CASE STUDY 1-08: UNON OFFICE BUILDING | KENYA

GEOGRAPHICAL AND CLIMATE INFORMATION	
Location	Parklands/Highridge, United Nations Ave, Nairobi, Kenya
Latitude; Longitude	-1.2326008075647548, 36.81796828684429
Climate zone (Köppen–Geiger classification)	Cwb: subtropical highland climate. Temperate, dry winter, warm summer
BUILDING INFORMATION	
Building Type	Offices
Project Type	New construction
Completion Date	2011
Number of buildings	8
Number of storeys	3
Total Floor Area (m²)	20 000
Net Floor Area (m²)	-
Thermally conditioned space area (m²)	0
Spaces with Natural Ventilation (with or without Ceiling Fans) Only (m²)	20 000
Total cost (€)	18 500 000
Cost /m² (€/m²)	925,0
Performance Standards or Certification	ISO 14001 (2004)
Awards	Top 6 stars by Australia's Green Star
STAKEHOLDERS	
Building Owner/ Representative	United Nations Office at Nairobi (UNON)
Architect / Designer	Beglin Woods Architects
Construction manager	Harold R. Fenwick & Associates, Chartered Quantity Surveyors
Environmental consultancy	UN-HABITAT / UNEP

Structural Engineer, Civil Engineer	EngPlan Consulting Engineers
Building Services Engineers	Geomax Consulting Engineers
Certification company	-

PROJECT DESCRIPTION [1] [2] [3]

Figure 128: Exterior view of the UNON Office building [1]

The UNON Office building is the first facility in sub-Saharan Africa, which hosts the headquarters of both the United Nations Environment Programme (UNEP) and the United Nations Human Settlements Programme (UN-HABITAT). The building is composed of four blocks linked by airy walkways, flooded with natural light and with green areas. 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. In terms of renewable energy, this building has been designed to generate electricity for all of its 1 200 occupants thanks to 6 000 square meters of solar panels of 550 kWp [2].

(a) *(b)*

Figure 129: (a) Fountains and ponds at the entrance of the building using collected rainwater and (b) vegetation in the atrium area of the building [1].

SITE INTEGRATION

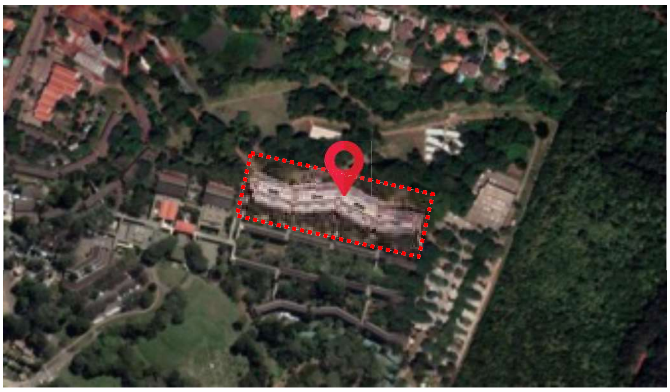

Figure 130: Aerial view of the UNON building (Source : google map)

For the landscaping of the new building the building was deliberately sited in such a way that the maximum number of existing trees could be preserved. Moreover, thanks to the preservation of indigenous plants more drought-resistant the building encourages birds and other smaller wildlife. Besides, the building follows traditional principles of Kenyan build like for the colour of the façades that refers to old traditional buildings.

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CLIMATE ANALYSIS

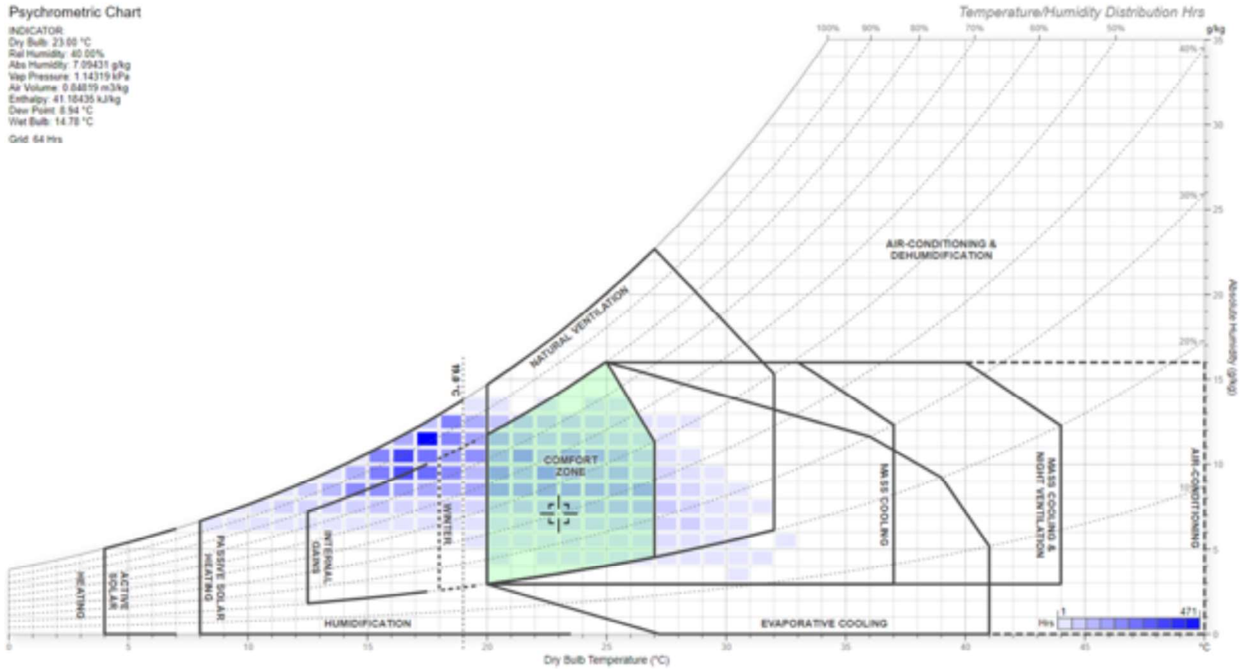


Figure 131: Givoni Bioclimatic chart for the climate of Nairobi using Andrew Marsh online tool [4]. Climate data are extracted from http://climate.onebuilding.org/WMO_Region_1_Africa/KEN_Kenya/NB_Nairobi/KEN_NB_Nairobi-Kenyatta.Intl.AP.637400_TMYx.2004-2018.zip

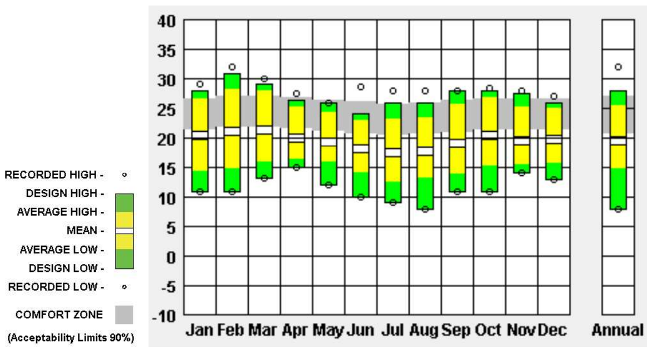


Figure 132: Temperature range by month for Nairobi. Source: Climate consultant – Adaptative Comfort model [5].

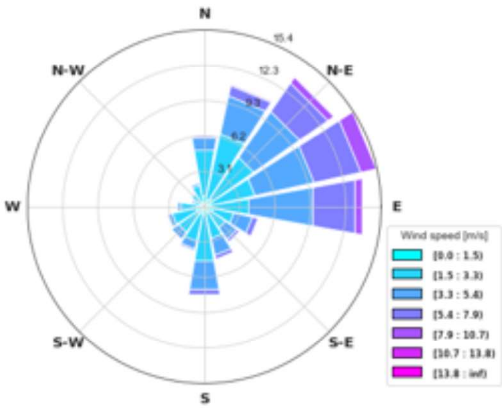


Figure 133: Annual wind rose for Nairobi (Beaufort wind scale) [5].

Global horizontal radiation (Avg daily total) Min (month) / Max (month)	Min: **4025** Wh/m² (Jun) Max: **6243** Wh/m² (Feb) Mean: **5084** Wh/m²
Annual Degree-Days for weather classification according to ASHRAE Standard 169-2020	HDD 18°C: **315** CDD 10°C: **3 480**
Annual Degree-Days for the Adaptive Comfort Base Temperature according to the ASHRAE 55-2017 for 80% of acceptability	HDD: **765** CDD: **6**
Annual Degree-Days for a static comfort temperature approach	HDD 18.6ºC: **419** CDD 26º: **32**

KEY BIOCLIMATIC DESIGN PRINCIPLES [1] [2] [3]	
Passive cooling strategy	Natural ventilation via chimney effect of warm air moving through the atrium. Fixed louvres at the top of the building allow free air movement out of the atrium Open plan offices Windows can be opened and closed by occupants for temperature regulation
Passive heating strategy	E-W elongated orientation to minimize heat intake. Main facades are facing N and S High thermal capacity walls (stones)
Solar protection	Canopy produces shade which reduces solar gain in through windows.
Building orientation	N/S orientation for daylighting
Insulation	High quality solar glass insulates the building against heat and cold. The roof is protected by all solar panels
Vegetation	Rainwaters is collected to irrigate the landscape areas all around the building, indigenous tree has been planted. Atrium encourages landscape areas and so biodiversity with a minimal of irrigation water.
Natural daylighting	N/S orientation achieving maximum daytime lighting. Atrium and glass permit natural daylighting. Indeed, 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.
Use of local and embedded materials	Locally produced cement and steel and blockwork form building superstructure Maximum use of stones
Water saving and heat recovery on hot water drain	Water saving taps and lavatories reduce water consumption. Installation of high-efficiency water systems, which include features such as dual flush toilets and push taps. Waste water is also treated. 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. All the water from the offices, kitchens, washrooms and recreation centre ends up at the local wastewater plant. There are three oxidation ponds that use natural UV rays and biological processes to treat the water, which is then reused for irrigation around the compound [6].
Waste management	All waste produced in the buildings are recycled to produce other materials. One of the UNON objectives is to reduce the amount of waste from the complex that goes directly to landfill. Since 2008, the Near Zero Station has been sorting waste produced on the compound and reducing the amount sent for disposal. In 2017, a new waste sorting station was built,

	and waste collected from the complex is now sorted and measured, and either recycled or disposed of appropriately. Waste sorting bins are located in each office building on the complex to enable sorting at source [6].
Others features	The 1200 employees of the building walk on a 100% recyclable carpet, and the paint used on the walls is environmentally friendly. The green spaces surrounding the building are made up of local plants and trees.

(a) (b)

Figure 134 : sewage is treated in a state-of-the-art aeration system (a) and recycled to irrigate the beautifully landscaped compound (b) [1].

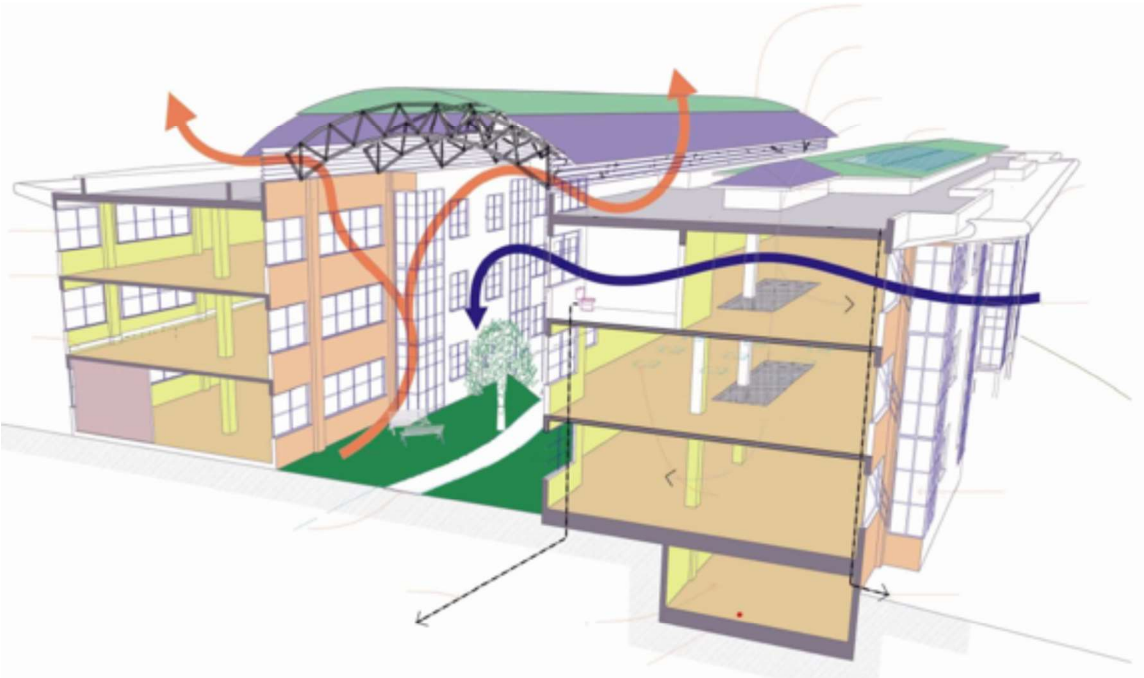


Figure 135: The UNON Office building's natural ventilation principle via chimney effect of warm air moving through the atrium. Fixed louvres at the top of the building allow free air movement out of the atrium [2].

INFRASTRUCTURES and REGULATIONS to enable SUFFICIENCY ACTION	
Dressing code	Informal dressing, adapted to the season, is welcome and promoted (e.g. short trousers and short leaves in hot periods): Yes
Protected bike parking and showers	Yes. There are several bike parkings within the complex to allow cycling from the entrance of the complex situated two km away to the building.
Ceiling fans	In every room, even those conditioned: No
Lighting system fractioned to allow using light only in zones occupied and where daylighting insufficient	In every room, even those conditioned: Yes There are no switches. Sensors of presence operate the lighting.
Space and facilities for line drying clothes (especially important in residences, hotels, sport facilities…)	In every room, even those conditioned: No
Book of instruction for correct use of the passive features (windows, solar protections, water savings) and active (lighting…) in order to promote sufficiency and efficiency actions	Available through leaflets and posters at relevant places, online, etc.: No

BUILDING FABRIC AND MATERIALS	
Roof	Bricks Thickness Unknown
	Overall R-value : Unknown
Windows	High performance glazing, double glazing aided by a system of light reflectors
	Window-to-wall ratio (WWR): Unknown
	U-value : Unknown
	Visual transmittance: Unknown
Walls	Stones, Thickness: 20 cm
	Overall R-value : Unknown

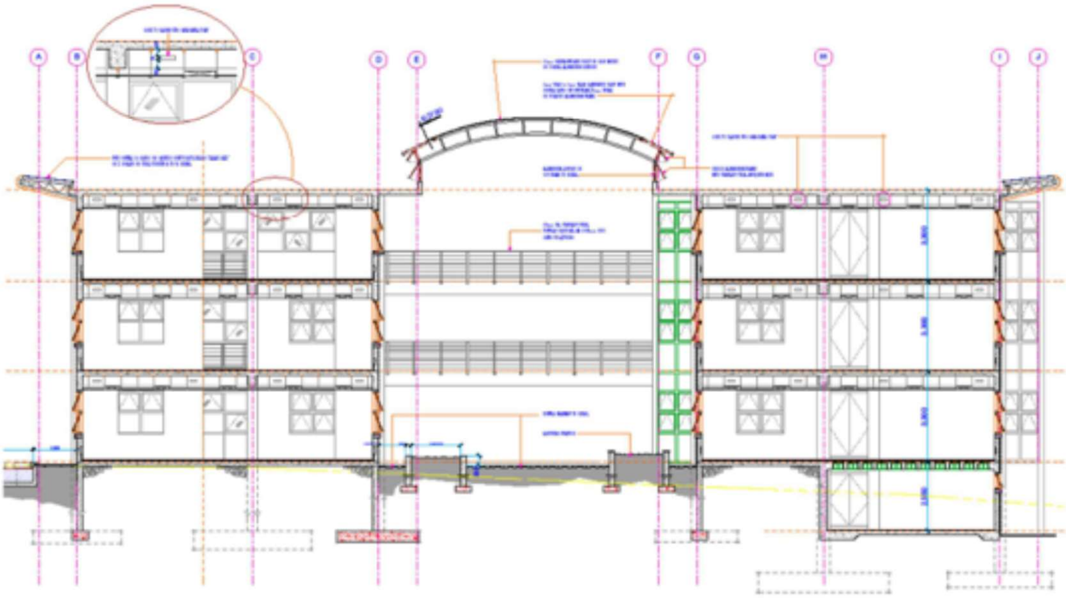


Figure 136: Atrium and light well section of the UNON building [1].

ENERGY EFFICIENT BUILDING SYSTEMS [1] [3]	
Low-energy cooling systems	Uses of passive cooling system, natural airflow, fans, vegetation. These systems work firstly thanks to natural airflow though the building that contributes to decrease the temperature felt. Also, the vegetation contributes to decrease the temperature during heating days. Fans are only used for the refreshment of IT systems against to the use of air conditioning.
Low-energy heating systems	Uses of natural heating. The double glazing contributes to retain the heat during fresh days, also the concrete contributes to capture the heat and redistribute the heat when temperature goes down.
Ceiling fans	Fans are used only in the computer rooms.
Mechanical ventilation / air renewal	Not applicable
Domestic Hot Water	Few solar water heaters provide water to the kitchens (bars)
Artificial lighting	Use of fluorescent luminaires - Low energy fluorescent lighting Density by spaces (W/m^2): Unknow
Control and energy management	Energy management strategies are used to decrease the total consumption of the active systems: - daylight sensing and presence detection system - Water saving taps Only laptop computers are allowed in the office

(a) (b)

Figure 137 : Interior views of the offices with natural daylighting wells and the energy efficient artificial lighting systems installed [1]

RENEWABLE ENERGY	
PV	**Type :** Solar **Technology :** Mixed polycrystalline and amorphous silicon solar modules. **Nominal power :** 550 kWp. The building was designed for maximum solar energy yield, with panels set on the flat, E/W elongated roof.
Solar thermal	Solar water heater
Wind	None
Geothermal	None
Biomass	None

Figure 138: 6000 m2 of solar panels of 550 kWp are installed on the rooftop of the building [1].

BUILDING ANALYSIS AND KEY PERFORMANCE INDICATORS

Thermal comfort indicators

1. Percentage of time outside an operative temperature range (Adaptive) : 0%
2. Percentage of time outside an operative temperature range (Fanger) : 0%
3. Degree-hours (Adaptive)
4. Degree-hours (Fanger)
5. Percentage of time inside the Givoni comfort zone of 1m/s: **≥ 96 % (from Nov-22 to May-23)**
6. Percentage of time inside the Givoni comfort zone of 0m/s: **≥ 96 % (from Nov-22 to May-23)**
7. Number of hours within a certain temperature range, tables available

	METER 10B roof		METER 19 Cecilia Office C		METER 31 Raf Window		METER 66 Vincent office C		OUTSIDE	
	n.Hours	Freq.	n.Hours	Freq.	n.Hours	Freq.	n.Hours	Freq.	n.Hours	Freq.
Ta<16°C	2	0,%	0	0%	0	0%	0	0%	7	1%
16°C≤Ta<18°C	42	3%	0	0%	0	0%	0	0%	90	7%
18°C≤Ta<20°C	122	9%	0	0%	0	0%	17	1%	206	15%
20°C≤Ta<22°C	120	9%	215	16%	91	7%	325	24%	182	13%
22°C≤Ta<24°C	130	10%	727	53%	737	54%	635	46%	234	17,%
24°C≤Ta<26°C	168	12%	376	27%	486	36%	298	22%	297	22%
26°C≤Ta<28°C	202	15%	50	4%	54	4%	89	7%	205	15%
28°C≤Ta<30°C	209	15%	0	0%	0	0%	4	0%	124	9%
30°C≤Ta<32°C	186	14%	0	0%	0	0%	0	0%	23	2%
32°C≤Ta<34°C	143	10%	0	0%	0	0%	0	0%	0	0%
Ta≥34°C	44	3%	0	0%	0	0%	0	0%	0	0%

Energy performance indicators

1. Energy needs for heating: **-** [kWh/m²/year]
2. Energy needs for cooling: **-** [kWh/m²/year]
3. Energy use for lighting: **-** [kWh/m²/year]
4. Energy needs for sanitary hot water: **-** [kWh/m²/year]
5. Total Primary energy use: **-** [kWh/m²/year]
6. Renewable Primary energy generated on-site: **-** [kWh/m²/year]
7. Renewable Primary energy generated on-site and self-consumed: **-** [kWh/m²/year]
8. Renewable Primary energy exported to the grid: **-** [kWh/m²/year]
9. Ratio of renewable primary energy over the total primary energy use (with and without compensation): **-** %
10. Delivered energy (from electricity bills): **-** [kWh/m²/year]

Acoustic comfort indicators

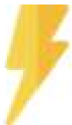
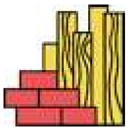
1. Airborne sound insulation
2. Equivalent continuous sound Level
3. HVAC noise level
4. Reverberation time
5. Masking/barriers

Visual comfort indicators

1. Light level (illuminance)
2. Useful Daylight Illuminance (UDI)

	3. Glare control
	4. Quality view
	5. Zoning control
Indoor Air Quality indicators	1. Organic compound
	2. VOCs
	3. Inorganic gases
	4. Particulates (filtration)
	5. Minimum outdoor air provision
	6. Moisture (humidity, leaks)
	7. Hazard material
Users' feedback	Users are overall very satisfied by their working environment. No complains have been listed.

LESSONS LEARNED AND RECOMMENDATIONS	
Lessons learned	This is the first energy plus building in Sub Saharan Africa. It has inspired the construction of more than 20 other buildings with solar rooftop in Nairobi. It also helped the adoption of a legislation on net metering. In fact, the building does not have batteries, excess energy is feed into the national grid during the day. At night, the energy is consumed from the grid. This was also the first bioclimatic architecture design of the architect who learned by doing. The main lesson learnt is that air conditioning is not necessary in Nairobi. It is possible to design a comfortable bioclimatic office building in Nairobi with no active air conditioning systems. Thermal comfort conditions can be easily reached with a good ventilated building, an appropriate orientation and insulation in walls and roofs in subsequent projects, using local materials, such as bio-sourced fibers. Ceiling fans are not necessary as well.
Recommendations	After the construction of the building, several recommendations were made to reproduce a bioclimatic building such as: - Set clear objectives for the building from the start - Work from general targets towards specific actions and not the other way around - Involve the future occupants from the start - Prepare background studies on all major issues - Set up green task force - Keep an eye on development technology

BUILDING STRENGTHS		
Strengths		
		

Passive Design	Energy Efficiency	Renewable Energy	Water conservation	Local Materials
				
Weaknesses				
-				

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