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GGGI TECHNICAL REPORT NO. 3

Rapid Building Performance Assessment of Ministry of Foreign Affairs and International Cooperation, Kigali, Rwanda

APRIL 2021

PART OF GGGI'S TECHNICAL REPORTS SERIES

1. Rapid Building Performance Assessment of Nyarugenge Pension Plaza Kigali, Rwanda 2020
2. Rapid Building Performance Assessment of Administrative Office Complex, Kigali, Rwanda 2021
3. Rapid Building Performance Assessment of Ministry of Foreign Affairs and International Cooperation, Kigali, Rwanda 2021

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ACRONYMS

ACP	Aluminum Composite Panel
AC	Air Conditioner
AOC	Administrative Office Complex
CFL	Compact Fluorescent Lamp
DG	Diesel Generator
EUCL	Energy Utility Corporation Limited
EPI	Energy Performance Index
EEI	Energy Efficiency Index
EUI	Energy Use Intensity
EER	Energy Efficiency Ratio
GBMCS	Green Building Minimum Compliance System
GGGI	Global Green Growth Institute
GWP	Global Warming Potential
kW	Kilo Watt
kVA	Kilo-volt-ampere
kWh	Kilo-watt hour
LED	Light Emitting Diode
LPM	Litres Per Minute
LPF	Litres Per Flush
MINAFFET	Ministry of Foreign Affairs and International Cooperation
MINICOM	Ministry of Trade and Industry
NPP	Nyarugenge Pension Plaza
ODS	Ozone Depleting Substance
RCC	Reinforced Cement Concrete
RURA	Rwanda Utilities Regulatory Authority
RSB	Rwanda Standards Board
RWF	Rwandan Franc
SHGC	Solar Heat Gain Coefficient
SF	Solar Factor
SRI	Solar Reflective Index
Sq. m.	Square Meter
VRF	Variable Refrigerant Flow
VLT	Visual Light Transmittance
VVVF	Variable Voltage and Variable Frequency
W	Watt
WASAC	Water and Sanitation Corporation
WEI	Water Efficiency Index
WWR	Window to Wall Ratio

EXECUTIVE SUMMARY

In addition to the unprecedented growth in the global building sector, nearly two-thirds of the building area that exists today will still exist in 2050. Therefore, any transition to low carbon/ carbon neutral built environment must address both new construction and existing buildings. In order to achieve the target set by the Paris Agreement – to limit the rise in global average temperature to below the 2 degrees Celsius threshold – a significant increase in the rate of energy efficiency renovations in existing buildings and the generation and procurement of renewable energy (energy upgrades) is required.[1]

Energy use, water consumption and waste generation are the main components of resource use in public building operation. With the advancement of resource efficiency practices and technologies to reduce energy consumption, water consumption and better waste management, it is possible to cut down the operational costs significantly in the buildings without reducing the comfort and productivity of the building occupants and at the same time reduce the associated Green House Gas (GHG) emissions. This can normally be achieved by the building owners and managers through the initiation of a systematic assessment/ audit of their building, followed by the implementation of cost-effective resource efficiency measures.[2]

The purpose of this report on 'Rapid Building Performance Assessment of Ministry of Foreign Affairs and International Cooperation (MINAFFET), Kigali, Rwanda' is to provide the Government of Rwanda as the building owner, an opportunity to understand how their building is performing on key resource efficiency parameters (energy, water and waste) by benchmarking against similar facilities within comparable context, and suggest a list of recommendations for improvement and the associated climate actions and operational cost savings with an aim to convert the existing building into a green building.

Greening existing public buildings in Rwanda is a project initiated by the Global Green Growth Institute (GGGI) in 2020 with support from partners including the Ministry of Infrastructure (MININFRA), Rwanda Housing Authority (RHA), and Ministry of Environment (MoE) - to improve the performance of existing public building stock in Rwanda based on green building parameters. The project is a scale-up of Rwanda Green Building Minimum Compliance System, which is part of Rwanda Building Code 2019 and aims to provide pathways to green existing public buildings in Rwanda.

Summary of MINAFFET Building Performance

The Energy Performance Index (EPI) of MINAFFET based on monthly utility electricity consumption stands at approx. 42.8 kWh/m^2/year and the Water Efficiency Index (WEI) based on monthly utility water consumption stands at approx. 0.81 m^3/m^2/year. For comparison purposes, the benchmark EPI for office buildings in a composite climate zone in India with less than 50% air conditioned built up area would receive 1 star label if the EPI falls between 80-70 kWh/m^2/year and 5 star label (highest recognition) if the EPI is below 40 kWh/m^2/year. Similarly, in Singapore, the median value of WEI for Office buildings with water-cooled cooling tower (a type of air-conditioning system)

1 Extracted from https://architecture2030.org/existing-buildings-operation/
2 Modified and extracted from 2009 USAID ECO-III Project, Energy Assessment Guide for Commercial Buildings

is 1.1 m^3/m^2/year. Although, the comparative benchmarking from a high level suggests that the building has low energy and water consumption, there are significant opportunities for MINAFFET to reduce its energy and water consumption -thereby reducing the operational expenditure and the associated GHG emissions.

Opportunities for Improvement

The resource efficiency of MINAFFET under three fronts namely – energy, water and waste can be substantially improved by implementing the recommendations which would also help in reducing the associated GHG emissions from the building. The recommendations are classified under short-term and medium to long-term depending on when the cost reductions can be realized, payback period and the extent of interference to the day-to-day operations of the building. Below are some of the short-term recommendations (see the overall recommendations on page 27):

Energy Conservation Measures

1. Replace all CFL, fluorescent light fixtures inside the building with LED light fixtures.
2. Replace all non-LED outdoor lights with LED projector lights
3. Install occupancy sensors in washrooms, conference/meeting rooms and closed cabin spaces.
4. Encourage the occupants to make use of the openable windows in each office space to facilitate natural ventilation and take advantage of the ambient weather conditions, reducing the need for air conditioning.
5. Install smart virtual sub-metering devices to measure electricity consumption at various end uses, such as lighting, air-conditioning system, wastewater treatment, diesel generators and elevators. The quick break-down of electricity consumption provides an opportunity to have targeted energy conservation measures.
6. Apply high Solar Reflective Index (SRI) paint for the exposed roof area of metal and concrete roof of the building. The suggested minimum initial SRI value is 78. The high reflective paint will reduce the direct heat gain and minimize heat island effect.

Water Conservation Measures

1. Install a rainwater collection tank and reuse the collected rainwater for landscape irrigation, as well as cleaning and flushing applications.
2. Replace inefficient plumbing fixtures, such as taps and single flush water closets, with water efficient plumbing fixtures to meet or exceed the baseline rate mentioned in the Rwanda Green Building Minimum Compliance System 2019.
3. Install a wastewater treatment plant and explore the idea of installing a common wastewater treatment plan for all the adjoining government buildings

Waste Management Measures

1. Encourage occupants to segregate waste at source, by providing easily accessible colour coded bins in every office space, and explore recycling opportunities to avoid the recyclable waste sent to landfill.
2. Designate a space to store the segregated waste.

An attempt has also been made to showcase the savings potential, cost of implementation and simple payback period for some of the recommendations.

INTRODUCTION

Background

The Ministry of Foreign Affairs and International Cooperation (MINAFFET) requested that the Global Green Growth Institute (GGGI) Rwanda program conducts a rapid building performance assessment of their premises. The building was constructed in 2008 and hosts the MINAFFET and the Ministry of Trade and Industry (MINICOM). The building has a gross floor area of 8,580 sq.m [3] with Ground + 5 storeys.

Objective of the Assessment

The objective of the rapid building assessment is to take stock of the performance of MINAFFET building focusing on energy efficiency, water efficiency and waste management practices and the associated costs. This has been carried out by conducting a walkthrough audit, followed by recommendations to promote efficient energy, water and waste management practices in existing government-owned public buildings with an aim to convert them into green buildings.

Scope of the Assessment

The scope of the rapid building assessment is limited to evaluating the resource efficiency of the building on three parameters, namely energy, water and waste. The assessment does not focus on the structural integrity, emergency preparedness, or indoor environmental quality aspects of the building.

Outcome of the Assessment

Improved energy, water, and waste management practices in Rwanda's existing government-owned public buildings.

Linkages to Existing National Green Building Initiatives

GGGI worked with Rwanda Housing Authority (RHA) and stakeholders to develop the Rwanda Green Building Minimum Compliance System (GBMCS), which is adopted as an Annex-3 of the Rwanda Building Code 2019. The green building minimum compliance system is applicable for new large-scale public buildings and major refurbishments of Category 4 and 5. It stresses on holistic building performance with focus on energy efficiency, water efficiency, environment protection, indoor environmental quality and green innovation.

Although Rwanda has relatively less large-scale existing building stock, there is an opportunity to improve building performance, starting with public buildings and with government leading by example, so that the future building stock that will be built to meet Rwanda's development and urbanization target can draw valuable lessons.

Linkages to Global Program on Building Energy Efficiency led by GGGI HQ

GGGI HQ has developed a global program to mainstream energy efficiency standards of

3 The gross floor area of the building is an estimate and is arrived from the Google Earth image of the building.

Photo 1: Outdoor shaded parking spaces on grass paver blocks

appliances and materials in new and existing buildings, that would result in significant reduction in energy consumption of buildings. Rwanda is part of the global program and the assessment of select existing public buildings such as MINAFFET will feed into the global output with possibility of cross-country learning and information exchange through the program.

About the MINAFFET building

The building has a gross floor area of 8,850 sq. m with Ground + 5 storeys. The MINICOM[4] is on first and second floor and MINAFFET and the Office of the Government Spokesperson (OGS) occupy the third to fifth floor. The building is oriented along the North-South axis with longer sides of the building facing the east and west direction. The building has no basement floors but has ancillary buildings that accommodates facilities, such as electricity transformer and distribution room, water tank, pump and firefighting room, and a Diesel Generator room. The building has a surface parking facility with parking spaces all around the building and constructed with paver blocks that helps in increasing the permeability by percolating the rainwater and reducing the stormwater runoff compared to a paved surface. Also, the building footprint is approx. 20% of the plot area and rest of the plot area is allocated for landscaping and parking. The building is operational for 5 days a week from 7 AM to 7 PM and on weekends approx. 20% of the staff report to work as needed. An approx. 217 people work from the building which include 182 staff from MINAFFET, OGS and MINICOM and 35 support staff that includes security, cleaners, maintenance personnel etc.

Facility Management of MINAFFET

The general maintenance of the building is done by Beijing Construction Engineering Group (BCEG) Rwanda Ltd. and the contract is managed by the building owner, which is RHA. The maintenance for the air-conditioning systems in done by a private company by the name of Omega and the contract is managed by MINAFFET. The building does not have a full-time estate manager and the maintenance for the building is managed by the logistics officer.

Types of Building Performance Assessments

There are three levels of building performance assessments. Each level is designed to meet specific needs of the building owner. For each level of assessment, the level of effort and expertise required differs. Each of the three types are briefly described below:

4 It was informed during the walkthrough audit that MINICOM has plans to vacate the building soon and the whole building will be eventually occupied by MINAFFET and OGS.

- Level 1 Assessment: Preliminary performance assessment; simple assessment based on available documents and information, physical inspection/walkthrough audit, and staff interviews to create a baseline and identify obvious energy efficiency, water efficiency and waste management measures which are easy to implement.
- Level 2 Assessment: Comprehensive performance assessment; thorough review of data, existing and newly gathered, to identify all energy saving, water saving and waste management measures and identify high potential measures for further investigation
- Level 3 Assessment: Detailed analysis of capital-intensive measures; also known as investment grade audit used to give a detailed assessment of costs and benefits derived from energy conservation, water conservation and waste management measures

Level 1 Building Performance Assessment of MINAFFET

GGGI team comprising of the Sr. Officer – Green Buildings and District Technical Assistant conducted a Level 1 Assessment of the building which includes preliminary data gathering and walkthrough audit conducted on 28 October 2020. The objectives of the Level 1 assessment include:

- To determine the baseline of energy and water use, and waste generation
- To identify no/low cost measures for energy, water and waste reduction
- List down potential projects for further consideration and implementation

The specific activities conducted by GGGI team under the Level 1 assessment include:

- Development of Building Audit Walkthrough checklist (refer Annex 1)
- Determine building's total area and primary use
- Collect data based on a minimum of one year of utility bills (refer Annex 2 and 3)
- Brief walk-through survey of the facility to check the following:
    - Construction
    - Equipment
    - Operations and maintenance
- Meeting with building owner/facility manager, maintenance person, staff and occupants
- Develop energy, water use, waste generation and cost indices
- Identify and list low-cost/no-cost measures
- Identify potential capital projects for further consideration and possible implementation

AUDIT OBSERVATIONS

Architectural Observations

Building orientation

MINAFFET is oriented along the North-South axis with longer sides of the building facing the east and west direction. Kigali is approx. 2 degrees South of Equator and the ideal building orientation should be the length of the building facing the North and South and the width facing the East and West to minimize direct sun exposure, thereby reducing heat gain into the building. Also, the plot had favorable conditions to orient the building most appropriately to reduce the direct heat gain, but it was a missed opportunity. Hence, interventions related to building orientation are not feasible.

Window to Wall Ratio (WWR)

WWR is defined as the ratio of the total area of the window or other glazing area (including mullions and frames) divided by the gross exterior wall area. The WWR is calculated with the following equation:

$$\text{WWR (\%)} = \sum \text{Glazing area (m}^2\text{)} / \sum \text{Gross external wall area (m}^2\text{)}$$

Finding the correct balance between the transparent (glass) and the opaque surface in the external façades helps to maximize daylight while minimizing unwanted heat transfer, resulting in reduced energy consumption. Windows generally transmit heat into the building at a higher rate than walls do. In fact, they are usually the

Photo 2: MINAFFET on Google Maps indicating the building orientation.

Photo 3: Part view of MINAFFET showing East façade with optimum WWR with recessed windows providing some form of shading.

Photo 4: South façade of MINAFFET with large windows

weakest link in the building envelope as glass has much lower resistance to heat flow than other building materials. Heat flows out through a glazed window more than 10 times faster than it does through a well-insulated wall.[5]

From visual inspection, it was observed that the east and west facades of the building have optimum Window to Wall Ratio (WWR) with recessed windows and the North and South have large floor to ceiling length window surfaces to allow uninterrupted daylight into the space but without the heat. There is no baseline for optimum WWR as it also depends on the orientation of the façade but generally a WWR of 20-40% may be considered optimum.

Shading Devices

Structural controls like 'external shading devices' are essential environmental controls that either obviate or greatly reduce the need for mechanical cooling to maintain thermal comfort inside buildings, by controlling heat gain through openings. Along with glazing type and size of the window, shading devices are equally important in limiting heat gain from outside through radiation. External and internal shading devices can thus be used as an essential solution for achieving energy efficiency[6].

The type of shading devices is also linked to the orientation of the building. In MINAFFET,

5 IFC EDGE User Guide
6 Extracted from https://nzeb.in/knowledge-centre/passive-design/shading/

Photo 5: Recessed windows on the west façade of MINAFFET

the predominant shading devices are recessed windows (almost 0.3m deep) which provide both horizontal and vertical shading. However, since the longer sides of the building face the east and west direction, it becomes harder to effectively shade the windows thereby leading to tremendous heat gain especially from the western façade. Furthermore, it was observed that blinds were installed internally to cut down the excessive glare, which further indicates that the excessive daylighting and unwanted heat gain is a concern among the occupants.

Building Envelope

The MINAFFET building is a Reinforced Cement Concrete (RCC) structure with cement block as the main walling material and finished with a combination of stone cladding, recessed fenestration on the east and west façade, structural glazing on the north and south facades and sky lighting in the atrium.

The fenestration is in clear glass with a combination of fixed and sliding windows. The building has a combination of flat RCC roof with and metal roof. The total thickness of the wall assembly and roof assembly are unknown, as the information was not available. Similarly, the U-value, Solar Heat Gain Coefficient (SHGC) or Solar Factor (SF) and the Visual Light Transmittance (VLT) of the windows and sky lighting is unknown due to unavailability of technical specifications.

Photo 6: Sky light on the rooftop to bring daylight in the atrium

Photo 7: Skylight bringing in abundant natural light into the atrium.

Trends in Electricity Consumption

Three yearly electricity consumption reports (from 2017/18 to 2019/20) were provided by the building management team to analyze the trends in electricity consumption. The trends in annual electricity consumption in kWh (kilowatt hour) was plotted in the graph below. From the chart, it is evident that the electricity consumption is increasing with a gradual increase from 2017/18 to 2018/19 and a steep increase in 2019/20. The associated electricity costs have also increased accordingly.

It should also be noted that, in January 2020, the Rwanda Utilities Regulatory Authority (RURA) increased electricity tariffs for non-residential customers with a consumption greater than 100 kWh per month from 222 Rwf /kWh approx. to 255 Rwf/KWh which is approx. 15% increase. Although, the monthly electricity bills for MINAFFET could not be verified, we can assume that MINAFFET's expenditure for electricity consumption could have increased from February 2020.

Benchmarking the Electricity Consumption

The Energy Performance Index (EPI) - also known as Energy Efficiency Index (EEI) or Energy Use Intensity (EUI) - is a key metric used for benchmarking energy usage in commercial buildings. EPI is the total energy consumed in

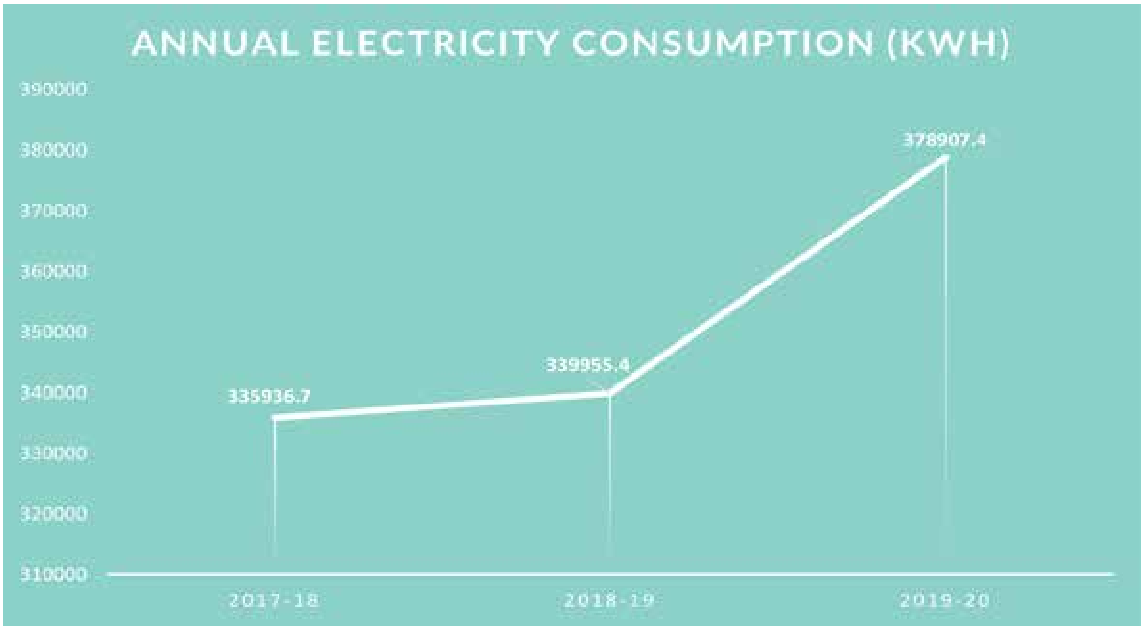

Figure 1: MINAFFET trends in electricity consumption

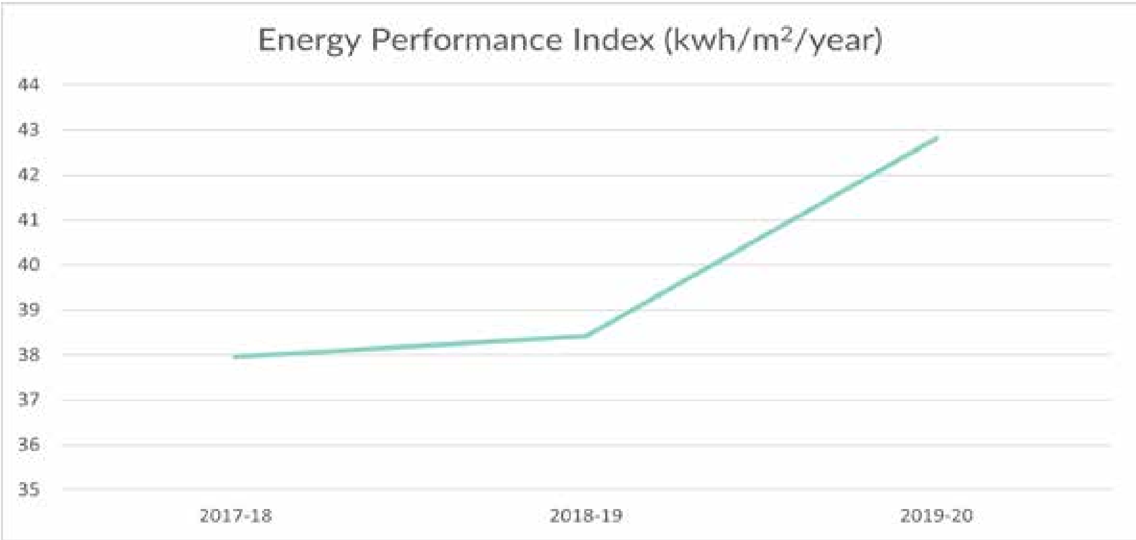

Figure 2: MINAFFET trends in EPI

a building over a year divided by total built up area expressed as kWh/m^2/year (read as kilowatt hour per square meter per year) is considered as the simplest and most relevant indicator for qualifying a building as energy efficient or not. Based on the past three yearly cumulative utility electricity consumption and the built-up area the EPI for MINAFFET was computed. The EPI for MINAFFET based on monthly utility electricity consumption from 2019 to 2020 stands at approx. 43 kWh/m^2/year.

As a general practice, the EPI value should also include the annual electricity consumption from Diesel Generating (DG) sets in kWh, but since the information was not available, the EPI value including this crucial data could not be computed. Once this information is included, the EPI value for MINAFFET could be higher. As a good practice, one would need to compare the current EPI value with the future EPI values to check the performance of the building.

For comparison purposes, the benchmark EPI for office buildings in a composite climate zone in India with less than 50% air-conditioned built-up area will receive 1-star label if the EPI falls between 80-70 kWh/m^2/year and 5-star label (highest recognition) if the EPI is below 40 kWh/m^2/year.

The present EPI value for MINAFFET at 43 kWh/m^2/year (excluding electricity consumption from DG sets) shows that the building has significant potential in reducing energy consumption thereby further reducing EPI by promoting energy conservation measures.

While the current EPI value for MINAFFET at 43 kWh/m^2/year seems to be comparable with a 5-star labelled building in India, if we compare MINAFFET with the EPI value of Administrative Office Complex, their neighboring building, (36 kWh/m^2/year) and Nyarugenge Pension Plaza (80 kWh/m^2/year), it is clear that MINAFFET is doing well compared to NPP but can compete with AOC by further reducing the electricity consumption and the associated electricity costs.

Annual Green House Gas (GHG) Emissions

Based on the 2019/20 electricity consumption data, the annual indirect GHG emissions of MINAFFET from grid supplied electricity is 113.6 tCO_2e[7]. The direct GHG emissions from diesel generator sets could not be calculated as the data was not accessible.

7 Excludes Scope 1 emissions from diesel generator sets. Rwanda grid-emission factor considered as 0.3 $kgCO_2$/kWh

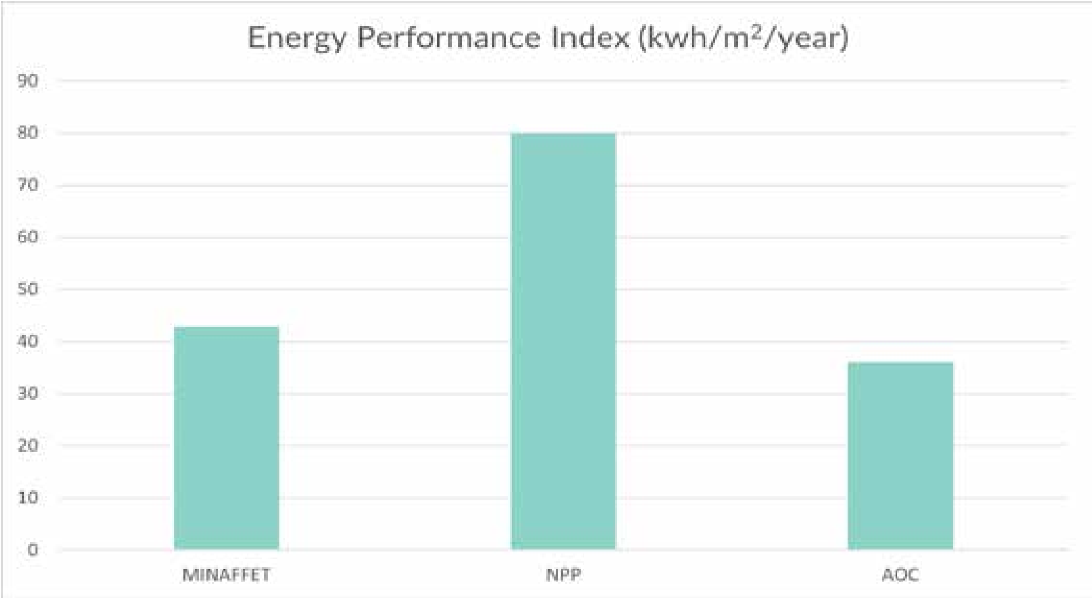

Figure 3: EPI of MINAFFET compared to NPP and AOC buildings

Energy Consumption and management

Lighting Systems

Lighting Systems could be categorized into indoor and outdoor lighting systems. MINAFFET has predominantly five types of indoor lights and three types of outdoor light.

Indoor Lighting

The building has a combination of the following light fixtures:

1. CFL bulbs and 40W fluorescent tube lights in corridor spaces,
2. 40W fluorescent tube lights in office spaces,
3. Panel lights and LED fixtures in the conference room and
4. Warm white CFL in dining hall
5. CFL fixtures in restrooms and kitchen

Majority of the lights are non-LED and could be upgraded to LED, resulting in significant energy savings.

The Lighting Power Density (LPD) is found to be very high in some of the offices spaces. For example, in an office space of 30 sqm in area, there were 12 numbers of 40W fluorescent tube lights with the LPD value as 15W/sqm. In addition the problem is amplified by not using the natural light from the windows and covering the windows with curtains as the windows are not optimally sized resulting in significant glare in the space. By replacing the 12 numbers of tube lights with few numbers of LED lights the LPD could be lowered resulting in significant energy savings.

Photo 8: CFL light fixture in corridors.

Photo 9: 40W fluorescent tube fixture in office spaces

Photo 10: Warm white CFL bulbs in dining hall

Outdoor lighting

The building is equipped with Solar PV LED streetlight, LED projector light and designer fluorescent garden lighting. There is a potential to upgrade all non-LED outdoor lighting to LED lighting to achieve further reduction in energy savings.

Photo 11: Solar PV LED Streetlight

Photo 12: LED Projector Light

Photo 13: Designer fluorescent garden lighting

Air-conditioning System and Refrigerants

MINAFFET has a decentralized air-conditioning system with several dedicated outdoor units placed on the building terrace and façade. The power input of these ACs range from 970W to 2110W. The ACs observed were of O'General, LG and GREE make. The ACs are used only on a need basis and the control remains with the occupants, making it difficult to control if someone forgets to switch off the air conditioner.

Photo 14: Specification of one of the AC outdoor unit

In the conference rooms, tower AC units were observed but the efficiency of the system could not be verified.

Photo 16: Tower AC unit in conference room

Based on the specifications mentioned on the AC outdoor units, it was understood that R22 is the type of refrigerant used in the AC systems. R22 is an Ozone Depleting Substance (ODS) and a banned substance that is being phased out under the Montreal Protocol as it damages the ozone layer. It is suggested to opt for a centralized VRV based air-conditioning system for the whole building with zero ODS and low Global Warming Potential (GWP) refrigerant.

Elevators

MINAFFET has total of three elevators. During the walkthrough audit, it was not clear whether the elevators are equipped with Variable Voltage Variable Frequency (VVVF) drives which could help in energy savings.

Photo 15: AC Outdoor units on the building terrace

Electricity Back-up System

As of December 2019, a new Diesel Generator (DG) power back-up systems of rated power 600 kVA have been installed at MINAFFET. The DG room is also equipped with a dedicated 1000-liter diesel tank and the maintenance team maintains a dedicated logbook to record the monthly fuel consumption of these generators. The record could not be verified by the audit team.

Photo 17: Specifications of the diesel generator

Sub-metering for Electricity Consumption

An electricity meter for the whole building was observed during the audit. However, no sub-meters were observed to measure electricity consumption/generation at various end uses - such as lighting, air-conditioning system, wastewater treatment, diesel generators, elevators and other major energy consuming equipment in the building.

Photo 19: EUCL Electricity Meter

The wooden false celling in the transformer room is in a dilapidated condition due to water seepage from the roof and the problem needs to be immediately fixed to avoid any kind of damage to the transformer room and electrical failure/ electrical safety issues.

Trends in Water Consumption

Similar to electricity, three yearly water consumption (from 2017/18 to 2019/20) were provided by the building management team to analyze the trends in water consumption. The trends in annual water consumption in cu.m (cubic meter) was plotted in the graph below. From the chart, it is evident that the water consumption

Photo 18: 600 kVA Diesel Generator

Photo 20: Dilapidated roof in the transformer room

is decreasing on a yearly basis. However, the reasons for the decrease are not quite clear to the audit team. WASAC charges a flat rate of 895 RWF/cu.m of water consumption.

Benchmarking the Water Consumption

The Water Efficiency Index (WEI) serves as the performance indicator for water efficiency and refers to the amount of water used per business activity indicator. Office building WEI reflects the amount of water used by an office building for its operations for each gross floor area annually.[8]

Office building WEI = Annual Water Consumption (cu.m/year)/ Gross Floor Area (m^2)

Based on the 2019/20 annual water consumption data and the built-up area the WEI for MINAFFET was computed. The WEI for MINAFFET stands at approx. 0.81 m^3/m^2/year.

In Singapore, the median value of WEI for office buildings with water-cooled cooling tower (a type of air-conditioning system) is 1.1 m^3/m^2/year. The median value of WEI for office buildings without water-cooled cooling tower could not be located.

While the present WEI value for MINAFFET at 0.81 m^3/m^2/year seems to be low compared to Singapore benchmark, if we compare MINAFFET with the WEI value of Administrative Office Complex, the neighboring building, (0.47 m^3/m^2/year) and Nyarugenge Pension Plaza (0.66 m^3/m^2/year), it is clear that MINAFFET can further reduce the water consumption thereby reducing the associated costs.

Water consumption and management

Rainwater Harvesting

No rainwater harvesting/collection system was observed during the site visit. Based on a conservative estimate, MINAFFET has an available rooftop area of 1600 sq. m. (office block and dining hall block combined) and considering the annual precipitation in Kigali of 1000mm and the runoff coefficient of the metal/concrete roof of 0.95, the annual rainwater harvesting potential from the rooftop of MINAFFET is 1520 cubic meters.

MINAFFET can lead by example by installing a rainwater collection tank to capture the runoff from the roof and reuse the collected water for landscape irrigation, cleaning, and flushing applications. As the MINAFFET building occupies approximately 20% of the site area and the rest of the site is either used for parking and landscaping, a large amount of water is required to maintain the landscaping and it would be good to see the collected rainwater be used rather than WASAC potable water. A reduction in rainwater runoff from the MINAFFET premises would also result in reduced inflows into the surrounding wetlands, especially during the wet season, and could contribute to the reduction in flooding.

8 Extracted from https://www.pub.gov.sg/savewater/atwork/WaterEfficiencyBenchmarks#:~:text=For%20the%20office%20building%20sector,each%20gross%20floor%20area%20annually.

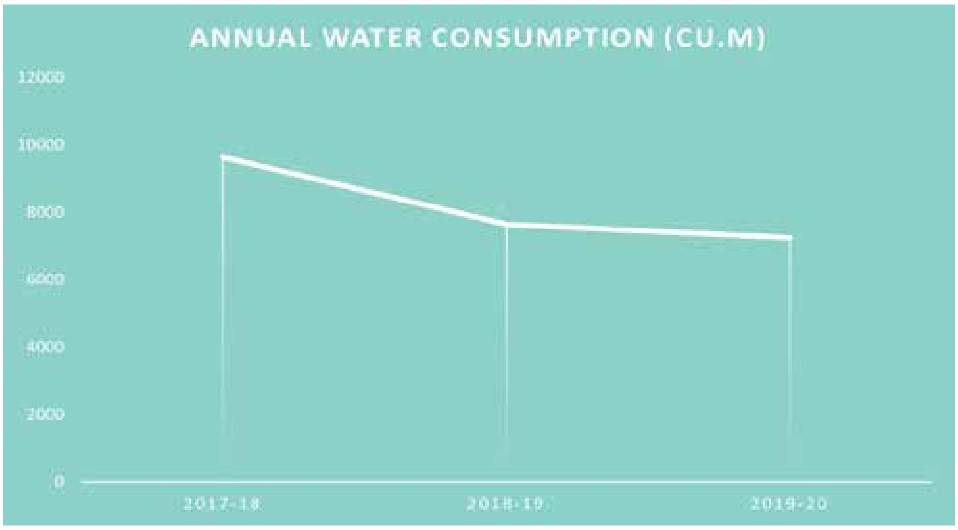

Figure 4: MINAFFET trends in water consumption

Photo 21: Stormwater drain on the premises that conveys the rainwater to the nearby wetland. The common drain passes through the AOC building.

Photo 22: Rainwater down take pipes on the building but not connected to rainwater collection system.

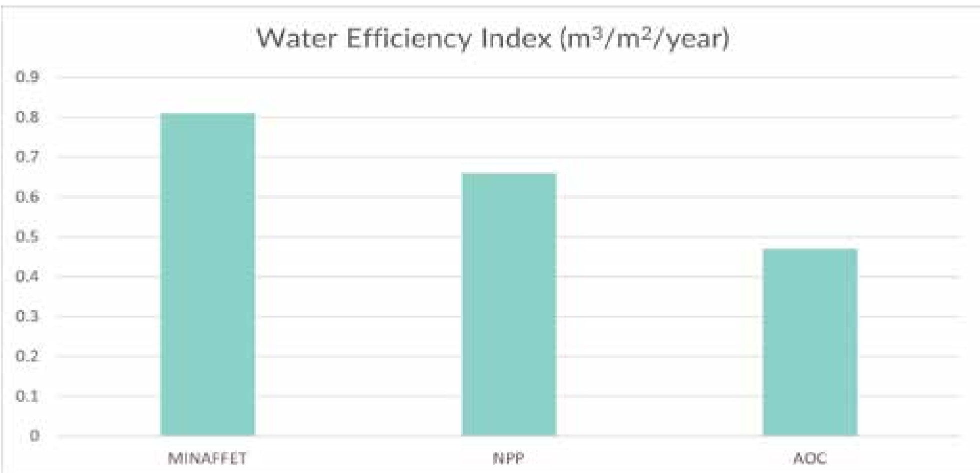

Figure 5: WEI of MINAFFET compared to NPP and AOC buildings

Plumbing Fixtures

1. Taps: The efficiency of the restroom washbasin taps could not be measured, but from visual observation, it was noticed that the taps are not equipped with aerators to reduce the flow of water leading to potential waste of potable water. According to the Rwanda Green Building Minimum Compliance System 2019, the baseline flow rate range for tap shall be 4 to 6 Litres Per Minute (LPM) at a reporting pressure of 3 bar or 43.5 psi.
2. Water Closets: Dual flush tank water closets were observed in the washrooms. From a water efficiency aspect, dual flush tanks are preferred with a baseline flush rate range of 4 to 4.5 Litres Per Flush (LPF) for full flush and 2.5 to 3 LPF for half-flush according to the Rwanda Green Building Minimum Compliance System 2019. The water efficiency of the water closets could not be verified because of lack of technical specifications. It would be good to have signages in the washrooms to sensitize users to use part flush/full flush, depending on the requirement, and get the benefit of having dual flush tanks.

Photo 23: Tap in Men's restroom

Photo 24: Dual flush water closet in Men's restroom

3. Urinals: The urinals in men's restroom are touch-free. However, their efficiency could not be verified due to lack of technical specifications. According to the Rwanda Green Building Minimum Compliance System 2019 the baseline flow rate range for urinal shall be 1 to 1.5 LPF.

Photo 25: Urinal in Men's restroom

Wastewater Treatment Plant

There is no wastewater treatment plant on the MINAFFET premises. The building is connected to a septic tank that is emptied every two months. MINAFFET can set an example by installing a wastewater treatment plant on the premises. Perhaps, to achieve economies of scale, a common wastewater treatment plant idea can be explored as there are several government buildings adjoining each other which would reduce both the CAPEX and OPEX of treatment plants.

Sub-metering for water consumption

MINAFFET is connected by piped water supply from Water and Sanitation Corporation (WASAC) and the consumption is measured through a water meter as below. However, no other water meters were observed to measure the water consumption for flushing and landscape irrigation.

Photo 26: Potable water meter

During the audit, it was mentioned that the building was not equipped with an overhead tank and the WASAC water was stored at the ground level in the water pump room. The building uses a pressurized pumping system which also increases the electricity consumption. A water tank on the rooftop may be helpful in reducing some of the electricity consumption.

Photo 27: Water pumping system in the pump room

Waste Management

Waste segregation and management

During the site visit it was observed that the collected waste can be predominantly classified into paper, cardboard, plastic, metal, and landscape trimming waste that was unsegregated and temporarily stored in bins located at the south-west corner of the premises. As per the MINAFFET, organic waste is also generated from the in-house kitchen and dining hall. The unsegregated waste is collected by a waste collection company and is most likely sent to the landfill for disposal.

MINAFFET can be an example and segregate the waste at source by using different colored bins to store paper, cardboard, plastic, and organic waste, and designate a dedicated space to store the segregated waste, measure the annual amount of waste generated from the building, and tie up with recyclers and waste management start-up companies to ensure that the segregated waste (where possible) is recycled and does not end up in landfills. The organic waste (food and landscape waste) could be composted and converted into manure for landscaping.

Photo 28 Water storage tank on ground level

Photo 29: Unsegregated waste stored in bins.

Photo 30: Landscape waste.

RECOMMENDATIONS

Short-term Recommendations

Short-term recommendations are those that can immediately be taken up by the MINAFFET management to achieve quick results. Most of the recommendations are less capital-intensive, include no/minimal costs, and have a short payback period.

Energy Conservation Measures

1. Replace all CFL, fluorescent light fixtures inside the building with LED light fixtures.
2. Replace all non-LED outdoor lights with LED projector lights.
3. Install occupancy sensors in washrooms, conference/meeting rooms and closed cabin spaces.
4. Install daylight sensors for spaces that have access to daylight - especially workspaces close to the windows.
5. Encourage the occupants to make use of the openable windows in each office space to facilitate natural ventilation and take advantage of the ambient weather conditions to reduce the need for air conditioning.
6. Motivate occupants to turn off lights and air conditioners when they leave the office space. This can be encouraged through green awareness and energy conservation campaigns.
7. Ensure that the door and the windows are closed when the air conditioning is turned on.
8. Set the air conditioning temperature setpoint between 24 – 26 degrees C (as prescribed by the Rwanda Building Code 2019) so that people need not open the windows when the space becomes excessively cold.
9. Install smart virtual sub-metering devices to measure electricity consumption at various end uses - such as lighting, air-conditioning system, wastewater treatment, diesel generators and elevators. The quick break-down of electricity consumption provides an opportunity to have targeted energy conservation measures.
10. Apply high Solar Reflective Index (SRI) paint for the exposed roof area of metal and concrete roof of the building. The suggested minimum initial SRI value is 78. The high reflective paint will reduce the direct heat gain and minimize heat island effect.

Water Conservation Measures

1. Install a 100 cu.m. rainwater collection tank and reuse the collected rainwater for landscape irrigation, cleaning, and flushing applications.
2. Replace inefficient plumbing fixtures such as taps and single flush water closets with water efficient plumbing fixtures to meet or exceed the baseline rate mentioned in the Rwanda Green Building Minimum Compliance System 2019.
3. Install signages in the restrooms to sensitize users on the usage of dual flush tanks.
4. Install a wastewater treatment plant and explore the idea of installing a common wastewater treatment plan for all the adjoining government buildings.

Waste Management Measures

1. Encourage occupants to segregate waste at source by providing easily accessible colour coded bins in every office space and explore recycling opportunities to avoid the recyclable waste sent to landfill.
2. Designate a space to store the segregated waste.

Medium to Long-term Recommendations

Medium to long-term recommendations are those that require detailed studies to estimate the impact of implementing the measures: GHG emission reduction potential, the associated capital requirements, cost savings and payback period.

Energy Conservation Measures

1. Install anti-glare window film - which can reduce the amount of sunlight coming from windows especially on the east and western façade without changing the building appearance.
2. The refrigerants used in the air-conditioning system have high Ozone Depletion Potential (ODP). Replace the decentralized air-conditioning system with a VRV based centralized air-conditioning system. Explore the usage of climate-friendly refrigerants in the air-conditioning systems.
3. Install 100 kW grid connected Solar PV plant on the building rooftop and unobstructed open area around the building. A solar PV with Lithium-ion battery storage system can also be explored to store the excess electricity produced and reduce dependence on grid electricity. A feasibility study can be commissioned.

Water Conservation Measures

1. Install sub-metering at various end uses such as treated wastewater consumption, water consumption for flushing and landscape irrigation.

Waste Management Measures

1. Engage with building occupants and maintenance crew to explore ways to reduce the most produced waste from the building (paper, packaging etc.).

Cross-cutting themes

1. Hire a full-time estate manager with specific experience in building operations and management.
2. Introduce green procurement rules to ensure all energy and plumbing equipment replacement in the building comply with the requirements of the Rwanda Green Building Minimum Compliance System 2019.
3. Develop a green education program on reducing energy and water use and better managing the waste to increase the awareness of facility management team, staff, and occupants.
4. Develop a regular capacity building program for the facility management team, including technicians from the general maintenance company, to improve the performance of the building. The training should be focusing on utility data management, conducting regular audits, strategies to green existing buildings and proper maintenance of equipment.

Indicative Cost Benefit Analysis of Select Recommendations

S. No.	Description	Potential Savings	Cost to Implement	Simple Payback Period
1	Install a 100kW grid connected solar PV on the building rooftop and unobstructed open area on ground. Approximately 6-7 sq.m of roof area would be required to install 1kW of solar PV.	16% energy cost savings Considering 11 hour of building operation on 240 working days per year.	120,000,000 RWF Cost of 1kW grid connected solar PV = 1,200,000 RWF. For a solar PV with Lithium-ion battery storage system the cost would be three times expensive compared to a grid-connected system.	5-6 years
2	Apply high Solar Reflective Index (SRI) paint for the exposed concrete and metal roof area.	Intangible.	4,755,000 RWF The building has a roof area of 1585 sq.m and its costs approx. 3000RWF to apply high SRI for every sq.m of roof	
3	Install a 100 cubic meter (Cu.m.) rainwater collection tank and reuse the collected rainwater for landscape irrigation, cleaning, and flushing applications (if possible).	16.5% water cost savings Considering 604 Cu.m. as the average monthly water consumption of operation on all days.	8,000,000 RWF Cost of plastic water tank 10 Cu.m. capacity= 730,000 RWF each.	7-8 years The payback period is high because the cost of potable water is too low (895 Rwf per cu.m.) and does not provide the right incentive to collect and reuse rainwater. But nevertheless, MINAFFET can lead by example by collecting and reusing the water and reducing its stormwater runoff.

ANNEXES

Appendix 1 – Building Audit Checklist

Form 1: General Building Information

No.	Item		Value
	Name of the Building		
	Year of Building Construction		
	Year of last innovation (if any)		
	Plot area (sq. m)		
	Building footprint (sq. m)		
	Permeable area (sq. m)		
	Non-permeable area (sq. m)		
	Building orientation		
	Numbers of habitable floors in the building		
	Number of basement/parking floors in the building		
	Area of the building (exclude parking, lawn, roads, etc.)	a. Total Built Up area (sq. m)	
		b. Carpet Area (sq. m)	
		Air-conditioned area (sq. m)	
		Non-Conditioned area (sq. m)	
	Working days/week (5/6/7 days per week)		
	Typical working hours of the building		
	Total numbers of employees working in the building		
	% of male employees		
	% of female employees		

Form 2: Building Energy Data Collection Form

No.	Item		Value
	Connected Load (kW) or Contract Demand (kVA)		
	Peak Demand or Maximum Demand Indicated (MDI) (kW)		
	Installed capacity: DG Sets (kVA or kW)		
	a. Annual Electricity Consumption, purchased from Utilities (kWh)		
	b. Annual Electricity Consumption, through Diesel Generating (DG) Sets (kWh)		
	c. Total Annual Electricity Consumption, Utilities + DG Sets (kWh)		
	Electricity Cost		
	a. Annual Electricity Cost, purchased from Utilities (Rwf)		
	b. Annual Electricity Cost generated through DG Sets (Rwf)		
	If not available, please provide the fuel consumed in the last 3 years and the unit cost of fuel		
	c. Total Annual Electricity Cost, Utilities + DG Sets (Rwf)		
	Installed capacity of Air Conditioning System	a. Centralized AC Plant (TR)	
		b. Packaged ACs (TR)	
		c. Window/Split ACs (TR)	
		Total AC Load (TR)	
		Type of refrigerant used in the AC system	
	Installed lighting load (kW)		
	Sub-metering of electricity consumption	Interior, common, and exterior area lighting (Yes/No)	

No.	Item		Value
		Air-conditioning system (Yes/No)	
		Wastewater treatment (Yes/No)	
		Renewable energy generation (Yes/No)	
		Power backup system (Yes/No)	
		Elevators (Yes/No)	
		On-site pumping for water storage (Yes/No)	
	Any electricity generation from On-site Renewable Energy system (Yes/No)		
	If Yes, Type of On-site RE system (Solar, wind etc.)		
	Annual electricity generation from On-site RE system (kWh)		
	Any heating/hot water or cooling generation from On-site Renewable Energy system (Yes/No)		
	If Yes, Type of On-site RE system (Solar water heater, solar cooling, etc.)		
	Annual heating/cooling generation from On-site RE system (kWth)		

Form 3: Summary of Connected Load / Equipment Inventory

No.	Details of Connected Load	Nos.	Watts/Unit	Total kW	Efficiency (COP/EER) only applicable to AC systems	Operating Hours
1	**Indoor Lighting**					
	Fluorescent Lamps					
	Incandescent Bulb					
	CFL					
	Halogen					
	Any other					
2	**Outdoor Lighting**					
	High-pressure mercury vapor (HPMV)					
	Metal Halide					
	Flood lights					
	Sodium vapor					
	Any other					
3	**Ventilation Systems**					
	Ceiling Fans					
	Wall-mounted Fans					
	Pedestal Fans					
	Air Purifier					
	Exhaust Fans					
4	**Air-conditioning**					
i.	Localized AC Systems					
	Window AC					
	Split AC					

No.	Details of Connected Load	Nos.	Watts/Unit	Total kW	Efficiency (COP/EER) only applicable to AC systems	Operating Hours
	Precision AC					
	Package Unit					
ii.	Central AC Systems					
	Chiller package					
	Condenser pump					
	Chilled water pump					
	Cooling Tower					
	Air Handling Unit					
5	**Office Equipment**					
	Printers					
	Photocopier Machines					
6	**Lifts**					
	Passenger Lift					
	Goods Lift					
7	**Pumps**					
	Water Pumps					
	Hydro pneumatic pumps					
	Sewage pumps					
	Wastewater treatment pumps					
8	**Uninterrupted/ stabilized power systems**					
	UPS					
	Voltage Stabilizer					

Form 4: Building Water Data Collection Form

No.	Item	Value
	Annual Water Consumption, purchased from WASAC (Kilo litres)	
	Annual Water Consumption, through any other sources of water (Kilo litres)	
	a. Bore hole	
	b. Collected rainwater	
	c. Treated wastewater	
	Total Annual Water Consumption, WASAC + Any other source (Kilo litres)	
	Annual Water Cost (Rwf)	
	Estimated hot water consumption in the year (kilo liters)	
	Source of hot water (electric/solar)	
	Rainwater harvesting (Yes/No)	
	If Yes, total capacity of rainwater harvesting storage (Kilo litres)	
	Available roof area to capture rainwater (sq. m)	
	Roof surface type (Flat roof/Metal roof/Tiled roof/Any other type)	
	Sub-metering of water consumption	
	a. Piped water supply (Yes/No)	
	b. Reuse of stored rainwater (Yes/No)	
	c. Treated wastewater consumption (Yes/No)	

No.	Item	Value
	d. Water consumption for flushing (Yes/No)	
	e. Water consumption for air-conditioning cooling tower make-up (if installed) (Yes/No)	
	f. Water consumption for landscape requirements (Yes/No)	
	Wastewater treatment plant	
	Annual wastewater generated that is treated in the treatment plant (kilo litres)	
	Is the quality of treated water monitored (Yes/No)?	
	Is the treated wastewater reused in the building?	
	If Yes, annual treated wastewater reused in the building (kilo litres)	
	Annual Waste generated from the building (Kgs)	
	Is the waste segregated at source (Yes/No)	
	If Yes, please specify the types that it is segregated into (Food, paper, plastic, e-waste, bio-medical, landscape etc.)	
	Is there a dedicated storage facility to store the segregated waste (Yes/No)	
	How is the recyclable waste handled in the building?	

Form 5: Building Waste Data Collection Form

No.	Item	Value
	Annual Waste generated from the building (Kgs)	
	Is the waste segregated at source (Yes/No)	
	If Yes, please specify the types that it is segregated into (Food, paper, plastic, e-waste, bio-medical, landscape etc.)	
	Is there a dedicated storage facility to store the segregated waste (Yes/No)	
	How is the recyclable waste handled in the building?	

Form 6: Building Envelope Data Collection Form

No.	Item	Value
	Building Orientation	
External Wall Assembly		
	Main walling material (Clay bricks, concrete blocks)	
	External finish (ACP cladding, Plaster, and paint)	
	Internal finish (plaster and paint, others)	
	Total thickness of the wall assembly (mm)	
External Roof Assembly		
	Type of roof (Flat/slope)	
	Main roofing material (concrete, clay tiles, metal roofing, others)	
	Internal ceiling material (gypsum tile, others)	
	Total thickness of the roof assembly (mm)	
Fenestration – Vertical Glazing (Windows)		
	Type of window (Fixed/Sliding/Louvered/casement/awning/clerestory)	
	Type of glass (clear, tinted, reflective, single glazing, double glazing)	
	U-value of the glass (if available)	

No.	Item	Value
	Solar Heat Gain Coefficient (SHGC) of Solar Factor (SF) of the glass (if available)	
	Visual Light Transmittance (VLT) of the glass (if available)	
	Glass brand and product number	
Shading Devices		
	Depth of shading device	
	Length of shading device	
	Typical height of window	
	Typical width of window	
	Any presence of blinds (Yes/No)?	

Appendix 2 – Monthly Electricity Consumption

Month	Electricity Consumption (kWh)
2017-18	335936
2018-19	339955
2019-20	378907

Appendix 3 – Monthly Water Consumption

Month	Electricity Consumption (kWh)
2017-18	9641
2018-19	7651
2019-20	7248

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