

## Case Study Title: Norrsken Kigali house

As-built building photograph (Please insert only one representative picture in a landscape format, 300 dpi, JPEG)



Photo credit: Chris Schwagga

Project Name	Norrsken Kigali House
Location	Kigali, Nyarugenge District, Rwanda
Climate Zone	Am (Tropical monsoon)
Latitude/Longitude	1.9512° S, 30.0600° E
Building Type	Workspace
Floor Area [sqm]	5090m2 (Classroom renovation: 1290m2, New Build: 4200m2)
Building Height [m]	12
Number of Storeys	B1, G, 2F
Completion Year	2022
Project Team	Norrsken (developer), MASS Design Group (Master Planning, Capital Project Planning, Visioning, Pre-Design, Concept Design, Architectural Design, Landscape Design, Structural Engineering, MEP Engineering, Environmental Engineering, Solar Engineering, Fire Engineering, Geotechnical Engineering, Construction Documents), Arup (fire engineering technical advisory), Transolar (environmental engineering technical advisor), Sweco: Client Representative and Project Management, Seyani Brothers: contractor,

\*mock-up experiments and other research-based experiments could be included as case study, aside from actual building construction projects if similar information could be provided.

## 1. Project Description

### Passive Cooling Case Studies

## Project Overview

Please describe the project overview, touching upon 1) project background (100 words), 2) passive cooling intervention (100 words), 3) project achievements (100 words). [Max 300 words] (Please write the brief explanation as the detailed info can be provided in the following sections.)

### 1) Project background

Located on the historic site of the École Belge de Kigali in central Kigali, Rwanda — originally established in 1965 — Norrsken Kigali House was conceived as an entrepreneurship hub for East Africa to help accelerate investment and scale-up of small and growing businesses. Rather than demolish the older school buildings, the project team undertook an adaptive-reuse strategy, retaining and reinforcing three of the classroom blocks and combining them with a new building component to create a campus of four buildings plus an outdoor pergola event space. The ambition was not only to create workspace but to generate a catalytic environment for entrepreneurship, innovation and community engagement in a rapidly growing region.

### 2) Passive cooling intervention

In order to reduce energy demand and enhance thermal comfort in Kigali's climate, the design incorporates several passive and low-energy strategies. The new façade uses locally-manufactured clay-shaded screens, solar control glazing and carefully designed natural ventilation openings to reduce solar gain and promote air movement. The roof incorporates insulation and rooftop solar panels, which reduce solar heat gain further. A key feature is a basement “thermal labyrinth” a low-energy ventilation system that draws air from a shaded exterior courtyard, circulates it slowly through an underground labyrinth which cools the air through contact with the labyrinth's high thermal mass walls, then delivers the cooler air to zones such as the auditorium (designed to encourage air flow through the whole building), coworking space and lobby during the day. The labyrinth is cooled with nighttime air. The surrounding landscape is heavily vegetated and trees provide shading, which improves outdoor comfort and lowers temperatures considerably. Together these interventions reduce dependence on mechanical cooling, helping the building achieve high efficiency and meet certification targets.

### 3) Project achievements

The project demonstrates strong sustainability outcomes: it is designed for EDGE Advanced certification (targeting 40 %+ on-site energy savings). Embodied carbon is reduced by roughly 32 % compared to the global average for similar office buildings, through strategies such as material reuse (e.g., reused steel from the old gym for the pergola, bricks from demolition re-used for site benches and feature walls). The building also includes rooftop photovoltaics, on-site stormwater management, non-potable water harvesting and landscape restoration — delivering multiple sustainability and circular-economy benefits. On the socioeconomic side, the hub supports entrepreneurs in East Africa, providing workspace, networks and access to investment in a landmark campus that bridges built heritage, sustainability and economic development.

## 2. Climate & Site Context

Basic Climate Conditions		
Temperature	Annual Average	20.4°C
	Annual Range	20°C (January) - 24°C (September) (average)
Relative Humidity	Annual Average	73%
	Annual Range	50% (August) - 98% (March)
Annual Degree-Days (ASHRAE Standard 169-2020)		HDD 10°C: 0 CDD 18°C: 1010
Climate Analysis		
<p>Kigali has a tropical warm and humid climate with average daytime highs between 23°C and 31°C and average nighttime lows between 11°C and 27°C. However, Warmer temperatures (up to 34°C) have been experienced in Kigali over the past few years especially from June to August.</p> <p>Monthly precipitation levels vary between 12mm to 1440mm. The relative humidity ranges between approximately 30% to 90%.</p> <p>Kigali is 2° south of the equator. The sun passes overhead and provides high horizontal solar radiation (approximately) of 1993 kWh/m<sup>2</sup>/year.</p> <p>The Predominant wind is from the South and North West direction with an average wind speed of 2m/s during the day and 1 m/s at night</p>		
Site Analysis		
<p>Original site pre construction: The site generally falls from the highest point at the south east corner to the lowest point at the north west corner. The overall level change is approximately 9 m, and there are a number of existing retaining walls and staircases across the site which deal with this slope. The site strategy includes the addition of several ramps to provide ADA access to all buildings.</p>		

### 3. Passive Cooling Design Details

Passive Cooling Strategies (please tick implemented passive cooling strategies)
<ul style="list-style-type: none"> <li><input checked="" type="checkbox"/> Building Orientation &amp; Form (site orientation, building shape, etc.)</li> <li><input checked="" type="checkbox"/> Envelope Design (insulation, air-tightness, shading, window system, thermal mass, etc.)</li> <li><input checked="" type="checkbox"/> Natural Ventilation (cross ventilation, stack ventilation, night ventilation, etc.)</li> <li><input type="checkbox"/> Evaporative Cooling (direct/indirect evaporative cooling, etc.)</li> <li><input checked="" type="checkbox"/> Ground Cooling (geothermal, ground-coupled systems, basement/underground space, etc.)</li> <li><input type="checkbox"/> Radiative Cooling (cool roof, night sky radiation, radiant barriers, reflective surfaces, etc.)</li> <li><input checked="" type="checkbox"/> Nature-based Solutions (green roof/wall, tree shading, etc.)</li> <li><input checked="" type="checkbox"/> Others (human behavior, clothing, semi-passive (fans, etc.))</li> </ul>

<b>Description</b> (please describe one strategy per box – you can add more boxes below if needed)
<p style="color: #808080; font-size: small;">Please describe the feature of the adopted passive cooling strategies [Max 200 words]</p> <p><b>Building Orientation &amp; Form (site orientation, building shape, etc.)</b>                      The reused classrooms are optimally orientated along the east-west axis, with the long facades facing north and south. External covered walkways offer shading the facade and windows receive no direct sunlight throughout the year.</p> <p>Due to the available land, site orientation and structural limitations, the new building faces east-west and, therefore the fenestrations, shading and glazing selection has been carefully considered to manage solar heat gain (see enveloped design below).</p> <p>All buildings are compact with a low form factor that lowers heat gain and increases energy efficiency.</p>
<p style="color: #808080; font-size: small;">Please describe the feature of the adopted passive cooling strategies [Max 200 words]</p> <p><b>Envelope Design (insulation, air-tightness, shading, window system, thermal mass, etc.)</b>                      The east and west façades of the new building use locally-manufactured clay-shaded screens and solar control glazing. Roof build ups fitted with thermal insulation.</p>
<p style="color: #808080; font-size: small;">Please describe the feature of the adopted passive cooling strategies [Max 200 words]</p> <p><b>Natural Ventilation (cross ventilation, stack ventilation, night ventilation, etc.)</b>                      All occupied rooms are provided with operable windows for single-sided or cross ventilation, depending on their size and aspect. Fixed, secure louvres are integrated into the tops of windows to provide nighttime ventilation that purges heat from the spaces. The triple story atrium in the new building is incorporated with high level louvers to aid stack ventilation as people open windows on the lower level.</p>
<p><b>Ground Cooling (geothermal, ground-coupled systems, basement/underground space, etc.)</b>                      A basement thermal labyrinth constructed with concrete masonry units (CMUs) provides cooled air to the atrium, reception and some working spaces during the day. A low energy fan drives air from outside through the labyrinth. As air passes over the labyrinth walls, floor and ceiling, heat is transferred and stored in the CMUs and concrete slabs, i.e. is passively cooled. The air is supplied into occupied at a lower temperature than outside without the need for refrigerant based cooling. To ‘recharge’ the labyrinth, cool nighttime air is passed through its maze to purge heat during nighttime hours.</p>
<p><b>Nature-based Solutions (green roof/wall, tree shading, etc.)</b>                      Existing trees were retained and extensive vegetation and shading provided in the courtyards between buildings. The green oasis provides improved outdoor thermal comfort through shading and evapotranspiration that lowers temperatures.</p>
<p>Others (human behavior, clothing, semi-passive (fans, etc.))                      Occupants are given control over their space through operable windows and efficient ceiling fans to increase comfort.</p>

**4. Active Components**

**Active (Hybrid) Cooling Strategies**

(please describe one strategy per box – you can add more boxes below if needed)

Please describe the feature of the adopted energy-efficient active cooling strategies (e.g., mechanical cooling integration (AC, fans), controlled strategies (automated shading/windows), radiative cooling, evaporative cooling, earth coupled heat exchangers, renewables, etc.) [Max 200 words]

**Mechanical ventilation supply and extract support natural ventilation and thermal labyrinth strategies****Efficiency mechanical fans are used in various instances:**

- The atrium is served by a large extract fan at high level to ventilate the building and purge heat when conditions mean natural ventilation is insufficient.
- The thermal labyrinth is supplied by a mechanical fan
- Rooms without windows are supplied with fresh air mechanically

**Server and IT rooms are served by split and multi-split air conditioning systems.****5. Performance Data****Cooling Energy Use**

Excluding the AC used for IT rooms, the energy demand for comfort cooling comes from the mechanical supply and extract fans (for the atrium, labyrinth and rooms without windows) and ceiling fans. Whilst these are not sub-metered, the actual energy demand is estimated to be considerably lower than an air conditioned building.

Norrskan Kigali House is EDGE Advanced certified, meaning its buildings will have 40 percent or more on-site energy savings. This is not an accurate determination of actual energy use but an indicator, or benchmark, of how the building performs in comparison to similar buildings in the region.

**Indoor Thermal Comfort**

An adaptive thermal model

The building adopts an ‘adaptive thermal comfort’ approach, based on the principle that an individual’s thermal expectations and preferences are determined by their experience of recent (outdoor) temperatures and a range of contextual factors, such as their access to environmental controls (such as open windows and blinds). The adaptive thermal comfort model allows for the natural adaptation of human physiology to extended periods of hot events. By using the adaptive thermal comfort model, contrary to the use of static comfort temperatures, the periods of discomfort and therefore the potential energy demand for active cooling are not overestimated. An adaptive comfort approach

encourages the following for naturally ventilated buildings when temperatures rise above 25oC, which is predominantly the case during the day in Kigali:

- Relaxation of formal office dress to encourage individual adaptation to conditions ● Individual control over the thermal environment, where practicable, such as by opening windows,
- Using blinds or moving out of sunny areas
- Flexible working so people can work at more comfortable times
- Availability of hot or cold drinks
- Increased air movement; e.g. the cooling effect of local fans can be equivalent to reducing the operative temperature by around 2oC. Breezes through openable windows also help.

The building fluctuates with outdoor temperatures. Anecdotal the building and its landscape are notably more comfortable than the surrounding city and non-airconditioned buildings in Kigali during warm spells.

## 6. Financial Data

Cost Benefits
Not calculated but expected to have significantly lower electricity bills than a comparable air conditioned workspace.

\*Please try to extract passive cooling cost and savings; however, if it is difficult, please annotate the premise. (e.g., the calculation includes the cost for both passive heating and cooling, etc.)

## 7. Passive Cooling Operation

Maintenance Requirement
<p>Please describe the maintenance requirement to sustain the passive cooling performance [Max 150 words]</p> <p>Typical periodic maintenance of mechanical supply and extract fans and ceiling fans is necessary. Filter cleaning where they are used.</p> <p>Cleaning of the labyrinth air pathway every year.</p> <p>General cleaning and maintenance of operable windows as necessary (low maintenance).</p> <p>Fixing and replacement of tile shading as necessary (low maintenance).</p>

## 8. Lesson Learnt / Recommendations

### Technical Challenges, Solutions and Achievement

Please describe the challenges and solutions of passive cooling strategies in the design/construction/operation phase [Max 150].

It is extremely important that the client / building operator / users understands how the passive and mechanical systems interact and how they are operated, particularly if they are unusual for the context.

Equally important is communicating the comfort performance of passive and hybrid systems. E.g. a building designed to meet adaptive comfort criteria may overheat in the hottest or unusually hot weather. It will not feel the same as an air conditioned space .

### Financial Challenges, Solutions and Achievement

Please describe the challenges and solutions of passive cooling strategies from the financial perspective (e.g., what are the factors of incremental costs (e.g., imported materials, lack of labor skills, additional analysis cost, etc.), and how could these be mitigated (e.g., tax rebate, preferential loans, subsidies, business incentives, etc.) [Max 150].

Wood fibre insulation (low embodied carbon insulation specified for the project) not a typical product in Rwanda and needs to be imported from Europe.

### Other Challenges, Solutions and Achievement

Please describe the challenges and solutions other than the two above (e.g., capacity of design professionals, material availability, cultural resistance, users' low awareness, etc.) [Max 150].

EDGE Advanced Certification

## 9. Free Description

### Free Description

Please describe the information that could be useful to readers (e.g. replicability of case studies, tips on design and material specifications, cost information, etc.) [Max 300].

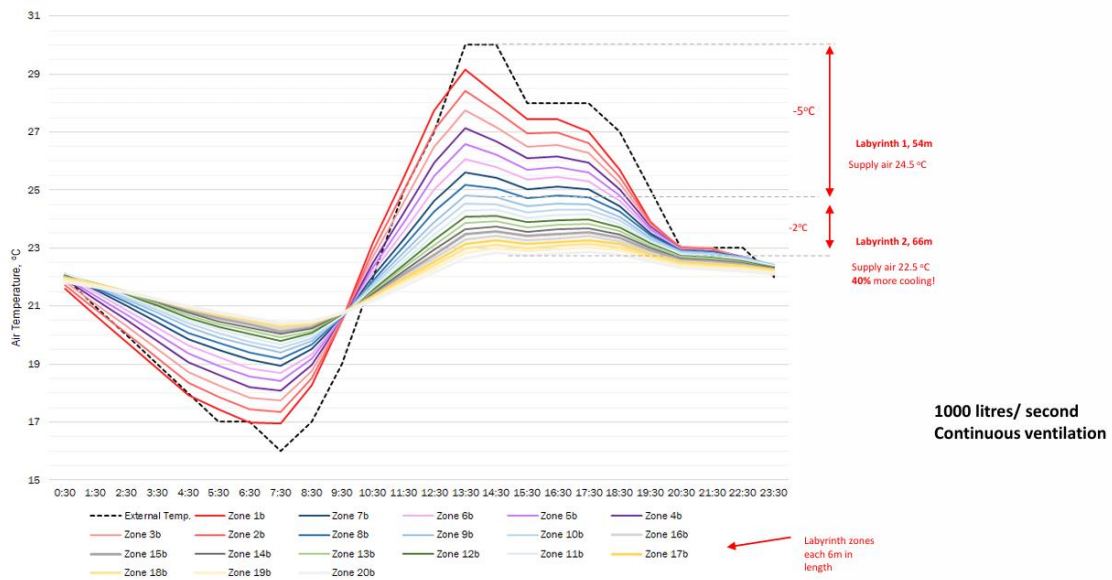
## 10. Annex

### Supporting documentations

Please insert any complementary visual materials such as drawings, analysis, performance data, thermal fluid simulation imaging, 3D rendering, as well as descriptions to explain those, etc.

#### Design

#### Labyrinth Cooling Performance



Estimated cooling performance of the thermal labyrinth modelled using IES Virtual Environment. The graph shows the performance on one hot day when outdoor temperatures reach 30°C. Each line on the graph shows the temperature of supply air along the length of the labyrinth. **A total cooling effect of 7°C** is predicted for a 66m long labyrinth with a supply ventilation rate of 1000 litres per second.



Photo: Outdoor landscape and shaded outdoor seating areas

## 11. Citation

### Citation

<https://www.norrskan.org/houses/kigali>

<https://massdesigngroup.org/work/design/norrskan-kigali-house>

<https://www.archdaily.com/999752/norrskan-kigali-house-mass-design-group>

## 12. Contact

<b>Contact Person</b>	
Name	<b>Tilly Lenartowicz / <a href="#">Anton Larsen</a></b>
Title	<b>Senior Officer / Principal</b>
Organisation	<b>Sustainable Energy for All / Mass Design Group</b>
E-mail	<b><a href="mailto:tilly.lenartowicz@seforall.org">tilly.lenartowicz@seforall.org</a></b>