3.7 Design and Construction

OVERVIEW

Responses to global environmental crises such as global warming, energy security and the depletion of natural resources have driven an increasing move towards sustainable design, architecture and construction. The built environment is responsible for a major proportion of global resource use and environmental degradation, especially climate change. The design of buildings has a broad range of environmental impacts including those associated with:

· the use of energy and water,

· the loss of biodiversity from raw material extraction,

· the clearing of vegetation under the footprint of new infrastructure and,

· waste streams that emanate from construction activities and the operation of facilities.

These and related issues have been dealt with in earlier chapters in the guideline.

Many terms are used internationally to describe efforts by built environmental professionals to minimize these impacts, such as green building, eco-design, and environmental design; with the term sustainable design becoming more acceptable globally. Sustainable design encompasses the three pillars of sustainable development, namely environmental, social and economic sustainability, rather than being limited to 'green' environmental resource issues. It is not merely substituting 'greener' alternatives for resource use, materials or technologies, but represents an integrated process within architectural design.

The broad aim of sustainable design is to reduce the environmental impacts of buildings and increase the social and economic benefits during the production of building components, during the construction process, as well as during the lifecycle of the building, as follows:

- **Environmental sustainability** considers the limits of natural resources by maintaining ecological integrity, limiting the use of natural resources (including land) to a level that allows nature to regenerate, thus minimizing the use of non-renewable resources.

- **Social sustainability** is principally about ensuring stakeholder participation, user comfort and health, designing inclusive environments with broad access and providing a range of facilities, amenities and services. It also incorporates the education of labour and building users to raise awareness of environmental issues.

- **Economic sustainability** focuses on development that is viable, fair and efficient, and which occurs at a rate which does not exceed the ability of the natural and social systems to support this growth. It also supports the local economy and promotes design for adaptability and flexibility over time. A lifecycle costing approach is necessary, which takes into account not merely the capital cost of a component or technology, but the ongoing costs of operation and maintenance over a longer term period.

Why build green?

The built environment is responsible for:

- 20–30% of greenhouse gas emissions,
- 30-40% of global energy use, and
- 40% of materials entering the global economy each year are turned into building components.

At the planning phase of projects, the principles of Sustainable Planning should be applied. These principles advocate compact development with good access to public transport; mixed use development including a variety of uses (commercial, retail, residential) and design for walking and cycling. It promotes protected areas, wildlife corridors and on-site power generation and wastewater treatment.

The concepts of Sustainable Landscaping include the selection of indigenous plants that enhance biodiversity and reduce water consumption, efficient irrigation technologies, the use of vegetation to moderate the effects of climatic extremes on building users, and hard landscaping designed to allow stormwater infiltration.

Certain components used in sustainable design may cost more than conventional technology, such as photovoltaic panels for the in-situ generation of electricity. In contrast, the so-called passive design approaches actually reduce construction and operational costs by investing in a building's form and envelope (e.g. optimising building orientation, shading, and thermal performance of the building envelope) so that the heating, cooling, and lighting loads are reduced, and in turn, less costly ventila-tion and air conditioning systems are needed.

The Construction Phase

The construction phase of a project entails activities that have significant environmental impacts. In particular, the use of energy and water during construction, the production of wastes, pollution of land, air and water and impacts on biodiversity need to be mitigated and well managed. Procurement methods should ensure that sustainable materials from local sources are used as far as possible. As a condition of approval in terms of environmental legislation, projects may be required to implement an Environmental Management Plan (EMP) under the supervision of an Environmental Site Manager (ESM). Ideally, an EMP should be subject to periodic audit by an independent environmental consultant. An EMP must be included in the package of tender documents issued to contractors and it then becomes part of a binding contractual agreement with the main contractor. The City of Cape Town's (CoCT) generic EMP for civil engineering construction projects even requires the contractor to appoint an Environmental Representative who interacts with the ESM in ensuring sound environmental management of construction. The full EMP can be obtained from the City of Cape Town, free of charge, by e-mailing: enviro@capetown.gov.za.

Guidelines and Assessment Methods

There are no universal solutions for the design of sustainable buildings, as each context will have appropriate local responses. General guidelines should be adjusted to the specific climatic, environmental, economic and social conditions of the location. The local availability of materials, products and services and locally appropriate technologies should also be taken into account.

There are sustainability assessment tools for the built environment available in many countries, including South Africa, that provide guidance and a broad range of strategies, checklists and indicators towards achieving a sustainable design. Some have a bias towards 'green' environmental issues and tend not to deal with socio-economic aspects. The South African context requires a unique balance between environmental, social and

Photovoltaic panels at BP Head Office, Cape Town

economic issues. Moreover, each project will have different priorities depending on the local context and the values/ vision of the project team and other participants.

Examples of assessment tools include:

- **LEED** (Leadership in Energy and Environmental Design), United States Green Building Council
- **BREEAM** (Building Research Establishment Environmental Assessment Method), The Building Research Establishment (BRE), United Kingdom
- **Green Star** rating system, Green Building Council of Australia
- **SBAT** (Sustainable Building Assessment Tool), CSIR, South Africa.

Review of Greening Status of the Stadia for the 2010 World Cup South Africa, May 2008

A consulting team was commissioned by DEAT to undertake a review of the greening status of stadia in Cape Town and Durban, being constructed for the 2010 World Cup in South Africa. The Review lists all the greening initiatives included in the design for stadia relating to water, energy, waste, materials and rates these against the criteria of 'good practice', 'best practice' and 'cutting edge'. Cutting edge initiatives include:

- A hybrid pitch, which is a combination of synthetic and natural grass requiring 50% less irrigation (potential saving of R78,975 per annum)
- Water-cooled variable refrigerant cooling system
- Carbon dioxide monitors in the parking garage to switch fans on only when required,
- Low emitting finishes

Best practice initiatives include:

- Rainwater harvesting from detention pond for irrigation (potential saving of R187,725 per annum)
- A mesh fabric facade, combined with insulated panels that reduces heat gain while allowing breezes through for natural ventilation
- Purchase of 'green energy' for stadia
- Reuse of demolition material from the old stadium.

The Review finds that most of the 'low hanging fruit' initiatives have been included in the stadia designs. The limitations in financial feasibility that arise due to the short operating hours of stadia, making the pay-back period for green technologies much longer than for other building types, are acknowledged. During the design phase of the stadia many sustainability interventions had been considered by the design teams, but were not implemented due to a lack of funding.

Stadium specific recommendations are made for further greening and these are prioritised as 'must have', 'should have' and 'nice to have'. For example, for Green Point Stadium the Review recommends the inclusion of 'must have' features, namely a Building Management System (BMS), and sub-metering of water and electricity allowing monitoring of consumption. The list of 'should haves' includes a sewer treatment facility, solar water heaters, intelligent or drip irrigation systems, and recycled plastic seating. Waterless urinals and PV for lighting are listed as 'nice to haves'. The proposed initiatives are assessed in terms of their environmental impact (resource conservation), economic feasibility and barriers to practical implementation.

Source: DEAT 2008 Review of Greening Status of the Stadia for the 2010 World Cup South Africa: Fact-finding mission and desktop review. Final draft, May 2008

Challenges in Achieving Sustainable Buildings

An important factor in achieving a sustainable building is defining a common vision and promoting inter-disciplinary collaboration amongst the design professionals in the project team, the owners and users of a building, and a range of interested and affected parties. Without this approach, non-conventional design proposals are not likely to receive adequate support and may fail to come to fruition. The common vision should be driven by the client or building owner and be captured in a 'Sustainable Design Brief' that should be developed prior to commencing the conceptual design. Without this brief and in the absence of legislation, there may be little incentive for the design team to move away from conventional approaches. The brief should include specific performance targets where available and applicable, for example, average annual energy consumption should not exceed 300kWh/m·a. When considering project timeframes, the project team should anticipate that research and evaluation of design or technological alternatives are likely to take additional time and resources.

Achieving a sustainable design requires a life-cycle approach to costing, including both capital cost and ongoing operational and maintenance costs, in order to ensure that budget is made available for sustainable construction and technologies. Taking a short-term view is unlikely to result in more capital intensive solutions appearing economically feasible.

Motivating non-conventional design approaches is more readily achieved by highlighting the benefits of sustainable buildings, which include:

- More productive, comfortable and healthy living and working environments
- Reduced long-term maintenance and energy costs
- Compliance with legislation
- Avoiding the costs of retrofitting to achieve compliance and
- Marketing differentiation, by making it easier to secure operators, tenants, buyers (applicable for sports facilities?)

The main drivers of sustainable design include environmental benefits and a reduction in running costs. Increasing pressure can be expected from the adoption by central and local government of regulations to enforce compliance with sustainability policies.

New and innovative approaches to payment of professional fees may be necessary for sustainable designs. For example, the Eastgate Centre in Harare was cheaper to build than a conventionally air conditioned, high rise building because of its passive thermal design. The reduced cost would have resulted in lower fees for the design team, who typically get paid a set percentage of building cost. A new fee structure was negotiated to adequately compensate the design team for the extra time and expense involved in the research and development of this innovative building.

Sporting Events and Sustainable Design

Major sports events typically require the erection of new sports facilities or upgrading of existing facilities, where sustainable design strategies should be set as a requirement by the organising body. This requirement should also apply to the construction of temporary structures for outdoor events, such as communication towers, spectator stands, and ablutions facilities. The design of associated urban parks should be guided by sustainable landscaping principles.

Green Buildings in South Africa

Until recently, there has been little awareness and few examples of sustainable buildings in South Africa. In the last few years, however, there has been an increasing shift towards this approach in keeping with international trends. A South African Green Building Council was recently established and their aim is to develop a Green Rating system based on the Australian Green Star model. The system would initially be voluntary, allowing project teams to evaluate the degree of sustainability achieved. At the local level some municipalities have initiated green building guidelines that are intended to be voluntary initially, but that can be expected to become mandatory in due course[35].

South Africa has specific, critical issues relating to resource efficiency, in particular electricity supply and energy security, water supply, water quality and landfill space. Please refer to the accompanying sections on Climate Change and Energy, Water, and Waste.

Legislation and Policy

International commitments

- Agenda 21
- Habitat Agenda
- Millennium Development Goals
- Johannesburg Plan of Implementation of the World Summit for Sustainable Development

National Legislation

- National Environmental Management Act, NEMA (Act 107 of 1998)
- NEMA: Environmental Impact Assessment Regulations, 2006

OBJECTIVES

The key objectives with respect to sustainable design and construction are to achieve:

1. Environmental sustainability
2. Social sustainability
3. Economic sustainability.

Objective 1: Environmental Sustainability

Achieving environmental sustainability in building design and construction begins with site selection followed by the location of a building or facility on the chosen site. Existing natural habitats on the site should be seen as a resource that can add value to a project and should be conserved and even enhanced. The use of all resources should be minimised including energy, water, materials and land. Sporting facilities provide an opportunity for the use of renewable energy, either by on-site generation using photovoltaic panels or wind turbines, or off-site though 'Green Energy Certificates' (Refer to Text box on page 14 in the Climate Change and Energy Section). Purchasing Green Energy certi-ficates avoids the cost of new infra-structure to provide on-site renewable energy. Alternative waste water technologies can be employed to recycle greywater for irrigation and flushing of toilets, reducing the use of potable water. Stormwater runoff from a site to muni-cipal drains should be minimised to recharge groundwater and promote a more natural water cycle. Infiltration of stormwater on site can be maximised by using permeable paving, retention ponds, swales and other storage structures. A number of the stadia for the FIFA World Cup™ in Germany installed stormwater storage systems (Figure 1) underneath the playing fields to harvest rainwater for reuse or to recharge groundwater [36].

35 The City of Cape Town initiated a process of developing Green Building Guidelines in 2006.

Johannesburg, South Africa

Materials selection should be guided by a range of criteria that need to be balanced or traded-off against each other, taking into consideration other project criteria such as cost, maintenance and aesthetics. This balancing process can be aided by using guidelines such as the BRE '*Green Guide to Specification*' [37]. Criteria include the use of renewable or recycled materials, materials and products with low embodied energy (see Info Box on Embodied Energy), indoor air quality, pollution in manufacture and minimizing fossil fuel consumption.

Objective 2:
Social sustainability

Social considerations are less tangible than resource issues, and not driven by cost considerations, so it is important that they be highlighted and acknowledged in the process of project planning, design development, construction and in the operational phase. At the planning stage, participation by the intended users should be facilitated, so that users can express their needs. Designs can promote inclusive environments by providing access for the disabled, and by providing a range of services such as internet access, banking and good access to public transport. A high priority should be given to designing healthy, comfortable and safe living and working environments through good ventilation, daylighting and views, noise reduction and good security. Opportunities to provide skills development arise in the construction phase, including induction of site staff on environmental issues. Once operational, communication about the sustainable design strategies adopted in a building can be achieved through interpretive signage and by making the interventions visible.

Objective 3:
Economic sustainability

Local economic development is an important objective in the South African context, and involves the use of local labour, materials and components, and the support of small, emerging businesses. Designs which allow for adaptability and flexibility of use over the lifespan of the building – to accommodate the changing needs of users over time – ensure optimum use of the resources originally used in the structure. A lack of adaptability to changed patterns of use can result in demolition and rebuilding which is wasteful of resources. Design decisions should be in informed by the ongoing, long-term costs of operation and maintenance.

Embodied Energy

The embodied energy of building materials and products is defined as the non-renewable energy consumed in the mining and transportation of raw materials, processing and manufacturing, transportation to site and incorporation in the building during construction.

[36] FIFA (2006) Green Goal Legacy Report

[37] BRE (2002) Green guide to Specification: An Environmental Profiling System for Building Materials and Components, 3rd edition

STRATEGIES

The strategies contained in this section are derived from international and local precedent as per the following sustainability assessments methods, namely, LEED, BREAAM, Green Star and SBAT. These primary sources should be referred to for more detailed guidance, including specific indicators.

1. Environmental sustainability

- Site:

- Protect and enhance the natural environment on the site to provide habitat and promote biodiversity.
- Minimise damage to sensitive landscapes, e.g. wetlands.
- Minimise the building footprint to conserve land.
- Provide as much indigenous vegetation on site as possible.
- Rehabilitate contaminated sites before construction commences.
- Control erosion and sand transport during construction to reduce impacts on water and air quality.
- Retain topsoil and valuable plants and set aside for reuse and replanting.

- Water use:

- Minimise the use of potable water.
- Install water efficient devices, e.g. waterless urinals, low flush toilets, and low-flow shower heads and taps.
- Install flow meters to monitor consumption and leaks. Measure the water consumption and compare to predicted consumption.
- Adopt a water management strategy during construction.
- Harvest rainwater and store for use in irrigation or flushing of toilets.

- Waste water:

- Adopt innovative waste water technologies to reduce generation of waste water and recycle waste water to reduce potable water demand, e.g. Greywater reuse, biological filtration (Biolytix), reed beds filtration.

- Stormwater:

- Minimise run-off using permeable paving that allows infiltration.
- Collect stormwater on site in retention ponds or storage structures and allow infiltration or use for irrigation.

- Landscaping:

- Select plants and irrigation systems to reduce water use, e.g. drip irrigation.
- Select indigenous and endemic plants that promote biodiversity.
- Provide areas of habitat on site, e.g. ponds and refuges in landscaping structures for invertebrates.

- Energy and Atmosphere:

- Design for passive ventilation, cooling and heating and minimise the use of conventional air-conditioning systems.
- Design the building envelope to achieve thermal performance in accordance with best practice.
- Optimise use of natural lighting, and install energy-efficient lighting appli-ances and controls such as movement sensors to reduce energy use.
- Maximise the use of renewable energy systems, e.g. solar water heating, small wind turbines, and photovoltaic panels.
- Avoid the use of ozone depleting substances in air-conditioning or fire equipment, or in the production of materials, e.g. thermal insulation.
- Provide facilities for cyclists to encourage non-mechanised transport, e.g. secure bicycle storage and provision of showers.
- Model the building during design to predict energy consumption. Install easily accessible measurement equipment that can be used for regular data collection, communication and display of information.

- Materials:

- Reuse and adapt existing structures wherever possible to conserve resources.
- Select most sustainable materials and products available that meet a range of sustainability criteria, such as maxi-mizing use of renewable, recycled, low embodied energy, and non-toxic materials, and minimizing pollution in manufacture and fossil fuel consumption.

- Waste:

- Design adequate facilities for waste recycling and management.
- Implement a waste management plan during construction and divert as much waste from landfill as possible by reducing waste, reusing materials for fill or recycling.

2. Social sustainability

- User comfort:

- Provide adequate daylighting, effective solar and glare control.
- Provide adequate fresh air supply to ensure indoor air quality is to acceptable standards.
- Provide adequate security lighting.

- Healthy indoor environments:

- Consider physical health when specifying materials and finishes, e.g. paints that reduce emissions of toxic compounds such as formaldehyde and Volatile Organic Compounds (VOCs).

- Safety:

- Comply with all legislation on the construction site and within the building.

· Inclusive environments:

- Design for environmental control by users, e.g. vents, shading devices, and operable windows.
- Facilitate consultation with all stakeholders during the design process.
- Provide a User Manual that explains the sustainability features.
- Make provision for disabled access.
- Locate the building close to public transport.
- Provide a range of services including retail, banking, communication and recreation.
- Participation and control by users, e.g. consultative design process, and user operated sun control devices.

- Education:

- Provide construction skills training and induction on environmental management on site.
- Make the sustainability strategies visible to the building users.

3. Economic sustainability

- Local economic development

- Use local contractors and labour (within 100km of the site).
- Ensure that the construction employee mix reflects the Equity Act requirements.
- Use locally procured building material and components.
- Support small manufacturers and contractors.

- Efficiency of use

- Maximise the proportion of 'usable' to 'non-usable' space (circulation).

- Adaptability and flexibility

- Design spaces that are adaptable for different uses.
- Configure services to allow for different internal arrangements.
- Employ structural systems that allow easy renovation.

- Ongoing costs

- Consider ongoing costs in the specification of materials and equipment to enhance serviceability of components over life of building.
- Install meters to allow for easy monitoring of costs energy and water consumption.
- Display information on consumption of resources and waste production, e.g. integrated electronic notice boards.

Stadium Australia, Sydney Olympics

Stadium Australia, built for the Sydney Olympic Games in 2000, achieved sustainable standards far above those of conventional stadia at the time. A wide range of innovative design approaches and technologies achieved the following key results in comparison to conventional stadia:

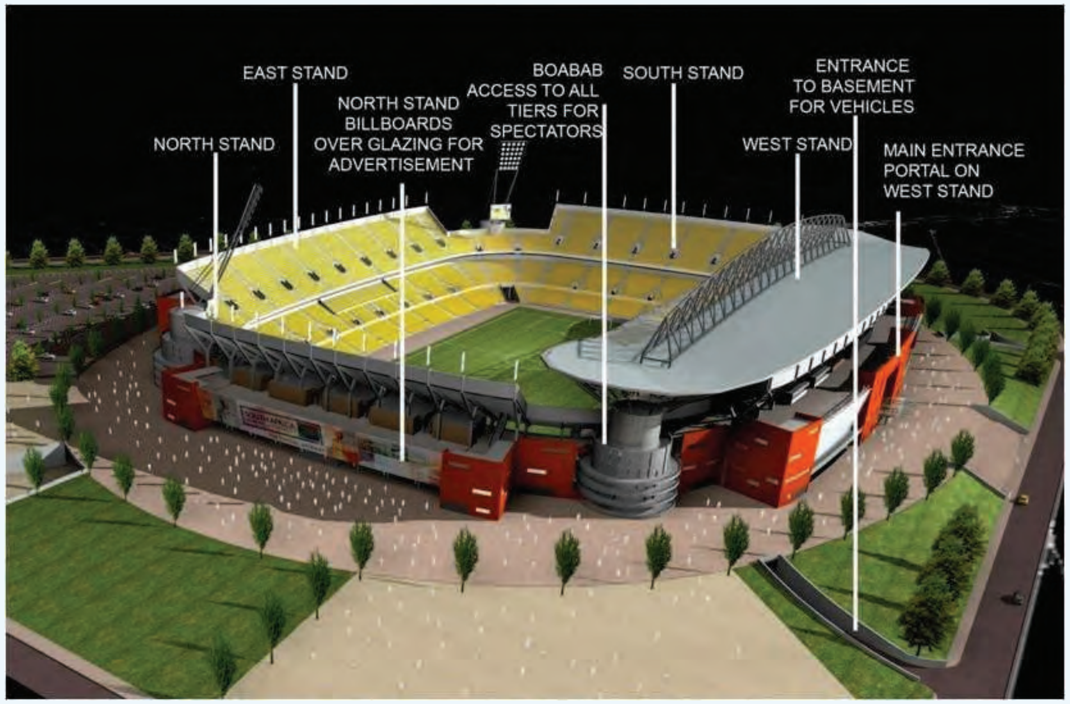
- 30% reduction in energy use
- 37% reduction in greenhouse gas emissions
- 13% reduction in water use with 77% of water used either recycled or collected on site

Energy usage is reduced by the natural ventilation of major spaces in the stands, a move which cuts air-conditioning requirements; installing energy efficient lighting and electrical fixtures; and using 'gas co-generation' plants to simultaneously produce both hot water and electricity from gas. The natural ventilation system utilises the natural buoyancy of warm air to expel rising air at high levels in the stands, and pull in cooler external air at low levels in individual rooms.

On summer nights, the louvres in these spaces automatically open to allow cool air in through the building, thus reducing the temperature of the structure. The following day the spaces are cool and the louvres are closed to emit hot external air. This process is known as 'night flushing'.

Stadium Australia not only reduces energy use, but the energy that it purchases is 'Green Energy' meaning that it is produced using renewable technologies such as solar and wind, that do not emit greenhouse gases.

Rainwater is collected off the roofs of the Stadium and stored for cleaning and pitch irrigation, which both involve high water consumption. In addition the Stadium has 'dual water reticulation' enabling the more precious drinking water to only be used where necessary, and other 'grey' water to be used for toilets and cleaning.



Artists impression of the new Peter Mokaba Stadium, Polokwane

Source: Environment Australia (2000) Greening the Games: Australia Creating Sustainable Solutions for a New Millennium

Green roof on Tsoga Environmental Education Centre, Samor CT

MONITORING

Project-specific indicators for the success of each objective will need to be identified. Examples of indicators that could be used to measure success in achieving that relate to Sustainable Buildings are provided in the Table below:

TABLE 3.7.1.: Sample Sustainable Building Monitoring and Evaluation Indicators

OBJECTIVE	INDICATOR	TARGET	RESULT	COMMENT RE SUCCESS
Minimise energy use	% of operating energy from renewable primary energy sources, both off-site and on-site	20%	18%	On site wind turbines proved to be effective and affordable
	Reduction in electricity consumption over baseline study before event	20%	15%	Moderate success. Challenges: required air-conditioning in spectator suites
Minimise water consumption	% reduction in water use over baseline	20%	25%	Very successful due to retrofit and behavioural change
	% of non-potable water used (greywater, rainwater, and treated effluent) of total water used for event	25%	12%	Moderate success. Challenges: high cost of water storage
Local economic development	% of total cost spent on local contractors	50%	40%	Shortage of local labour was a minor challenge

3.8 Other Related Areas

The following two related areas have also been identified as important aspects in the greening of large sports events:

- Accommodation
- Health and Wellbeing

3.8.1 Accommodation

OVERVIEW

The service sectors such as tourism have traditionally been behind in embracing the concepts of eco-efficiency. However, tourism is the largest and fastest growing industry in the world, and thus environmental impact, as well as the opportunity to do things differently, is substantial. The 2010 FIFA World Cup™ to be held in South Africa adds an urgency to this environmental focus, as the industry will need to improve its profile in this regard substantially for the event. Although the South Africa tourism industry has emerged to maturity, and its rapid growth is fuelling the national economy (GDP contribution now larger than gold), little headway has been made in terms of either understanding its impact on the environment or, better still, minimising and monitoring this impact.

While there is an increasing presence of accreditation systems internationally, within South Africa there are still relatively few players working in this area, and efforts have not been coordinated. It is in the tourism industry's interests, and in national interest, that a green accreditation system is consistent, and that a proliferation of different systems or approaches is avoided.

International experience shows that such proliferation is usually not advantageous to all involved – leading to lower brand recognition and industry buy-in. Recent work studies in the South Africa Tourism and hospitality industry confirms that there are substantial opportunities for improving environmental and sustainability profile in a cost effective manner, and that knowledge of sustainability is generally lacking amongst hotels and other hospitality establishments.

An important national motivation for the hospitality industry is the upcoming 2010 FIFA World Cup™ in South Africa. Efforts to improve the environmental profile of the 2006 event in Germany through the "Green Goal" programme showed that hospitality is one of the three big focus areas for such initiatives – with transport and stadia being the other key areas. A green rating system will also support the National Cleaner Production Strategy which the National Cleaner Production Centre is moving to implement.[38]

A **"green rating system"** for the hospitality industry in South Africa will:

- Provide marketing benefits to hotel guests and offer the choice to support businesses that are environmentally and socially rated
- Facilitate a more competitive operation as many interventions are highly cost effective
- Lower operating costs and facilitate market access for small entrepreneurs
- Support local and national efforts to move towards a responsible and sustainable economy