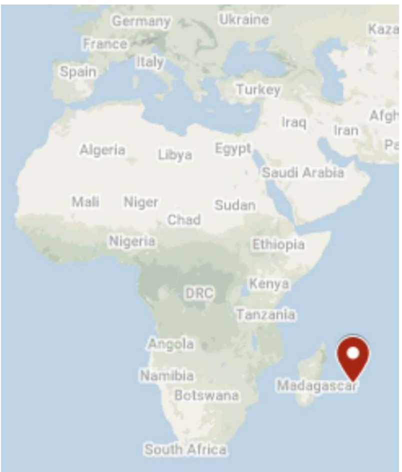
CASE STUDY 2-05: MALACCA FLORES | LA REUNION

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GEOGRAPHICAL AND CLIMATE INFORMATION	
Location	Mail de l'Océan, Le Port, La Réunion
Latitude; Longitude	-20.938530579904032, 55.29597022970212
Climate zone (Köppen–Geiger classification)	Aw: Tropical savannah with dry winter
BUILDING INFORMATION [1][2]	
Building Type	Mixed – Residential, Offices and Shops
Project Type	New construction
Completion Date	2017
Number of buildings	Malacca: 3 Flores: 2
Number of storeys	7
Total Floor Area (m²)	-
Net Floor Area (m²)	8 780 (7 800 m² of housing areas and 980 m² of business premises surfaces)
Thermally conditioned space area (m²)	0
Spaces with Natural Ventilation (with or without Ceiling Fans) Only (m²)	8 780
Total cost (€)	20 300 000
Cost /m² (€/m²)	2268.2
Performance Standards or Certification	The accommodations meet the recommendations of the local PERENE tool (acronym for Energy performance of buildings)
Awards	None
STAKEHOLDERS [2][3]	
Building Owner/ Representative	SIDR
Architect / Designer	AP architectures, 2APMR
Environmental consultancy	LEU Réunion
Structural Engineer, Civil Engineer	GECP

ABC21 is funded by the EU's H2020 programme

MEP consultancy	SOCETEM
PV engineering firm	TOP BIS

PROJECT DESCRIPTION [2][3]

Figure 68 : Exterior view of the Malacca Flores operation and the newly created axis towards the sea. (© Hervé DOURIS)

Figure 69 : Optimized solar shading devices, over-roofs and external passageways are architecturally integrated in the Malacca Flores project. (© Hervé DOURIS)

Delivered in late 2011, the two triangular islets Malacca and Flores belong to a large urban development project initiated by the city of Le Port for the requalification and the densification of its city centre. The compact programme induces a high density - 509 dwellings per hectare.

The five buildings of the operation are designed according to passive bioclimatic principles to provide 138 comfortable and energy efficient housing units (including 53 student apartments, 24 social rented housings and 61 intermediate rental housings).

On the ground floor services and businesses: tax office, post office and a restaurant.

In the North, 3 buildings make up the Malacca residence while in the South, Flores consists of two buildings, all crossed by vegetation. The whole operation is strictly drawn, with sharp base, dressed basalt stones, currents floors with varied treatments and a crowning of attics, types of houses in duplex overlooking. Fractionation of high volumes partially mitigates the perception of height. Both plots with diverse orientation raise the issue of the management of the sunshine on the directions east and west. The answers vary depending on the orientation and berries to protect: louvered verandas, corridors deported, caps, vertical blades. Parking is under the building for convenience of access and comfort reasons and for bioclimatic reasons, since the building is so surrounded by green spaces, not paved areas, increasing the heat island effect urban.

SITE INTEGRATION [3]

Figure 70 : Aerial view of the building in its surrounding environment. (Source: Google Map)

The housing projects Malacca and Flores are designed as an urban complex and forms the entrance of the development zone Mail de l'Ocean, which aims to open the city to the port. It is located in a dense area of the city centre, on a rectangular plot split in half diagonally. The project therefore proposes a simple functional organisation with the creation of legible and identifiable entities, easily appropriable, distributed in two blocks facing each other: To the south, Flores is organised into two buildings linked by a break that integrates vertical movements. To the north, Malacca is divided into 3 buildings to meet the requirements of alignment and the breakthrough (public green space) towards the rue de Montpellier.

CLIMATE ANALYSIS

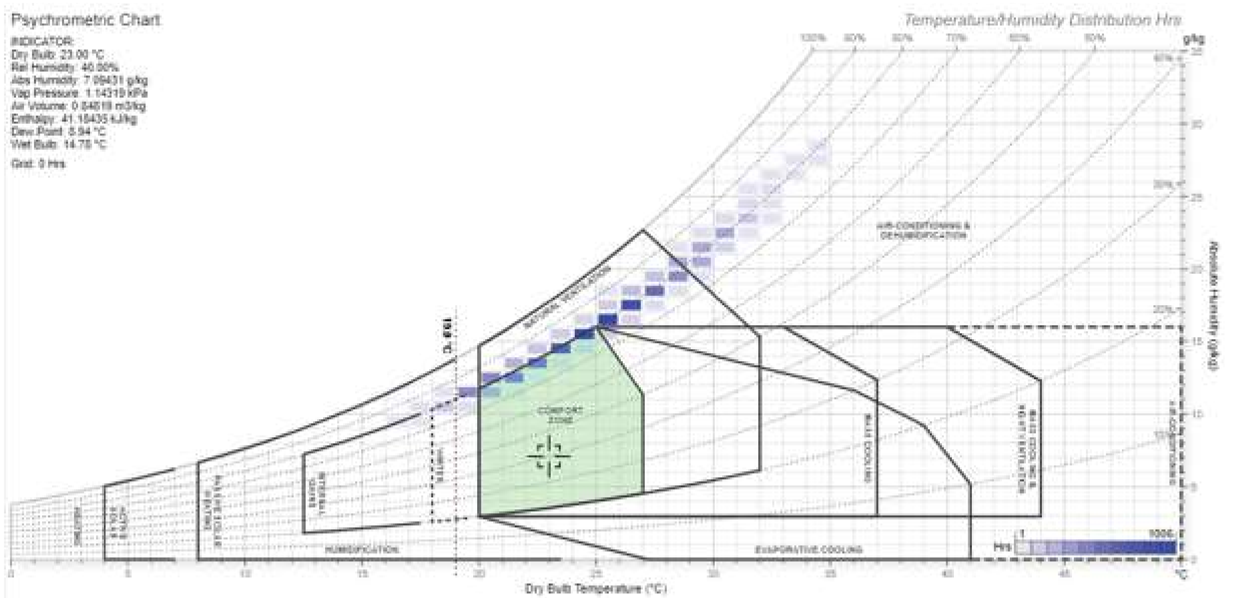

Figure 71: Givoni Bioclimatic chart for the climate of Le Port, La Reunion using Andrew Marsh online tool [2].

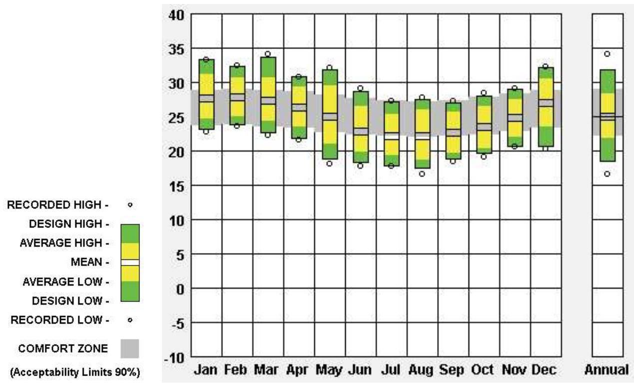

Figure 72: Temperature range by month for Le Port, La Reunion (Source: Climate consultant – Adaptative Comfort model).

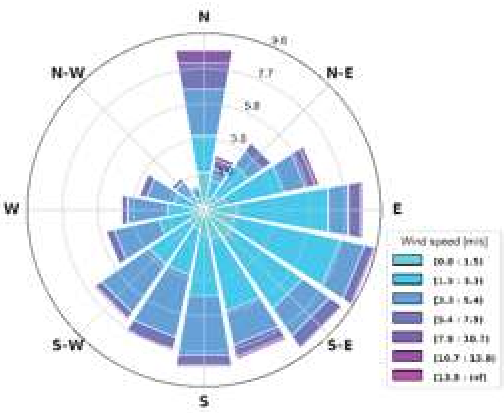

Figure 73: Wind rose for Le Port, La Reunion (Beaufort wind scale).

Global horizontal radiation (Avg daily total) Min (month) / Max (month)	Min: **3 809** Wh/m² (Jun) Max: **6 133** Wh/m² (Dec) Mean: **5 048** Wh/m²
Annual Degree-Days for weather classification according to ASHRAE Standard 169-2020	HDD 18°C: **0** CDD 10°C: **5 447**
Annual Degree-Days for the Adaptive Comfort Base Temperature according to the ASHRAE 55-2017	HDD: **71** CDD: **25**
Annual Degree-Days for a static comfort temperature approach	HDD 18.6ºC: **1** CDD 26º: **294**

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KEY BIOCLIMATIC DESIGN PRINCIPLES [2][3]	
Passive cooling strategy	**Comfort ventilation** (natural cross ventilation) Cooling is performed by natural ventilation combined with the evapotranspiration induced by the omnipresent native vegetation: all housing units are cross naturally ventilated and equipped with louvered windows; offices and shops are equipped with fans and the breakdown of the buildings facilitates the air flow at the scale of the building block.
Passive heating strategy	None
Solar protection	Solar shading is achieved by various architecturally integrated features designed according to the orientation of the facades, the views and the openings to protect: louvered porches, shading external passageways; horizontal blinds, vertical fins, trellised screens, over-roofs with wide overhangs. The design and optimisation of the solar shading devices were performed thanks to dynamic solar simulation using the Sketchup tool. The design of the various solar shading devices is adapted according to the orientation of the façade and the room operation.
Building orientation	The buildings are orientated facing the dominant wind for natural cross ventilation.
Insulation	PV panels and solar thermal collectors are integrated to the over-roofs which are used for shading the roofs of the buildings and limiting the adverse thermal gains through material conduction. East and West facades are thermally protected with wooden cladding. A reflective cladding is also installed and allows reflects up to 90% of the solar radiation.

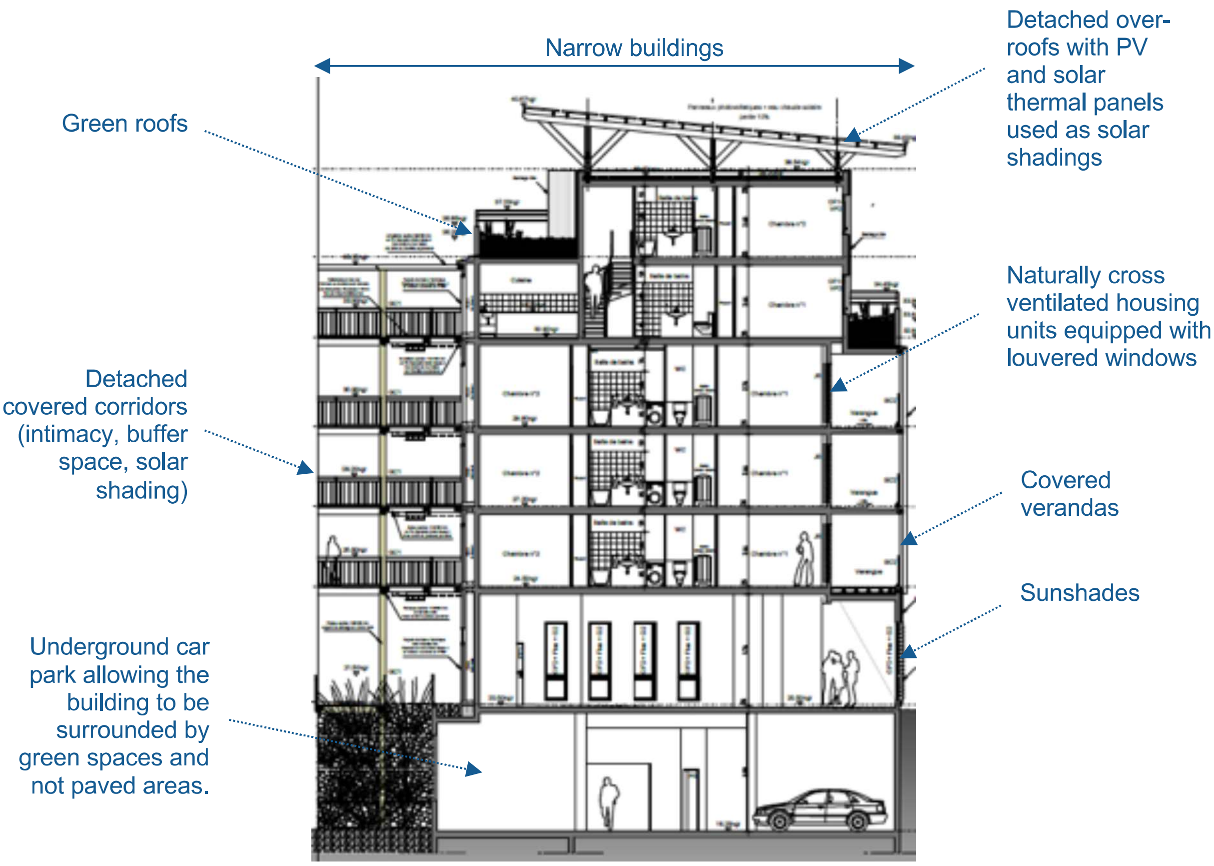
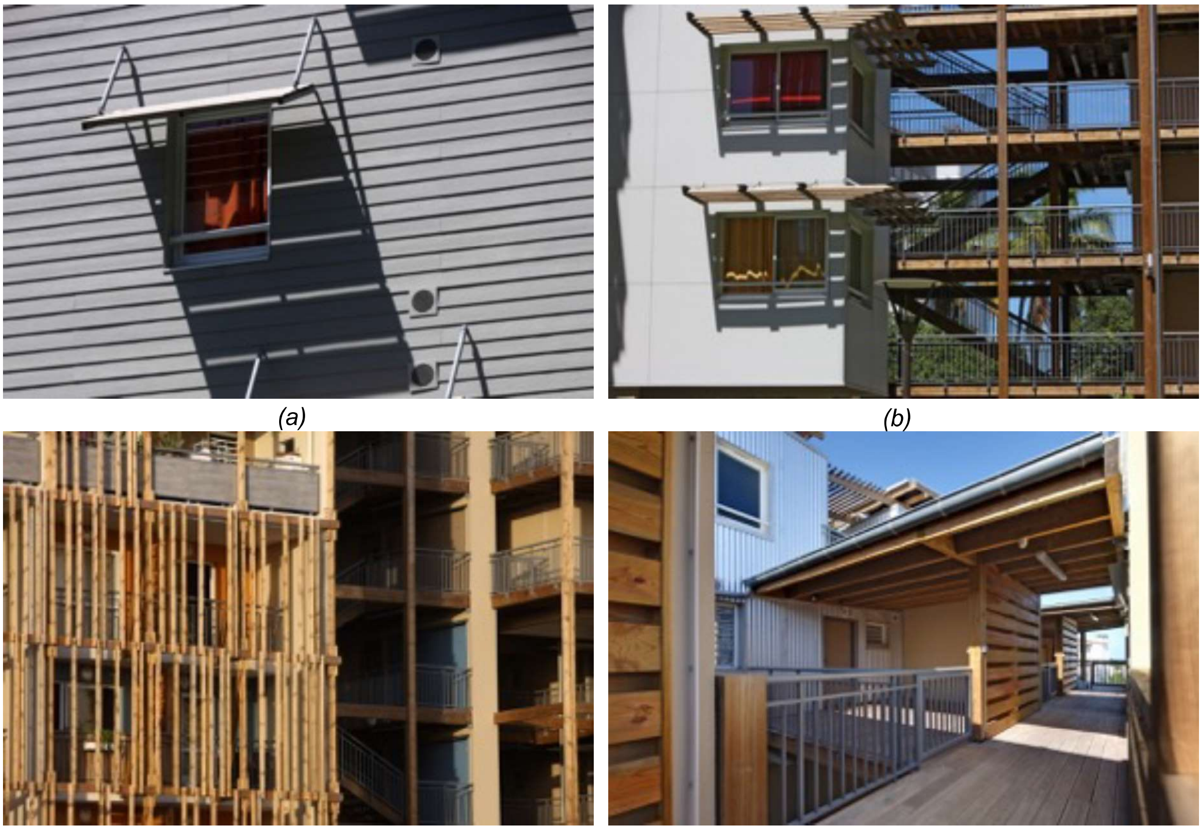


Figure 74: Cross-section of the main bioclimatic principles implemented. © Antoine Perrau Architectures

Vegetation	The greening of buildings around is dense and based on a plant palette rich in endemic dry area. Indeed, the permeable spaces in the centre of the operation and on the periphery represent 24% of the land area (650m^2) that are planted with trees and shrubs. The building also includes flat roofs and some green walls. As far as possible, the feet of the facades are planted with species adapted to the environment, requiring little watering and maintenance.
Natural daylighting	Natural lighting is favoured in all spaces (housing and external traffic). The dwellings all benefit from large bay windows necessary for good natural ventilation, and these large windows also contribute to the comfortable lighting of the living areas.
Use of local and embedded materials	Perennial materials were chosen for their intrinsic qualities in a setting simple and consistent work. The choice was also focused on safe building products for health, benefiting labels. This includes wood (pine class IV), ONDULIT sheet panels and fibre cement siding. To reduce the green gas emissions related to construction materials, wood is widely used and integrated in the project: structure, over-roofs, pergolas, passageways, decks, solar shadings, façade cladding.
Water saving and flood management	Rainwater harvesting and temporisation by infiltration and overflow to the network; Recovery of grey water from the communal laundry room and part of the dwellings for watering the adjoining public gardens by means of a pit and a landfill.
Waste management	Building waste was sorted in order to reduce the environmental impact of the construction of the buildings. The buildings are equipped with specific bins for recyclable waste (paper, cardboard, plastic and metal).

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** If yes, Ratio with number of users: **-**
Ceiling fans	In every room, even those conditioned: **No, only in offices and shops located at the ground level.**
Lighting system fractioned to allow using light only in zones occupied and where daylighting insufficient	In every room, even those conditioned: **Yes**
Space and facilities for line drying clothes (especially important in residences, hotels, sport facilities…)	In every room, even those conditioned: **Yes**
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.: **Unknown**



(a) (b) (c) (d)

Figure 75: Different solar protection strategies have been implemented depending on the orientation and the type of openings to protect such as concrete caps (a), vertical and horizontal wooden blades(b) (c) and deported covered corridors (d). © Hervé DOURIS

BUILDING FABRIC AND MATERIALS	
Roof	The main roof structure is composed of PV and solar thermal panels integrated to a detached over roof structure made of wooden frame.
	Different types of green roofs have also been set up. The **green roofs created as private gardens** are composed of (from top to bottom): ▪ Vegetal earth [0.42m], ▪ Draining gravel [0.15m], ▪ Geotextile, ▪ Expanded polystyrene drainage sheet for terraces (SOPRADRAIN ®) [0.055m], ▪ Two-layer elastomer waterproofing ▪ Concrete slab [0.18 m] U-value= **0.488** [W / m²K] Overall R-value: **2.05** [m^{2}K/W]
Windows	▪ Louvered windows of different dimensions [0.9×1.10 m] [1.8×1.10 m] ▪ 3-leaf sliding aluminium door [2.4×2.10 m] Type of materials: Clear glass - thickness of 0.006 m
	Window-to-wall ratio (WWR): **20 %** of glazed area in the bedrooms and **46%** in the living rooms.

Walls	Different types of siding materials have been used to protect the facades exposed to solar radiation. Part of the **exterior walls** are composed of (from outside to inside): ▪ ONDULIT metal siding [-m] or fibre cement cladding [0.01m] ▪ Air gap [0.03m] ▪ Reinforced concrete wall [0.16m]

	ONDULIT metal siding	Fibre cement cladding
U-value [W/m²K]	2.268	3.125
Overall R-value [m2K/W]	0.441	0.320

The **most exposed exterior walls** are composed of (from outside to inside):

- Plasterboard and mineral insulation composite panel [-m]
- Reinforced concrete wall [0.16m]

U-value= **1.01** [W / m²K]

Overall R-value: **0.991** [m^2K/W]

Figure 76: Exterior view of the facades showing the different types of finishing materials used for the exterior walls, i.e., ONDULIT sheet panels and fibre cement siding. © Hervé Douris.

ENERGY EFFICIENT BUILDING SYSTEMS	
Low-energy cooling systems	None
Low-energy heating systems	None
Ceiling fans	No ceiling fans in the apartments. Only the offices and shops at the ground level are equipped with ceiling fans.
Mechanical ventilation / air renewal	Limited use of mechanical systems for the ventilation of the bathrooms and toilets of some apartments. Wet rooms are preferably located on the facades and naturally ventilated throughout louvered windows.
Domestic Hot Water	Solar hot water production system.
Artificial lighting	All the dwellings are equipped with low-energy compact fluorescent lamps. All the corridors are outside and therefore do not require artificial lighting during the day. The lighting in the communal areas (external walkways, car park, corridors, halls) is of the fluorescent type controlled by motion detectors with integrated timers and photocells.
Control and energy management	None

RENEWABLE ENERGY	
PV	Integrated photovoltaic plant in overlaid roofs consists of 420 m^2 of PV panels Sharp, an 88 kWp power fed back into the network.
Solar thermal	Domestic hot water for all the buildings is produced thanks to 219 m² of solar thermal collectors. Individual water tanks are installed in each apartment. An electric backup power supply is installed and can be used in case of low solar availability during the winter period.
Wind	None
Geothermal	None
Biomass	None

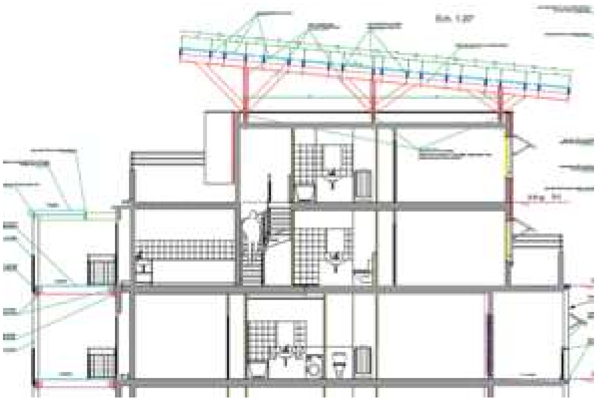


Figure 77 : Detached building integrated PV roof principle. This architectural feature enhances the efficiency of the panels by avoiding potential overheating and limits solar radiation on the roofs (© LEU Reunion)

Figure 78 :Aerial view of the PV system and solar thermal panels. (© Hervé Douris)

BUILDING ANALYSIS AND KEY PERFORMANCE INDICATORS	
Thermal comfort indicators	1. Percentage of time outside an operative temperature range (Adaptive)
	2. Percentage of time outside an operative temperature range (Fanger)
	3. Degree-hours (Adaptive)
	4. Degree-hours (Fanger)
	5. Percentage of time inside the Givoni comfort zone of 1m/s
	6. Percentage of time inside the Givoni comfort zone of 0m/s
	7. Number of hours within a certain temperature range
Energy performance indicators	1. Energy needs for heating= **-** [kWh/m^2/year]
	2. Energy needs for cooling = **-** [kWh/m^2/year]
	3. Energy use for lighting = **-** [kWh/m^2/year]
	4. Energy needs for Sanitary Hot water = **-** [kWh/m^2/year]
	5. Total Primary energy use = **60** [kWh/m^2/year] (total Primary Energy Factor (PEF) equal to 3.00 for electrical energy from the grid)
	6. Renewable Primary energy generated on-site= **16** [kWh/m^2/year]
	7. Renewable Primary energy generated on-site and self-consumed= **0** [kWh/m^2/year]
	8. Renewable Primary energy exported to the grid= **16** [kWh/m^2/year]
	9. Ratio of renewable primary energy over the total primary energy use = **80** %

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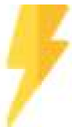
	10. Delivered energy (from electricity bills) = **20** [kWh/m^2/year]
Acoustic comfort indicators	1. Airborne sound insulation
	2. Equivalent continuous sound Level
	3. HVAC noise level
	4. Reverberation time
	5. Masking/barriers
Visual comfort indicators	1. Light level (illuminance)
	2. Useful Daylight 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	People are overall satisfied about the comfort conditions. The building works so well that people from the surroundings come to look for fresh air. The consequence is that people who lives in the building complain about safety issues.

LESSONS LEARNED AND RECOMMENDATIONS	
Lessons learned	▪ The breakdown of the operation into two islets and five narrow buildings enhances natural ventilation throughout both islets. ▪ The mix managed strata and not bodybuilding between such students and families, has led to tensions within the residences. This solution requires a prior tenant awareness and a learning among people for living together. ▪ The common areas and corridors designed as real meeting places have attracted the presence of external persons not necessarily desired. The multiplication operations offering qualities similar spaces should overcome this inconvenience.
Recommendations	▪ A large part of the heat input comes through the roof in this climate. Consequently, this element of the design should be treated with the utmost consideration and care. Over-roofs are a very efficient feature mutualizing energy generation and solar protection. ▪ A high level of porosity of the facades combined with optimized solar shading devices and vegetated surroundings is recommended since these measures ensure good visual and thermal comfort even in harsh tropical conditions. ▪ Noise and safety issues as well as visual intimacy should be considered when designing a building since these aspects can have a negative impact on the proper functioning of the bioclimatic strategies set up, especially on natural ventilation.

BUILDING STRENGTHS AND WEAKNESSES

Strengths

		
Passive Design	**Energy Efficiency**	**Renewable Energy**

Weaknesses

- Concrete caps, serving as sun protection, store and release their heat through the openings.
- Lack of safety and visual intimacy because of windows of some living spaces that open onto the corridor pathways. This has a negative impact on the natural ventilation operation since people do not open these windows.

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