining trends in the construction sector. The concept has now caught the attention of decision makers in the World, but a lack of real examples has prevented its adoption on a larger scale. To meet this need in Belize, and to serve as a role model for future projects, the developer of “Better in Belize” facilitated the establishment of an “Ecological Advisory Board” to establish design, construction and living guidelines for the project. This document serves as a guide to help land owners in “BIB” to adopt the principles of ecological sustainability in the design of their living and work space.

Eco-housing integrates several mature disciplines and design objectives that need to be applied during the entire lifecycle of a housing project design; construction, maintenance and "end of life" activities. It also tries to merge traditional and modem day architectural practices. Many of its concepts have been used by humans for centuries to ensure comfort conditions in their habitats. The drivers of environmental and social externalities in the construction sector are dynamic in nature. Hence the guidelines cannot be rigid, but needs to blend itself in to the bio-climatic features and socio-cultural aspects of the site. Site selection, material selection, energy performance, water management and waste management, are key areas of the concept. Integrating and implementing so many objectives and disciplines requires an effective interdisciplinary team with good project management skills.

In general, an objective of the integrated design process is to create minimum disturbance to the existing site and minimise the requirements of natural resources, energy and water with the help of its bio-climatic features, A more challenging eco-housing target would be to enhance the existing site features and even be net producers of energy, water etc, within the traditional framework of economic-efficiency. The design, construction, and maintenance of houses have a major impact on our environment and on the stock of natural resources. Huge amounts of natural resources and energy are consumed in a building's life cycle, polluting air, water, and land. The rapid growth of the global economy and the rising trends in population, urbanization and rural migration is contributing to the expansion of the built environment, threatening natural habitats and wildlife. “BIB” and other visionary eco-developments will and must stop this impact on the earth. Take this document as a trail into this new land; let us together create the future.

Eco Construction Guidebook (ECB)

The formation of the ECB was intended to present to land owners in BIB an overview of sustainable building designs, methods, materials and techniques as to facilitate the construction of their own sustainable project. The term project is used, because in sustainable design, we quickly learn that the building, the land, and the surrounding ecosystem must all be considered in the design, planning and construction process for habitation. The development of a successful project from the overall site to each individual sites and their evolution, will be an organic process of growth and change, firmly rooted by the governance of the EAB and basic eco construction guidelines. The basis and foundation of this workbook will consist of 6 tenets of eco construction as follows:

1. Pre-design guidelines
2. Site planning and construction
3. Material and product selection
4. Energy performance
5. Water management
6. Waste management

1. Pre-design Guidelines

Discussions and goal setting are beneficial to the project over its entire life cycle. It sets out definitive goals, charters project directions, and provides opportunities for cost optimization to achieve the desired goals in innovative ways. The generic guidelines for the pre-design stage include:

1. Select an effective, interdisciplinary design team. The team could include the owner, architects, engineers, and subject consultants. Known the essence of the site, its uniqueness, and how you idea of sustainability will enhance and coexist within its natural beauty and bio-diversity

2. Finalise appropriate procedures for contracting and contractor selection.

3. Appropriate guidelines, specifications and procedures should be laid within the contract document to meet eco-design objectives.

4. Develop design goals, which include the following.

- A vision statement that clearly sets out goals, objectives, and processes. It should be based on careful site analysis, resource availability, available best practices and technologies, and cost effectiveness. The project must also identify if the design goals intend to achieve improvements over the conventional standards, e.g., better envelope standards than minimum energy goals, better water efficiency, etc than most developers use.

- The goals needs to be prioritized based on the need, project constraints, and relative importance of the criteria. e.g., water quality and conservation will be a priority in “Better In Belize”.

- Laws, codes, and standards: Prepare a list of applicable codes, standards, laws relevant to the project, contained in the BIB eco-guidelines and environmental guidelines of the Government of Belize which may include:

    Rules or bye-laws related to water and waste management,

    Financial incentives of eco-measures, (e.g., subsidies or ROI for renewable energy systems, energy-efficient equipment)

    Energy codes/standards,

    Relevant building codes,

    Regulations related to measures like rainwater .harvesting, solar water heating, etc,

    Environmental clearances required, if any, and disaster mitigation measures. Identify the damage reversals that need to be addressed prior to implementation of the eco-housing project (e.g., groundwater contamination, snake bite or fire hazard areas).List out the actions that are required to address these issues, from escalation to contacts with roles and responsibilities.

5. Owner must do a proper topographical land survey of lot before commencement of drawings or any submission to the “Ecological Advisory Board” It is important to observe both climate and hydrology conditions on the site, archaeological, game trails and other factors that may affect design.

6. All final plans for contract bid and construction shall be submitted by the owner from a professional firm and should bear official seal or stamp of the said firm. The plans should include all architectural, electrical, mechanical drawings and landscape architecture with specifications so EAB can clearly identify location, layout materials, and design guidelines of proposed structure, ancillary buildings, and landscaping. (See appendix F for format)

7. The “BIB” community will be one of resource sharing and collaboration. With that in mind all participants in the vision are entitled and encourage sharing their knowledge and dreams, and contributing to the goal of sustainability and regenerative design within our group and this document.

2. Site Planning and Construction

The purpose of sustainable site planning is to integrate design and construction strategies by modifying both, the site and building to achieve greater human comfort and operational efficiency. It ensures minimum site disruption; maximum usage of microclimate features; minimum requirement for intra/inter-site transportation; appropriate erosion and sedimentation control plans; and appropriate landscaping. In all cases the sun, rain and wind from the macro to micro scale should be accounted for each lot design. The guidelines for achieving this are as follows.

The climate in Belize is generally humid tropical and the base of all designs in this zone should consider the following basics:

-Build homes close to hills or elevated sites for more air circulation

- Build thin walls so humidity does not accumulate

- Have good slopes on roofs to evacuate rainwater, create a buffer space for rising heat, less roof heat because of sun's indirectness.

-Use bug, moisture and mold resistant natural materials

- Make sure all buildings on land have adequate spacing for wind to circulate

- Large verandas around home are desirable for rain protection

- Elevate the ground floor to avoid excessive earth moisture and humidity

- Use large windows for greater ventilation; also remember light purifies the inside of the house from molds, fungus, bacteria and viruses

-Use gardens around the house to promote natural cooling

To mitigate light pollution, design exterior lighting such that all exterior luminaries with more than 1000 initial lamp lumens are shielded and all luminaries with more than 3500 initial lamp lumens meet full cut off2 IESNA3 classification. Any luminary within a distance of 2.5 times its mounting height from property boundary should have shielding such that no light from the luminary crosses the boundary.

Discourage use of fossil fuel-based vehicles on site.

Make a spill prevention and control plan that clearly states measures to stop the source of the spill, contain the spill, dispose the contaminated material, and provide training of personnel. Some of the hazardous wastes to be cautious about are pesticides, paints, cleaners, and petroleum products.

The run-off from construction areas and material storage sites should be collected or diverted so that pollutants do not mix with storm water runoff from undisturbed areas. Temporary drainage channels, perimeter dike/swale, etc. should be constructed to carry the polluted water directly to municipal drains. The plan should indicate how the above is accomplished on site well in advance of the commencement of construction activity.

The site layout should allow for wind protection and solar access in winter and at the same time, adequate sun protection and ventilation in summer. Having a mix of building types could help achieve this.

Carefully design vegetation wind funnels for in modulating airflows in and around a building. Good design- Allows free rear ventilation as well as funnel at front and through sides, creating air jet of increased velocity Use neighbouring land forms, structures, of vegetation to increase exposure to cooling winds. Have a building design that incorporates balconies, overhangs and sloped roofs to capture wind. Landscaping may also may provides the required shading for outdoor areas, but be aware of how it modifies the micro climate.

Care needs to be taken to avoid undesirable increase in humidity levels, by excessive plantations.

Selection of plant species should be based on its water requirements and the micro climatic benefits that should result from it.

Preserve existing vegetation on site. Mark all the existing vegetation in tree survey plan. Evolve tree preservation guidelines.

Do not alter the existing drainage pattern on site. Existing grades should be maintained around existing vegetation. Maintenance activities should be performed as needed to ensure that the vegetation remains healthy.

The most effective way to prevent soil erosion, sedimentation, and to stabilize soil is through the provision of vegetative cover by effective planting practices. The foliage and roots of plants provide dust control and a reduction in erosion potential by increasing infiltration, trapping sediments, stabilizing soil, and dissipating the energy of hard rain. Temporary seeding can be used in areas disturbed after rough grading to provide soil protection until the final cover is established. Permanent seeding/planting is used in buffer areas, vegetated swales, and steep slopes. The vegetative cover also increases the percolation of rainwater thereby increasing the groundwater recharge.

Use of organic mulches has to be done to enhance soil stabilization. Organic mulches include shredded bark, wood chips, straw, composted leaves, etc. Inorganic mulches such as pea gravel, crushed granite, or pebbles can be used in unplanted areas. Stone mulches should not be used adjacent to the building as they can easily get heated and cause glare. Mulching is good for stabilizing soil temperature also.

Pervious surfaces allow rainwater to seep through them while impervious or hard surfaces prevent it. A site contains hard or impervious surfaces (roads, impervious pavements, parking, etc.) and soft and pervious surfaces (vegetative cover, pavements, parking, walkways which are pervious). A site planned for a higher proportion of impervious surface results in less groundwater recharge and higher run-off. Conventional drainage methods used on site usually involve transporting water as fast as possible to a drainage point, either by storm water drainage or a sewer. Sustainable drainage systems work to slow down the accumulation and flow of water into these drainage points and increases on-site infiltrations. This results in a more stable ecosystem as the water level and the water flow speed in the watercourse is more stable, and hence, less erosion will take place. Avoid standing and stagnant pools for mosquito breeding.

In this climate type, building should ideally be located at highest point for water runoff

Although the ceiling may be sealed off from the roof for bug protection, etc, ensure the attic space is well ventilated and open

3. Material and Product selection

Using eco-friendly materials contributes towards creating an eco-habitat. They help conserve natural resources and are characterized by low-embodied energies. They are convenient for recycling and reuse, and have low-emissions. Wastes and by-products generated from various manufacturing processes could form secondary resources for production of building materials. This would allow savings in consumption of primary grade raw materials, energy, labour, and capital investments in plants. Selection of appropriate materials is driven by local/regional availability and cost effectiveness. The points to be noted for material and product selection are:

- Use materials with low-embodied energy content.
- Use locally available materials and technologies, employing local work force
- Reuse/recycle construction debris
- Composite wood products made from recycled wood scrap or salvaged timber and reused wood products.
- Materials/products made from rapidly renewable small-diameter trees and fast-growing, low-utilized species harvested within a ten-year cycle or shorter, such as bamboo
- Products made from wastes. These could be wood waste, agricultural wastes, and natural fibres, such as sisal, coir, and glass fibre in inorganic combination with gypsum, cement, and other binders.
- Use water-based acrylics for paints Use acrylics, silicones, and siliconized acrylic sealants for interior use. Use adhesives with low emissions for indoor use. It could be acrylics or phenolic resins such as phenol formaldehydes. Use water-based urethane finishes on wooden floors. Use particleboard made with phenol-formaldehyde resin rather than urea formaldehyde, to control indoor vac emissions
- Minimise the use of metallic surfaces and metallic pipes, fitting, and fixtures
- Use products and materials with reduced packaging and/or encourage manufacturers to reuse or recycle their original packaging materials

- People spend a large part of their time indoors, at home, school, and work. Hence indoor environmental quality is an important parameter in sustainable habitat. Poor indoor air quality causes headaches, tiredness, shortness of breath, and allergic reactions such as sinus congestion, irritation of the eyes and throat, sneezing, coughing, and wheezing. In some cases, an allergic reaction of the lungs (hypersensitivity pneumonitis) has also been reported. Indoor air quality is affected by ventilation rates, temperature and humidity, building materials, kind of devices used indoor (mainly unflued devices), and outdoor air pollution entering into the home. Biological contaminants also contribute to the poor indoor air quality. In Belize warm, humid conditions provide an excellent environment for breeding of dust mites, moulds, and fungi. The contaminants include animal dander, water-borne microbes, moulds, etc., all of which can cause an allergic reaction. Some organisms can contaminate water sources and become air-borne through humidifiers. Combustion by-products due to incomplete burning of fuels (oil, gas, kerosene, wood, coal, etc.) generate gases and tiny particles like carbon monoxide and respirable suspended particulate matter, nitrogen dioxide, formaldehyde, ammonia, etc, which are known to cause adverse health impacts.

4. Energy Performance

The primary function of a building envelope is to protect its occupants from sun, rain, and to provide thermal and visual comfort for work and leisure. In order to achieve comfort conditions, it is almost always essential to provide energy-consuming space conditioning and lighting devices. An eco-building should have an optimum energy performance and yet provide the desirable thermal and visual comfort. The energy usage of the built environment can be improved by better a) energy management and by b) use of renewable energy sources

Fundamental strategies that could be adopted to optimize energy performance can be broadly classified as follows:

• Reduction in energy demand

• Improving energy efficiency

Reduction in energy demand entails adoption of design measures to reduce space conditioning, lighting, and service water-heating loads. The first step to reduce the energy demand is to design for the macro and microclimate of the site by adoption of suitable bio-climatic design principles. Bio-climatic design varies from one climatic zone to the other. A building designed for a hot climate would have measures to reduce the solar gain such as, smaller window sizes; shaded walls; minimum exposure to the west and east; external wall and roof insulation; or use of design elements like solar chimneys, wind towers, etc., to maximize ventilation.

The humidity levels of a climatic zone govern the use of water-based measures for cooling of buildings. While measures like water bodies, fountains, and roof gardens are conducive for a hot-dry climate, these should be used with caution in a humid climatic zone such as Belize.

Site microclimate is an important aspect that makes building designs in the same climatic zone distinct from one another. Each building site would have distinct topography, vegetation, wind-flow pattern, solar and daylight access. The design should be able to address these site conditions and requirements.

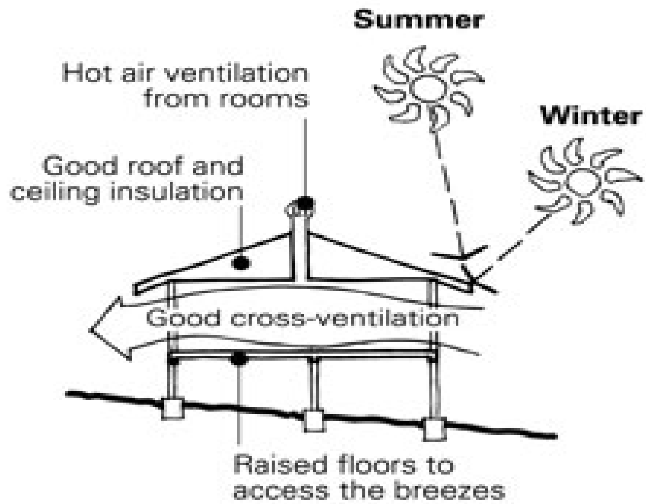
Maximizing the energy efficiency of the building system offers further opportunity for energy savings. Use of efficient lighting, air-conditioning, and service water heating systems can reduce the energy use in a building by 30% to 40%.

Environmental architecture, including passive solar design is a site-specific endeavour. The broad design areas that are considered in the context of environmental architecture are listed below.

• Sitting: It is important to properly locate the building to take maximum benefit of the sun, wind, and daylight. This includes proper orientation to enable solar access, and air flows.

• Fenestration design: Windows are a very important component of any building. They contribute to daylight and airflow, in turn, letting in heat. Hence, proper fenestration design is required to keep the heat away during the day and yet allow air flows (if desirable) and daylight.

• Passive cooling with natural ventilation: Incorporation of natural or induced ventilation strategies to enable enhancement of energy performance of buildings in most locations. In warm and wet climate high-air velocities are needed to increase the efficiency of sweat evaporation and to avoid as far as possible, discomfort due to moisture on skin and clothes.



The following are the guidelines for reducing energy demand, in terms of strategies for natural ventilation, wall/roof construction and day-lighting:

A building need not necessarily be oriented perpendicular to the prevailing outdoor wind. It may be oriented at any convenient angle between 0- 30 degrees without losing any beneficial aspect of the breeze. If the prevailing wind is from east or west, the building can be oriented at 35 degrees to the incident wind so as to diminish the solar heat sacrificing slightly the reduction in air motion indoors.

Large openings, doors, and windows are of advantage in a warm-wet climate provided they are effectively protected from penetration of solar radiation, driving rain, and intrusion of insects.

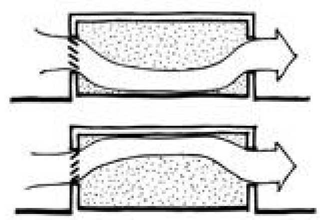
Inlet openings in buildings should be well-distributed and should be located on the wind-ward side at a low level, and outlet openings should be located on the leeward side. Inlet and outlet openings at a high level would only clear the air at that level without producing air movement at the level of occupancy.

For a total area of openings (inlet and outlet) of 20%- 30% of floor area, the average indoor wind velocity is about 30% of the outdoor velocity. Further increase in the window size increases the available velocity but not in the same proportion. In fact, even under most favourable conditions, the maximum average indoor wind speed does not exceed 40% of the outdoor velocity.

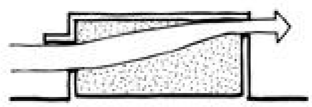
Where the direction of wind is quite constant and dependable, the size of the inlet should be kept within 30%-50% of the total area of openings and the building should be oriented perpendicular to the incident wind. Where the direction of the wind is quite variable, the openings may be arranged equally on all sides, to the extent possible. Thus, no matter what the wind direction may be, some openings would be directly exposed to the wind pressure and others to air suction and effective air movement through the building would be assured.

Windows of living rooms should open directly to an open space. In places where this is not possible, open space could be created in buildings by providing adequate courtyards. o In case of rooms with only one wall exposed to the outside, provision of two windows on that wall is preferred to that of a single window. Windows located diagonally opposite each other with the wind-ward window near the upstream corner gives better performance than other window arrangements for most building orientations.

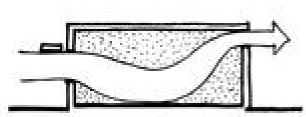
A single-side window opening can ventilate a space up to a depth of 6-7 m. With cross-ventilation, a depth up to 15 m may be naturally ventilated. Integration with an atrium or chimney to increase the 'stack effect' can also ventilate deeper plan spaces.



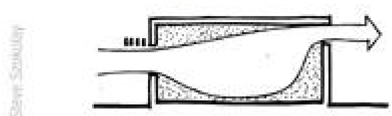
Louvres can direct airflow upward or downward.



A canopy over a window tends to direct air upward.



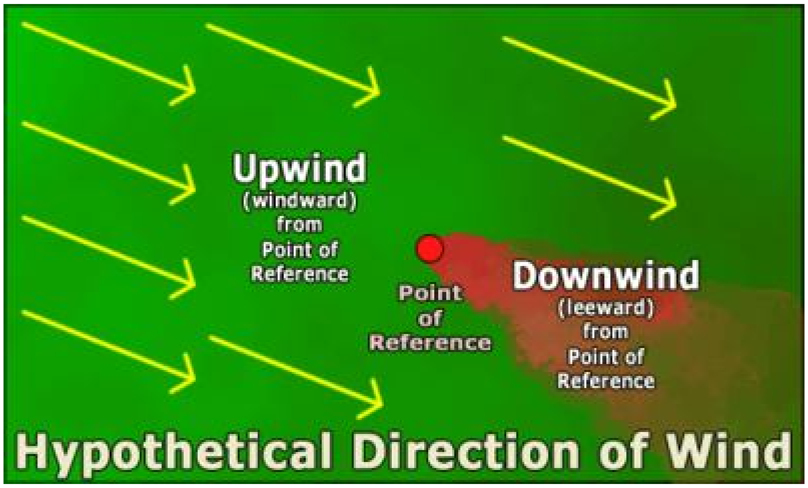
A gap between canopy and wall ensures a downward pressure.



Downward pressure is improved further in the case of a louvered sunshade.

Use window styles with 100 per cent opening area such as louvre and casement.

Horizontal louver, a sunshade atop a window, deflects the incident wind upwards and reduces air motion in the zone of occupancy. Roof overhangs help promote air motion in the working zone inside buildings. Verandas open on three sides is to be preferred as it increases room air motion with respect to the outdoor wind, for most orientations of any building.



Air motion in a building is not affected by constructing another building of equal or smaller height on the leeward side, but it is slightly reduced if the building on the leeward side is taller than the windward block.

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The ventilation indoors can be improved by constructing buildings on earth mound, having a slant surface with a slope of 10 degrees on the upstream side. Raising the building on stilts is an advantage in the warm and wet climate, it enables cooling of the floor from below, which is particularly beneficial at night.

Provision should be made for forced ventilation strategies by use of ceiling/wall-mounted fans, exhaust fans.

Hedges and shrubs deflect air away from the inlet openings and cause a reduction in the indoor air motion. These elements should not be planted up to a distance of about 8 m from the building because the induced air motion is reduced to a minimum in that case. However, air motion in the leeward part of the building can be enhanced by planting low hedges at a distance of 2 m from the building.

Trees with large foliage mass having trunks bare of branches up to the top level of the window, deflect the outdoor wind downwards and promote air motion in the leeward portion of buildings.

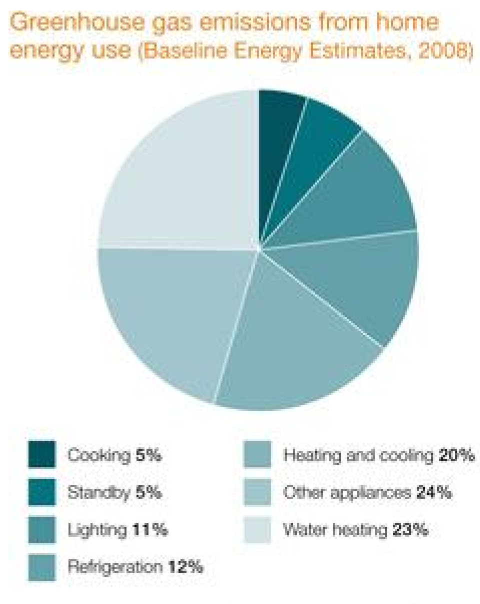
Due to the climate characteristics of warm--wet region, with small diurnal temperature range, the heat capacity of buildings should be as low as possible. This will avoid accumulation of heat in the day time and its subsequent release in the night time.

External wall with high thermal resistance is recommended to minimize the heat flow from external surfaces warmed by the sun. Wall insulation should be considered in the event of a building being air conditioned. Some commonly used wall insulation types like mineral wool slabs, polystyrene, etc could be used for this purpose.

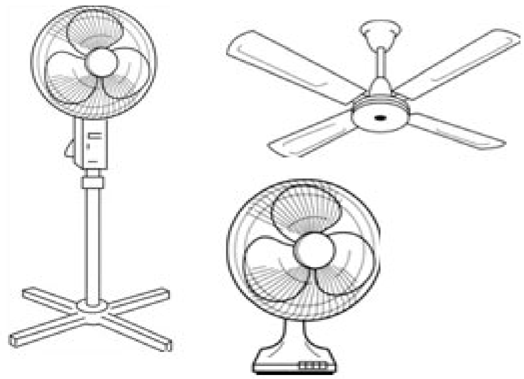
The main heat flow from roof to the space below is due to radiation. The roof could be painted with light colour, instead of a dark colour. Light colour helps reflect heat and solar. These paints are energy-efficient, energy-saving, flexible coatings, made from a water-based pure acrylic resin system. These coatings are non-toxic, friendly to the environment, and form a seamless membrane that bridges hairline cracks. They have high reflectance and high emittance as well as a very low conductivity value. Roof coats greatly reduce thermal shock and heat penetration by keeping roof surfaces much cooler in hot humid weather.

All rooms should have good access to day light. Daylight analysis for site specific conditions should be carried out. The fenestration should be optimized for day-lighting and thermal comfort. Day-lighting goals should be based on the intended usage of the room. Automated light control strategies could be applied after an analysis for integrating day-lighting and artificial lighting. Efficient glazing systems that maximize day-lighting and providing sun control should be adopted.

The main energy consuming equipments in buildings are outlined in the simple graph below. The efficiencies of these systems could vary depending on the technology used and the way they are operated and maintained. Following are few guidelines for getting the best out of them and thereby minimising energy consumption. But, never use mechanical systems to replace good design to use natural sources to reduce energy consumption.



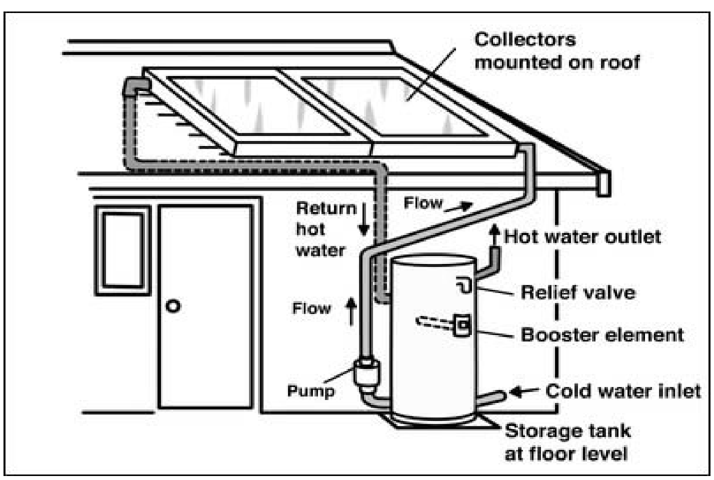
Use renewable energy-based lighting systems for internal and external lighting. Lighting power density could be restricted to 7.5 W/m2. Use Fluorescent/compact fluorescent or HID (high-intensity discharge) lamps. Apply control and automation devices, such as timers or photocells, to turn lights on and off. o Avoid excessive illumination levels inside, which will add to the cooling load inside the ·building. Only types of lighting that efficiently convert electrical energy into light, instead of heat, e.g., CFL's instead of incandescent bulbs can be used. LED lighting is another good sustainable technology.



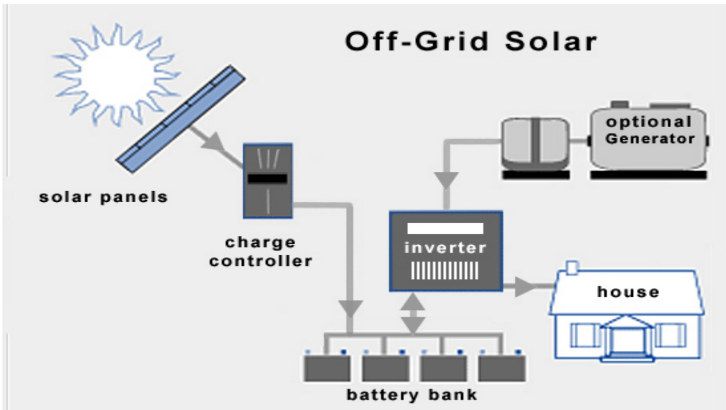
Important to remember that fans are the cheapest to run and has the least greenhouse gas impact. They do not reduce heat or humidity so good building design must complement them. They also can compliment a air conditioning system if one is needed and reduce setpoints.

Use high efficiency window air conditioners if possible. The window air conditioners have lower operating efficiencies, compared to split or central air conditioners. Window air-conditioning systems have energy-saving features, such as sleep mode and filter-clean reminder. The sleep mode feature helps to save electric energy by increasing the set temperature, when the occupants are sleeping. While sleeping, the human metabolic rate drops. The single-biggest reason for inefficiency in window air conditioners is a dirty filter. A clogged filter results in increased power consumption and poor cooling. The filter-clean reminder feature reminds the user, when the filter is to be cleaned. Though split air-conditioners are more expensive than the window type, they are preferred for their low noise levels as the noisier components are kept outside the conditioned space. Some newer split/fixed systems are becoming the most efficient way to cool indoor space. Always consider noise for your neighbours, and keep outside components out of direct sun.Water cooled AC systems should be preferred over air cooled systems.

By installing the most appropriate and efficient water heater for your household size and water use patterns you can save money and reduce greenhouse gas emissions without compromising your lifestyle. An efficient water heater may cost more to buy but it will usually pay for itself over time through energy savings. More than half of hot water use is in the bathroom, a third is in the laundry and the remainder is in the kitchen. One of the best ways to reduce your energy bills is to reduce hot water use by installing water efficient showerheads and taps – you will save on energy and water. 25-23 per cent of energy used in the home is used to heat water. Newer on-demand systems should be considered or depending on your lot solar heating water systems.



Use of renewable forms of energy, based on solar, wind, and biomass energy helps in reducing demand for polluting, conventional fossil fuel based energy. Fossil fuels supply 80 percent of the world's primary energy at present, but resource depletion and long term environmental impacts might curb their use in future. Hence policy makers are increasingly turning to renewable energy as a more sustainable option. At present renewable energy such as hydropower, solar energy, wind energy, biomass, and geothermal energy meets 13.5 percent of the global energy. All designers and owners should collaborate designs with all other owners in "Better in Belize" to plan either a standalone or distributed energy renewable energy systems. The EAB will make every effort to coordinate such activities for the ultimate benefit to the community for resource sharing and pooling.



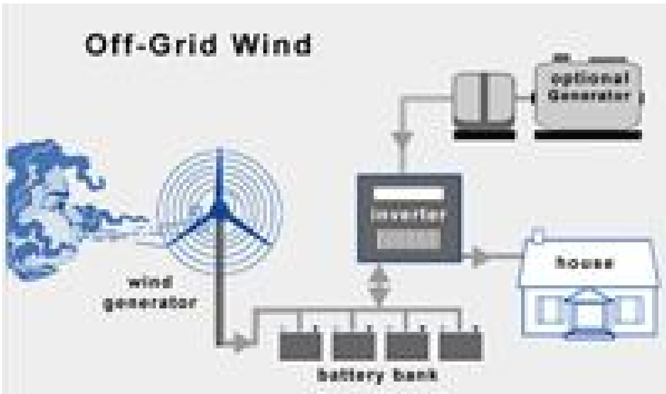
The most likely application of renewable energy in the residential sector would be based on solar, wind or biomass energy. The solar PV (photovoltaic) technology is primarily semiconductor based and is used to convert solar radiation into electricity. A PV system comprises photovoltaic modules, which collect and convert solar energy into electrical energy and the balance of systems designed to store, and deliver the generated electricity. Balance of systems includes the support structure; wiring; batteries; power electronics and controls.

Generation is possible only when the sun is shining, so a battery is needed to store electricity and use it at night or during periods of insufficient sunshine. In BIOB sales to the grid may be possible and attractive, the user could avoid the use of batteries, by using the grid as the storage medium. The user could sell electricity to the grid when demand is low, and take electricity from the grid, when demand is high. An inverter is used to convert the DC current into AC current, which is required by all common loads.

PV arrays are normally mounted on special-support structures. However, they can also be mounted on buildings or even be made an integral part of the building envelope. There are several building elements that can readily accommodate PV, such as curtain walls, atria, and roofs. In addition, new products are being developed with PV as an integral component, such as active shading elements, building glazing, or roof tiles. By definition, each BIPV product is either integrated into a building element or completely replaces existing building elements. Once put in the building context, PV can be regarded as multi functional building elements that provide both shelter and power. For instance, the BIPV as roof serves the following functions: provides structural stability and durability; provides protection against chemical and mechanical damage; provides fire prevention; protection against rain, sun, wind, and moisture; allows heat absorption and heat storage; controls diffusion of light, etc. In addition, as an electricity generator, it will meet a part of the electrical load of the building.

An important decision when considering wind power is determining whether or not your chosen site has enough wind to generate the power for your needs, whether it is available consistently, and if it is available in the season that you need it. The power available from wind varies as the cube of the wind speed. If the wind speed doubles, the power of the wind (ability to do work) increases 8 times. For example, a 10 mile per hour wind has one eighth the power of a 20 mile per hour wind. (10 x 10 x 10 =1000 versus 20 x 20 x 20 = 8000).

One of the effects of the cube rule is that a site which has an average wind speed reflecting wide swings from very low to very high velocity may have twice or more the energy potential of a site with the same average wind speed which experiences little variation. This is because the occasional high wind packs a lot of power into a short period of time. Of course, it is important that this occasional high wind come often enough to keep your batteries charged. If you are trying to provide smaller amounts of power consistently, you should use a generator that operates effectively at slower wind velocities. Generally your site needs at least 12 MPH of wind velocity.



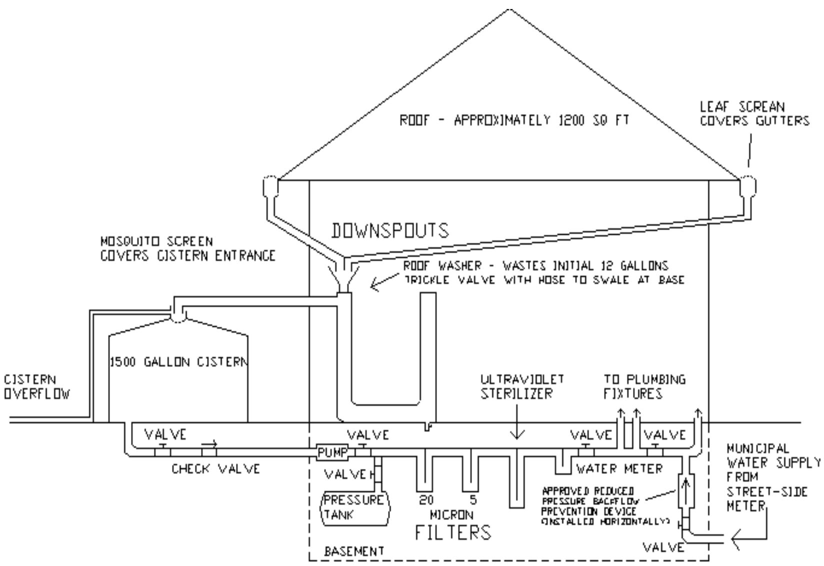
A mini-grid of distributed renewable energy sources is refers to small power plants that supply three-phase AC electricity through low-tension distribution networks to households for domestic power, commercial (for example, shops, cycle repair shops, and flour mills) activities, and community requirements such as drinking water supply and street lighting. State-of-the-art batteries and inverters are used to ensure long life and reliable field performance. An appropriately designed mini-grid can easily supply power to the community. At the local level, the village community is expected to play a critical role in facilitating payment collection, monitoring of theft, complaint redress, etc. The EAB will hold community and owners discussions about coordinating the community resources and energy plans to create such a mini-grid.

Do not buy appliances that you don't really need. If you need to buy an appliance, choose one that is the right size for your needs and is as efficient as possible. Appliance rating schemes can help you to select the most efficient appliance, such as "EnergyStar" etc. Purchase the most efficient appliance available by choosing the highest rating product. Turn appliances off when not in use, preferably at the power outlet. Many appliances continue to draw standby power when switched off, contributing up to ten per cent of household electricity use. Purchase the most efficient appliance available by choosing the highest rating for each product. Think about the best layout and placement of appliances to maximize efficiency when designing a new laundry or kitchen.

5. Water management

Water supply, water quality, and its management is an important component while designing an eco-friendly and sustainable habitat. Considering the increasing demand and limited availability of water, it is important that it be used and managed efficiently. In efficiently managing its water resources, most countries lag behind. Just alone the combined consumption of toilets, showers, and faucets is around 2/3rd of indoor water use.

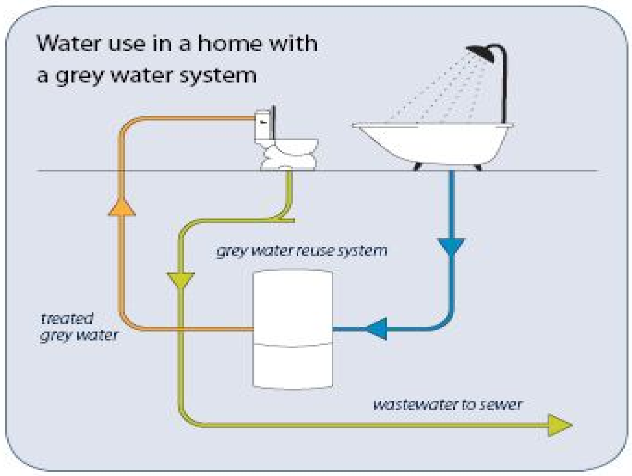
Rainwater harvesting is traditionally practised in many parts of world and is the only source of drinking water in some locations. Residents of BIB are encouraged to utilize this resource. PVC tanks are predominantly used for storing rainwater. The decision whether to store or recharge water depends on the rainfall pattern of a particular region. Belize being a high rainfall zone, rain falls throughout the year, more limited during the dry period. In this case, one can depend on storage tank.



Rainwater drainage pipes collect rainwater from roof to storage container. Appropriate precautions should be taken to prevent contamination of stored water. Mesh filters provided at mouth of drain pipe prevent leaves and debris from entering the system further, a first-flush device should be provided in the conduit before it connects to the storage container. If stored water is to be used for drinking, an appropriate filter should also be provided. Underground masonry/RCC (reinforced cement concrete) tanks/ over ground PVC tanks could be used for storage of rainwater. Each tank must have an overflow system connected to the drainage/recharge system.

The quantity of water stored in a rainwater-harvesting system depends on the size of the catchment area and the size of the storage tank which is designed based on the water requirements, rainfall, and catchment availability. Rainwater is free of mineral pollutants like fluoride and calcium salt but is likely to be contaminated by air and surface pollutants. See rainfall chart and calculation example in appendix for the Cayo district in Belize where BIB is located for calculating your rainwater system.

With appropriate treatment wastewater can be used to flush toilets, water the garden and even to wash clothes. Different types of wastewater produced in a household need to be treated differently before they can be re-used. Grey water is wastewater from non-toilet fixtures such as showers, basins and taps which does not contain human excreta. Black water is wastewater containing human excreta. Grey water from bathrooms and laundry (but not the kitchen) is the easiest to treat for reuse. Re-use of wastewater containing black water may be permissible only outdoors for subsurface irrigation after suitable on-site treatment. BIB owners should consider the use of grey water recovery systems for reusing this resource and saving potable water.



Use efficient fixtures for uniform distribution of water at the desired pressure and avoid wastage and losses. Ensure regular monitoring of both consumption patterns and quality. To minimize water consumption for flushing, low-flush toilets with a flow rate of 6 litres/flush or ultra-low-flush toilets with flow of 3.8 litres flush could be used. Composting toilets do not require any water. This is based on the biological process of conversion of solids present in human waste into enriched manure. The system consists of two chambers. After filling up of the first chamber, the usage of second chamber starts while the first chamber waste is acted upon by bacteria resulting in digested sludge, which is odourless and safe to be used as a soil fertilizer.

The use of conventional faucets results in flow rates as high as 20 lpm (litres per minute). Low-flow faucets are available which can result in withdrawal of water at a flow rate of 9.5 lpm at pressures of 80 psi (pound per square inch). In addition to this, further reduction of water consumption is possible by using auto control valves, pressure-reducing device, aerators and pressure inhibitors for constant flow, and magic eye solenoid valve self-operating valves.

6. Waste Management

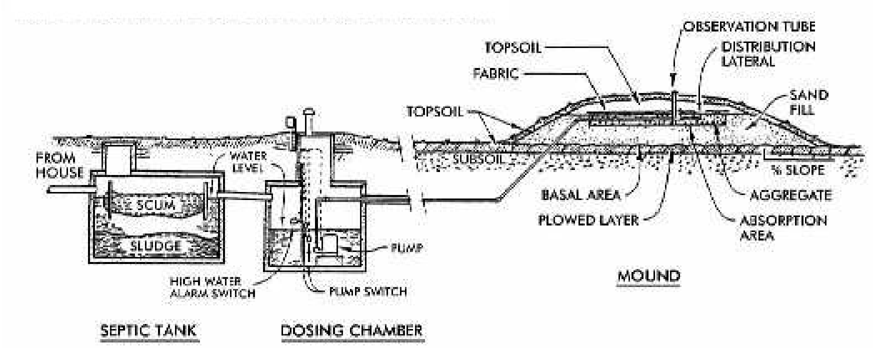
Waste generation is associated with every human activity. Waste generated from housing colonies consists of a mix of biodegradable, non-biodegradable, and inert waste. Organic wastes include vegetable, food, animal, leafy, and agriculture wastes. Municipal solid waste is usually dumped in landfill sites. This leads to air and water pollution. Through efficient waste management methods, a significant amount of solid waste entering the landfill could be diverted and reused. Natural waste decomposing is a very slow process and therefore, it is better to go for alternative technologies, such as bio-methanation. Among the various options available for treatment of the organic fraction of solid waste, bio-methanation is the most desirable because it has two benefits: it yields biogas, which can replace conventional fuels and it provides digested sludge, which can be used as organic manure.

The inorganic part of solid wastes, like paper, metals, and plastic should be diverted for recycling purposes. Recycling reduces the need to extract virgin natural resources. For this, the organic fraction of waste has to be separated, before it gets mixed with the other components forming a heterogeneous mixture that become difficult to handle. A separate bin system as per BIB guidelines should be arranged for storing non-degradable waste such as metal scrap, rubber, and recyclable wastes such as paper and plastics. These bins should be in different colours to facilitate disposal. The BIB community will be responsible for the collection of non-degradable, recyclable, and reusable waste.

Provide facilities for collection of segregated waste at the household. Identify facilities for recycling of non-biodegradable wastes such as plastics, glass, and paper. Develop decentralized treatment systems at site based on composting or anaerobic digestion process for segregated organic waste.

Identify appropriate options for use of by-products from treated organic waste, such as biogas and manure and develop norms for disposal of non-degradable and inert waste in landfills based on local standards, to ensure safe environment in the surrounding areas o Establish an efficient waste reduction, recycling, and reuse programme. Minimize toxic wastes by recycling items such as ballasts, mercury-based lighting products, used oil, unusable batteries, etc.

It is the goal of the community is to promote low-cost decentralized waste water treatment system. Designers should us towards alternative septic design which include aerobic septic systems, chemical, composting, incinerating & waterless toilets, evaporation-transpiration (ET) septic systems, septic media filters, greywater systems, holding tank septic systems, mound septics, raised bed septics, pressure dosing septic systems, sand bed filters, peat beds, constructed wetlands, wastewater lagoons, constructed wetlands, and septic disinfection systems. Alternative onsite wastewater disposal systems can reduce the soil absorption area or leach field size requirement substantially and can in fact in some cases reduce the needed area to zero. The alternative septic system designer conducts the site and soil inspection and testing, prepares the system design and installation plan, supervises the septic system construction, and certifies that the system was installed as designed.



Source: ASAE Converse and Tyler, 1998b.

Alternative septic system designs are used on difficult sites where soil conditions (such as a rocky site, limited soil percolation rate, or high ground water level), or other terrain conditions (such as limited space for a septic system or steeply sloped sites) do not permit the installation of a conventional septic tank and drainfield system. The BIB Community is such a place where traditional septic field design is not usable.

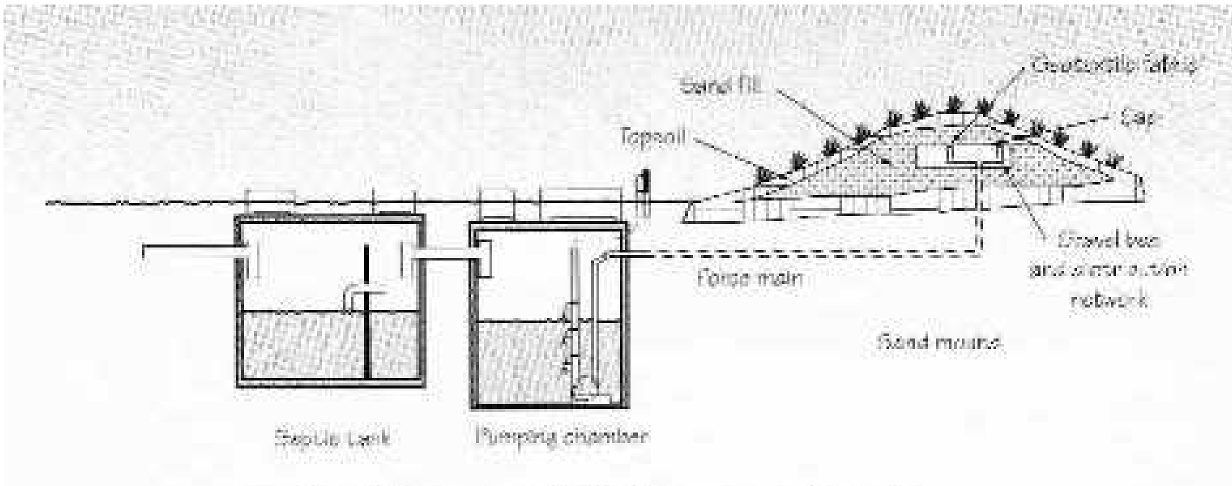


Figure 4. Illustration courtesy of the United States Environmental Protection Agency.