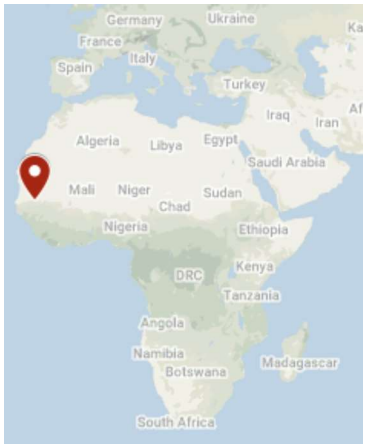
CASE STUDY 1-07 : MAISON DES ENERGIES | SENEGAL



GEOGRAPHICAL AND CLIMATE INFORMATION	
Location	Sinthiou Bamambe, District Ngapougou, Matam SENEGAL
Latitude; Longitude	15.3726727929116, -13.12709036192232
Climate zone (Köppen–Geiger classification)	BWh : Hot desert
BUILDING INFORMATION	
Building Type	Offices & Housing
Project Type	New construction
Completion Date	2009
Number of buildings	2
Number of storeys	2
Total Floor Area (m²)	2 200
Net Floor Area (m²)	600
Thermally conditioned space area (m²)	Room: 11,08 m² Questionnaire office: 16,8 m²
Spaces with Natural Ventilation (with or without Ceiling Fans) Only (m²)	-
Total cost (€)	~91 544,18 (60.000.000 FCFA) excluding PV system
Cost /m² (€/m²)	~152,55 (100.000 FCFA) excluding PV system
Performance Standards or Certification	None
Awards	None
STAKEHOLDERS	
Building Owner	Country council of Kanel
Project Manager	Community of municipalities of the “Val de Drôme”, in collaboration with the municipality of Sinthiou Banadji and the rural community of Ndendory
Architect / Designer	Mathieu Hardy
Construction manager	SASERCO, Association la Voûte Nubienne, VN burkinabès

Environmental consultancy	-
Structural Engineer, Civil Engineer	-
Product Manufacturer	Association la Voûte Nubienne, VN burkinabès
Certification company	-
Others	-

PROJECT DESCRIPTION

Figure 115: Exterior view of the building « Maison des Energies ». It is a traditional structure in adobe banco.

The house of alternative energies, located in Matam, Senegal, is a house with a useful surface of 2700 m² which includes offices and housing on two levels (DRC and R+1). The building is made of traditional structure in adobe banco.

This house was designed in such a way as to be able to respect key principles of bioclimatic comfort such as the use of natural ventilation.

In addition, its Nubian-vaulted technical concept offers numerous solutions to Africa's economic and environmental problems while offering comfort to its users.

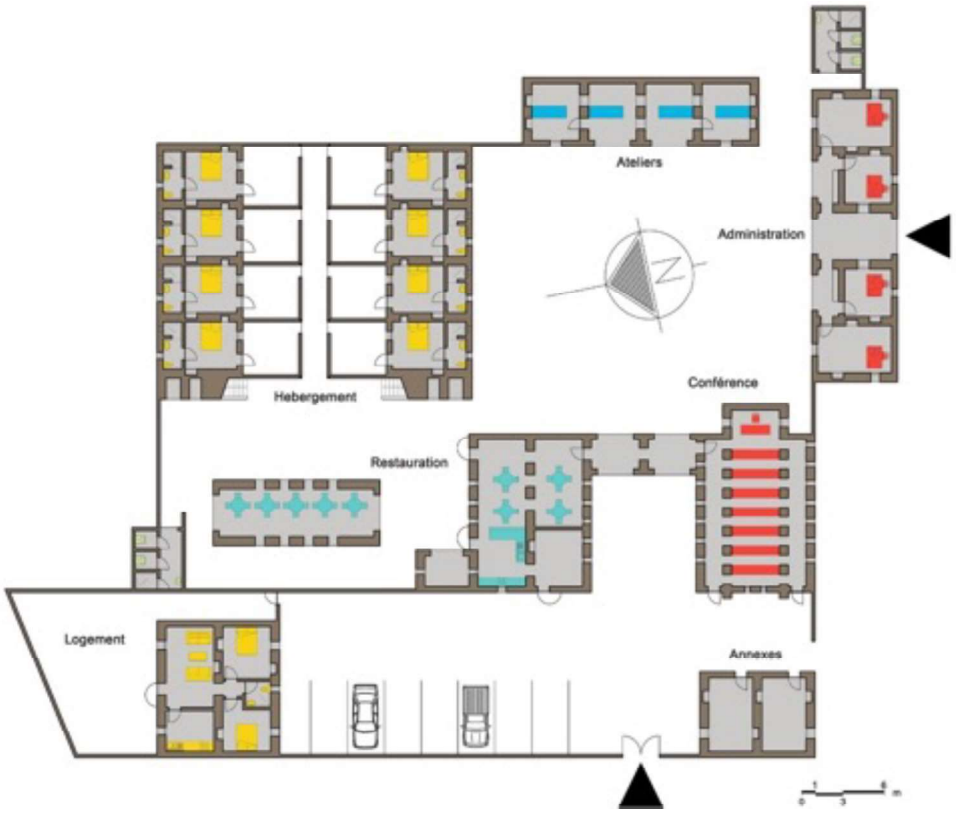


Figure 116 : Floor plan of the building [1]

SITE INTEGRATION

Figure 117: Aerial view of the building.

The house of alternative energies is located in the middle of a rural area. It is a desert area where the vegetation is very little present, hence the importance of adding small gardens within the building. This allows to decrease the air temperature, clearly felt especially in the summer period, but also to have a beautiful atmosphere for the users.

CLIMATE ANALYSIS

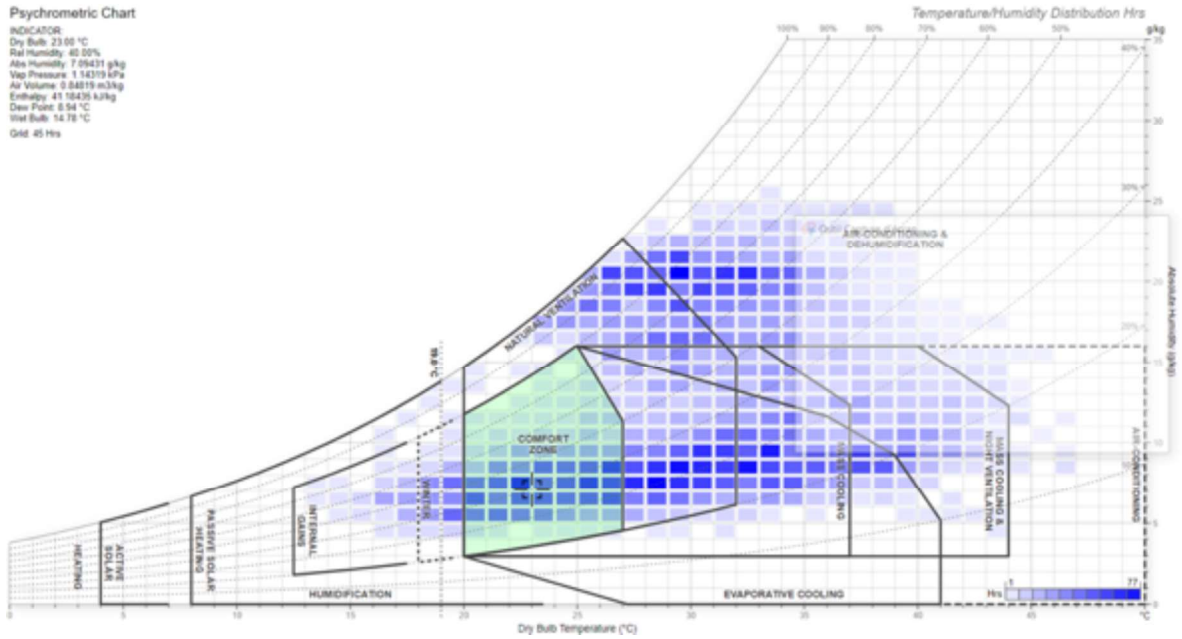


Figure 118: Givoni Bioclimatic chart for the climate of Matam using Andrew Marsh online tool [2]. Climate data are extracted from http://climate.onebuilding.org/WMO_Region_1_Africa/SEN_Senegal/SEN_MT_Matam.616300_TMYx.2004-2018.zip

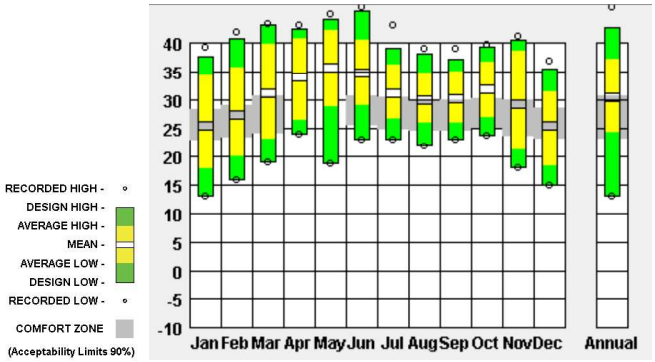


Figure 119: Temperature range by month for Matam. Source: Climate consultant – Adaptative Comfort model [3].

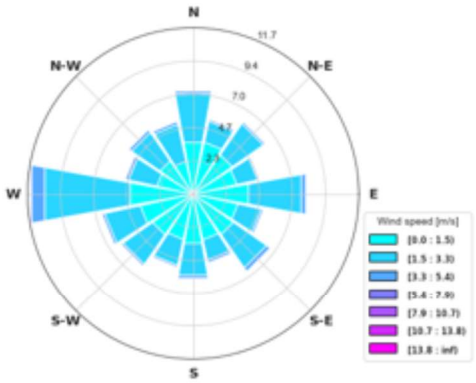


Figure 120: Annual wind rose for Matam (Beaufort wind scale) [3].

Global horizontal radiation (Avg daily total) Min (month) / Max (month)	Min: **5422** Wh/m² (Dec) Max: **7550** Wh/m² (Apr) Mean: **6421,25** Wh/m²
Annual Degree-Days for weather classification according to ASHRAE Standard 169-2020	HDD 18°C: **6** CDD 10°C: **7500**
Annual Degree-Days for the Adaptive Comfort Base Temperature according to the ASHRAE 55-2017 for 80% of acceptability	HDD: **92** CDD: **783**
Annual Degree-Days for a static comfort temperature approach	HDD 18.6ºC: **10** CDD 26º: **1940**

KEY BIOCLIMATIC DESIGN PRINCIPLES	
Passive cooling strategy	**Comfort Ventilation:** The strategy mainly used is the natural ventilation due to the presence of a large outdoor courtyard, shutter doors and louvre shutter system with adjustable slats, which allow optimal air circulation. The presence of ceiling fans in each zone of the building, allows to ensure ventilation when it is slightly hot and natural ventilation is not favourable enough. In addition, they are used to avoid the use of air conditioning. Not to mention that in order to dehumidify the air, air conditioners are also present in these areas to ensure a comfortable atmosphere.
Passive heating strategy	None
Solar protection	**Zone 1:** Three windows with swivel blades and a half-blind door with swivel blades **Zone 2:** Three half-blind doors with swivel blades and a fixed blind window with swivel blades But there is also the presence of sunshades on some windows. Indeed, the swivel blades will make it possible to stop the solar radiation in the room while keeping a certain luminosity inside it.
Building orientation	North-West
Insulation	**Mineral wool (rock, glass)**: cheap, strong insulating power, very good fire resistance (insulation of roofs, walls and floors) **Cork:** Good sound and thermal insulation, waterproof, flame retardant (insulate slabs, walls, ceilings and roofs) **Perlite:** Fire and heat resistant (for floors and hollow walls) **Polystyrene:** Better insulation, good moisture resistance **Coconut wool:** Thermal and acoustic insulation, high moisture resistance, very elastic (filling of cavities (between walls and frames for example)) **Hemp wool:** Good moisture regulator, no risk of irritation (roof insulation, walls and floors) **Linen wool:** Easy to handle, good sound insulation, insulates surfaces very well (insulation of exterior walls and hard-to-reach areas)
Vegetation	At the level of the exterior courtyard, we have the presence of small gardens, in order to be able to decrease the air temperature at the different zones but also to allow a beautiful atmosphere for the users.
Natural daylighting	The louvre shutter system with the adjustable slats installed in the building allow to optimise the use of the natural light.

Use of local and embedded materials	Locally used Mud Bricks
Water saving and heat recovery on hot water drain	None
Waste management	None
Others features	-

Figure 121: View of the exterior courtyard of the « Maison des Energies » and its garden [1].

Figure 122: Interior view of the building "Maison des Energies" with the ceiling fans [1].

Figure 123: Office's photos

Figure 124: Room's photos

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	No Ratio with number of users: -
Ceiling fans	In every room, even those conditioned: Yes
Lighting system fractioned to allow using light only in zones occupied and where daylighting insufficient	In every room, even those conditioned: No
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	Type of materials: Mud Bricks (banco)
	Overall R-value: 0.95 [W m^{-2} K^{-1}]
Windows	Type: Fixed structure in steel and louvre shutter system with adjustable slats
	Window-to-wall ratio (WWR): -
	U-value: -
	Visual transmittance: -
Walls	Type of materials: Mud walls
	Overall R-value: 0.95 [W m^{-2} K^{-1}]

Figure 125: The roof-terrace made of raw clay[1].

Figure 126: View of the banco walls

ENERGY EFFICIENT BUILDING SYSTEMS	
Low-energy cooling systems	Natural ventilation Air conditioners: 4 of the brand Westpoint whose power per unit is 2 200W and 2 of the brand Samsung whose power per unit is 2 100W
Low-energy heating systems	No heating system
Ceiling fans	Yes – 1 ceiling fan in each room Power=75W
Mechanical ventilation / air renewal	No mechanical ventilation but possibility of air renewal by natural ventilation and air mixing by ceiling fans
Domestic Hot Water	None
Artificial lighting	Compact and fluorescent light bulbs Power: 18W (Zone 1) and 11W (Zone 2)
Control and energy management	None

Figure 127: View of the cooling equipment of the rooms

RENEWABLE ENERGY	
PV	Yes, but the technical data are not available
Solar thermal	Unknown
Wind	None
Geothermal	None
Biomass	None

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: - [kWh/m^2/year]
	6. Renewable Primary energy generated on-site: - [kWh/m^2/year]
	7. Renewable Primary energy generated on-site and self-consumed: - [kWh/m^2/year]
	8. Renewable Primary energy exported to the grid: - [kWh/m^2/year]
	9. Ratio of renewable primary energy over the total primary energy use (with and without compensation): - %
	10. Delivered energy (from electricity bills) : - [kWh/m^2/year]
	1. Airborne sound insulation
	2. Equivalent continuous sound Level

Acoustic comfort indicators	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	N/A

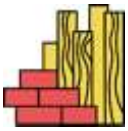
LESSONS LEARNED AND RECOMMENDATIONS

Lessons learned	The Association "la Voûte Nubienne" (www.lavoutenubienne.org) was a strong partner in the project. The construction work on site was accompanied by this organisation, as well as technical training activities for a local workforce. A little more than 10 years later, awareness-raising activities in order to widen access to the Nubian Vault concept is continuing in the Senegalese Fouta, thanks to the joint efforts of the Association "la Voûte Nubienne" and its local partners, in particular the NGO "Le Partenariat" which is located in Saint Louis (www.lepartenariat.org).
Recommendations	▪ In a desert area like that, more plants and more green areas are suitable for a more comfortable built environment. ▪ Some air-conditioners are installed. In order to have a more sustainable design, it's better to use only natural ventilation. ▪ Different artificial materials are used for insulation: mineral wool, perlite, polystyrene. In order to have a more sustainable design, it's better to use only natural and local materials.

BUILDING STRENGTHS AND WEAKNESSES

Strengths

Passive Design



Local Materials

Weaknesses

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REFERENCES

[1] https://almizan-sahel.com/maison-des-energies
[2] PD: Psychrometric Chart n.d. https://drajmarsh.bitbucket.io/psychro-chart2d.html(accessed May 7, 2021).
[3] Milne (UCLA) M. Climate Consultant 6.0. n.d. http://www.energy-design-tools.aud.ucla.edu/climate-consultant/request-climate-consultant.php.