INTRODUCTION TO THE DETAILED TECHNICAL PROGRAM

The Detailed Technical Programme is a compilation of the needs of the users, the requirements of the client and the constraints of the site. It is by no means a prefiguration of the architectural expression and technical solutions.

It constitutes the project owner's commitment, on the basis of which the design team will also be able to commit to the architectural and technical aspects, costs, phasing and completion deadlines.

Composition of the Detailed Technical Program (DTP):

The Detailed Technical Programme for the Ruhengeri referral hospital is made up of 4 Tomes which form a whole whose various elements - surface tables, texts, functional diagrams, feasibility and technical sheets - must be used together and in a complementary manner.

Together, these elements form a complete deliverable that aims to implement the hospital project in line with the recommendations and conclusions of the feasibility study.

The programme will ensure that the planned facility is optimally organised to meet the health needs of the population, while guaranteeing adequate functionality and operational efficiency.

Tome I: the functional program

The functional programme describes in detail the organisation and functionality of each space or service within the facility, and also proposes feasibility on the site selected by the project owner, environmental requirements and takes into account the provision of an *Isange One Stop Center* (IOSC).

Tome II: Technical programme and medical equipment plan

The technical programme specifies the detailed technical characteristics and/or expected performance regarding the organisation and design of the hospital project, as well as a detailed equipment plan.

Tome III: detailed fact sheets by type of premises

Detailed information sheets for each room are included in a separate volume. They are published space by space with all the architectural and technical characteristics as well as the medical equipment and furniture.

Tome IV: The bioclimatic and environmental program

The bioclimatic and environmental program specifies the detailed bioclimatic and environmental characteristics and/or expected performances concerning the organisation and design of the hospital project in relation to the requirements of the French High Environmental Quality (HQE) approach.

Annexes from Tome I, II, III and IV

RUHENGERI REFERENCE HOSPITAL

Tome 4

BIOCLIMATIC AND ENVIRONMENTAL PROGRAM

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ABBREVIATIONS

AFD	Agence Française de Développement - French Development Agency
AHU	Air Handling Unit
AP-HP	Public Assistance - Paris Hospitals
BMS	Building Management System
CBRN	Chemical, biological, radiological and nuclear
CHU	University Hospital Centre
CI	Carbon Indicators
CTM	Centralized Technical Management
CRI	Colour Rendering Index
DF	Daylight factor
DCW	Domestic Cold Water
DHW	Domestic Hot Water
HACCP	Hazard Analysis Critical Control Point
HQE	High Environmental Quality
IOSC	Isange One Stop Center
LCA	Life Cycle Assessment
MRI	Magnetic Resonance Imaging
OWNER	Owner
EPC	Project manager
GDP	Gross Domestic Product
RBC	Rwanda Biomedical Center
SDO	Surface in Work
SDP	Floor Area
SEER	Seasonal Efficiency Energy Ratio
SU	Useful Area
TDS	Table of Surfaces
UGR	Unified Glare Rating
UHCD	Short stay hospital unit

UTA	Technical Delivery Unit
VIP	Very Important Person
VOC	Volatile Organic Compound
VRD	Roads and Miscellaneous Networks
VVIP	Very Very Important Person

TOME IV: BIOCLIMATIC AND ENVIRONMENTAL PROGRAMME

1. GENERAL PRINCIPLES

1.1. Leading by example in terms of energy performance and the High Environmental Quality (HEQ) approach

Setting an example in terms of sustainable development is a major focus of the project. The architecture will have to take into account the climatic and socio-cultural constraints and the specific features of the site. It must be integrated into its environment and allow for efficient maintenance.

Government priorities: these principles are based on a number of environmental issues that need to be prioritised according to various factors, including national policy guidelines, site constraints and the purpose of the building.

The minimum requirements for sustainable construction, introduced in 2019 within the Rwandan building code, are determined by a rating system composed of 29 green construction indicators, which are categorized into five modules.

Each indicator is assigned a specific weight and awarded points based on its significance in achieving green building objectives. These points are determined by considering factors such as environmental impact, implementation efforts, and associated costs. Together, these indicators can accumulate a maximum total of 190 points.

The 5 modules selected are:

1) Energy efficiency, based in particular on the bioclimatic and passive design of the building, and the performance of active energy equipment (102 points)
2) The efficiency of water management, which includes rainwater harvesting, the use of efficient terminals, wastewater treatment and various water-saving devices to reduce the use of drinking water while the building is in operation. (31 points)
3) Environmental protection, covering a wide range of issues such as green spaces and biodiversity, mitigating the heat island effect, reducing the carbon footprint through concrete usage control, addressing the impact of refrigeration systems on the ozone layer and global warming, and implementing effective waste management practices within businesses. (28 points).
4) Indoor environmental quality, a category that focuses on design strategies that improve indoor environmental quality, including indoor air quality, thermal comfort and acoustic comfort (10 points).
5) Innovation and other green features that encourage the adoption of innovative practices and new technologies with beneficial environmental potential (19 points).

Of these five categories, compliance with the following ten indicators is mandatory, while the others are optional.

- 1.4 Artificial lighting efficiency
- 1.8 Solar hot water systems
- 2.1 Rainwater harvesting
- 2.4 Wastewater treatment
- 3.4 Low-impact refrigerants: zero ozone depletion potential
- 4.1 Minimum supply of fresh outside air - mechanically ventilated spaces
- 4.2 Thermal comfort - mechanically ventilated spaces
- 4.3 Noise levels
- 5.2 Universally accessible buildings

The weighting of the modules and the mandatory indicators clearly reflect the government's priorities.

Particular attention will be paid to this aspect by the main contractor to respond to environmental issues by designing an eco-efficient structure that limits the environmental footprint, the use of fossil fuels and greenhouse gas emissions (incorporating the principles of High Environmental Quality).

The architecture should also propose simple solutions to limit the use of techniques requiring heavy maintenance. For example:

- Prioritizing passive temperature control methods is essential, emphasizing strategies such as building orientation for optimal sunlight exposure, implementing shading mechanisms, and utilizing other cost-effective solutions. Promoting natural air circulation can be a straightforward and economical approach to enhancing indoor comfort levels.
- The materials used must be able to cope with humidity, ambient heat and external heat; the architectural and engineering team must encourage the use of local materials.
- The size of openings (bay windows, windows, etc.) will be designed to meet the requirements of controlling ambient temperature and providing access to natural light.
- Installing efficient sun breakers on the facade aligned with window orientation to regulate sunlight penetration.

1.2. The High Environmental Quality approach

The aim of the French HQE® (High Environmental Quality) approach to building projects is to reconcile the quest for a better quality of life with the preservation of the environment. This is a completely voluntary approach, and one to which the project owner wished to commit.

The French HQE® association has drawn up a set of "benchmarks" that provide a structured description of the environmental quality of a building. These standards enable all stakeholders to reach agreement:

- The best possible compromise in a given environmental context;
- On the objectives to be achieved and the means to achieve them.

The issues to be taken into account are broken down into "14 targets" presented below:

TABLE 1 - FRENCH HQE® (HIGH ENVIRONMENTAL QUALITY) 14 TARGETS

Controlling the building's impact on the external environment	Creating a satisfying outdoor environment
ECO-CONSTRUCTION	**COMFORT**
C1: Site C2: Components C3: Worksite	C8: Hygrothermal comfort C9: Acoustic comfort C10: Visual comfort C11: Olfactory comfort
ECO-MANAGEMENT	**HEALTH**
C4: Energy C5: Water C6: Waste C7: Upkeep - Maintenance	C12: Quality of spaces C13: Air quality C14: Water quality

In line with the national policy on sustainable construction for level 4 and 5 buildings (Annex 9: RWANDA GREEN BUILDING MINIMUM COMPLIANCE SYSTEM), the contracting authority also wanted to develop a High Environmental Quality approach as part of the construction of the new referral hospital in Ruhengeri.

The designer will therefore have to be fully committed to an environmental design approach for this project, the main objectives of which are as follows:

- **Designing with practicality**: leveraging architectural principles from the outset to enhance hygrothermal comfort and reduce operational expenses. This includes optimizing building morphology, preventing overheating, managing internal heat loads, and leveraging climatic conditions.
- **Choosing healthy, robust materials and equipment**, giving priority to **local** resources, and ensuring that the carbon footprint of construction is kept under control.

- **Ensuring the comfort of all users** (patients, caregivers, administrative and technical staff) within the facility: bioclimatic design (protection against direct and indirect solar gain, thermal quality of the building envelope, appropriate composition of facades, etc.), efficient lighting management and the choice of high-performance technical equipment to reduce energy consumption and related operating costs as much as possible.
- **Recovering the energy released by the building's energy needs and using the renewable energies** available on site.
- Organise **efficient water management** through economical design of drinking water distribution circuits and terminals, recovery of rainwater and water discharged by osmosis plants.
- Allowing **spaces to evolve** while guaranteeing the longevity of the systems in place, which require little maintenance.
- Equip managers with **appropriate, high-performance maintenance tools** to monitor consumption, detect deviations and be able to intervene quickly in the event of a malfunction.
- Maintaining a tidy and organized construction site while minimizing disruptions and effectively managing construction waste.

1.3. Obligation to achieve results and completeness

This Detailed Technical Program (DTP) describes the environmental requirements and characteristics for the design and construction of the future Ruhengeri Referral Hospital.

This major operation will take place within the existing Ruhengeri hospital. The work will be carried out on an occupied site. The current technical installations will have to undergo a major overhaul. The project manager must anticipate all technical, staging, and coordination issues with the hospital to ensure **uninterrupted operation 24/7** while minimizing disturbances and health risks associated with the site's proximity.

2. Bioclimatic approach

Beyond the functional requirements associated with the capacity program and the desired healthcare services, the unique characteristics of the site and the prevailing climate inherently shape the overall design, spatial organization, and facade aesthetics of the project. This is essential to facilitate optimal control of the internal environment, especially regarding temperature regulation, in accordance with local practices and relevant regulations.

In tropical or humid equatorial climates, architectural design must accommodate local customs in terms of use and functionality while addressing climate constraints. It should offer straightforward, passive solutions to shield interior spaces from the often intense and prolonged climatic challenges they face daily. Alternatively, it should leverage climatic conditions to reduce heating needs, particularly during night-time.

2.1. Climate characterisation

Outside temperature and relative humidity

The climate in Ruhengeri, at an altitude of almost 1,880 m, is characterised by an average annual temperature of around 17°C, with significant day/night variations.

The daily minimum and maximum temperatures are shown below:

Figure 1 - Maximum daily temperatures -2023

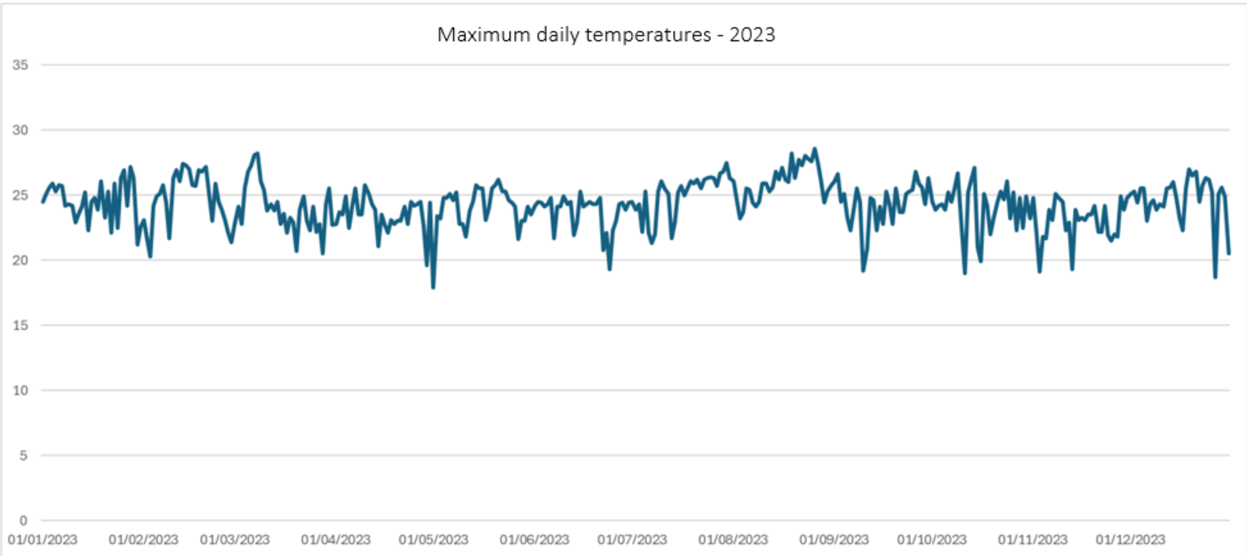
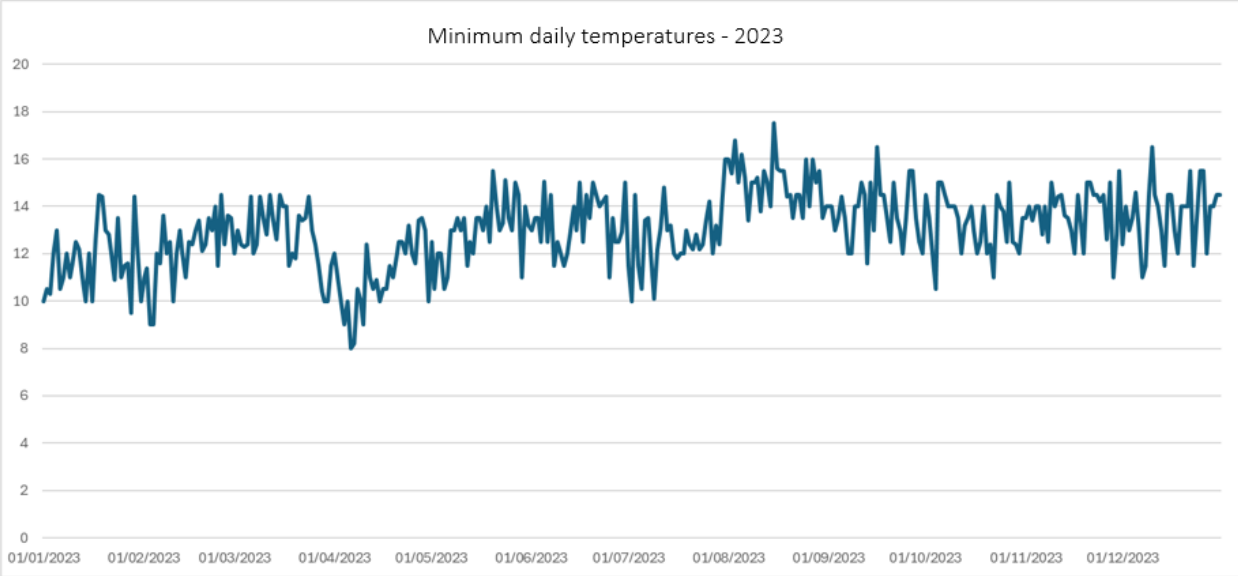


Figure 2 - Minimum daily temperatures - 2023



With average maximum and minimum temperatures of 23°C and 13°C respectively, it is possible to characterise temperature levels by a daily average of 21°C and a nightly average of 15°C.

More detailed observation of the data reveals regular temperature and relative humidity conditions over long sequences of consecutive days, with the latter fluctuating between 40% during the day and 70% to 80% at night when the temperature has fallen.

FIGURE 3 - TEMPERATURES / RELATIVE HUMIDITY - FROM 17 TO 31 JULY 2022

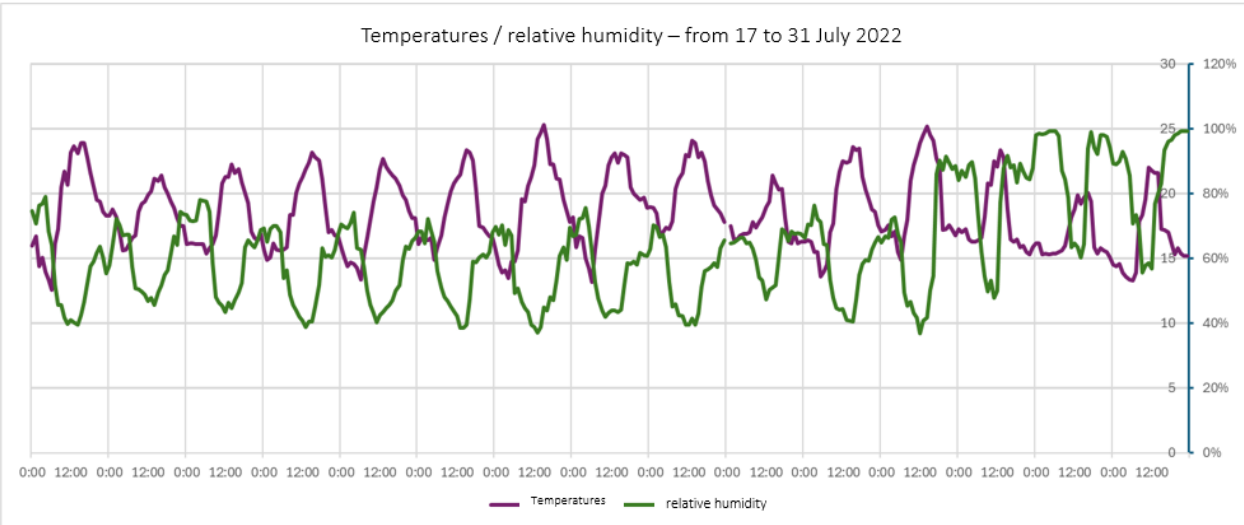
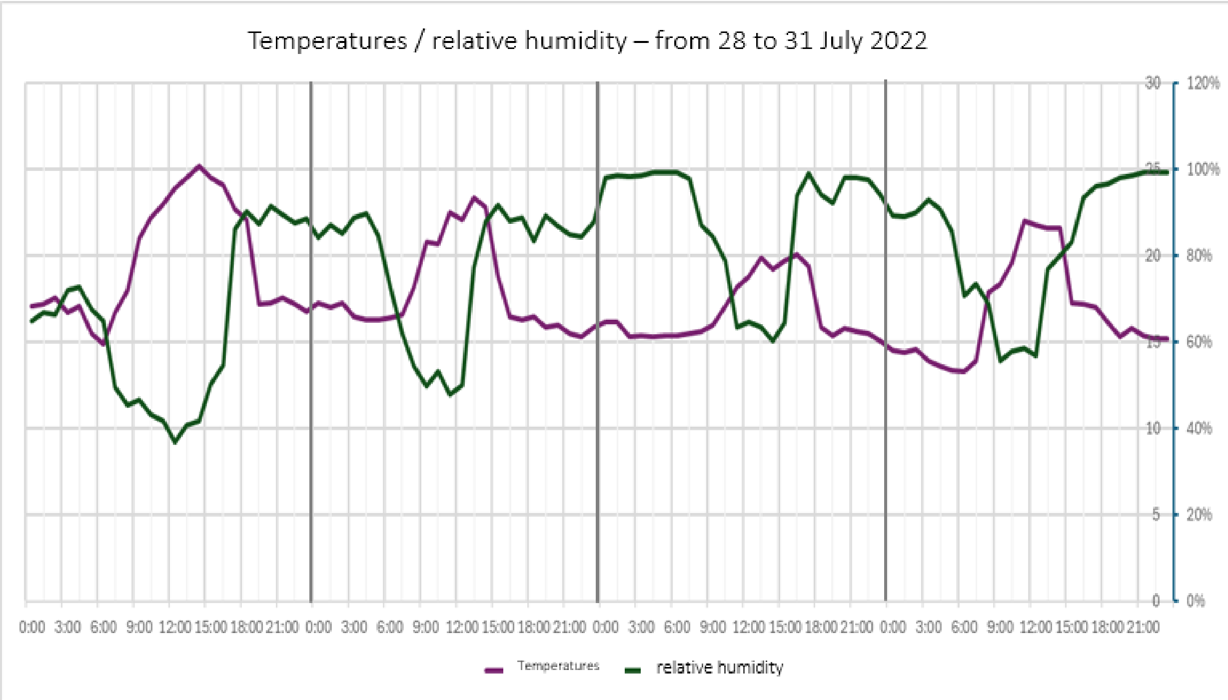


FIGURE 4 - TEMPERATURES / RELATIVE HUMIDITY - FROM 28 TO 31 JULY 2022



A few particularly rainy periods may occur from time to time, with relative humidity levels between 60% and 80% during the day (for temperatures between 20 and 23°C) and close to 100% at night for temperatures around 15°C.

Weight of water and enthalpy

Specific humidity, which corresponds to the weight of water contained in 1 m^3 of dry air, is very moderate for a tropical environment, with regular oscillations between 8 and 15g of water/kg of dry air, occasionally reaching values close to 20g during particularly rainy seasons.

The enthalpy, which characterises the total energy contained in the air, can however reach a maximum value of 70 kJ/kg dry air, as shown in the graph below.

FIGURE 5 - ENTHALPY AND SPECIFIC HUMIDITY - FROM 17 TO 31 JULY 2022

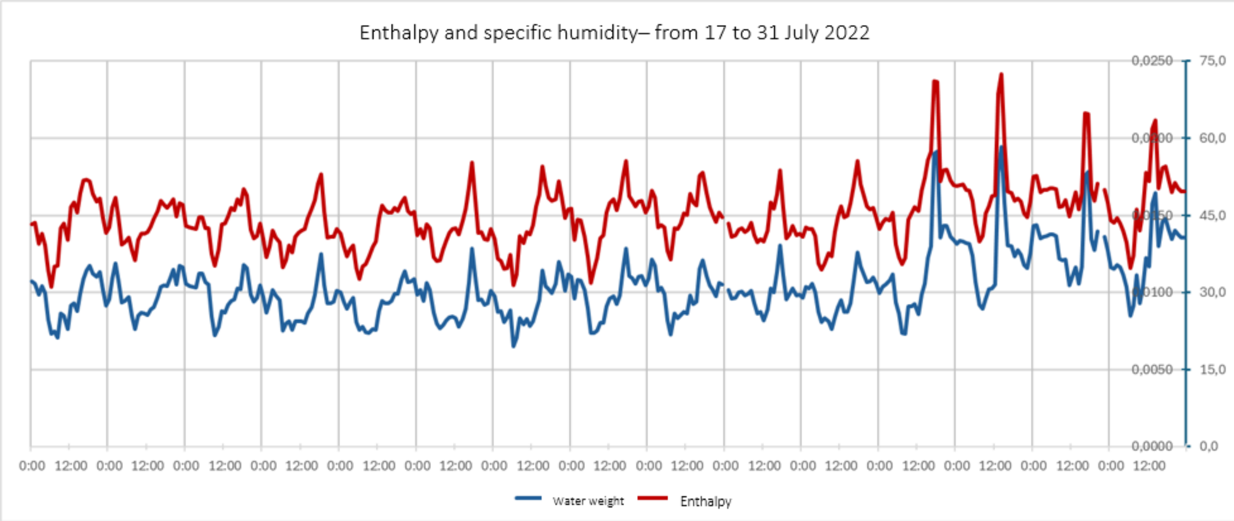
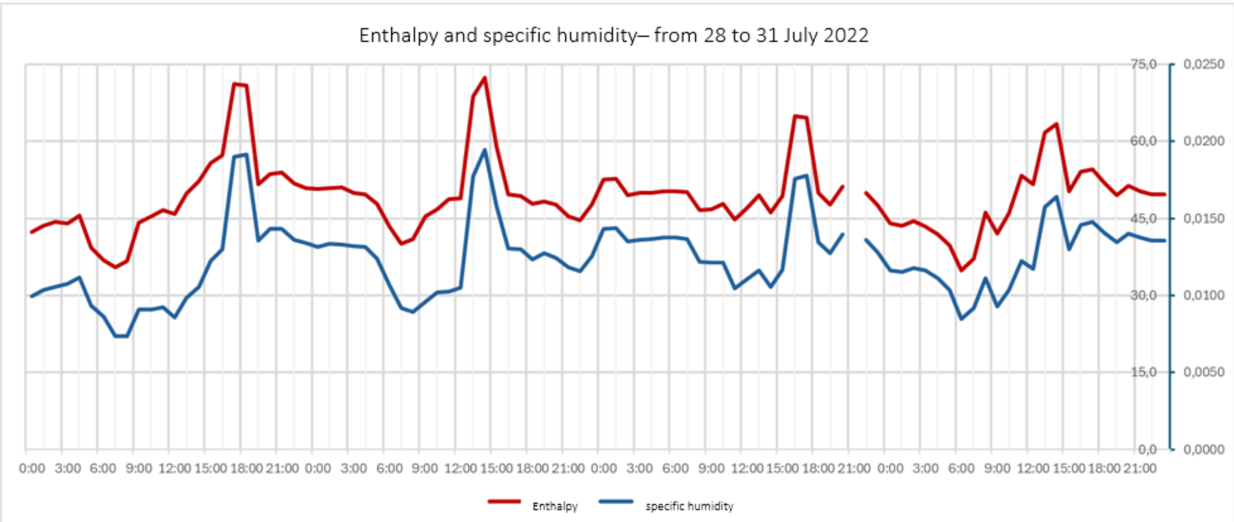


FIGURE 6 - ENTHALPY AND SPECIFIC HUMIDITY - FROM 28 TO 31 JULY 2022



Solar radiation

Moreover, Ruhengeri experiences consistent solar radiation, characterized by exceptionally high levels of maximum power on the horizontal plan, often surpassing 1200 W/m^2 and occasionally nearing the solar constant of 1370 W/m^2. This phenomenon is attributed to the region's altitude and minimal cloud cover, likely a result of the limited industrial activity in the area.

FIGURE 7- SOLAR RADIATION - AUGUST 2022

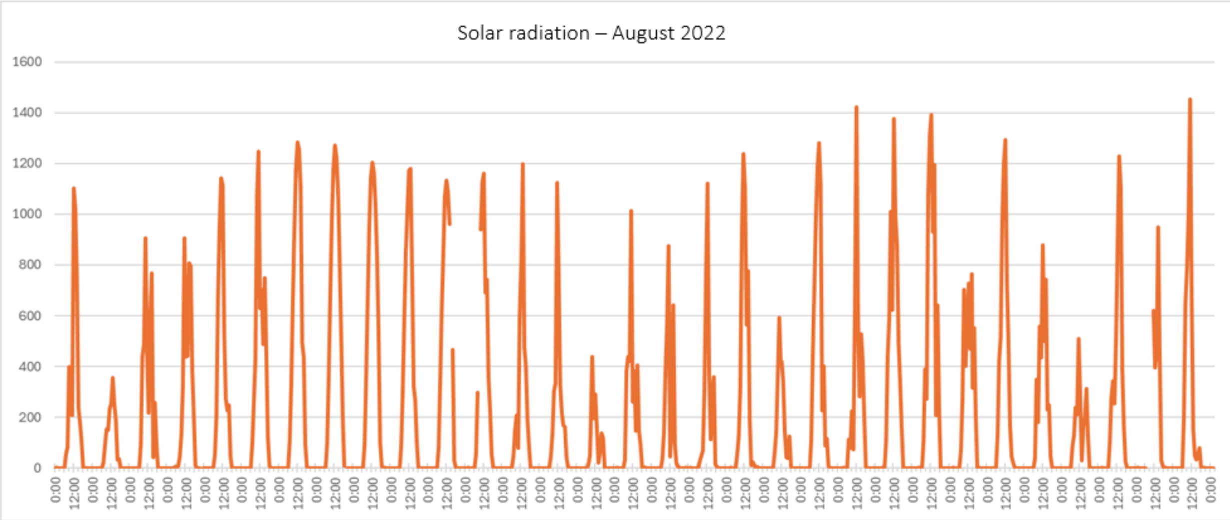
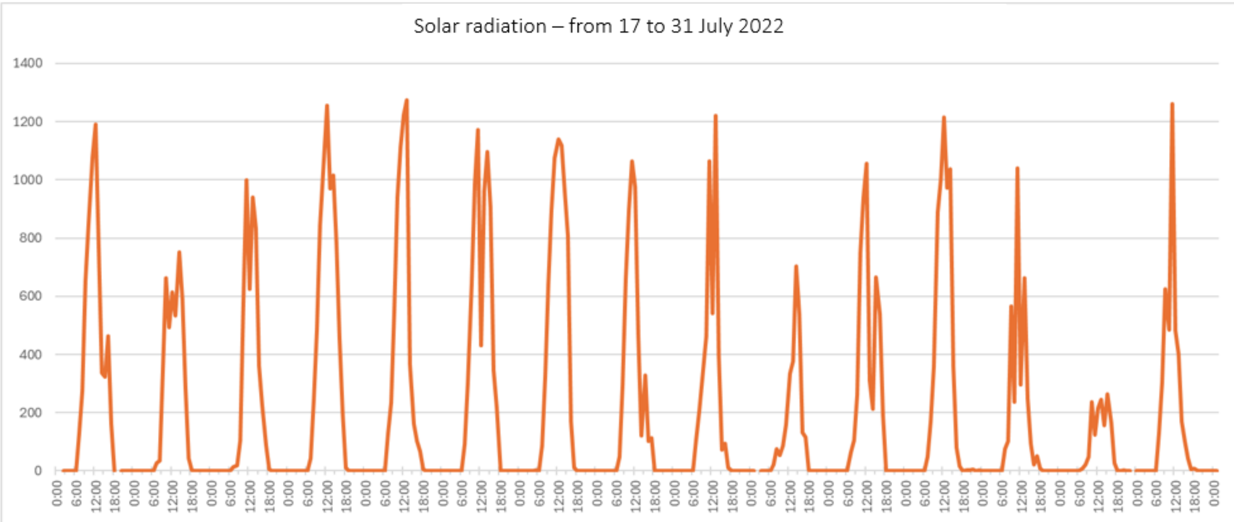


FIGURE 8 - SOLAR RADIATION - FROM 17 TO 31 JULY 2022



Wind speed and direction

The site has very little wind. The maximum speed observed over 3 years is 9 m/s, or around 32 km/h.

The prevailing wind direction in Ruhengeri is West-Northwest to North for over 50% of the time, while it shifts to South-East to South-West for approximately 30% of the time.

FIGURE 9 - WIND SPEED

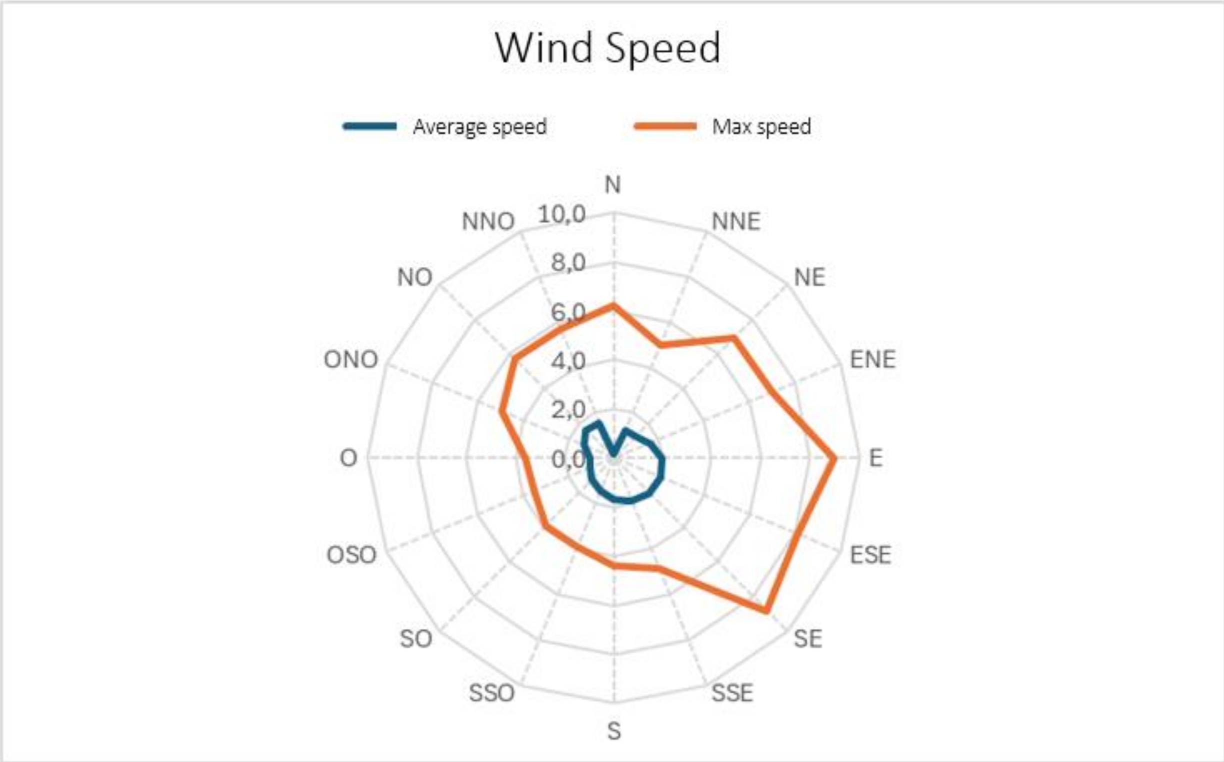
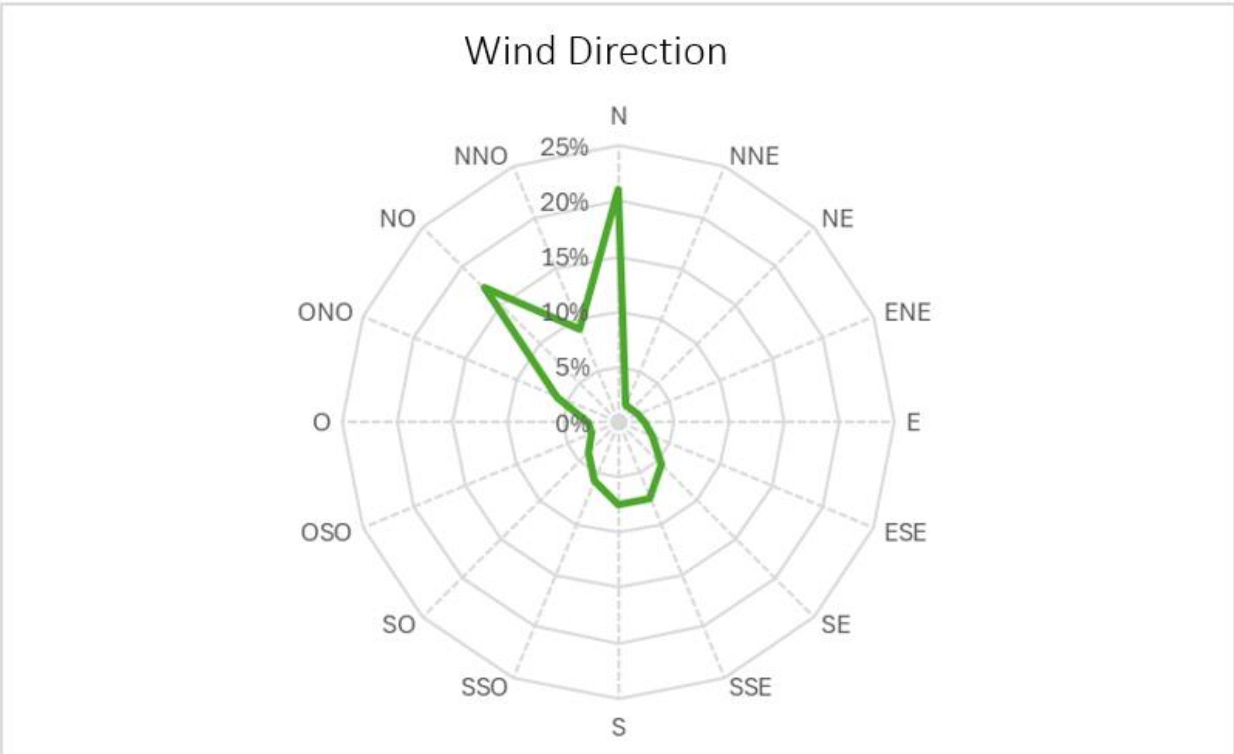


FIGURE 10 - WIND DIRECTION



Rainfall

Annual rainfall varies from one year to the next by almost 75%, as shown in the graph below.

FIGURE 11 - MONTHLY RAINFALL - 2021 TO 2023

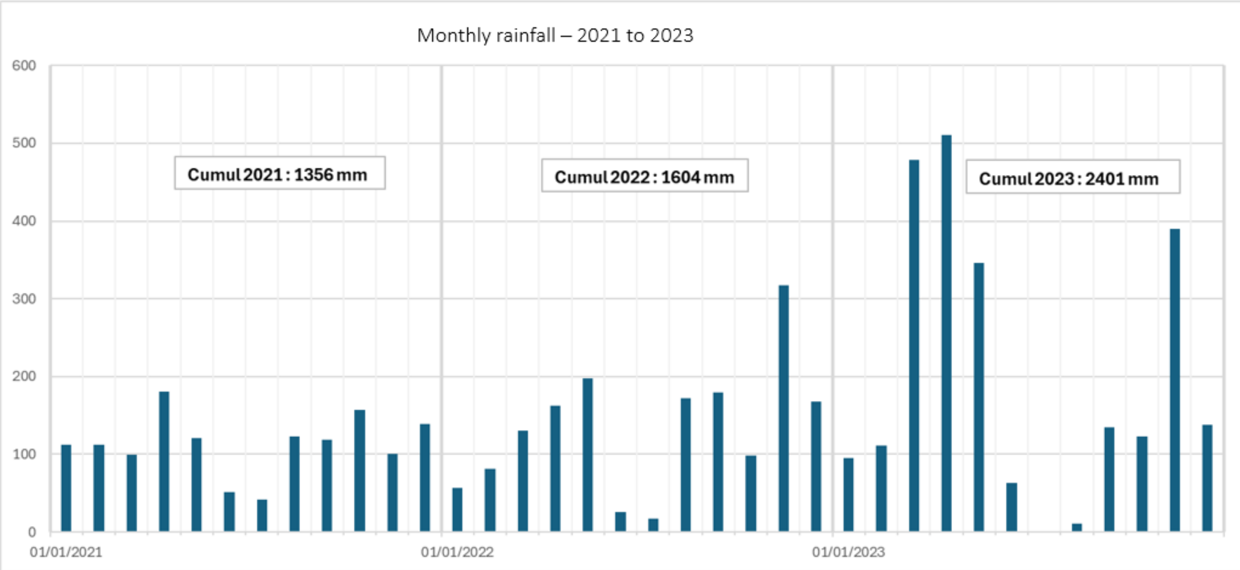
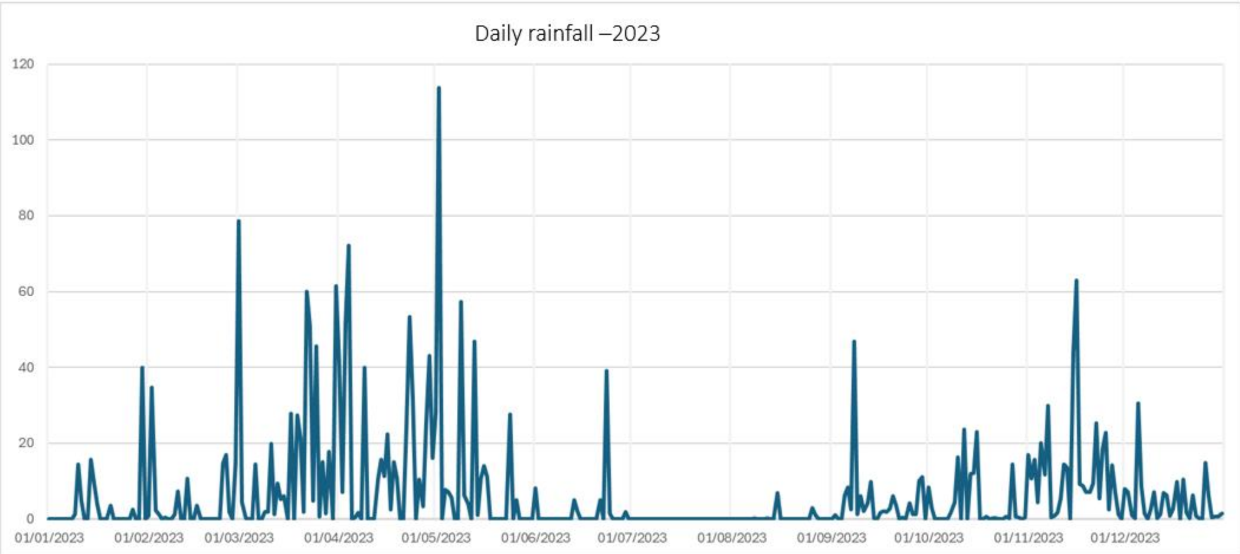


FIGURE 12 - DAILY RAINFALL - 2023

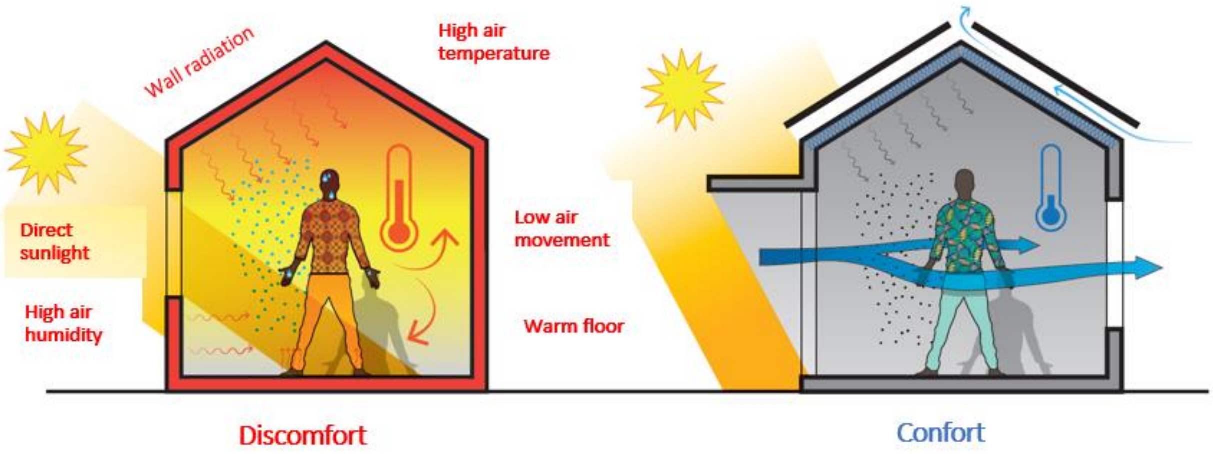


In 2023, the maximum daily rainfall reached almost 120 mm, but this was still an exceptional event. Over the previous 2 years, the daily maximum remained below 60 mm.

The months of June and July often see virtually no rainfall.

2.2. Comfort in a tropical environment

FIGURE 13 - CONDITIONS FOR A CONFORTABLE ENVIRONMENT



The human body regulates its temperature, aiming to maintain it around 37°C, by adjusting blood flow and sweating. Blood vessels contract (vasoconstriction) to conserve heat or dilate (vasodilation) to release heat. Sweating allows heat to dissipate through evaporation, drawing heat from the body. This mechanism is most effective in dry air with higher airflow across the skin's surface.
The less these thermal regulation processes are used, the more the body will be in its so-called "hygrothermal physiological comfort zone". On the contrary, the more these processes are used, the greater the feeling of discomfort.

These exchanges with the outside world take place by different methods of heat transfer: radiation, convection, conduction and evaporation. They are determined by:

- Clothing;
- Ambient air temperature;
- The temperature of the surrounding walls;
- Air humidity;
- Air speed;
- The intensity of the individual's activity.

2.3. Bioclimatic requirements

Bioclimatic architecture is therefore an obvious way of laying the serious foundations for creating a pleasant, long-lasting climatic environment, as well as for energy sobriety - an essential quality for mastering the project's energy signature - with a concern for rationalising the associated technical resources.

Observation of the climate is, of course, the cornerstone of the thinking that goes into designing the project.

This results in the following bioclimatic orientations:

- The building will need to be protected against night-time cooling due to lower outside temperatures and heat radiation towards the sky.
- It is not necessary to protect opaque walls from the sun's rays on all façades. The colour of the façades will be light on the north-east and south-east façades, and may be freely chosen on the other façades, independently of any bioclimatic impact.
- The composition of the roof should be designed to provide effective protection from the sun's rays during the day, while allowing some of the solar energy received during the day to be transferred indoors at night.
- Glazing should be protected with devices that allow the effect of the protection to be modulated, so that the incident solar energy can be either repelled or accepted depending on the position of each window, the time of day and the season.
- The building's internal inertia could be exploited in conjunction with the bay windows on the north-west and south-west façades, depending on the constraints imposed by the project's modularity and flexibility requirements.

The bioclimatic design of the building should therefore be characterised by the integration of the following ambitions into the design of the building:

- The compactness and thermal inertia of the spaces
- Optimum thermal performance of envelope elements depending on their position
- The effectiveness of solar protection and the technical design of façades
- Controlled access to natural light
- Natural ventilation for thermal comfort in non-sensitive areas.

Compactness and thermal inertia

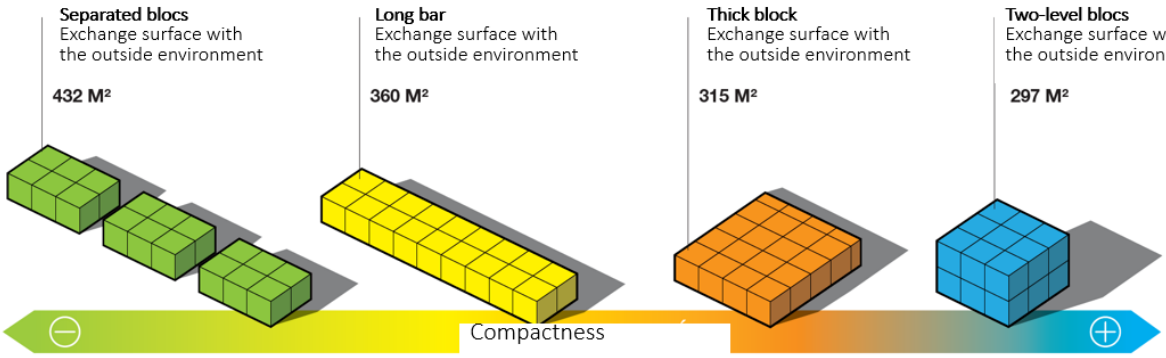
The compactness of the building will depend on the capacity program, the possible phasing and the available land.

It must limit the ratio of envelope surface area to floor area, by reducing horizontal cuts, slab overhangs and construction setbacks to a strict minimum, while ensuring the desired functions of amenity and well-being, particularly for caregivers and patients.

It will be the result of a necessary compromise between the rationalisation of distances between departments, functional needs and adjacencies, and access to natural light, in particular through the patios that will have to orchestrate its composition.

Although wind patterns at the site are generally mild, the building's design must consider prevailing winds to minimize facade exposure to wind and maximize natural ventilation. Facades should ideally be oriented tangentially to prevailing winds to create airflow and minimize humidity infiltration.

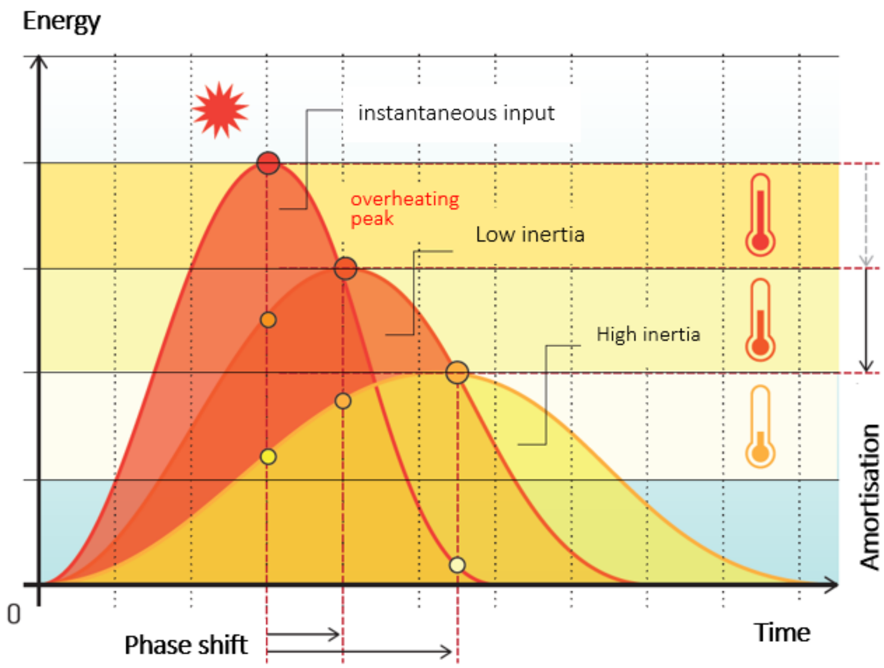
FIGURE 14 - COMPARISON OF BLOCK COMPACTION



Example for a built area of 160 m^2 SU

Areas on the north-west and south-west facades should feature construction elements with medium to high thermal mass, such as walls and floors, to absorb solar radiation during the day and release it gradually in the evening.

FIGURE 15 - THERMAL IMPACT OVER TIME AND AMORTISATION



The thermal performance of the envelope

The aim is to design a building with thermally insulating walls that absorb little solar radiation, to maintain the internal surface temperature of the walls close to the desired ambient temperature in the premises.

When designing the project, the thermal resistances of the external walls should be adapted to the local climatic context, to find a balance between limiting heating loads in cold periods and at night, reducing overheating in uncooled rooms in hot periods, and cooling loads in other areas.

Iterative dynamic thermal simulations, based on the site's hourly weather file, will have to be carried out before any precise definition of the building's thermal insulation strategy.

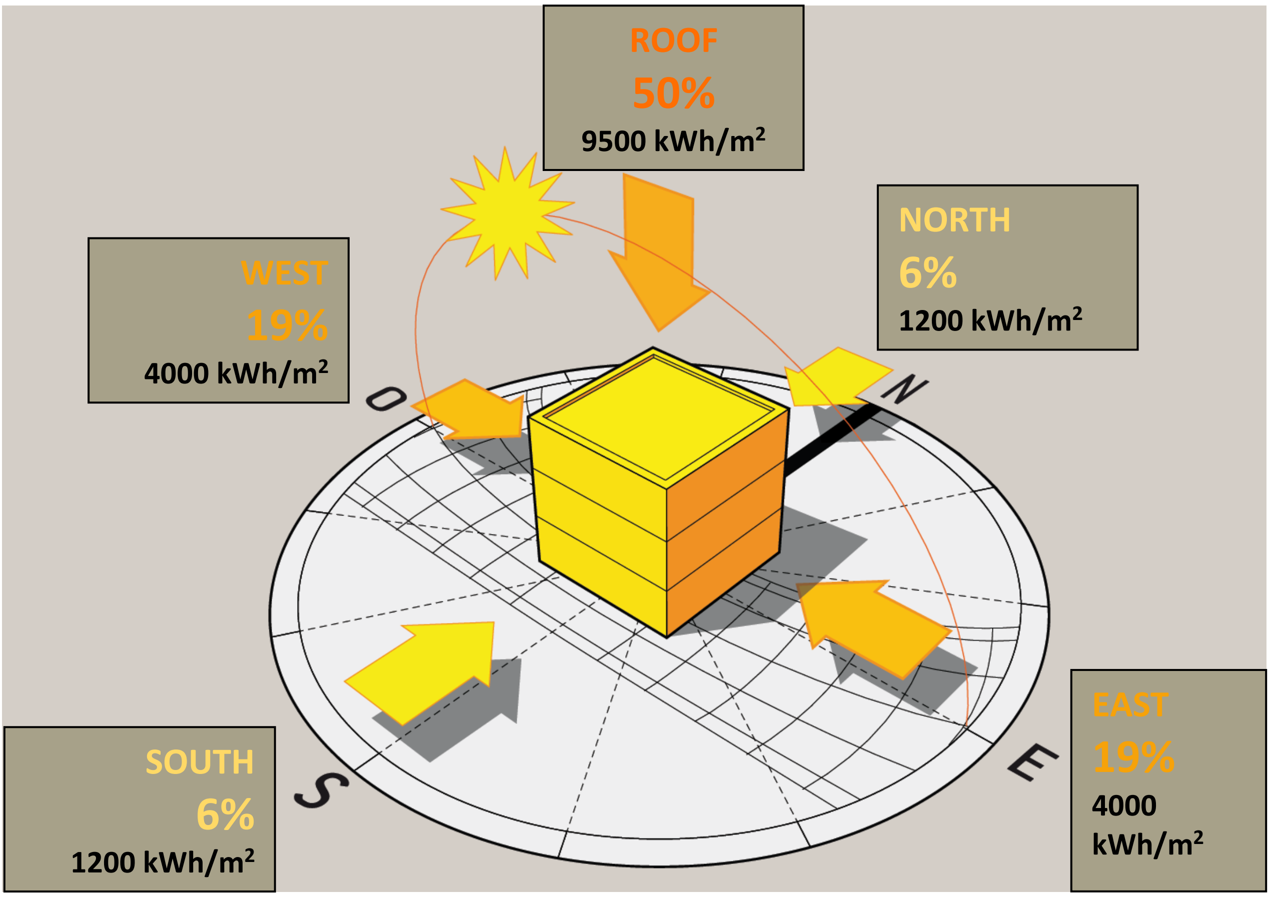
The position, thickness and type of insulation will therefore need to be studied according to the type and location of the walls concerned.

The thermal phase shift capacity of the insulation is a particularly important characteristic, depending on the purpose of the premises it houses, the local climate and the altitude of the location, especially for insulation installed on roofs.

For example, roofs should preferably be insulated with an exterior layer of insulation whose characteristics will enable it to provide a relevant phase shift, ideally of 9 hours, and in any case of more than 6 hours (e.g., 20 cm of polyurethane or 10 cm of cork or wood fibre panels).

Due to the intense daytime solar exposure and nocturnal radiative cooling, exposed roofs should have a minimum thermal resistance of $R = 4.5\ m^2\ K/W$. Opaque vertical walls, exposed to thermal fluctuations, should be thermally insulated from either the interior or exterior, depending on local standards, utilizing insulation with a minimum thermal resistance of $R = 1.5\ m^2\ K/W$.

FIGURE 16 - COMPARISON OF DIRECTIONS AND THERMAL EXPOSITION



On the flip side, we'll opt for lighter tints on the external surfaces of opaque exterior walls, both horizontal and vertical. This includes single skin cladding and waterproofing on flat roofs. The aim is to attain a maximum solar absorption coefficient of approximately 0.4. This means that only 40% of the solar energy that reaches the roof gets absorbed, resulting in moderate heating. The remaining 60% is directly reflected.

TABLE 2 - COMPARISON OF SHADE CATEGORIES AND THERMAL IMPACT

Shade categories	Colors	Corresponding alpha value
Light	White, yellow, Orange, beige, cream, light red	0,4
Medium	Dark red, light green, light blue	0,6
Dark	Brown, dark green, Bright blue, light grey, dark blue	0,8
Black	Dark grey, dark Brown, black	1

As a corollary, it should be noted that this low solar absorption coefficient also contributes to the durability of the roof, thanks to less heating of the exposed surfaces (the paint does not bake, and the cladding and structure do not undergo significant expansion).

The same applies to façades facing north-east and south-east, which will receive a lot of sunlight in the morning, and which should also be light in colour so as not to raise the indoor temperature during the day.

Airtightness

Controlling air transfers is a highly effective way of improving the energy efficiency of buildings, particularly in humid equatorial environments where humidity is a source of thermal discomfort, air conditioning costs and the risk of pathologies.

Double-flow ventilation systems can effectively regulate the required air flow for occupancy, but their efficacy hinges on a tight building envelope.

The primary vulnerabilities in building waterproofing typically lie at the juncture of external joinery (such as façade-joining joinery), façade-slab joints, service ducts, hatches, and insulation penetrations.

Specific detailed measures must be taken at both design and installation level to achieve optimum airtightness, with a target of N50 = 0.6 vol/h (i.e., 0.6 Vol/h at a pressure of 50 Pa).

Access to natural light

The positioning of new buildings in relation to the masks created by existing buildings that have been preserved, as well as the masks created by the morphology of new buildings on themselves, should be studied to find locations, volumes and organisations around patios that maximise both access to natural light and protection from direct sunlight.

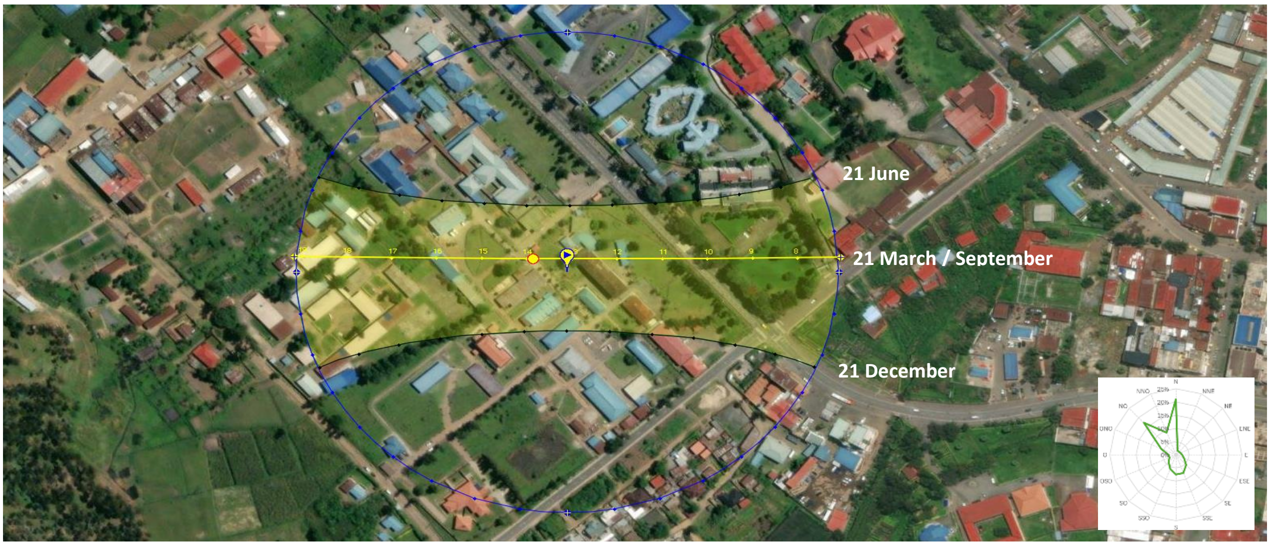
Access to natural light is an increasingly important requirement in the aspirations of patients and care staff and is indirectly linked to energy performance objectives through its ability to reduce the need for artificial lighting, and therefore the associated electricity consumption.

The size of the patios, and the interplay of any recesses and terraces that animate them, should help to guarantee satisfactory conditions of access to natural light for the different spaces, depending on their respective uses.

The effectiveness of solar protection

Given the location's latitude (1.65°S), the sun's path is virtually symmetrical to the seasons.

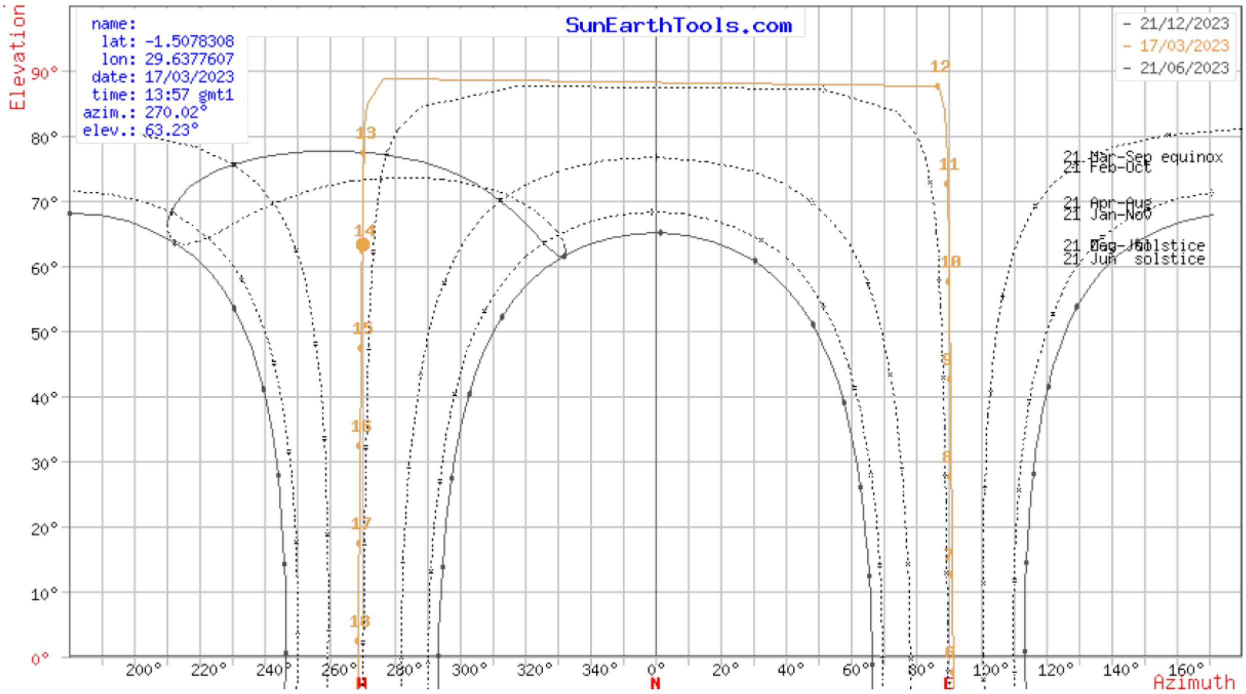
FIGURE 17 - EFFECTIVENESS OF SOLAR PROTECTION



Half the year (from September to March), the sun's path is in the south, while during the other six months (from April to August), it is in the north.

As a result, the dimensions of the solar protection on the south and north façades must be adapted to this situation, with the sun at its lowest point at a height of 70° both to the south during the winter solstice and to the north during the summer solstice, while being vertical during the equinoxes.

FIGURE 18 - SOLAR PROTECTION OVER ELEVATION AND AZIMUTH



What's more, around the equinoxes (March/April and September/October), the sun stays alternately in the East (in the morning) and West (in the afternoon) during the day, passing briefly overhead at solar noon.

As a result, eastern and western exposures are particularly exposed to strong solar radiation during this period.

This entails implementing suitable sun protection measures for all facade orientations, primarily comprising:

- Horizontal overhangs, rooflights, and panels recesses on the north and south façades, designed to shield glazing from direct solar radiation by 21 June on the north side and 21 December on the south side.
- Solar shading devices deployed across the height of the glazing on the east and west sides, including horizontal louvres—preferably adjustable or alternatively fixed—and external grid ceilings.

It should also be noted that the frequent cloudiness observed on the site also makes it necessary to treat the glazing itself appropriately, to limit the effect of the resulting high levels of diffuse solar radiation, which causes the greenhouse effect and contributes to rising indoor temperatures and increased air-conditioning loads.

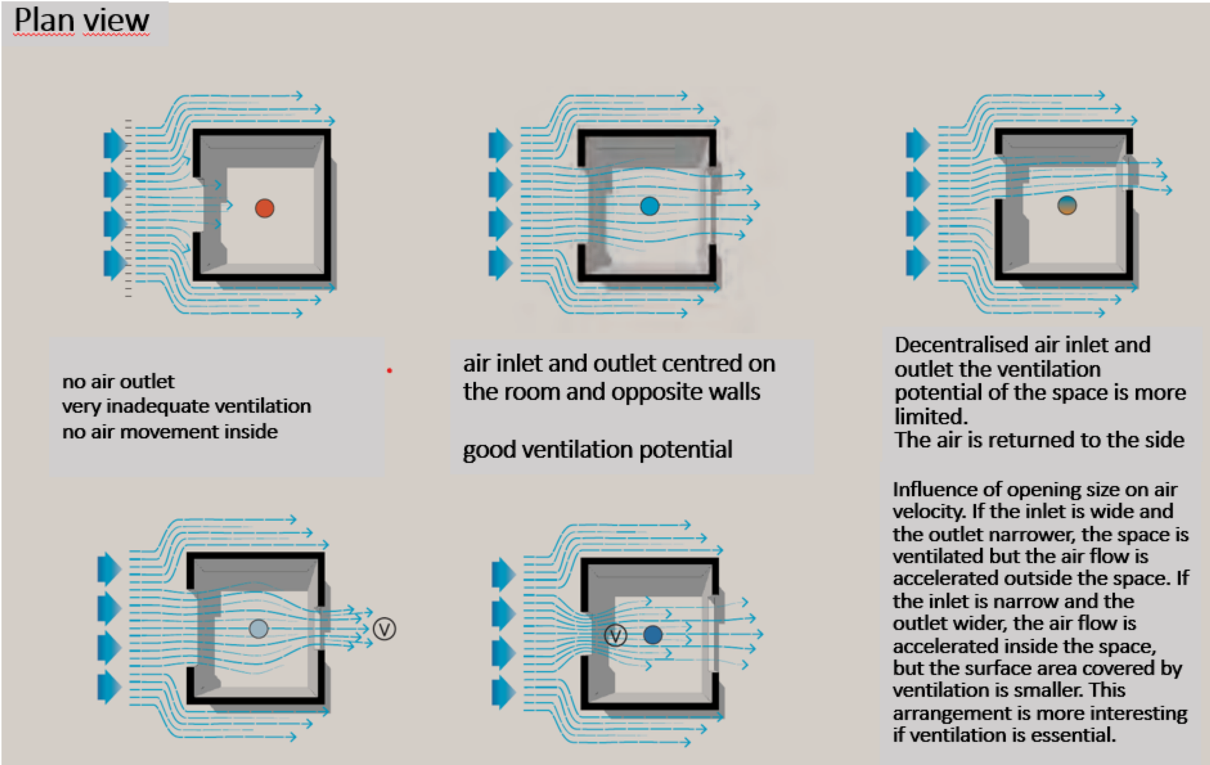
The solar factor of glazing, whatever its orientation, will be a maximum of 0.4.

It will therefore be necessary to propose architecture that controls views, natural light penetration and solar efficiency according to the exposure of the façades and the conditions of use of the premises.

Natural ventilation

For less sensitive areas like the reception hall and waiting and admission areas on the ground floor, an assessment will explore the potential for natural ventilation using appropriately sized openings. These openings can be adjusted based on climate variations to assess anticipated comfort conditions alongside the already mentioned thermal performance of the building envelope and solar protection measures.

FIGURE 19 - PLAN VIEW OF NATURAL VANTILATION OPTIONS



Planting outside areas and surroundings

Landscaping around the building enhances user comfort in several ways:

- By offering solar shading for the walls through foliage, with shading quality influenced by foliage density (which can block 60% to 90% of the sun's rays).
- By preventing the ground cover from reflecting solar radiation back towards the building, thus reducing the urban heat island effect caused by environmental mineralization.

- By cooling the nearby environment through vegetation's water evaporation, offering protection against wind-borne dust.
- By deflecting or directing wind flow.

The first function, to limit the urban heat island effect and the reflection of solar radiation, can be achieved by favouring horizontal vegetation (lawns, shrubs and flowers).

FIGURE 20 - EXAMPLES OF HORIZONTAL VEGETATION

3. THE PROJECT'S CARBON FOOTPRINT

The anticipated carbon footprint of the project will largely hinge on the architectural decisions made by the design team, as well as the selection of services and construction methodologies employed during the project's execution.

Assessing this footprint necessitates a comprehensive Life Cycle Assessment (LCA) study of every component (including materials and equipment) utilized in construction. This study follows a standardized methodology, which involves defining a functional unit and its associated lifespan.

At this preliminary stage and drawing from the polybloc feasibility outlined in Tome 1 of the DTP, it's feasible to approximate the project's carbon footprint. This approximation is based on average batch-by-batch ratios derived from recent insights gleaned from similar hospital construction endeavours.

3.1. Methodology

The methodology employed is rooted in the French RE 2020 Environmental Regulations, as delineated in the Order of 4 August 2021.

The carbon studies consider a lifespan of 50 years.

The assessment of the project comprises five Carbon Indicators (CI), serving as contributors:

- CI Components: All the environmental impacts of construction products and equipment used in the construction of a building.
- CI Energy: All the impacts associated with energy consumption during the building's operational phase. The energy uses considered are the same as those used to calculate the building's energy performance.
- CI Water: All impacts related to water consumption and discharge during the building's operational phase. This contribution covers the impact of water purification, wastewater treatment and rainwater management.
- CI Site: All the impacts associated with energy consumption during the construction phase, water consumption and discharges from the site, and the disposal and treatment of earthworks waste.
- CI Plot: All the impacts associated with the development of the plot and the impacts of the use of the plot.

At this juncture, the assessment is confined to the contributors implemented during building construction, namely CI Components and CI Site. These form the construction indicator CI Construction, which aggregates Greenhouse Gas Emissions across the entire life cycle of the building, deducting greenhouse gas benefits beyond the study perimeter.

Components contributor

Each material is associated with an environmental data sheet from the INIES reference environmental and health database). This data sheet presents all the information on the environmental and health impacts of a product or system over its entire life cycle.

There are two types of sheets:

- Specific environmental declarations

- Environmental and health declaration sheet (EHSDS):

Data sheets produced by manufacturers for specific products in accordance with standard NF EN 15804. These sheets can be collective (produced by a group of manufacturers) or individual (produced by a manufacturer).
EHSDS sheet to be chosen when the nature of the product is known, and the sheet is available.

- Product Environmental Profile (PEP):

Data sheets produced for electrical, electronic and HVAC equipment covered by RT 2012 in accordance with the ISO 14025 standard. They are produced by manufacturers and can also be individual or collective.
PEP sheet to be used only for the detailed method of technical lots.

- Default Environmental Data (DED) :

- Data sheets produced in accordance with standard NF ISO 14044.

These sheets are available for the environmental assessment of new buildings when no equivalent specific environmental data is available (FDES).
DED sheet to be selected by default when the FDES sheet cannot be considered.

- Functional Unit (FU) and Life Cycle (LC)

For each data sheet, the environmental impacts are presented for a given Functional Unit (FU). This allows a representative element of a construction to be presented, for a predetermined Typical Lifetime (TVL).
Setting the TVL of the component allows the renewal of materials to be taken into account over the entire lifespan of the building.

- Environmental indicators

Various environmental indicators can be assessed on the basis of these declaration forms, such as the potential for destruction of the stratospheric ozone layer (ODP) [kg CO2eq CFC 11], soil and water acidification (AP) [kg CO2eq SO2], eutrophication (EP) [kg CO2eq PO43-],....

The carbon footprint of the construction of the project is based on the global warming potential (GWP) expressed in kg CO2eq.

Site contributor

The Site contributor considers:

- The impact of the site's energy consumption
- Impacts of water consumption and discharges from the site
- Disposal and treatment of earthworks waste
- Site components

These impacts are assessed using a simplified method and are considered here in the form of an average ratio.

3.2. Assumptions

Surface and Reference Indicators

The indicators are defined for a Reference Area (RA) of 48,257 m².

Components contributor

The ratios used are derived from detailed quantities of materials observed on similar projects, based on lump-sum price breakdowns (LPB), combined with definitions of the various types of materials taken from the project descriptions.

- Breakdown into lots

The quantities are summarised according to a breakdown into lots imposed by the RE 2020 as shown below:

TABLE 3 - COMPONENTS CONTRIBUTOR BY LOTS

Architectural lots
1. Roads and miscellaneous networks
2. Foundations and infrastructure
3. Superstructure - Masonry
4. Roofing - Waterproofing - Structural work - Zinc work
5. Partitioning - Doubling - Suspended ceilings - Interior joinery
6. Facades and external joinery
7. Floor, wall and ceiling coverings - Screeds - Paints - Decoration products
Technical Packages
8. HVAC (Heating - Ventilation - Cooling - Domestic hot water)
- 8.1 Production equipment (heating/cooling) [excluding cogeneration].
- 8. 3 Transmission systems
- 8.4 Air treatment and smoke extraction systems
- 8.5 Networks and ducts
- 8.7 Refrigerants
9. Sanitary installations
10. Energy networks (heavy current)
11. Communication networks (low voltage)
12. Lifts and other indoor transport equipment
13. Local electricity generation equipment

- Brief description of the constituent materials considered:

The foundations are estimated to require 4,000 m^3 of concrete, with a ratio of 110 kg of steel per m^3.

The building's superstructure consists mainly of reinforced concrete (walls, floors, columns, and beams), with some columns and beams made of metal. CEM II type concrete is utilized for both the infrastructure and superstructure, with an average carbon impact of 210 kg CO_2eq/m^3.

The estimated quantity of concrete needed is 36,100 m3, with a ratio of 51 kg of steel per m^3.

For both foundations and superstructures, the steels under consideration have a carbon impact of 1.3 kg CO_2eq/kg.

The facades comprise a non-load-bearing concrete shell with 50 mm rock wool insulation and fibre cement board cladding, with a CO_2eq per m2 content of 14 kg. The double-glazed joinery is aluminium, featuring solar protection of the BSO type on the external facades and roller shutters on the patios.

Partition walls are constructed using 72 mm placostyl type partitions with BA 18mm.

The majority of floor coverings consist of PVC strips.

Solid wood core doors are employed throughout the building.

Site contributor

The assumptions used to calculate the worksite contributor are as follows:

- Estimated duration of the project: 40 months
- Quantity of excavated soil [m3]: 80,000 m^3
- Quantity of soil removed [m3]: 65,000 m^3
- Distance between site and land disposal site [km]: 10 km

The quantities and environmental data sheets to be entered into the software are as follows:

TABLE 4 - ENVIRONMENTAL DATA BY POSITION AND QUANTITIES

Position	Quantitative	Unit	Environmental data
Water consumption	2000	m^3	MDEGD - Drinking water on tap
Water discharge	2000	m^3	MDEGD - Collective sanitation of domestic wastewater
Transporting soil to the waste treatment centre	942 500	T.km	MDEGD - Transport by tipper truck
Waste treatment	94 250 000	kg	MDEGD - Treatment of inert waste by landfill
Fuel consumption	80 000	L	MDEGD - Diesel fuel for non-road mobile construction machinery
Electricity consumption	455 000	kWh	MDEGD - Provision of one kWh of electricity for other uses

This corresponds to an impact of 22.6 $kgCO_2eq/m^2$ Sref.

3.3. Estimated carbon impact

The detailed results showing the impact of each architectural and technical specifications are presented in the table below:

TABLE 5 - CARBON IMPACT OF ARCHITECTURAL AND TECHNICAL SPECIFICATIONS

	RESULTS EGES		
	EGES [kgeqC02/m²Sref]]	% carbon impact	
1. EXTERNAL WORKS	50	6,0%	Ratios based on feedback
2. Foundations and infrastructure	45	5,4%	Ratios based on feedback
3. Superstructure - Masonry	202	24,3%	Ratios based on feedback
4. Roofing - Waterproofing - Structural work - Zinc work	19	2,3%	Ratios based on feedback
5. Partitioning - Doubling - Suspended ceilings - Interior joinery	67	8,1%	Ratios based on feedback
6. Facades and external joinery	55	6,6%	Ratios based on feedback
7. Floor, wall and ceiling coverings - Screed - Paintwork - Decoration products	54	6,5%	Ratios based on feedback
8. HVAC (Heating - Ventilation - Cooling - Domestic hot water)	157	18,9%	Flat-rate estimate RE 2020
9. Sanitary installations	9	1,1%	Flat-rate estimate RE 2020
10. Energy networks (heavy current)	116	14,0%	Flat-rate estimate RE 2020
11. Communication networks (low voltage)	12	1,4%	Flat-rate estimate RE 2020
12. Lifts and other indoor transport equipment	45	5,4%	Ratios based on feedback
13. Local electricity generation equipment	0	0	
CI_components	831	**100%**	
CI_Construction	23		
CI_CONTRUCTION	**854**		

The objective assigned to the building is to remain below the threshold of **900 kg CO_2eq/m^2 Sref.**

4. DETAILED ENVIRONMENTAL REQUIREMENTS

Rwanda's public policies on green growth, climate resilience and the fight against greenhouse gas emissions and climate change call for the general principles of sustainable development to be incorporated into the design of the Ruhengeri referral hospital, adapted to the local context.

4.1. Prioritising targets

The targets, which are prioritised according to the purpose of the building, the intrinsic characteristics of the site and the owner's priorities, are broken down into three performance levels, as set out below:

FIGURE 21 - PRIORITISING TARGETS ACCORDING THE CHARACTERISTICS OF THE SITE AND PERFORMANCE LEVELS

The performance levels are designated by the following abbreviations:

- "TP" for Very High Performance,
- "P" for Performant,
- "B" for Base.

They comply with the "HQE® Performance Environnementale Bâtiment Santé" (HQE® Environmental Performance in Health Buildings) standards published by CERWAY on 26 February 2020, which will be the basis for the environmental requirements, supplemented by the specific requirements set out in this document.

Achievement of these requirements will be verified at each stage of the project, based on the principle of assessing the Environmental Quality of the Building (EQB) using the grid proposed by CERWAY. The aggregation of this profile enables the project to aim for the "**VERY GOOD**" level, corresponding to 7 stars.

It should be noted that achieving the environmental performance sought on this project should not be relegated to the design team's environmental specialist alone. The success of this approach depends on the involvement of each member of the design team, who must put their expertise to work in the interests of environmental performance.

4.2. Environmental targets treated at "very high performance" level

4.2.1. TARGET 4 - Energy

Context: based on the architectural project drawn up by the client, in which the location of services, the orientation and the volume of the building are fixed, it will be necessary to argue the relevance of these choices from the point of view of controlling energy requirements.

In the first instance, the bioclimatic performance of the building will therefore be based essentially on the thermal quality of the envelope, and in particular the insulation of the opaque walls, the characteristics of the glazed openings and the solar protection, which must provide effective protection against solar gain.

Next, the performance of the technical equipment (output, energy efficiency, regulation methods, servicing/maintenance requirements, etc.) will complete the overall search for energy performance.

The aim is to keep active air-conditioning consumption to a minimum, by highlighting the bioclimatic potential of the architecture, the energy efficiency of the equipment and its effective regulation and control and the building performance.

Sequentially, the first rule that should be followed to ensure that energy consumption is kept to a minimum relates to the performance of the building and its volumetric organisation, both inside and out: type and nature of facades (surface area and position of glazing), making the most of solar gain, reusing internal heat, creating buffer spaces, but also the intrinsic performance of the elements of its envelope: insulation, airtightness, inertia.

Bioclimatic design: the building's ability to passively reduce its energy requirements for heating, cooling and artificial lighting must be demonstrated using a dynamic thermal simulation (DTS). In this way, the bioclimatic performance of the building will be assessed globally at the scale of the project.

- Building orientation and layout

To reduce heating consumption in cool periods, solar radiation should be captured through the windows, but care should be taken to avoid glare.

To limit cooling requirements for the rest of the year, the premises will need to be effectively protected from overheating, particularly due to solar gain.

Subject to the requirements of the building permit, priority will therefore be given to external solar protection adapted to the different orientations of the bay windows (e.g. fixed sun breakers on the south facade or external blinds that can be raised and directed on the east and west facades), possibly supplemented by high performance solar control glazing (solar factor ≤ 0.4), in line with the Daylight Factor requirements set out elsewhere (see target 10).

➢ Insulation

All rooms benefiting from a cooling set point will be insulated on their vertical walls, whether these are in contact with the outside or with an uncooled room. The minimum thermal resistance value is 2 m^2 K/W, and will be optimised through an iterative search for performance using a dynamic thermal simulation study.

All the building's roofs will be insulated from the outside with a complex providing a minimum thermal resistance of 6 m^2 K/W. In addition, they will be able to support shaded areas.

Walls should preferably be insulated from the outside. Consideration will be given to finding the best compromise between inertia and rapid thermal response for premises with intermittent use.

Generally speaking, facades should be light-coloured to limit their solar absorption coefficient and thus the transfer of thermal loads to the interior of the building.

➢ Inertia

It will be sought in the internal walls (partition walls, core, etc.) and the floors separating each level, in order to improve the building's behaviour in cooling mode.

➢ Internal provisions

Premises hosting activities that generate internal emissions must be arranged in such a way as to limit disruption to the building's thermal balance.

➢ Access to natural light

Artificial lighting requirements will be limited by implementing measures such as:

- Plenty of natural lighting in work and circulation areas,
- Exploiting the north-facing aspect,
- Use light colours for interior cladding,
- Second day for deep rooms,
- Glazing on the upper parts of the façades.

➢ Airtightness

A procedure for implementing technical measures to limit airtightness faults in the building envelope will be drawn up, with a log of details of airtightness-sensitive elements of the project.

It will apply to all areas with a cooling system.

A procedure for controlling the building's air permeability must be proposed and formalised by the design team prior to the works phase. This procedure will specify the following points in particular:

- Identify all sensitive links in a specific, exhaustive document and propose a treatment suited to the construction principles adopted;
- Raising awareness among professionals working on the site;
- Inform professionals working on the site about how sensitive connections should be handled;
- Plan stop-off points to check that building materials, equipment and waterproofing products are correctly installed on site in accordance with the various construction details;
- Documenting the verification of points dealt with at stop-off points and, more generally, during site visits;
- Document actions taken in response to deviations observed on site;
- List all the areas of the building where this approach has been applied or is being applied, together with the results of the air tightness tests;
- Conduct permeability measurements using the "blower door" method as specified in standard NF EN 13829. These measurements should be performed by an independent body on a sample of 50 test premises, representing the diverse construction situations encountered in the building.

Consumption and choice of equipment: to limit energy consumption, a real effort is required in terms of the intrinsic performance of each piece of equipment used to produce, distribute, regulate and emit energy in the building in the various forms required (heat, cold, light, etc.).

In general, the designer should take the following recommendations into account:

➢ Heating and cooling

Heating and air-conditioning systems and auxiliary equipment (circulators, etc.) must have energy-saving features: high efficiency, electronic variable speed drives, low temperatures, heat recovery units....

The air/water refrigeration production units will have maximum efficiency, i.e. a minimum SEER (Seasonal Efficiency Energy Ratio) of 4 under Ruhengeri outdoor temperature conditions. Some of these units will be connected to a heat recovery system to preheat DHW and reheat the air after dehumidification.

➢ Ventilation

The ventilation system will be of the double-flow type **with energy recovery units adapted to the different health risk configurations of the premises served, enabling an average annual efficiency of over 70% to be achieved.**

In premises with intermittent operation (administrative offices, medical offices, consultations, meeting rooms, operating theatres, etc.), ventilation must be able to be switched off or reduced to a minimum when not occupied (presence detection, programmed switch-off and manual switch-on, etc.) in order to reduce consumption.

Electricity consumption by ventilation systems will be kept to a minimum by selecting Air Handling Units with a weighted average SFP (Specific Fan Power) of less than 1 for the entire project.

- Lighting

Natural lighting should be used as much as possible in areas where this is justified.

In order to reduce the consumption of artificial lighting, the **formal requirement is to limit the average power installed to 10 W/m² over the entire project.**

The lighting circuits will be zoned and intelligently managed: back of the room, part close to the glazed walls, back + task lighting principle, etc. The choice of equipment to limit artificial lighting consumption will be based on the natural lighting autonomy obtained per zone.

LED lighting will be preferred, taking care to avoid interference with computer networks. Light intensity adapters will be provided for premises where this is justified: offices (photosensitive cells).

The overall efficiency of each lighting point, taking into account the combination of lamps and luminaires, must comply with a minimum useful luminous flux ratio of 105 Lumen/Watt.

Presence detectors and/or timers are required in corridors, bathrooms and staircases. A 1/3 - 2/3 night-time operating mode is also required in corridors.

Efforts should also be directed towards artificial lighting, beyond the visual comfort of users, including outdoor, parking, security, and accent lighting. These efforts will emphasize limiting installed power, adjusting it based on requirements, and effectively managing various lighting systems through measures such as time programming, dimming based on external conditions, and presence detection.

External lighting will be planned and designed using the same approach to energy optimisation as for internal lighting, giving priority to presence detectors and twilight sensors.

- Lifts

Particular attention must be paid to the lifts installed in the project, with the following preferred choices:

- Opt for a counterweight lift rather than a hydraulic lift, which consumes 2 to 3 times less energy. In fact, the energy required for traction in a lift is proportional to the speed of ascent and the weight lifted.
- Limit speed of ascent (depending on traffic study).
- Use a variable-speed motor drive system with a frequency converter (savings of up

to 20%).

Choosing energy and conserving resources:

➢ Recovery of waste energy

The designer is therefore asked to study all the possibilities of recovering and using the energy rejected by the condenser of the refrigeration units to meet all the reheating needs after dehumidification of the relative humidity-controlled zones, and to preheat the domestic hot water, with the following objectives:

- Evaluate all unavoidable energy released (refrigeration unit, sterilisation, etc.)
- Locate and quantify these energies
- Propose appropriate recovery and recycling systems and techniques

➢ Renewable energies

The technical, economic and environmental feasibility of using renewable energies in the project must be studied. The environmental impact of these solutions will be assessed in terms of atmospheric emissions (CO_2 (eq-CO_2) and SO_2 (eq-SO_2)). The percentage of requirements covered by the chosen renewable energies will be detailed by energy source.

This feasibility study will also examine the possibility of using renewable energies:

- Photovoltaic systems on flat roofs or facades, producing no more than 15% of the hospital's total electricity needs.
- Solar thermal energy to provide 100% of DHW production, in addition to the recovery of unavoidable energy sources described above.

Particular attention will be paid to the positioning and orientation of the solar collectors to avoid any solar masking that could lead to a loss of productivity from the panels, especially if they are positioned on a terrace.

The total percentage of the project's energy needs covered by local renewable energy sources will be clearly indicated and must reach a minimum of 20%.

Energy performance objective: the project owner's aim is to achieve an energy-efficient building through this approach and within the budget allocated to the project.

In addition to the thermal and bioclimatic performance of the building, which has been established elsewhere, it is therefore concerned with the energy performance of the systems used, particularly in terms of the production, distribution, regulation and emission of heat, cold, ventilation and DHW...

The building will therefore have to justify its use of dynamic thermal simulations (DTS) to estimate, on a comparative basis, the forecast consumption for the different possible combinations of systems, depending on opportunities and performance trends, particularly those linked to emerging technologies.

The consumer items selected are: heating, cooling, DHW, artificial lighting, ventilation auxiliaries (fans, extractors, etc.) and hydraulic auxiliaries (heating, cooling and DHW distribution pumps).

These simulations will be carried out in a comparative manner, on the basis of the bioclimatic performance solution for the building agreed beforehand, and expressed as a percentage reduction in reference consumption, itself calculated by means of a DTS, with standard performance assumptions to be specified by the project owner when the time comes.

Based on the reference consumption, **a minimum improvement of 30% will be sought.**

Reduction of pollutant emissions into the atmosphere: the quantities of CO_2 (eq-CO_2) and SO_2 (eq-SO_2) generated for the building by the use of energy on the items taken into account in 4.2.1. will be calculated.

Justification that the energy choice (calculation of the quantities of CO_2 (eq-CO_2) and SO_2 (eq-SO_2) generated for different energy variants) corresponds to the best compromise with regard to these CO_2 emissions and the project owner's environmental objectives is expected, particularly in relation to the types and quantities of renewable energy used.

The reduction in CO_2 emissions compared with reference CO_2 equivalent emissions (as for energy performance) generated by the use of energy for building-related items, justifying a minimum gain of 20%.

In addition, refrigeration production equipment will use refrigerants with zero OPD (Ozone Depletion Potential) and GWP (Global Warming Potential) < 50.

The respective quantities of all the refrigerants present on the site will be calculated, and their environmental impact (destruction of the stratospheric ozone layer (ODP) and climate change (GWP)) will be assessed. The choices made regarding these two indicators will be justified.

4.2.2. TARGET 5 - Water

General requirements for water usage in buildings can be categorized into three main areas: drinking water, a valuable resource requiring conservation; rainwater, which should be effectively managed; and wastewater, requiring pollution load reduction and proper treatment before discharge into the natural environment.

This target sets out requirements for saving drinking water, managing rainwater and controlling wastewater discharges. Achieving the associated targets also provides benefits for both the building's operators and the environment:

- Preserving the planet's water resources.
- Operating savings for users, for a resource whose price per m3 continues to rise (currently 900 FRW excl. tax/m^3).

Preventing leaks (effective detection) and using efficient water-saving appliances can significantly reduce drinking water consumption.

Special features linked to the context: the project could envisage recovering rainwater, for example from roofs, for watering green areas and cleaning outdoor areas, as well as cleaning outdoor logistics areas dedicated to waste and service vehicles.

A study on the possibility of reusing rainwater after sanitary treatment for toilet flushing will be carried out within the framework of Rwandan sanitary regulations.

The composition of the soil, and in particular its permeability, will be assessed in order to study the possibilities for direct infiltration of rainwater, and consideration will be given to reducing the site's impermeable coefficient.

In addition, the project will step up its efforts to promote effective solutions for saving drinking water.

Reducing drinking water consumption:

- The installation of pressure reducers (if P > 3 bars) will be required to limit withdrawal flows.
- The maximum flow rates of plumbing terminal appliances must comply with the following requirements:

TABLE 6 - FIXTURE TYPE BY BASELINE FLOW RATE RANGE

Fixture type	Baseline Flow Rate Range
Water Closets (Full flush)	4 to 4.5 LPF
Water Closets (Half flush)	2.5 to 3 LPF
Urinals	1 to 1.5 LPF
Faucets / Taps*	4 to 6 LPM
Showerhead / Handheld spray*	7 to 9 LPM
Sink / Bib taps	6 to 8 LPM

* Reporting pressure for these fixtures shall be at 3 bar

LPF – Litres per flush
LPM – Litres per minute

- In addition to the above minimum requirements, the project will incorporate:
  - Identification of the drawing points required for the building's activities (toilets in technical areas, watering needs for planted areas, cleaning of car parks, maintenance activities, etc.) and the equipment that uses drinking water.
  - Draw-off points equipped with water-saving devices:
    - Timed taps with flow limiters,
    - Surgical sinks with infrared detectors,
    - Pressure reducers,
    - Star jet breakers.
- The percentage of these requirements covered by water from a source other than the drinking water distributed by the network (e.g. rainwater, water recovered from osmosis units, grey water from the laundry, etc.) will be determined and must be greater than 25%.

The percentage savings in drinking water resulting from these measures must be justified using the Target 5 "water" calculation tool proposed by the certification body (2b3b0b-Outil_Eval_Cible5_20151014).

The water requirements for sanitary facilities (flushing toilets, urinals, showers, washbasins, sinks) based on the various planned equipment for the project (referred to as B sanitary facilities), assessed using the calculation tool mentioned above, should be compared with those of a "reference" project (referred to as B ref, sanitary facilities) - i.e. the water requirements that the project would have with reference equipment. This comparison should ensure that **B sanitary facilities ≤ 0.6 B ref, sanitary facilities**.

The conventional reference values are as follows:

- Flush: 6 litres/flush

- Urinal: 3 litres/flush
- Washbasin tap: 10 litres/minute
- Shower: 12 litres/minute

Generally speaking, and in addition to the percentage calculations mentioned above, the projected consumption of total water and drinking water distributed throughout the building will be calculated by the designer at the initial stage of the project, according to the different functional units of the operation.

Managing rainwater on plots of land: managing rainwater is an important environmental issue, in terms of the right sizing of rainwater drainage networks, consistency with local regulatory requirements, flood prevention and soil pollution.

The waterproofing coefficient and leakage rate for the construction of the building will be calculated and must meet the requirements below.

- The waterproofing coefficient, which is the ratio between the waterproof surfaces and the total surface area of the plot dedicated to the project, will not exceed 80%.
- However, waterproofed areas will be kept to a minimum. Vegetated areas will be given pride of place, to drain rainwater as much as possible in order to respect the natural course of water.
- In order to comply with the regulatory leakage rate for the plot, infiltration should be favoured first (wells, ditches, draining asphalt, etc.), with a delay if necessary:
  - A rainwater retention basin to regulate run-off in order to comply with the regulatory leakage rate.
  - A rainwater harvesting system will be installed on the building's roofs to capture 100% of the runoff. The sizing of this recovery system and the associated storage will comply with RS 187: 2013 "Systèmes de récupération des eaux de pluie - Code de bonnes pratiques". It will help to slow down the inflow from storm rainfall, and may be used for cleaning vehicles, car parks and/or watering green spaces.
- In order to combat chronic pollution and based on a rainfall regime corresponding to the typical occurrence for the city of Ruhengeri, measures will be taken to collect potentially polluted run-off water from the roads and car parks and treat it before discharge via a hydrocarbon separator.

Controlling liquid effluent discharges: The designer must define and implement architectural, technical and managerial measures to separate discharges by type and to treat specific discharges from care processes.

Recycling of grey water from the laundry: a system for recovering rinse water with a view to its reuse will be studied, together with all the storage, microfiltration and final treatment systems needed to enable it to be re-injected into the washing cycles.

Recycling of water from the dialysis department's osmosis machines: a system for recovering, treating, and reusing the residues from the manufacture of ultrapure water by the osmosis machines will be implemented, depending on the intended use of the recovered water. The designer will have to propose the most suitable residue treatment technique (reverse osmosis, nanofiltration, electrodialysis, etc.) depending on the normative electrical conductivity values of the intended uses (watering green spaces, reintroduction into the dialysis system, toilet flushing, external uses).

Wastewater treatment: The existing hospital features a basic lagoon situated on the development site, currently responsible for treating and disposing of all the hospital's wastewater. This system, deemed ineffective from a health perspective, will be replaced prior to the commencement of construction by a Phyto-treatment system situated to the southwest of the plot, between the boundary with the training centre and the infectious diseases building (which falls outside the scope of this contract).

The designer will be tasked with connecting to this system from a central collection point for the building's wastewater. This collection point will be equipped with an automatic bar screen and a tank/booster unit to facilitate the sequential pumping of wastewater to the treatment plant.

4.3. Environmental Targets treated at "Performant" level

4.3.1. TARGET 2 - Materials

Constructive choices for the durability and adaptability of the structure: the designer will have to think about the adaptability of the structure's premises.

To do this, it must meet the following requirements:

- Choosing processes and shell products adapted to the building's desired lifespan.
- Consider the adaptability of the building: demonstrate the modularity of the spaces and their adaptability to heating, glazing and ventilation systems, etc.
- Draw up a notice including the classification of areas according to the level of adaptation expected: areas with frequent adaptation, occasional adaptation or areas that are not intended to be adapted.

All the materials or construction processes used in the project must have a technical opinion or equivalent.

Construction choices to make the structure easy to maintain: the project must incorporate maintenance and cleaning issues as early as possible in the design phase.

The designer must consider the need to facilitate these operations and reduce costs by:

- An appropriate choice of materials: avoid grainy or porous surfaces, and materials that require specialist cleaning.
- A study of the accessibility of the various elements of the envelope (facade, solar protection, roofs) is requested, including the frequency of access and the conditions of access.

Integrated choice of construction products to limit the environmental impact of the building: the designer must produce a calculation of the environmental impact (consumption of energy resources in kWh eq/m²SHON per year and climate change in kg eq CO_2/year/m² SHON) for 50% of the elements in at least 3 product families (one for structural work, two for finishing work).

As part of the HQE approach, designers are asked to orient their materials and construction choices towards processes that are recognised for their low embodied energy and their ability to be recycled, as well as for their health quality (low VOC – Volatile Organic Compound - emissions) in the following families:

- Infrastructure and shell:

Designers are invited to study their construction principles with a view to limiting as far as possible the greenhouse gas emissions produced using building materials and equipment, in particular by:

- Limit the use of concrete as much as possible. To this end, the CUI ratio (Concrete

Use Index = Volume of concrete in m^3 / Built floor area in m^2) will be calculated and must be less than 0.5 (see 3.1 SUSTAINABLE CONCRETE USAGE in Annex 9).

- Work with the cement manufacturer near the site (PRIMECIMENT) to find the least carbon-intensive concrete formulations possible, based on the strength and exposure classes required for the various situations.
- To study the possibilities of introducing wood materials into structures, floors, facades and joinery, in line with availability and the local channels available, and in line with the risks and Rwandan fire regulations.

➢ Insulation:

Propose an alternative to mineral wool and study the use of healthy insulation materials for external walls; this should be done by targeting insulation materials with high thermal compactness, such as cellulose fibre or wood fibre.

➢ Partitioning and lining:

Propose an alternative to plasterboard by studying the use of gypsum cellulose boards.

All the materials or construction processes used must be certified, have a French or European technical opinion, or be equivalent.

A lifecycle analysis calculation highlighting the project's impact in terms of greenhouse gas emissions for construction products and equipment will be carried out by the designer at each stage of design, and at the end of construction.

Choice of construction products to limit health impacts: measures must be taken to limit sources of indoor air pollution:

➢ Strict enforcement of regulatory bans on certain materials such as asbestos and lead,

➢ Choice of interior coverings with low Volatile Organic Compound (VOC) emissions: knowledge of VOC and formaldehyde emissions for 50% of surfaces in contact with indoor air,

➢ Inside premises, VOCs are emitted by:

- Materials used in construction, decoration, and furnishing,
- Varnishes, glues, and paints,
- Cleaning and maintenance products,
- Wood preservatives,
- Tobacco smoke.

As part of this project, the designer will have to use materials recognised for their ecological value and low VOC emissions in the following families:

➢ <u>False ceilings:</u>

Offer an alternative to mineral ceilings: ceilings such as zeolite-based ceilings are beginning to appear, or perforated plaster with sufficient acoustic performance to dispense with mineral wool.

As a minimum, all suspended ceilings must have been awarded a quality label such as the "Eco-Label du Cygne" or "Indoor Climate Label" or demonstrate equivalent performance.

- Interior paintwork:

All paints and varnishes must carry the "NF-Environment" or "Eco-Label" or have a VOC content of <10g/l.

- Glues:
  - Give preference to adhesives that have undergone VOC emission measurements and are classified C (low emission) or C+ (very low emission); if not, opt for solvent-free adhesives (coating, waterproofing under tiles, etc.).
  - The wood used, whether softwood or hardwood, must be eco-certified PEFC (Programme for the Endorsement of Forest Certification schemes) or FSC (Forest Stewardship Council). The PEFC logo certifies that the wood used in marked products has been harvested from forests whose owners are committed to respecting the rules of sustainable management.
  - Where chemical treatment is required, vacuum autoclave treatment using CTB-P+ certified products (fewer toxic biocides) or equivalent should be mandatory.

4.3.2. TARGET 3 - Site

The primary objective will be to minimize the inconvenience caused by construction activities, especially for hospital users and operational services during the construction phase (such as noise, dirt, and dust), conserve resources (such as water and energy), and reduce pollution (including waste and water pollution). Additionally, ensuring proper environmental management for all individuals involved in the project will be essential for effective site management.

As the worksite will be taking place in the immediate vicinity of various departments that will continue to operate, controlling the health risks associated with the worksite, particularly infectious risks (aspergillosis), will be a priority, in addition to ensuring the safety and comfort of patients and staff.

As part of the High Environmental Quality approach, the designer is responsible for drafting and including in the tender documents for all contractors a low-hazard worksite charter, which will be binding on all contractors holding a work package, including by requiring the subcontractors of each contractor to comply with this charter, which will form part of the contractual documents for each works contract.

All these documents must be signed by all the companies working on the site.

This document will define the contractual objectives of a low-impact worksite (reminder of and compliance with regulations on waste sorting, worksite organisation, HQE® meeting, noise limitation, etc.) and will specify the terms of application and any internal penalties.

Optimising site waste management:

➢ <u>Reducing site waste at source</u>

The designer will endeavour to:

- Reduce concrete waste through good site preparation, reservation plans and summary meetings to avoid spiking with a jackhammer.
- Prohibit polystyrene waste by using other materials for reservation boxes.
- Reduce wood waste by using metal formwork and returning delivery pallets to suppliers.
- Reduce waste and off-cuts by optimising packaging methods and the layout of materials used.
- Reduce site waste by favouring dry construction methods.
- Encourage companies to reprocess waste (partitions, false ceilings, paint, etc.) directly with manufacturers or their suppliers.

➢ <u>Organising waste sorting and storage</u>

The project owner requires selective sorting to be carried out. The aim is to recover at least 50% of recoverable site waste, including at least 20% in the form of materials.

Particular attention should be paid to the following points:

- Quantify site waste by category (inert waste, household waste, hazardous waste, non-hazardous waste, packaging waste).
- Seek out local recovery channels.
- Traceability: collect the waste disposal slips, which must also indicate their destination (100% of all waste). The design consortium will be responsible for collecting these monitoring slips and will have to submit monthly waste management reports (type, quantity, place of disposal) and a report at the end of the worksite.
- The site installation plan must include the following elements:
    - Sorting and storage areas for materials and waste,
    - Traffic and parking areas for delivery and waste disposal vehicles,
    - Site fencing,
    - Signage,
    - Traffic routes for users of buildings in operation.

The designer is required to set up a selective sorting system that recycles at least all of the following waste: wood, scrap metal, inert waste, non-hazardous industrial waste and special industrial waste.

The designer will have to require construction companies to sort waste as close as possible to the sources of production:

- By setting up internal collection systems that allow the worker to continue his or her work without any additional effort when creating the waste,
- By anticipating the position of skips or requesting intermediate containers (big-bags, small skips).

These points will need to be discussed at site meetings during the preparation phase, in order to establish the best working strategy for achieving high-quality selective sorting.

It is up to the designer to ensure that the best strategy is defined to ensure that selective sorting is correctly implemented and maintained throughout the worksite (number of sorting zones, signage on skips, human resources dedicated to sorting, etc.).

Controlling the impact on health:

- Assess the infectious risks associated with the work and plan preventive measures (dust removal, site cleaning, checking existing ventilation and fitting filters if necessary).

- Provide airtight ducts to prevent dust penetration. Before installation, degrease, clean and disinfect. After installation, seal all vents to prevent the ingress of dust until commissioning.
- Ensure that procedures are in place for cleaning and disinfecting pipes before they are put into service.

Mitigating on-site disturbances:

- Noise pollution

Compliance with current acoustic regulations governing the noise level of the various items of equipment and machinery. Companies must work with equipment that is in good condition, particularly in terms of noise. All noise-producing machinery and tools used on the site must:

- Comply with the relevant manufacturing standards.
- Have a a periodic inspection report attesting to the noise level of the equipment in operation and its compliance with current legislation.

The noise level from site machinery at a distance of 10m must be less than 85 dB(A).

Measurements may be taken during the construction phase to monitor noise levels. These measures will limit the nuisance caused to local residents and protect the health of site workers.

- Visual disturbances

A special effort will be made to ensure that the visual amenity of the site is not damaged and that the site does not become unsightly. The following will be required:

- Correctly organise the parking areas for both site machinery and site staff vehicles,
- To clean up around the site on a daily basis,
- Complete closure of the site at each phase.

- Traffic disturbances

The number of lorries on a site, whether delivering materials or removing waste, is always a significant source of nuisance.

As a general rule, a great deal of communication and prevention will be required between the various players (site managers and faculty management).

As part of this project, certain measures will need to be taken:

- Regulating traffic.
- Position the site entrance(s) judiciously to avoid truck manoeuvres.
- Set up a lorry traffic plan for the site.
- Requiring regular maintenance checks on motorised equipment to ensure the quality of exhaust gases.

- Disturbances caused by dust, mud and concrete laitance

These types of disturbances have a direct impact on the risk of water, soil and air pollution on the site if measures are not taken to limit them. To this end, the following measures must be taken:

- Limiting the dispersion of dust by covering the ground and watering the roads if necessary, during dry periods, while limiting stagnant water.
- Seal off the ends of ventilation ducts during storage on site and once they have been installed, to limit the build-up of dust inside them.
- Daily cleaning of roads and site.
- Installation of a wheel washing area at the end of the worksite.
- Treatment of wash water from concrete plants using a settling tank.
- Use of natural vegetable oils for formwork if oil-free formwork systems are not already available.
- Favour the use of materials that do not need to be manufactured on site.
- Waterproofing storage areas for various materials.
- Label all receptacles containing toxic and harmful products.
- All toxic effluents must be collected.

Limiting consumption of resources on the site: the designer will require the installation of a metering system for water and electricity used to supply the site.

These meters will have to be read every week, followed by a comparative analysis to detect over-consumption and take the necessary measures to curb it. An overall assessment of consumption will be carried out at the end of the works.

In addition, rainwater recovery during the works could be envisaged for cleaning lorries as they leave the site.

4.3.3. TARGET 6 - Waste

General target requirements: waste disposal is increasingly controlled by national and local regulations.

Integrating sorting into the internal organisation of a building is not always easy when it is not thought through at the initial design stage: lack of space for containers, inconsistency of collection routes between waste production sites and storage sites prior to disposal, mismatch between the specific nature of activities, existing local channels and collection resources.

The aim of this target is to ensure the smooth operation of the waste management system in the building industry:

- Estimated quantities of waste by category produced.
- Number, volume and location of the various receptacles used for sorting.
- Location and size of marshalling areas.
- Means to facilitate links between production sites and waste storage sites.

Special features linked to the context: the simultaneous presence in the building of specific waste (Infectious medical wastes) and vulnerable people means that the health risks linked to waste management have to be tightly controlled.

In addition, the individual use of single-use hospital equipment generates a large quantity of specific waste, which needs to be considered when sizing waste rooms.

Waste collection at the current hospital site is handled by an external service provider under contract with the local authorities. The introduction of selective sorting on the project will be carried out considering current practices with a view to consistency and optimisation, although any proposal for a new organisation cannot be ruled out.

The aim is to provide clear answers to the following questions:

- Production: What types of waste (particularly in terms of regulatory constraints) are produced and where?
- Collection: How is the various types of waste transported? Which containers? What modes of transport? What weights? What volumes? Which collection routes?
- Intermediate storage: where can the various types of waste be grouped together close to where they are produced? (Optimisation of collection routes, location of waste rooms).
- End-of-pipe storage: How are the different types of waste grouped together, and on what surfaces? What are the interfaces with external disposal channels?

Waste optimisation and recovery:

- Identify the activities carried out within the facility: care activities, catering, cleaning, maintenance, office activities, accommodation, etc.

- Identify in detail the waste generated by each of the establishment's activities and estimate the quantities produced and the rate of production by category of waste.
- Identify existing and future local recovery and disposal channels, and define waste categories: medical waste, other hazardous waste, healthcare waste, organic waste, packaging waste (unsoiled), waste electrical and electronic equipment (WEEE), mercury waste, radioactive waste, waste from cancer treatments, ...
- Identify available and future removal services, public or private (nature, frequency, etc.).
- For each category of waste, choose the most satisfactory method from an environmental, technical and economic point of view, giving priority to recovery wherever possible.
- Encourage source separation of regulated and non-regulated waste (Infectious Medical Wastes, Care Activity Wastes, Dangerous Wastes, Non-Dangerous Wastes and packaging wastes). The areas of the development where source separation is an issue will be identified. This study will enable satisfactory architectural arrangements to be made to allow sorting at source (sufficient office space, proximity of sorting areas to production areas, etc.).
- Define the volumes and characteristics of containers and storage spaces for each category of waste, by production station, on the basis of the quantities of waste produced and estimated, for intermediate storage and for final storage, taking into account the optimisation of sorting.
- More specifically for Infectious Medical Wastes, the premises intended for their storage will be sized to take into account the regulatory storage times and will be located away from the activity areas and at a distance from the new ventilation air intakes. A container cleaning and disinfection area close to the final waste storage area.

Waste management system: The design of waste production areas should encourage sorting at source and the deposit of waste (both inside and outside the building) in line with the collection arrangements (nature and frequency) of the private service providers and/or public collection services responsible for this.

- Design waste rooms and/or areas adapted to the context of the operation and sized accordingly (size, volume, location). Justify the dimensions of the waste room or area.
- Intermediate storage facilities should be laid out in such a way as to be consistent with production sites, with possibilities for grouping and horizontal and vertical links to facilitate subsequent transfers of waste by optimising journeys and handling.
- Encourage the collection and specific grouping of regulated waste through appropriate architectural measures. For example: provide a dedicated area for storing hazardous waste (ventilated and protected from the weather).

- Waste sorting areas will be set up at strategic points in the building (battery, paper, glass and printer cartridge collectors).
- Consistency of waste flows: facilitating the collection, grouping and removal of waste to optimise waste handling through architectural arrangements.
- Study and optimise the interaction between waste flows and other traffic flows in the structure.
- The terminal storage area must be designed to ensure safety, health and hygiene, while limiting the visual and olfactory impact. Waste should not be placed in an inconspicuous place (encouraging uncontrolled dumping).
- Provide means of cleaning the waste areas, taking care to minimise nuisance to occupants. In particular, provide a water supply point, a floor drain and suitable ventilation to ensure hygiene conditions in these areas.
- Distinguish between regulated waste circuits and other waste circuits and optimise them.
- Anticipating possible changes to the facility, future treatment methods and future collection services.
- To evaluate the viability of implementing on-site waste management equipment for healthcare activities involving infectious risks (Healthcare Waste).
- Carry out a study to assess the feasibility of an on-site recovery unit for organic waste (food waste and green waste), or connection to an existing ex-situ recovery system, the terms of which will be passed on to the future site operator.
- For waste that does not come from healthcare activities, ensure that at least 50% of its volume goes to material and/or energy recovery channels.

4.3.4. TARGET 8 - Hygrothermal comfort

General target requirements: Thermal comfort is crucial for an individual's well-being and is influenced by the exchange of heat and moisture with the surroundings. It is determined by multiple factors including activity level, clothing, air temperature, humidity, and the physical characteristics of the surrounding environment. Therefore, thermal comfort is a multifaceted concept that cannot be solely defined by a specific air temperature.

This highly subjective concept has also been the subject of a great deal of scientific research, leading to the development of a European standard (ISO EN 7730) that statistically characterises people's sensation of thermal comfort as a function of the above-mentioned parameters.

Architectural design is particularly important in terms of thermal comfort. The layout of the premises should enable areas with similar or identical hygrothermal requirements to be grouped together: thermal zoning. This should make the most of the opportunities offered by the site, and propose a volumetric layout and façade modelling with the aim of:

- Making the most of the inertial effect, the structure, and the building envelope,
- Suggest solar protection devices adapted to each orientation,
- Limit the use of active cooling systems, which consume a lot of energy,
- Exploit the building's natural ventilation potential,
- Favour passive systems.

Particularities linked to the context: in a hospital, vulnerable people who are present, sometimes for long periods, must be able to benefit from satisfactory hygrothermal conditions. The feeling of freshness should be achieved by using passive cooling systems as a priority (appropriate solar protection, natural ventilation, etc.).

The client wanted to limit active cooling to all non-specialist premises (offices, shared spaces, etc.).

Architectural measures to optimise hygrothermal comfort:

- ➢ The architectural design of the project will incorporate a bioclimatic approach based on the climatic characteristics of the site. This will involve using solar protection, the solar control qualities of glazing, thermal inertia and ventilation to keep the <u>resulting temperature</u> in the premises always below the outside air temperature.
- ➢ Orient the glazed facades to provide simple and effective solar protection. The choice of solar protection will be adapted to the type and orientation of the façades and will avoid direct solar gain in the rooms, particularly bedrooms and offices, in summer.

Premises not using a cooling system:

<u>General requirements</u>

- ➢ Solar protection must be placed outside and differentiated by orientation to achieve the desired effectiveness. Preference should be given to:

- Horizontal and fixed, integrated into the architecture of the building or added (roof overhang, slab overhang, canopies, etc.) for southern exposure.
- Horizontal, distributed, and movable (adjustable and raisable) over the height of the glazing (external louvres) for east and especially west orientations.

➢ However, the designer is invited to present any relevant solution that he deems effective, if he can justify it.

➢ Horizontal blades can therefore be tilted and raised, with a requirement for quality that justifies a long service life (minimum 15 years) and limited maintenance requirements.

➢ Solar protection will be adapted to the orientation of the bays, seeking a good compromise between solar and light requirements and the preservation of views.

➢ Particular attention will be paid to the solar control qualities of the glazing on all openings. The solar factor of glazing will be less than 0.15 with movable solar protection lowered.

➢ The opening ratio for openings (with solar protection in place) must be ≥ 30%. It must be possible to hold the opening devices in position.

➢ Zenith glazing without effective solar protection should be avoided. Roofs, which are traditional sources of overheating, will receive special attention to ensure they are well-insulated, use materials with low solar absorption properties (such as light colors or low-absorbent materials), and incorporate appropriate natural ventilation, especially in attic spaces.

In free evolution, i.e., without activation of the cooling system, all the premises concerned by this situation, and in particular the administrative offices, common premises, reception area, consultations, and accommodation rooms, **must not exceed the comfort range (as defined in the HQE certification guide published by CERWAY) for more than 2% of the time during the year**.

<u>Optimisation using dynamic thermal simulation</u>

In order to verify compliance with this temperature constraint (exceeding the comfort range limited to 2% of the time over the year), the designer will have to carry out a dynamic thermal simulation, known as a "comfort simulation", to simulate annual temperature changes in all the premises affected by this requirement.

Thus, on the basis of a complete 3D model of the project, divided into homogeneous thermal zones, the homogeneity of which will have to be justified, and according to the thermal characteristics of all the construction elements, the resulting free changes in temperature will be calculated hour by hour over the whole year.

On the basis of this observation, and if the 2% threshold is exceeded, successive iterations will be carried out by the designer to reduce the excess by optimising the building's passive performance.

These simulations will be carried out as soon as the project design begins, and then repeated and consolidated as the project develops.

Premises using an air conditioning system: the client wishes to install an air conditioning system in certain premises identified in the technical programme. For these:

- The maximum air velocity V in the occupied zones of air-conditioned premises will be less than 0.22 m/s.
- Fresh air supply temperatures will be adapted to ensure user comfort, i.e. close to 26°C in summer for extended use premises.
- Temperature control will be possible on a room-by-room basis.
- For premises requiring specific treatment, and in particular all areas of the technical platform, the temperature instructions, which must be strictly maintained, depend on the premises and are stipulated in the terms of reference for the HVAC package.
- Spaces requiring humidity control must be clearly identified, with strict humidity guidelines adapted to the conditions of occupancy and equipped with devices to control relative humidity.
- Maximum air velocities in high-volume health risk areas (e.g. operating theatres) must be adapted to the health requirements of these areas and justified.

Temperature and humidity set points: the temperature set points required for each type of premises are presented in the terms of reference for air conditioning and mechanical ventilation.

4.3.5. TARGET 9 - Acoustic comfort

Position of sensitive and very sensitive areas with respect to internal nuisances: the areas of the structure are classified according to their sensitivity and aggressiveness, using the method defined in the CERWAY practical guide, as follows:

- Highly sensitive areas: operating theatres, obstetrics and labour rooms.
- Sensitive premises: accommodation and treatment rooms, examination and consultation rooms, waiting rooms (excluding emergency department waiting rooms), relaxation rooms, medical and nursing offices, other premises where patients may be present.
- Highly aggressive premises: technical rooms, workshops, central kitchen, catering room, halls.
- Aggressive premises: traffic areas, toilets, meeting rooms, group offices, training rooms.

The designer must justify the measures taken to optimise the position of sensitive and very sensitive areas in relation to aggressive and very aggressive areas, and also in terms of vertical or horizontal contiguity, with or without the same entity.

Position of sensitive and highly sensitive areas in relation to external nuisance: take account of acoustic nuisance outside the building in the architectural provisions relating to sensitive and highly sensitive areas, including access for delivery vehicles, emergency zones, helipads and technical equipment.

Acoustic quality of interior spaces: The designer must justify compliance with the requirements set out below for each acoustic indicator by means of a calculation note based on a method that complies with Rwandan regulations, in particular for the following indicators:

- Weighted Standardised Impact Sound Pressure Level from the outside
  - $L_{nT,w} \geq 30$ dB with respect to noise from land transport infrastructures
- Airborne noise isolation (at reception) from adjacent spaces (in dB)

The weighted standardised sound insulation, $L_{nT,w}$, expressed in dB, between the different types of premises must be equal to or greater than the values shown in the table below.

TABLE 7 - WEIGHTED STANDARDISED SOUND INSULATION BETWEEN THE DIFFERENT TYPES OF PREMISES

Emission local → Reception room ↓	Accommodation and care premises	Examination and consultation rooms, medical and nursing offices, waiting rooms	Operating theatres, obstetrics and labour rooms	Internal circulation	Other premises
Operating theatres, obstetrics and labour rooms	47	47	47	32	47
Accommodation and care rooms, examination and consultation rooms, waiting rooms (*), medical and nursing offices, other rooms where patients may be present	42	42	47	27	42

(*) Excluding emergency waiting rooms

- L'nT,w ≤ 57 dB for 100% of hospital rooms and care areas, and L'nT,w ≤ 60 dB for offices and associated areas.
- Equipment noise levels in premises

  The standardised impact sound pressure level, LnT, of noise generated in an accommodation room by building equipment outside this room must not exceed 35 dB(A).

  The standardised impact sound pressure level, LnT, of noise transmitted by the operation of building equipment must not exceed the following values:

  - in examination and consultation rooms, medical and nursing offices, waiting rooms: 35 dB(A);

  - in treatment rooms: 40 dB(A);

  - in operating theatres, obstetrics wards and labour rooms: 42 dB(A).

- Internal room acoustics

  The values of the reverberation times RT, expressed in seconds, to be respected in the premises are given in the table below. They correspond to the arithmetic mean of the reverberation times in the octave intervals centred on 500, 1,000 and 2,000 Hz. These values apply to normally furnished and unoccupied premises.

TABLE 8 - VALUES OF THE REVERBERATION TIMES RT TO BE RESPECTED IN THE PREMISES

Volume of premises (V)	Type of premises	Average reverberation time (in seconds)
$V \leq 250\ m^3$	Catering room	RT ≤ 0.8 s
	Staff rest room	RT ≤ 0.5 s
	Public reception area	RT ≤ 1.2 s
	Accommodation or care premises, examination and consultation rooms, medical and nursing offices	RT ≤ 0.8 s
$V > 250\ m^3$	Premises and traffic accessible to the public (*)	RT ≤ 1.2 s If $250\ m^3 < V \leq 512\ m^3$ $RT \leq 0.15^3 \sqrt{V}$ If $v > 512\ m^3$

(*) With the exception of common internal corridors in the accommodation and care sectors.

- Sound when walking

The equivalent absorption area (EAA) of absorbent coverings in common internal corridors in accommodation and care areas must be at least one third of the floor area of these corridors and EAA total ≤ 0.6 S(floor area) in hospital rooms.

The equivalent absorption area (EAA) of an absorbent covering is given by the formula:

EEA = S*αw

where S designates the surface area of the absorbent coating and αw its absorption evaluation index.

Under no circumstances, in accordance with Rwandan noise standards (RS 236: 2014), may the sound pressure level inside buildings exceed 50 dB.

4.3.6. TARGET 13 - Air quality

General requirements of the target: pollution that affects air quality can come from a variety of sources:

- **Outdoor air** (road and air traffic, allergens produced by certain plant species, radon, emissions from industrial infrastructures, soil pollutants and heavy metals, etc.),
- **Indoor air** (particles, fibres, molecules emitted by interior coverings, mould, sanitary products, etc.).

This target therefore aims to identify sources of air pollution in order to better control them, and to ensure effective ventilation in order to guarantee appropriate air renewal and filtration.

Special features linked to the context: air renewal plays an essential role in controlling air quality and must protect users from external pollutants (pollution and nearby transport routes) and remove odours linked to the operation of the building (toilets, waste rooms, odours linked to care, etc.).

Controlling sources of pollution: external sources of pollution are mainly linked to:

- Atmospheric pollution caused by various human activities: transport, energy, industry, agriculture (burning, pesticides, etc.), etc.
- Discharges specific to the project: kitchen, waste rooms, car park, exhaust air, etc.

The designer is therefore expected to pay particular attention to controlling sources of pollution in order to meet the following requirements:

- To limit pollutant ingress, fresh air inlets should be positioned according to the following principles:
  - Sufficiently far from external sources of pollution and exhaust air vents

- Depending on the prevailing winds on the plot.

- A specific study incorporating the relative positioning of the ventilation equipment rooms, the internal organisation of these rooms and the prevailing winds on the plot will demonstrate that no air recirculation will be possible between the fresh air intake and stale air discharge vents.
- Particular attention will be paid to the positioning and diameter of the Quench tube (for MRI) in relation to the air intakes in the building and window openings (this tube will be straight, with no bends along the way, and with a discharge whistle).
- The ventilation link between the waste rooms, mortuary, etc. and the bedrooms or offices must be handled with great care when organising the interior space.
- A filtration system for incoming air, adapted to external pollutants, will be installed. It will be linked to a Building Management System (BMS) to prevent any risk of clogging.
- Identify internal and external sources of pollution and the degree of health risk associated with these sources and take the necessary steps to reduce their effects in a satisfactory and justified manner.
- Products in contact with indoor air must not emit carcinogenic particles and fibres (materials meeting the tests set out in European Directive 97/69/EC of 5/12/97).
- The designer is required to know the VOC and formaldehyde emissions of ceiling, floor and wall coverings in order to:
    - 75% of surfaces in contact with indoor air in occupied premises,
    - All paints and varnishes.
- The choice of products will take account of health criteria for at least 50% of the surfaces selected.

Ensuring effective ventilation:

- Ventilation will ensure that the air is renewed with the windows closed, by means of double-flow ventilation or single-flow ventilation in the case of natural ventilation.
- Air flow rates should be optimised according to the activities carried out in the premises, to improve air quality and olfactory comfort in these areas.
- The designer is asked to describe the specific ventilation system chosen and justify its performance for each zone.
- At a minimum, a system for modulating airflow according to CO2 levels will be provided in spaces that are intermittently occupied (meeting rooms in particular).
- Ventilation must be restarted before the start of the occupancy period in premises that are not permanently occupied, to ensure a healthy atmosphere for the occupants.

- The airtightness of the ductwork must be guaranteed, by improving the quality and installation of the joints. It must comply with or be equivalent to class B of standard EN 12237.
- Air handling units must have an airtight envelope that complies with or is equivalent to class L2 of standard EN 1886.
- A clogging warning system (alarm) and ventilation flow control will be installed and connected to the BMS.
- To limit health risks, the ends of the ventilation ducts will be systematically sealed with plastic film, both during storage on site and once they have been installed, in order to limit the deposit of dust inside them.
- The system will be cleaned before commissioning and the hygiene of the system, and the quality of the air will be checked after commissioning in accordance with an appropriate health acceptance procedure.

4.4. Environmental Targets treated at "Base" level

4.4.1. TARGET 1 - Site

The development of the plot must be consistent with the sustainable urban development policy of the national government and local authorities, and be designed to optimise the consumption of resources, by encouraging the use of local renewable energies.

The project will encourage the use of public transport, in line with the transport policy developed by the city of Ruhengeri, promote soft modes of transport and ensure a clear separation of the different flows (pedestrians, bicycles, cars, lorries) within the site. The pedestrian walkways will be protected, and a secure bicycle access will be provided to the dedicated car park.

Accessibility for disabled people, whether patients or staff, will be studied and satisfactory arrangements will be put in place.

The project will promote the least polluting modes of transport, and will provide for:

- A parking area reserved for clean vehicles (including electric vehicles) equipped with devices to encourage their use, representing at least 10% of parking spaces (cars).
- An area reserved for secure bicycle parking for staff, protected from the rain, with bicycle spaces sized according to estimated traffic flows, and an appropriate communal area (changing rooms, showers).

A specific study will be carried out to optimise the number of parking spaces in the context of the operation.

Generally, all types of access will be secured by provisions adapted to their specific features.

Architectural quality: the designer will be asked to ensure that the development of the plot is consistent with the local authority's planning and sustainable development policy.

The siting of the building and the architectural treatment of the project must take account of the following environmental issues:

- Integrate the introduction of renewable energies in line with Rwandan regulations on local production.
- Consistency with the rational use of locally available networks or resources (energy, water, sewerage).
- Durability and accessibility constraints for maintenance (see targets 2 and 7).

The designer is therefore asked to make provision for the following requirements:

- Plan and provide a floor plan that is scalable and sufficiently flexible to allow for any functional changes to the building.

- Incorporate differentiated access for emergency, delivery, waste, patient and pedestrian zones.
- Reducing the visual impact of technical aediculae
- Treat the "building" to provide thermal protection in line with the local climate.
- Incorporating renewable energy into the project.

Ecological quality: the designer must seek to reduce as far as possible the environmental impact of the building on the site, i.e.:

- Provide a plan of ecological continuity with the vegetated areas adjoining the plot.
- Carry out a specific study justifying the species planted with a view to improving biodiversity and restoring the habitat and living conditions of the fauna on the plot.
- Choose plant species with a minimum impact on health (no allergenic, invasive or toxic species). The number of allergens classified as risk 3 to 5 will be limited to less than 15% of the species selected.
- Encourage the presence of plants (facades, car parks), and wherever possible, make the roof productive (water management, biodiversity, energy production, recreational uses).
- The species planted complement each other, are non-invasive and well adapted to the climate and terrain, to limit the need for watering, maintenance and fertiliser.
- A minimum of 25% of outdoor parking spaces will be planted with vegetation.
- Limiting the discharge of rainwater into the network: the designer is therefore asked to include a study of the possibility of infiltration or retention on the plot.
- Recover and treat unpolluted run-off water.
- Optimise the layout of the premises according to the constraints of the site: accommodation in quiet areas.
- Optimising access for delivery and waste disposal areas.
- Use exterior cladding with added environmental value.

Management of natural, technological and health risks and soil-related constraints: the designer must draw up a comprehensive risk analysis document based on the site survey.

It will then have to identify the natural risks (earthquakes, volcanic eruptions, flooding, soil swelling, radon, etc.), technological risks (logistical risks, fire, CBRN, etc.) and health risks (risk of contamination from stagnant water, allergenic plants, etc.) in order to put in place appropriate architectural and technical provisions to manage these risks beyond the applicable regulations, and to ensure that the facility operates in degraded mode.

The designer must make all the necessary arrangements in the event of an exceptional "white plan" type event: crisis room for management, access, traffic and parking plan to accommodate large numbers of patients or victims.

Ambience and health quality of outdoor spaces for users:

➢ <u>Climate and visual ambience</u>

Protect users from prevailing winds and rain (building orientation), with special provisions for areas where the local effects of wind and rain are to be feared.

Design the building from a bioclimatic point of view and provide protection from the sun (e.g. sunshades) in exposed areas.

The external pedestrian walkways, building entrance, parking areas, waste sorting and delivery areas will be specifically lit. The plot will be laid out in such a way as to offer as many views as possible over natural areas.

➢ <u>Acoustic ambience</u>

The designer must consider the acoustic effects of noise from the building's own equipment and increase the insulation of the facades accordingly.

Architectural and/or technical measures will be taken to limit noise pollution from the building to the exterior of the plot, and the justification for these measures will be provided.

➢ <u>Accessibility, well-being and conviviality</u>

The designer will endeavour to comply with regulations, particularly in terms of PRM accessibility, and will propose a building accessible to disabled and elderly people, in accordance with the requirements specified in "Facilities for disabled people in public buildings" published by RHA in November 2011, and reiterated in the RWANDA GREEN BUILDING MINIMUM COMPLIANCE SYSTEM - indicator 5.2 **Universally accessible building:**

- Dedicated parking areas with easy access near the main entrance and/or as close as possible to the lift lobby.
- Installation of non-slip ramps with handrails
- Lifts must have wide access doors, with control buttons at the right height, Braille lettering and audio assistance for the visually impaired.
- Waiting and rest areas near lift landings
- Uniform ground level for unobstructed movement in communal and outdoor areas.
- Toilets in communal areas designed for the disabled.
- Main walkways/pathways with adequate width in outdoor areas, and rest areas with benches for patients

- Visual signage adapted to the functionality of the site will also be installed in the communal and outdoor areas.

Impact of the building on the surrounding area: the Designer will study the impact in terms of masking of the building's location in relation to existing or planned constructions. This study will also consider the impact in terms of acoustic and olfactory pollution. Particular attention will be paid to the following impacts:

➢ The right to sun and light

The right to light and sunlight will be ensured for neighbouring developments and existing buildings on the site: check that the existing or planned situation is not adversely affected by the siting of the buildings.

➢ Right to views

The designer will have to limit visual nuisance and take measures to optimise the right to views for neighbouring developments and existing buildings on the site: check that the existing situation is not degraded by the siting of the buildings and, if necessary, create views to planted outdoor areas.

➢ Residents' right to health

It is requested that thought be given to the species to be planted (non-allergenic, non-invasive), the positioning of waste areas, the positioning of air discharges from building AHUs in relation to neighbouring operations and existing buildings on the site.

➢ The right to peace and quiet - Odour nuisance

It will be necessary to take measures to deal with the odour nuisance that may be caused by the construction site, as well as by building activities (waste, catering, etc.).

In addition, targets for noise levels and emergence (in dB(A)) not to be exceeded will be set for noise produced by the building's equipment and activities (technical and architectural provisions will have to be studied). To this end, measurements of the initial noise situation will be carried out by the designer as soon as he is appointed. These will serve as a basis for establishing the levels not to be exceeded by the building's equipment and activities, to comply with any emergence criteria defined by the regulations in force.

4.4.2. TARGET 7 - Maintenance

General requirements of the target: to ensure that the efforts made for the other environmental targets can guarantee that the building functions optimally in relation to its internal and external environment over the long term, it is essential to ensure that the building and its equipment are maintained in good conditions: this is the purpose of this target.

From an environmental point of view, maintenance management must meet the following criteria:

- Optimising maintenance requirements,
- Choice of cleaning products and maintenance processes with reduced impact on the environment and health (waste, toxicity, water, and energy consumption, etc.),
- Provisions to facilitate its execution in all situations (reduced inconvenience for users, easy access to equipment, etc.),
- Monitoring equipment and systems to check and maintain performance.

Special features linked to the context: to simplify upkeep and maintenance operations, and above all to be able to control fluid consumption and operating constraints, this target must be included in the design from the outset.

Network design and choice of equipment for simplified maintenance:

- Measures will be taken to avoid disturbing occupants during servicing and maintenance work, including equipment replacement.
- The choice of materials and technical equipment must have good durability characteristics. All materials that are not subject to rapid replacement must be durable and resistant to cleaning products and impact (moving equipment, etc.).
- The choice of materials and technical equipment will have to incorporate a standardisation approach and good stock management to prevent any supply difficulties.
- Ensuring easy access for the upkeep and cleaning of the building, as well as for the upkeep and maintenance of the equipment (management of the various fluids, medical fluids and waste management).
- Equipment (production, distribution, and management systems) will be accessible either in technical rooms or in corridors rather than in patients' rooms or offices. Care must be taken to ensure easy access for servicing and maintenance of:
  - Energy:
    - Sizing of accesses for the replacement of heavy and bulky equipment (air conditioning equipment, generators, transformers, etc.).
    - Sizing work zones around fixed equipment.
    - Correct distribution of sockets and lighting, particularly in technical rooms and areas requiring periodic inspection or maintenance.
  - Water:
    - Avoid embedding pipes for easy maintenance (outside sensitive areas).

  - Access to indoor water treatment (where applicable).
  - Access to storage and recovery tanks.
- Ventilation:
  - Access to fresh air intakes and extractions.
  - Access to distribution ducts and technical components.
  - Access to filters.
  - Access to Air Handling Unit (AHU) control and measurement devices.
- Lighting systems:
  - Access and safety of access to luminaires and lamps placed at height (particularly for large premises...).
  - Access and security of access to outdoor luminaires.
  - Favour recessed luminaires and standardised equipment to make it easier to replace lamps and prevent them becoming dusty (or provide a non-dusting device).
- Medical fluids: to ensure a smooth (or even quick) supply of components, or to be able to carry out standard component exchanges, so as to limit the duration of malfunctions.
- Waste: Consideration to be given to the size of sorting areas and waste storage facilities (easy manoeuvring and cleaning of containers).

➢ Specify the measures taken to facilitate the cleaning of premises and waste containers (water points, washing areas, etc.). The final "waste" room (before removal) must have appropriate signage for easy identification of sorting.

➢ The networks can be maintained quickly and efficiently, in particular by sectoring the networks so that work can be targeted. For example, the design of the networks will make it possible to disinfect only part of the network without disrupting the operation of the entire facility.

➢ Installing equipment (temperature sensors, sensors, meters, etc.) linked to the BMS to facilitate diagnostics in the event of malfunctions and enable rapid detection of malfunctions in heating, cooling, lighting, air treatment and water and medical fluid supply systems.

Resources for managing active systems:

➢ Steps will be taken to ensure that the building can continue to be operated (in downgraded mode) during a temporary equipment failure. The designer will propose downgraded mode scenarios.

➢ Analysing operating priorities and the risks incurred in degraded operating mode.

- ➢ Define the measures taken to combat scaling, corrosion, and the development of micro-organisms.
- ➢ Propose a systems preventive maintenance plan (planning, traceability, and costing of work).
- ➢ Implementing a Building Management System (BMS).

All metering and performance monitoring systems will be connected to the BMS.

To set up a high-performance BMS, the designer must identify:

- Areas relevant to the operation;
- And/or uses;
- And/or systems;
- And/or the technical structure of the operation.

Using a dashboard, the BMS will enable the following elements to be monitored, managed and controlled:

For all cooling, ventilation, lighting and water management systems:

- Counting and monitoring energy and water consumption by type of energy, functional area and/or service, then for the main uses structuring the project's energy and water consumption:
  - ✓ for energy: heating, cooling, DHW, interior lighting, exterior lighting, car park lighting, electromechanical equipment (lifts).
  - ✓ for water: DHW, raw cold water, softened water, water for osmosis, laundry, kitchen, watering, recovered laundry water, recovered rainwater, recovered osmosis water.
- Detecting faults and leaks.
- Archiving of values for historical, statistical and analytical purposes.
- Monitoring the operating status of installations.
- Management/optimisation systems for energy subscription contracts.

Specifically for cooling systems:

- Comfort level monitoring by zone.
- Control and management of intermittent cooling.
- Control by zones (functional, spatial or process) and optimisation of operating times according to occupancy.
- Refrigeration production control.
- Controlling the recovery of unavoidable energy.

- Control of electrical power calls.
- Sectorised control of zones with different occupancy levels and management of setpoint temperatures adapted to each zone.
- Means for balancing systems.
- System for managing/optimising energy subscription contracts.

Specifically for ventilation systems:

- Control and management of ventilation intermittence.
- Zone control and optimisation of fan operating times according to occupancy.
- Optimisation of extractor operating times.
- Sector-based control of circuits and fans according to occupancy.
- System balancing devices.

Specifically for lighting systems:

- Zone and room control.
- Control and monitoring of lighting by zone, use and premises.

A computerised consumption monitoring tool, connected to the BMS, will process the metering and temperature data, providing monthly summaries of all consumption by energy, functional area and use, with alerts when thresholds are exceeded.

4.4.3. TARGET 10 - Visual comfort

Ensuring optimum natural lighting while avoiding its disadvantages:

➢ <u>Access to daylight in rooms with prolonged occupancy</u>

The aim of natural lighting is to create pleasant visual comfort for occupants while saving on artificial lighting.

The designer must comply with the following requirements:

- Ensuring 100% of offices, hospital rooms and relaxation areas have access to natural daylight.
- Ensure access to daylight for at least 70% of care areas, and for all other areas as far as possible.

The designer will also have to ensure horizontal views to the outside from 100% of offices, hospital rooms and relaxation areas, and 70% of care staff workstations excluding technical platforms.

➢ <u>Minimum natural lighting levels in occupied areas</u>

At this target performance level, the following values must be achieved:

- 1-bed rooms: average DF (Daylight factor) ≥ 1.2% in the front zone (80% of the zone within 2m of the façade), for 80% (by surface area) of all the rooms.
- 2-bed and split rooms: average DF ≥ 1.2% in 80% of the front area **and** DF ≥ 0.5% for 80% of the area between 2m and 4m from the façade in 80% (by surface area) of all the rooms concerned.

Avoiding direct or indirect glare: all bedrooms must be equipped with anti-glare devices to protect them from the sun to limit direct or indirect glare.

Ensure comfortable artificial lighting:

➢ Avoid glare from artificial lighting (UGR (Unified Glare Rating) ≤19 for all premises) and aim for a balance of luminances in the indoor lighting environment.

In general, for all premises, the risks of glare from artificial lighting will be identified and measures will be taken to install luminaires according to the layout to avoid glare from artificial lighting, in compliance with the recommendations of standard EN 12464-1 [A] or equivalent.

Indirect or direct off-centre lighting with low-glare luminaires (UGR ≤17) will be preferred for patient corridors.

For hospital rooms, a unified glare index (UGR) ≤19 will be respected, except for bathrooms and toilets where it will be such that UGR ≤22.

In addition, light sources must be positioned and chosen in such a way as not to create annoying reflections and to obtain an appropriate colour rendering, such as:

- ✓ For hospital rooms and nursing staff stations: 3300 K ≤Tc ≤ 5300 K and CRI (colour rendering index) ≥ 85.
- ✓ For technical premises: Tc ≥ 4000 K and CRI ≥ 85

All bedrooms will be equipped with a lighting control accessible from the bed.

Devices to control artificial lighting in relation to natural lighting: presence detectors and light detectors for 50% of offices and administrative workstations, reception and visitor waiting areas, corridors.

➢ Optimum lighting levels for the planned activities

The illumination levels to be achieved for care staff (excluding technical platforms) are as follows:

- ✓ Nurse's station: 400 lux.
- ✓ Treatment preparation rooms and treatment rooms: 500 lux in the work area (bench) and/or treatment area.
- ✓ Consultation offices: 300 lux in the office area (work area). Illumination levels in the

examination area must be adapted to the different specialities.

4.4.4. TARGET 11 - Olfactory comfort

General target requirements:

Olfactory comfort can be broadly defined as follows:

- It must prevent the influx of odours that are considered strong or unpleasant.
- It should favour smells that are considered pleasant.

This target is closely linked to target 13 (health-related air quality), as they share a common sub-target: ventilation efficiency.

Particularities linked to the context: the nuisances to be avoided are odours coming from kitchens, waste rooms, dirty linen rooms, the mortuary, sanitary facilities, stale air extractors or odours due to construction elements such as coatings and cleaning products.

It is also important to ensure good daily air renewal, considering climatic hazards (wind, rain, humidity, sunshine), particularly in accommodation, in order to evacuate body odours in particular.

Controlling sources of odours: the following requirements relating to environmental concerns must be met:

- Identify sources of odours both inside (toilets, kitchens, use of gas, preparation of medicines, regular cleaning/disinfection, etc.) and outside (traffic routes, stale air emissions, etc.).
- Position the fresh air inlets so that they are protected from the stale air outlets. The position of air inlets and outlets should take account of prevailing winds.
- Ensure that odours are adequately evacuated from the building and limit their persistence by choosing low-porosity, properly sealed coverings (limit and reduce the number of sealing joints, etc.).
- Locate odour sources in such a way as to limit the transfer of odours to neutral areas.
- Extract and treat odours from kitchens, waste rooms, mortuary, bathrooms, decontamination rooms....
- Ensure that the fresh air supply starts up before the premises are occupied.
- Keep premises with specific pollution (toilets, storerooms, etc.) sufficiently depressurised to prevent odours being transferred.

Ensure effective ventilation: See "Target 13 - Air quality" below.

4.4.5. TARGET 12 - Quality of spaces

General requirements of the target: target 12 concerns the sanitary conditions of the building's interior spaces and equipment, as well as the materials making up the solid surfaces.

Areas hosting specific activities, subject to specific hygiene conditions, are also concerned by the reflection carried out on this target. Two themes are of particular interest to the project owner:

- Limiting nuisance from interior spaces and surfaces.
- Create good specific hygiene conditions in the case of collective and professional facilities. Target 12 takes a more in-depth look at the hygiene conditions in different areas: food reserves, storage areas for toxic products, waste, etc.

It also aims to protect users from the nuisance caused by electromagnetic waves and various forms of pollution, and to isolate them from their sources: transformer rooms, power cables, photocopiers, and printers, etc.

Particularities linked to the context: the designer must identify any sources of electromagnetic fields present on the site and take them into account in his protection strategy.

The quality of the interior walls (type of coverings and quality of installation) must be such that they are easy to clean: no walls with crevices that trap dust, skirting boards without edges, floors that are not very slippery, good resistance to marks from trolleys and certain types of footwear.

Premises for prolonged use (patient rooms and offices in particular) must be kept away from sources of electromagnetic waves (power supply or transformer).

Limiting nuisance due to electromagnetic fields: sources of low-frequency electromagnetic emissions (external and from the project) and radio frequencies (immediate environment) must be identified. In particular, the following points should be taken into account.

- **Outside**: telephony, public lighting, electricity transmission and distribution, transformers.
- **Inside**: electrical installations, lamps, electrical appliances, mobile phones, audio-visual equipment, photocopiers, computer screens.

The effect of electromagnetic fields on health may be thermal (requiring the body to regulate its internal temperature) or non-thermal.

Some studies have blamed electromagnetic fields for sleep disorders, abnormal fatigue, nervousness, headaches, stress, depression, memory loss, concentration problems, etc.

- Patients' offices and bedrooms will be kept as far away as possible from electrical power transformers (HV/LV), which generate an electromagnetic field.
- Internal wiring:
    - Choose equipment that generates as little magnetic field as possible.

- Keep equipment as far away as possible from areas of prolonged occupancy (radios, image transmitters).
- Earth all appliances (to eliminate radiation from metal parts).
- Unplug or switch off electrical appliances when not in use.
- Avoid concentrations of wires or electrical equipment in sensitive areas (bedrooms and living areas in homes, infirmaries, etc.).
- Principle of electrical wiring: cables should only pass through the rooms they serve. For large power cables, a cloverleaf layout may be considered.

The designer is therefore expected to give real thought and justification to the position of premises housing major electrical power equipment, as well as to the routing of ducts and service trunks in relation to sensitive premises such as bedrooms and offices.

Create specific hygiene conditions: the products used on the project may contribute to the development of micro-organisms and therefore, indirectly, to the spread of infectious agents in the establishment.

- Identify sensitive areas with specific hygiene conditions (toilets, maintenance rooms, treatment rooms, etc.). For these areas, choose smooth floors suited to the operating conditions, suggest installing a siphon on the floor and creating a vacuum in the area, and increase the ventilation rate if necessary.
- Maintenance rooms must also be equipped with a water supply and access to the electricity network.
- Food preparation areas: Measures taken to enable the various basic operations leading to the preparation of dishes/food to be carried out in a forward direction. Justified and satisfactory architectural arrangements to promote compliance with ISO 22000 [A], particularly with regard to the HACCP (Hazard Analysis Critical Control Point) method, during the operational phase.

The overall design of the premises must improve ergonomics to make cleaning easier (rounded skirting boards, floor coverings running up the walls, radiators without fins, etc.).

4.4.6. TARGET 14 - Water quality

General requirements of the target: Water can come from different sources and be used for different purposes: water from the drinking water network, rainwater that can be collected and reused (see Target 5), contaminated water that is generally sent to a wastewater treatment plant, etc.

It can be used for hygiene (personal hygiene, laundry), cleaning (floors, car parks, facades, etc.), watering, food (meals/drinks) or specific needs linked to processes (osmosis, sterilisation, etc.).

A distinction is made between water intended for human consumption, which must meet potability criteria, and water intended for other uses.

Several networks can supply a building with water: the drinking water network and a parallel network, which drains reclaimed water (rainwater, osmosis, laundry, etc.) for cleaning and/or watering. The risk associated with diversifying the sources of water is linked to the pathogens likely to contaminate users through ingestion, inhalation or skin contact.

To limit the deterioration in the sanitary quality of the water, action can be taken on the choice of materials (durability and suitability for the quality of the water), the organisation of the networks (avoiding accidental tapping), protection against backflow (non-return valves), temperature maintenance (combating the risk of legionella), anti-scale and anti-corrosion prevention, etc.

Choice of equipment and network organisation: Water quality can be affected by damage to indoor networks. Maintaining and protecting the network means avoiding health risks for building users through possible exposure to pollutants and pathogens through ingestion, inhalation, skin contact and the risk of burns:

The designer will ensure that:

- All water uses within the project are identified and located.
- All organic materials (and water network accessories) used will have a sanitary conformity authorisation (SCA) in accordance with the French decree of 29 May 1997 and its application circulars.
- All materials in contact with water intended for human consumption will comply with regulations and will respect the impurity levels defined therein.
- The choice of pipe materials will be compatible with the quality of the water, its use and their electrochemical potential, and will provide for the installation of drains at high points.
- EA type non-return valves are also required to protect branches in accordance with the water distributor's recommendations.
- When choosing taps, make sure they are easy to clean and maintain.
- The internal network will be organised and protected in Type Networks (RT) in accordance with the CSTB Technical Guide or that of Rwanda if it exists.
- Identifying networks and protecting connections against backflow are particularly important, especially when it comes to reusing rainwater (non-drinking water). Appropriate precautions must be taken, including identification of networks, protection against "accidental" use by third parties, and appropriate treatment.
- A colour code should differentiate the drinking water network from the non-potable water network, and the direction of flow should be indicated.

Regulating indoor temperature: Legionella growth thrives in water temperatures ranging from 25°C to 45°C. Hence, it's crucial to monitor and control the temperature of both cold and domestic hot water systems:

- The DHW (domestic hot water) temperature in the distribution networks must be at least 55°C at all points of the distribution loops, except for antennas serving at-risk drawing points with a volume of less than 3 litres.
- The temperature of the cold water must not exceed 25°C.
- To avoid any risk of burns, the temperature will be limited to 42°C at taps in contact with patients, and 38°C at taps in contact with sensitive patients.
- The DHW and DCW (domestic cold water) networks must be insulated separately. Particular attention should be paid to the type of insulation: self-balancing system, speed > 0.20 m/s guaranteed in all loop returns.
- Automatic monitoring and management system for DHW networks to control flow and return temperatures and weak points, with data repatriation via the BMS-CTM (Building Management System - Centralized Technical Management) and data processing protocol.

Treatment control: to prevent corrosion and limescale damage, the following elements are required:

- The choice of treatment should take into account the compatibility between the proposed treatment and the materials in contact with the water.
- The installation of control tubes on the DHW and DCW outlets, and on the DHW return, with the installation of flammable sampling valves downstream of each of these tubes and the compliance of the installation diagram with the terms of the CSTB technical guide or its equivalent in Rwanda will be verified.
- The choice of treatment products will depend on the existence of a technical opinion or equivalent approval recognised in Rwanda.

Control of the conditions for acceptance, commissioning and operation of the installation:

- Implement a sanitary acceptance procedure for the installation, including cleaning and disinfection before it is put into operation, and check the sanitary quality (bacteriological analyses) of the water. The client imposes an additional criterion for the acceptance of cold-water systems: absence of *Pseudomonas aeruginosa*.
- Set up a separate site network (with meter).
- To ensure water quality, for example during possible future rehabilitation operations, anticipate the sectioning of networks and the possibility of eliminating backwaters.