Case Study Title: Bioclimatic terminal: extension of the Roland-Garros airport in La Réunion

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Project Name	Bioclimatic terminal: extension of the Roland-Garros airport in La Réunion
Location	74 Avenue Roland Garros 97438 SAINTE-MARIE, France
Climate Zone	[Af] Tropical Wet. No dry season.
Latitude/Longitude	20.8902°N, 55.5173°E
Building Type	Airport
Floor Area [sqm]	13 000 m^2
Building Height [m]	
Number of Storeys	G+3F
Completion Year	2024
Project Team	Contractor: Aéroport de La Réunion Roland-Garros Construction Manager: AIA LIFE DESIGNERS Designer: AIA LIFE DESIGNERS Designer: Olivier Brabant Other consultancy agency: AIA Ingénierie, AIA Environment, AIA Territories Environmental consultancy: INCOM (Saint-Denis), Inset, AD-ET (Suisse).

*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

Project Overview
1) The Bioclimatic Terminal Extension of Roland Garros Airport in Sainte-Marie, La Réunion, was designed to meet the island's growing air traffic needs while significantly reducing environmental impact. Located in a tropical climate, the airport faced challenges related to heat, humidity, and high energy demand for cooling. The new terminal, an extension of the existing structure, was conceived as a pioneering project to demonstrate how large-scale infrastructure in tropical regions can combine functionality, passenger comfort, and sustainability. The project redefines airport architecture by integrating passive bioclimatic design principles within an operational international hub. 2) Instead of relying on conventional air conditioning, the design focuses on *natural ventilation and passive cooling*. A system of large wooden canopies, open façades, and roof openings creates a natural airflow through the terminal, using the island's prevailing winds to maintain comfort. The layout incorporates shaded walkways, double roofing, and solar protections to reduce heat gain, while vegetation and water elements enhance evapotranspiration. Materials with low thermal inertia were selected to avoid overheating. Together, these strategies enable a comfortable indoor environment with minimal mechanical cooling, drastically lowering energy consumption and carbon emissions. 3) The project stands as the *first large-scale bioclimatic airport terminal in the world*, achieving exceptional energy performance in a tropical context. It reduces energy use by approximately **40% compared to a conventional air-conditioned terminal** and optimizes natural light and ventilation throughout. Locally sourced timber structures and modular construction methods minimized embodied carbon and supported regional industries. Beyond its environmental results, the terminal enhances the passenger experience through open, luminous, and comfortable spaces. The project demonstrates that tropical airports can be both modern and sustainable, setting a new global benchmark for bioclimatic architecture in public infrastructure.

2. Climate & Site Context

Basic Climate Conditions		
Temperature	Annual Average	27°C
	Annual Range	24°C (August) - 30°C (February)
Relative Humiditiy	Annual Average	68%
	Annual Range	64% (June) - 75% (March)
Annual Degree-Days (ASHRAE Standard 169-2020)		

Climate Analysis
Located in La Réunion, the project site experiences a tropical maritime climate characterised by high humidity and limited seasonal temperature variation. Average monthly temperatures range from 24 °C in August to 30 °C in February, with relative humidity averaging 70 % year-round. The region is influenced by trade winds from the southeast, which provide consistent natural ventilation opportunities. Solar radiation is strong throughout the year, averaging 5–6 kWh/m²/day, with intense sunlight requiring effective shading and orientation strategies. The site's exposure to high humidity, intense solar gain, and occasional cyclones called for robust yet passive architectural responses. The bioclimatic design capitalises on prevailing winds, natural light, and shading to ensure comfort without mechanical cooling, while its timber structure and open façades support both airflow and resilience in this warm, humid context.

Site Analysis
The Roland Garros Airport is located on the northeast coast of La Réunion, between the Indian Ocean and the steep volcanic mountains that shape the island's topography. The site is flat and exposed, offering unobstructed access to prevailing southeast trade winds and direct solar radiation, key drivers for the project's passive design strategies. Surrounded by existing airport infrastructure, the extension had to integrate seamlessly with dense operational areas while maintaining open visual and physical connections to the surrounding landscape. Landscaping plays a vital environmental role: vegetated areas, water features, and shaded walkways help cool the microclimate and enhance passenger comfort. The proximity to the sea and the risk of cyclones and saline air also informed the choice of durable, low-maintenance materials and a resilient structural system. Together, these site conditions shaped a design that is both bioclimatic and contextually adapted.

3. Passive Cooling Design Details

Passive Cooling Strategies (please tick implemented passive cooling strategies)
☐ Building Orientation & Form (site orientation, building shape, etc.) ☑ Envelope Design (insulation, air-tightness, shading, window system, thermal mass, etc.) ☑ Natural Ventilation (cross ventilation, stack ventilation, night ventilation, etc.) ☐ Evaporative Cooling (direct/indirect evaporative cooling, etc.) ☐ Ground Cooling (geothermal, ground-coupled systems, basement/underground space,etc.) ☐ Radiative Cooling (cool roof, night sky radiation, radiant barriers, reflective surfaces, etc.) ☑ Nature-based Solutions (green roof/wall, tree shading, etc.) ☑ Others (human behavior, clothing, semi-passive (fans, etc.))
Description (please describe one strategy per box – you can add more boxes below if needed)
The design is based on innovative principles, including natural ventilation through a cross-canyon and a system of motorized louvers regulated by a weather station. The presence of native vegetation and the use of natural materials (particularly wood) reinforce the environmental commitment of the airport, already recognized for its carbon reduction efforts. The terminal's design relies primarily on **natural ventilation**, eliminating the need for mechanical air conditioning in most spaces. Only a few enclosed, windowless areas such as customs and operations offices in the baggage claim zone are air-conditioned. The rest of the building uses air circulation fans to support airflow when needed. This approach drastically reduces energy consumption and enhances passenger comfort by allowing continuous air renewal driven by the island's natural climatic conditions.
The project's **geometry was shaped by the goal of optimizing natural airflow**. Inspired by the Cirque de Mafate landscape, a "depression canyon" was created to channel the island's trade winds through the terminal. These winds, coming from the east-northeast to south-southeast and averaging over 6 m/s in summer, are guided through architectural openings and roof undulations that accelerate air movement and maintain thermal comfort.
To preserve airflow between the new and existing buildings, the extension is positioned in an L-shape, creating a climatic gap that safeguards ventilation. A climatic barrier at the gap's northern end increases pressure on the main intake façade, while the canyon acts as an extraction pump. Additional buffer shafts ensure that even the northern areas benefit from efficient, naturally driven ventilation.

4. Active Components

Active (Hybrid) Cooling Strategies (please describe one strategy per box – you can add more boxes below if needed)
Although the terminal relies primarily on passive systems, a few targeted active cooling strategies were integrated to maintain comfort and operational efficiency in specific zones. Only the customs and baggage claim areas, which are enclosed and windowless, are equipped with mechanical air conditioning. These systems are designed for high efficiency and limited use, operating only where natural ventilation is not feasible. Across the terminal, low-energy ceiling fans are installed to enhance natural air circulation and increase perceived comfort without major energy demand. Automated systems regulate airflow and lighting based on occupancy and temperature conditions, ensuring that mechanical equipment is activated only when necessary.
The building envelope and orientation further support energy efficiency through **controlled shading and solar protection**, minimizing heat gain and reducing the cooling load. Combined with the naturally ventilated spaces and the bioclimatic roof geometry, these selective active systems allow the terminal to achieve significant energy savings while maintaining stable indoor comfort. Overall, the integration of light mechanical support within a predominantly passive framework illustrates a balanced and context-sensitive approach to tropical climate design.

5. Performance Data

Cooling Energy Use
From a consumption point of view, the widespread use of natural ventilation and the significant contribution of natural light, makes it possible to reduce the energy consumption (lighting, ventilation and cooling) of the extension by around 60% compared to an equivalent building that would be air-conditioned to the same level of comfort.
Indoor Thermal Comfort
The shade created by different elements helps protect the occupants of the direct solar radiation and therefore that they are subjected to the air temperature mainly. The second part of the well-being of the occupants is therefore the reduction of the sensation of heat with the creation of natural ventilation. To characterize this comfort, the Givoni diagram makes it possible to value air speeds up to 1.5m/s for a sensation of perceived temperature reduced by 4 to 5°C. For periods when the wind weakens and to support the natural ventilation of certain disadvantaged areas, large air mixers are integrated to guarantee annual thermal comfort.

6. Financial Data

Cost Benefits
Primary energy consumption: 39.2 kWhep/m2.an The project's design approach demonstrates a positive return on investment through lower operational expenses and reduced mechanical infrastructure. The reliance on durable, locally sourced materials and passive systems further limits replacement and servicing costs. Over time, these cumulative savings offset the initial investment in bioclimatic design features, creating a resilient and cost-effective model for tropical airport infrastructure. The result is a facility that delivers long-term economic value while aligning with sustainability and carbon reduction goals.

*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
Maintenance focuses mainly on keeping airflow paths clear, including the depression canyon, ventilation shafts, and shading elements, to ensure continuous and unobstructed air movement. Periodic inspections of louvers, openings, and roof structures are carried out to verify optimal operation, especially after cyclonic events common to the region. Routine cleaning of vegetation and shading devices helps maintain natural airflow and daylight efficiency, while low-energy fans require only basic servicing. The simplicity of these systems translates to lower maintenance costs, reduced downtime, and consistent performance over time. Overall, sustaining the terminal's passive cooling performance primarily depends on preventive upkeep and environmental monitoring rather than intensive technical intervention.

8. Lesson Learnt / Recommendations

Technical Challenges, Solutions and Achievement
One of the main challenges we faced was ensuring effective natural ventilation in a tropical, high-traffic airport environment while maintaining comfort and safety. From the beginning, we identified the development of natural ventilation as the project's central challenge. To address it, we designed a unique geometry shaped by the prevailing trade winds, creating a depression canyon that allows air to flow naturally through the terminal. The L-shaped layout and climatic gap between the new and existing buildings were carefully configured to prevent air stagnation and preserve cross-ventilation. During operation, we integrated motorised openings and automated window drives managed by 30 D+H controllers, programmed to respond to temperature, wind, rain, and smoke extraction conditions. Together, these architectural and technical strategies ensure stable airflow, comfort, and safety while drastically reducing the need for mechanical cooling.
Financial Challenges, Solutions and Achievement
N/A

Other Challenges, Solutions and Achievement
N/A

9. Free Description

Free Description
The terminal demonstrates that the combination of natural ventilation, natural lighting, and thoughtful building geometry can achieve a 60% reduction in energy consumption compared to a conventional, air-conditioned terminal with similar comfort levels. A key takeaway for replication is the use of architectural form as a climatic tool. The creation of a depression canyon, an L-shaped configuration, and a climatic gap between new and existing buildings ensure constant airflow driven by prevailing trade winds. The case study provides detailed climatic data, including local wind patterns and average speeds, which can serve as a reference for similar designs. Material selection is also central to the project's success. The use of a timber structure, locally sourced materials, and prefabricated elements reduces embodied carbon while facilitating assembly in a tropical context. These choices balance environmental performance, construction efficiency, and resilience against cyclonic conditions.

10. Annex

Supporting documentations
Energy consumption Primary energy consumption :39,20 kWhep/m2.an Calculation method: Other **Breakdown for energy consumption:** Building not subject to RT. Actual consumption according to STD is detailed below. The value entered above corresponds to the consumption in kWhef/m2, the details of which are given in the appendices below. Actual consumption. The extension and the existing building are distinguished. The envelope and production of the existing building have not been reworked.

Répartitions des consommations par poste (kWhef/m^2)

		Locaux	Surface [m^2 SDO]	Eclairage	Climatisation statique	Climatisation dynamique sensible	Climatisation dynamique latente	Auxiliaires	Total
Locaux climatisé	N0	Locaux techniques	414	22.5	11.1	7.0	7.0	8.0	**55.6**
	N1	Bureaux douanes et litiges	510	19.2	16.5	6.1	6.1	6.9	**54.7**
		Commerce	58	50.0	43.1	15.5	15.5	17.2	**141.4**
		Total partie climatisée	**982**	**22.4**	**15.8**	**7.0**	**7.0**	**7.9**	**60.2**
Locaux en ventilation naturelle	N0	Salle de tri bagage	6 504	49.1	0.0	0.0	0.0	0.1	**49.2**
	N1	Salle d'arrivées	5 918	23.2	0.0	0.0	0.0	1.7	**24.8**
		Total partie Vnat	**12 422**	**36.7**	**0.0**	**0.0**	**0.0**	**0.9**	**37.6**
		TOTAL PROJET	**13 404**	**35.7**	**1.2**	**0.5**	**0.5**	**1.4**	**39.2**
								Objectif	**< 135kWhef/m^2**
EXISTANT		Bureaux	8 040	22.3	13.2	7.1	7.1	7.9	**57.6**
		Commerces	2 317	129.4	16.6	33.1	33.0	36.6	**248.7**
		Salle embarquement	5 310	24.6	6.8	34.0	33.9	37.5	**136.8**
		Hall arrivées	975	35.6	1.1	24.8	24.7	27.4	**113.6**
		Kiss & Fly	515	22.3	37.1	33.8	33.8	37.3	**164.3**
		PAF	1 002	20.9	0.5	26.8	26.8	29.7	**104.8**
		Passerelles	2 898	45.0	6.7	29.5	29.4	32.6	**143.3**
		LT	1 836	0.0	71.1	9.6	9.6	10.7	**101.0**
		Hall enregistrement	3 676	24.6	0.0	0.0	0.0	2.1	**26.7**
		Mezzanine restaurant	1 090	28.2	0.0	0.0	0.0	3.6	**31.7**
		Circulations	175	45.7	0.0	0.0	0.0	0.0	**45.7**
		TOTAL Existant	**27 834**	**399**	**153**	**199**	**198**	**225**	**100.9**

11. Citation

Citation
https://www.construction21.org/case-studies/fr/bioclimatic-terminal-extension-of-the-roland-garros-airport-in-la-reunion-en.html

12. Contact

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