Building for the future

A United Nations showcase in Nairobi

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Building for the future

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UN HABITAT

UNEP

UNITED NATIONS OFFICE AT NAIROBI
unon The UN Headquarters in Africa

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" In combating climate change the United Nations should lead by example."

Ban Ki-moon
United Nations Secretary-General

foreword

The new office facility in Nairobi, which houses the headquarters of both the United Nations Environment Programme (UNEP) and the United Nations Human Settlements Programme (UN-HABITAT), may well be a first in sub-Saharan Africa.

With 6,000 square metres of solar panels, energy saving lighting, natural ventilation systems and other green features, the office is designed to generate as much electricity as its 1,200 occupants consume.

The logic is simple and compelling: the building sector is the single largest contributor to global greenhouse gas emissions with one third of global energy use taking place in offices and homes – a figure that is set to double by 2030 unless urgent action is taken.

So the design and construction of new buildings – and the refitting of existing ones – represents one of the key, low cost ways of combating climate change while reducing electricity bills and dependence on fossil fuels.

Along with green transportation, buildings are thus a central part of a transition to a Green Economy and a sustainable 21st century.

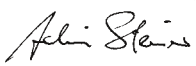
Our new office building is the result of a committed partnership between the United Nations Office at Nairobi, UN-HABITAT, UNEP, local architects and contractors, and international technology firms.

It is a practical and impressive expression of the United Nations desire to green its operations as part of the Sustainable United Nations initiative.

And as a smart, green building in Africa, the benefits of its 21st century technology for now and the future are a cause for some celebration.

This is a working building but it is also in many ways a research facility and a sustainable building showcase.

We invite other United Nations duty stations, and architects and planners from Kenya, across the continent and beyond, to come, learn and become part of a community that is helping sustainable buildings to play their role in a greener future.



Achim Steiner
Director-General United Nations Office at Nairobi
Executive Director United Nations Environment Programme
February 2011

























introduction

When the United Nations outgrew the office accommodation at its 140-acre Gigiri compound in Nairobi, it was clear that any new building had to meet several challenges head-on. It needed to be energy and water efficient, to reduce and recycle, and to maximize sustainability without compromising the quality of the working environment.

Buildings are an intrinsic part of our lives. The shelter they provide is enshrined in the Universal Declaration of Human Rights, and those of us who spend our working lives in offices know that buildings – in the form of a well-designed working environment – also have a significant influence on productivity, health and contentment.

But buildings are also responsible for more than one third of global energy use and are – in most countries – the largest source of greenhouse gas emissions. The Intergovernmental Panel on Climate Change estimates that emissions from buildings will rise to 11.1 billion tonnes by 2020. The manufacture of building materials contributes a further 4 billion tonnes of CO_2 emissions annually, a figure that is increasing with the continuing rise in construction globally, most of it in developing countries.

The ambitious goal was to make the new building energy neutral, where the electricity requirements of the building and its occupants are met over the year by the power generated by solar panels. In this the designers and project team were helped by the location of the building. There are many who say that Nairobi enjoys an almost perfect climate. Situated almost 1,800 m above sea level and just south of the equator, it benefits from warm, sunny days and cool evenings, and while the two rainy seasons and its 'winter' in July and August bring cloud and cooler weather, with good design there is no need for either heating or cooling in Nairobi's buildings.

The United Nations compound is a beautiful 'green lung' on the outskirts of Kenya's capital city. More than 600 indigenous tree species are found there, as well as many species of birds and small mammals. Already rainwater is harvested, waste water recycled, and wetlands maintained. All buildings are cooled by natural ventilation, and office waste is separated and recycled.

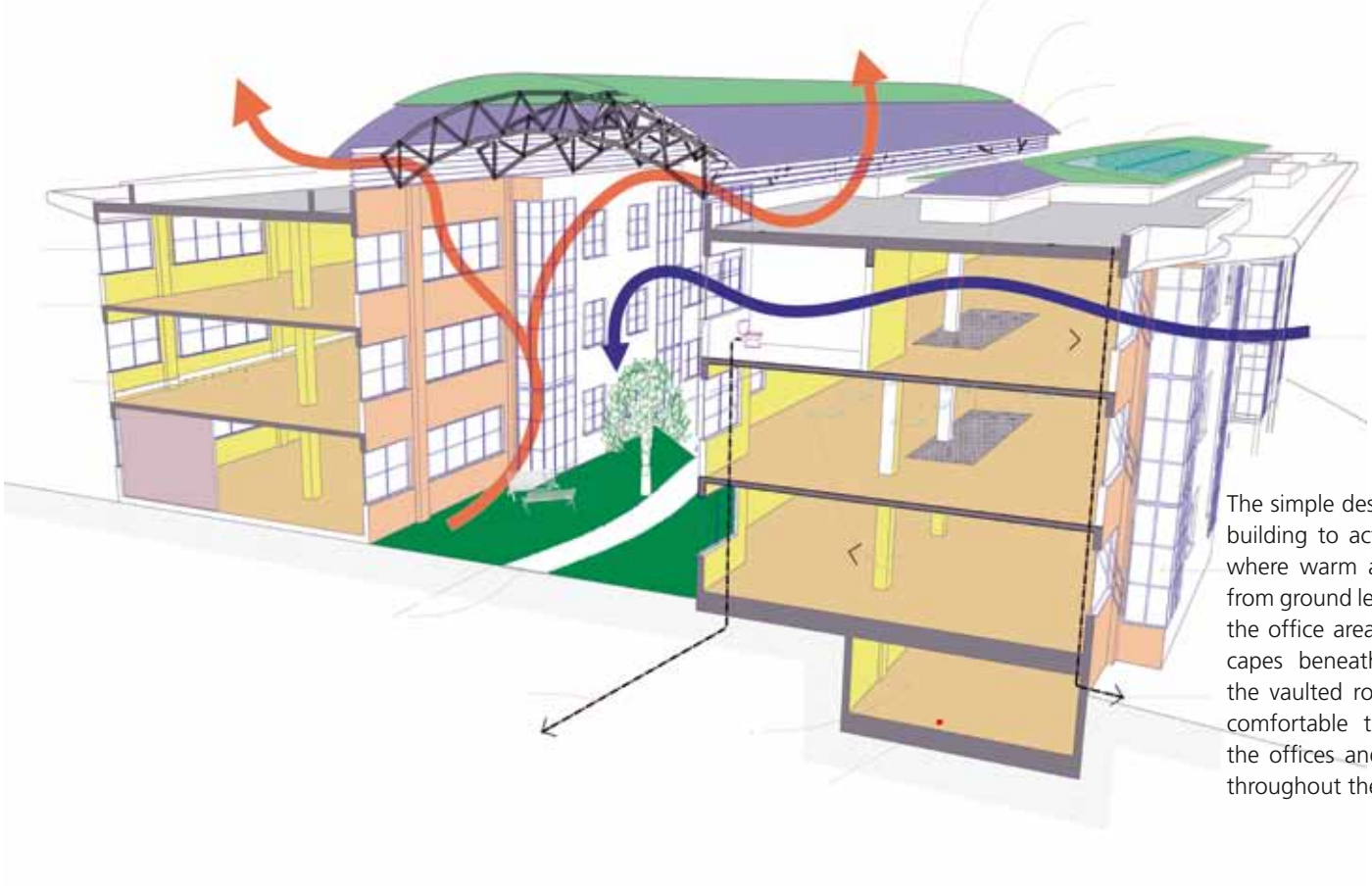
But the new building takes environmental sustainability to a new level. Four buildings, linked by airy walkways, flooded with natural light, and with green areas individually landscaped and themed, can accommodate 1,200 staff. Solar panels cover the roof space, automated low energy lighting illuminates workspaces, and energy efficient computers sit on desks. Rainwater is collected from the roofs to feed the fountains and ponds at the four entrances, and sewage is treated in a state-of-the-art aeration system and recycled to irrigate the beautifully landscaped compound. Water saving lavatories, a central atrium and lightwells in every office zone, together with an inventive design that maximizes cooling natural airflow through the building, all contribute further to sustainability. And far from compromising the working environment, the new building and its environmentally responsible features are acknowledged to be a huge enhancement of the surroundings and comfort in which its new occupants work.

There were those who doubted it would be possible to bring in such an ambitious project on time and in budget, and they have been proved decisively wrong. Instead the new office facility has become an international showcase for sustainable buildings, and a central pillar of the United Nations broader goal of reducing its greenhouse gas emissions.

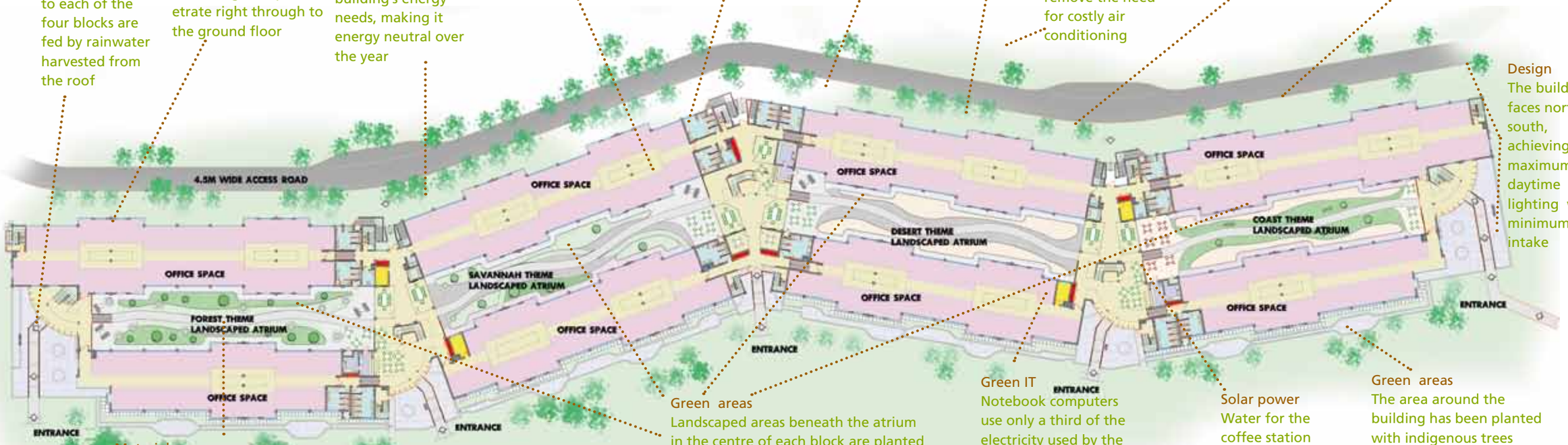
The new office facility in Nairobi is the perfect opportunity for UNEP and UN-HABITAT to walk the talk on sustainable buildings and climate change.

"The new building is a showcase for sustainability and a huge enhancement of the working environment."
Stephen Stannah, Chief Facilities, UNON

environmental features at a glance



The simple design enables the building to act as a chimney, where warm air is drawn up from ground level and through the office areas, and then escapes beneath the sides of the vaulted roof, maintaining comfortable temperatures in the offices and air circulation throughout the building.



Water
Water features at the entrance to each of the four blocks are fed by rainwater harvested from the roof

Lighting
Glazed roof lights are set into the building's flat roof, and toughened glass set at floor level beneath them on each floor, enabling natural light to penetrate right through to the ground floor

Solar power
Solar panels cover the roof space and will generate all the building's energy needs, making it energy neutral over the year

Light and ventilation
A central atrium runs the length of the building, allowing natural light to flood into offices, while encouraging airflow and comfortable internal temperatures by drawing warm air up and out of the building (see left)

Water
Water saving taps and lavatories will reduce water consumption. Waste water is treated in a state-of-the-art on site aeration facility and the clean water used to irrigate the landscaped compound

Lighting
Low energy fluorescent lighting, together with a daylight sensing and presence detection system significantly reduces energy use while ensuring adequate light to work by

Ventilation
Open plan offices help air circulation and temperature control, and also encourage a more cooperative working environment

Technology
Data centres that use air and cool water to maintain server temperatures remove the need for costly air conditioning

Water
Rainwater is collected from the roof and used to irrigate the landscaped areas around the building. No fresh water will be needed to irrigate the planted areas.

Ventilation
Windows can be opened and closed for temperature regulation, while high quality solar glass insulates the building against heat and cold

Design
The building faces north-south, achieving maximum daytime lighting with minimum heat intake

Materials
The carpet has a very high recycled content and is 100 per cent recyclable, and all paints are environmentally friendly

Green areas
Landscaped areas beneath the atrium in the centre of each block are planted to need minimal water, to encourage biodiversity, and to create cool and beautiful interior gardens

Green IT
Notebook computers use only a third of the electricity used by the desktop PCs they are replacing throughout the building

Solar power
Water for the coffee station kitchens is solar heated

Green areas
The area around the building has been planted with indigenous trees

architecture

When the opportunity arose to design a functioning office facility that would also be a showcase sustainable building for Africa, Nairobi architects Beglin Woods jumped at the chance.

Says partner, Simon Woods, "It was a chance to show that you can really enhance the working environment while making the building as green as possible. From the earliest stages of design this shaped our ideas and decisions, and of course to be able to do it in such a favourable climate as Nairobi was ideal."

Nairobi temperatures are typically in the mid-20s Celsius, and the building uses this benevolent climate to maximum effect, with natural heating and cooling, abundant natural light, and solar energy. Construction used as many renewable and recycled materials as possible to minimize energy use and hazards to human health, and local materials were selected when available in order to avoid excessive emissions caused by transport.

The construction process itself was exemplary. When the architecture tender was approved and the design finalized, contractors mobilized in April 2009 and the ambitious sustainable project was completed on time and in budget in December 2010. The contractors set up a green construction site, sorting waste and minimizing the impact on the surrounding environment and landscaping.

"We had an excellent working relationship with the building contractor," says Woods. "One of the most enjoyable elements of the whole project was the exchange of ideas on materials, techniques and fittings to make the building as energy efficient as possible."

Where local materials were not a viable option, the highest quality materials were imported from elsewhere. These include the frameless curved glass and spider fittings on the stunning, full height, east and west entrances; the solar glass in the windows that limits solar penetration and insulates the building – helping to keep it cool in hot weather and warm in cold weather; the maintenance-free external wall covering; and the dual flush lavatory cisterns that will cut water use in bathrooms by up to 60 per cent.

The main entrances are through light and airy atrium spaces, where coffee stations are also located. Each block and floor is interconnected by spacious central staircases and walkways with views over the interior landscaped gardens. Footpaths through these themed gardens also provide horizontal access to the building without disturbing office areas. All office wings benefit from a centrally monitored access control system, which identifies everyone who has entered or left the building.

"There's no doubt it is a fantastic working environment," concludes Woods. "Without doubt one of the best on the continent."

key facts

- Local is often best: a local architect is familiar with the climate and conditions, and knows the best contractors and where to source materials
- The design works best when offices are left open plan, but has the flexibility to accommodate individual offices and private meeting spaces too
- Nobody has all the answers: cooperation and sharing of ideas led to many of the best features of the building
- Making a building sustainable can have a huge positive impact on the working environment, as well as on running and maintenance costs

energy neutrality

"Nairobi is the headquarters of UNEP, so of course the building has to be green. It's a showcase. Energy neutrality is a key part of that goal."

So says Rob de Jong, whose role was to lead efforts to maximize the sustainability of the new office facility.

The first step to achieving energy neutrality – whereby all power used by the building and its occupants over the year is met by renewable sources – was to assess the amount of electricity that could be generated by covering the roof with solar panels. With that figure established at 750,000 kilowatt hours (kWh) per year, Rob and his team looked at ways of meeting the needs of 1,200 staff, their computers and associated IT, lighting, and other miscellaneous requirements such as cafeterias, within the solar capacity.

The target figure of 750,000 kWh per year is about a third of existing comparable consumption in the United Nations Nairobi offices. Such a figure represents energy use of around 42.5 kWh per square metre per year. Although the best green buildings around the world have reduced consumption to as little as 15 kWh per square metre per year, this figure excludes heating and cooling, which are far and away the biggest consumers of energy in buildings. Conversely, this new building's target of 42.5 kWh per square metre per year includes the cooling required by IT infrastructure, and so enables the new building to be counted amongst those ranked highly in terms of global energy efficiency standards.

The next step was a detailed study to see where energy use could be reduced. Key areas included internal and external lighting, and computers and IT infrastructure, so detailed action plans were developed for each. Maximum use has been made of natural light and of energy efficient lighting, while notebook computers that use only a third of the energy of older desktops are being phased in.

Excess solar power can be used by other buildings on the compound and any shortfall will be met by the national power supply and standby generators when necessary.

"We're aiming for the building to be energy neutral over the course of the year, not for it to be completely energy independent," explains de Jong. "There will be some days when the panels will produce more than we need and others where there may not be enough sun, but over the year we are confident of producing as much as we consume."

In the meantime, efficiencies have been made in all major electrical equipment such as switchgear and pumps. Transformers are cast resin types that prevent pollution from oil drips, and standby generators are load-sensing and switch on only the capacity that is required.

The team is confident that, with time and experience, opportunities to reduce consumption further will become clear.

"We'll be monitoring it closely over the next year to see if there are opportunities for even greater efficiencies," says de Jong.

key facts

- Energy neutrality means the building will produce as much power as it consumes over the year
- It is estimated that the building will consume 750,000 kWh per year, or 42.5 kWh per square metre per year, which ranks it highly amongst green buildings worldwide
- IT and lighting are the biggest energy consumers in offices, and are also the areas where the largest efficiencies can be made
- Designers and builders are often used to conventional construction and may need to be encouraged to look at more sustainable ways of doing things

Standing on the roof of the new building, Bernd Wolff shields his eyes against the glare of the light reflected off the expanse of solar panels that glisten like giant fish scales in every direction.

As part of the quest for energy neutrality – where electricity needs are met by renewable energy generated by the building itself over the year – the solar panels are of central importance. Over the months of construction, Wolff has made several trips from Germany – where main suppliers Energiebau are based – to Nairobi to plan and then to install almost 6,000 m^2 of photovoltaic panels.

"In a sunny country like Kenya, solar is the obvious route to go," he says.

Wolff and the project team calculate that, over the year, the mixed polycrystalline and amorphous silicon solar modules – the latter donated by Kaneka of Japan – will generate at least the 750,000 kWh that the building and its occupants will require. The very high solar yield in Nairobi supplies the panels with energy from the sun, which is then fed to inverters and converted to the power that will run computers, lights and cafeterias.

The building was designed for maximum solar energy yield, with panels set on the flat, north/south oriented roof of all four blocks. The panels are mounted using aluminium profiles and stainless steel connectors, and are anchored to the roof of the building with concrete blocks to protect them against the risk of lifting off in high winds. Once installed, the only maintenance they require is simple cleaning with a little water to remove atmospheric dust that, if allowed to build up, would diminish the panels' efficiency.

Early in the process, and largely for reasons of cost, the decision was taken not to create energy storage capacity with batteries.

"The system as it stands will meet the building's needs averaged over the year and any excess will be used by other buildings in the Gigiri compound," explains Wolff. "But reducing the need to run generators in case of power cuts by installing some battery storage capacity in the future remains an option."

The panels are an economical as well as environmentally responsible choice over the longer term.

"The payback period will become clearer as the building is used and occupied over the first year," says Wolff. "Our best estimate is currently about between 7 and 10 years. But UNON is certainly profiting from the panels immediately in terms of sustainability, and it's right that the headquarters of the United Nations Environment Programme should be a showcase for environmental responsibility."

And that is something that the installation team, made up of individuals from Kenya, Tanzania, Rwanda, Ghana and Germany can be proud of.

key facts

- Nairobi's high solar yield almost all year round makes solar power the best renewable energy source
- The 6000 m^2 of solar panels will generate the estimated electricity needs of the new building over a year – 750,000 kWh
- Any excess solar power produced can be used by other buildings on the campus
- The payback period estimated on the basis of current electricity prices is around ten years

landscaping

"The landscaping of the new building was a terrific opportunity not only to create a stunning environment, but also to show how beautiful and creative gardens can be created and maintained using minimum amounts of water."

So says Bruce Hobson, the landscape designer commissioned to see that occupants of the new green building look out onto green views.

From the outset considerable thought was given to the environment in which construction would take place. The building was deliberately sited in such a way that the maximum number of existing trees could be preserved, and those few – mostly exotic species – that had to be removed were replaced elsewhere in the compound with indigenous varieties.

Now the gently rolling land around the building is newly planted with more indigenous trees, which will grow to create valuable shade and encourage biodiversity while helping absorb CO_2 from the atmosphere. Indigenous plants are also more drought-resistant and encourage birds and other smaller wildlife.

But it is the landscaped areas within the building, beneath the central atrium that runs the length of the four blocks, that are particularly unique. Each of the four interior gardens is planted to represent a different climatic zone of Kenya, beginning with the coast at the eastern end of the building, and moving through desert, savannah, and eventually to high altitude forest at the western end. Fossilised coral, rocks laid out to simulate a dry river bed, the colourful blooms and myriad greens of a Nairobi garden, and exquisite indigenous orchids clinging to the clefts between branches, all help create the mood of each climatic area.

Each garden is watered by an automated irrigation system that can be programmed to give the appropriate amount of moisture for each area, and all are frugal in their water needs.

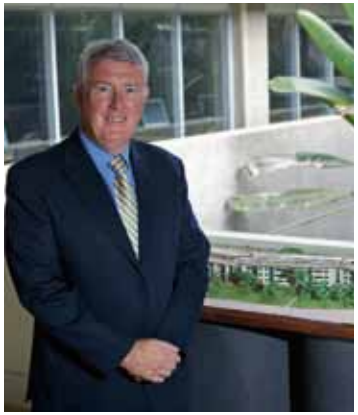
Says Hobson, **"The planting in each of the areas reflects what you would find in the natural environment, in that a mixture of ground cover, short, medium height and tall plants all grow together. Since each garden is a captive area, a micro-ecosystem is created whereby the moisture produced by plants' natural transpiration is absorbed by other plants, encouraging growth and further reducing the amount of watering they need."**

A majority of plants indigenous to Kenya have been mixed with others indigenous to Africa and elsewhere to show the staggering variety of plants that thrive in Kenya. Within a year the gardens will be fully established, and within five years all the indigenous trees will have grown to their mature shape, many of them reaching towards the sunny vault of the atrium roof. Butterflies and other visitors will come in, increasing biodiversity and further beautifying the outlook from the offices that overlook the atrium.

"These gardens will be cool, green spaces that will only get better over time," says Hobson.

key facts

- Micro-ecosystems will be created in the interior gardens through planting that reflects combinations found in the wild
- Indigenous species were used in combination with plants from elsewhere in Africa, reflecting the incredible botanical variety that is part of Kenya's history
- As the gardens grow, biodiversity will increase alongside the plants' capacity to absorb CO_2
- Automated irrigation maximizes efficient water use and can be programmed to meet the requirements of the plants in each zone



At almost 1,800 m above sea level, and a little over one degree south of the equator, Nairobi enjoys one of the kindest climates in the world. Daytime temperatures are typically in the mid-20s Celsius, while evenings are sometimes cool enough to warrant a log fire. Two rainy seasons – typically from late March until early May, and mid-November until mid-December – and the 'winter' months of July and August bring cloud and cooler days, but the city and its surroundings offer a comfortable and pleasant climate all year round.

Neil Reece-Evans sat on the new office facility committee, made up of assorted stakeholders, whose job was to ensure that the building was as sustainable as possible, while meeting the needs and preferences of the staff who now occupy it. He is a ready champion of the warm, clear days and cool evenings that are a feature of the Kenyan capital.

"One of the great benefits of the Nairobi climate is that, with good design, there is no need for either heating or cooling in buildings. Since air conditioning and central heating are both huge consumers of energy and very expensive, this is a great bonus when you're designing a building that aims to be energy neutral."

Running lengthways through the centre of the building is an atrium with a translucent vaulted roof. All office windows can be opened and closed so that cross ventilation can take place through the offices into the atrium. This simple design feature enables the building to act as a chimney, where warm air is drawn up from ground level and through the office areas, and then escapes beneath the sides of the vaulted roof, maintaining comfortable temperatures in the offices and air circulation throughout the building.

The building's open office layouts not only encourage a cooperative working atmosphere, but also greatly assist in airflow and temperature regulation.

When staff of UNEP and UN-HABITAT, who now occupy the building, were consulted they overwhelmingly said they wanted to be able to open their windows to enjoy fresh air, and close them completely in colder weather, thus keeping some control over their office environment. Windows can be operated by staff, and are fitted with solar glass to prevent internal heating from sunlight, but to retain heat in colder weather.

Says Reece-Evans, "The building is a huge improvement on existing facilities. There are better bathrooms, better cafeterias, comfortable office temperatures and an outlook on to green space from everywhere in the building. The excellence of the environment will have a massive positive impact on people's working lives."

key facts

- Heating and cooling are the biggest consumers of energy in most buildings
- The building's simple chimney design ensures good airflow and comfortable internal temperatures
- Operable windows give staff some control over their environment and also help airflow and temperature regulation
- Open offices are cooler as well as more convivial places to work

Lighting is a crucial element of workspace design.

The new building was planned to make maximum use of natural light, simultaneously reducing costs and energy consumption, while creating an attractive working environment. The three-storey building has a central atrium running throughout, covered by a barrel vaulted translucent roof. Offices occupy each floor on both sides of the central atrium, and the blocks are separated by glazed entrance and core areas.

Glazed roof lights are set into the roof above in each open plan office area, and toughened glass with a diffusing inter-layer is set at floor level beneath them on each floor, enabling natural light to penetrate right through to the ground floor. Most of the external wall space is given over to windows that are designed to allow light in while protecting occupants from the heat of the equatorial sun.

But even in a city as blessed with such high natural light intensity as Nairobi, there are overcast days of cloud and rain, so it is not possible to rely on natural light alone.

Peter Grayson is an electrical engineer who worked on the new building from when construction began.

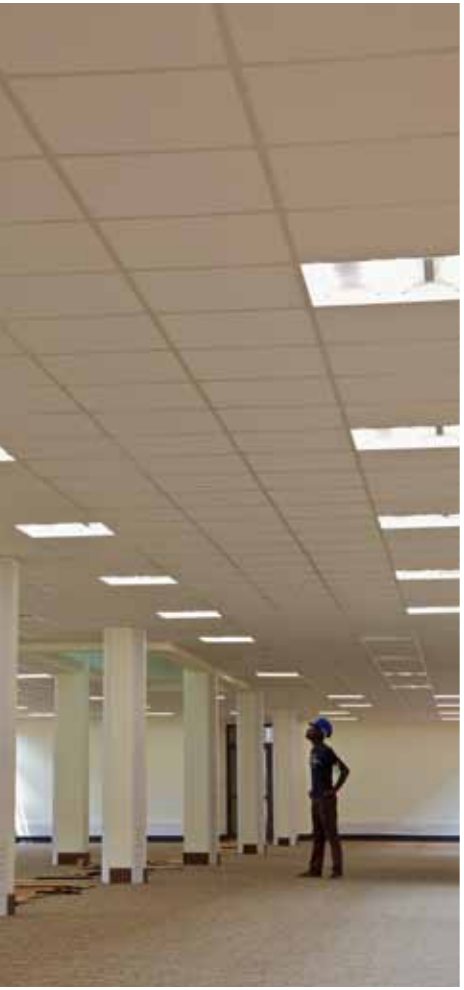
"Lighting is a major consumer of energy in offices. We needed to ensure everyone had adequate light to work by but also to make dramatic reductions in energy use, for both cost and sustainability reasons."

To find the best solution the project team commissioned a comprehensive study that combined sophisticated software and detailed climate data for Nairobi to model light availability in the building year round. Results showed that, on average, the 300 lux considered adequate for desk work was available from natural light around two thirds of the time. Ensuring that it was available 100 per cent of the time, and eliminating variations caused by position within the building was the next task.

The team sourced the most efficient fluorescent luminaires and combined them with a daylight sensing and presence detection controller system that automatically dims or increases lighting as needed, and switches lights off completely if it detects no-one is in the sensor area. With no light switches in office areas the risk of lights being left on overnight is eliminated. This, in combination with sensors and greater use of natural light, means potential savings of up to 70 per cent on lighting costs can be gained.

But Grayson knows that industry developments will create scope for improvements.

"Lighting is evolving incredibly fast and it's likely that LED technology will soon offer even greater energy savings. One of the strengths of the system is we have built in the capacity to change or upgrade as better technologies become available."



key facts

- It is estimated that lighting will account for around 20 per cent of energy use in the new office facility
- Connecting the lighting network to the building management system enables use to be monitored and adjusted and gives greater efficiencies on maintenance
- The combination of low energy bulbs and tubes with a lighting level and presence detection controller can yield savings of up to 70 per cent
- Lighting is evolving very fast, so it is vital to keep abreast of new developments and products in the marketplace

Like most cities in the developing world, Nairobi faces a water crisis.

Its rapidly growing population and unplanned urban sprawl outstrip available resources and the capacity of local authorities to provide a reliable water supply.

The United Nations compound in Nairobi has long used a combination of city council supplies and its own borehole water, but the months following the new building's opening will see more than 1,000 additional staff moving on to the compound, substantially increasing demand with no prospect of improved supply. That meant that reducing water use, increasing water efficiency and boosting water recycling were always at the top of the agenda in the planning and construction of the new facility.

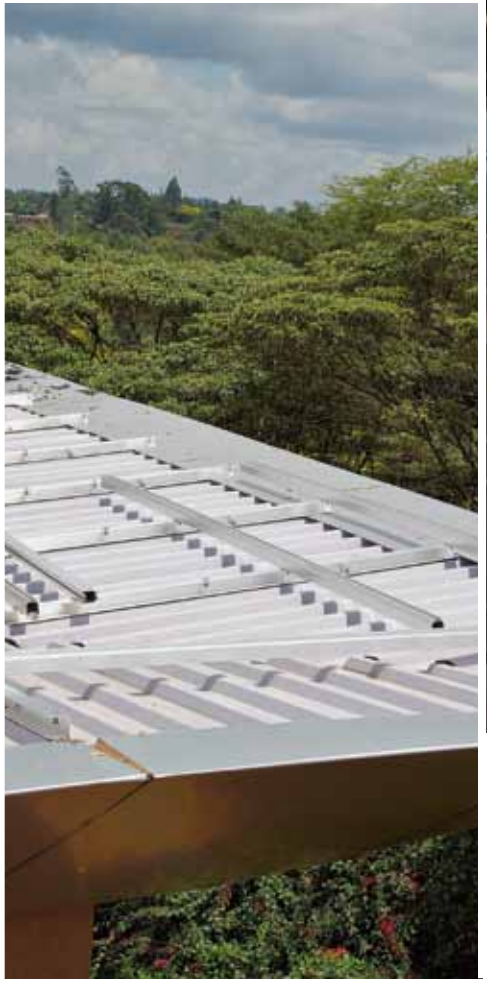
Ravi Chana of the project team says, **"Water was always a concern. There's a perennial shortage in Nairobi, and we wanted to avoid mistakes that were made in the past both in terms of wasting water, and of complicated maintenance."**

All rainwater is harvested from the roof of the new building, a measure that could yield around 7.5 million litres of water in an average rainfall year. This water goes directly to fill the pond and fountain at the western entrance to the building, from where it is gravity fed through an outlet pipe to the three lower lying water features at the entrance to the other three blocks. When the last pond at the eastern entrance is full, the water is carried by pipe down the gently sloping land to the lagoon on the northern boundary of the compound.

All sewage and wastewater goes to the new state-of-the-art sewage processing plant where it is purified by aeration and emerges clean, ready to join the rainwater in the lagoon. This harvested and recycled water is then used to irrigate the landscaped areas around the new building, so no fresh water is required to maintain the gardens and trees that make the new office complex so beautiful and sustain so much biodiversity.

The project team worked closely with the architects to source the best and most efficient plumbing fittings. All lavatories are dual flush, saving between six and nine litres per flush on older models, and all taps are fitted with aerators that reduce consumption by around 10 per cent. For ease of maintenance all plumbing is accessible via ducts in each of the wet core areas where lavatories and coffee stations are situated.

Says Chana, "Ultimately all water processes in the new office complex will be monitored by the automated building management system. This means we'll be able to see any problems or wastage very quickly and respond immediately, which will make our water efficiency even better."



key facts

- Around 7.5 million litres of rainwater could be harvested from the roof of the new building in an average rainfall year
- Rainwater and recycled water will meet all the irrigation needs of the new building compound
- Dual flush lavatories can reduce water consumption by between 40 and 60 per cent
- Water technology changes quickly so it is important to keep abreast of developments to ensure maximum efficiency and economy

Akimasa Nishizono was a member of the team tasked with ensuring that information and communication technology in the new building was as sustainable and environmentally friendly as the building itself.

"There's more to green IT than simply reducing electricity consumption," he explains. "Good IT decisions can also dramatically reduce an organization's carbon footprint by reducing the need for international travel, streamlining purchasing and hardware maintenance, and ensuring hazardous materials are properly dealt with through correct disposal of equipment at the end of its useful life."

The most obvious IT difference in the new building will be the shift from desktop to notebook computers over the coming months, yielding an immediate energy saving of around two thirds. Working from United Nations best practice guidelines on notebook computers, the green IT team identified a supplier that could offer local maintenance and warranties, together with an intelligent A/C adaptor which, unlike many others, reduces energy consumption to almost nil when machines are off or in standby mode.

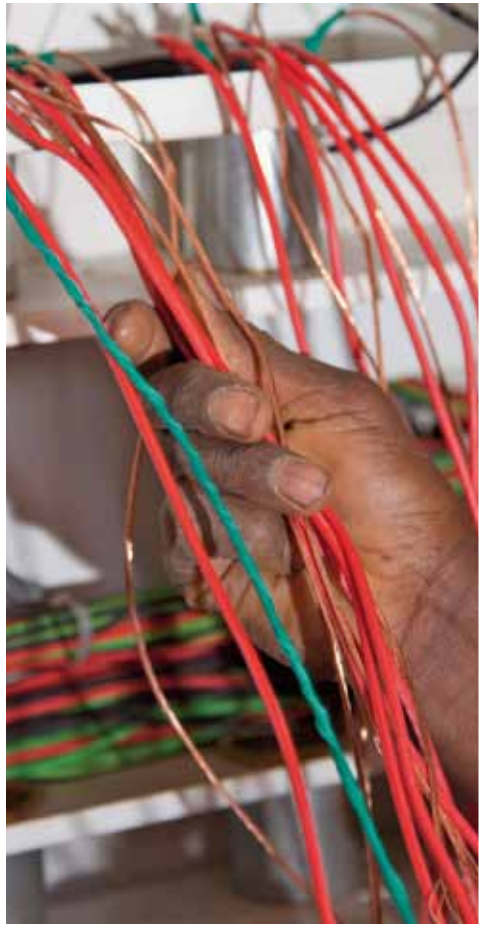
Using a single vendor for IT equipment is a central tenet of green procurement. Significant discounts can be negotiated on purchase price – adding to the savings already made by choosing notebooks over more expensive and bulky desktop computers – and maintenance is streamlined and made both cost and energy efficient via planned spare parts stock levels, and their timely replacement on site. Additionally, carbon emissions are substantially reduced through a single bulk shipment rather than multiple smaller international dispatches.

But there's more to IT than computers, and Nishizono stresses the need to view the topic holistically to obtain maximum benefits.

"Computers account for only a small proportion of total IT energy consumption, so it's vital to consider printers, copiers, telephones, and particularly servers, which consume large amounts of energy and need to be kept cool. Reducing server numbers through new technologies that enable multiple application systems to use one physical server is one possible way forward."

Since some 85 per cent of UNEP carbon emissions are generated by international travel, maximum use is being made of Internet Protocol telephony, which enables international video conferencing and reduces both costs and carbon footprint.

And solutions that will reduce the estimated $100,000 annually that it costs to run the data centre air conditioning on the Nairobi compound are at hand. Intelligent data centre containers that use fans, and air that is drawn through cool water to maintain suitable operating temperatures for servers, are being introduced in the quest to make IT a pillar of sustainability.



key facts

- Notebook computers use only a third of the electricity of desktop PCs
- Air conditioning in data centres accounts for up to 90 per cent of IT energy consumption, so it is vital to think beyond computers when planning green IT solutions
- ICT must be integrated into intelligent building planning from the outset to optimize solutions and ensure users' current and future needs are met, not only in terms of equipment and access points but also with regard to adaptability to new ICT
- Green procurement saves time, money and energy, and ensures a full life cycle approach is taken to IT

lessons learned

UNEP led efforts to ensure that the United Nations' new building in Nairobi was sustainable. Some of the lessons learned in the course of the project are highlighted here, and may be of value to those contemplating a similar project.

- **Be involved from the start.** Select an architect and contractor that have an interest and track record in sustainable buildings, and work closely with the architect from the start. Adding green features late in the process increases costs and can cause delays.

- **Set clear objectives for the building from the start.** Discuss and develop clear targets for the building as soon as possible. These might include "the aim is to recycle all water used in the building", or "design a building that will use only natural ventilation" etc. Prepare a report on what these targets mean and how they can be achieved. Each key area should then be further reviewed by detailed, issue-specific studies.

- **Work from general targets towards specific actions** and not the other way around. First set general targets such as energy neutrality, full water recycling, exclusive use of natural cooling, etc., and then develop action plans. For example, energy neutrality was a key goal, so calculating how much energy a solar power system on the roof could generate helped consumption targets and plans to be developed. Set green targets first and then consider the implications: revisions can be made if necessary.

- **Involve the future occupants from the start.** The success of green initiatives will depend in large part on the buy-in and support of the people that will work in the office. Information and communication is essential. Representatives from UNEP and UN-HABITAT sought views from staff, and were an important two-way link between staff and the project team.

- **Prepare background studies on all major issues.** Although these can be costly and time consuming, they are essential for refining targets and plans. Background studies were centrally important in helping to identify major energy consuming areas and in setting baselines for action plans. In fact, with hindsight, it is clear that more background studies would have been valuable on, for example, IT infrastructure. Background studies should be actively shared so that other building projects can make use of them.

- **Use international resources and references.** Many resources are available. Especially useful are case studies and technical baseline studies of other building projects. International references are also useful for comparing targets and plans with international standards – such as energy consumption per square metre – helping to show that specific green plans are demonstrably achievable.

- **Upfront investment will be needed** and must be budgeted for from the outset. Almost all green features have an upfront cost and a payback period of several years. For example, while the solar power system was a major upfront cost, it means that there will be no electricity bills for the building for decades to come.

- **Set up a green task force.** This should include the key building project staff and those that are responsible for the sustainability aspects of the building. Better still, fully integrate environmentalists into the building project team. Green building will often be new to the architect and the project team, and much background research and discussion will be needed to get green plans implemented.

- **Keep an eye on developing technology.** Green IT, lighting and other areas are developing fast, so it's vital to design systems that can be updated or changed quickly and inexpensively.

the importance of background studies – examples

Comprehensive background studies for all major areas where green alternatives are desired are crucial, and should be carried out at the earliest stage possible.

lighting

A major study to assess ways of maximizing natural light was undertaken for the new Nairobi building. A full 3D computer model of the building was developed and, using weather and sunshine data from Nairobi, inside lighting levels for every day for a full year were calculated. The results showed that, by using light wells and a state-of-the-art artificial lighting system incorporating motion and lux sensors, energy consumption could be reduced by up to 70 per cent.

The computer generated images on the left show the light that penetrates the building via the light wells on the top floor and on the ground floor.

IT cooling

Some way into the project it became clear that the computer server rooms would need to be cooled by power-hungry air conditioners, making it difficult to achieve energy neutrality. A study led to the decision to procure a highly efficient IT Pre-Assembled Component (ITPAC) external server room (see below). ITPACs use fans to create negative presssure, drawing air through the container to cool equipment. If the air is too warm, it is drawn through cool water to reduce its temperature, and the water is then recycled. The expected energy savings are such that the substantial cost of purchase can be recouped in less than five years through savings in electricity bills.

ITPACs benefit the environment by dramatically reducing typical data centre carbon footprint and materials such as:

- building, water consumption, and concrete
- steel, piping, copper etc., packaging and shipping materials
- transport of servers, equipment, and supplies.

Above and two images, far right ©Microsoft

further resources

UNEP and sustainability

While UNEP has been climate neutral since 2008, new efficiency measures in the UNEP Climate Neutral Strategy will enable the organization to lead by example in promoting sustainability. Greenhouse gas emissions from UNEP offices – due primarily to electricity use – make up around 15 per cent of the organization's carbon footprint. To reduce workplace emissions, all UNEP offices with ten or more staff members will undertake in-house greenhouse gas emission reduction audits based on the Sustainable United Nations (SUN) Guide to Climate Friendly Buildings and Offices. In addition to putting emission reduction plans in place, the SUN is helping UNEP offices and other United Nations agencies to consider broader resource use challenges such as office paper and e-waste.

A key area for emission reductions is work-related travel. At present, air travel is responsible for around 85 per cent of UNEP carbon emissions. More journeys will be undertaken by train and there will be greater investment in e-conference technology. UNEP will establish an e-communication plan where all UNEP employees are provided with access to online communication tools and online meeting rooms.

For more information and to download the UNEP Climate Neutral Strategy, please visit www.unep.org/sustainability

For more information on broader United Nations sustainability efforts, please visit Sustainable United Nations - www.unep.org/sun

Greening the Blue - www.greeningtheblue.org

UNEP Sustainable Building and Climate Initiative

While smart design, improved insulation, low energy appliances, high efficiency ventilation and heating/cooling systems, and the behaviour of building users can have a significant impact, systemic change demands more. UNEP's Sustainable Buildings and Climate Initiative (SBCI), based in Paris, is a global partnership between UNEP and leading companies worldwide to promote and support sustainable solutions in the buildings and construction sector. Construction is one of the key sectors for sustainable development, both in terms of the important benefits it contributes to society and the considerable negative impact of failing to give proper consideration to the entire life span of buildings. SBCI aims to promote change by:

- providing a common stakeholder platform for dialogue and action
- developing tools and strategies to achieve sustainable building practices
- establishing baselines for a life cycle approach to buildings, with an initial focus on energy efficiency and CO_2 emissions
- influencing and supporting policy that recognizes the role of buildings in mitigation and adaptation to climate change.

For more information on the UNEP Sustainable Buildings and Climate Initiative please visit www.unep.org/sbci

Publications

The following publications are available as e-books, downloadable pdfs, or to purchase:

Moving Towards a Climate Neutral UN
www.unep.org/publications/MovingTowardsClimateNeutralUN

Kick the Habit – A UN Guide to Climate Neutrality
www.unep.org/publications/ebooks/kick-the-habit

A Case for Climate Neutrality: Case Studies on Moving Towards a Low Carbon Economy
www.unep.org/publications/contents/pub_details_search.asp?ID=4081

Climate Friendly Buildings and Offices – A Practical Guide
www.unep.fr/scp/publications

Buildings and Climate Change – A Summary for Decision Makers
www.unep.org/publications/contents/pub_details_search.asp?ID=4113

Buildings and Climate Change – Status, Challenges and Opportunities
www.unep.org/publications/contents/pub_details_search.asp?ID=3934

Common Carbon Metric Protocol for Measuring Energy Use and Reporting Greenhouse Gas Emissions from Building Operations
www.unep.org/sbci/pdfs/Common-Carbon-Metric-for_Pilot_Testing_220410.pdf

Design for Sustainability: A Step by Step Approach
www.unep.org/publications/contents/pub_details_search.asp?ID=4117

Design for Sustainability: A Practical Approach for Developing Economies
www.unep.org/publications/contents/pub_details_search.asp?ID=4124

annex 3

sustainable communities and green buildings

Green buildings and green technology have a central role to play in creating sustainable communities. But truly sustainable communities are only possible if we create places where it is easy for people to adopt a sustainable lifestyle.

At the start of this millennium Kofi Annan, then United Nations Secretary-General, framed the challenge eloquently:

"Our biggest challenge this new century is to take an idea that seems abstract – sustainable development – and turn it into a reality for all the world's people."

By any measure, most of us are living beyond our ecological means.

The Global Footprint Network divides the Earth's biocapacity – the 12.6 billion hectares of productive land and sea on the planet – equally between its almost 7 billion inhabitants, and assigns each of us a notional 'fairshare ecological footprint' of around 1.8 hectares. In reality, current consumption patterns mean the average European has a footprint of between four and six hectares. In other words if everyone on Earth consumed as many resources as the average European, we would need three planets to support us. If we all lived like Americans, we would need five planets.

As concern over issues such as climate change have grown, so too has awareness of the impact of individual and collective lifestyle choices on the planet we share. As a result, greener communities are taking root around the world. One example is the 100-home Beddington Zero fossil Energy Development (BedZED) in south London, completed in 2002.

Many green innovations at BedZED have worked very well – others less so – but all have been useful learning in the quest for sustainable communities and the role of green buildings within them. Surveys among residents show not only that many are leading greener lives, but also that living in a sustainable community provides a better quality of life.

BedZED's homes consume 40 per cent less energy than conventional housing, with photovoltaic panels successfully generating renewable energy. A wood-fired combined heat and power plant, however, was less successful, and there are plans to replace this emerging technology with a simpler wood heating system.

But truly sustainable living is about more than buildings: it's about behaviour change. Reducing carbon emissions from homes has no impact on emissions from car use, so car parking spaces at BedZED were reduced by 60 per cent and a car club introduced that allows residents to call on pool

BedZED – ©BioRegional

cars by phone or via the Internet when needed. The resultant increase in walking, cycling and public transport has led to a 65 per cent fall in car use and created the largest single carbon saving at BedZED. With fewer cars, the development is a quieter, cleaner place where children are free to play and where residents can meet each other – increasing neighbourliness and quality of life. In addition, the exercise of walking and cycling is likely to have a positive effect on health. With volatile oil prices and the economic difficulties currently faced by many countries, reducing car dependence can also protect people's hard earned incomes and make them more economically resilient.

Food is also central to sustainable living, since the land and energy needed to grow and process food is one of the biggest contributors to greenhouse gas emissions and ecological footprint. Sustainable communities should therefore make it easy for people to access healthy, sustainable food that features local produce and seasonal fruit and vegetables. Communities themselves can do a good deal to increase sustainability by, for example, promoting farmers' markets, allotments and other urban agriculture.

Since consumer waste is another significant contributor to ecological footprint, each home at BedZED is fitted with segregated bins, and collection points are conveniently sited around the estate, resulting in a doubling of recycling rates.

By making sustainable communities places where it is easy, attractive and affordable to adopt a fully sustainable lifestyle, ecological footprints can be substantially reduced. BedZED's developer, BioRegional, calls this One Planet Living and, armed with the lessons and experience from BedZED, is coordinating an international network of One Planet Communities. Among these is One Brighton, on the south coast of England, where the first residents moved in during September 2009. The development is free of private cars (with only car club cars and disabled parking) and will be run completely from a combination of on- and off-site renewable energy. Constructed using green materials, the project also spread a culture of sustainability by, for example, by making sure that everyone working on the project understood the principles of One Planet Living, and by offering healthy local food and vegetarian options in the workers' canteen.

Designing a sustainable community is important, but long term community engagement and property management is equally so. A caretaker works on site at One Brighton, helping residents with, among other things, recycling and promoting deliveries of local food from farms in the area.

BioRegional and other enlightened developers and partners have begun to build sustainable communities that are leading the way across the globe, from California, Portugal, Australia, South Africa and the UAE to China, Brazil, Germany and Sweden. With committed people working hard, sustainable community best practice is being pioneered.

The revolution has begun.

Further information:
www.bioregional.com
www.globalfootprintnetwork.org
www.oneplanetcommunities.org

This Annex was contributed by Pooran Desai, co-founder of BioRegional, an international environmental organization. Desai is also Sustainability Director of eco-property development company, BioRegional Quintain Ltd (BQL). He lives at BedZED with his wife and co-founder of BioRegional, Sue Riddlestone.

In 2002 Pooran Desai coined the term "One Planet Living" which has become the name of an international initiative. He has written a book called *One Planet Communities*, which was published in 2009.

green buildings in the sun

Three of the four examples of best practice sustainable office buildings highlighted here are located in the tropical and subtropical zones of the southern hemisphere. With the exception of CH2 in Melbourne, Australia, the buildings have been realized within the constraining conditions of developing countries, which include limited resources, and restricted availability of certain building materials and other inputs.

Typical challenges include:

- achieving a balance between maximum use of external natural light while insulating the building against the heat that generally accompanies it in tropical and sub-tropical parts of the world
- adapting natural ventilation for cooling and good internal environment quality to avoid expensive and energy-hungry air conditioning
- developing technical solutions that enable greater use of locally available materials
- protecting ecosystems and the environment during construction and enhancing their post-construction recreational value by, for example, integrating wetlands into the building's water management system
- using innovative green building projects to develop capacity in the local building industry.

All four examples show that, even where a particular efficiency measure stands out, sustainability in the context of buildings requires a holistic approach that integrates a range of green components.

Eastgate Centre in Harare, Zimbabwe, is a sustainable office building in which design has achieved excellent natural ventilation.

Eastgate Centre in Harare, Zimbabwe
Source: Wikipedia

The architects and engineers applied biomimicry, in which natural processes are studied and adapted to solve human problems, to the building's design and created highly effective natural ventilation inspired by indigenous Zimbabwean masonry and the self-cooling mounds of African termites.

Completed in 1996, the Eastgate Centre is Zimbabwe's largest office and shopping complex. That the building, made largely of concrete, requires neither conventional air conditioning nor heating means its energy needs are less than 10 per cent those of conventional buildings of similar size.

At an altitude of almost 1,500 metres, Harare has a temperate climate despite being in the African sub tropics. Daily temperatures range between 10° C and 30° C: ideal conditions for making use of a passive cooling system. Still, actual heating and cooling needs over the year and the course of the day are complex, and the building would have been impossible without highly sophisticated computer simulation and analysis. This is also reflected in some of the distinctive features of the complex, such as its characteristic chimneys, restricted window area, adjustable blinds and deep overhangs. The deep eaves are a traditional solution against heat in this part of Africa, shading walls from high summer sun while allowing low winter sun to warm the building in the morning.

The same principles are the basis for the passive cooling mechanism used by termites, who are able to keep the inner parts of their mounds at constant temperature by building flues which vent through the top and sides. The mound itself is tall enough to catch the breeze, drawing hot air from the main chambers below ground out of the structure as a chimney does.

Reference:
www.architectsforpeace.org/mickprofile.php

The ZEO Building, Bandar Baru Bangi, Malaysia, like the new United Nations building in Nairobi, achieves energy neutrality through a combination of reduced consumption and solar energy generation. Completed in 2007, the building is the first of its kind in South-East Asia.

Key features include energy efficient double glazing and well insulated walls and roofs, maximizing natural light to illuminate the interior, and energy efficient office equipment. These measures have reduced consumption to about 40 kWh per square metre per year, including cooling in the hot and humid climate of Malaysia: a remarkable achievement. ZEO meets 75 per cent of its cooling needs by radiant cooling – where water is piped through the floor slabs to draw off heat during the day, while ambient cooling and evaporation from the roof-mounted solar panels during the night cools the water for use the following day. The building harvests rainwater, so only 33 per cent of its water requirement has to come from the mains supply.

The ZEO Building, Bandar Baru Bangi, Malaysia,
Source: The Star, Malaysia

Ultraviolet and infrared radiation is reflected away by high performance glazing or spectrally selective, sealed double glazing on windows, aided by a system of light reflectors that ensure direct sunlight and heat are not transmitted into the building.

Reference:
Kristensen, Poul E., Tang, CK, Reimann, Gregers, and, Ahmad Ismail, 2007. The design of the zero energy office building for Pusat Tenaga Malaysia, Conference on Sustainable building South East Asia, 5-7 November 2007, Malaysia.

The Inspiration Office in Cochin, Kerala, India, is an attractive, functional and cost effective building that relies almost entirely on engineered bamboo as a construction material. Completed in 2002, the office complex was the first of a number of buildings where bamboo is used for floors, roofing material and walls. It covers an area of about 850 m^2 and remains the largest of its kind in India.

The Inspiration Office in Cochin, Kerala, India
©INSPIRATION

Kerala, on India's south-west coast, has a warm and humid tropical climate. The building's orientation allows north-east morning winds, cooled by a lake, to flow into the office area. The use of natural lighting and cross ventilation minimizes use of fans and artificial lighting. The building design helps to keep interior temperatures a comfortable 4-5° C below those outside on a hot summer day. In addition, the two-storeyed building is placed on a system of footings and raised columns to support the bamboo-reinforced floor slab. This technique further aids cooling while reducing the risk of damp, and of rodent and insect invasion.

Around 2,500 bamboo stems about 3 m long and average diameters of 90 mm were used in construction, along with reinforced cement concrete slabs, ferro-cement, and a limited quantity of reinforced plaster. A neighbouring bamboo plantation supplied a quarter of the bamboo construction material. Use of steel and concrete was reduced by between 70 and 80 per cent compared to a building of similar size and style built in the conventional way.

There is a long vernacular tradition of building with bamboo in many parts of the world, especially in tropical climates. The plant reaches maturity and can be used for building in only five to six years, compared to 30-60 years for any comparable wood species. It is also cheap and incredibly strong, and replenishes important nitrates in the soil, preventing and correcting soil degradation.

Reference:

Architecture and Development, Energy efficiency and high environmental quality buildings in India, Case Study IV: Inspiration Office in Cochin, by Jaygopals, Douchan Palacios, January 3 2008

The Council House Building 2 (CH2) in Melbourne, Australia, is made up of ten storeys of offices and ground level retail space. Designed by the same architect as Harare's Eastgate, CH2 demonstrates the adaptability of passive cooling and ventilation to a temperate climate.

The building was completed in 2006 and was awarded a top six stars by Australia's Green Star sustainable building rating for its environmental design and performance. This award is based on criteria such as energy and water efficiency, quality of indoor environment and resource conservation.

The architects adopted a holistic approach to the environmentally sustainable design of the CH2 complex and incorporated numerous sustainable building technologies. The building's energy consumption is an impressive 35 kWh per square metre per year.

Green strategies and technologies include a design based on local climate and ecology, natural light and temperature regulation, renewable energy and waste management.

Melbourne has a temperate climate, and airflow at CH2 harnesses convection to maintain fresh air and comfortable temperatures. Air enters through floor-level ventilation and exits through the ceiling, a feature which has not only made staff more comfortable, but has seen significantly increased work productivity. Further outstanding features include a water-mining plant, a gas-fired cogeneration plant and photovoltaic energy generation to power the movement of louvres that

The Council House Building 2 (CH2) in Melbourne, Australia,
© City of Melbourne 2010.

shade the façade. The environmental features of the building on their own are not new, but the way they have been integrated and combined creates synergies that make the sustainability features of the building unique.

References:

Hartkopf, Volker, Yang, Xiaodi, and, Azizan Aziz, 2009. Case studies of high performance sustainable buildings, for UNEP-SBCI. Carnegie Mellon University (unpublished)

This Annex was contributed by Peter Graham, acting Head of Discipline – Architecture & Design, Faculty of the Built Environment at the University of New South Wales, Australia. Graham is the Technical Advisor and former Coordinator of the United Nations Environment Programme's Sustainable Building and Climate Initiative. In this role Peter works closely with the public, civil and private sectors to assist the global transition to a sustainable building and construction industry.

















UN HABITAT

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