



Ministry of Environment

REVIEW AND AMEND DESIGN OF GREEN BUILDING TO ATTAIN BREEAM CERTIFICATION

Promoting Energy Efficient Buildings through
Strengthening Low Carbon Energy
Island Strategies (LCEI) Project





Ministry of Environment

Strengthening Low Carbon
Energy Island Strategies (LCEI)
Project



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Feasibility Report



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FOR MINISTRY OF ENVIRONMENT

February 2021



FEASIBILITY REPORT

Review and Amend Design of Green Building to attain BREEAM Certification

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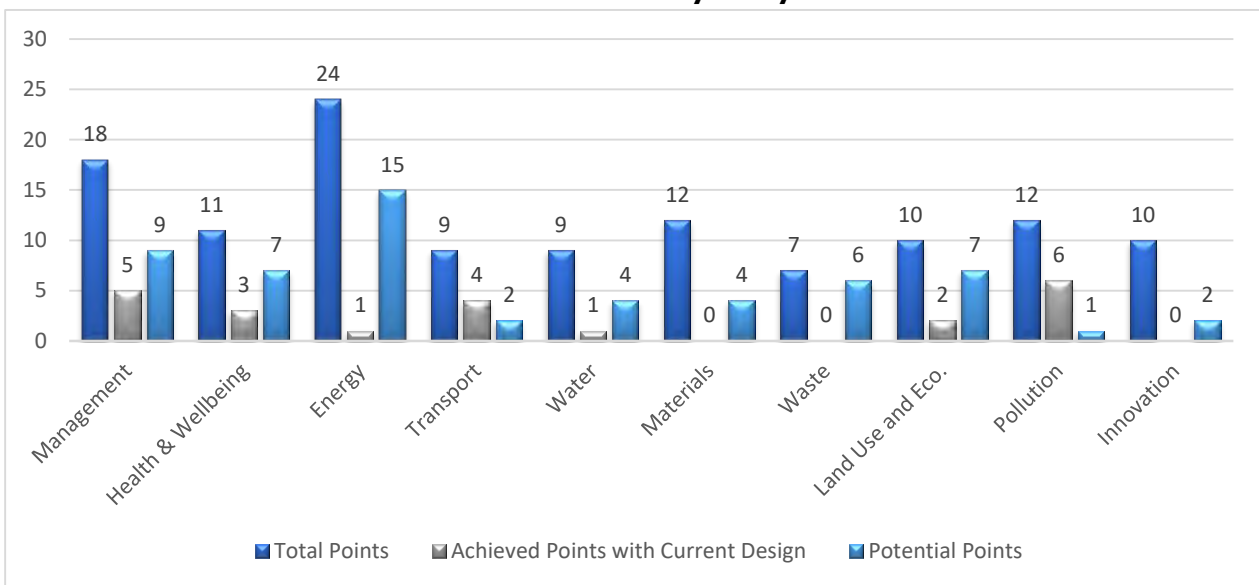
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EXECUTIVE SUMMARY

This report outlines the results of BREEAM design review and feasibility analysis conducted on behalf of Ministry of Environment Male’ Republic of Maldives and Housing Development Corporation Ltd. (HDC) under the “Strengthening Low Carbon Energy Island Strategies Project (LCEI).

(Table 1) highlights the results of the study, indicating achievable points, potential points and total points for Green Office project under BREEAM International 2016 New Construction scheme.

Table 1. Feasibility Study Results



According to the study conducted, the proposed building design will be able to achieve a BREEAM score of 18.40%. As the minimum score to achieve any level of BREEAM certification is 30% and above the building does not fit into any of the BREEAM certification levels. Some critical issues such as equipment efficiency, material selection and measures needed to be tracked during construction phase were not included in the construction documents. With the amendments and achievement of potential points stated above, the project may reach up to 69.17% score which corresponds to BREEAM Very Good level certification. Other points are determined as too difficult or impossible to achieve due to project type, operational difficulties and other drawbacks.

Further recommendations for strategies and applications to achieve potential points stated here shall be provided in the upcoming reports during the course of this project.

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1 INTRODUCTION

1.1 Project Background

The existing design of the Green Office project has been reviewed and evaluated in accordance with the BREEAM International New Construction 2016 criteria. The following project sets provided by Owner were used for the purpose of this study:

- Architectural design drawings
- Mechanical design drawings
- Plumbing design drawings
- Electrical design drawings
- Auxiliary design drawings
- Structural design drawings

Project Location : Hulhumale, Maldives

Project Phase : Design Phase

Project Type : Core & Shell

Total Gross Floor Area : 7,683 m²

Total Site Area : 940 m²

Car Parking Spots : 11

Occupancy Info*:

FTE : ~ 250

Visitors : ~ 15

**Number of FTE and visitors is calculated according to default occupancy based on ASHRAE Standard.*

1.2 Objectives and Scope of Work

BREEAM (Building Research Establishment's Environmental Assessment Method) is the world's first sustainability rating scheme for the built environment and has contributed much to the strong focus in the UK on sustainability in building design, construction and use. BREEAM is now an International standard that is locally adapted, operated and applied through a network of International operators, assessors and industry professionals.

The rating system evaluate buildings under nine main categories, including Management, Health and Wellbeing, Energy, Transport, Water, Materials, Waste, Land Use and Ecology, Pollution, Innovation.

The credits scored are shown as a weighted percentage score, which itself corresponds to an overall rating of Pass, Good, Very Good, Excellent or Outstanding:

- ≥30 - <45 Pass
- ≥45 - <55 Good
- ≥55 - <70 Very Good
- ≥70 - <85 Excellent
- ≥85 Outstanding

Minimum Standards for BREEAM International 2016 New Construction for Very Good Level

To achieve a particular BREEAM rating, the minimum overall percentage score must be achieved and the minimum standards must be met. Detailed in the below table are the credit requirements applicable for the green building and the current project status corresponding to the project to earn BREEAM very good rating.

Table 2. Credit Details, Requirements & Status

Credit Name	Requirement	Project Status
Man 03 Responsible construction practices	<p>All national health and safety legislation and regulations for construction sites should be considered and implemented during;</p> <ul style="list-style-type: none"> ● The design of the asset; to minimise health and safety risks ● Pre-construction work planning and organisation; to collate health and safety 	<p><i>The principal contractor must have an occupational health and safety management system compliant with OHSAS 18001:2007 OR relevant standards.</i></p> <p><i>Requirements must be included in Construction Specifications.</i></p>

	<p>information from all relevant stakeholders</p> <ul style="list-style-type: none"> • Site set-up; to implement health and safety features • Construction; to manage, monitor and report on the health and safety of construction site staff. 	
<p>Hea 01</p> <p>Visual comfort</p>	<p>All fluorescent and compact fluorescent lamps should be fitted with high frequency ballasts</p>	<p><i>Fluorescent lamps will be used in the Project. The requirement regarding high frequency ballasts must be added to Electrical Technical Specifications.</i></p>
<p>Hea 02</p> <p>Indoor air quality</p>	<p>Materials containing asbestos should be prohibited from being specified and used within the building.</p>	<p><i>Requirements must be included in Construction Specifications.</i></p>
<p>Hea 09</p> <p>Water quality</p>	<p>All water systems in the building should be designed in compliance with the measures outlined in the relevant national health and safety best practice guides or regulations to minimise the risk of microbial contamination, e.g. legionellosis</p>	<p><i>Requirements must be included in Mechanical Technical Specifications.</i></p>
<p>Ene 02a</p> <p>Energy monitoring</p>	<p>Energy metering systems should be installed that enable at least 90% of the estimated annual energy consumption of each fuel to be assigned to the various end-use categories of energy-consuming systems.</p> <p>The energy-consuming systems in buildings with a gross internal area greater than 1,000m² should be metered using an appropriate energy monitoring and management system.</p>	<p><i>Energy meters must be arranged for sub-systems (cooling system, domestic hot water system, ventilation system, pumps, lighting system etc.). Requirements must be included in Mechanical Technical Specifications.</i></p>

<p>Wat 01 Water consumption</p>	<p>The project must achieve at least one credit with using efficient water-consuming components and alternative systems.</p>	<p><i>Maximum flow and flush rates for water fixtures must be added to Construction Specifications.</i></p>
<p>Wat 02 Water monitoring</p>	<p>The specification of a water meter on the mains water supply to each building; this includes instances where water is supplied via a borehole or other private source.</p>	<p><i>Water meter is provided on mains water supply according to existing design drawings.</i></p>
<p>Mat 03 Responsible sourcing of Construction products</p>	<p>All timber and timber-based products used on the project should be Legally harvested and traded timber.</p>	<p><i>Requirements must be included in Construction Specifications.</i></p>

1.3 Administrative Issues

1.3.1 Project Brief and Design

General Requirements:

- A clear sustainability brief which sets out client requirements, sustainability objectives and targets, timescales and budget, consultees and professional appointments, constraints should be developed.
- A sustainability champion for design and construction stages should be appointed to facilitate the setting and achievement of BREEAM performance targets for the project.

Project Status:

- *Regular meetings have been conducting between project delivery stakeholders (client, design team, consultation team). And the requirements regarding sustainability will be integrated to the project design.*
- *BREEAM consultant and Sustainability champion for design stage have been involved to Project team.*

1.3.2 Responsible Construction Practices

General Requirements:

- All timber and timber-based products used during the construction process of the project should be legally harvested and traded timber.
- All national health and safety legislation and regulations for construction sites should be considered and implemented during the design, pre-construction, site set-up and construction phases.
- The principal contractor should operate an environmental management system (EMS) covering their main operations. The EMS must be third party certified to ISO 14001/EMAS or an equivalent standard. Best practice pollution prevention policies and procedures should be implemented on site.
- A sustainability champion should be appointed to monitor the project to ensure ongoing compliance with the relevant sustainability performance and process criteria, and therefore BREEAM targets, during the construction, handover and close out work stages.
- The principle constructor should operate the site in a manner that provide safe and adequate access, considerate surrounding neighbours, mitigate the impact on the environment and ensure the wellbeing of site workers.
- The site energy and water consumption, the transport movements and impacts resulting from delivery of the majority construction materials to the site and construction waste from the site should be monitored and recorded.

Project Status:

- *The credit requirements should be included in Construction Specifications and construction site impacts and implementations should be monitored during the construction stage.*
- *A sustainability champion should be also appointed for construction stage.*

1.3.3 Commissioning and Handover

General Requirements:

- A suitable timescale for commissioning and recommissioning of building services and control systems as well as testing and inspecting the building fabric should be prepared.
- A specialist commissioning manager should be appointed during design stage with responsibility for undertaking design reviews and giving advice on suitability for ease of commissioning, providing commissioning management input to construction programming and during installation stages and management of commissioning, performance testing and handover or post-handover stages.
- The integrity of the building fabric, including continuity of insulation, avoidance of thermal bridging and air leakage paths is quality assured through completion of post-construction testing and inspection.
- A building user guide should be developed, prior to handover for distribution to the building occupiers and premises managers.

Project Status:

- *CIBSE standard is referred in Mechanical Technical Specifications for commissioning of HVAC systems.*
- *ANSI/IEEE standards are referred in Electrical Technical Specifications for commissioning of the electrical systems.*
- *Commissioning Schedule, program of works and main contractor's program also needed.*
- *No information found about testing and inspecting building fabric in technical specifications.*

1.3.4 Construction Waste Management

General Requirements:

- The amount of site construction waste created should be monitored.
- Procedures should be in place for sorting, reusing and recycling construction waste into at least five defined waste groups (packaging, metals, timber, concrete, gypsum, glass, ceramics, plastics, brick etc.).

- Waste materials should be sorted into separate key waste groups (according to the waste streams generated by the scope of the works) either on site or off-site through a licensed contractor for recovery.

Project Status:

Requirements should be added to Construction Specifications

2 Project Findings & Recommendations

2.1 Project Site & Location

2.1.1 Site Conditions & Surroundings

General Requirement for Office Buildings:

The project should be located within the 500 meters’ proximity of at least two of the three core amenities which are cashpoint (bank), restaurant and sports centre.

Project Status:

According to the project location, all core amenity types are accessible and walking distance is less than 500 meters. Also, the central location of the building allows access to outdoor open areas such as parks and child care facilities such as schools. The amenities according to their types are shown in the image below.



2.1.2 Public Transportation Access

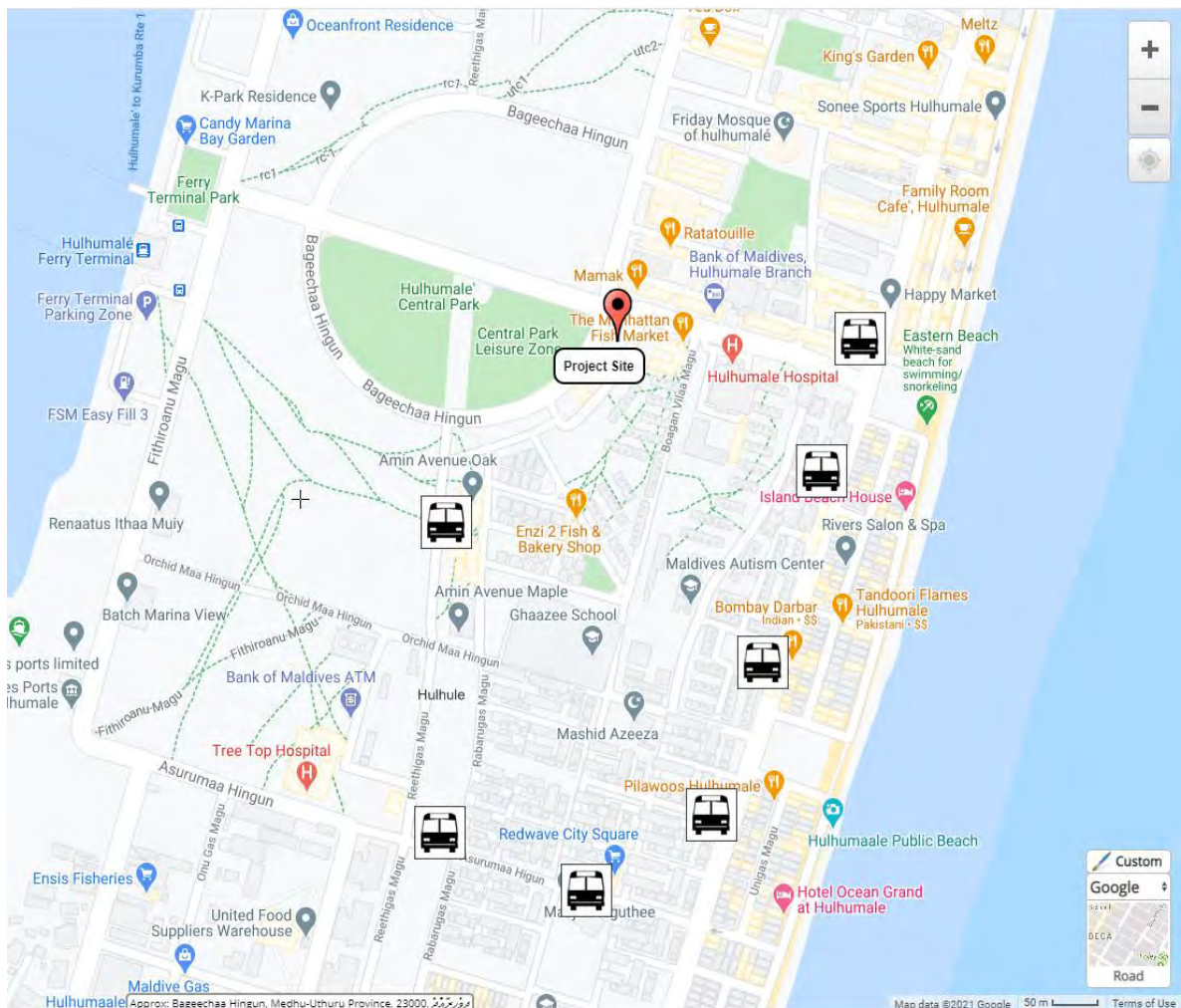
General Requirement for Office Buildings:

The project should be located within the walking distance with transportation nodes.

Project Status:

According to the project location, 6 public transportation nodes are located within 800 meters walking distance. Distance between Project site and:

- *Main bus stop is 350 m*
- *N2 Bus Stop 1 is 350 m*
- *N2 Bus Stop 2 is 650 m*
- *N2 Bus Stop 3 is 750 m*
- *N2 Bus Stop 4 is 700 m*
- *N2 Bus Stop 5 is 650m*
- *N2 Bus Stop 6 is 450 m*



2.2 Architectural Design

2.2.1 Daylight

General Requirements:

For Office buildings, average daylight illuminance should be at least 300 lux for 2000 hours per year or more for regularly occupied areas.

Project Status:

The daylight transmittance of the proposed façade glass should be at least 50% to ensure sufficient daylight in the regularly occupied spaces. According to provided document 'A5000 Schedules' **SOLAR E PLUS GRAPHITE BLUE** is identified as façade glass. Daylight transmittance of the selected glass is below 50%.

Monolithic Performance Data^{1,10}

	Nominal Glass Thickness		Visible Light ²			Solar Energy ²			U-Factor ⁵			Solar Heat Gain Coefficient ⁷	Shading Coefficient ⁸
	in.	mm	Transmittance ³ %	Reflectance ⁴ %		Transmittance ³ %	Reflectance ⁴ %	UV Transmittance ² %	U.S. Summer ⁶	U.S. Winter ⁶	European ^{6**}		
				Outside	Inside								
Pilkington Solar-E™ solar control low-e (coating on #2 surface)													
Clear	1/8	3	60	8	9	46	8	48	0.50	0.66	3.7	0.54	0.63
	5/32	4	60	8	9	45	8	46	0.50	0.65	3.7	0.54	0.62
	3/16	5	60	7	9	44	7	44	0.50	0.65	3.7	0.53	0.61
	1/4	6	60	8	9	44	7	44	0.50	0.65	3.7	0.53	0.61
	5/16	8	59	8	9	42	7	41	0.50	0.64	3.7	0.52	0.59
EverGreen	3/8	10	60	8	9	40	7	38	0.49	0.64	3.6	0.50	0.58
	1/4	6	45	6	9	20	5	8	0.50	0.65	3.7	0.35	0.40
EverGreen	5/16	8	40	7	9	16	5	5	0.50	0.64	3.7	0.32	0.36
	Pilkington Solar-E™ Plus solar control low-e (coating on #2 surface)												
Grey	1/4	6	24	5	9	19	5	12	0.50	0.65	3.7	0.34	0.39
	5/16	8	19	5	8	15	5	9	0.50	0.65	3.7	0.31	0.36
Blue-Green	1/4	6	41	6	9	24	5	19	0.50	0.65	3.7	0.38	0.43
	5/16	8	30	6	9	21	5	15	0.50	0.65	3.7	0.25	0.40
Graphite Blue	1/4	6	35	6	9	28	5	23	0.50	0.65	3.7	0.41	0.47
	5/16	8	30	6	9	23	5	18	0.50	0.65	3.7	0.37	0.43
Arctic Blue	1/4	6	30	5	8	17	5	11	0.50	0.65	3.7	0.32	0.37
	5/16	8	27	6	8	14	5	9	0.50	0.65	3.7	0.30	0.35

2.2.2 Views

General Requirements:

95% of the floor area space within relevant building areas should be within X metres of a window or permanent opening that provides an adequate view out, as outlined below table:

Table 3. Distance for adequate view and window opening size

Distance from window to workspace or desk (X)	Window or opening size (as % of surrounding wall area)
7m or less	20%
8m-11m	25%
11m-14m	30%
14m or more	35%

Project Status:

The depth of the typical office floors is more than 20m. Window size of the surrounding Wall area is more than 35%.

2.2.3 Car Parking Capacity

General Requirements:

For office building max. parking capacity should not exceed 1 space per 4 building users.

Project Status:

Since the number of total car parking space is 11, the parking capacity do not exceed the requirement.

2.2.4 Alternative modes of transport

General Requirements:

- Electric recharging stations should be provided for at least 3% of the total car parking capacity for the building.

AND / OR

- Required number of bicycle storage and shower/changing facilities is provided below

Required number of bicycle storage	Required number of shower/changing facilities
24	3 pcs

Project Status:

- *Bicycle parking area is defined within the site boundary. However, the number of bicycle racks is not specified. There is no shower & changing facility in the building.*
- *Electrical vehicle charging station is not provided in the project.*

2.2.5 Potential for Natural Ventilation

General Requirements:

The openable window area in each occupied space should be equivalent to 5% of the gross internal floor area of that room or floor plate. For room or floor plates between 7m–15m depth, the openable window area must be on opposite sides and evenly distributed across the area to promote adequate cross ventilation.

Project Status:

According to provided document 'A5000 Schedules' fixed and awning windows are designed. In order to fulfil natural ventilation requirements, windows should be fully openable.

2.2.6 Accessibility

General Requirements:

- Building access roads and dedicated cycle lanes should meet the following minimum width dimensions:
 - Where pedestrian and cycle routes are shared, the minimum total width of the combined path is 3.0m
 - Where the cycle lane is segregated from both the pedestrian route and carriageway, the minimum width of the cycle path is 2.0m and the pedestrian path is 1.5m
 - Where the cycle route forms a part of the carriageway, the minimum width of the lane is 1.5m.
- Dedicated cycle paths should provide direct access from the site entrances to any cycle storage provided, without the need to deviate from the cycle path and, if relevant, connect to off-site cycle paths (or other appropriate safe route) where these run adjacent to the development's site boundary.
- Footpaths on site should provide direct access from the site entrances to the building entrances and connect to public footpaths off-site (where existing), providing practical and convenient access to local transport nodes and other off-site amenities (where existing).
- Where provided, drop-off areas should be designed off, or adjoining, the access road and provide direct access to pedestrian footpaths, therefore avoiding the need for the pedestrian to cross vehicle access routes.
- Dedicated pedestrian crossings should be provided where pedestrian routes cross vehicle access routes, and appropriate traffic calming measures are in place to slow traffic down at these crossing points.
- Pedestrian footpaths should be signposted to other local amenities and public transport nodes off-site (where existing).

- The building should be designed to be fit for purpose, appropriate and accessible by all potential users.
- An access strategy that address access to and throughout the development for all users, with particular emphasis (disabled users, people of different age groups, genders, ethnicity and fitness levels, parents with children) should be developed.

Project Status:

- *The width of the pedestrian path is more than 1.5m in the project.*
- *Safe pedestrian route (sidewalks and ramps) is provided from the pedestrian exit of the car park and site entrance to the Building entrance.*
- *The general layout of building and site design provide practical access to and through the places.*

2.2.7 Designing for durability and resilience

General Requirements:

Suitable durability and protection measures, or designed features or solutions should be incorporated to prevent damage to vulnerable parts of the internal and external building and landscaping elements:

- Protection from the effects of high pedestrian traffic in main entrances, public areas and thoroughfares (corridors, lifts, stairs, doors etc.)
- Protection against any internal vehicular or trolley movement within 1m of the internal building fabric in storage, delivery, corridor and kitchen areas
- Protection against, or prevention from, any potential vehicular collision where vehicular parking and manoeuvring occurs within 1m of the external building façade for all car parking areas and within 2m for all delivery areas.

Project Status:

Measures to protect building and landscaping elements are not seen in the provided documents. In order to meet requirements measures stated above should be integrated to the building design.

2.2.8 Operational Waste

General Requirements:

- Dedicated space should be provided for the segregation and storage of operational recyclable waste volumes generated by the assessed building or unit, its occupants and activities. This space should be:
 - Clearly labelled, to assist with segregation, storage and collection of the recyclable waste streams
 - Accessible to building occupants or facilities operators for the deposit of materials and collections by waste management contractors

- Of a capacity appropriate to the building type, size, number of units (if relevant) and predicted volumes of waste that will arise from daily or weekly operational activities and occupancy rates.
- If there is a high amount of packaging waste or domestic waste is likely to exist, the following facilities should be provided:
 - Static waste compactors or balers situated in a service area or dedicated waste management space
 - Vessels for composting suitable organic waste resulting from the building's daily operation and use; OR adequate space for storing segregated food waste and compostable organic material prior to collection and delivery to an alternative composting facility.Where organic waste is to be stored or composted on site, a water outlet is provided adjacent to or within the facility for cleaning and hygiene purposes.

Project Status:

There is no dedicated space for recyclable wastes in the project drawings. In order to meet requirements, above criteria should be integrated to the building design.

2.2.9 Acoustic performance

General Requirements:

Architectural acoustic measures should be taken and the following conditions should be taken into consideration during the design:

- External sources of noise impacting the chosen site
- Site layout and zoning of the building for good acoustics
- Acoustic requirements for users with special hearing and communication needs
- Acoustic treatment of different zones and façades

Indoor ambient noise level should comply with national building regulations or other appropriate good practice standards.

Project Status:

There is no any document provided regarding acoustical comfort.

2.2.10 Material Selection

General Requirements:

- Materials containing asbestos should be prohibited from being specified and used within the building.
- All timber and timber-based products used during the construction process of the project should be legally harvested and traded timber (including wood used during construction).

- A purchase policy should be established to search for certain sustainability criteria (using FSC certified wood, using materials with recyclable content, using local raw materials, etc.) in the materials to be used in the project.
- At least 10 products specified at Design Stage and installed by Post-Construction Stage should be covered by verified Environmental Product Declarations (EPD).

Project Status:

Schedule of the finishes, doors and facade glass is provided without brand-model name. The relevant criteria should be added to the specifications.

2.2.11 Water Efficiency

General Requirements:

Water fixture flush/flow features should not exceed the followings. In the later stages, the relevant criteria should be added to the specifications.

- Taps : Max. 1.9 liter/min
- Kitchen taps : Max 5 liter/min
- Shower : Max 6 liter/min
- Urinal : Max. 1 liter/flush
- WCs : Max. 3/6 liter/flush

If a washing machine or dishwasher will be provided in the project, efficiency values must meet the following conditions:

- Commercial sized dishwashers : Max. 5 liter/rack
- Commercial sized washing machines : 7.50 liter/kg
- Domestic sized dishwashers : 12 liter/cycle
- Domestic sized washing machines : 40 liter

Collecting and reusing of alternative water sources such as rainwater, grey water are recommended to reduce the use of mains water.

Project Status:

- *Project water supply calculations made according to Uniform Plumbing Code (UPC) Data Book Table 6.3 (Fixture Unit Loads per Plumbing Fixture). Brand/model name and water consumption of the selected flow and flush fixtures are not provided. The relevant criteria should be added to the specifications.*
- *Rainwater and condensate drain water are collected and reused for irrigation.*

2.3 Landscape Design

2.3.1 Plant Selection

General Requirements:

Native, adapted, and drought tolerant plants should be selected. Monocultural plants should not be used.

Project Status:

Vegetated landscape plan with narrative for plant species and water requirements could not be found in the provided documents.

2.3.2 Irrigation System

General Requirements:

One or more of the following water efficiency practices should be implemented:

- Drip-fed subsurface irrigation incorporating soil moisture sensors
- Reclaimed or recovered water from a rainwater collection or waste water recovery system with appropriate storage
- External landscaping and planting that relies solely on precipitation, during all seasons of the year

Project Status:

Irrigation plan could not be found in the provided documents. Rainwater and condensate drain water are collected and reused for irrigation in the project.

2.3.3 Protection of Ecological Features & Enhancing Site Ecology

General Requirements:

- An ecological report defines the existing condition of site and ecological recommendations adopted to the landscape design to enhance the ecology of the site should be prepared by landscape architect.
- All existing features of ecological value within the assessment zone and site boundary area should be adequately protected from damage during clearance, site preparation and construction activities.

Project Status:

An ecological report is not seen in the provided documents. Requirements regarding protection of existing trees located in the project site should be added to specifications.

2.4 Mechanical Design

2.4.1 Building Envelope Performance

General Requirements:

Building envelope performance values based on ASHRAE 90.1-2013 for project's climate zone (Maldives' Climate Zone: 1A) are shown below table. Building envelope performance values should be designed based on these values.

Building Envelope Elements	BREEAM Target U Value [W/m ² K]
Above Grade Wall	≤ 0.705 W/m ² K
Roof	≤ 0.273 W/m ² K
Exposed Floor	≤ 1.986 W/m ² K
Slab on Grade Floor	≤ 0.300 W/m ² K
U _{windows} * * include glass+frame effect	U ≤ 1.82 W/m ² K SHGC ≤ 0.25 and VLT > 50%

Project Status:

- Performance values requirement for building envelope are shown above comparison table. It seems that there is no shared document about building's fabric performance values. U values of building's fabric elements and heat insulation thicknesses for opaque areas should be checked.
- Window type is defined in "A5000 Schedules" document as an "Aluminium - Framed Curtain Wall; Double Glazed, Solar E Plus Graphite Blue". SHGC value of this glazing is 0.32 and U value is 1.6 W/m²K according to catalogue values of manufacturer. Double glazing with Solar E will be appropriate to comply ASHRAE 90.1-2013 minimum requirements.

2.4.2 Mechanical Projects & Equipment, Requirements

General Requirements & Project Status:

- **Cooling System:** There are two equally sized air-cooled screw type chiller with VFD to meet building's cooling load. Cooling capacity of each chiller is 906 kW. Minimum full load and part load efficiency values defined in ASHRAE 90.1-2013 for air-cooled chiller are shown below table. Air-cooled screw chiller with VFD in project should be selected based on minimum performance requirements shown below.

Chiller Type	Cooling Capacity (kW)	ASHRAE 90.1-2013 Minimum Performance Values
Air-Cooled Chiller	Cooling Capacity < 528 kW	COP ≥ 2.866 @Full Load
	Cooling Capacity ≥ 528 kW	IPLV ≥ 4.758 @Part Load

- **Air Handling Units (AHU):** It seems that there is no air handling unit in mechanical drawings. Please provide how fresh air delivered to zones to comply BREEAM indoor air quality requirements.

The following requirement must be met in case of project ventilation (Outdoor air supply) will be provided by air handling units.

 - a) Air handling unit filter type should be minimum F7 class.
 - b) Heat recovery system effectiveness should be over 75% for mechanical ventilation system.
 - c) Specific fan power for the mechanical ventilation system should be ≤1.8W/liter/second for central mechanical ventilation system including heating and cooling.
 - d) System has a form of variable flow control fitted, i.e. variable speed and can be controlled in accordance with the recommendations of ASHRAE Standard 90.1.
 - e) All ductwork and air handling units (AHUs) are certified to meet the best leakage standards. (EUROVENT best leakage standards).
- **Circulation Pumps:** It is proposed that circulation pump efficiency class (except for used emergency or lower than 1.1 kW) should be at least IE3 class to improve energy efficiency of mechanical system.
- **Process and Exhaust Fans:** It is proposed that supply and exhaust fan efficiency class (except for used emergency or lower than 1.1 kW) should be at least IE3 class to improve energy efficiency of mechanical system.
- **Split AC Units:** Where cooling requirement is solved with wall-mounted split air conditioners, the minimum efficiency of air conditioner should be SCOP= 4.0, SEER= 5.6.
- **Pipe Insulation Thickness:** The pipe insulation thicknesses in heating and cooling system are specified in the ASHRAE 90.1-2013 standard as follows.

System Type	Fluid Temperature Range	Conductivity (W/m°C)	Nominal Pipe Size (mm)				
			<25	25-40	40-100	100-200	≥200
			Insulation Thickness (mm)				
Hot Water	61°C-93°C	0.036-0.042	40	40	50	50	50
Domestic Hot Water	41°C-60°C	0.032-0.040	25	25	40	40	40
Chilled Water	4°C-16°C	0.030-0.039	15	15	25	25	25

For piping smaller than 40 mm and located in partitions within conditioned spaces, reduction of these thicknesses by 25 mm shall be permitted (before thickness adjustment required in footnote a) but not to thicknesses below 25 mm.

In addition, no insulation is required in the following cases.

- a) Piping that conveys fluids having a design operating temperature range between 16°C and 41°C, inclusive.
- b) Piping that conveys fluids that have not been heated or cooled through the use of fossil fuels or electricity (such as roof and condensate drains, domestic cold-water supply, natural gas piping),
- c) Where heat gain or heat loss will not increase energy usage (such as liquid refrigerant piping).
- d) In piping 25 mm or less, insulation is not required for strainers, control valves, and balancing valves.

2.4.3 Indoor Environmental Quality / Ventilation System

General Requirements:

An indoor air quality plan should be produced and implemented, with the objective of facilitating a process that leads to design, specification and installation decisions and actions that minimize indoor air pollution during the design, construction and occupation of the building. The indoor air quality plan must consider the following:

- Removal of contaminant sources
- Dilution and control of contaminant sources
- Procedures for pre-occupancy flush out
- Third party testing and analysis
- Maintaining indoor air quality in-use
- There should be at least 10 m distance between the fresh air inlets (supply) and the air outlets (return) points.
- Fresh air inlets and openable windows should be at least 10 m from the pollutants such as parking, garbage collection area etc.

- Areas of the building subject to large and unpredictable or variable occupancy patterns such as dining hall, meeting room, seminar room, lobby, etc. should have carbon dioxide (CO₂) or air quality sensors that are linked to the mechanical ventilation system.
- Amounts of fresh air supplied to the spaces should comply with international standards (ASHRAE 62.1-2010).

Project Status

- *Since the project is Core&Shell, ventilation system in Office areas will be in tenant scope.*
- *Fresh air rates supplied to (lobby, common halls, meeting rooms, multipurpose areas, admin Office could not be checked as fresh air rates supplied these areas are not provided in design drawings.*
- *Location of CO₂ sensors are specified in existing design drawings.*

2.4.4 Thermal Comfort

General Requirements:

In order to provide thermal comfort for building users, design temperatures of conditioned spaces should be provided according to the ASHRAE 55-2010 standard.

Project Status

Cooling/heating design temperatures for spaces are not found in the provided documents.

2.4.5 Water Metering

General Requirements:

- Each meter (main and sub) should be pulsed or other open protocol communication output to enable connection to an appropriate utility monitoring and management system, e.g. a building management system (BMS), for the monitoring of water consumption.
- Separate pulsed water meter (strain) should be installed in all tenanted areas.
- Water-consuming plant or building areas, consuming 10% or more of the building's total water demand, should have pulsed filter meters integrated with the automation system.

Project Status

Water meter is provided on mains water supply.

Water meters are available for potable and non-potable water lines in tenant spaces.

According to existing drawings water meters are not provided for building areas consuming 10% or more of the building's total water demand.

2.4.6 Water Leak Detection and Prevention

General Requirements:

- A leak detection system which is capable of detecting a major water leak on the mains water supply should be installed. The water leak detection system should alert the building occupants to the leak or have automated diagnostic procedure for detecting leaks.
- Flow control devices that regulate the supply of water to each WC area or facility according to demand should be installed (and therefore minimise water leaks and wastage from sanitary fittings).
- Isolation valves should be located in an accessible place that allows hot and cold water to be isolated by hand separately (switched on or off) for the following supplies: incoming supply to the dwelling, taps, showers, heating or hot water systems, appliances (e.g. dishwasher, washing machine etc.).

Project Status

According to provided documents water leak detection system is not designed in the project.

2.4.7 Water Quality

General Requirements:

All water systems in the building should be designed in compliance with the measures outlined in the relevant national health and safety best practice guides or regulations to minimise the risk of microbial contamination, e.g. legionellosis.

Project Status

No information found in provided documents.

2.5 Electrical Design

2.5.1 Energy Metering

General Requirements:

All the main building utility systems should be sub metered individually at the system level. All the design of electrical panels and power distribution panels should be designed accordingly. The systems to be sub metered may be summarized as:

- Space cooling (chiller)
- Domestic hot water system
- Ventilation System (AHU, supply fans etc.)
- Pumps
- Lighting System

The energy consumption of the tenant areas should be monitored separately.

Project Status

There is a main energy meter in main distribution panel and there are only sub meters for tenant spaces. Electricity meters should be arranged for sub-systems as stated above.

2.5.2 Lighting System

General Requirements:

High Frequency Ballast

- All fluorescent and compact fluorescent lamps used in the building should be fitted with high frequency ballasts (>30 kHz).

Internal Lighting

- Illuminance level (lux) and uniformity ratio should comply with CEN EN 12464-1 Light and lighting - Lighting of workspaces, 2011 standard.
- Lighting density values should be designed to be minimum 20% lower than these values to increase building energy performance. Interior lighting power density values for some spaces according to ASHRAE 90.1-2013 standard are shown in below table.

Space Types	ASHRAE 90.1-2013 Space by Space Method Reference LPD Values (W/m ²)
Office (Open)	10.6
Office (Closed)	12.0
Meeting Room	13.3
Lobby	9.675
Corridors	7.1

Stairs	7.4
Restrooms	10.6
Restaurant / Dining Room	7.0
Storage Room	6.8
Locker Room	8.1
Fitness Area	7.8
Mechanical/Electrical Room	4.6
Kitchen	13.1
Parking Garage	2.1

External Lighting

- All external lighting located within the construction zone should be designed to provide illuminance levels that enable users to perform outdoor visual tasks efficiently and accurately, especially during the night. To demonstrate this, external lighting provided should be specified in accordance with EN 13201 series Road Lighting and EN 12464-2:2014 Light and lighting - Lighting of workplaces - Part 2: Outdoor workplaces.
- The average initial luminous efficacy of the external light fittings within the construction zone should not be less than 60 luminaire lumens per circuit Watt.
- All external light fittings should be automatically controlled for prevention of operation during daylight hours and presence detection in areas of intermittent pedestrian traffic.
- The external lighting intensity values should be at least 20% lower than the LPD values specified in the table below. Exterior lighting power density values according to ASHRAE 90.1-2013 standard are shown in below table.

Space Type	ASHRAE 90.1-2013 External Lighting LPD Values (W/m ²)
Parking Areas	1.1 W/m ²
Walkways less than 3 wide	2.6 W/m
Walkways 3 m wide or greater	1.7 W/m ²
Plaza Areas, Special Feature Areas	1.7 W/m ²
Stairs	10.8 W/m ²
Landscaping	0.54 W/m ²
Main Entries	98 W/m
Building Façades	1.6 W/m ² or 12.3 W/m

Project Status

Technical datasheets of selected lighting fixtures and ballasts are not provided. According to selected lighting fixtures required calculations should be conducted.

2.5.3 Low Carbon Technologies

General Requirements:

Passive Design:

The passive design analysis should be carried out in case that passive systems are designed to reduce the overall building energy consumption. It should be reported that primary energy consumption or CO₂ emissions are reduced by at least 5%, in line with the passive design analysis. The passive design analysis should cover the following:

- Site location
- Site weather
- Microclimate
- Building layout
- Building orientation
- Building form
- Building fabric
- Thermal mass or other fabric thermal storage
- Building occupancy type
- Daylighting strategy
- Ventilation strategy
- Adaptation to climate change

- If free cooling is considered in the building, the strategies should be determined by analysing.

Low or zero carbon technologies:

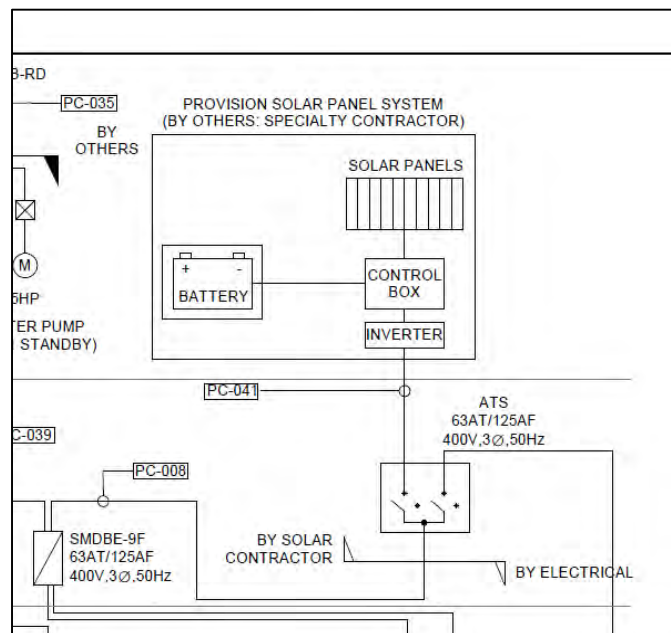
A feasibility study should be carried out by an energy specialist to establish the most appropriate recognized local (on-site or near-site) low or zero carbon energy sources for the building. A local low or zero carbon (LZC) technology specified for the building should be installed in line with the recommendations of this feasibility study.

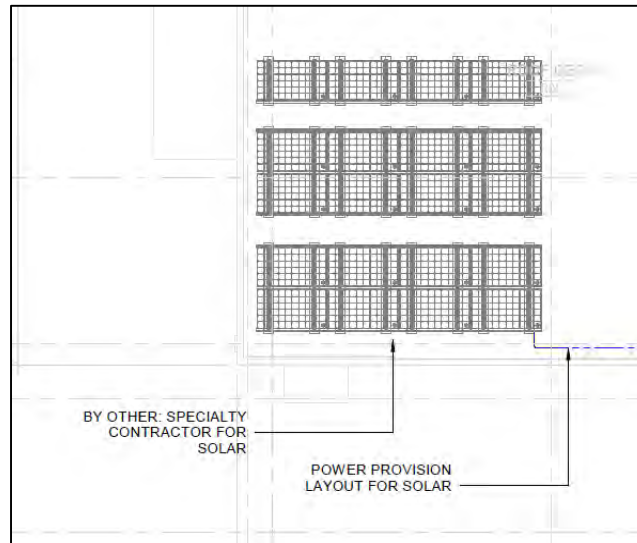
The LZC study should cover as a minimum:

- Energy generated from LZC energy source per year
- Carbon dioxide savings from LZC energy source per year
- Life cycle cost of the potential specification, accounting for payback
- Local planning criteria, including land use and noise
- Feasibility of exporting heat or electricity or both from the system
- Any available grants
- All technologies appropriate to the site and energy demand of the building
- Reasons for excluding other technologies
- CHP system features, if any.

Project Status

There are solar panels on building's roof as can be seen electrical drawings' snapshots below. Capacity of solar system and simulation report that includes annual electricity production of system are not provided.





2.5.4 Lifts

The followings should be considered while choosing lifts:

- An analysis of the transport demand and usage patterns for the building should be carried out to determine the optimum number and size of lifts, escalators or moving walks.
- The energy consumption of lifts should be estimated in accordance with “ISO/DIS 25745 Energy performance of lifts, escalators and moving walks”, “Part 2: Energy calculation and classification for lifts (elevators)” or “Part 3: Energy calculation and classification for escalators and moving walks”. While determining the lifts to be used, 2 lift models or strategy should be compared by considering the energy expenditures and the most efficient lift should be selected.
- For each lift, the following minimum energy efficient features are specified:
 - The lifts should be operable in a standby condition during off-peak periods.
 - The lift car lighting and display lighting should have an average lamp efficacy (across all fittings in the car) of >55 lamp lumens/circuit Watt.
 - The lift should have a drive controller capable of variable speed, variable-voltage, and variable-frequency (VVVF) control of the drive motor.

Project Status

No specific information provided about the lifts. Requirements mentioned above should be added to specifications.

3 Conclusion

Existing architectural, mechanical, electrical design drawings and technical specifications of Green Office Building has been reviewed and results are outlined in this report. General requirements to meet potential design credits are summarized for architectural, landscape, mechanical and electrical disciplines. In addition, administrative issues needed to be added technical specifications are identified.

As a conclusion, with the amendments outlined in this report the project may reach Very Good level certification. Recommendations and strategies to achieve potential points stated in this report shall be provided in the next reports. Comprehensive studies, daylight and energy simulations shall be conducted.



Ministry of Environment

Review and Amend Design of Green Building to attain BREEAM Certification

Final Solution and Recommendation Report



Promoting Energy Efficient Buildings through
Strengthening Low Carbon Energy
Island Strategies (LCEI) Project





FOR MINISTRY OF ENVIRONMENT

April 2021



FINAL SOLUTION AND RECOMMENDATION REPORT

Review and Amend Design of Green Building to attain BREEAM Certification

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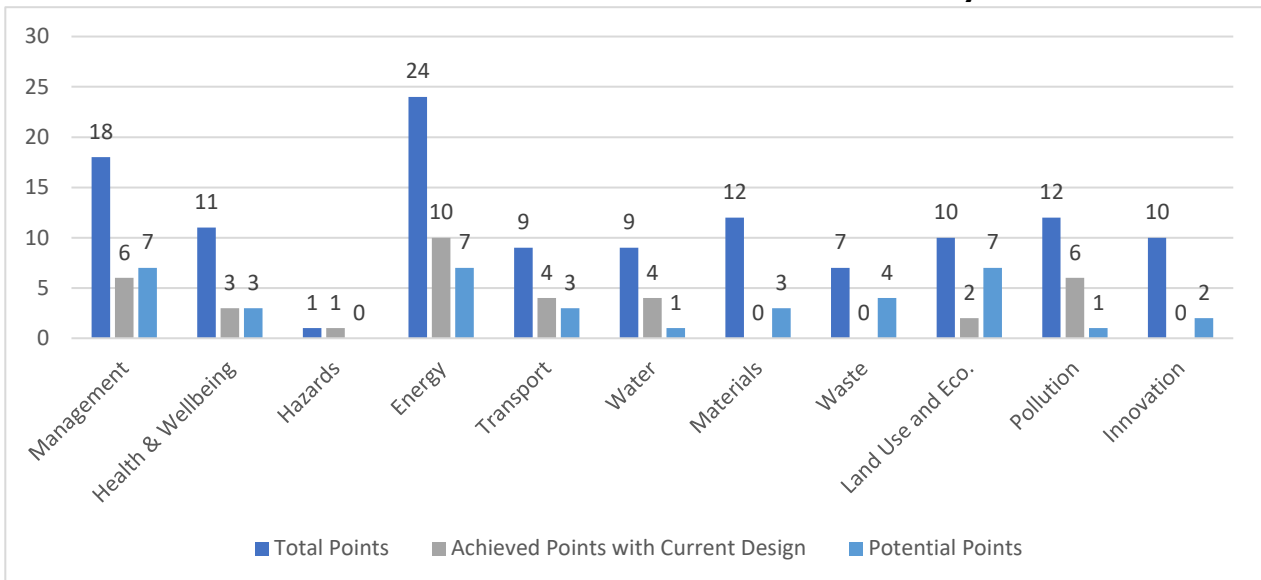
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EXECUTIVE SUMMARY

This final report on solutions and recommendation in design of the Green Office building is conducted on behalf of Ministry of Environment Male’ Republic of Maldives and Housing Development Corporation Ltd. (HDC) under the “Strengthening Low Carbon Energy Island Strategies Project (LCEI). This document is intended to inform, and provide the basis for, detailed discussions regarding the current design proposals and the credits to be targeted to achieve the desired BREEAM rating for the building. This document is also intended to provide detailed guidance to achieve particular credits.

(Table 1) highlights the results of the study, indicating achievable points, potential points and total points for Green Office project under BREEAM International 2016 New Construction scheme. Recommendations in terms of energy and water efficiency provided in this study are expected to be implemented in the project.

Table 1. Final Solutions and Recommendation Study Results



According to the study conducted, the proposed building design has the potential to achieve a BREEAM score of 63.34%. The applicability of the potential points was discussed and specific points were identified that can be targeted with minor architectural design changes and submission of documentations. The overall score with the achieved credits and the targeted credits corresponds to BREEAM Very Good level certification. The BREEAM scorecard is provided as Annex 4 with this report.

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1 INTRODUCTION

1.1 General Information

This report has been developed according to following information provided by design team and calculations made according to existing design of the project.

Project Location : Hulhumale, Maldives

Project Phase : Design Phase

Project Type : Core & Shell

Total Gross Floor Area: 7,683 m²

Total Site Area : 940 m²

Car Parking Spots : 11

Occupancy Info*:

FTE : ~ 250

Visitors : ~ 15

**Number of FTE and visitors is calculated according to default occupancy based on ASHRAE Standard.*

1.2 BREEAM International 2016 Standard

BREEAM (Building Research Establishment's Environmental Assessment Method) is the world's first sustainability rating scheme for the built environment and has contributed much to the strong focus in the UK on sustainability in building design, construction and use. BREEAM is now an International standard that is locally adapted, operated and applied through a network of International operators, assessors and industry professionals.

The rating system evaluate buildings under nine main categories, including Management, Health and Wellbeing, Energy, Transport, Water, Materials, Waste, Land Use and Ecology, Pollution, Innovation.

The credits scored are shown as a weighted percentage score, which itself corresponds to an overall rating of Pass, Good, Very Good, Excellent or Outstanding:

- ≥30 – <45 Pass
- ≥45 – <55 Good
- ≥55 – <70 Very Good
- ≥70 – <85 Excellent
- ≥85 Outstanding

Minimum Standards for BREEAM International 2016 New Construction for Very Good Level

To achieve a particular BREEAM rating, the minimum overall percentage score must be achieved and the minimum standards must be met. Detailed in the below table are the credit requirements applicable for the green building and the current project status corresponding to the project to earn BREEAM very good rating.

Table 2. Minimum Standards for BREEAM International 2016 New Construction for Very Good Level

Credit Name	Requirement
Man 03 Responsible construction practices	All national health and safety legislation and regulations for construction sites should be considered and implemented during; <ul style="list-style-type: none"> ● The design of the asset; to minimise health and safety risks ● Pre-construction work planning and organisation; to collate health and safety information from all relevant stakeholders ● Site set-up; to implement health and safety features ● Construction; to manage, monitor and report on the health and safety of construction site staff.
Hea 01 Visual comfort	All fluorescent and compact fluorescent lamps should be fitted with high frequency ballasts

Hea 02 Indoor air quality	Materials containing asbestos should be prohibited from being specified and used within the building.
Hea 09 Water quality	All water systems in the building should be designed in compliance with the measures outlined in the relevant national health and safety best practice guides or regulations to minimise the risk of microbial contamination, e.g. legionellosis
Ene 02 Energy monitoring	<p>Energy metering systems should be installed that enable at least 90% of the estimated annual energy consumption of each fuel to be assigned to the various end-use categories of energy-consuming systems.</p> <p>The energy-consuming systems in buildings with a gross internal area greater than 1,000m² should be metered using an appropriate energy monitoring and management system.</p>
Wat 01 Water consumption	The project must achieve at least one credit with using efficient water-consuming components and alternative systems.
Wat 02 Water monitoring	The specification of a water meter on the mains water supply to each building; this includes instances where water is supplied via a borehole or other private source.
Mat 03 Responsible sourcing of Construction products	All timber and timber-based products used on the project should be Legally harvested and traded timber.

2 BREEAM International 2016 Credits and Recommendations

2.1 Management

This category encourages the adoption of sustainable management practices in connection with design, construction, commissioning, handover and aftercare activities to ensure that robust sustainability objectives are set and followed through into the operation of the building. Issues in this section focus on embedding sustainability actions through the key stages of design, procurement and initial occupation from the initial project brief stage to the appropriate provision of aftercare.

Category Summary Table

Issue	Credits	Credit Summary
Man 01 Project brief and design	4	<ul style="list-style-type: none"> Stakeholder consultation covering project delivery and relevant third parties. Sustainability champion appointed to facilitate the setting, monitoring and achievement of BREEAM performance targets for the project.
Man 02 Life cycle cost and service life planning	4	<ul style="list-style-type: none"> Recognising and encouraging the use of life cycle costing and service life planning and the sharing of data to raise awareness and understanding.
Man 03 Responsible construction practices	6	<ul style="list-style-type: none"> The principal contractor demonstrates sound environmental management practices and consideration for neighbours across their activities on site. Site related energy, water and transport impacts are monitored and reported to ensure ongoing compliance during the Construction, Handover and Close Out stages and to improve awareness and understanding for future projects.
Man 04 Commissioning and handover	4	<ul style="list-style-type: none"> Schedule of commissioning including optimal timescales and appropriate testing and commissioning of all building services systems and building fabric in line with best practice. Inspecting, testing, identifying and rectifying defects via an appropriate method. Provision of a non-technical building user guide and user training or operator training timed appropriately around handover and proposed occupation.

2.1.1 Man 01 Project Brief and Design

Total Points	Target Points		
4	Y	?	N
	4		

Intent

To recognise and encourage an integrated design process that optimises building performance.

Requirements

Stakeholder Consultation (2 points): A clear sustainability brief which sets out client requirements, sustainability objectives and targets, timescales and budget, consultees and professional appointments, constraints should be developed. AND/OR

Sustainability Champion – Design (1 point): Sustainability champion has been appointed to facilitate the setting and achievement of BREEAM performance targets for the project. AND/OR

Sustainability Champion – Monitoring process (1 point): The credit for sustainability champion (design) has been achieved. A sustainability champion is appointed to monitor progress against the agreed BREEAM performance targets throughout the design process and formally report progress to the client and design team.

Solutions and Recommendations

Stakeholder Consultation (YES): Regular meetings have been conducting between project delivery stakeholders (client, design team, consultation team). The requirements regarding sustainability will be integrated to the project design.

Sustainability Champion – Design & Monitoring Process (YES): BREEAM consultant and Sustainability champion (BREEAM AP) for design stage have been involved to Project team to facilitate the setting, monitoring and achievement of BREEAM performance targets for the project.

2.1.2 Man 02 Life cycle cost and service life planning

Total Points	Target Points		
4	Y	?	N
			4

Intent

To deliver whole life value by encouraging the use of life cycle costing to improve design, specification, through-life maintenance and operation, and through the dissemination of capital cost reporting to promote economic sustainability.

Requirements

Elemental life cycle cost (2 points): An outline, entire asset elemental LCC plan should be carried out at the Concept Design stage together with any design option appraisals in line with 'Buildings and constructed assets – Service life planning – Part 5: Life cycle costing ISO 15686-5:2008. The LCC plan should provide an indication of future replacement costs over a period of as required by client and includes service life, maintenance and operation cost estimates. AND/OR

Component level LCC options appraisal (1 point): A component level LCC options appraisal including envelope, services, finishes and external spaces should be developed by the end of Process Stage 4 (equivalent to Technical Design Stage) in line with ISO 15686-5:2008. AND/OR

Capital cost reporting (1 point): The capital cost of the building should be reported.

Solutions and Recommendations

BREEAM requires the relevant analysis to be completed during the Concept Design stage (RIBA Stage 2). The main intent of this analysis is to analyse and compare the life cycle cost effects of alternative design options at the beginning of the project with the involvement and input from the design team. Due to current status of the design, lack of any input from principal designer and time limitation this credit is marked as "NO".

2.1.3 Man 03 Responsible construction practices

Total Points	Target Points		
6	Y	?	N
		6	

Intent

To recognise and encourage construction sites which are managed in an environmentally and socially considerate, responsible and accountable manner.

Requirements

Credit prerequisite: All timber and timber-based products used during the construction process of the project are 'legally harvested and traded timber'.

Credit prerequisite & Minimum Requirement for Very Good level: All national health and safety legislation and regulations for construction sites are considered and implemented during the design, pre-construction, site set-up and construction phases.

Environmental Management (1 point). The principal contractor operates an environmental management system (EMS) covering their main operations. The EMS must be third party certified to ISO 14001/EMAS or an equivalent standard. Best practice pollution prevention policies and procedures should be implemented on site. AND/OR

Sustainability Champion-construction (1 point). A sustainability champion should be appointed to monitor the project to ensure ongoing compliance with the relevant sustainability performance and process criteria, and therefore BREEAM targets, during the construction, handover and close out work stages. AND/OR

Considerate Construction (2 points). The principle constructor should operate the site in a manner that provide safe and adequate access, considerate surrounding neighbours, mitigate the impact on the environment and ensure the wellbeing of site workers. AND/OR

Monitoring of site impacts (2 points). The site energy and water consumption, the transport movements and impacts resulting from delivery of the majority construction materials to the site and construction waste from the site should be monitored and recorded.

Solutions and Recommendations

In order to achieve credit, the requirements should be included in Construction Specifications and construction site impacts and implementations should be monitored during the construction stage. A sustainability champion should be also appointed for construction stage.

2.1.4 Man 04 Commissioning and handover

Total Points	Target Points		
4	Y	?	N
	2	1	1

Intent

To encourage a properly planned handover and commissioning process that reflects the needs of the building occupants.

Requirements

Commissioning and testing schedule and responsibilities (1 point). A suitable timescale for commissioning and recommissioning of building services and control systems as well as testing and inspecting the building fabric should be prepared. An appropriate project team member should be appointed to monitor and programme pre-commissioning, commissioning, testing and recommissioning. AND/OR

Commissioning building services (1 point). A specialist commissioning manager should be appointed during design stage with responsibility for undertaking design reviews and giving advice on suitability for ease of commissioning, providing commissioning management input to construction programming and during installation stages and management of commissioning, performance testing and handover or post-handover stages. AND/OR

Testing and inspecting building fabric (1 point). The integrity of the building fabric, including continuity of insulation, avoidance of thermal bridging and air leakage paths is quality assured through completion of post-construction testing and inspection. Any defects identified in the site inspection, thermographic survey and the airtightness testing reports are rectified prior to building handover and close out. AND/OR

Handover (1 point). A building user guide should be developed, prior to handover for distribution to the building occupiers and premises managers. Also, a training schedule including the design intent of the building, the available aftercare provision, installed systems and maintenance requirements should be prepared for building occupiers or premises managers.

Solutions and Recommendations

Commissioning and testing schedule and responsibilities & Commissioning building services (YES): CIBSE standard is referred in Mechanical Technical Specifications for commissioning of HVAC systems. ANSI/IEEE standards are referred in Electrical Technical Specifications for commissioning of the electrical systems. Commissioning Schedule, program of works and main contractor's program is also needed.

Testing and inspecting building fabric (NO): Thermographic survey, as well as an airtightness test and inspection should be conducted. The survey and testing should be undertaken by a suitably qualified professional in accordance with the appropriate standard.

Handover (MAYBE): A Building User Guide is related with the post-construction stage. The owner or developer should commit for the requirements to achieve this credit.

2.2 Health and Wellbeing

This category encourages the increased comfort, health and safety of building occupants, visitors and others within the vicinity. Issues in this section aim to enhance the quality of life in buildings by recognising those that encourage a healthy and safe internal and external environment for occupants.

Category Summary Table

Issue	Credits	Credit Summary
Hea 01 Visual comfort	3	<ul style="list-style-type: none"> • Good practice daylighting levels have been met. • Floor space in the relevant building areas has an adequate view out to reduce eye strain and provide a link to the outside. • External lighting systems are designed to avoid flicker and provide appropriate illuminance (lux) levels.
Hea 02 Indoor air quality	2	<ul style="list-style-type: none"> • Minimising sources of air pollution through careful design, specification, and planning. • Building ventilation strategy is designed to be flexible and adaptable to potential future building occupant needs and climatic scenarios
Hea 04 Thermal comfort	2	<ul style="list-style-type: none"> • Thermal modelling carried out to appropriate standards. • Projected climate change scenarios considered as part of the thermal model.
Hea 05 Acoustic Performance	1	<ul style="list-style-type: none"> • The building meets appropriate acoustic performance standards and testing requirements in terms of: <ul style="list-style-type: none"> • Sound insulation • Indoor ambient noise levels • Reverberation times.
Hea 06 Accessibility	2	<ul style="list-style-type: none"> • Provision of effective measures which support safe access to and from the building. • Security needs are understood and taken into account in the design and specification.
Hea 07 Hazards	1	<ul style="list-style-type: none"> • Risk assessment for natural hazards that may affect the building and the implementation of measures to mitigate any risks.
Hea 09 Water quality	1	<ul style="list-style-type: none"> • Reduction of water contamination risk and provision of clean fresh sources of water

2.2.1 Hea 01 Visual Comfort

Total Points	Target Points		
3	Y	?	N
	1	1	1

Intent

To ensure daylighting, artificial lighting and occupant controls are considered at the design stage to ensure best practice in visual performance and comfort for building occupants.

Requirements

Credit prerequisite & Minimum requirement for Very Good level: All fluorescent and compact fluorescent lamps should be fitted with high frequency ballasts.

Daylight: For Office buildings, average daylight illuminance should be at least 300 lux for 2000 hours per year or more for regularly occupied areas OR Average daylight factor should be minimum 1.5% for 80% of the relevant building areas and a uniformity ratio should be at least 0.3.

View out: 95% of the floor area space within relevant building areas should meet distance and window size requirements.

External lighting level: All external lighting located within the construction zone should be designed to provide illuminance levels that enable users to perform outdoor visual tasks efficiently and accurately, especially during the night. To demonstrate this, external lighting provided should be specified in accordance with EN 13201 series Road Lighting and EN 12464-2:2014 Light and lighting – Lighting of workplaces – Part 2: Outdoor workplaces.

Solutions and Recommendations

Credit prereq.: Fluorescent lamps will be used in the Project according to design documents. The requirement regarding high frequency ballasts must be added to Electrical Technical Specifications.

Daylight (NO): According to provided document ‘A5000 Schedules’ SOLAR E PLUS GRAPHITE BLUE is identified as façade glass. Daylight simulation has been conducted according to daylight transmittance of selected glass which is provided below table. According to results of daylight modelling the building could not meet daylight criteria as the depth of the relevant building areas is over the required limit and the transmittance percentage of is about 30% which is too low. Alternatively, simulations were conducted with 50% and 60% transmittance which did not meet the daylight criterion set by BREEAM. Daylight report for the building is provided as Annex 1. Alternative glazing reports with 50% and 60% transmittance is provided as Annex 2.

Monolithic Performance Data^{1,10}

	Nominal Glass Thickness		Visible Light ²			Solar Energy ²			U-Factor ⁵			Solar Heat Gain Coefficient ⁷	Shading Coefficient ⁸
	in.	mm	Transmittance ³ %	Reflectance ⁴ %		Transmittance ² %	Reflectance ⁴ %	UV Transmittance ² %	U.S. Summer [*]	U.S. Winter [*]	European ⁶		
				Outside	Inside								
Pilkington Solar-E™ solar control low-e (coating on #2 surface)													
Clear	1/8	3	60	8	9	46	8	48	0.50	0.66	3.7	0.54	0.63
	5/32	4	60	8	9	45	8	46	0.50	0.65	3.7	0.54	0.62
	3/16	5	60	7	9	44	7	44	0.50	0.65	3.7	0.53	0.61
	1/4	6	60	8	9	44	7	44	0.50	0.65	3.7	0.53	0.61
	5/16	8	59	8	9	42	7	41	0.50	0.64	3.7	0.52	0.59
EverGreen	3/8	10	60	8	9	40	7	38	0.49	0.64	3.6	0.50	0.58
	1/4	6	45	6	9	20	5	8	0.50	0.65	3.7	0.35	0.40
5/16	8	40	7	9	16	5	5	0.50	0.64	3.7	0.32	0.36	
Pilkington Solar-E™ Plus solar control low-e (coating on #2 surface)													
Grey	1/4	6	24	5	9	19	5	12	0.50	0.65	3.7	0.34	0.39
	5/16	8	19	5	8	15	5	9	0.50	0.65	3.7	0.31	0.36
Blue-Green	1/4	6	41	6	9	24	5	19	0.50	0.65	3.7	0.38	0.43
	5/16	8	29	6	9	21	5	15	0.50	0.65	3.7	0.35	0.40
Graphite Blue	1/4	6	35	6	9	28	5	23	0.50	0.65	3.7	0.41	0.47
	5/16	8	30	6	9	23	5	18	0.50	0.65	3.7	0.37	0.43
Arctic Blue	1/4	6	30	5	8	17	5	11	0.50	0.65	3.7	0.32	0.37
	5/16	8	27	6	8	14	5	9	0.50	0.65	3.7	0.30	0.35

View out (YES): The depth of the typical office floors is more than 20m. Window size of the surrounding Wall area is more than 35%.

External lighting level (MAYBE): Technical datasheets of selected lighting fixtures' and relevant calculations should be provided with the existing design documents. Also, relevant section or clauses of the building specification or contract OR A letter of formal confirmation of compliance from the relevant design team member is required to achieve criteria.

2.2.2 Hea 02 Indoor Air Quality

Total Points	Target Points		
2	Y	?	N
	1	1	1

Intent

To recognise and encourage a healthy internal environment through the specification and installation of appropriate ventilation, equipment and finishes.

Requirements

Credit prerequisite & Minimum requirement for Very Good level: Materials containing asbestos should be prohibited from being specified and used within the building.

Ventilation (1 point). Provide fresh air into the building in accordance with the criteria of the national best practice standard for ventilation. The location of fresh air intakes are designed to minimise the entry of air pollutants into the building. Areas of the building subject to large and unpredictable or variable occupancy patterns should have carbon dioxide (CO₂) or air quality sensors specified. AND/OR

Adaptability - Potential for natural ventilation (1 point). The building ventilation strategy is designed to be flexible and adaptable to potential building occupant needs and climatic scenarios. Occupied spaces of the building are designed to be capable of providing fresh air entirely via a natural ventilation strategy.

Solutions and Recommendations

Credit prereq.: The requirement should be added to Construction Specifications OR appropriate legislations forbids using asbestos in buildings should be provided.

Ventilation (NO): Since the project is Core&Shell, ventilation system in Office areas will be in tenant scope. Fresh air rates supplied to (lobby, common halls, meeting rooms, multipurpose areas, admin Office could not be checked as fresh air rates supplied these areas are not provided in design drawings.

Adaptability - Potential for natural ventilation (MAYBE): According to provided document 'A5000 Schedules' fixed and awning windows are designed. In order to fulfil natural ventilation requirements, windows should be fully openable. Thus, the design of the windows can be changed to swing doors to meet the requirements.

2.2.3 Hea 04 Thermal comfort

Total Points	Target Points		
2	Y	?	N
			2

Intent

To recognise and encourage a healthy internal environment through the specification and installation of appropriate ventilation, equipment and finishes.

Requirements

Thermal modelling (1 point). Thermal modelling (or an analytical measurement or evaluation of the thermal comfort levels of the building) should be carried out using the predicted mean vote (PMV) and predicted percentage of dissatisfied (PPD) indices in accordance with ISO 7730:2005 taking full account of seasonal variations. AND/OR

Adaptability - for a projected climate change scenario (1 point). The thermal modelling demonstrates that thermal comfort levels in occupied spaces meet the Category B requirements set out in Table A.1 of Annex A of ISO 7730:2005 are achieved for a projected climate change environment.

Solutions and Recommendations

Design temperatures of conditioned spaces should comply with the relevant standards. Full HVAC drawings, fresh air intake of individual spaces and cooling/heating design temperatures for spaces are required to achieve the 2 maybe points in his category. Therefore, these 2 potential points in this section will not be targeted.

2.2.4 Hea 05 Acoustic Performance

Total Points	Target Points		
1	Y	?	N
			1

Intent

To ensure the building's acoustic performance, including sound insulation meets the appropriate standards for its purpose.

Requirements

Credit prerequisite: A suitably qualified acoustician (SQA) should be appointed. AND

Indoor ambient noise and sound insulation (1 point). All unoccupied spaces should comply with the indoor ambient noise level targets according to national building regulations or good practice standards defined by BREEAM. An ambient noise measurement should be carried out by SQA to ensure that the relevant spaces achieve the required levels.

Solutions and Recommendations

Credit prereq.: A SQA should be appointed at the design stage to provide design advice on:

- External sources of noise impacting the chosen site
- Site layout and zoning of the building for good acoustics
- Acoustic requirements for users with special hearing and communication needs
- Acoustic treatment of different zones and façades

Indoor ambient noise and sound insulation (NO): Indoor ambient noise level should meet national building regulations or other appropriate good practice standards. A SQA should carry out ambient noise measurements to ensure that the relevant spaces achieve the required levels. Where the measurements identify that spaces do not meet the standards, remedial works are carried out and the measurements repeated to confirm that the levels are achieved prior to handover and occupation.

Due to time limitations on design process the credit is marked as NO.

2.2.5 Hea 06 Accessibility

Total Points	Target Points		
2	Y	?	N
	2		

Intent

To recognise and encourage effective measures that promote safe and secure use, and access to and from the building.

Requirements

Safe access (1 point). Dedicated cycle lanes and footpaths should be provided in project area. Where provided, drop-off areas are designed off, or adjoining, the access road and provide direct access to pedestrian footpaths, therefore avoiding the need for the pedestrian to cross vehicle access routes. Dedicated pedestrian crossings are provided where pedestrian routes cross vehicle access routes, and appropriate traffic calming measures are in place to slow traffic down at these crossing points. AND/OR

Inclusive and accessible design (1 point). The building should be designed to be fit for purpose, appropriate and accessible by all potential users. The access strategy addresses, as a minimum, access to and throughout the development for all users, with particular emphasis on the following:

- Disabled users; addressing and proposing design solutions that remove obstacles that define disability
- People of different age groups, genders, ethnicity and fitness levels
- Parents with children (where appropriate to building use or type).

Solutions and Recommendations

The following features are already designed:

- The width of the pedestrian path is more than 1.5m in the project.
- Safe pedestrian route (sidewalks and ramps) is provided from the pedestrian exit of the car park and site entrance to the Building entrance.
- The general layout of building and site design provide practical access to and through the places.

Dedicated pedestrian crossings should also be provided where pedestrian routes cross vehicle access routes, and appropriate traffic calming measures are in place to slow traffic down at these crossing points.

2.2.6 Hea 07 Hazards

Total Points	Target Points		
1	Y	?	N
	1		

Intent

To reduce or negate the impact of a natural hazard on the building.

Requirements

A risk assessment is carried out at the outline proposal or Concept Design stage by an appropriate person, or persons, to identify any potential natural hazards in the region of the development.

Where a potential hazard is identified, mitigation measures appropriate to the level of risk should be identified by an appropriate person and implemented.

Solutions and Recommendations

Natural hazards risk assessment reports for Hulhumale island meet credit requirements.

2.2.7 Hea 09 Water quality

Total Points	Target Points		
1	Y	?	N
		1	

Intent

To minimise the risk of water contamination in building services and ensure the provision of clean, fresh sources of water for building users.

Requirements

Building services water systems: Minimising risk of contamination (1 point). All water systems in the building should be designed in compliance with the measures outlined in the relevant national health and safety best practice guides or regulations to minimise the risk of microbial contamination, e.g., legionellosis.

Solutions and Recommendations

The relevant section or clauses of the Building specification or contract should be provided for the following water systems to minimise risk of contamination:

- Cooling towers
- Evaporative condensers
- Domestic hot and cold-water systems
- Other plant and systems containing water which is likely to exceed 20°C and which may release a spray or aerosol during operation or when being maintained, for example:
 - Humidifiers and air washers
 - Spa baths and pools
 - Car or bus washes
 - Wet scrubbers
 - Indoor fountains and water features.

To achieve this credit compliance documents within the Maldives context in relevance to the national health and safety best practice guides or regulations must be submitted. Within the current design of the building, the requirements will be applied to maintaining water quality for domestic hot and cold-water systems.

2.3 Energy

This category encourages the specification and design of energy efficient building solutions, systems and equipment that support the sustainable use of energy in the building and sustainable management in the building's operation. Issues in this section assess measures to improve the inherent energy efficiency of the building, encourage the reduction of carbon emissions and support efficient management throughout the operational phase of the building's life.

Category Summary Table

Issue	Credits	Credit Summary
Ene 01 Reduction of energy use and carbon emissions	15	<ul style="list-style-type: none"> Recognise improvements in the energy performance of the building above national building regulations in relation to heating and cooling energy demand, primary energy consumption and carbon dioxide emissions. Encourage steps taken to reduce energy demand through building design and systems specification.
Ene 02 Energy monitoring	2	<ul style="list-style-type: none"> Energy metering systems are installed to enable energy consumption to be assigned to end uses. Sub-meters are provided for high energy load and tenancy areas.
Ene 03 External lighting	1	<ul style="list-style-type: none"> Specification of energy efficient light fittings for external areas of the development and controls to prevent use during daylight hours or when not needed.
Ene 04 Low carbon design	3	<ul style="list-style-type: none"> Analysis of the proposed building design and development is undertaken to identify opportunities for and encourage the adoption of passive design solutions, including free cooling. A feasibility study has been carried out to establish the most appropriate on site or near site low or zero carbon (LZC) energy sources for the building or development, and is specified
Ene 06 Energy efficient transport systems	3	<ul style="list-style-type: none"> An analysis of the transport demand and usage patterns is undertaken to determine the optimum number and size of lifts, escalators or moving walks. Energy efficient installations are specified.

2.3.1 Ene 01 Reduction of energy use and carbon emissions

Total Points	Target Points		
15	Y	?	N
	9	1	5

Intent

To recognise and encourage buildings designed to minimise operational Energy demand, Primary energy consumption and CO₂ emissions.

Requirements

Calculate an Energy Performance Ratio for International New Constructions (EPRINC).

The methodology for the EPRINC calculation considers three performance metrics of the modelled building when determining the number of credits achieved for this issue. The three-performance metrics are:

- The building's heating and cooling energy demand (MJ/m²)
- The building's primary energy consumption (kWh/m²)
- The total resulting CO₂ emissions (kgCO₂/m²)

Calculate the baseline building performance according to ASHRAE Standard 90.1–2013, using a simulation model.

- 1 credit → 0.06 EPRINC
- 15 credits → 0.9 EPRINC

Solutions and Recommendations

The building's energy efficiency has been calculated and results are shared as Annex 3. The followings should be taken into consideration in order to achieve desired level of energy efficiency:

- **Roof insulation:** Insulation thickness is 12 cm for roof to meet 0.273 W/m²K Performance value defined in ASHRAE 90.1-2013 Table 5.5.1.
- **Windows Selection:** Solar low-e double glazing glass has been selected in this project according to project design documents. Window (glass+frame) performance values should be 1.8 W/m²K and SHGC: 0.32.
- **Outdoor Air System:** Outdoor air should be provided to zones to meet ASHRAE 62.1-2013 requirements. Required total outdoor air flow rate equals 17,800 m³/h. Please see the 'Ventilation_62.1_2013_Green Offices Maldives.pdf' document that includes zone by zone outdoor air calculations.
- **Heat Recovery:** Heat recovery device in AHUs should be placed. Effectiveness value of these devices is higher or equal to %70.
- **Lighting System:** Lighting density values (LPD) should be 25% efficient than LPD values defined in ASHRAE 90.1-2013 Table 9.6.1 for each zone type.

- **Air Cooled Chiller with VSD control:** Air cooled chiller should have VSD control type and full load/part load efficiency values should be higher or equal to Performance values defined in ASHRAE 90.1-2013 Table 6.8.1.3. These values are; COP: 2.866, IPLV: 4.758.
- **Fan and Pump Motor Efficiency:** Fans and pump motor efficiency class should be higher or equal to IE3 class.
- **PV System:** It is proposed that photovoltaic system should be designed in project's roof area with over 40 kW capacity.

Currently the project achieves 9 out of 15 points. By experience, this is a quite challenging target to achieve for a core & Shell office building this size. To aim for full points from this credit, it will require additional features like advanced insulation and glazing, extra efficient HVAC equipment and alternative systems that may not be available or too costly to supply.

Additionally, BREEAM calculates the energy efficiency via energy modelling, which is basically comparing the annual energy consumption of the proposed building with a baseline building defined in the Standard, using a simulation software. Since Green Office building shall be constructed and certified as Core & Shell, most of the area in the building is out of the scope and will be considered neutral in energy model, resulting in narrowing the ways to improve proposed design compared to baseline in terms of energy efficiency.

The additional credit marked as (MAYBE) can potentially be achieved by installing a PV system with a minimum capacity of 40KW.

2.3.2 Ene 02 Energy Monitoring

Total Points	Target Points		
2	Y	?	N
	1	1	

Intent

To recognise and encourage the installation of energy sub-metering that facilitates the monitoring of operational energy consumption.

Requirements

Minimum requirement for BREEAM Very Good level: Sub-metering of major energy-consuming systems (1 point). Energy metering systems should be installed that enable at least 90% of the estimated annual energy consumption of each fuel to be assigned to the various end-use categories of energy-consuming systems. The energy-consuming systems in buildings with a gross internal area greater than 1,000m² should be metered using an appropriate energy monitoring and management system. AND/OR

Sub-metering of high energy load and tenancy areas (1 point). An accessible energy monitoring and management system or separate accessible energy sub-meters with pulsed or other open protocol communication outputs to enable future connection to an energy monitoring and management system are provided, covering a significant majority of the energy supply to tenanted areas or, in the case of single occupancy buildings, relevant function areas or departments within the building or unit.

Solutions and Recommendations

Sub-metering of major energy-consuming systems (MAYBE): There is a main energy meter in main distribution panel. All the main building utility systems that consumed more than 10% of the overall energy demand of the building should be sub metered individually at the system level. All the design of electrical panels and power distribution panels should be designed accordingly. The systems to be sub metered may be summarized as:

- Space cooling (chiller)
- Domestic hot water system
- Ventilation System (AHU, supply fans etc.)
- Transportation System
- Lighting System

Sub-metering of high energy load and tenancy areas (YES): Each tenanted unit are submetered seperately in existing design drawings.

2.3.3 Ene 03 External Lighting

Total Points	Target Points		
1	Y	?	N
		1	

Intent

To recognise and encourage the specification of energy efficient light fittings for external areas of the development.

Requirements

The average initial luminous efficacy of the external light fittings within the construction zone should not be less than 60 luminaire lumens per circuit Watt. OR

All external light fittings should be automatically controlled for prevention of operation during daylight hours and presence detection in areas of intermittent pedestrian traffic.

Solutions and Recommendations

Selected external lighting fixtures should meet the credit requirements. The relevant section or clauses of the building specification or contract should be provided.

2.3.4 Ene 04 Low carbon design

Total Points	Target Points		
3	Y	?	N
		1	2

Intent

To encourage the adoption of design measures, which reduce building energy consumption and associated carbon emissions and minimise reliance on active building services systems.

Requirements

Passive design analysis (1 point). If the Hea 04 Thermal Comfort credit Thermal Modelling is achieved this option can be targeted. The building should use passive design measures to reduce the overall building energy demand, primary energy consumption or CO₂ emissions by at least 5%, in line with the findings of the passive design analysis. AND/OR

Free cooling (1 point). Passive design analysis should be achieved. Free cooling should apply to all occupied spaces in the building. The free cooling analysis should demonstrate consideration of appropriate technologies from the following: night time cooling, ground coupled air cooling, displacement ventilation, ground water cooling surface water cooling, evaporative cooling, desiccant dehumidification and evaporative cooling, absorption cooling. AND/OR

Low and zero carbon technologies (1point). A feasibility study should be carried out by an energy specialist to establish the most appropriate recognised local (on site or near site) low or zero carbon energy sources for the building or development. A local LZC technology has been specified for the building or development in line with the recommendations of this feasibility study.

Solutions and Recommendations

Passive design analysis (NO): If the Hea 04 Thermal Comfort credit Thermal Modelling is achieved this option can be targeted.

Free cooling (NO): Free cooling is not designed in the project.

Low and zero carbon Technologies (MAYBE): It is proposed that photovoltaic system should be designed in project’s roof area with over 40 kW capacity. Feasibility study covers the followings should be conducted:

- Energy generated from LZC energy source per year
- Carbon dioxide savings from LZC energy source per year
- Life cycle cost of the potential specification, accounting for payback
- Local planning criteria, including land use and noise
- Feasibility of exporting heat or electricity or both from the system
- Any available grants
- All technologies appropriate to the site and energy demand of the development
- Reasons for excluding other technologies
- Where appropriate to the building type, connecting the proposed building to an existing local community CHP system or source of waste heat or power OR specifying a building or

site CHP system or source of waste heat or power with the potential to export excess heat or power via a local community energy scheme.

2.3.5 Ene 06 Energy Efficient Transportation System

Total Points	Target Points		
3	Y	?	N
	3		

Intent

To recognise and encourage the specification of energy efficient transport systems.

Requirements

Energy consumption (1 point). An analysis of the transport demand and usage patterns for the building has been carried out to determine the optimum number and size of lifts, escalators or moving walks.

Energy efficient features (2 points). Energy consumption criterion is achieved. For each lift, the following three energy efficient features are specified:

- The lifts operate in a standby condition during off-peak periods. For example, the power side of the lift controller and other operating equipment such as lift car lighting, user displays and ventilation fans switch off when the lift has been idle for a prescribed length of time
- The lift car lighting and display lighting provides an average lamp efficacy (across all fittings in the car) of >55 lamp lumens/circuit Watt
- The lift uses a drive controller capable of variable speed, variable-voltage, and variable-frequency (VVVF) control of the drive motor.

Where the use of regenerative drives is demonstrated to save energy, they are specified.

Solutions and Recommendations

An analysis of the transport demand and usage patterns should be conducted and the most energy efficient features should be assessed and included in the specifications.

2.4 Transport

This category encourages better access to sustainable means of transport for building users. Issues in this section focus on the accessibility of public transport and other alternative transport solutions (cyclist facilities, provision of amenities local to a building) that support reductions in car journeys and, therefore, congestion and CO₂ emissions over the life of the building.

Category Summary Table

Issue	Credits	Credit Summary
Tra 01 Public transport accessibility	3	<ul style="list-style-type: none"> Recognition of developments in close proximity to good public transport networks, thereby helping to reduce transport-related pollution and congestion.
Tra 02 Proximity to amenities	1	<ul style="list-style-type: none"> Recognition of developments in close proximity of, and accessible to, local amenities which are likely to be frequently required and used by building occupants.
Tra 03 Alternative modes of transport	2	<ul style="list-style-type: none"> Provision of facilities to encourage travel using low carbon modes of transport and to minimise individual journeys.
Tra 04 Maximum carparking capacity	2	<ul style="list-style-type: none"> Recognition of developments that limit car parking capacity.
Tra 05 Travel plan	1	<ul style="list-style-type: none"> To promote sustainable reductions in transport burdens by undertaking a site specific travel assessment or statement and developing a travel plan based on the needs of the particular site.

2.4.1 Tra 01 Public Transport Accessibility

Total Points	Target Points		
3	Y	?	N
	1		2

Intent

To recognise and encourage development in proximity of good public transport networks, thereby helping to reduce transport-related pollution and congestion.

Requirements

The public transport Accessibility Index (AI) for the assessed building should be calculated.

Accessibility Index	≥ 0.5	≥ 1	≥ 2	≥ 4	≥ 8	≥ 10	≥ 12	≥ 18
Building type			BREEAM credits available					
Offices, Industrial, Long term residential institutions, Other building - Staffed	-	-	1	2	3	-	-	-
Preschool, School	-	-	1	2	3	-	-	-
Retail, Higher education - Off campus, Hotels and short term residential institutions, Other building - Visitors	-	-	1	2	3	3	4	5
Higher education - On campus	-	-	1	2	3	4	5	-
Rural location sensitive buildings, Other buildings - Rural,	-	-	1	2	-	-	-	-
Residential dwellings	1	2	3	4	-	-	-	-

Solutions and Recommendations

According to the project location, 3 public transportation nodes are located within 400 meters walking distance. Number of bus lines and frequency of bus lines have been checked. Public transport accessibility index has been calculated as 3.63. Therefore; 1 point awarded.

BREEAM International 2016 Tra 01 Public transport accessibility calculator **BREEAM**[®]

Using the drop down boxes make the relevant selections and press the 'Select' button

Building type: Select

No. nodes required:

Dedicated bus service:

NODE 1

Public transport type	Bus									
Distance to node (m)	400									
	Service 1	Service 2	Service 3	Service 4	Service 5	Service 6	Service 7	Service 8	Service 9	Service 10
Average frequency per hour	3									

NODE 2

Public transport type	Bus									
Distance to node (m)	350									
	Service 1	Service 2	Service 3	Service 4	Service 5	Service 6	Service 7	Service 8	Service 9	Service 10
Average frequency per hour	2	2								

NODE 3

Public transport type	Bus									
Distance to node (m)	45									
	Service 1	Service 2	Service 3	Service 4	Service 5	Service 6	Service 7	Service 8	Service 9	Service 10
Average frequency per hour	1									

Accessibility Index	3.63
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Tra01 total credits achieved	1
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2.4.2 Tra 02 Proximity to Amenities

Total Points	Target Points		
1	Y	?	N
	1		

Intent

To encourage and reward a building location that facilitates easy access to local services and so reduces the environmental, social and economic impacts resulting from multiple or extended building user journeys, including transport-related emissions and traffic congestion.

Requirements

All building types must be located within the stated proximity of at least two accessible core amenities:

Table 32 Credits available for Tra 02 for different building types

Criteria	Building types					
	Type 1	Type 2	Type 3	Type 5 (Two credits available)		Type 6
No. of BREEAM credits	1	1	1	1	1	1
No. of amenities required	3	3	4	4	7	2
Proximity (metres)	500	500	500	500	1000	500
Appropriate food outlet	C	C	C	C	C	✓

Criteria	Building type:					
	Type 1	Type 2	Type 3	Type 5 (Two credits available)		Type 6
Access to cash	C	C	C	C	C	✓
Access to a recreation or leisure facility for fitness or sports	C	C	C	✓	✓	✓
Access to an outdoor open space (public or private, suitably sized and accessible to building users)	✓	✓	✓	C	C	✓
Publicly available postal facility	✓	✓	✓	✓	✓	✓
Community facility	✓	✓	✓	✓	✓	✓
Over the counter services associated with a pharmacy	✓	✓	✓	✓	✓	✓
Public sector doctor's surgery or general medical centre	-	-	✓	✓	✓	✓
Child care facility or school	✓	-	✓	✓	✓	✓

Key:
 C - Core amenity for building type
 ✓ - Amenity relevant to building type.

Solutions and Recommendations

According to the project location, all core amenity types indicated above table are accessible and walking distance between project entrance and core amenities is less than 500 meters. Also, the central location of the building allows access to outdoor open areas such as parks and child care facilities such as schools.

2.4.3 Tra 03 Alternative Modes of Transport

Total Points	Target Points		
2	Y	?	N
		2	

Intent

To provide facilities which encourage building users to travel using low carbon modes of transport and to minimise individual journeys.

Requirements

One of the following options should be implemented:

- Consultation with the local authority on the state of the local cycling network and how the development could contribute to improving it.
- Negotiations with local bus companies have resulted in an increase of the local service provision in the development’s local area.
- Electric recharging stations have been provided for at least 3% of the total car parking capacity for the building.
- A car sharing group or facility has been set up to facilitate and encourage building users to sign up to a car sharing scheme.
- Compliant cycle storage spaces should be provided for staff and customers.

Solutions and Recommendations

One of the following two alternatives could be implemented in project:

- Electric recharging stations should be provided for at least 3% of the total car parking capacity for the building. Number of required EV recharging stations is 1.

AND / OR

- **Compliant cycle storage spaces:**
 - Required number of bicycle storage: 24 pcs
 - Required number of shower/changing facilities: 3 pcs

Bicycle parking area is defined within the site boundary. However, the number of bicycle racks is not specified. There is no shower & changing facility in the design documents of the building.

If, two of the options above have been implemented in project, an additional point (Innovation point) can be also targeted.

2.4.4 Tra 04 Maximum Carparking Capacity

Total Points	Target Points		
2	Y	?	N
	2		

Intent

To encourage the use of alternative means of transport other than the private car to and from the building, thereby helping to reduce transport-related emissions and traffic congestion associated with the building's operation.

Requirements

For office building max. parking capacity should not exceed 1 space per 4 building users.

Solutions and Recommendations

Since the number of total car parking space is 11, the parking capacity do not exceed the requirement.

2.4.5 Tra 05 Travel Plan

Total Points	Target Points		
1	Y	?	N
		1	

Intent

To recognise the consideration given to accommodating a range of travel options for building users, thereby encouraging the reduction of reliance on forms of travel that have the highest environmental impact.

Requirements

A site-specific travel plan should be developed as part of the feasibility and design stages. The travel plan should include a package of measures to encourage the use of sustainable modes of transport and movement of people and goods during the building's operation and use.

Solutions and Recommendations

The credit is related to design and building operational phases. In order to achieve credit an appropriate travel plan would be developed and implemented in design phase by Owner or Design Team. The travel plan is structured to meet the needs of the site and covers the following (as a minimum):

- Where relevant, existing travel patterns and opinions of existing building or site users towards cycling and walking so that constraints and opportunities can be identified
- Travel patterns and transport impact of future building users
- Current local environment for walkers and cyclists (accounting for visitors who may be accompanied by young children)
- Disabled access (accounting for varying levels of disability and visual impairment)
- Public transport links serving the site
- Current facilities for cyclists.

If a sample Travel Plan complying with these requirements can be developed with input from the Client and/or Facility management, this credit can be achieved.

2.5 Water

This category encourages sustainable water use in the operation of the building and its site. Issues in this section focus on identifying means of reducing potable water consumption (internal and external) over the lifetime of the building and minimising losses through leakage.

Category Summary Table

Issue	Credits	Credit Summary
Wat 01 Water consumption	5	<ul style="list-style-type: none"> Reducing the demand for potable water through the provision of efficient sanitary fittings, rainwater collection and water recycling systems.
Wat 02 Water monitoring	1	<ul style="list-style-type: none"> Specification of water meters on the mains water supply to encourage water consumption management and monitoring to reduce the impacts of inefficiencies and leakage.
Wat 03 Water leak detection	2	<ul style="list-style-type: none"> Recognition of leak detection systems capable of detecting a major water leak on the mains water supply Flow control devices that regulate the supply of water to each WC area or facility to reduce water wastage Easily accessible leak isolation valves, to allow leaks to be stopped and then fixed quickly and with minimum water wastage.
Wat 04 Water efficient equipment	1	<ul style="list-style-type: none"> Identify a building's water demand from uses other than domestic-scale drinking and sanitary components and mitigate or reduce their consumption.

2.5.1 Wat 01 Water Consumption

Total Points	Target Points		
5	Y	?	N
	3		2

Intent

To reduce the consumption of potable water for sanitary use in new buildings from all sources through the use of water efficient components and water recycling systems.

Requirements

Minimum requirement for BREEAM Very Good level: The project must achieve at least one credit with using efficient water-consuming components and alternative systems.

Carry out an assessment of the efficiency of the building's domestic water-consuming components using the BREEAM Wat 01 calculator. Compare the water consumption (L/person/day) for the assessed building against a baseline performance and BREEAM credits awarded based upon the relevant BREEAM guide.

WCs, urinals, taps, showers, baths, dishwashers and washing machines should be included in the assessment. Specify the use of greywater or rainwater system to offset non-potable water demand. Any greywater systems must be specified and installed in compliance with the national best practice standard.

Solutions and Recommendations

Water fixture flush/flow features should not exceed the followings. In the later stages, the relevant criteria should be added to the specifications.

- Taps : Max. 1.9 liter/min
- Kitchen taps : Max 5 liter/min
- Shower : Max 6 liter/min
- Urinal : Max. 1 liter/flush
- WCs : Max. 3/6 liter/flush

Project water supply calculations made according to Uniform Plumbing Code (UPC) Data Book Table 6.3 (Fixture Unit Loads per Plumbing Fixture). Brand/model name and water consumption of the selected flow and flush fixtures should be provided. The relevant criteria should be also added to the specifications.

If a washing machine or dishwasher will be provided in the project, efficiency values must meet the following conditions:

- Commercial sized dishwashers : Max. 5 liter/rack
- Commercial sized washing machines : 7.50 liter/kg
- Domestic sized dishwashers : 12 liter/cycle
- Domestic sized washing machines : 40 liter

In addition, rainwater and condensate drain water are collected and reused for irrigation.

2.5.2 Wat 02 Water Monitoring

Total Points	Target Points		
1	Y	?	N
		1	

Intent

To ensure water consumption can be monitored and managed, and therefore encourage reductions in consumption.

Requirements

Minimum requirement for BREEM Very Good level: Install a water meter on the mains water supply to each building; this includes instances where water is supplied via a borehole or other private source.

Also, meter water-consuming plant or building areas that consuming 10% or more of the building's total water demand.

Each meter (main and sub) should have an open protocol communication output to enable connection to an appropriate utility monitoring and management system, e.g. a building management system (BMS), for the monitoring of water consumption.

Solutions and Recommendations

Water meter is provided on mains water supply.

Water meters are available for potable and non-potable water lines in tenant spaces.

In addition, water meters should be provided for building areas consuming 10% or more of the building's total water demand such as indoor plumbing fixtures, irrigation system, reclaimed water.

Water meters should have pulsed outputs or other open protocol communication outputs, such as Modbus. Relevant requirements should be added to Mechanical Technical Specifications.

Wat 03 Water Leak Detection

Total Points	Target Points		
2	Y	?	N
			2

Intent

To reduce the impact of water leaks that may otherwise go undetected.

Requirements

Leak detection system (1 point). A permanent leak detection system must be capable of detecting a major water leak on the mains water supply within the building and between the building and the utilities' water meter is installed. It should have an automated system that alerts the building occupants to the leak or an inbuilt automated diagnostic procedure for detecting leaks.

- A permanent automated water leak detection system that alerts the building occupants to the leak or an inbuilt automated diagnostic procedure for detecting leaks
- Activated when the flow of water passing through the water meter or data logger is at a flow rate above a pre-set maximum for a pre-set period of time
- Able to identify different flow and therefore leakage rates, e.g. continuous, high or low level, over set time periods
- Programmable to suit the owner's or occupiers' water consumption criteria
- Where applicable, designed to avoid false alarms caused by normal operation of large water-consuming plant such as chillers.

Flow control devices (1 point). Install flow control devices that regulate the supply of water to each WC area or facility according to demand.

Solutions and Recommendations

Leak detection system: The leak detection equipment installed must have the flexibility to distinguish between different flow rates to enable it to be programmed to suit the building type and owner's or occupiers' usage patterns.

Flow control devices: Flow control systems may control combined WC areas, such as male and female toilets within a core; they are not required for each individual sanitary appliance. A time controller, a volume controller, a presence detector and controller or a central control unit could be considered as types of flow control devices.

2.5.3 Wat 04 Water Efficient Equipment

Total Points	Target Points		
1	Y	?	N
	1		

Intent

To reduce water consumption by encouraging specification of water efficient equipment.

Requirements

The design team should identify all water demands from uses other than domestic-scale drinking and sanitary use components, e.g. vehicle wash and irrigation equipment.

Consider the systems or processes to reduce the water demand and demonstrate through a good practice design or specification and have a meaningful reduction in the total water demand of the building.

Solutions and Recommendations

The following are some examples of solutions deemed to satisfy compliance for a number of different building types or functions (where the water demand for that function is one of the significant contributors in the building).

- Drip-fed subsurface irrigation incorporating soil moisture sensors. The irrigation control should be zoned to permit variable irrigation to different planting assemblages.
- Reclaimed or recovered water from a rainwater collection or wastewater recovery system with appropriate storage, i.e. greywater collection from building functions or processes that use potable water, e.g. vehicle wash, sanitary facilities, irrigation etc. Provided in project.
- External landscaping and planting that relies solely on precipitation, during all seasons of the year.
- All planting specified is restricted to contextually appropriate species that thrive without irrigation and will continue to do so in those conditions likely as a result of climate change, i.e. typically warmer and drier conditions.

2.6 Materials

This category encourages steps taken to reduce the impact of construction materials through design, construction, maintenance and repair. Issues in this section focus on the procurement of materials that are sourced in a responsible way and have a low embodied impact over their life including extraction, processing and manufacture, and recycling.

Category Summary Table

Issue	Credits	Credit Summary
Mat 01 Life cycle impacts	Up to 6	<ul style="list-style-type: none"> • Reductions in the building's environmental life cycle impacts through assessment of the main building elements.
Mat 03 Responsible sourcing of construction products	4	<ul style="list-style-type: none"> • Materials sourced in accordance with a sustainable procurement plan. • Key building materials are responsibly sourced to reduce environmental and socio-economic impacts.
Mat 05 Designing for durability and resilience	1	<ul style="list-style-type: none"> • The building incorporates measures to reduce impacts associated with damage and wear and tear. • Relevant building elements incorporate appropriate design and specification measures to limit material degradation due to environmental factors.
Mat 06 Material efficiency	1	<ul style="list-style-type: none"> • Opportunities and measures have been identified and taken to optimise the use of materials.

2.6.1 Mat 01 Life Cycle Impacts

Total Points	Target Points		
6	Y	?	N
		1	5

Intent

To recognise and encourage the use of robust and appropriate life cycle assessment tools and consequently the specification of construction materials with a low environmental impact (including embodied carbon) over the full life cycle of the building.

Requirements

Prepare a Life Cycle Assessment (LCA) tool for the project including at least the mandatory building elements indicated in the 'Materials assessment scope' section of the BREEAM International Mat 01 calculator. Depending on the percentage of BREEAM Mat 01 calculator points achieved the project can earn credits 1 (25%) to 5 (82.5%) Points with an additional exemplary performance credit for achieving 85%.

One credit can be achieved when a range of at least five products specified at Design Stage and installed by Post-Construction Stage are covered by verified Environmental Product Declarations (EPD). Additionally, a range of at least 10 products specified at Design Stage and installed by Post-Construction Stage are covered by verified manufacturer specific Environmental Product Declarations (EPD) to achieve an exemplary performance.

Solutions and Recommendations

Life Cycle Assessment (LCA) (NO): covers building fabric (external walls, external windows and rooflights, internal floor finishes, upper floors) should be conducted.

Environmental Product Declarations (EPD) (MAYBE): The existence of the relevant certificates should be questioned in the construction materials planned to be used in the project. In order to target this credit, this issue should be considered while making the product selection and purchasing and relevant criteria should be added to Construction Specifications.

A minimum of 5 EPD certified construction products must be included in the construction specifications to achieve this credit. Additionally, if 10 EPD certified products are included the project can achieve an additional point under the innovation category.

2.6.2 Mat 03 Responsible sourcing of construction products

Total Points	Target Points		
4	Y	?	N
	2		2

Intent

To recognise and encourage the specification and procurement of responsibly sourced construction products.

Requirements

Credit Prerequisite & Minimum requirement for BREEAM Very Good level: All timber and timber-based products used on the project are Legally harvested and traded timber.

Sustainable procurement plan (1 point). A documented policy and procedure is necessary to encourage the specification of products with responsible sourcing certification over similar products without certification and held by the client or developer. It must be disseminated to all relevant internal and external personnel. AND/OR

Responsible sourcing of construction products (3 points): Additional credits can be achieved where the applicable construction products are responsibly sourced in accordance with the BREEAM methodology where BREEAM recognised responsible sourcing certifications scheme (RSCS) certification or environmental management system (EMS) certification is obtained. For all routes the BREEAM International Mat 03 tool is used to collect information and reporting tool. The material categories used in the BREEAM International Mat 03 tool must be accordance with the following.

- Timber or timber-based products
- Concrete or cementitious
- Metal
- Stone or aggregate
- Clay-based
- Gypsum
- Glass
- Plastic, polymer, resin, paint, chemicals and bituminous
- Animal fibre, skin, cellulose fibre
- Other

Solutions and Recommendations

Sustainable procurement plan (MAYBE): The Sustainable Procurement Plan must be included in the construction contract, or a written commitment to do so. There must be a policy in the plan to encourage the specification of products with responsible sourcing certification. This option is easily achievable.

Responsible sourcing of construction products (MAYBE-1 point): The available responsible sourcing credits will be awarded where the applicable construction products from the construction categories are responsibly sourced in accordance with the BREEAM methodology.

To achieve Mat 03 credit manufacturers of applicable products must be covered by Environmental Management System (EMS) or a responsible sourcing certification scheme (RSCS) recognized by BREEAM. If the client approves the procurement plan, one point can be achieved under this credit. Construction materials should meet responsible sourcing criteria such as FSC certified wood, recycled content. While some of these certifications could be easily achievable in all countries generally, some of them could be challenging.

Therefore, one additional point (addition to Procurement plan point) is marked as maybe. The requirements shall be added to Construction Specifications and tracked during the material procurement stage.

2.6.3 Mat 05 Designing for durability and resilience

Total Points	Target Points		
1	Y	?	N
			1

Intent

To recognise and encourage adequate protection of exposed elements of the building and landscape, therefore minimising the frequency of replacement and maximising materials optimisation.

Requirements

Protect the vulnerable parts of the building from the effects of high pedestrian traffic in main entrances, public areas and thoroughfares (corridors, lifts, stairs, doors etc.) and protect against any internal vehicular or trolley movement within 1m of the internal building fabric.

Protect the exposed parts of the building from environmental factors including solar radiation, temperature variation, water or moisture, wind, precipitation, e.g. rain and snow and extreme weather conditions. Building elements should be protected against degradation effects such as corrosion, fading or discolouration, rotting, leaching, melting, abrasion etc.

Solutions and Recommendations

Vulnerable areas should be identified and robust design measures should be implemented. Suitable durability and protection measures to vulnerable parts of the building can include:

- Bollards or barriers, or raised kerbs to delivery and vehicle drop-off areas
- Robust external wall construction, up to 2m high
- Protection rails to walls of corridors
- Kick plates or impact protection (from trolleys etc.) on doors
- Hard-wearing and easily washable floor finishes in heavily used circulation areas (i.e. main entrance, corridors, public areas etc.)
- Designing out the risk without the need for additional materials specification to protect vulnerable areas.

Since targeting this credit would include major changes to the overall architectural design of the building, this credit will not be pursued for this project.

2.6.4 Mat 06 Material efficiency

Total Points	Target Points		
1	Y	?	N
			1

Intent

To recognise and encourage measures to optimise material efficiency in order to minimise the environmental impact of material use and waste without compromising on structural stability, durability or service life of the building

Requirements

Identify the opportunities and take appropriate measures to investigate and implement the optimization of the more efficient use of materials in building design, procurement, construction, maintenance and end of life. The design or construction team in consultation should consider these aspects at the following work stages:

- Preparation and Brief
- Concept Design
- Developed Design
- Technical Design
- Construction

Solutions and Recommendations

The process of undertaking a building project to enable the most efficient use of materials over the life cycle of the building and its components. This includes using fewer materials, reusing existing demolition and strip-out materials and, where appropriate, procuring materials with higher levels of recycled content. It may also include the adoption of alternative means of design or construction that result in lower materials usage and lower wastage levels including off-site manufacture and use of pre-assembled service pods. BS 8895 Designing for material efficiency in building projects standard outlines specific material efficiency processes, key tasks, team members and their responsibilities and outputs specific to each work stage, along with supporting guidance and tools. This standard may be a useful tool to assist the design team in developing and implementing material efficiency strategies for their developments. Due to time limitations in design process the credit is marked as "NO".

2.7 Waste

This category encourages the sustainable management (and reuse where feasible) of construction and operational waste and waste through future maintenance and repairs associated with the building structure. By encouraging good design and construction practices, issues in this section aim to reduce the waste arising from the construction and operation of the building, encouraging its diversion from landfill. It includes recognition of measures to reduce future waste as a result of the need to alter the building in the light of future changes to climate.

Category Summary Table

Issue	Credits	Credit Summary
Wst 01 Construction waste management	3	<ul style="list-style-type: none"> • Development of a construction resource management plan. • Reducing construction waste related to on site construction and off-site manufacture or fabrication. • Diverting non-hazardous construction (on site and dedicated off-site manufacture or fabrication), demolition and excavation waste (where applicable) generated by the project from landfill.
Wst 02 Recycled aggregates	1	<ul style="list-style-type: none"> • Percentage levels of recycled or secondary aggregate specified against set targets.
Wst 03 Operational waste	1	<ul style="list-style-type: none"> • Provision of suitable space and facilities to allow for segregation and storage of operational recyclable waste volumes generated by the assessed building or unit, its occupants and activities.
Wst 05 Adaptation to climate change	1	<ul style="list-style-type: none"> • Encourage consideration and implementation of measures to mitigate the impact of more extreme weather conditions arising from climate change over the lifespan of the building.
Wst 06 Functional adaptability	1	<ul style="list-style-type: none"> • Encourage consideration and implementation of measures to accommodate future changes to the use of the building and its systems over its lifespan.

2.7.1 Wst 01 Construction waste management

Total Points	Target Points		
3	Y	?	N
		3	

Intent

To promote resource efficiency via the effective and appropriate management of construction waste.

Requirements

The amount of site construction waste created should be monitored and regularly reviewed by an individual responsible nominated by the design team or site management. The amount of non-hazardous and hazardous waste produced on site are set in m³ of waste per 100m² and report via the BREEAM scoring and reporting tool.

Complete a pre-demolition audit to determine if refurbishment or reuse is feasible and, if not, to maximise the recovery of material from demolition for subsequent use, prioritising high grade or value applications.

Create a procedure for sorting, reusing and recycling construction waste into at least five defined waste groups either on site or off-site through a licensed external contractor.

Solutions and Recommendations

According to construction and demolition waste management plan; the following procedures should be implemented to achieve diversion goals.

- Establish on-site infrastructure, practices, and policies for off-site sorting, and develop a tracking system, as applicable. Identify at least three material streams that will be diverted.
- Track all the construction and demolition waste leaving the site. Retain waste hauler reports for documentation. Record estimated weight or volume of materials that are reused on site or salvaged for reuse on other projects by subcontractors or vendors.
- Retain receipts and estimate weight or volume for materials donated to charities, reuse retailers, or other recipients that can verify and track incoming and outgoing materials.

The relevant criteria should be added to Construction Specifications. The contractor will be responsible to implement construction waste management strategies.

Usually these kind of waste management activities are common application and only negligible costs are expected for implementation.

2.7.2 Wst 02 Recycled Aggregates

Total Points	Target Points		
1	Y	?	N
			1

Intent

To recognise and encourage the use of recycled and secondary aggregates, thereby reducing the demand for virgin material and optimising material efficiency in construction.

Requirements

At least 25% of the high grade aggregate (within the development) are provided by secondary or recycled aggregate. That can be construction, demolition and excavation waste obtained on site or off-site. This percentage can be measured using either weight or volume.

Where the total amount of recycled or secondary aggregate specified is greater than 50% (by weight or volume) of the total high grade aggregate, exemplary level criteria can be achieved or not transporting more than 30km by road transport.

Solutions and Recommendations

Since, using recycled aggregates may have some challenges, the credit is not targeted.

2.7.3 Wst 03 Operational Waste

Total Points	Target Points		
1	Y	?	N
		1	

Intent

To recognise and encourage the provision of dedicated storage facilities for a building's operational-related recyclable waste streams, so that this waste is diverted from landfill or incineration.

Requirements

Provide dedicated space for the segregation and storage of operational recyclable waste volumes generated by the assessed building or unit, its occupants and activities. This space must be clearly labelled, accessible to building occupants or facilities operators, and with an appropriate size.

Where the consistent generation in volume of the appropriate operational waste streams is likely to exist provide static waste compactors or balers, vessels for composting suitable organic waste resulting from the building's daily operation and use and water outlet for the place of organic waste storage for cleaning and hygiene purposes.

Solutions and Recommendations

Minimum 14 m² dedicated space for the segregation and storage of recyclable waste should be provided. This space should be:

- **Clearly labelled, to assist with segregation, storage and collection of the recyclable waste streams**
- **Accessible to building occupants or facilities operators for the deposit of materials and collections by waste management contractors**
- **Of a capacity appropriate to the building type, size, number of units (if relevant) and predicted volumes of waste that will arise from daily or weekly operational activities and occupancy rates**

Since the function of the project is not retail or industrial and the project does not contain large catering facility, large amounts of packaging or compostable waste is not likely to be generated during the building's operation. Therefore, no need to install compactors or balers. If organic waste is to be stored or composted on site, a tap should be provided adjacent to or within the facility for cleaning and hygiene purposes.

This credit can easily be achieved for this project.

2.7.4 Wst 05 Adaptation to climate change

Total Points	Target Points		
1	Y	?	N
			1

Intent

To recognise and encourage measures taken to mitigate the impact of extreme weather conditions arising from climate change over the lifespan of the building.

Requirements

Carry out a systematic (structural and fabric resilience specific) risk assessment to identify and evaluate the impact on the building over its projected life cycle from expected extreme weather conditions arising from climate change and, where feasible, mitigate against these impacts. The assessment should cover hazard identification and assessment, risk estimation, risk evaluation and management.

An exemplary credit can be achieved through responding to adaptation to climate change considering the credits Hea 04 Thermal Comfort, Hea 07 Hazards, Ene 01 Reduction of energy use and carbon emissions, Ene 04 Low carbon design, Wat 01 Water consumption, Mat 05 Designing for durability and resilience and Pol 03 Surface water run-off.

Solutions and Recommendations

In order to achieve credit climate change adaptation strategy appraisal for structural and fabric resilience should have been conducted by the end of Concept Design. Therefore, the credit is not targeted.

2.7.5 Wst 06 Functional adaptability

Total Points	Target Points		
1	Y	?	N
			1

Intent

To recognise and encourage measures taken to accommodate future changes of use of the building over its lifespan.

Requirements

A building-specific functional adaptation strategy study should be undertaken by the client and design team by completion of the concept design which includes recommendations for measures to be incorporated to facilitate future adaptation.

Implement the functional adaptation measures in the design by completion of the technical design in accordance with the functional adaptation strategy recommendations, where practical and cost effective.

Solutions and Recommendations

In order to achieve credit, a building-specific functional adaptation strategy should have been conducted by the end of Concept Design. Therefore, the credit is not targeted.

2.8 Land Use and Ecology

This category encourages sustainable land use, habitat protection and creation, and improvement of long-term biodiversity for the building's site and surrounding land. Issues in this section relate to the reuse of brownfield sites or those of low ecological value, mitigation and enhancement of ecology and long-term biodiversity management.

Category Summary Table

Issue	Credits	Credit Summary
LE 01 Site selection	3	<ul style="list-style-type: none"> To encourage the use of previously occupied or contaminated land and avoid land which has not been previously disturbed.
LE 02 Ecological value of site and protection of ecological features	2	<ul style="list-style-type: none"> To encourage development on land that already has limited value to wildlife and to protect existing ecological features from substantial damage during site preparation and completion of construction works.
LE 04 Enhancing site ecology	3	<ul style="list-style-type: none"> To encourage actions taken to enhance the ecological value of the site as a result of development.
LE 05 Long term impact on biodiversity	2	<ul style="list-style-type: none"> To minimise the long term impact of the development on the site and the surrounding area's biodiversity.

2.8.1 LE 01 Site Selection

Total Points	Target Points		
3	Y	?	N
	2		1

Intent

To encourage the use of previously occupied or contaminated land and avoid land which has not been previously disturbed.

Requirements

Option 1 Previously occupied land (2 points): If the proposed development's footprint is on an area of land which has previously been occupied by industrial, commercial or domestic buildings with 75% (1 point) and 95% (2 points), this can be achieved.

AND/OR

Option 2 Contaminated land (1 point): The site is deemed to be significantly contaminated, i.e. could not be developed or built to the proposed end use without remediation

Solutions and Recommendations

Since the project is located highly developed region, the project is expected to meet the BREEAM requirements for this credit.

2.8.2 LE 02 Ecological Value of Site and Protection of Ecological Features

Total Points	Target Points		
2	Y	?	N
	2		

Intent

To encourage development on land that already has limited value to wildlife and to protect existing ecological features from substantial damage during site preparation and completion of construction works.

Requirements

Ecological value of site (1 point). An assessment is required for the land using the BREEAM checklist for defining `land of low ecological value` or with a report prepared by a suitably qualified ecologist (SQE). AND/OR

Protection of ecological features (1 point). All existing features of ecological value within the assessment zone and site boundary area should be adequately protected from damage during clearance, site preparation and construction activities.

Solutions and Recommendations

The content of the ecology report is to be representative of the existing site's ecology prior to the commencement of initial site preparation works (i.e. before construction). An ecological report relating to BREEAM comparing the pre-construction site conditions and what is proposed during the project is required to achieved this credit.

According to recommendations from the landscape architect/ecologist, the contractor shall implement ecological protection measures.

2.8.3 LE 04 Enhancing Site Ecology

Total Points	Target Points		
3	Y	?	N
		3	

Intent

To encourage actions taken to enhance the ecological value of the site as a result of development.

Requirements

Ecologist's report and recommendations (1 point). The appointed SQE by the client or their project representative no later than the conclusion of the design brief, should provide an ecology report with appropriate ecological recommendations for the enhancement of the site's ecology. At least 50% of the recommendations within the ecology report for enhancement of site ecology have been, or will be, implemented in the final design and build. AND/OR

Increase in ecological value (2 points). A percentage of the recommendations within the ecology report for enhancement of site ecology have been, or will be, implemented in the final design and build with a ratio of 75% (1 point) or 95% (2 points).

Solutions and Recommendations

Ecological recommendations are defined as measures adopted to enhance the ecology of the site. These are measures that the ecologist reasonably expects can be implemented, considering their feasibility taking into account building or site constraints. Measures may include but are not limited to:

- The planting of locally appropriate native species or non-native species with a known attraction or benefit to local wildlife
- The adoption of horticultural good practice (e.g. no, or low, use of residual pesticides)
- The installation of bird, bat or insect boxes at appropriate locations on the site
- Development of a full biodiversity management plan including avoiding clearance or works at key times of the year (e.g. breeding seasons)
- The proper integration, design and maintenance of sustainable drainage systems (SuDS1) (such as rain gardens), green roofs, green walls, community orchards, community allotments etc.

Detailed ecological report should be prepared by landscape architect (or environmental engineer or an expert holds a degree or equivalent qualification in ecology or a related qualification). No need for a detailed Environmental Impact Assessment (EIA) to achieve this credit.

2.8.4 LE 05 Long Term Impact on Biodiversity

Total Points	Target Points		
2	Y	?	N
		2	

Intent

To minimise the long term impact of the development on the site and the surrounding area's biodiversity.

Requirements

The appointed SQE confirm that all relevant EU, local and national regulations or legislation requirements relating to the protection and enhancement of ecology have been complied with during the design and construction process.

A landscape and habitat management plan should be produced covering at least the first five years after project completion. This is to be handed over to the building owner or occupants and includes:

- Management of any protected features on site
- Management of any new, existing or enhanced habitats
- A reference to any current or future legislation requirements regarding the protection of species and habitats
- Confirmation from the SQE that all relevant aspects of ecology are included within the plan

Moreover, additional measures for the improvement of long term biodiversity can be provided like training the site workforce on how to protect site ecology during the project, recording actions taken to protect biodiversity and monitor their effectiveness throughout key stages of the construction process or creating a new ecologically valuable habitat appropriate to the local area.

Solutions and Recommendations

In order to achieve this credit, a landscape and habitat management plan should be produced in accordance with the BREEAM requirements by SQE.

An ecological report should be prepared as a part of the landscape design. Therefore, no cost effect is expected.

2.9 Pollution

This category addresses the prevention and control of pollution and surface water run-off associated with the building's location and use. Issues in this section aim to reduce the building's impact on surrounding communities and environments arising from light pollution, noise, flooding and emissions to air, land and water.

Category Summary Table

Issue	Credits	Credit Summary
Pol 01 Impact of Refrigerants	3	<ul style="list-style-type: none"> Avoidance or reduction of the impact of refrigerants through specification and leak prevention or detection.
Pol 02 NOx emissions	2	<ul style="list-style-type: none"> Reduction in emissions of NOx arising from the building's space and water heating systems.
Pol 03 Surface water run-off	5	<ul style="list-style-type: none"> Development of sites with a low probability of flooding where the design minimises the impact of flooding through careful master-planning. Surface water run-off is managed to be no worse than the predevelopment scenario. Watercourse pollution prevention systems are in place.
Pol 04 Reduction of night time light pollution	1	<ul style="list-style-type: none"> External light pollution is eliminated through effective design or the removal of the need for unnecessary external lighting.
Pol 05 Reduction of noise pollution	1	<ul style="list-style-type: none"> Measures to reduce the likelihood of disturbance arising as a result of noise from fixed installations on the development.

2.9.1 Pol 01 Impact of Refrigerants

Total Points	Target Points		
3	Y	?	N
	1		2

Intent

To reduce the level of greenhouse gas emissions arising from the leakage of refrigerants used to heat or cool the building.

Requirements

Credit prerequisite: For the buildings that use refrigerants all systems must comply with the requirements of EN 378:2008+A2:2012 and where refrigeration systems containing ammonia are installed, the Institute of Refrigeration Ammonia Refrigeration Systems Code of Practice.

Ozone depleting potential (1 point). The refrigerants used must have an ozone depleting potential of zero. AND/OR

Impact of refrigerant (1 point). The direct Effect Life Cycle CO₂e equivalent emissions should less than 100 kg – 1000 kg (1 Point) CO₂e/KW and the refrigeraton system must have Global Warming Potential (GWP) less than 10. AND/OR

Leak detection (1 point). The systems using refrigerants have a permanent automated refrigerant leak detection system installed.

Solutions and Recommendations

Ozone depleting potential (YES): HFC-407C, HFC-410A or equivalent type refrigerants (ozone depleting potential of zero) will be used in the project according to technical specs.

Impact of refrigerant (NO): Global warming potential of most of the refrigerants are more than 10. Therefore, this option is marked as NO.

Impact of refrigerant (NO): Cooling systems using refrigerants should have a permanent automated refrigerant leak detection system installed; OR where an inbuilt automated diagnostic procedure for detecting leakages should be installed. In all instances a robust and tested refrigerant leak detection system must be installed and must be capable of continuously monitoring for leaks.

2.9.2 Pol 02 NOx emissions

Total Points	Target Points		
2	Y	?	N
			2

Intent

To contribute to a reduction in national NOx emission levels through the low emission heat sources in the building.

Requirements

The Building that has a plant installed to meet the building's heating and hot water demand, under normal operating conditions, a NOx emission level should be less than 56 mg/kWh (1 point), or less than 40 mg/kWh (2 points).

Solutions and Recommendations

Heating system is not designed in the project. Therefore, the credit is not targeted.

2.9.3 Pol 03 Surface water run-off

Total Points	Target Points		
5	Y	?	N
	5		

Intent

To avoid, reduce and delay the discharge of rainfall to public sewers and watercourses, thereby minimising the risk and impact of localised flooding on and off-site, watercourse pollution and other environmental damage.

Requirements

Flood Resilience (2 points). The site-specific flood risk assessment (FRA) must take all current and future sources of flooding into consideration to define the site as having a low annual probability of flooding. If there is medium or high flood risk after the assessment, the ground level of the building and access to both the building and the site, should be designed to be at least 600mm above the design flood level of the flood zone. AND/OR

Surface water run-off (2 points). An appropriate consultant is appointed to carry out, demonstrate or confirm the development's compliance where drainage measures are specified to ensure that the peak rate and also climate change is considered. AND/OR

Minimising watercourse pollution (1 point). Depending on the watercourse, an appropriate level of pollution treatment should be provided, using appropriate Sustainable Drainage Systems (SuDS) techniques.

Solutions and Recommendations

Flood Resilience: Flood risk maps for Hulhumale island meet credit requirement.

Surface water run-off & Minimising watercourse pollution: Rainwater harvesting system will help to meet credit requirements. The drainage measures and SuDS techniques are also designed in the project

2.9.4 Pol 04 Reduction of night time light pollution

Total Points	Target Points		
1	Y	?	N
		1	

Intent

To ensure that external lighting is concentrated in the appropriate areas and that upward lighting is minimised, reducing unnecessary obtrusive light pollution, energy consumption and nuisance to neighbouring properties.

Requirements

The Building should have an effective design to eliminate the external obtrusive lighting that removes the need for external lighting without adversely affecting the safety and security of the site and its users. OR

If the building does have external lighting, all of them can be automatically switched off between 23:00 and 07:00 or they can be used with considering the maximum illuminance levels for safety and security lighting according to CIE 150-2003 and CIE 126-1997.

Solutions and Recommendations

If the external lighting strategy is designed in compliance with the relevant standards, the credit can be targeted.

2.9.5 Pol 05 Reduction of noise pollution

Total Points	Target Points		
1	Y	?	N
			1

Intent

To reduce the likelihood of noise arising from fixed installations on the new development affecting nearby noise-sensitive buildings.

Requirements

If there are no noise-sensitive areas or buildings within an 800m radius of the assessed site the credit can be achieved.

If the building does have noise-sensitive areas or buildings within an 800m radius of the site, the following should be provided:

- A noise impact assessment should be carried out for the noise levels according with ISO 1996 series if there are noise-sensitive areas or buildings within an 800m radius of the site.
- The noise level from the proposed site or building, as measured in the locality of the nearest or most exposed noise-sensitive development, is a difference no greater than +5dB during the day (07:00 to 23:00) and +3dB at night (23:00 to 07:00) compared to the background noise level.
- The noise impact assessment must be carried out by a suitably qualified acoustic consultant holding a recognised acoustic qualification.

Solutions and Recommendations

The followings are defined as noise-sensitive areas according to BREEAM definition.

- 1. Residential areas
- 2. Hospitals, health centres, care homes, doctor's surgeries etc.
- 3. Schools, colleges and other teaching establishments
- 4. Libraries
- 5. Places of worship
- 6. Wildlife areas, historic landscapes, parks and gardens
- 7. Located in an area recognised as having outstanding natural beauty, scientific or ecological interest
- 8. Any other development that can be considered noise-sensitive.

Since there are residential buildings, hospital, mosque within the 800 m radius of project and noise impact assessment is not provided the point is marked as No.

2.10 Innovation

This The innovation category provides opportunities for exemplary performance and innovation to be recognised that are not included within or go beyond the requirements of the credit criteria. This includes exemplary performance credits, for where the building meets the exemplary performance levels of a particular issue. It also includes innovative products and processes for which an innovation credit can be claimed, where they have been approved by BRE Global Ltd.

The cost-saving benefits of innovation are fostered and facilitated by helping encourage, drive and publicise accelerated uptake of innovative measures.

2.10.1 Inn 01 Innovation

Total Points	Target Points		
10	Y	?	N
	2	8	

Intent

To support innovation within the construction industry through the recognition of sustainability related benefits which are not rewarded by standard BREEAM issues.

Requirements

The building should demonstrate exemplary performance by meeting defined exemplary level performance criteria in one or more following criteria considering the relevant BREEAM assessment issues.

- Man 03 Responsible construction practices
- Man 05 Aftercare
- Hea 02 Indoor air quality
- Ene 01 Reduction of energy use and carbon emissions
- Tra 03 Alternative modes of transport
- Wat 01 Water consumption
- Mat 01 Life cycle impacts
- Mat 03 Responsible sourcing of construction products
- Wst 01 Construction waste management
- Wst 02 Recycled aggregates
- Wst 05 Adaptation to climate change

One innovation credit can be awarded for each innovation application approved by BRE Global, where the building complies with the criteria defined within an approved innovation application form.

Solutions and Recommendations

One innovation point can be achieved by providing two options stated under Tra 03 credit. The second innovation point can be achieved by installing 10 EPD certified products as mentioned under Mat 01 credit.

3 Conclusion

This report includes a summary of achieved, potential and targeted credits for the Green Office Building project to achieve a BREEAM “Very Good” level certification. Solutions and recommendations to achieve each BREEAM criterion that are being pursued are summarized in this report. In addition, results of Energy and Daylight simulations with glazing in the current design and alternative glazing are also provided. Where cost implications might occur, they have been addressed and summarized as well.

As a conclusion, with the amendments outlined in this report the project may reach “Very Good” level certification which requires a minimum score of 55%. Recommendations and strategies to achieve potential points stated in this report could result in an overall BREEAM score of 63.34%.

4 Appendix 1 – Fresh Air Rates for Relevant Building Areas

ASHRAE 62.1-2013 VENTILATION CONTROL TABLE										
FLOOR	Zone	Zone	Occupancy	Area	Design Air Flow	Occupancy (based on Project Design Values)	Ez	Ev	Vot	Complies
Number	Number	Description	Category	m ²	m ³ /h	#			m ³ /h	w / A62.1
GF	G12	Cafe	Cafeteria / fast food dining	129.40	2800	130	0.80	1.00	2,747	YES
GF	G03	Lobby	Main entry lobbies	79.40	200	8	0.80	1.00	197	YES
GF	G08	Admin	Office space	29.40	100	2	0.80	1.00	62	YES
GF	G09/G10	MRF	Computer (not printing)	13.70	100	1	0.80	1.00	30	YES
F01	112	Cafe	Cafeteria / fast food dining	66.50	1500	67	0.80	1.00	1,415	YES
F01	104	MDF	Computer (not printing)	5.90	100	1	0.80	1.00	19	YES
F01	106/107	TELCO	Computer (not printing)	13.80	100	1	0.80	1.00	30	YES
F01	108	Security Room	Office space	20.50	100	2	0.80	1.00	50	YES
F03	311/312/313/314	Prayer Room	Places of religious worship	55.60	900	67	0.80	1.00	829	YES
F03	303	Corridor	Corridors	48.00	100	0	0.80	1.00	65	YES
F03	315	Office	Office space	448.00	900	23	0.80	1.00	864	YES
F04	403	Corridor	Corridors	46.40	100	0	0.80	1.00	63	YES
F04	411	Office	Office space	498.40	1000	25	0.80	1.00	954	YES
F05	503	Corridor	Corridors	46.40	100	0	0.80	1.00	63	YES
F05	511	Office	Office space	498.40	1000	25	0.80	1.00	954	YES
F06	603	Corridor	Corridors	46.40	100	0	0.80	1.00	63	YES
F06	611	Office	Office space	498.40	1000	25	0.80	1.00	954	YES
F07	703	Corridor	Corridors	46.40	100	0	0.80	1.00	63	YES
F07	711	Office	Office space	498.40	1000	25	0.80	1.00	954	YES
F08	816/817/818	Multipurpose	Multi-purpose assembly	239.50	3600	288	0.80	1.00	3,563	YES
F08	803	Corridor	Corridors	130.00	200	0	0.80	1.00	176	YES
F08	814	Meeting Room2	Conference / meeting	30.30	300	16	0.80	1.00	221	YES
F08	813/815	Meeting Room	Conference / meeting	58.90	500	30	0.80	1.00	417	YES
F08	811	Pantry	Occupiable storage rooms for dry materials	31.20	100	1	0.80	1.00	53	YES
F09	911	Pantry	Occupiable storage rooms for dry materials	18.50	100	1	0.80	1.00	36	YES
F09	912	Indoor Space	Breakrooms (office buildings)	183.00	1600	92	0.80	1.00	1,529	YES
F09	903	Corridor	Corridors	53.50	100	0	0.80	1.00	72	YES
				Total Area	Total Supplied Fresh Air	Total Peak Occupancy			Total Required Fresh Air	
				3,834	17,800	830			16,442	27
										27
										YES



FOR MINISTRY OF ENVIRONMENT

April 2021



ANNEX 1. DAYLIGHT REPORT

Review and Amend Design of Green Building to attain BREEAM Certification

BREEAM Health and Wellbeing Credit HEA 01 Daylighting Report

The aim of the daylighting credit is to encourage and recognize designs that provide appropriate levels of daylight for building users.

A pass requires that at least 80% of net lettable floor area in occupied spaces is adequately daylighted on the working plane height 0.7m above the floor under a uniform CIE overcast design sky.

A zone is adequately daylighted if both the following conditions are met:

- a) Average daylight factor is at least 1,5%.
- b) A uniformity ratio of at least 0,3 or a minimum point daylight factor of 0,5% (spaces with glazed roofs, such as atria, must achieve a uniformity ratio of at least 0,7 or a minimum point daylight factor of at least 1,4).

The results below were calculated using the Radiance simulation engine which provides a detailed multi-zone physics-based calculation of illumination levels on the working planes of the building. Daylighting Analysis Report generated by DesignBuilder v5.5.0.012

Daylighting data

Sky model	CIE overcast day (specify illuminance)
Location	MALE
Working plane height (m)	0,700
Max Grid Size (m)	0,300
Min Grid Size (m)	0,300
Daylight factor threshold (%)	1,5

Summary Results

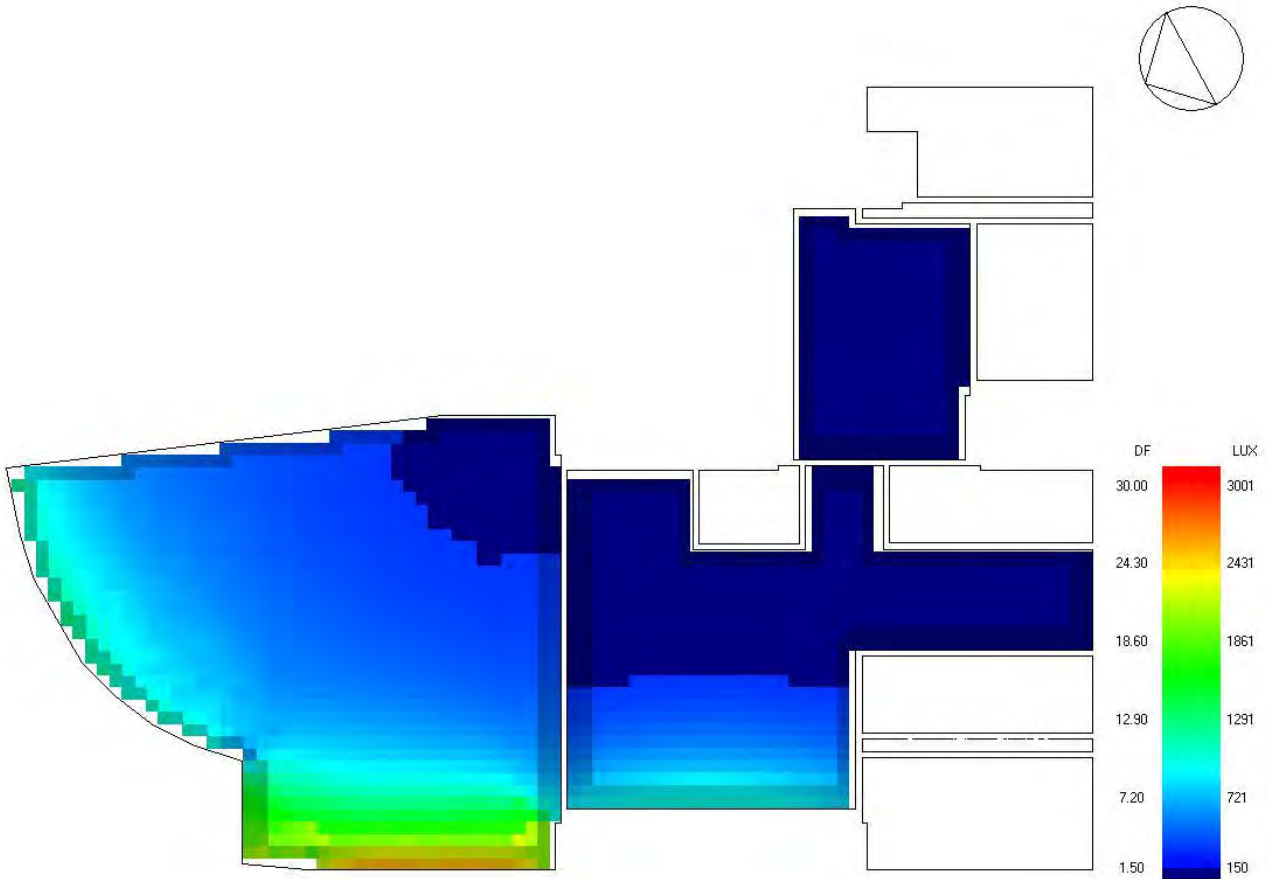
Total area (m2)	3509,96
Total area meeting requirements (m2)	742,43
% area meeting requirements	21,1
BREEAM Health and Wellbeing Credit HEA 01 Status	FAIL

Eligible zones for daylighting

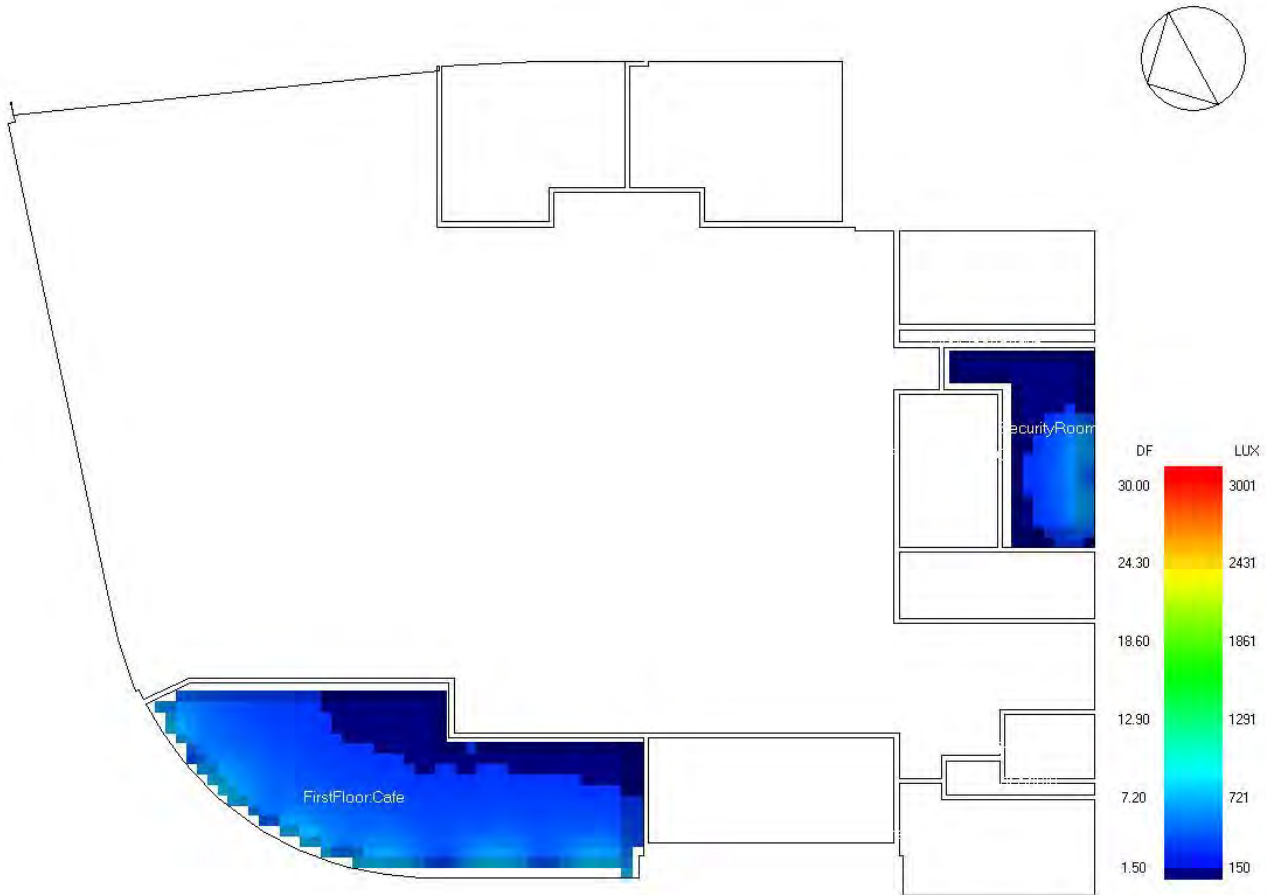
Zone	Block	Floor area (m2)	Min DF (%)	Uniformity ratio (Min / Avg)	Average Daylight Factor (%)	Area Adequately Daylit (m2)
Admin	GroundFloor	27,34	0	0	0	0
Lobby	GroundFloor	72,86	0,03	0,02	1,4	0
Cafe	GroundFloor	130,00	1,2	0,22	5,5	130,00
Security Room	FirstFloor	21,38	0,13	0,08	1,7	0
Cafe	FirstFloor	86,58	1,09	0,44	2,5	60
PrayerRoom	ThirdFloor	32,88	0,55	0,28	1,9	32,88
Office	ThirdFloor	455,11	0,54	0,16	3,4	455,11
Office	4thFloor	498,35	0,28	0,18	1,6	0
Office	5thFloor	498,35	0,29	0,17	1,7	0
Office	6thFloor	498,35	0,31	0,17	1,8	0
Office	7thFloor	498,35	0,33	0,17	1,9	0
Multipurpose	8thFloor	363,94	0,01	0	1,7	0
MeetingRoom2	8thFloor	31,55	0,73	0,39	1,9	31,55
MeetingRoom	8thFloor	58,31	0	0	0	0
Pantry	8thFloor	32,89	1,03	0,34	3	27,2
Pantry	9thFloor	19,7	0	0	0	0
IndoorSpace	9thFloor	184,02	0,34	0,15	2,3	0
Total		3509,96				742,43

Zones with data flagged in red in the table above fail daylighting uniformity criteria.

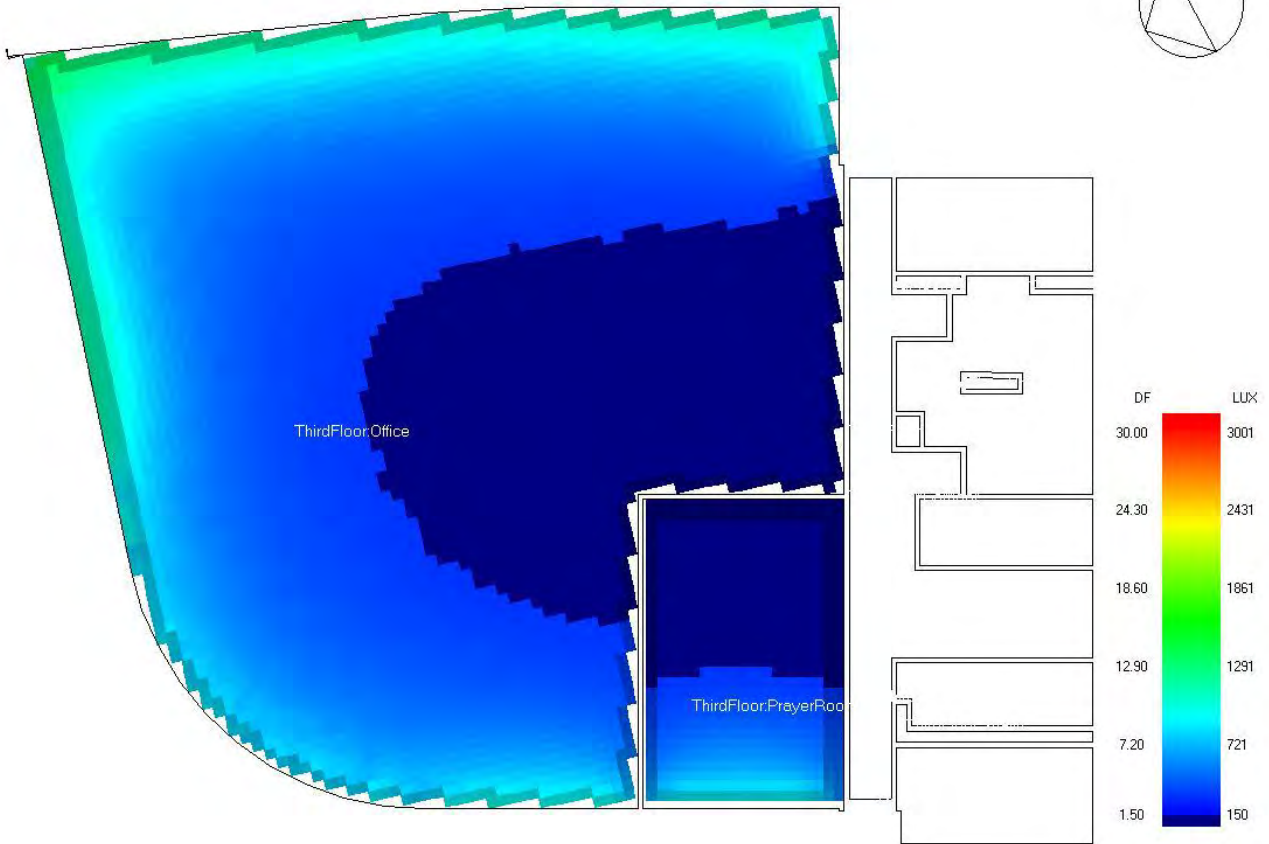
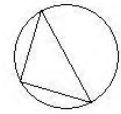
Green Office, Ground Floor



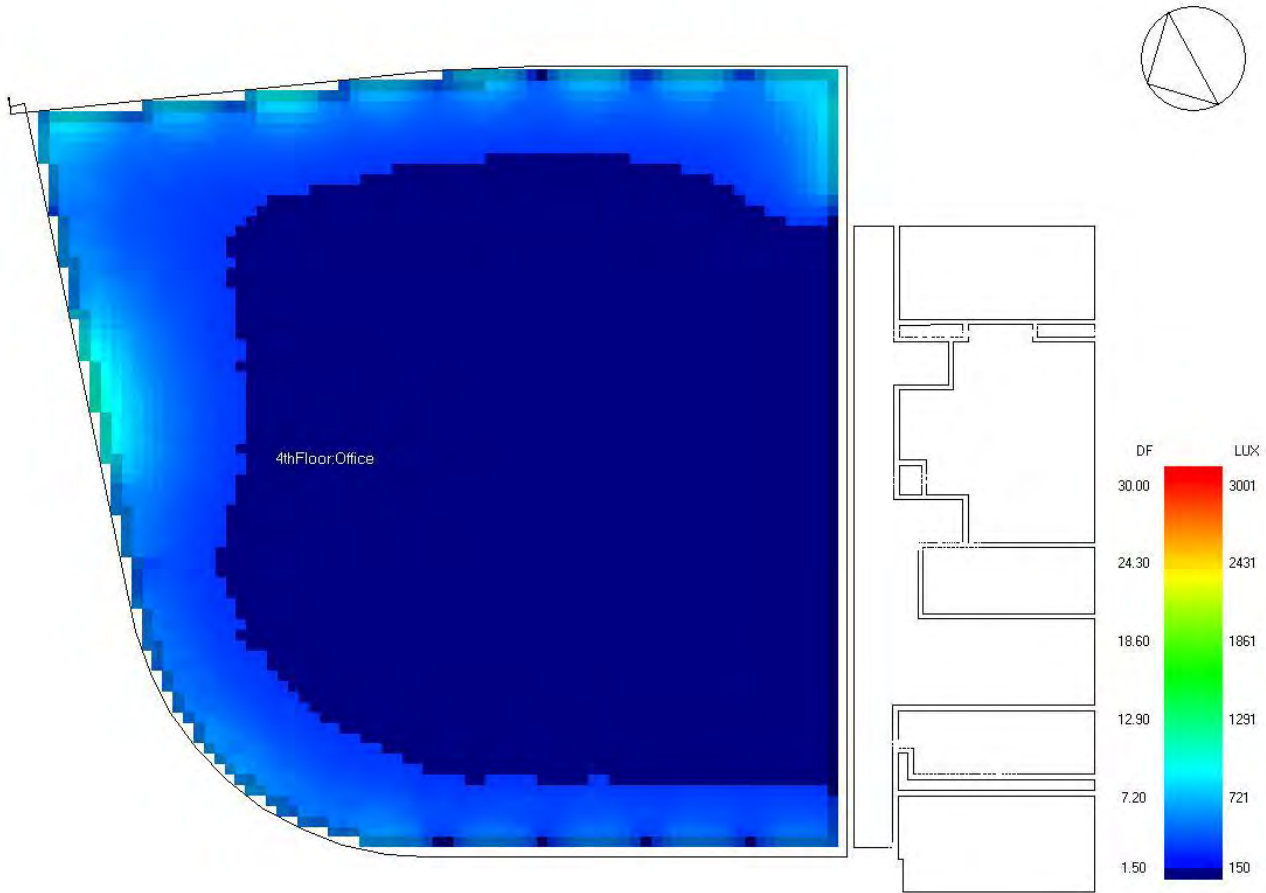
Green Office, First Floor



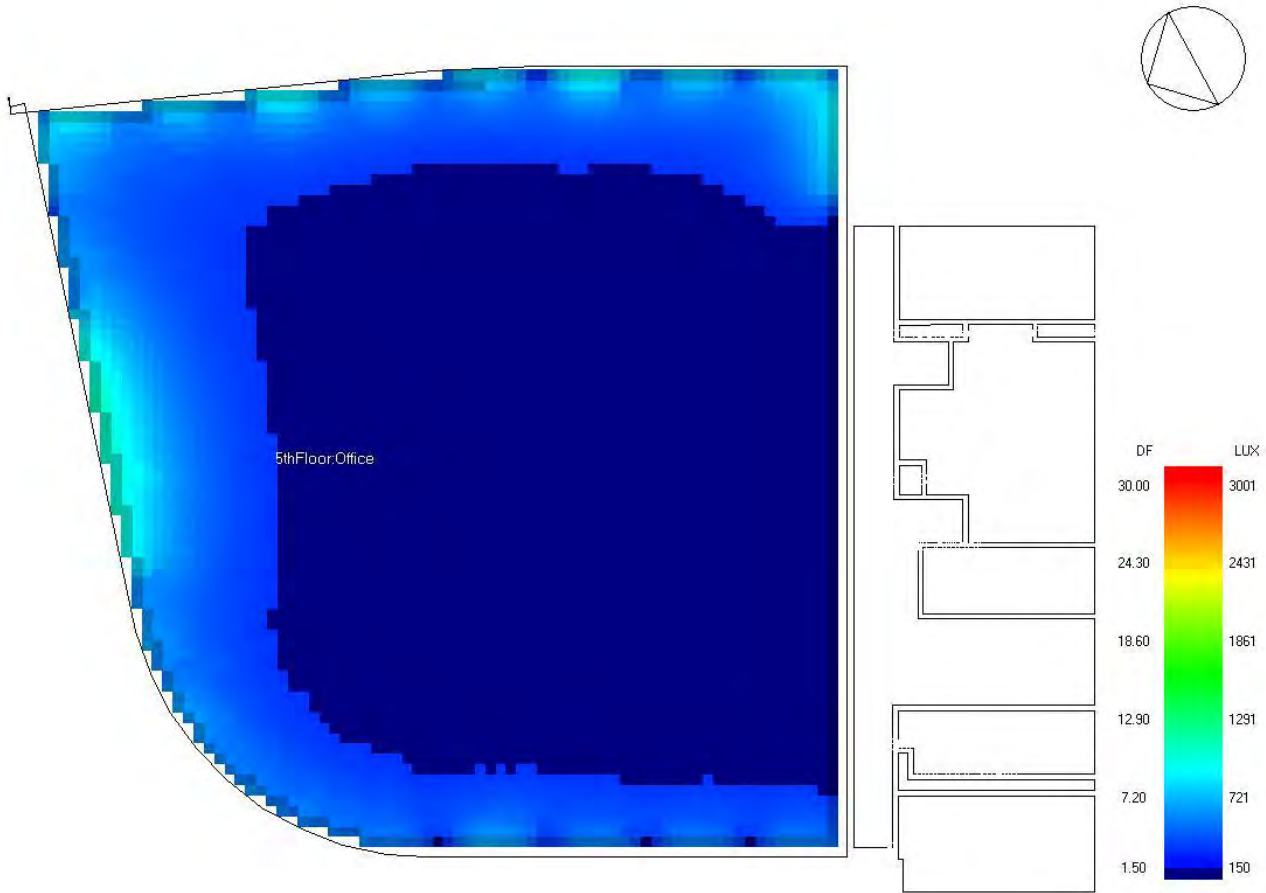
Green Office, Third Floor



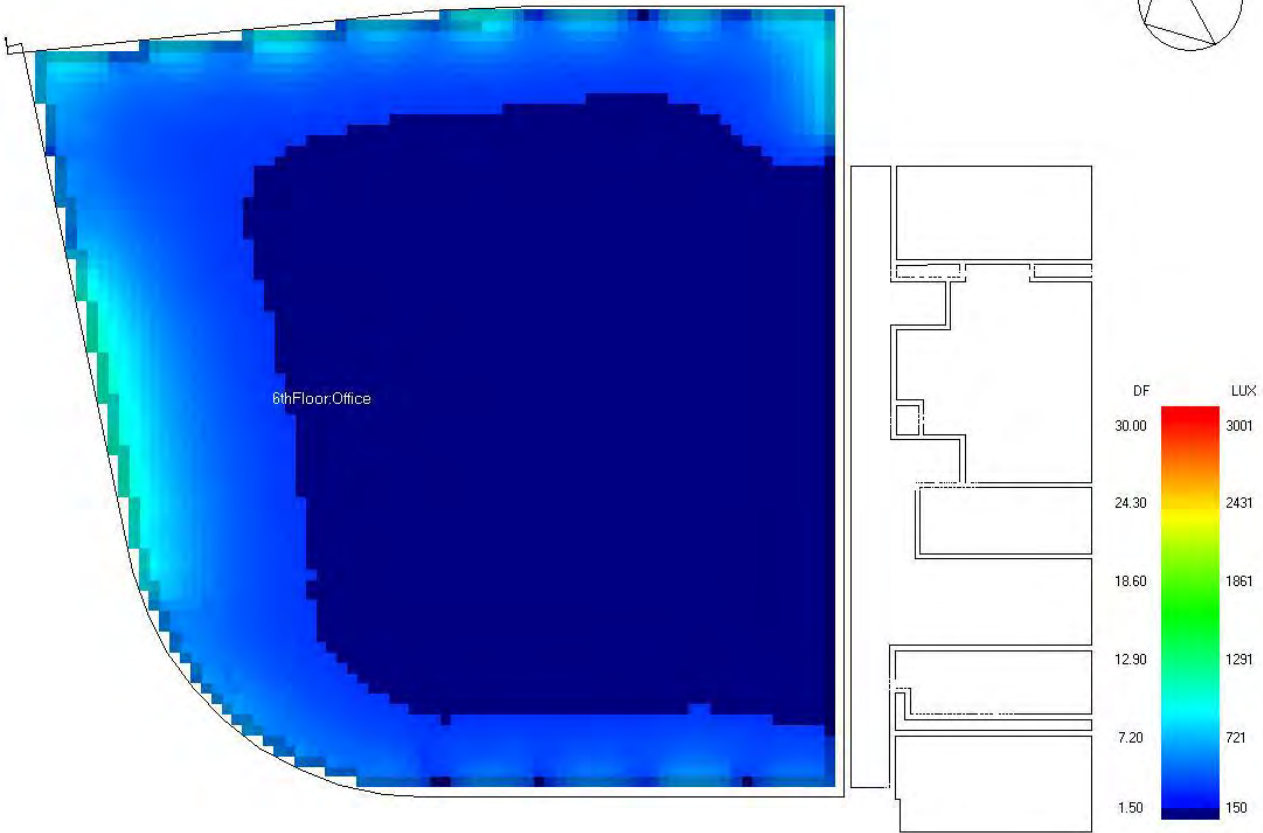
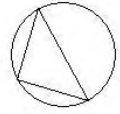
Green Office, 4thFloor



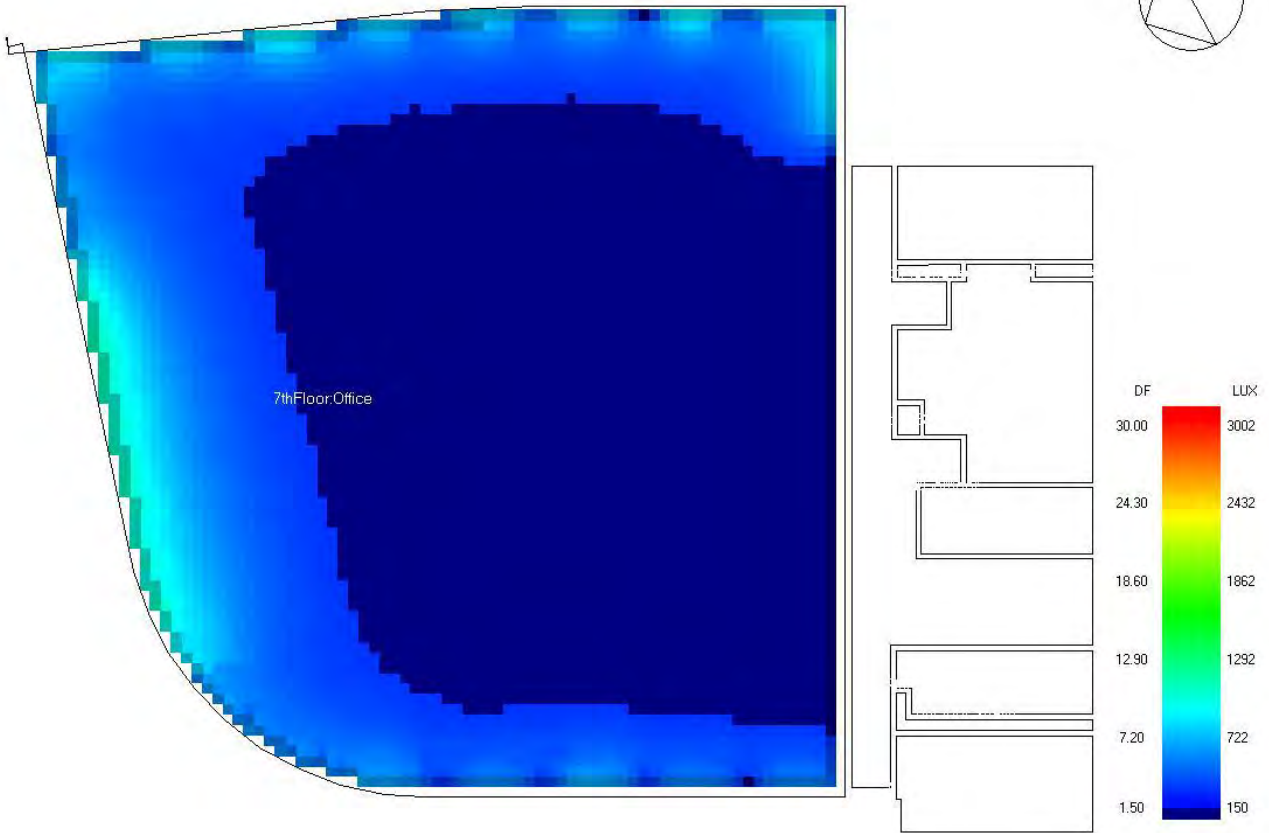
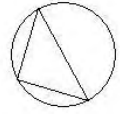
Green Office, 5thFloor



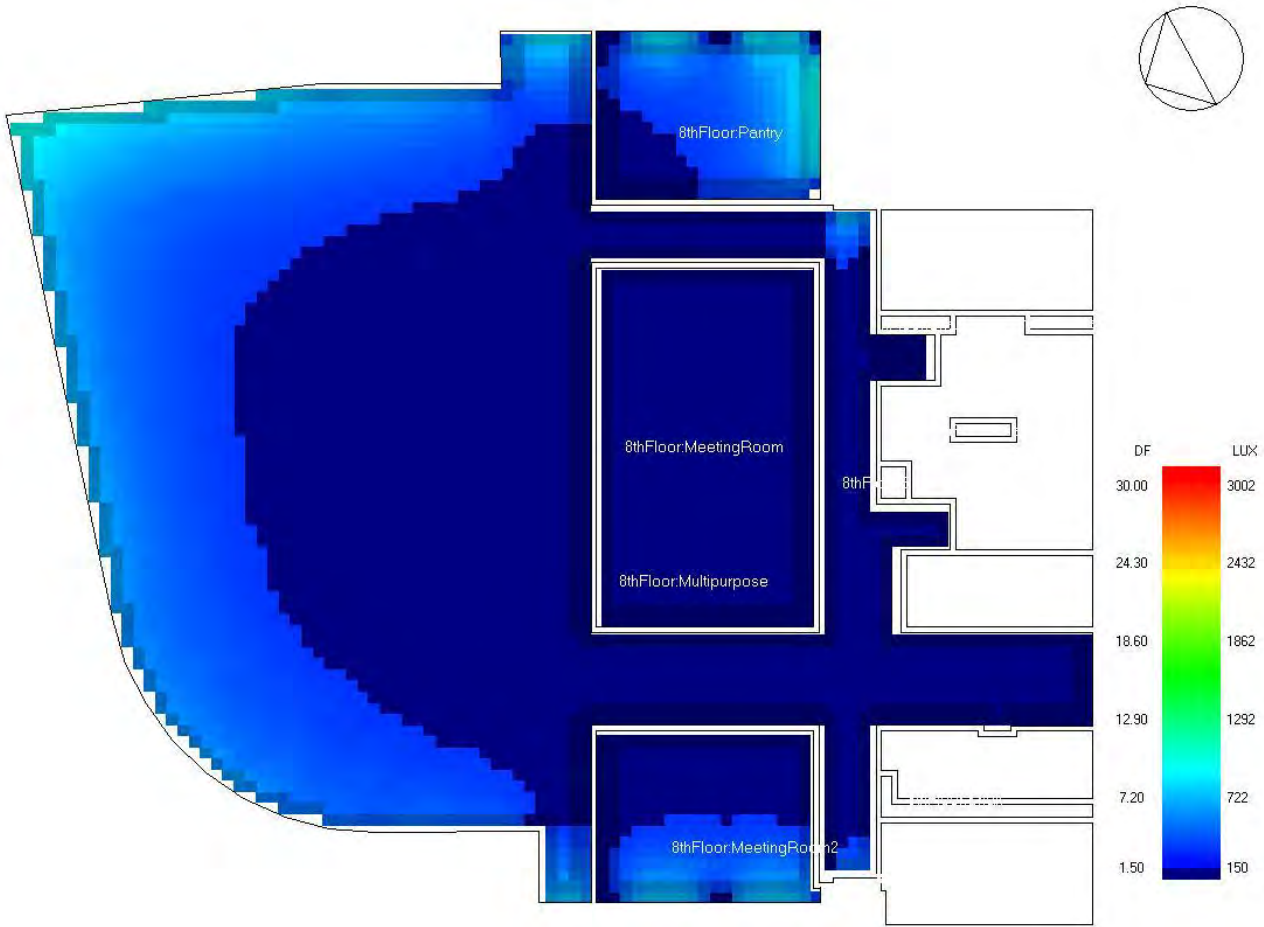
Green Office, 6thFloor



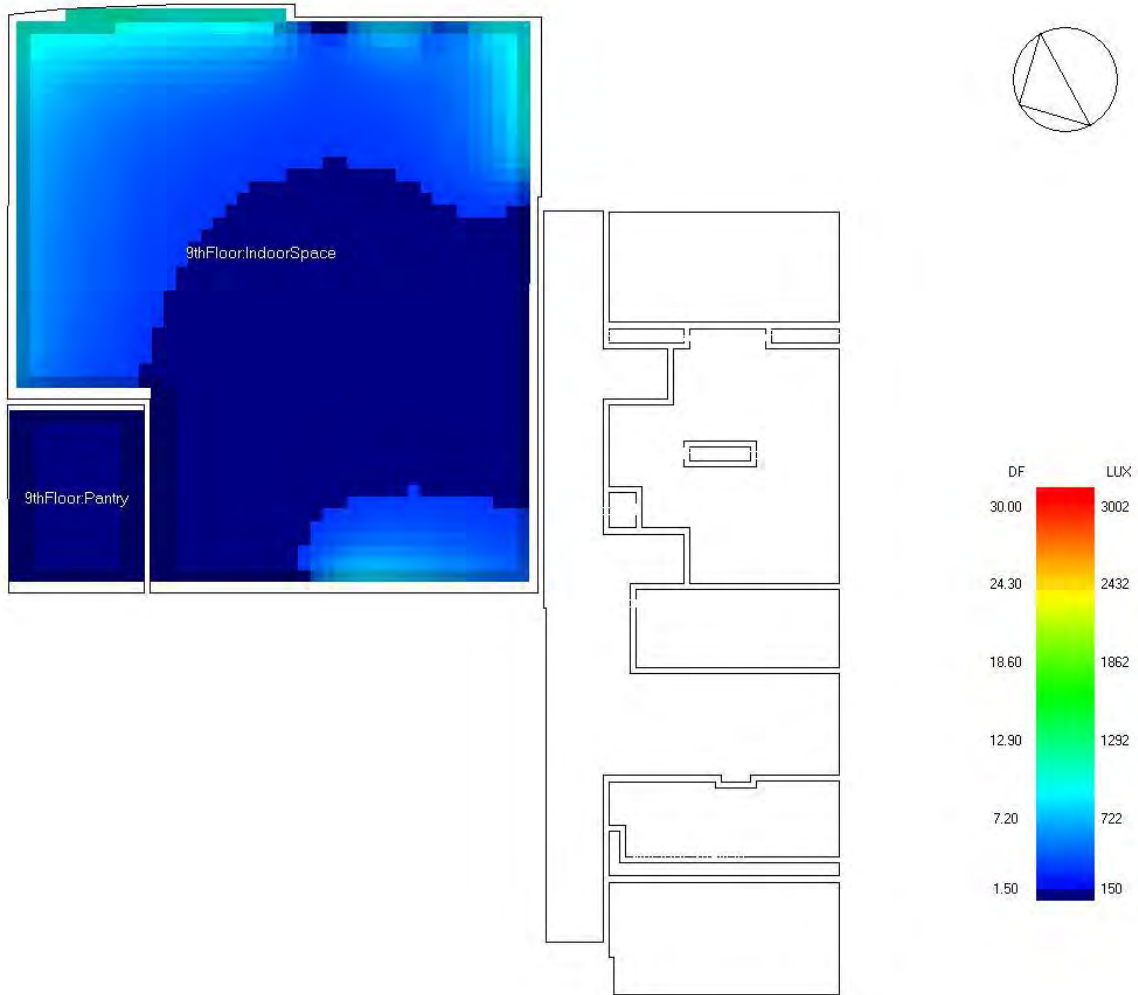
Green Office, 7thFloor



Green Office, 8thFloor



Green Office, 9thFloor





FOR MINISTRY OF ENVIRONMENT

April 2021



ANNEX 2. ALTERNATIVE GLAZING REPORT

Review and Amend Design of Green Building to attain BREEAM Certification

BREEAM Health and Wellbeing Credit HEA 01 Daylighting Report

The aim of the daylighting credit is to encourage and recognize designs that provide appropriate levels of daylight for building users.

A pass requires that at least 80% of net lettable floor area in occupied spaces is adequately daylighted on the working plane height 0.7m above the floor under a uniform CIE overcast design sky.

A zone is adequately daylighted if both the following conditions are met:

- a) Average daylight factor is at least 1,5%.
- b) A uniformity ratio of at least 0,3 or a minimum point daylight factor of 0,5% (spaces with glazed roofs, such as atria, must achieve a uniformity ratio of at least 0,7 or a minimum point daylight factor of at least 1,4).

The results below were calculated using the Radiance simulation engine which provides a detailed multi-zone physics-based calculation of illumination levels on the working planes of the building. Daylighting Analysis Report generated by DesignBuilder v6.1.8.021.

Daylighting data

Report generation time	12.4.2021 16:28:15
Sky model	CIE overcast day (specify illuminance)
Location	MALE
Working plane height (m)	0,700
Max Grid Size (m)	0,300
Min Grid Size (m)	0,300
Daylight factor threshold (%)	1,5*

* You should check the daylight factor minimum threshold based on the BREEAM requirements of the local region and building type.

The detailed output of analysis for glazing alternatives with 50% and 60% visible light transmission are given below separately. Although VLT value is increased, the BREEAM requirements are not met due to depth of office areas located between 4 and 7 floors.

The daylighting summary results of glazing alternative with **50% visible light transmittance** value.

Summary Results

Total area (m2)	3509,96
Total area meeting requirements (m2)	742,43
% area meeting requirements	21,1
BREEAM Health and Wellbeing Credit HEA 01 Status	FAIL

The daylighting summary results of glazing alternative with **60% visible light transmittance** value.

Summary Results

Total area (m2)	3509,96
Total area meeting requirements (m2)	926,45
% area meeting requirements	26,4
BREEAM Health and Wellbeing Credit HEA 01 Status	FAIL

Glazing alternative with 50% VLT

Eligible zones for daylighting

Zone	Block	Floor area (m2)	Min DF (%)	Uniformity ratio (Min / Avg)	Average Daylight Factor (%)	Area Adequately Daylit (m2)
Admin	GroundFloor	27,34	0	0	0	0
Lobby	GroundFloor	72,86	0,03	0,02	1,4	0
Cafe	GroundFloor	130,00	1,2	0,22	5,5	130,00
Security Room	FirstFloor	21,38	0,13	0,08	1,7	0
Cafe	FirstFloor	86,58	1,09	0,44	2,5	60
PrayerRoom	ThirdFloor	32,88	0,55	0,28	1,9	32,88
Office	ThirdFloor	455,11	0,54	0,16	3,4	455,11
Office	4thFloor	498,35	0,28	0,18	1,6	0
Office	5thFloor	498,35	0,29	0,17	1,7	0
Office	6thFloor	498,35	0,31	0,17	1,8	0
Office	7thFloor	498,35	0,33	0,17	1,9	0
Multipurpose	8thFloor	363,94	0,01	0	1,7	0
MeetingRoom2	8thFloor	31,55	0,73	0,39	1,9	31,55
MeetingRoom	8thFloor	58,31	0	0	0	0
Pantry	8thFloor	32,89	1,03	0,34	3	27,2
Pantry	9thFloor	19,7	0	0	0	0
IndoorSpace	9thFloor	184,02	0,34	0,15	2,3	0
Total		3509,96				742,43

Zones with data flagged in red in the table above fail daylighting uniformity criteria.

Glazing alternative with 60% VLT

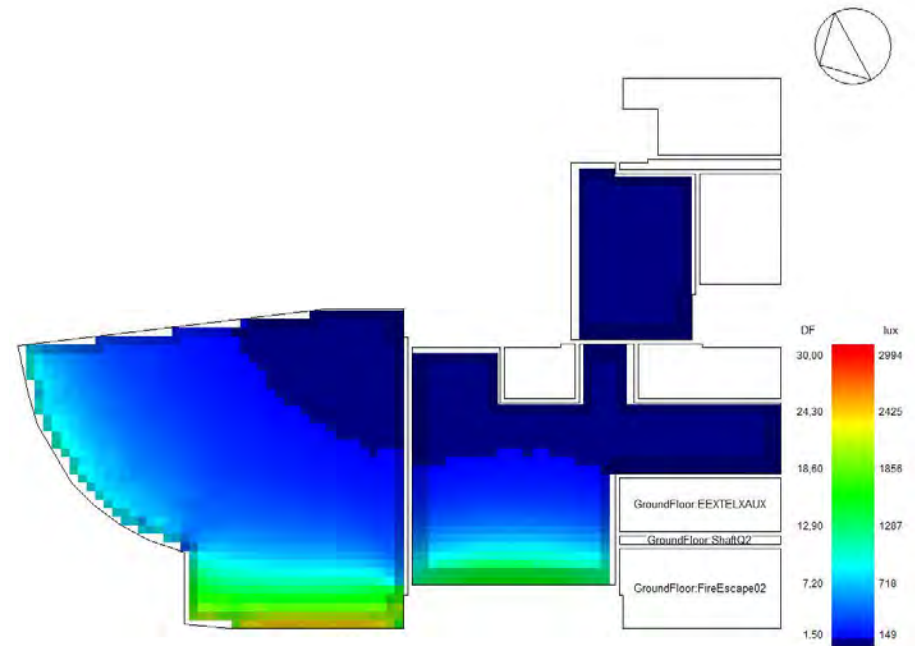
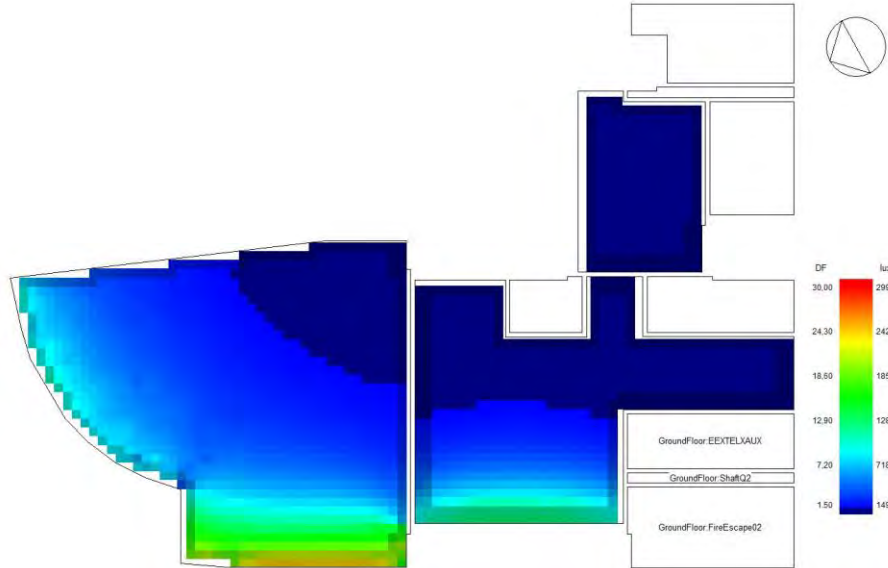
Eligible zones for daylighting

Zone	Block	Floor area (m2)	Min DF (%)	Uniformity ratio (Min / Avg)	Average Daylight Factor (%)	Area Adequately Daylit (m2)
Admin	GroundFloor	27,34	0	0	0	0
Lobby	GroundFloor	72,86	0,1	0,03	3,1	0
Cafe	GroundFloor	130,00	0,86	0,17	5,2	130,00
Security Room	FirstFloor	21,38	0,25	0,09	2,8	0
Cafe	FirstFloor	86,58	1,59	0,39	4,1	60
PrayerRoom	ThirdFloor	32,88	0,79	0,24	3,3	32,88
Office	ThirdFloor	455,11	0,68	0,12	5,6	455,11
Office	4thFloor	498,35	0,29	0,11	2,6	0
Office	5thFloor	498,35	0,32	0,11	2,8	0
Office	6thFloor	498,35	0,34	0,12	3	0
Office	7thFloor	498,35	0,37	0,12	3,1	0
Multipurpose	8thFloor	363,94	0,01	0	2,7	0
MeetingRoom2	8thFloor	31,55	1,08	0,33	3,3	31,55
MeetingRoom	8thFloor	58,31	0	0	0	0
Pantry	8thFloor	32,89	1,54	0,29	5,2	32,89
Pantry	9thFloor	19,7	0	0	0	0
IndoorSpace	9thFloor	184,02	0,48	0,12	3,9	184,02
Total		3509,96				926,45

Green Office, GroundFloor

Glazing alternative with **50% VLT**

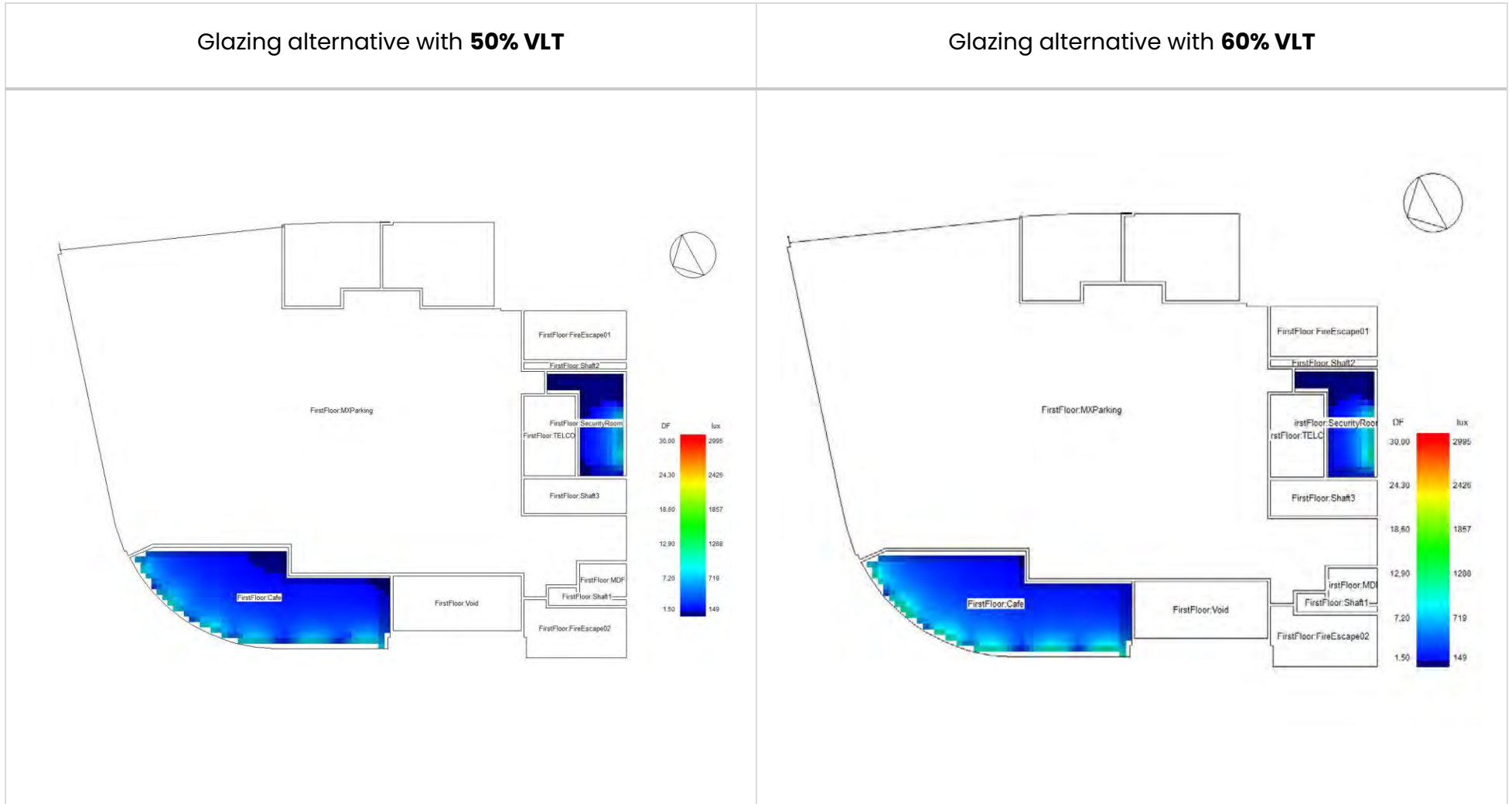
Glazing alternative with **60% VLT**



Green Office, FirstFloor

Glazing alternative with **50% VLT**

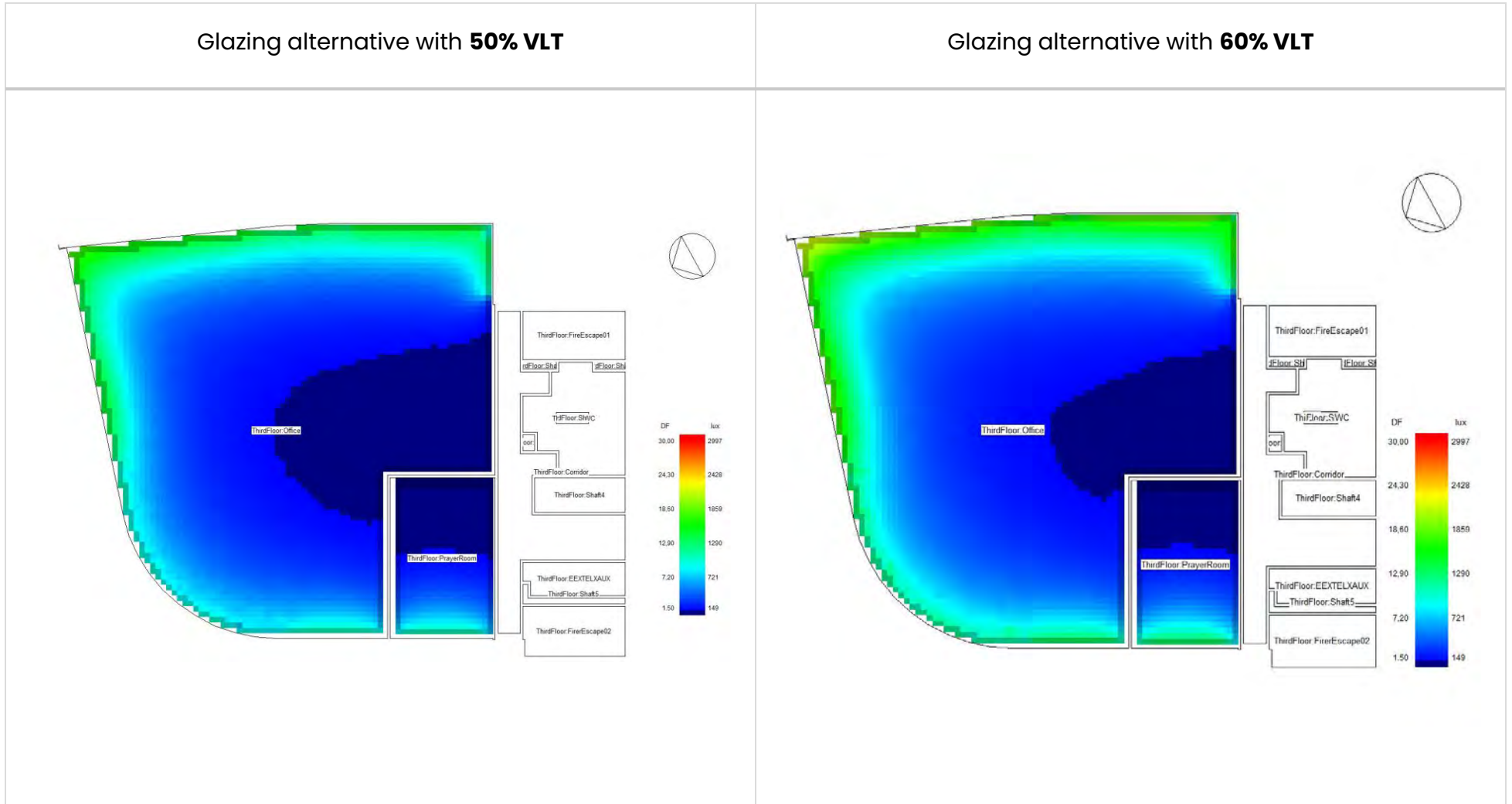
Glazing alternative with **60% VLT**



Green Office, ThirdFloor

Glazing alternative with **50% VLT**

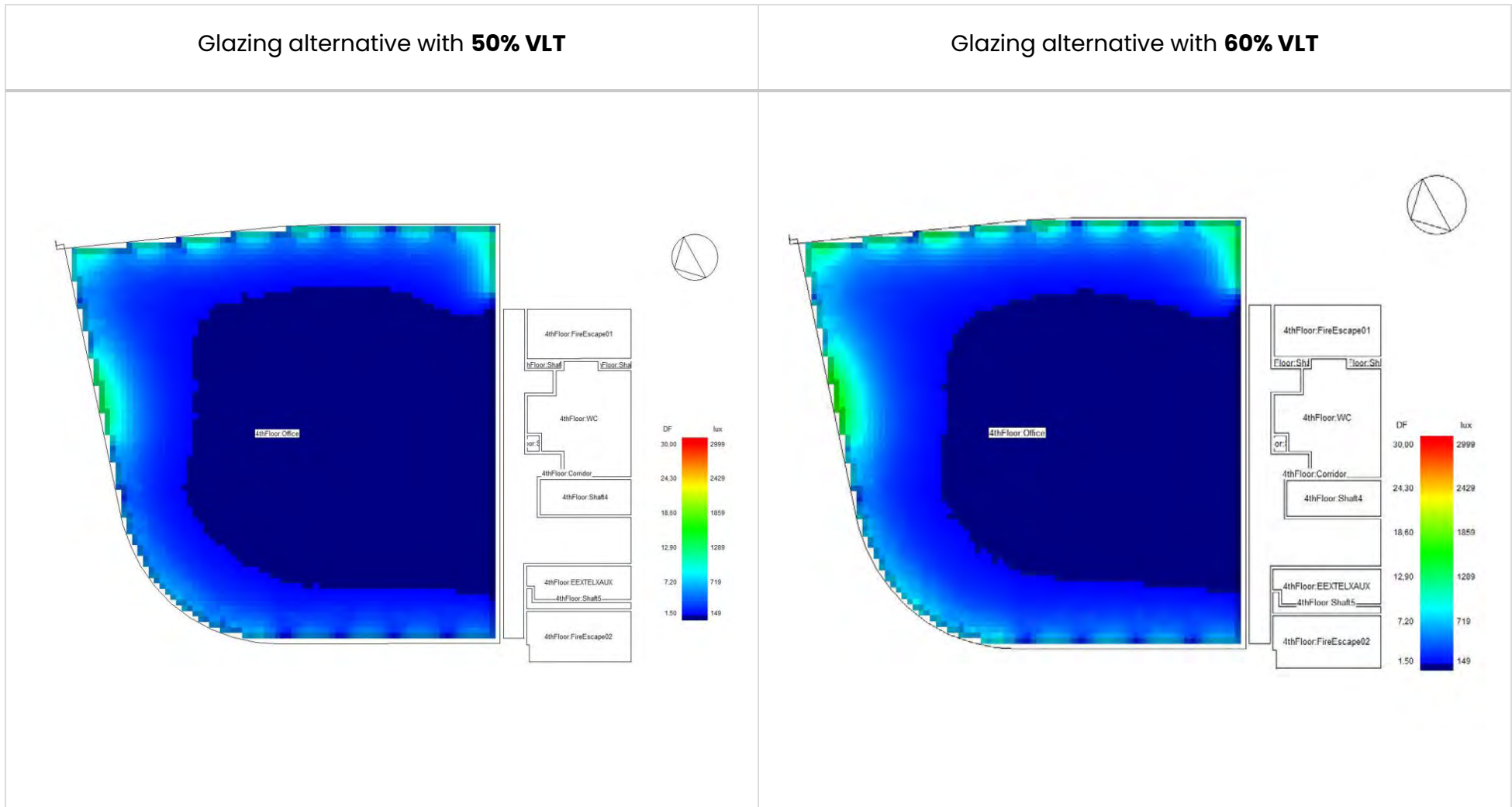
Glazing alternative with **60% VLT**



Green Office, 4thFloor

Glazing alternative with **50% VLT**

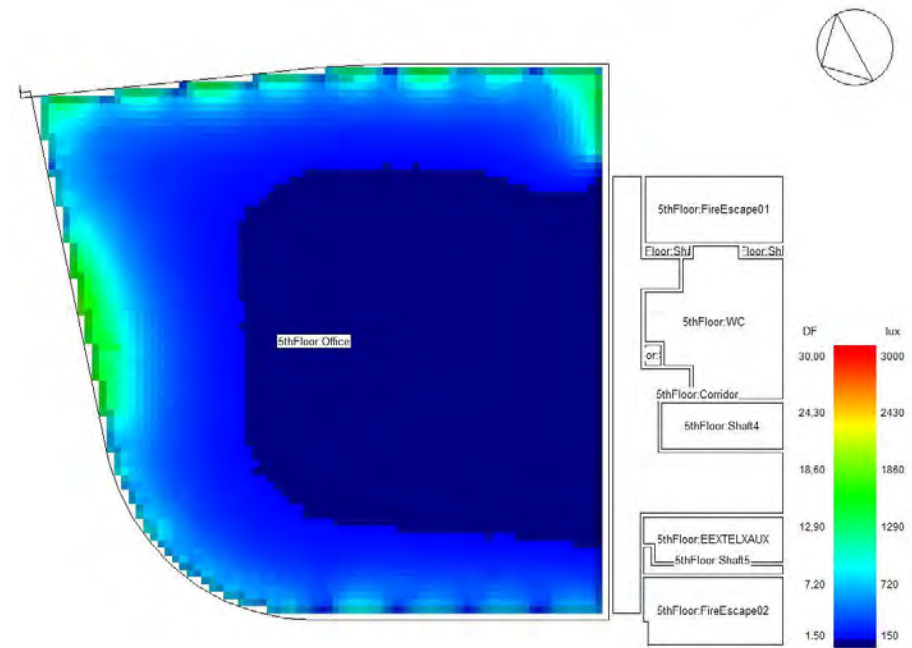
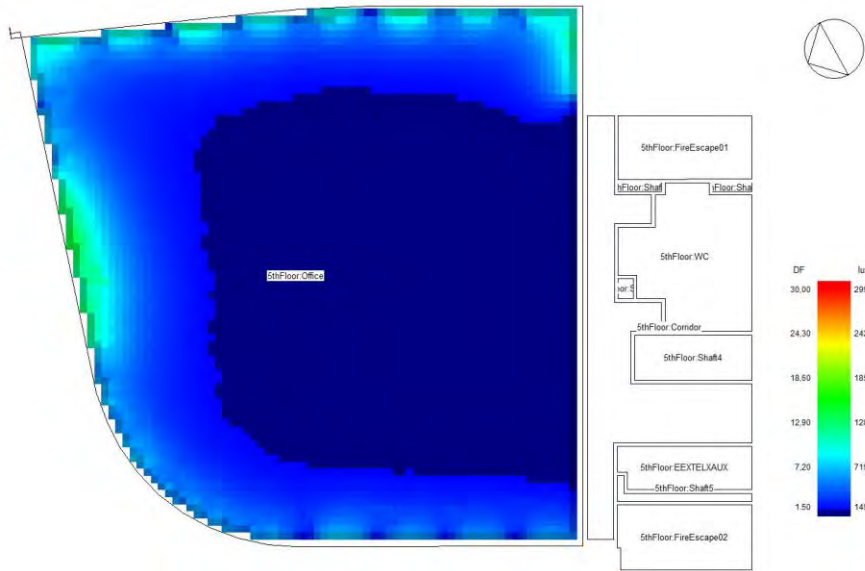
Glazing alternative with **60% VLT**



Green Office, 5thFloor

Glazing alternative with **50% VLT**

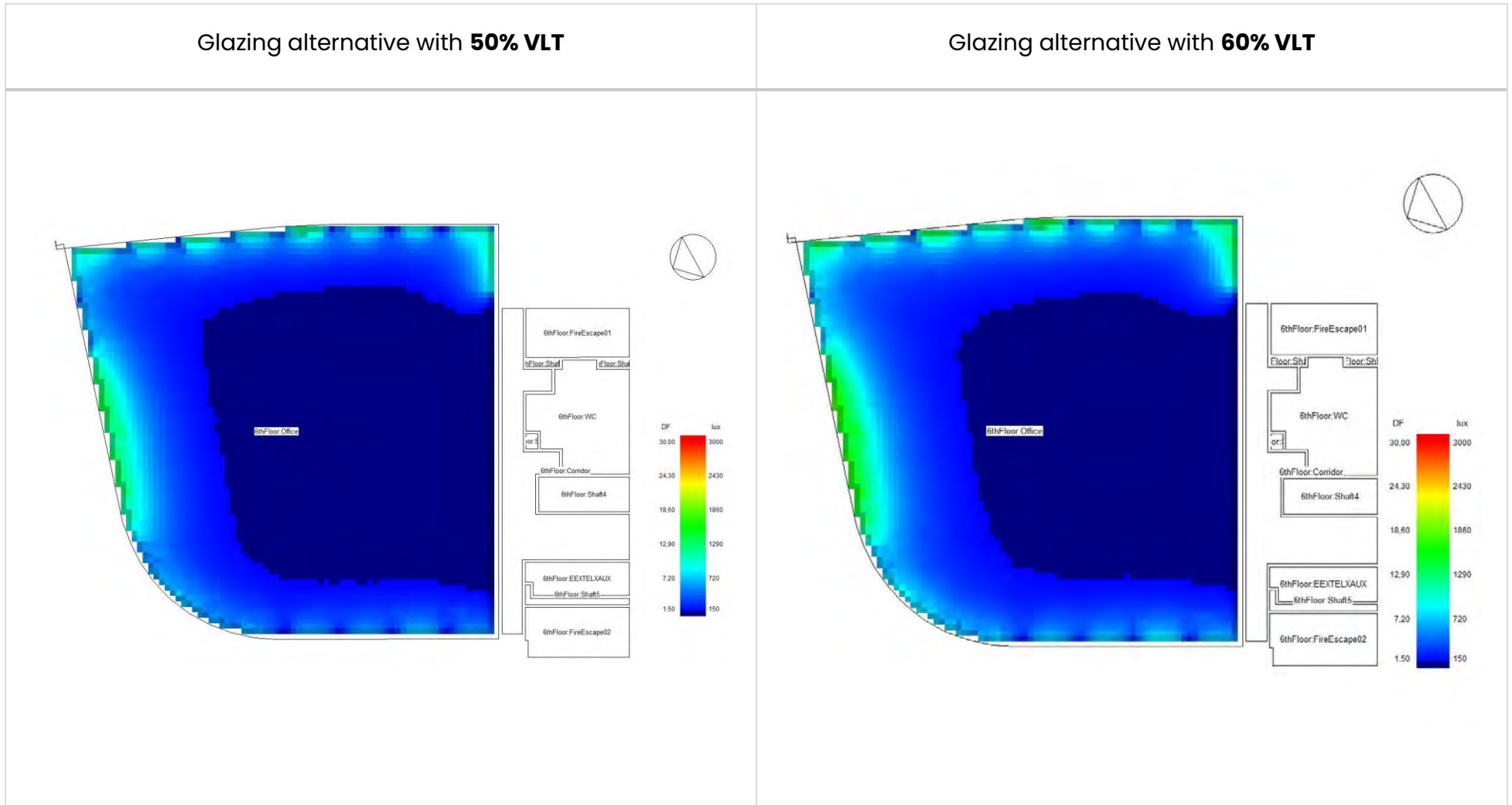
Glazing alternative with **60% VLT**



Green Office, 6thFloor

Glazing alternative with **50% VLT**

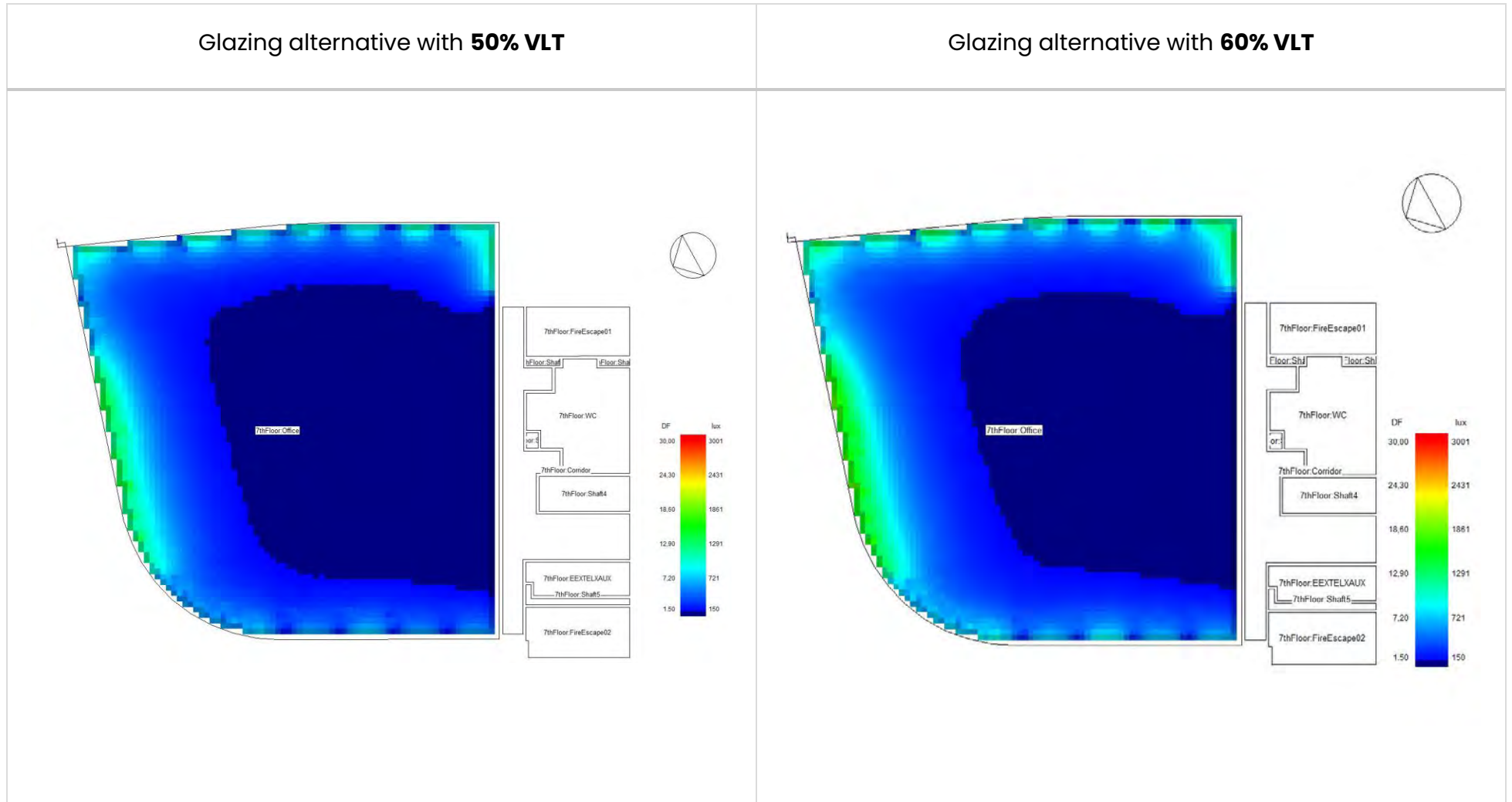
Glazing alternative with **60% VLT**



Green Office, 7thFloor

Glazing alternative with **50% VLT**

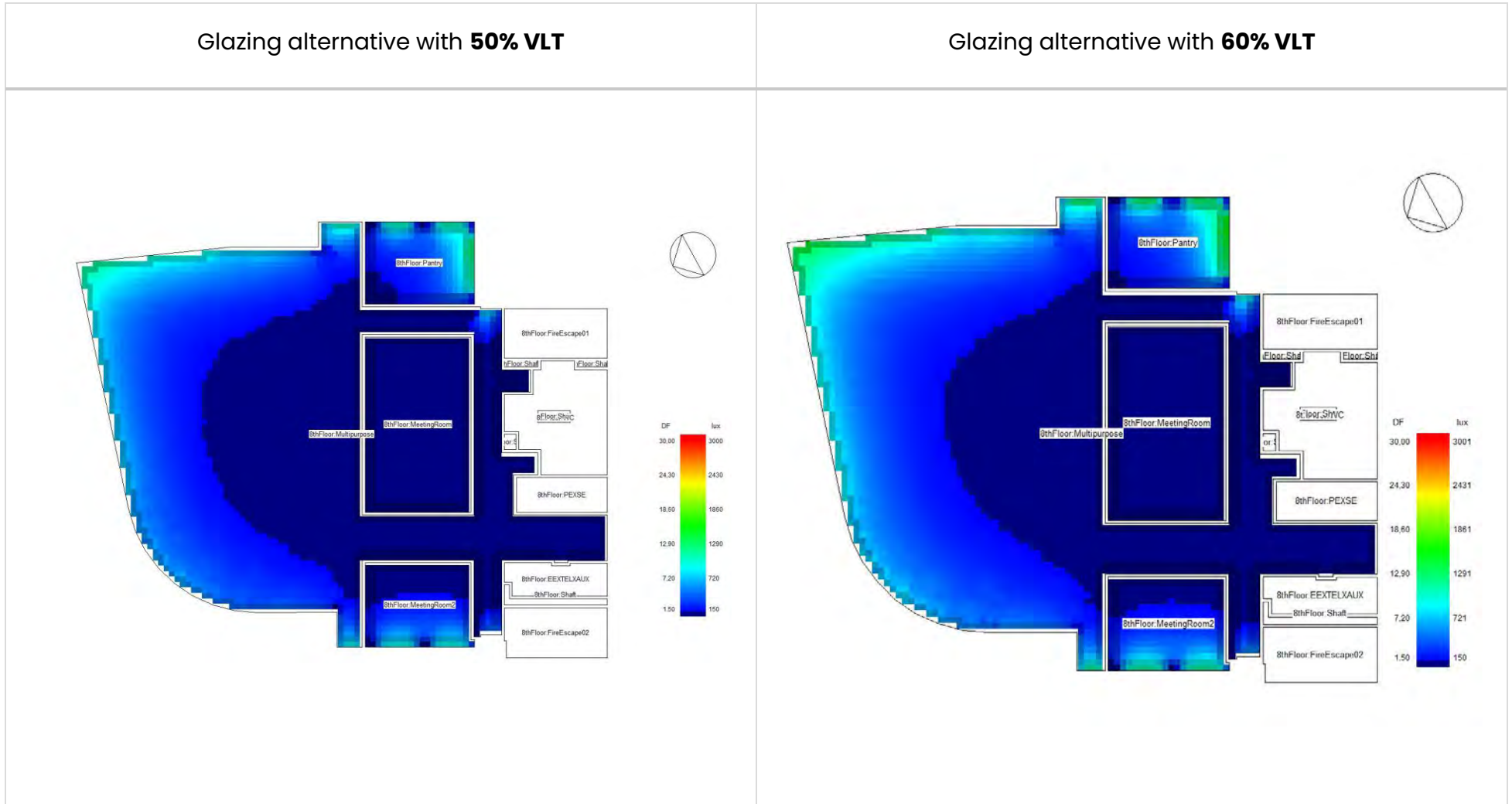
Glazing alternative with **60% VLT**



Green Office, 8thFloor

Glazing alternative with **50% VLT**

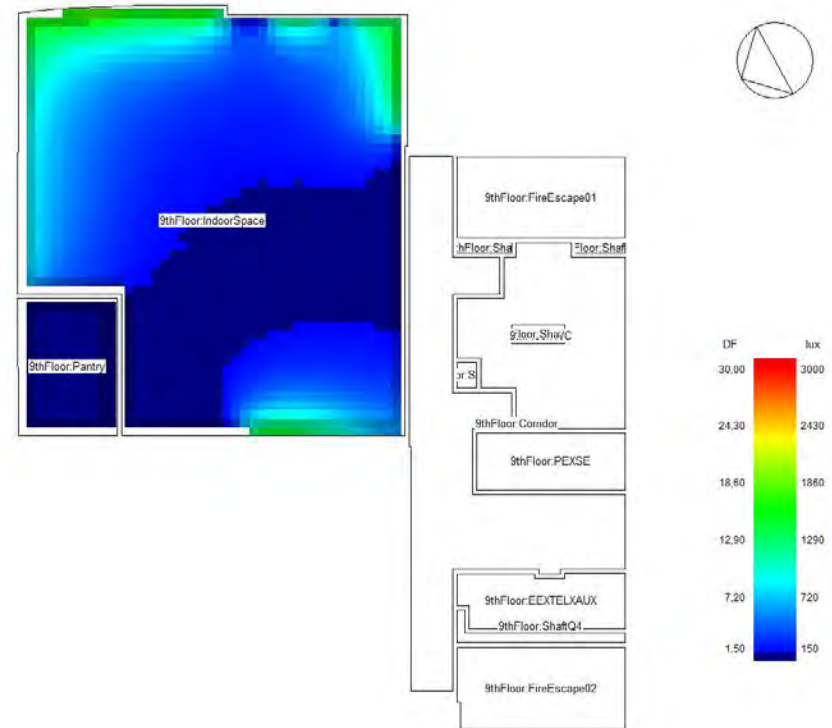
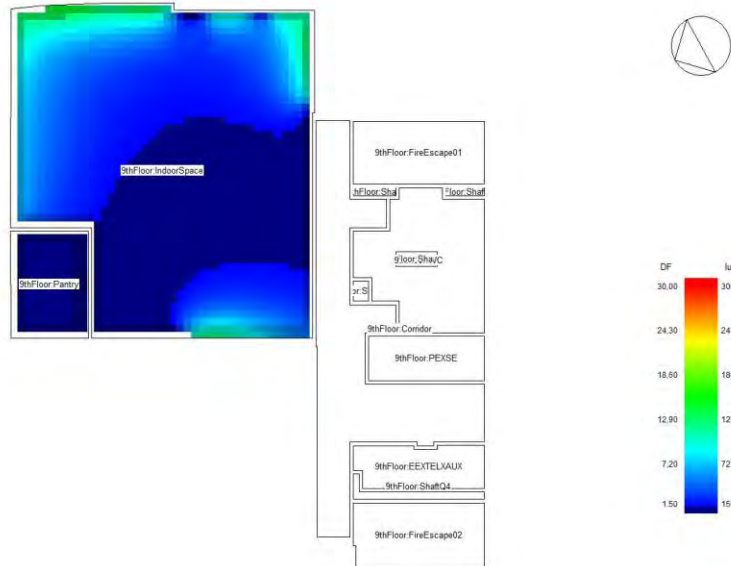
Glazing alternative with **60% VLT**



Green Office, 9thFloor

Glazing alternative with **50% VLT**

Glazing alternative with **60% VLT**





FOR MINISTRY OF ENVIRONMENT

April 2021



ANNEX 2. ENERGY SIMULATION REPORT

Review and Amend Design of Green Building to attain BREEAM Certification

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General Information		
1	Areas	~ 5,969 m ²
2	Building Type	Office Building
3	Location	Maldives
BREEAM ENE01 Credits Achieved		
1	ENE01 Credit Achieved without Renewable Energy Production	Saving of 10.8% were realized over ASHRAE 90.1- 2013 Energy Performance Standard Baseline.
2	ENE01 Credit Achieved with Renewable Energy Production	Saving of 14.9% were realized over ASHRAE 90.1- 2013 Energy Performance Standard Baseline.
3	Total Credits Achieved	To be evaluated after final version of Energy Modeling Analysis.
Details of Energy Conservation Measures		
1	Building envelope specific measure (solar low-e double glazing)	
2	Highly efficient air-cooled screw chiller with VSD control	
3	Efficient LED lighting systems	
4	Heat recovery units with 70% efficiency values in AHUs	
5	IE3 motor efficiency class in air handling unit fans	

Design Case	Energy Usage (kWh/year)	Energy Savings (%)
Baseline Design as per ASHRAE 90.1 2013 Appendix G	1,176,208.82	-
Proposed Design without Renewable Energy Production	1,049,508.90	10.8%
Proposed Design with Renewable Energy Production	1,001,508.90	14.9%
BREEAM Best Practice Building	913,709.62	22.3%

INTRODUCTION

The energy modelling report has been prepared for Green Offices project in Maldives. The project is a typical office building. Total modelled area of the project is approximately 5,969 square meters.

The project is required to demonstrate improvement in the proposed building performance rating compared to the baseline building performance rating as per ASHRAE/IESNA Standard 90.1-2013 by whole building project simulation using the Building Performance Rating Method in Appendix G of the Standard.

The analysis tool chain employed is shown in the following figure. DesignBuilder (v6.1.5.4) is used to create full three-dimensional architectural models that are exported to EnergyPlus (v8.9) as an input file which is used for analysis of both the baseline and proposed designs reported here.



3D Architectural Model
Preliminary modelling and analysis



Baseline & Proposed Design energy
modelling, parameter definition and
detailed analysis

Figure 1: Analysis Tool Chain

1 METHODOLOGY

A whole building energy simulation was performed for showing improvement in the building performance rating compared to the baseline building performance rating as per ASHRAE/IESNA Standard 90.1-2013.

1.1 Data Collection

The drawings of the site, floor plans of the space and section details were provided for developing thermal model. MEP consultants have given details of proposed design for lighting, envelope and HVAC, etc.

A building "surface" is the fundamental element in the building model. In the general sense, there are two types of "surfaces" in EnergyPlus. These are:

1. Heat transfer surfaces
2. Heat storage surfaces

Any surface, which is expected to separate spaces of significantly different temperatures, is defined as a heat transfer surface. Thus, exterior surfaces, such as outside walls, roofs and floors, are heat transfer surfaces. Interior surfaces (partitions) are heat storage surfaces if they separate spaces maintained at the same temperature; and heat transfer surfaces if they separate spaces maintained at different temperatures.

A "zone" is an air volume at a uniform temperature plus all the heat transfer and heat storage surfaces bounding or inside of that air volume. EnergyPlus calculates the energy required to maintain each zone at a specified temperature for each hour of the day. Since EnergyPlus performs a zone heat balance, the building was separated into zones. A "zone" is a thermal, not a geometric, concept. Thus, the objective was to define as few zones as possible without compromising the integrity of the simulation. Although defining building zones is somewhat of an art, there are a few general rules to smoothen the process. Each room in the building was not defined as a zone; instead a thermal zone was defined as a volume of air at a uniform temperature. Therefore, an important rule here is to use the number of fan systems (and radiant systems) instead of the number of rooms to determine the zones in the building. The minimum number of zones will usually be equal to the number of systems serving the building. The collection of heat transfer and heat storage surfaces defined within each zone includes all surfaces bounding or inside of the space conditioned by the system.

Surfaces that are specified as the outside boundary condition are ceilings, floors and partitions that divide temperature-controlled spaces. The program assumes that the surface temperatures on both sides of the surface are the same. This means that even though heat may be stored in a partition, ceiling, or floor, no heat flows through it. Some surfaces divide the temperature-controlled space from the outside environment. Surfaces that are both sun and wind exposed (e.g. exterior walls, exposed floors, roofs) feel the full effect of both solar radiation and outside temperature. Surfaces such as basement walls and slab floors separate the space from the earth

surrounding the surfaces. Therefore, outside surface temperatures become ground temperatures. Other surfaces separate zones that may be at different temperatures. These surface types allow heat transfer (by conduction through the walls) from a zone at a higher temperature to a zone at a lower temperature.

As stated above, the main objective was to define as few zones and surfaces as possible without compromising the integrity of the model. The number and complexity of surfaces in the input file were cut down by defining equivalent surfaces. EnergyPlus performs heat balances on individual zone surfaces and on the zone air. For the purpose of heat transfer calculations, importance of detailed geometric modelling of the zone surfaces is not significant. As long as the thermal zones (mass of air) and corresponding heat transfer surfaces are known, the program shall calculate all heat balances correctly.

For example, all heat storage surfaces of the same construction within a zone may be defined as a single rectangular surface. The total area of this surface will be equal the sum of all heat storage surface areas in the zone. These represent simplification options for the input data. Each simplification result was analyzed to determine if it would significantly impact certain shading, interior solar gains, or day lighting features. The goal was to seek an adequate level of detail to capture the key features of the building envelope without spending excess time computing results for details that are insignificant.

1.2 General Building Model

By following the above-mentioned guidelines and evaluating each simplification carefully in order to avoid any significant impact on simulation results, a representative model of the proposed building was prepared as shown in Figure 2 for the building shell.

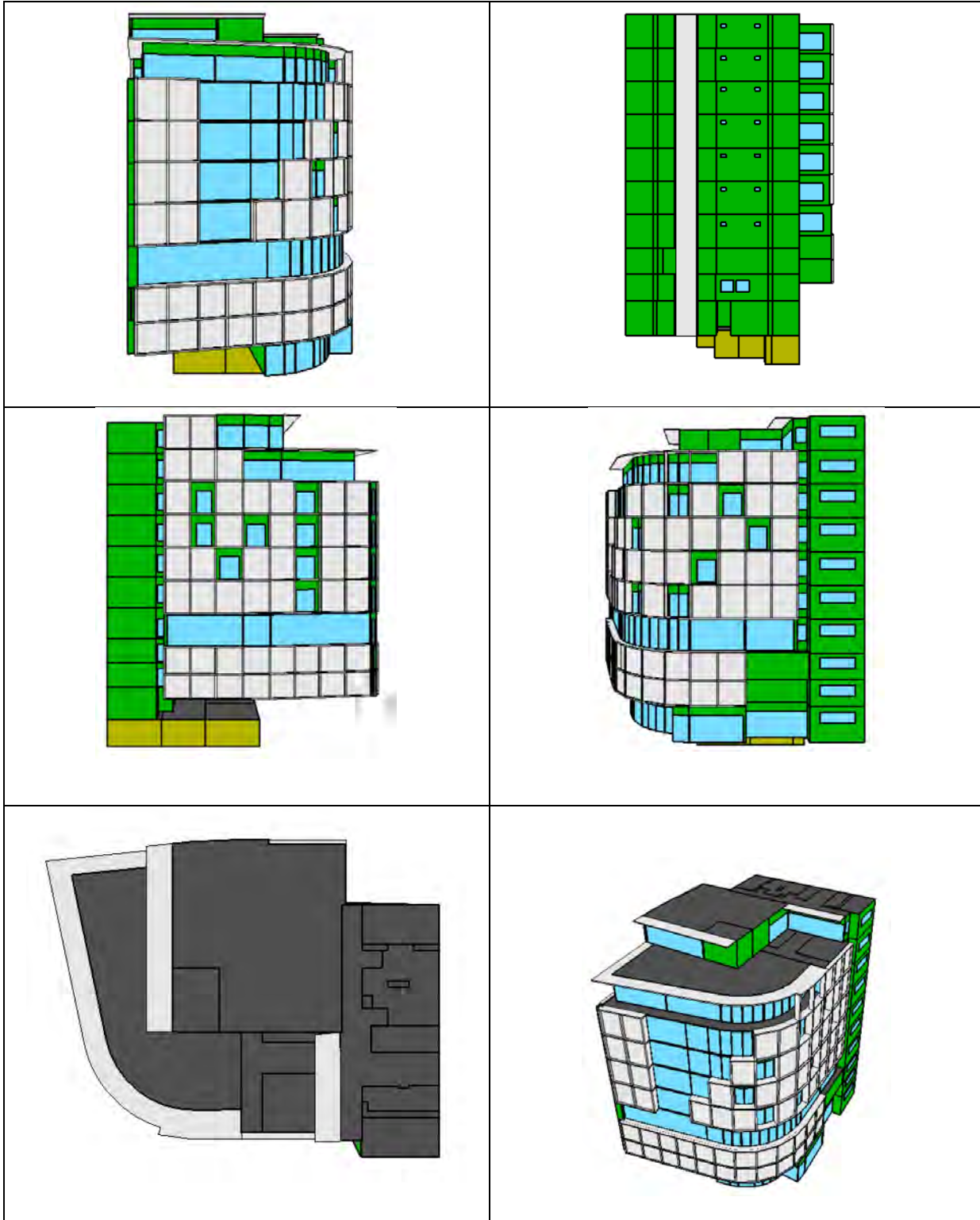


Figure 2: DesignBuilder 3-D Views of Model of the Project

The same methodology was applied for zoning while going through the floor plans. Briefly, the models, both proposed and baseline comprise of 122 zones, simplified to enhance speed of the EnergyPlus runtime. The average baseline performance for four different orientations was computed using the tools provided in EnergyPlus.

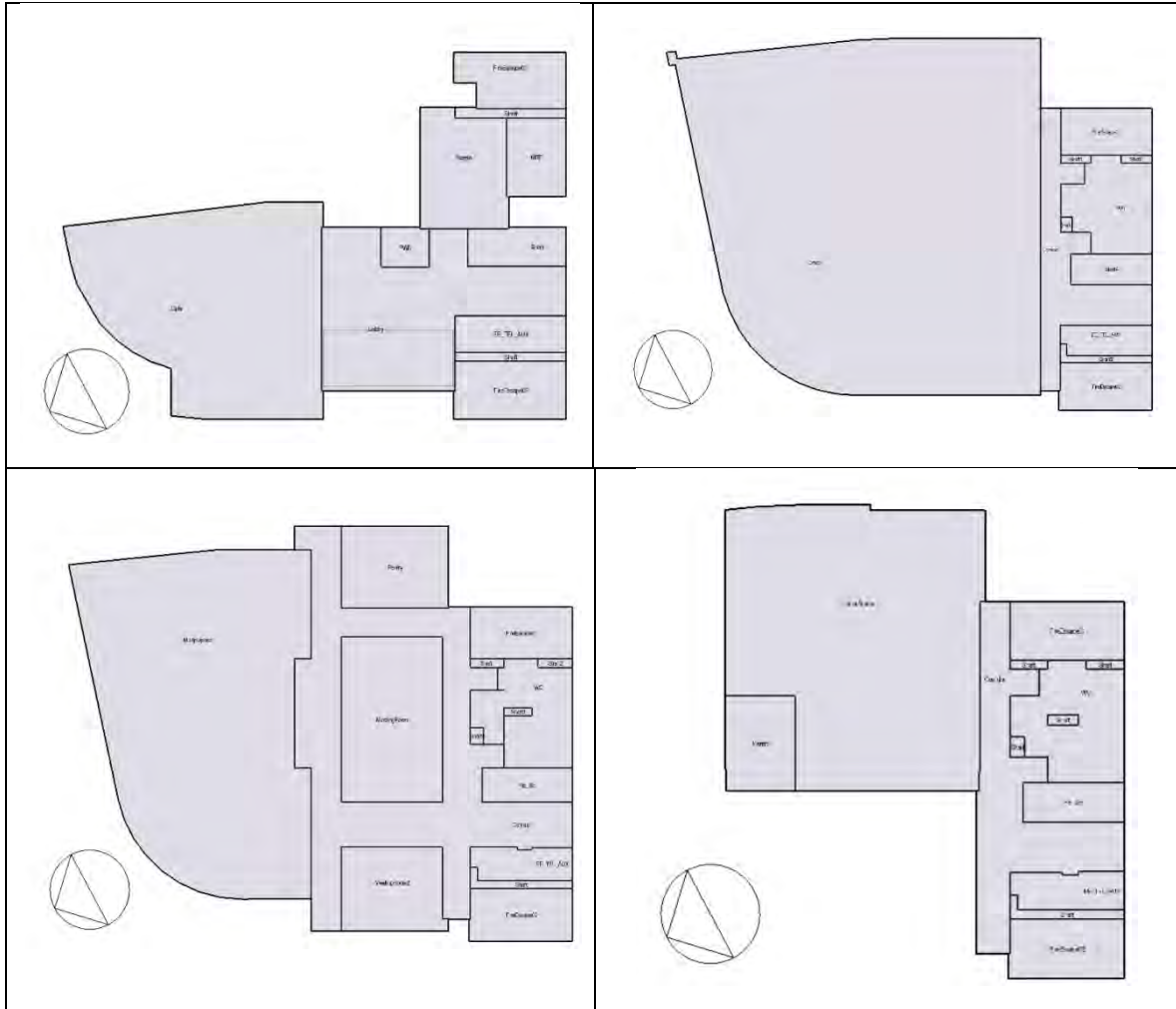


Figure 3: Some of the DesignBuilder Plan Views for the Model

2 BASELINE BUILDING DESCRIPTION

2.1 Baseline Area

The ASHRAE Baseline Model has the same number of floors and identical conditioned floor area as the Proposed Design.

2.2 Climate Data

The project's climate zone is Climate Zone 1A. The weather data file used in the simulations is the "MDV_MALE_SWERA.435550_EPW" weather data file. A plot of the dry bulb and wet bulb temperatures from the climate data is given in Figure 3.

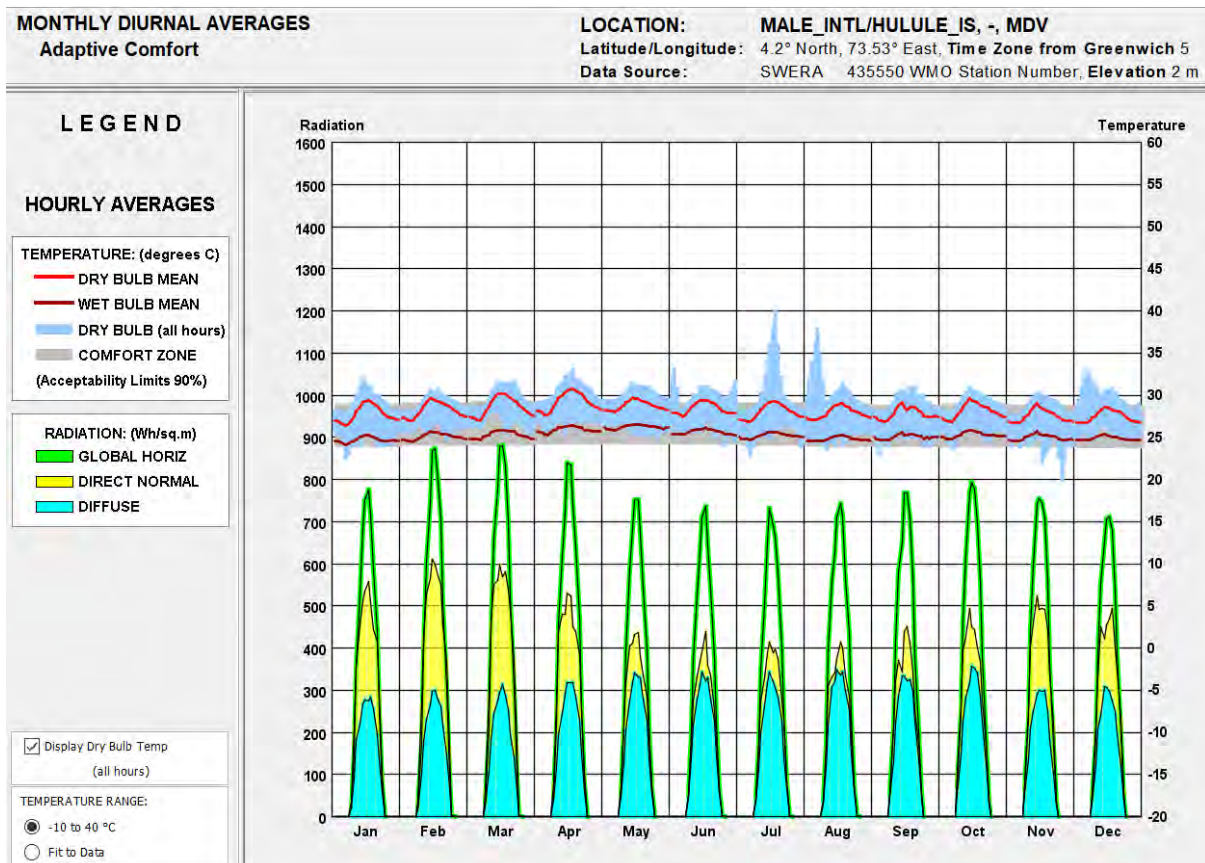


Figure 4: Ambient Dry Bulb and Wet Bulb Temperatures

2.3 Baseline Building Fabric

The ASHRAE/IESNA Standard 90.1-2013 describes a hypothetical code-compliant baseline building which shall be used as a reference point for the building benchmarking. It requires calculation of baseline energy consumption by rotating the building from its original orientation to 90°, 180°, and 270° and the respective annual energy consumptions for each orientation shall be averaged to compute the reference energy consumption. The baseline building is modelled such, that it does not shade itself.

ASHRAE/IESNA Standard 90.1-2013 specifically mandates minimum performance criterion for the building envelope, lighting system and HVAC system. Table 2 below lists the building envelope/fabric minimum performance specifications for baseline design specific to climate zone 1A as per ASHRAE classification.

Table 1: Baseline Building Envelope/Fabric Minimum Performance Specifications

Building Envelope	Subject Component	Detail of Performance Criteria as per ASHRAE/IESNA Standard 90.1-2013
	Roof	The roof space of the building is to be compliant with: $U = 0.273 \text{ W/m}^2\text{K}$
	Exposed Floor	The exposed floors of all the space of the building is to be compliant with: $U = 1.986 \text{ W/m}^2\text{K}$
	Walls	Walls above grade are to be compliant with: $U = 0.705 \text{ W/m}^2\text{K}$
	Slab-on-Grade Floor	Slab-on-Grade floors of building is to be compliant with: $F = 1.264 \text{ W/m}^2\text{K}$ ($U \sim 0.400 \text{ W/m}^2\text{K}$)
	Fenestration	For $\leq 40\%$ window to wall ratio, the glazing requirements are: $U_{\text{windows}} = 3.69 \text{ W/m}^2\text{K}$ $\text{SHGC}_{\text{all}} = 0.25$ Shading – No

***Source: Table 5.5 Building Envelope requirements of ASHRAE 90.1 2013 standard**

The glazing distribution in the Baseline model is determined in accordance with ASHRAE 90.1 Appendix G protocols. The rules are outlined in Table 4.

Table 2: ASHRAE Baseline Glazing Distribution

Proposed Design Façade Glazing Percentage	Baseline Model Façade Glazing Percentage
< 40%	= Proposed Design
> 40%	= 40%

Based on the architectural drawings, the Proposed Design has almost equal to 34% façade glazing; therefore, the Baseline Model's window to wall ratio was defined as 34% based on ASHRAE 90.1-2013 Appendix G requirements.

2.4 Baseline Building HVAC and Lighting System

Baseline HVAC system description is specified in ASHRAE 90.1–2013 Appendix G section as Systems 6: Packaged VAV with PFP Boxes type for this type building.

Table 3: Baseline Building HVAC System Min. Performance Specifications

		Detail of Performance Criteria as per ASHRAE/IESNA Standard 90.1–2013
HVAC System	Systems/Plants	
	Baseline Primary HVAC System	System 8—VAV with PFP boxes for Building Occupied Spaces
	Primary HVAC System—Heating	Electric Resistance
	Primary HVAC System—Cooling	Water cooled centrifugal chiller with VSD control Performance Value: COP:5.18, IPLV:8.00 (defined in ASHRAE 90.1–2013 Table 6.8.1.3)
	Ventilation System	Minimum outdoor air flow rates were defined according to ASHRAE 62.1–2013 standard requirements Exhaust air energy recovery is modeled with 50% efficiency as required by G3.1.2.11

***Source: Baseline HVAC system description as specified in Table G3.1.1–3 & G3.1.1–4 of Appendix G ASHRAE 90.1 – 2013 standard**

The baseline lighting power density is defined as space-by-space method in Table 5 below:

Table 4: Baseline Building Lighting System Minimum Performance Specifications

		Detail of Performance Criteria as per ASHRAE/IESNA Standard 90.1–2013
Lighting System	Space Type	
	Interior	The baseline building lighting power allowance for overall interior spaces is 8.72 W/m ² . <u>Space by Space LPD Value</u> Parking: 2.1 W/m ² Electrical/Mechanical Room: 4.6 W/m ² Storage: 6.8 W/m ² Prayer Room: 6.9 W/m ²

	<p>Cafeteria: 7.0 W/m²</p> <p>Corridor: 7.1 W/m²</p> <p>Stairs: 7.4 W/m²</p> <p>Breakroom: 7.9 W/m²</p> <p>Main Entry Lobby: 9.7 W/m²</p> <p>Restroom: 10.6 W/m²</p> <p>Office: 12.0 W/m²</p> <p>Meeting Room: 13.3 W/m²</p> <p>Multipurpose: 13.3 W/m²</p>
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***Source: Baseline lighting system description as specified in TABLE 9.6.1 ‘Lighting Power Densities Using the Space by Space Method’ of ASHRAE 90.1 – 2013 standard**

Appendix G of Standard 90.1-2013 requires that the energy analysis done by using the Building Performance Rating Method must include all the energy costs within and associated with the building project. The baseline building that complies with Appendix G to Standard 90.1-2013 shall have a default process energy cost which should be at least 25% of the total energy cost for the baseline building. Therefore, interior equipment power density values were entered to related section of energy model input files as 17.0 W/m² for all occupiable spaces in both cases.

Table 5: Baseline Building Interior Equipment Performance Specifications

Receptacle	Space Type	Detail of Performance Criteria as per ASHRAE/IESNA Standard 90.1-2013
	Interior	Interior equipment (receptacle equipment) power densities for all occupiable spaces in both cases is 17 W/m ² .

2.5 Schedules

In performing computer simulations of buildings, schedules/profiles need to be defined and assigned to parameters such as:

- ❖ Occupancy / People
- ❖ HVAC Plant Operation
- ❖ Internal Lighting
- ❖ Internal Equipment
- ❖ Infiltration
- ❖ Thermostat Setpoints

In defining these schedules, a usage percentage is allocated on an hourly basis, covering all 24 hours of a day and accounting for every single day of the year. Schedules/profiles used in the computer simulations are based on those stated in ASHRAE 90.1 Appendix G, and the same schedules/profiles are used in all the computer simulations. Representative schedule of office occupancy is shown in Appendix of this report.

3 PROPOSED DESIGN DESCRIPTION

The proposed design simulation parameters are described in the following tables:

Table 6: Proposed Building Envelope/Fabric Performance Specifications

Building Envelope/Fabric	Subject Component	Detail of Technical Specifications
	Roof	The roof space of the building is to be compliant with: $U = 0.273 \text{ W/m}^2\text{K}$
	Exposed Floor	The exposed floors of all the space of the building is to be compliant with: $U = 1.986 \text{ W/m}^2\text{K}$
	Walls	Walls above grade are to be compliant with: $U = 0.705 \text{ W/m}^2\text{K}$
	Slab-on-Grade Floor	Slab-on-Grade floors of building is to be compliant with: $F = 1.264 \text{ W/m}^2\text{K}$ ($U \sim 0.400 \text{ W/m}^2\text{K}$)
	Fenestration	For $\leq 40\%$ window to wall ratio, the glazing requirements are: $U_{\text{windows}} = 1.8 \text{ W/m}^2\text{K}$ $\text{SHGC}_{\text{all}} = 0.32$ Shading – Yes

Table 7: Proposed Building HVAC System Performance Specifications

		Systems/Plants	Detail of Performance Criteria
HVAC	HVAC System Description (Plant Side)		The central plant houses two air cooled screw chiller with VSD control.
	HVAC System Description (Zone Side)		There are three different type fan coil units (Ceiling Cassette, Ceiling Concealed FCU, Wall Mounted) in conditioned zones.
	HVAC System Description (Air Side)		<p>There was no air handling unit to meet fresh air requirement of zones in mechanical plans.</p> <p>Because of this reason it was modeled six AHUs to required provide outdoor air rates. Each office space has one HRV (HRV-01/02/03/04/05) and one AHU (AHU-01) is available to provide fresh air for common occupied areas in building such as cafeteria, meeting rooms, multipurpose and corridors.</p> <p>Outdoor air flow rates have been calculated based on ASHRAE 62.1.2013 requirements. Fan powers of AHU and HRVs were calculated according to ASHRAE 90.1-2013 Table G3.1.2.10 and Section 6.5.3.1.1. Calculations are provided in annex of this report.</p> <p>Heat recovery effectiveness values for all AHUs have been defined as 70%.</p>

The proposed design lighting power density is defined as space by space method in Table 8 below:

Table 8: Proposed Building Lighting System Performance Specifications

		Space Type	Detail of Performance Criteria
LPD			The proposed building lighting power allowance for overall interior spaces is 6.54 W/m ² .
		Interior	<p><u>Space by Space LPD Value</u></p> <p>Parking: 1.575 W/m²</p> <p>Electrical/Mechanical Room: 3.45 W/m²</p> <p>Storage: 5.1 W/m²</p> <p>Prayer Room: 5.175 W/m²</p> <p>Cafeteria: 5.25 W/m²</p>

		<p>Corridor: 5.325 W/m²</p> <p>Stairs: 5.55 W/m²</p> <p>Breakroom: 5.925 W/m²</p> <p>Main Entry Lobby: 7.275 W/m²</p> <p>Restroom: 7.95 W/m²</p> <p>Office: 9.0 W/m²</p> <p>Meeting Room: 9.975 W/m²</p> <p>Multipurpose: 9.975 W/m²</p>
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Table 9: Proposed Building Interior Equipment Performance Specifications

Receptacle Equipment	Space Type	Detail of Performance Criteria as per ASHRAE/IESNA Standard 90.1-2013
Receptacle Equipment	Interior	Interior equipment (receptacle equipment) power densities for all occupiable spaces in both cases is 17 W/m ² .

4 BREEAM BEST PRACTICE DESIGN DESCRIPTION

The BREEAM Best Practice design simulation parameters are described in the following tables:

Table 10: BREEAM Best Practice Building Envelope/Fabric Performance Specifications

Building Envelope/Fabric	Subject Component	*Detail of Technical Specifications
	Roof	The roof space of the building is to be compliant with: $U = 0.273 \text{ W/m}^2\text{K}$
	Exposed Floor	The exposed floors of all the space of the building is to be compliant with: $U = 1.986 \text{ W/m}^2\text{K}$
	Walls	Walls above grade are to be compliant with: $U = 0.705 \text{ W/m}^2\text{K}$
	Slab-on-Grade Floor	Slab-on-Grade floors of building is to be compliant with: $F = 1.264 \text{ W/m}^2\text{K}$ ($U \sim 0.400 \text{ W/m}^2\text{K}$)
	Fenestration	For $\leq 40\%$ window to wall ratio, the glazing requirements are: $U_{\text{windows}} = 1.8 \text{ W/m}^2\text{K}$ $\text{SHGC}_{\text{all}} = 0.32$ Shading – Yes

*BREEAM Best Practice Building U values are different from performance values shown in above table according to Guidance Note GN25. However, project climate zone is 1A, demands are much higher than proposed building when using building envelope performance values defined in Guidance Note GN25. Because of this reason building envelope performance values kept same as Proposed Building as required building fabric section of “Further guidance on BREEAM best practice specification”.

Table 11: BREEAM Best Practice Building HVAC System Performance Specifications

HVAC	Systems/Plants	Detail of Performance Criteria
	HVAC System Description (Plant Side)	The central plant houses two air cooled screw chiller with VSD control. Air cooled chiller efficiency value has been entered as 3.5 that is defined Table 2 of Guidance Note GN25.
	HVAC System Description (Zone Side)	Same as Proposed Building (FCUs in occupied zones). Terminal unit SFP has been modeled with 0.5 W/l/s .
HVAC System Description (Air Side)	System is same as Proposed Building but performance values are different as follows; Central ventilation unit SFP has been modeled with 1 W/l/s , Heat recovery effectiveness has been modeled with 75% efficiency	

	There was no air handling unit to meet fresh air requirement of zones in mechanical plans.
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The BREEAM Best Practice design lighting power density is defined as space by space method in Table 8 below:

Table 12: BREEAM Best Practice Building Lighting System Performance Specifications

LPD	Space Type	Detail of Performance Criteria
LPD	Interior	<p>The BREEAM best practice building lighting power allowance for overall interior spaces is 4.28 W/m².</p> <p>Lighting luminaire has been taken as 65 lm/Watt as required in Table 2 of Guidance Note GN25. EN 12464-1:2011 standard was used to define lux values of each zone type. Additionally, 10% improvement has been added to reflect occupancy and daylight control effect on lighting design.</p> <p><u>Space by Space LPD Value</u></p> <p>Parking: 1.04 W/m² Electrical/Mechanical Room: 2.77 W/m² Storage: 1.38 W/m² Prayer Room: 2.77 W/m² Cafeteria: 2.77 W/m² Corridor: 1.38 W/m² Stairs: 1.38 W/m² Breakroom: 2.77 W/m² Main Entry Lobby: 2.77 W/m² Restroom: 2.77 W/m² Office: 6.92 W/m² Meeting Room: 6.92 W/m² Multipurpose: 6.92 W/m²</p>

Table 13: BREEAM Best Practice Building Interior Equipment Performance Specifications

Receptacle Equipment	Space Type	Detail of Performance Criteria as per ASHRAE/IESNA Standard 90.1-2013
Receptacle Equipment	Interior	Interior equipment (receptacle equipment) power densities for all occupiable spaces in both cases is 17 W/m ² .

5 BASELINE vs PROPOSED SYSTEM COMPARISON

Systems	Baseline Building	Proposed Building	BREEAM Best Practice Building
Fenestration Window to Wall Ratio	%33.64	%33.64	%33.64
Heating/Cooling System	VAV with parallel fan power boxes and reheat	Central air-cooled screw chillers with fan coil units in zones	Central air-cooled screw chillers with fan coil units in zones
Cooling System Performance Values	Water cooled centrifugal chiller with VSD control COP: 5.18, IPLV: 8.00	Air cooled screw chiller with VSD control COP: 2.87, IPLV: 4.76	Air cooled screw chiller with VSD control COP: 3.5, IPLV: 5.81
Heating System Performance Values	Electric resistances with 1.0 efficiency value	Electric resistances with 1.0 efficiency value	Electric resistances with 1.0 efficiency value
Ventilation System	VAV with parallel fan power boxes and reheat	DOAS units with heat recovery units (%70 efficiency) and heating/cooling coils	DOAS units with heat recovery units (%75 efficiency) and heating/cooling coils
*Total Outdoor Air Flow Rate	16,442 m ³ /h	17,800 m ³ /h	17,800 m ³ /h
**Total Fan Power	Parallel Fan Power Boxes: 14.11 kW, VAV Units: 54.72 kW,	Fan Coils: 19.78 kW, AHU Units: 15.32 kW,	Fan Coils: 23.29 kW, AHU Units: 9.88 kW,

Systems	Baseline Building	Proposed Building	BREEAM Best Practice Building
Fan Type and Maximum Air Flow Rates	PIU: Constant Volume, 18.99 m ³ /s VAV: Variable Volume, 37.38 m ³ /s	FCU: On/Off, 46.59 m ³ /s AHU: Constant Volume, 9.9 m ³ /s	FCU: On/Off, 46.59 m ³ /s AHU: Constant Volume, 9.9 m ³ /s
***Pump Type and Power	Primary Cooling Circulation Pump: Variable Speed, 4.1 kW Secondary Cooling Circulation Pump: Variable Speed, 4.1 kW Cooling Tower Circulation Pump: Variable Speed, 10.6 kW DHW Pump: Variable Speed, 0.1 kW	Cooling Circulation Pump: Variable Speed, 29.8 kW DHW Pump: Variable Speed, 0.1 kW	Cooling Circulation Pump: Variable Speed, 29.8 kW DHW Pump: Variable Speed, 0.1 kW
****Lighting Power Density (W/m²) Values	LPD values were specified based on ASHRAE 90.1-2013 Table 9.6.1 for each zone type	LPD values are %25 much lower than Baseline Building LPD values	LPD values have been determined based on 65 lm/watt criteria that is defined in Appendix B section of Guidance Note GN25. Additionally, occupancy control and daylight control effect have been added with 10% improvement.

Systems	Baseline Building	Proposed Building	BREEAM Best Practice Building
*****PV System	There is no renewable energy production	*When considering the roof area of project which is almost 350 m ² , predicted PV capacity can be taken as around 40 kW. Predicted annual electricity generation will be around 48,000 kWh based on this capacity.	On site electric generation should be %50*Roof Area*120 kWh/m ² according to Guidance Not GN25. Because of this reason 21,160 kWh electricity generation from PV system has been subtracted from energy model total end use results. (Roof area taken as 350 m ²)

*Total outdoor air flow rates were defined according to ASHRAE 62.1-2013. Calculations are provided in appendix of this report.

** Fan powers of AHU and HRVs were calculated according to ASHRAE 90.1-2013 Table G3.1.2.10 and Section 6.5.3.1.1. Calculations are provided in appendix of this report.

***Baseline Building pump performance values were modeled based on ASHRAE 90.1-2013 Appendix G requirements. Proposed and BREEAM Best Practice Building pump capacity was taken from mechanical schedule provided by design team. Pump capacities and performance values are provided in appendix of this report.

****Lighting power density values for each building are provided in appendix of this report.

*****Electricity generation from PV system in Proposed Building is only predicted values that is calculated according to our previous experiences. It should be prepared PV simulation report that shows all details of system such as sunshine durations, direction of PV panels, efficiency values of PV panels etc.

6 RESULTS AND RECOMMENDATIONS

This report presents the energy savings results from analysis of the differences between proposed design and the code-compliant baseline developed using the Performance Rating Method as defined in ASHRAE/IESNA Standard 90.1-2013.

A computer simulation was performed to demonstrate these achievements and analyses the results of energy efficiency measures applied in the project. Assuming that the building envelope and systems are designed to maximize energy performance, computer simulation model is used to assess the energy performance and identify the most cost-effective energy efficiency measures.

As required by ASHRAE/IESNA Standard 90.1-2013, the code compliant baseline building model was generated and simulations were run for different orientations of the building (0, 90°, 180°, 270°) Average of these four performance results were computed and determined as baseline building energy performance. Following table represents a comparison of average baseline building energy performance and the proposed annual energy consumption output for Green Offices project generated by EnergyPlus:

Table 14: Comparison of Baseline, Proposed and BREEAM Best Practice Buildings Energy Consumption (kWh) by End Use

End Uses	Baseline Building (ASHRAE 90.1-2013 Appendix G)	Proposed Building without PV System	Proposed Building with PV System	BREEAM Best Practice Building
	Electricity (kWh)	Electricity (kWh)	Electricity (kWh)	Electricity (kWh)
Heating	776.86	185.99	185.99	278.02
Cooling	311,194.14	457,333.46	457,333.46	408,803.20
Interior Lighting	148,145.90	111,109.43	111,109.43	72,682.10
Interior Equipment	288,671.39	288,671.39	288,671.39	288,671.39
Exterior Equipment	8,376.01	8,376.01	8,376.01	8,376.01
Fans	195,534.49	74,421.17	74,421.17	48,469.21
Pumps	131,660.21	89,044.09	89,044.09	87,222.16
Heat Rejection	71,484.16	0.00	0.00	0.00
Water Systems	20,365.66	20,367.36	20,367.36	20,367.13
Renewables	0.00	0.00	-48,000.00	-21,159.60
Total End Uses	1,176,208.82	1,049,508.90	1,001,508.90	913,709.62
Total Savings	-	10.8%	14.9%	22.3%

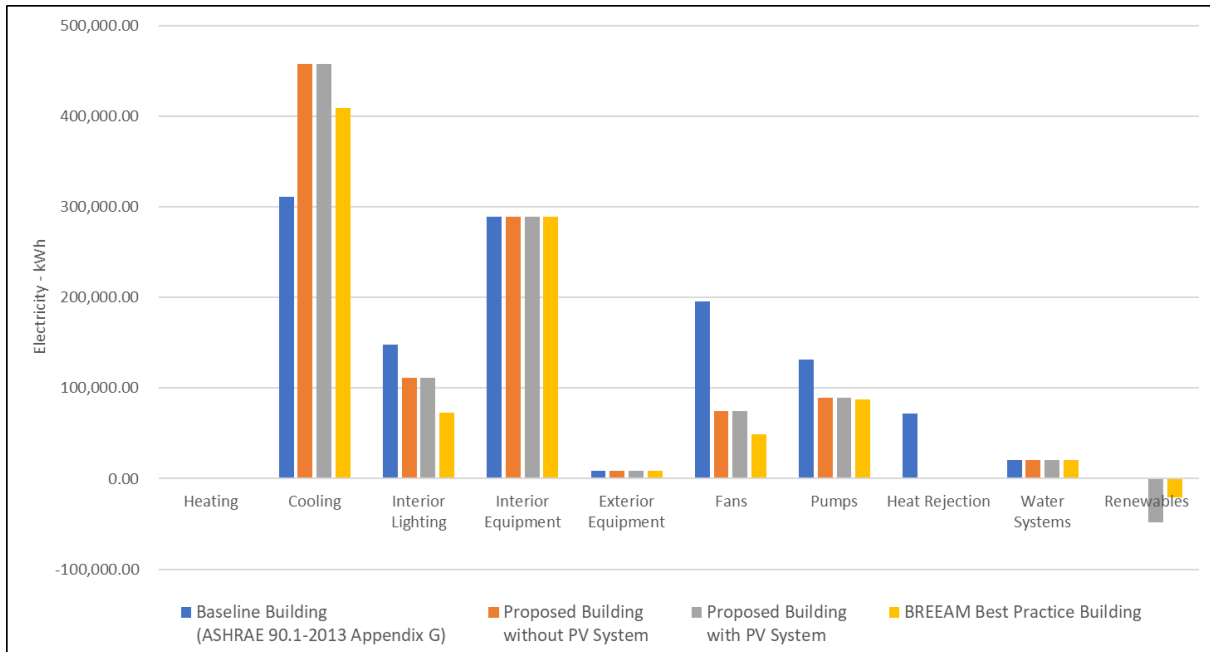


Figure 5: Comparison Chart of Baseline vs. Proposed Building

Table 15: Recommendations to comply Proposed Building Energy Performance

No	Systems	Recommendations
1	Roof Insulation	Insulation thickness is 12 cm for roof to meet 0.273 W/m ² K Performance value defined in ASHRAE 90.1-2013 Table 5.5.1.
2	Windows Selection	Solar low-e double glazing glass has been selected in this project according to project design documents. Window (glass+frame) performance values should be 1.8 W/m ² K and SHGC: 0.32.
3	Outdoor Air System	Outdoor air should be provided to zones to meet ASHRAE 62.1-2013 requirements. Required total outdoor air flow rate equals 17,800 m ³ /h. Please see the 'Ventilation_62.1_2013_Green Offices Maldives.pdf' document that includes zone by zone outdoor air calculations.
4	Heat Recovery	Heat recovery device in AHUs should be placed. Effectiveness value of these devices is higher or equal to %70.
5	Lighting System	Lighting density values (LPD) should be 25% efficient than LPD values defined in ASHRAE 90.1-2013 Table 9.6.1 for each zone type.
6	Air Cooled Chiller with VSD control	Air cooled chiller should have VSD control type and full load/part load efficiency values should be higher or equal to Performance values defined in ASHRAE 90.1-2013 Table 6.8.1.3. These values are; COP: 2.866, IPLV: 4.758
7	Fan and Pump Motor Efficiency	Fans and pump motor efficiency class should be higher or equal to IE3 class.
8	PV System	It is proposed that photovoltaic system should be designed in project's roof area with over 40 kW capacity.

7 ENERGY PERFORMANCE AND COMPLIANCE

The table below presents the key performance indicators resulting from an analysis of the differences between the baseline building, proposed building and BREEAM best practice building.

Table 16: ENE01 Key Performance Indicators with Renewable Energy Production

Ene01 Key Performance Indicators				
Notional building energy demand	1,048,596.47	MJ/year	175.67	MJ/m ² /year
Actual building energy demand	628,781.94	MJ/year	105.34	MJ/m ² /year
Best practice building energy demand	641,748.29	MJ/year	107.51	MJ/m ² /year
Notional building primary energy consumption	2,437,104.68	kWh/year	408.29	kWh/m ² /year
Actual building primary energy consumption	2,075,126.44	kWh/year	347.65	kWh/m ² /year
Best practice primary energy consumption	1,893,206.33	kWh/year	317.17	kWh/m ² /year
Notional building emission rate	725,720.84	kgCO ₂ /year	121.58	kgCO ₂ /m ² /year
Actual building emission rate	617,930.99	kgCO ₂ /year	103.52	kgCO ₂ /m ² /year
Best practice emission rate	563,758.84	kgCO ₂ /year	94.45	kgCO ₂ /m ² /year

Table 17: ENE01 Key Performance Indicators without Renewable Energy Production

Ene01 Key Performance Indicators				
Notional building energy demand	1,048,596.47	MJ/year	175.67	MJ/m ² /year
Actual building energy demand	628,781.94	MJ/year	105.34	MJ/m ² /year
Best practice building energy demand	641,748.29	MJ/year	107.51	MJ/m ² /year
Notional building primary energy consumption	2,437,104.68	kWh/year	408.29	kWh/m ² /year
Actual building primary energy consumption	2,174,582.42	kWh/year	364.31	kWh/m ² /year
Best practice primary energy consumption	1,893,206.33	kWh/year	317.17	kWh/m ² /year
Notional building emission rate	725,720.84	kgCO ₂ /year	121.58	kgCO ₂ /m ² /year
Actual building emission rate	647,546.99	kgCO ₂ /year	108.48	kgCO ₂ /m ² /year
Best practice emission rate	563,758.84	kgCO ₂ /year	94.45	kgCO ₂ /m ² /year

Note: Primary energy conversion factor for electricity has been taken as 2.072 and CO₂ emission conversion factor has been taken as 0.617. These values should be revised with conversion factors for Maldives.

According to energy model analysis results, 9 or 10 points can be taken for BREEAM ENE01 credit as shown below BREEAM ENE01 calculation tool results;

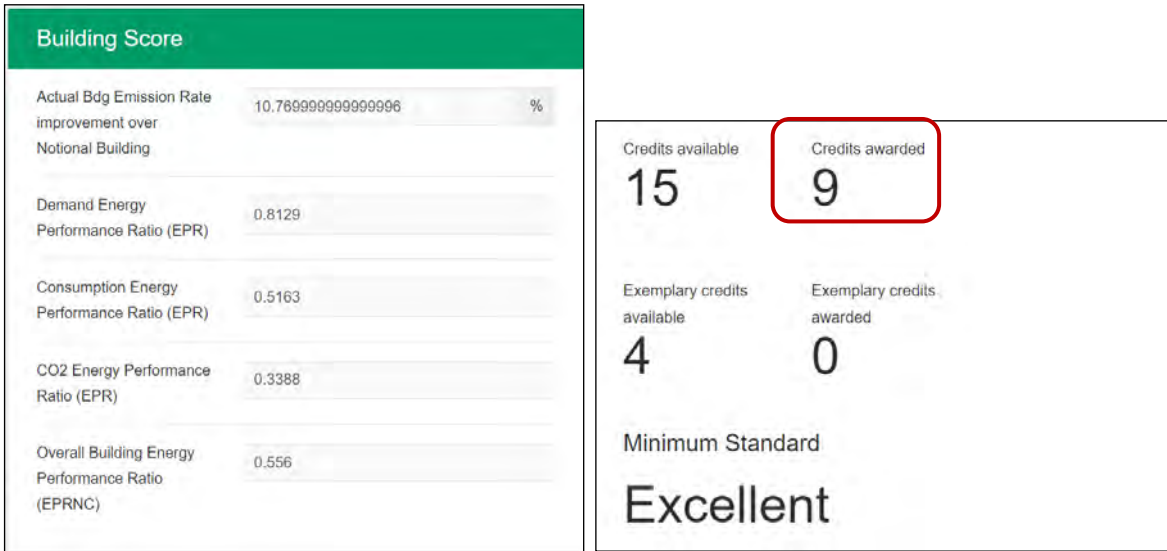


Figure 6: BREEAM ENE01 Building Score without Renewable Energy Production

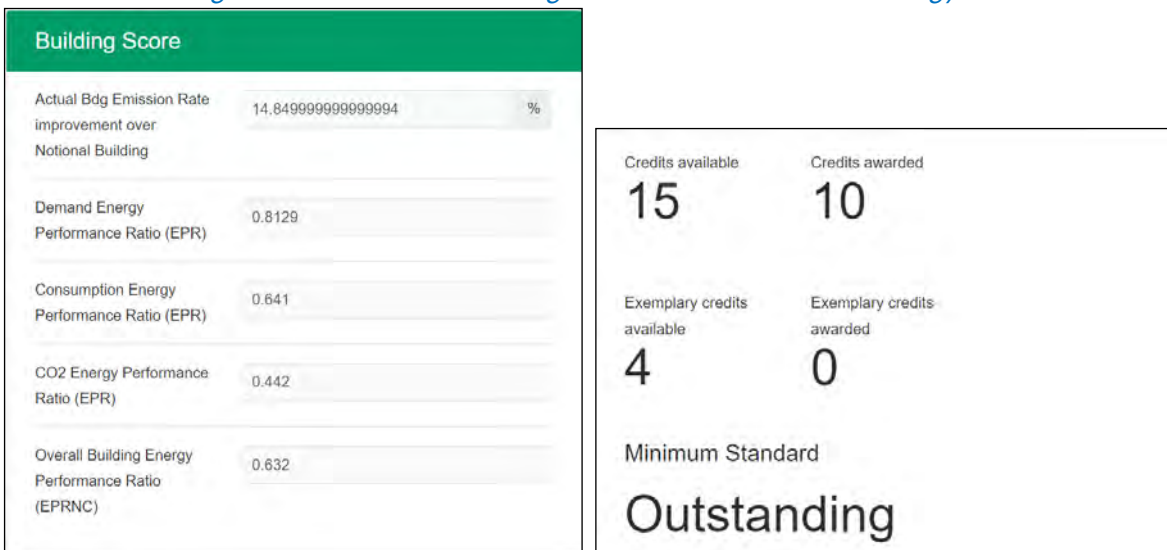
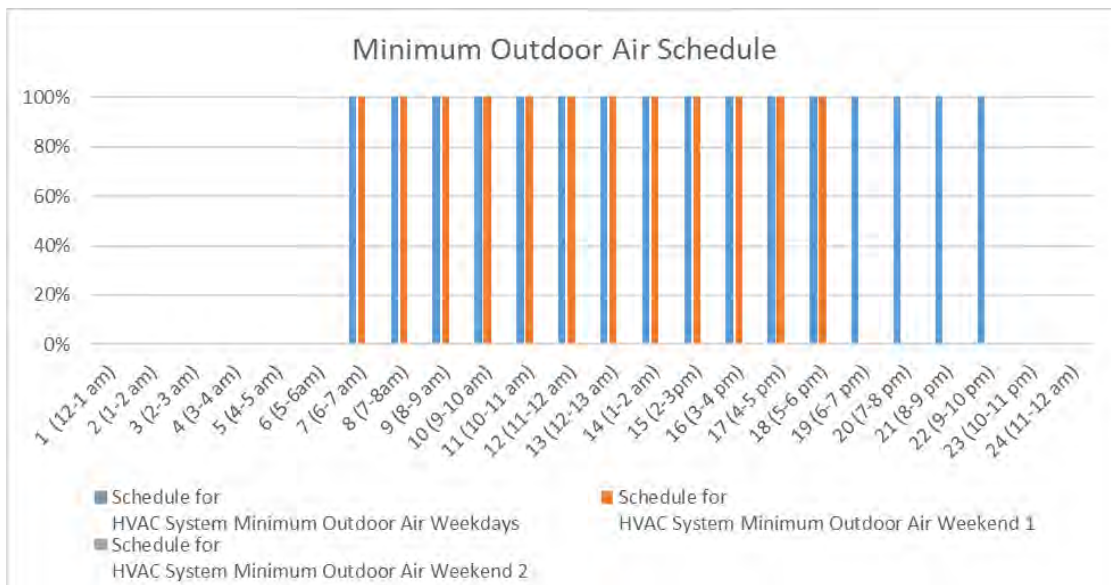
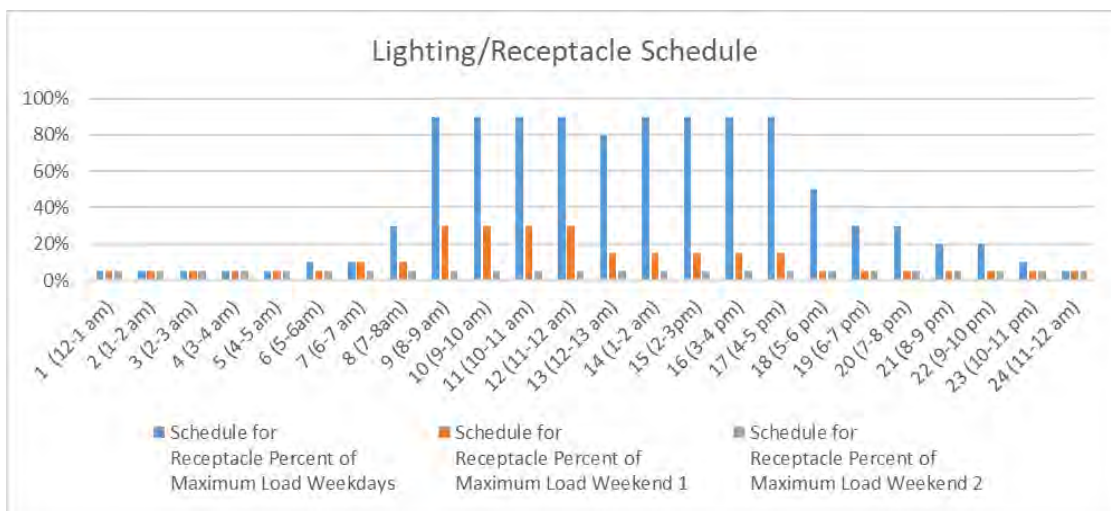
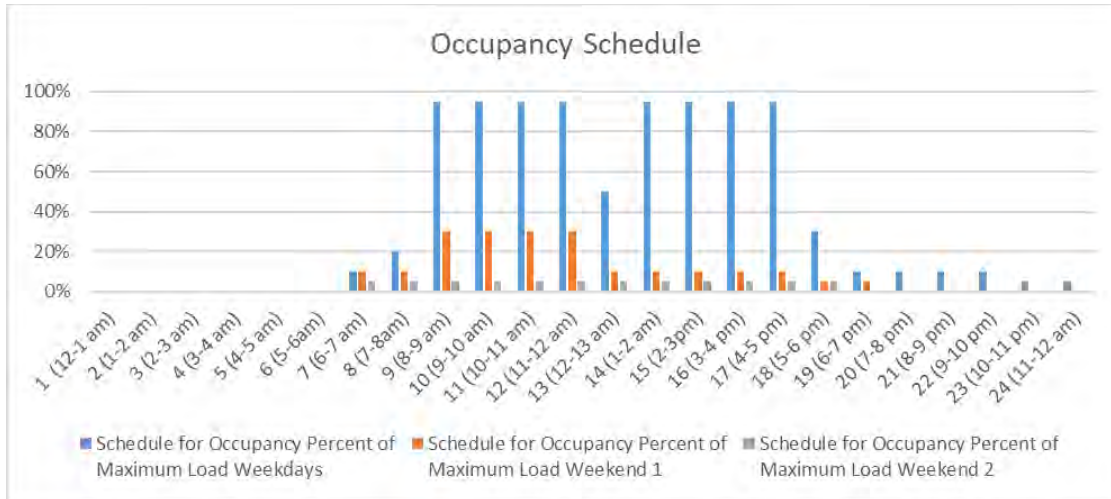
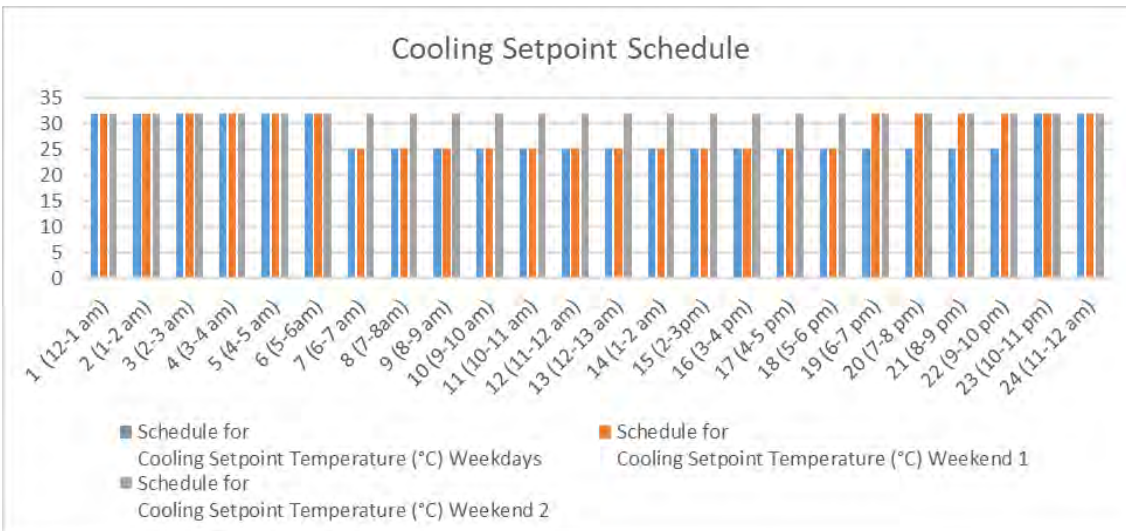
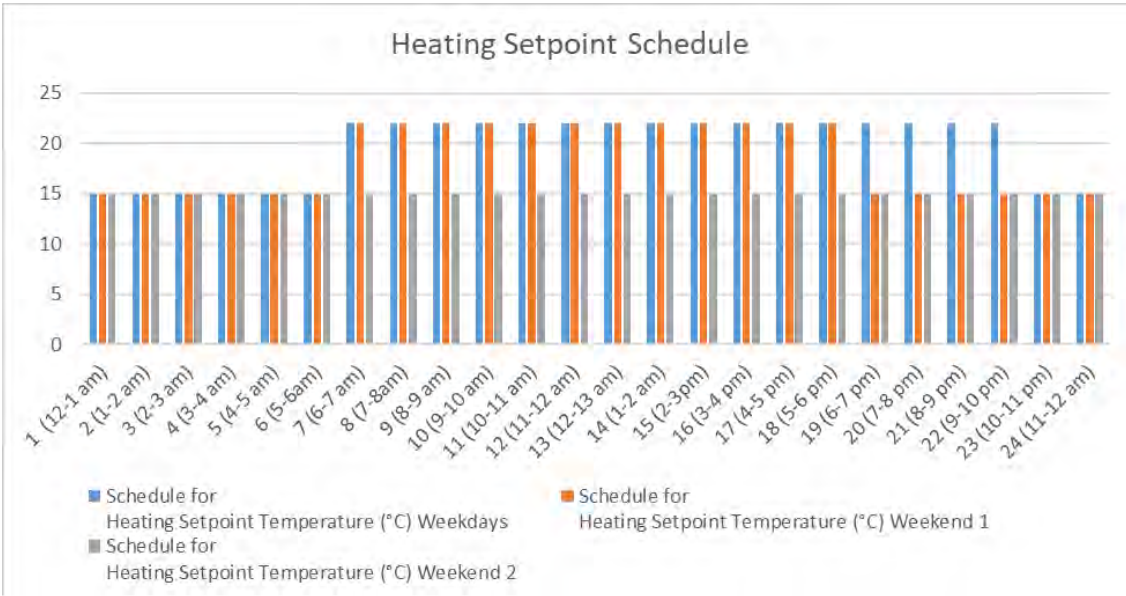


Figure 7: BREEAM ENE01 Building Score without Renewable Energy Production

APPENDIX

SCHEDULES





ASSUMPTIONS AND CALCULATIONS

Occupancy Values and Outdoor Air Flow Rates

Baseline Building, Proposed Building and BREEAM Best Practice Building outdoor air flow rates were calculated based on ASHRAE 62.1-2013 standard. Also occupancy values were taken from standard default values for each zone type as shown below tables. Please see the below table that includes zone by zone outdoor air flow rate calculations for Baseline Building.

ASHRAE 62.1-2013 VENTILATION CONTROL TABLE

FLOOR	Zone	Zone	Occupancy	Area	Design Air Flow	Occupancy (based on Project Design Values)	Ez	Ev	Vot	Complies
Number	Number	Description	Category	m ²	m ³ /h	#			m3/h	w / AS2.1
GF	G12	Cafe	Cafeteria / fast food dining	129.40	2800	130	0.80	1.00	2,747	YES
GF	G03	Lobby	Main entry lobbies	79.40	200	8	0.80	1.00	197	YES
GF	G08	Admin	Office space	29.40	100	2	0.80	1.00	62	YES
GF	G09/G10	MRF	Computer (not printing)	13.70	100	1	0.80	1.00	30	YES
F01	112	Cafe	Cafeteria / fast food dining	66.50	1500	67	0.80	1.00	1,415	YES
F01	104	MDF	Computer (not printing)	5.90	100	1	0.80	1.00	19	YES
F01	106/107	TELCO	Computer (not printing)	13.80	100	1	0.80	1.00	30	YES
F01	108	Security Room	Office space	20.50	100	2	0.80	1.00	50	YES
F03	311/312/313/314	Prayer Room	Places of religious worship	55.60	900	67	0.80	1.00	829	YES
F03	303	Corridor	Corridors	48.00	100	0	0.80	1.00	65	YES
F03	315	Office	Office space	448.00	900	23	0.80	1.00	864	YES
F04	403	Corridor	Corridors	46.40	100	0	0.80	1.00	63	YES
F04	411	Office	Office space	498.40	1000	25	0.80	1.00	954	YES
F05	503	Corridor	Corridors	46.40	100	0	0.80	1.00	63	YES
F05	511	Office	Office space	498.40	1000	25	0.80	1.00	954	YES
F06	603	Corridor	Corridors	46.40	100	0	0.80	1.00	63	YES
F06	611	Office	Office space	498.40	1000	25	0.80	1.00	954	YES
F07	703	Corridor	Corridors	46.40	100	0	0.80	1.00	63	YES
F07	711	Office	Office space	498.40	1000	25	0.80	1.00	954	YES
F08	816/817/818	Multipurpose	Multi-purpose assembly	239.50	3600	288	0.80	1.00	3,563	YES
F08	803	Corridor	Corridors	130.00	200	0	0.80	1.00	176	YES
F08	814	Meeting Room2	Conference / meeting	30.30	300	16	0.80	1.00	221	YES
F08	813/815	Meeting Room	Conference / meeting	58.90	500	30	0.80	1.00	417	YES
F08	811	Pantry	Occupiable storage rooms for dry materials	31.20	100	1	0.80	1.00	53	YES
F09	911	Pantry	Occupiable storage rooms for dry materials	18.50	100	1	0.80	1.00	36	YES
F09	912	Indoor Space	Breakrooms (office buildings)	183.00	1600	92	0.80	1.00	1,529	YES
F09	903	Corridor	Corridors	53.50	100	0	0.80	1.00	72	YES
				Total Area	Total Supplied Fresh Air	Total Peak Occupancy			Total Required Fresh Air	
				3,834	17,800	830			16,442	
									27	YES
									27	YES

Fan Powers

Fan powers in Baseline Building were calculated according to ASHRAE 90.1-2013 requirements shown in below snapshots.

	Limit	Constant Volume	Variable Volume
Option 1: Fan system motor nameplate kW	Allowable nameplate motor kW	$kW \leq L/S_G \cdot 0.0017$	$kW \leq L/S_G \cdot 0.0024$
Option 2: Fan system input kW	Allowable fan system input kW	$kW_I \leq L/S_G \cdot 0.0015 + A$	$kW_I \leq L/S_G \cdot 0.0021 + A$

a. where
 L/S_G – maximum design supply airflow rate to conditioned spaces served by the system in litres per second
 kW – maximum combined motor nameplate kW
 kW_I – maximum combined fan input kW
 A – sum of $(PD \times L/S_D/65,0000)$
 where
 PD – each applicable pressure drop adjustment from Table 6.5.3.1-2 in Pa.
 L/S_D – the design airflow through each applicable device from Table 6.5.3.1-2 in litres per second

Device	Adjustment
Credits	
Fully ducted return and/or exhaust air systems	125 Pa (535 Pa for laboratory and vivarium systems)
Return and/or exhaust airflow control devices	125 Pa
Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of device calculated at fan system design condition
Particulate Filtration Credit: MERV 9 through 12	125 Pa
Particulate Filtration Credit: MERV 13 through 15	225 Pa
Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2× clean filter pressure drop at fan system design condition
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition
Biosafety cabinet	Pressure drop of device at fan system design condition
Energy recovery device, other than coil runaround loop	$(550 \times \text{Energy Recovery Effectiveness}) - 125$ Pa for each airstream
Coil runaround loop	150 Pa for each airstream
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design condition
Sound attenuation section (fans serving spaces with design background noise goals below NC35)	38 Pa
Exhaust system serving fume hoods	85 Pa
Laboratory and vivarium exhaust systems in high-rise buildings	60 Pa/30 m of vertical duct exceeding 25 m
Deductions	
Systems without central cooling device	150 Pa
Systems without central heating device	75 Pa
Systems with central electric resistance heat	50 Pa

Please see the below table that includes fan powers and air flow rates for Baseline, Proposed and BREEAM Best Practice Buildings.

BREEAM Best Practice Building Fans					
Fan Name	Type	Delta Pressure [pa]	Max Air Flow Rate [m3/s]	Rated Electric Power [W]	Rated Power Per Max Air Flow Rate [W-s/m3]
GROUND FLOOR:ADMIN FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.38	188.89	500.00
GROUND FLOOR:MRF FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.38	188.89	500.00
GROUND FLOOR:LOBBY FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.70	351.39	500.00
GROUND FLOOR:CAFE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	1.89	944.44	500.00
FIRST FLOOR:SECURITYROOM FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.19	94.44	500.00
FIRST FLOOR:TELCO FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.38	188.89	500.00
FIRST FLOOR:MDF FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.19	94.44	500.00
FIRST FLOOR:CAFE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	1.13	566.67	500.00
THIRD FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.35	175.69	500.00
THIRD FLOOR:PRAYERROOM FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.76	377.78	500.00
THIRD FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	5.67	2,833.33	500.00
4TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.35	175.69	500.00
4TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	6.42	3,211.11	500.00
5TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.35	175.69	500.00
5TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	6.42	3,211.11	500.00
6TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.35	175.69	500.00
6TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	6.42	3,211.11	500.00
7TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.35	175.69	500.00
7TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	6.42	3,211.11	500.00
8TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	1.05	527.08	500.00
8TH FLOOR:MEETINGROOM2 FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.38	188.89	500.00
8TH FLOOR:MEETINGROOM FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.76	377.78	500.00
8TH FLOOR:PANTRY FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.38	188.89	500.00
8TH FLOOR:MULTIPURPOSE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	2.11	1,054.17	500.00
9TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.35	175.69	500.00
9TH FLOOR:PANTRY FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.19	94.44	500.00
9TH FLOOR:INDOORSPACE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	2.27	1,133.33	500.00
HRV04 AHU EXTRACT FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV04 AHU SUPPLY FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV01 AHU EXTRACT FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV01 AHU SUPPLY FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV02 AHU EXTRACT FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV02 AHU SUPPLY FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV03 AHU EXTRACT FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV03 AHU SUPPLY FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV05 AHU EXTRACT FAN	Fan:ConstantVolume	700.00	0.25	250.00	1,000.00
HRV05 AHU SUPPLY FAN	Fan:ConstantVolume	700.00	0.25	250.00	1,000.00
AHU01 AHU EXTRACT FAN	Fan:ConstantVolume	700.00	3.58	3,583.33	1,000.00
AHU01 AHU SUPPLY FAN	Fan:ConstantVolume	700.00	3.58	3,583.33	1,000.00

Proposed Building Fans					
Fan Name	Type	Delta Pressure [pa]	Max Air Flow Rate [m3/s]	Rated Electric Power [W]	Rated Power Per Max Air Flow Rate [W-s/m3]
GROUND FLOOR:ADMIN FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.70	0.38	127.00	336.17
GROUND FLOOR:MRF FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.70	0.38	127.00	336.17
GROUND FLOOR:LOBBY FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	0.70	730.00	1,038.73
GROUND FLOOR:CAFE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	1.89	635.01	336.18
FIRST FLOOR:SECURITY ROOM FAN COIL UNIT SUPPLY FAN	Fan:OnOff	174.71	0.19	55.00	291.18
FIRST FLOOR:TELCO FAN COIL UNIT SUPPLY FAN	Fan:OnOff	174.70	0.38	110.00	291.17
FIRST FLOOR:MDF FAN COIL UNIT SUPPLY FAN	Fan:OnOff	174.71	0.19	55.00	291.18
FIRST FLOOR:CAFE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.70	1.13	380.99	336.17
THIRD FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	0.35	365.00	1,038.73
THIRD FLOOR:PRAYER ROOM FAN COIL UNIT SUPPLY FAN	Fan:OnOff	174.71	0.76	220.01	291.18
THIRD FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	5.67	1,905.04	336.18
4TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	0.35	365.00	1,038.73
4TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	6.42	2,159.04	336.18
5TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	0.35	365.00	1,038.73
5TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	6.42	2,159.04	336.18
6TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	0.35	365.00	1,038.73
6TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	6.42	2,159.04	336.18
7TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	0.35	365.00	1,038.73
7TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	6.42	2,159.04	336.18
8TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	207.75	1.05	365.01	346.25
8TH FLOOR:MEETING ROOM 2 FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.70	0.38	127.00	336.17
8TH FLOOR:MEETING ROOM FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	0.76	254.01	336.18
8TH FLOOR:PANTRY FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.70	0.38	127.00	336.17
8TH FLOOR:MULTIPURPOSE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	2.11	2,190.00	1,038.73
9TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	1,869.72	0.35	1,095.00	3,116.20
9TH FLOOR:PANTRY FAN COIL UNIT SUPPLY FAN	Fan:OnOff	174.71	0.19	55.00	291.18
9TH FLOOR:INDOOR SPACE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.70	2.27	761.98	336.17
HRV04 AHU EXTRACT FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV04 AHU SUPPLY FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV01 AHU EXTRACT FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV01 AHU SUPPLY FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV02 AHU EXTRACT FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV02 AHU SUPPLY FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV03 AHU EXTRACT FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV03 AHU SUPPLY FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV05 AHU EXTRACT FAN	Fan:ConstantVolume	1,083.85	0.25	387.09	1,548.35
HRV05 AHU SUPPLY FAN	Fan:ConstantVolume	1,083.85	0.25	387.09	1,548.35
AHU01 AHU EXTRACT FAN	Fan:ConstantVolume	1,082.86	3.58	5,543.22	1,546.94
AHU01 AHU SUPPLY FAN	Fan:ConstantVolume	1,082.86	3.58	5,543.22	1,546.94

Baseline Building Fans					
Fan Name	Type	Delta Pressure [pa]	Max Air Flow Rate [m3/s]	Rated Electric Power [W]	Rated Power Per Max Air Flow Rate [W-s/m3]
GROUNDFOOR:ADMIN PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.18	130.47	742.33
GROUNDFOOR:MRF PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.07	55.53	742.33
GROUNDFOOR:LOBBY PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.60	446.81	742.33
GROUNDFOOR:CAFE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.76	566.66	742.33
FIRSTFLOOR:SECURITYROOM PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.12	90.22	742.33
FIRSTFLOOR:TELCO PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.08	62.06	742.33
FIRSTFLOOR:MDF PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.05	39.34	742.33
FIRSTFLOOR:CAFE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.51	378.51	742.33
THIRDFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.36	270.84	742.33
THIRDFLOOR:PRAYERROOM PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.37	274.39	742.33
THIRDFLOOR:OFFICE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	2.72	2,020.48	742.33
4THFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.31	226.86	742.33
4THFLOOR:OFFICE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	2.14	1,591.36	742.33
5THFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.29	214.99	742.33
5THFLOOR:OFFICE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	2.04	1,512.88	742.33
6THFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.29	211.95	742.33
6THFLOOR:OFFICE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	2.01	1,490.31	742.33
7THFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.28	209.66	742.33
7THFLOOR:OFFICE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	1.98	1,471.49	742.33
8THFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.70	518.42	742.33
8THFLOOR:MEETINGROOM2 PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.23	168.18	742.33
8THFLOOR:MEETINGROOM PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.21	159.35	742.33
8THFLOOR:PANTRY PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.16	121.01	742.33
8THFLOOR:MULTIPURPOSE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	1.13	841.33	742.33
9THFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.46	338.87	742.33
9THFLOOR:PANTRY PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.11	81.53	742.33
9THFLOOR:INDOORSPACE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.83	613.51	742.33
AIR LOOP AHU EXTRACT FAN	Fan:VariableVolume	879.88	1.58	2,312.77	1,466.47
AIR LOOP AHU SUPPLY FAN	Fan:VariableVolume	879.88	1.58	2,312.77	1,466.47
AIR LOOP 1 AHU EXTRACT FAN	Fan:VariableVolume	881.98	0.72	1,053.93	1,469.96
AIR LOOP 1 AHU SUPPLY FAN	Fan:VariableVolume	881.98	0.72	1,053.93	1,469.96
AIR LOOP 2 AHU EXTRACT FAN	Fan:VariableVolume	879.45	3.37	4,932.96	1,465.74
AIR LOOP 2 AHU SUPPLY FAN	Fan:VariableVolume	879.45	3.37	4,932.96	1,465.74
AIR LOOP 3 AHU EXTRACT FAN	Fan:VariableVolume	878.51	2.45	3,586.29	1,464.19
AIR LOOP 3 AHU SUPPLY FAN	Fan:VariableVolume	878.51	2.45	3,586.29	1,464.19
AIR LOOP 4 AHU EXTRACT FAN	Fan:VariableVolume	879.17	2.33	3,410.62	1,465.28
AIR LOOP 4 AHU SUPPLY FAN	Fan:VariableVolume	879.17	2.33	3,410.62	1,465.28
AIR LOOP 5 AHU EXTRACT FAN	Fan:VariableVolume	877.08	2.29	3,352.08	1,461.80
AIR LOOP 5 AHU SUPPLY FAN	Fan:VariableVolume	877.08	2.29	3,352.08	1,461.80
AIR LOOP 6 AHU EXTRACT FAN	Fan:VariableVolume	876.46	2.26	3,308.17	1,460.76
AIR LOOP 6 AHU SUPPLY FAN	Fan:VariableVolume	876.45	2.26	3,308.13	1,460.75
AIR LOOP 7 AHU EXTRACT FAN	Fan:VariableVolume	877.57	2.33	3,410.63	1,462.62
AIR LOOP 7 AHU SUPPLY FAN	Fan:VariableVolume	877.56	2.33	3,410.60	1,462.60
AIR LOOP 8 AHU EXTRACT FAN	Fan:VariableVolume	878.75	1.36	1,990.75	1,464.59
AIR LOOP 8 AHU SUPPLY FAN	Fan:VariableVolume	878.75	1.36	1,990.75	1,464.59

Performance Values of Pumps

Baseline Building pump performance values were modeled based on ASHRAE 90.1-2013 Appendix G requirements as shown below snapshots.

G3.1.3.10 Chilled-Water Pumps (Systems 7, 8, and 11). The baseline building design pump power shall be 349 kW/1000 L/s. Chilled-water systems with a cooling capacity of 11,148 m² or more shall be modeled as primary/secondary systems with variable-speed drives on the secondary pumping loop. Chilled-water pumps in systems serving less than 11,148 m² cooling capacity shall be modeled as a primary/secondary systems with secondary pump riding the pump curve. For computer room systems using System 11 with an integrated water-side economizer, the baseline building design primary chilled-water pump power shall be increased 80 kW/1000 L/s for flow associated with the water-side economizer.

The tower shall be controlled to maintain a 21°C leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. The baseline building design condenser-water pump power shall be 310 kW/1000 L/s. For computer room systems using System 11 with an integrated water-side economizer, the baseline building design condenser water-pump power shall be increased 80 kW/1000 L/s for flow associated with the water-side economizer. Each chiller shall be modeled with separate condenser water and chilled-water pumps interlocked to operate with the associated chiller.

Proposed and BREEAM Best Practice Building pump capacity was taken from mechanical schedule provided by design team.

Please see the below table that includes pump capacities, control types and performance values for Baseline, Proposed and BREEAM Best Practice Buildings.

Baseline Building Pumps						
	Type	Control	Head [pa]	Water Flow [m³/s]	Electric Power [W]	Power Per Water Flow Rate [W-s/m³]
CHW LOOP 1 SUPPLY PUMP	Pump:VariableSpeed	Intermittent	122,499.00	0.02	4,156.18	174,500.00
CHW LOOP SUPPLY PUMP	Pump:ConstantSpeed	Intermittent	122,499.00	0.02	4,156.18	174,500.00
DHW LOOP SUPPLY PUMP	Pump:VariableSpeed	Intermittent	179,352.00	0.00	9.10	255,487.18
CONDENSER LOOP SUPPLY PUMP	Pump:ConstantSpeed	Intermittent	217,620.00	0.03	10,614.08	310,000.00

Proposed Building Pumps						
	Type	Control	Head [pa]	Water Flow [m³/s]	Electric Power [W]	Power Per Water Flow Rate [W-s/m³]
CHW LOOP SUPPLY PUMP	Pump:VariableSpeed	Intermittent	640,354.53	0.03	29,840.00	912,185.94
DHW LOOP SUPPLY PUMP	Pump:VariableSpeed	Intermittent	179,352.00	0.00	9.10	255,487.18

BREEAM Best Practice Building Pumps						
	Type	Control	Head [pa]	Water Flow [m³/s]	Electric Power [W]	Power Per Water Flow Rate [W-s/m³]
CHW LOOP SUPPLY PUMP	Pump:VariableSpeed	Intermittent	556,393.45	0.04	29,840.00	792,583.26
DHW LOOP SUPPLY PUMP	Pump:VariableSpeed	Intermittent	179,352.00	0.00	9.10	255,487.18

Lighting Power Density Values

Baseline Building's lighting power density values (W/m^2) were taken from ASHRAE 90.1-2013 Table 9.6.1 for each zone type.

Proposed Building's lighting power density values (W/m^2) have been determined with %25 improvement according to lighting power density values in ASHRAE 90.1-2013 Table 9.6.1.

BREEAM Best Practice Building's lighting power density values have been determined based on 65 lm/watt criteria that is defined in Appendix B section of Guidance Note GN25. Additionally, occupancy control and daylight control effect have been added with 10% improvement according to lighting power density values.

Please see the below table that includes LPD values for Baseline, Proposed and BREEAM Best Practice Buildings.

Zone Category	Zone Area [m ²]	Baseline Building LPD [W/m ²]	Proposed Building LPD [W/m ²]	EN 12464-1:2011 Lux Values for Zone Types	BREEAM Best Practice Building LPD with Daylight and Occupancy Controls [W/m ²]
Parking	999.71	2.10	1.58	75	1.04
Elec_Mech_Tec	397.35	4.60	3.45	200	2.77
Storage	49.73	6.80	5.10	100	1.38
Prayer Room	55.62	6.90	5.18	200	2.77
Cafeteria	195.99	7.00	5.25	200	2.77
Corridor	417.06	7.10	5.33	100	1.38
Stairs	395.90	7.40	5.55	100	1.38
Breakroom	182.97	7.90	5.93	200	2.77
Main Entry Lobby	79.39	9.70	7.28	200	2.77
Restroom	216.54	10.60	7.95	200	2.77
Office	2,491.62	12.00	9.00	500	6.92
Meeting Room	89.15	13.30	9.98	500	6.92
Multipurpose Room	239.53	13.30	9.98	500	6.92

BREEAM Section GREEN OFFICE MALDIVES	Total Credits	Credits Targeted			Section Weight	Section Score	
		Y	?	N		Y	Y + ?
Management	18	6	7	5			
Man 01 Project brief and design	4	4			10.34%	3.45%	7.47%
Man 02 Life cycle cost and service life planning	4			4			
Man 03 Responsible construction practices	6		6				
Man 04 Commissioning and handover	4	2	1	1			
Health & Wellbeing	11	3	3	5			
Hea 01 Visual Comfort	3	1	1	1	9.94%	2.71%	5.42%
Hea 02 Indoor Air Quality	2		1	1			
Hea 04 Thermal comfort	2			2			
Hea 05 Acoustic Performance	1			1			
Hea 06 Accessibility	2	2					
Hea 09 Water quality	1		1				
Hazards	1	1	0	0			
Hea 07 Hazards	1	1			1.10%	1.10%	1.10%
Energy	24	10	7	7			
Ene 01 Reduction of energy use and carbon emissions	15	9	1	5	13.92%	5.80%	9.86%
Ene 02 Energy Monitoring	2	1	1				
Ene 03 External Lighting	1		1				
Ene 04 Low carbon design	3		1	2			
Ene 06 Energy efficient transportation systems	3		3				
Transport	9	4	3	2			
Tra 01 Public Transport Accessibility	3	1		2	6.58%	2.92%	5.12%
Tra 02 Proximity to Amenities	1	1					
Tra 03 Alternative modes of transport	2		2				
Tra 04 Maximum car parking capacity	2	2					
Tra 05 Travel Plan	1		1				
Water	9	4	1	4			
Wat 01 Water Consumption	5	3		2	18.64%	8.28%	10.36%
Wat 02 Water Monitoring	1		1				
Wat 03 Water Leak Detection	2			2			
Wat 04 Water Efficient Equipment	1	1					
Materials	12	0	3	9			
Mat 01 Life Cycle Impacts	6		1	5	10.97%	0.00%	2.74%
Mat 03 Responsible sourcing of construction	4		2	2			
Mat 05 Designing for durability and resilience	1			1			
Mat 06 Material efficiency	1			1			
Waste	7	0	4	3			
Wst 01 Construction Waste Management	3		3		10.97%	0.00%	6.27%
Wst 02 Recycled Aggregates	1			1			
Wst 03 Operational Waste	1		1				
Wst 05 Adaptation to climate change	1			1			
Wst 06 Functional adaptability	1			1			
Land Use & Ecology	10	2	7	1			
LE 01 Site Selection	3	2		1	8.77%	1.75%	7.89%
LE 02 Ecological Value of Site and Protection of Ecological Features	2		2				
LE 04 Enhancing Site Ecology	3		3				
LE 05 Long Term Impact on Biodiversity	2		2				
Pollution	12	6	1	5			
Pol 01 Impact of Refrigerants	3	1		2	8.77%	4.39%	5.12%
Pol 02 NOx Emissions	2			2			
Pol 03 Surface Water Run off	5	5					
Pol 04 Reduction of Night Time Light Pollution	1		1				
Pol 05 Noise Attenuation	1			1			
Innovation	10	0	2	8			
Inn 1 - Innovation	10		2	8	10%	0.00%	2.00%
Total Score						30.41%	63.34%
BREEAM Level						PASS	VERY GOOD



Ministry of Environment

Review and Amend Design of Green Building to attain BREEAM Certification

Sustainability Assessment Report



Promoting Energy Efficient Buildings through
Strengthening Low Carbon Energy
Island Strategies (LCEI) Project





FOR MINISTRY OF ENVIRONMENT

August 2021



SUSTAINABILITY ASSESSMENT REPORT

Review and Amend Design of Green Building to attain BREEAM Certification

DOCUMENT CONTROL SHEET

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EXECUTIVE SUMMARY

This sustainability assessment report for Green Office building is conducted on behalf of Ministry of Environment Male' Republic of Maldives and Housing Development Corporation Ltd. (HDC) under the "Strengthening Low Carbon Energy Island Strategies Project (LCEI)". This document is intended to outline the performance of the building with the design amendments in aspect of energy and water efficiency, indoor environmental quality, material selection, waste minimization and enhancing site ecology. This report also outlines the results of the energy modelling with expected energy use index, CO₂ savings compared to a baseline building.

The proposed building design had the potential to achieve a BREEAM score of 63.34 %, according to the study conducted for the "Final Solution and Recommendation Report". The applicability of the potential points was discussed during the design meetings with project team. The majority of the recommendations have been incorporated into the design. As a result of the design amendments made in response to the recommendations and solutions shared, the project achieves a BREEAM score of 62.76 % which corresponds to BREEAM Very Good level certification.

(Table 1) highlights the results of the study, indicating achievable points and points achieved with the design amendments and existing design for Green Office project under BREEAM International 2016 New Construction scheme. The BREEAM scorecard for the current design is provided as Annex I with this report.

Table 1. Comparison of Category Points

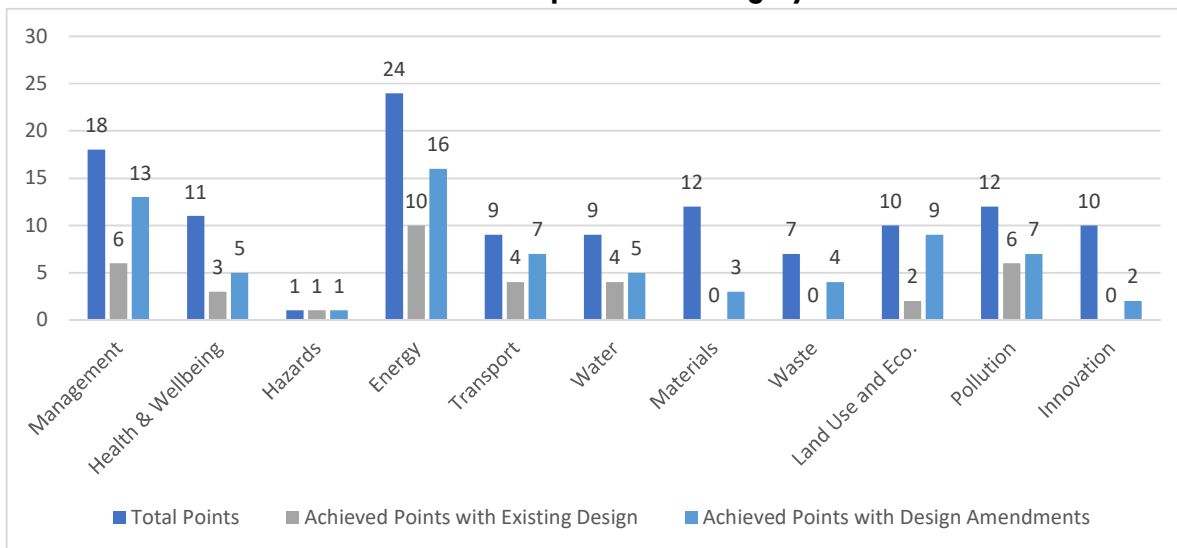


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1 INTRODUCTION

1.1 General Information

This report has been developed according to following information provided by design team and calculations made according to existing design of the project.

Project Location : Hulhumale, Maldives

Project Phase : Design Phase

Project Type : Core & Shell

Total Gross Floor Area: 7,683 m²

Total Site Area : 940 m²

Car Parking Spots : 11

Occupancy Info*:

FTE : ~ 250

Visitors : ~ 15

**Number of FTE and visitors is calculated according to default occupancy based on ASHRAE Standard.*

1.2 BREEAM International 2016 Standard

BREEAM (Building Research Establishment's Environmental Assessment Method) is the world's first sustainability rating scheme for the built environment and has contributed much to the strong focus in the UK on sustainability in building design, construction and use. BREEAM is now an International standard that is locally adapted, operated and applied through a network of International operators, assessors and industry professionals.

The rating system evaluate buildings under nine main categories, including Management, Health and Wellbeing, Energy, Transport, Water, Materials, Waste, Land Use and Ecology, Pollution, Innovation.

The credits scored are shown as a weighted percentage score, which itself corresponds to an overall rating of Pass, Good, Very Good, Excellent or Outstanding:

- ≥30 - <45 : Pass
- ≥45 - <55 : Good
- ≥55 - <70 : Very Good
- ≥70 - <85 : Excellent
- ≥85 : Outstanding

1.2.1 Minimum Standards for BREEAM International 2016 New Construction for Very Good Level

To achieve a particular BREEAM rating, the minimum overall percentage score must be achieved and the minimum standards must be met. Detailed in the below table are the credit requirements applicable for the green building and the current project status corresponding to the project to earn BREEAM very good rating.

Table 2. Minimum Standards for BREEAM International 2016 New Construction for Very Good Level

Credit Name	Requirement
Man 03 Responsible construction practices	All national health and safety legislation and regulations for construction sites should be considered and implemented during; <ul style="list-style-type: none"> • The design of the asset; to minimise health and safety risks • Pre-construction work planning and organisation; to collate health and safety information from all relevant stakeholders • Site set-up; to implement health and safety features • Construction; to manage, monitor and report on the health and safety of construction site staff.
Hea 01	All fluorescent and compact fluorescent lamps should be fitted with high frequency ballasts

Visual comfort	
Hea 02 Indoor air quality	Materials containing asbestos should be prohibited from being specified and used within the building.
Hea 09 Water quality	All water systems in the building should be designed in compliance with the measures outlined in the relevant national health and safety best practice guides or regulations to minimise the risk of microbial contamination, e.g. legionellosis
Ene 02 Energy monitoring	<p>Energy metering systems should be installed that enable at least 90% of the estimated annual energy consumption of each fuel to be assigned to the various end-use categories of energy-consuming systems.</p> <p>The energy-consuming systems in buildings with a gross internal area greater than 1,000m² should be metered using an appropriate energy monitoring and management system.</p>
Wat 01 Water consumption	The project must achieve at least one credit with using efficient water-consuming components and alternative systems.
Wat 02 Water monitoring	The specification of a water meter on the mains water supply to each building; this includes instances where water is supplied via a borehole or other private source.
Mat 03 Responsible sourcing of Construction products	All timber and timber-based products used on the project should be Legally harvested and traded timber.

1.2.2 The BREEAM Professionals

In general, each BREEAM professional role is geared towards supporting the successful application and assessment of BREEAM. This is with the purpose of helping a client achieve their target rating and sustainability aspirations in a cost effective and efficient way. Each role performs a different, but complementary function in meeting this purpose. Collectively they are designed to provide and facilitate the appropriate level of engagement with BREEAM at different stages of the design, procurement and construction process.

A licensed **BREEAM Assessor** has a deep level of understanding and competency in the scheme for which they are licensed and monitored by BRE Global Ltd. Their role is to manage the formal assessment process and apply for certification of that assessment on behalf of the client. In doing so they will confirm the appropriate scheme, apply the relevant scheme criteria, and liaise with the client and relevant stakeholders to facilitate an assessment. Only BRE Global Ltd licensed assessors can offer, register, undertake and apply for certification of assessment. Mr. Emre Ilıcalı who is an experienced International BREEAM Assessor is involved in project design amendment stage to manage the assessment process and validate a project's compliance against relevant BREEAM criteria.

A **BREEAM Accredited Professional (BREEAM AP)** has specialist skills in sustainability and environmental design combined with a high level of competence and understanding in BREEAM and its assessment process. The BREEAM AP is one type of 'sustainability champion' defined and recognised in BREEAM. The BREEAM AP uses their expertise to assist clients and project teams by facilitating cross-project consideration and collaboration on solutions to scheme compliance, target setting and performance monitoring. Ms. Müge Emen is involved in project design amendment stage to help achieve project's BREEAM targets and maximise opportunities for project performance.

1.2.3 BREEAM Certification Process

BREEAM is an international scheme that provides independent third-party certification of the assessment of the sustainability performance of individual buildings, communities and infrastructure projects. Green Office Building aims Very Good level certification under BREEAM International New Construction 2016 scheme.

Typical certification process for BREEAM rating system:

- Deciding which BREEAM standard applies to the project
- Appointing a licensed BREEAM Assessor to assess the project to the correct BREEAM standard
- Registering the project for assessment through the appointed licensed BREEAM Assessor
- Carrying out a pre-assessment with the assistance of appointed licensed BREEAM Assessor or BREEAM AP
- During the design and assessment progress, collating the necessary project information and passing these to BREEAM Assessor
- Submission of the assessment to the certification body for a certification decision by Licensed BREEAM Assessor
- If the documents are found sufficient during the Quality Audit process, the project will be entitled to receive a certificate.

BREEAM International New Construction 2016 scheme can be used to assess and rate the environmental impacts arising from a newly constructed building development (including external site areas), at the following life cycle stages:

1. New build design stage – leading to an interim BREEAM rating and certificate of assessment

The design stage (DS) assessment and interim BREEAM rating confirms the proposed new building's performance at the design stage of the life cycle. Assessment and ideally certification will occur prior to the beginning of operations on site. The BREEAM rating at this stage is labelled as 'interim' because it does not represent the building's final, new construction BREEAM performance.

To complete an assessment at this stage, the design must be advanced to a point where the relevant design information is available to enable the BREEAM Assessor to evaluate and verify the building's performance against the criteria defined in this scheme document. The interim DS assessment will therefore be completed and certified at the scheme design or detailed design stages. Green Office Building is a BREEAM interim certification candidate.

2. New build post-construction stage – leading to a final BREEAM rating and certificate of assessment

The post-construction stage (PCS) assessment and BREEAM rating confirms the final as-built performance of the building at the new construction stage of the life cycle. A final PCS assessment is completed and certified after practical completion of the building works.

BREEAM Evidential Requirements:

BREEAM is a third-party assessment and certification scheme operated in accordance with international standards. Operating to international standards ensures that certification schemes such as BREEAM are run in a consistent and reliable manner.

The BREEAM Assessor's assessment report and the BRE Global quality assurance process are the fundamental tenets of BREEAM, ensuring consistency of, and confidence in, the BREEAM rating awarded by the assessor.

Any evidence submitted for a BREEAM assessment must be robust in terms of its source and its traceability. Below is a list of the minimum types of evidence:

- Communication records
- Formal letters of correspondence
- Meeting minutes
- Drawings
- Specification
- Site inspection report

Calculating a building's BREEAM rating

The process of determining a BREEAM rating is outlined below:

1. Firstly, the scope of the project being assessed needs to be determined, i.e. Shell Only or Shell and Core. The appropriate BREEAM assessment tool or calculator then adjusts the scoring and weightings to reflect the categories and individual credits assessed.
2. The BREEAM Assessor will then determine for each of BREEAM's nine environmental sections (as applicable) the number of 'credits' awarded. This must be determined by the BREEAM Assessor in accordance with the criteria of each assessment issue.
3. The percentage of 'credits' achieved is then calculated for each section.
4. The percentage of 'credits' achieved in each section is then multiplied by the corresponding section weighting. This gives the overall environmental section score.
5. The section scores are then added together to give the overall BREEAM score.
6. The overall score is then compared to the BREEAM rating benchmark levels and, provided all minimum standards have been met, the relevant BREEAM rating is achieved.
7. An additional 1% can be added to the final BREEAM score for each 'innovation credit' achieved (up to a maximum of 10% and with the total BREEAM score capped at 100%).

BRE defines section weighting according to the scope of the project (fully fitted, shell only, or shell and core) for each country. Section weightings for the Green Office building are provided below:

- Management : 10.34%
- Health and Wellbeing : 9.94%
- Health and Wellbeing – Hazards : 1.10%
- Energy : 13.92%
- Transport : 6.58%
- Water : 18.64%
- Materials : 10.97%
- Waste : 10.97%
- Land Use and Ecology : 8.77%
- Pollution : 8.77%
- Innovation : 10.00%

2 Current Status of the Project

The following tasks have been completed within the scope of “Review and Amend Design of Green Office Building to attain BREEAM Certification” work:

1. Reviewing of the existing designs of the Green Office Building
2. Conducting feasibility study with findings from the review of the existing design of Green Office building
3. Preparing draft report on solutions recommendations in design of Green Office building
4. Running energy and daylight simulations based on existing design and design amendments
5. Holding consultation workshop and preparing workshop report
6. Preparing final report on solutions and recommendations in design of Green Office building
7. Updating of design incorporating the required changes in accordance with the BREEAM certification requirements
8. Preparing sustainability assessment report outlining the sustainability features, efficiency of the building

According to design review and feasibility analysis study, the existing building design shall achieve a BREEAM score of 18.40% which was not enough to get a certification of any level under the BREEAM standards. Some critical issues such as equipment efficiency, material selection and measures needed to be tracked during construction phase were not included in the construction documents.

Achievable points were analysed and solutions and recommendations to meet credit requirements were provided for each BREEAM credits in both Draft and Final Solution and Recommendation Reports. According to the study conducted, the proposed building design has the potential to achieve a BREEAM score of 63.34%. The majority of the recommendations provided in the recommendation report have been implemented during the course of the project. With the current design, the project achieves a BREEAM score of 62.76% which corresponds to BREEAM “Very Good” level certification.

The difference in points between the “Final Solution and Recommendation Report” and the “Sustainability Assessment Report” is due to capacity of the solar panel system. During the Initial design review of the building, the system was expected to yield a 40kW capacity which has been reduced to 18.24kW at the design amendment stage due to the lack of roof area space. Therefore, one point which was marked as potential point in previous submissions will not be attempted under “Ene 01 Reduction of energy use and carbon emissions” credit.

2.1.1 Energy Efficiency and CO₂ Emission Reduction

A whole building energy simulation was performed for showing improvement in the building performance rating compared to the baseline building performance rating as per ASHRAE/IESNA Standard 90.1-2013.

As required by ASHRAE/IESNA Standard 90.1-2013, the code compliant baseline building model was generated and simulations were run for different orientations of the building (0, 90°, 180°, 270°). Average of these four performance results were computed and determined as baseline building energy performance. The proposed building was generated according to amended design drawings and documents. Since no information about the efficiency of the HVAC equipment and lighting systems was found in the existing design package, recommendations to achieve the desired level of energy efficiency provided in previous deliverables were taken into consideration. These minimum efficiency rates were also added to construction specifications.

The building’s energy efficiency with design amendments is calculated and results are shared as Annex 2. Table 3 represents a comparison of average baseline building energy performance and the proposed annual energy consumption output for Green Offices project generated by EnergyPlus:

Table 3: Comparison of Baseline, Proposed and BREEAM Best Practice Buildings Energy Consumption (kWh) by End Use

End Uses	Baseline (Notional) Building (ASHRAE 90.1-2013 Appendix G)	Proposed (Actual) Building with PV System	BREEAM Best Practice Building
	Electricity (kWh)	Electricity (kWh)	Electricity (kWh)
Heating	776.86	0.00	278.02
Cooling	311,194.14	459,054.00	408,803.20
Interior Lighting	148,145.90	111,109.43	72,682.10
Interior Equipment	288,671.39	288,671.39	288,671.39
Exterior Equipment	8,376.01	8,376.01	8,376.01
Fans	195,534.49	76,513.14	48,469.21
Pumps	131,660.21	117,951.17	87,222.16
Heat Rejection	71,484.16	0.00	0.00
Water Systems	20,365.66	20,364.06	20,367.13
Renewables	0.00	-23,965.90	-21,159.60
Total End Uses	1,176,208.82	1,058,073.30	913,709.62
Total Savings	-	10.0%	22.3%

Table 4 represents the energy demand, primary energy consumption and emission rate for baseline (notional) building, best practice building and proposed (actual) building respectively.

Table 4: Key Performance Indicators with Renewable Energy Production

Ene01 Key Performance Indicators				
Notional building energy demand	1,048,596.47	MJ/year	175.67	MJ/m ² /year
Actual building energy demand	511,007.61	MJ/year	85.61	MJ/m ² /year
Best practice building energy demand	641,748.29	MJ/year	107.51	MJ/m ² /year
Notional building primary energy consumption	2,437,104.68	kWh/year	408.29	kWh/m ² /year
Actual building primary energy consumption	2,192,327.88	kWh/year	367.28	kWh/m ² /year
Best practice primary energy consumption	1,893,206.33	kWh/year	317.17	kWh/m ² /year
Notional building emission rate	1,366,754.65	kgCO ₂ /year	228.97	kgCO ₂ /m ² /year
Actual building emission rate	1,229,481.17	kgCO ₂ /year	205.97	kgCO ₂ /m ² /year
Best practice emission rate	1,061,730.58	kgCO ₂ /year	177.87	kgCO ₂ /m ² /year

Since no information about efficiency of the HVAC and lighting system and performance values for building fabric provided in the existing design drawings, it is not possible to compare energy efficiency of existing and current building designs.

2.1.2 Material Efficiency

To reduce the impact of construction materials, requirements on the procurement of materials that are sourced in a responsible way and have a low embodied impact over their life including extraction, processing and manufacture, and recycling are added in construction specifications.

2.1.3 Site Sufficiency

Ecological assessment was undertaken to define existing land ecological value. To enhance the ecological value of the site as a result of development, an ecologist prepared a ecological report with recommendations to minimize detrimental impacts on site biodiversity.

In addition, to manage construction site in an environmentally and socially considerate, responsible, and accountable manner requirements are added in construction specifications.

2.1.4 Transportation

To encourage building users to travel using low carbon modes of transport, electrical vehicle stations and bicycle facilities are located. A site-specific travel plan that includes a package of measures to encourage the use of sustainable modes of transport and movement of people during the building's operation and use is developed. Proximity to public transportation nodes and amenities is analyzed and stated in the travel plan.

2.1.5 Water Efficiency

Project water supply calculations were made according to Uniform Plumbing Code (UPC) Data Book Table 6.3 (Fixture Unit Loads per Plumbing Fixture) for the existing design. Brand/model name and water consumption of the selected flow and flush fixtures were not defined.

In order to improve water efficiency of the building, maximum flow and flush rates for indoor plumbing fixtures are defined in the construction specifications. With the rainwater harvesting, condensate drain water collection and reuse of the systems more than 40% water saving is achieved.

In addition to water meters on the mains water supply, in order to encourage water consumption management and monitoring and reduce the impacts of inefficiencies and leakage, sub-meters on systems consuming 10% or more of the building's total water demand are added.

2.1.6 Waste Minimization

Suitable space to allow for segregation and storage of operational recyclable waste volumes generated by the building occupants and activities is defined.

Requirements to reduce construction waste related to on site construction and divert non-hazardous construction waste generated by the project from landfill are added in construction specifications.

2.1.7 Occupant Wellbeing

Building natural ventilation strategy is re-designed to allow the occupants to get adequate fresh air. Effective measures which support safe access to and from the building are integrated to building design. To enhance the occupants' visual comfort as well as reduce energy consumption of the building, requirements regarding the selection of internal and external lighting fixtures are added to construction specifications.

3 List of Amendments and Updates

Additional credits that could be targeted within the scope of the project were discussed with the client and responsible parties during the feasibility study and preparation of solution and recommendation reports. Required revisions and amendments are made on existing design documents regarding the following credits agreed with the project team:

1. Man 04 Commissioning and Handover (1 point)

- Handover: A letter of commitment from the Client confirming that a Building User Guide will be developed is gathered.

2. Hea 01 Visual Comfort (1 point)

Ene 03 External Lighting (1 point)

Pol 04 Reduction of Night Time Light Pollution (1 point)

- Specific requirements have been included in the construction specifications. Additional lighting fixtures and technical specifications have been added to the existing lighting drawings to meet the credit requirements.

3. Hea 02 Indoor Air Quality (1 point)

- Adaptability – Potential for Natural Ventilation: Doors and windows schedule have been revised. All awning windows and window CW7 on the third floor office area are now fully openable to allow the total window openable area to cover 5% of the floor areas fulfilling the requirement for natural ventilation.

4. Hea 06 Accessibility (1 point)

- Safe Access: Dedicated pedestrian crossing added to site plan.

5. Ene 01 Reduction of Energy Use and Carbon Emissions (9 points)

- Efficiency rates for HVAC and lighting systems and minimum performance values for window (glass+frame) are added to construction specifications. Solar panel system with 18.24 kW capacity has been integrated to the project.

6. Ene 02 Energy Monitoring (1 point)

- Sub-metering of major energy-consuming systems: Sub-metering of high energy load and tenancy areas that consume more than 10% of the overall energy demand of the building is provided. Additional Direct in Line and CT meters have been added to the appropriate areas.

7. Ene 04 Low Carbon Design (1 point)

- A comprehensive solar feasibility report has been formulated that identifies the size of the system that could be installed in the building and the estimated return of investment.

8. Ene 06 Energy Efficient Transportation System (3 points)

- An analysis of the transport demand and usage patterns for the building have been carried out.
- Two lift suppliers who provide lifts that meet the minimum energy efficient requirements for this credit is identified. Requirements are also included in the construction specifications.

9. Tra 03 Alternative Modes of Transport (2 points)

- Electrical charging stations are provided on the ground floor and first floor parking area.
- Bicycle storage provided on the ground floor and shower / changing facilities provided on the second floor.
- The drainage and plumbing plans are amended as per the additional toilets.

10. Tra 05 Travel Plan (1 point)

- A site-specific travel plan has been developed by the Client.

11. Wat 01 Water Consumption (3 points)

- Maximum flow and flush rates for water fixtures are included in the construction specifications.

12. Wat 02 Water Monitoring (1 point)

- The schematic for potable and non-potable water supply have been amended by including additional sub meters in the supply system to meet the credit requirements.

13. Wst 03 Operational Waste (1 point)

- Dedicated space for the segregation and storage of recyclable waste is provided on the ground floor and a potable water tap has been provided for the dry and wet area separately.
- The drainage and plumbing plans are amended as per the additional taps added.

14. LE 02 Ecological Value of Site and Protection of Ecological Features (2 points)**LE 04 Enhancing Site Ecology (3 points)****LE 05 Long Term Impact on Biodiversity (2 points)**

- Relevant checklists and forms are filled out. Recommendations to enhance site ecology and biodiversity are provided by the ecologist.

15. Inn 01 Innovation (2 points)

- 1 innovation point is achieved by meeting two options (bicycle facilities and electrical vehicle charging stations) under Tra 03 credit.
- 1 innovation point is achieved by requiring construction specifications to include a requirement to install 10 EPD-certified products under Mat 01 credit.

For the following credits which are directly related with the construction stage, requirements are added to the construction specifications document:

- Man 03 Responsible Construction Practices (6 points)
- Mat 01 Life Cycle Impacts (1 point)
- Mat 03 Responsible Sourcing of Construction Products (2 points)
- Wst 03 Construction Waste Management (3 points)

4 Conclusion

This report includes a summary of design amendments and revisions made to achieve a BREEAM “Very Good” level certification for the Green Office Building. Performance improvements in terms of water efficiency, material use, site sufficiency, transportation, waste minimization and occupant health and wellbeing are also summarized.

During the course of the project, regular meetings have been conducting between project delivery stakeholders (client, design team, consultation team). The requirements regarding sustainability are integrated to the project design. BREEAM consultant and Sustainability champion (BREEAM AP) for design stage have been involved with the project team to facilitate the setting, monitoring and achievement of BREEAM performance targets for the project. For the targeted credits, required revisions and additions are made to the existing design drawings. Also, additional credit specific documents are prepared as a scope of design amendments.

The detailed energy simulation report is provided as Annex 2 which shows the results of the energy simulation analysis with expected energy use index, and CO₂ savings compared to a notional baseline building and BREEAM best practice building. According to the results of the energy simulation, actual building emission rate improvement over Notional building is 10.04%. A full cost analysis and feasibility study is done for the proposed PV system which has a total capacity of 18.24 kW.

More than 40% water saving is achieved with selection of low flow water fixtures, rainwater harvesting and condensate drain water collection systems. Sub-meters on systems consuming 10% or more of the building’s total water demand are added to encourage water consumption management.

In order to reduce emissions related with the transportation, bicycle facilities and electrical vehicle charging stations are added to existing design drawings. Travel plan based on the needs of the project site is prepared for building users. Ecological report to enhance site ecology and minimize impact on biodiversity is prepared by a qualified ecologist.

Requirements regarding the selection of construction materials, lighting fixtures, and HVAC equipment and issues to be followed throughout the construction stage (construction site waste management, considerate construction practices, monitoring of site impacts, protection of ecological features) are added in construction specifications.

As a conclusion, with the amendments and revisions made along with the assessment of the sustainability performance of the Green Office Building, the project achieves an overall BREEAM score of 62.76% which corresponds to BREEAM “Very Good” level certification.

BREEAM Section GREEN OFFICE MALDIVES	Total Credits	Credits Targeted		Section Weight	Section Score
		Y	N		
Management	18	13	5		
Man 01 Project brief and design	4	4		10.34%	7.47%
Man 02 Life cycle cost and service life planning	4		4		
Man 03 Responsible construction practices	6	6			
Man 04 Commissioning and handover	4	3	1		
Health & Wellbeing	11	6	5		
Hea 01 Visual Comfort	3	2	1	9.94%	5.42%
Hea 02 Indoor Air Quality	2	1	1		
Hea 04 Thermal comfort	2		2		
Hea 05 Acoustic Performance	1		1		
Hea 06 Accessibility	2	2			
Hea 09 Water quality	1	1			
Hazards	1	1	0		
Hea 07 Hazards	1	1		1.10%	1.10%
Energy	24	16	8		
Ene 01 Reduction of energy use and carbon emissions	15	9	6	13.92%	9.28%
Ene 02 Energy Monitoring	2	2			
Ene 03 External Lighting	1	1			
Ene 04 Low carbon design	3	1	2		
Ene 06 Energy efficient transportation systems	3	3			
Transport	9	7	2		
Tra 01 Public Transport Accessibility	3	1	2	6.58%	5.12%
Tra 02 Proximity to Amenities	1	1			
Tra 03 Alternative modes of transport	2	2			
Tra 04 Maximum car parking capacity	2	2			
Tra 05 Travel Plan	1	1			
Water	9	5	4		
Wat 01 Water Consumption	5	3	2	18.64%	10.36%
Wat 02 Water Monitoring	1	1			
Wat 03 Water Leak Detection	2		2		
Wat 04 Water Efficient Equipment	1	1			
Materials	12	3	9		
Mat 01 Life Cycle Impacts	6	1	5	10.97%	2.74%
Mat 03 Responsible sourcing of construction	4	2	2		
Mat 05 Designing for durability and resilience	1		1		
Mat 06 Material efficiency	1		1		
Waste	7	4	3		
Wst 01 Construction Waste Management	3	3		10.97%	6.27%
Wst 02 Recycled Aggregates	1		1		
Wst 03 Operational Waste	1	1			
Wst 05 Adaptation to climate change	1		1		
Wst 06 Functional adaptability	1		1		
Land Use & Ecology	10	9	1		
LE 01 Site Selection	3	2	1	8.77%	7.89%
LE 02 Ecological Value of Site and Protection of Ecological Features	2	2			
LE 04 Enhancing Site Ecology	3	3			
LE 05 Long Term Impact on Biodiversity	2	2			
Pollution	12	7	5		
Pol 01 Impact of Refrigerants	3	1	2	8.77%	5.12%
Pol 02 NOx Emissions	2		2		
Pol 03 Surface Water Run off	5	5			
Pol 04 Reduction of Night Time Light Pollution	1	1			
Pol 05 Noise Attenuation	1		1		
Innovation	10	2	8		
Inn 1 - Innovation	10	2	8	10%	2.00%
				Total Score	62.76%
				BREEAM Level	VERY GOOD



FOR MINISTRY OF ENVIRONMENT

August 2021



ANNEX 2. ENERGY SIMULATION REPORT

Review and Amend Design of Green Building to attain BREEAM Certification

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General Information		
1	Areas	~ 5,969 m ²
2	Building Type	Office Building
3	Location	Maldives
BREEAM ENE01 Credits Achieved		
1	ENE01 Credit Achieved without Renewable Energy Production	Saving of 8.0% were realized over ASHRAE 90.1- 2013 Energy Performance Standard Baseline.
2	ENE01 Credit Achieved with Renewable Energy Production	Saving of 10.0% were realized over ASHRAE 90.1- 2013 Energy Performance Standard Baseline.
3	Total Credits Achieved	To be evaluated after final version of Energy Modeling Analysis.
Details of Energy Conservation Measures		
1	Building envelope specific measure (solar low-e double glazing)	
2	Highly efficient air-cooled screw chiller with VSD control	
3	Efficient LED lighting systems	
4	Heat recovery units with 70% efficiency values in AHUs	
5	IE3 motor efficiency class in air handling unit fans	

Design Case	Energy Usage (kWh/year)	Energy Savings (%)
Baseline Design as per ASHRAE 90.1 2013 Appendix G	1,176,208.82	-
Proposed Design without Renewable Energy Production	1,082,039.20	8.0%
Proposed Design with Renewable Energy Production	1,058,073.30	10.0%
BREEAM Best Practice Building	913,709.62	22.3%

INTRODUCTION

The energy modelling report has been prepared for Green Offices project in Maldives. The project is a typical office building. Total modelled area of the project is approximately 5,969 square meters.

The project is required to demonstrate improvement in the proposed building performance rating compared to the baseline building performance rating as per ASHRAE/IESNA Standard 90.1-2013 by whole building project simulation using the Building Performance Rating Method in Appendix G of the Standard.

The analysis tool chain employed is shown in the following figure. DesignBuilder (v6.1.5.4) is used to create full three-dimensional architectural models that are exported to EnergyPlus (v8.9) as an input file which is used for analysis of both the baseline and proposed designs reported here.



Figure 1: Analysis Tool Chain

1 METHODOLOGY

A whole building energy simulation was performed for showing improvement in the building performance rating compared to the baseline building performance rating as per ASHRAE/IESNA Standard 90.1-2013.

1.1 Data Collection

The drawings of the site, floor plans of the space and section details were provided for developing thermal model. MEP consultants have given details of proposed design for lighting, envelope and HVAC, etc.

A building "surface" is the fundamental element in the building model. In the general sense, there are two types of "surfaces" in EnergyPlus. These are:

1. Heat transfer surfaces
2. Heat storage surfaces

Any surface, which is expected to separate spaces of significantly different temperatures, is defined as a heat transfer surface. Thus, exterior surfaces, such as outside walls, roofs and floors, are heat transfer surfaces. Interior surfaces (partitions) are heat storage surfaces if they separate spaces maintained at the same temperature; and heat transfer surfaces if they separate spaces maintained at different temperatures.

A "zone" is an air volume at a uniform temperature plus all the heat transfer and heat storage surfaces bounding or inside of that air volume. EnergyPlus calculates the energy required to maintain each zone at a specified temperature for each hour of the day. Since EnergyPlus performs a zone heat balance, the building was separated into zones. A "zone" is a thermal, not a geometric, concept. Thus, the objective was to define as few zones as possible without compromising the integrity of the simulation. Although defining building zones is somewhat of an art, there are a few general rules to smoothen the process. Each room in the building was not defined as a zone; instead a thermal zone was defined as a volume of air at a uniform temperature. Therefore, an important rule here is to use the number of fan systems (and radiant systems) instead of the number of rooms to determine the zones in the building. The minimum number of zones will usually be equal to the number of systems serving the building. The collection of heat transfer and heat storage surfaces defined within each zone includes all surfaces bounding or inside of the space conditioned by the system.

Surfaces that are specified as the outside boundary condition are ceilings, floors and partitions that divide temperature-controlled spaces. The program assumes that the surface temperatures on both sides of the surface are the same. This means that even though heat may be stored in a partition, ceiling, or floor, no heat flows through it. Some surfaces divide the temperature-controlled space from the outside environment. Surfaces that are both sun and wind exposed (e.g. exterior walls, exposed floors, roofs) feel the full effect of both solar radiation and outside temperature. Surfaces such as basement walls and slab floors separate the space from the earth

surrounding the surfaces. Therefore, outside surface temperatures become ground temperatures. Other surfaces separate zones that may be at different temperatures. These surface types allow heat transfer (by conduction through the walls) from a zone at a higher temperature to a zone at a lower temperature.

As stated above, the main objective was to define as few zones and surfaces as possible without compromising the integrity of the model. The number and complexity of surfaces in the input file were cut down by defining equivalent surfaces. EnergyPlus performs heat balances on individual zone surfaces and on the zone air. For the purpose of heat transfer calculations, importance of detailed geometric modelling of the zone surfaces is not significant. As long as the thermal zones (mass of air) and corresponding heat transfer surfaces are known, the program shall calculate all heat balances correctly.

For example, all heat storage surfaces of the same construction within a zone may be defined as a single rectangular surface. The total area of this surface will be equal the sum of all heat storage surface areas in the zone. These represent simplification options for the input data. Each simplification result was analyzed to determine if it would significantly impact certain shading, interior solar gains, or day lighting features. The goal was to seek an adequate level of detail to capture the key features of the building envelope without spending excess time computing results for details that are insignificant.

1.2 General Building Model

By following the above-mentioned guidelines and evaluating each simplification carefully in order to avoid any significant impact on simulation results, a representative model of the proposed building was prepared as shown in Figure 2 for the building shell.

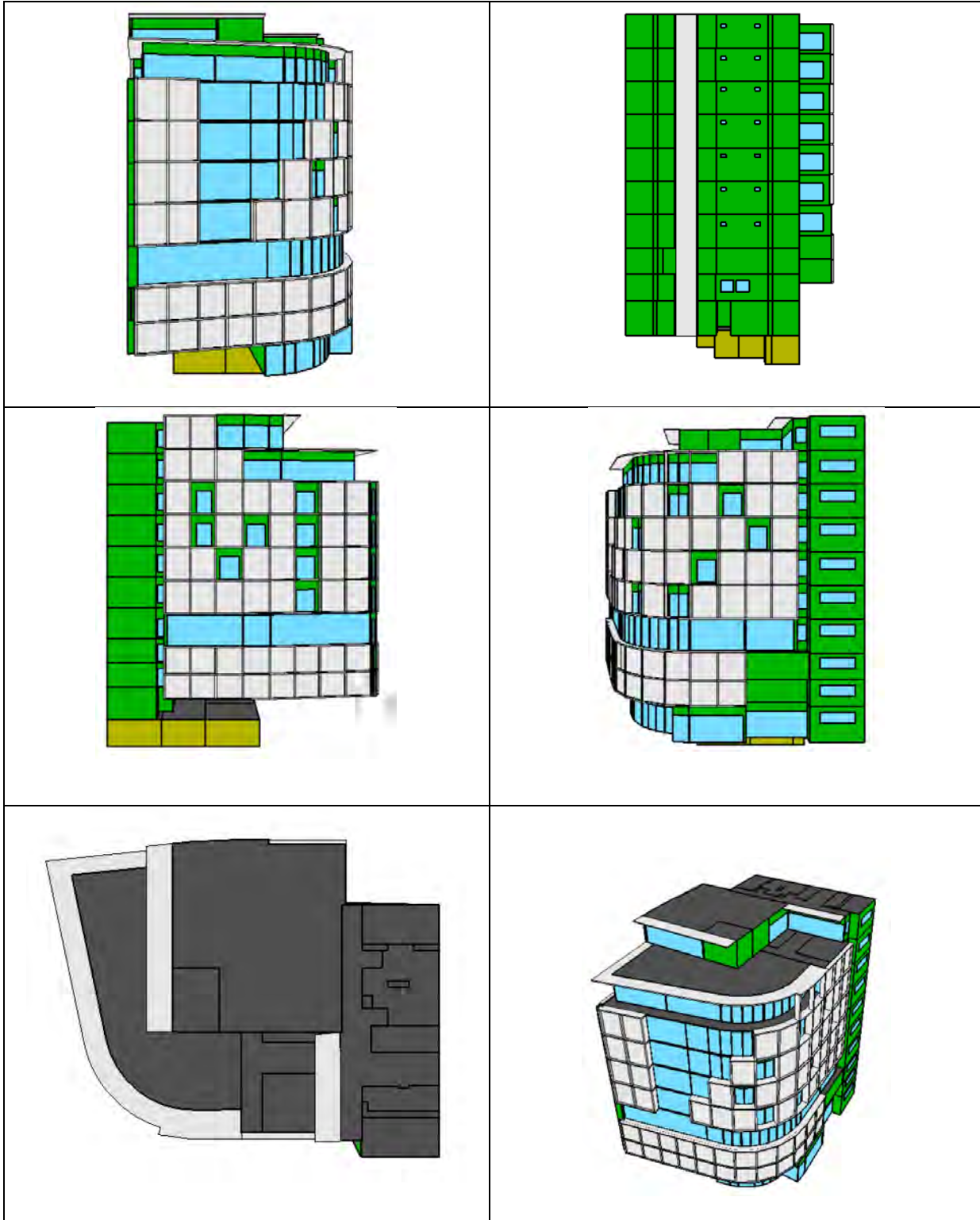


Figure 2: DesignBuilder 3-D Views of Model of the Project

The same methodology was applied for zoning while going through the floor plans. Briefly, the models, both proposed and baseline comprise of 122 zones, simplified to enhance speed of the EnergyPlus runtime. The average baseline performance for four different orientations was computed using the tools provided in EnergyPlus.

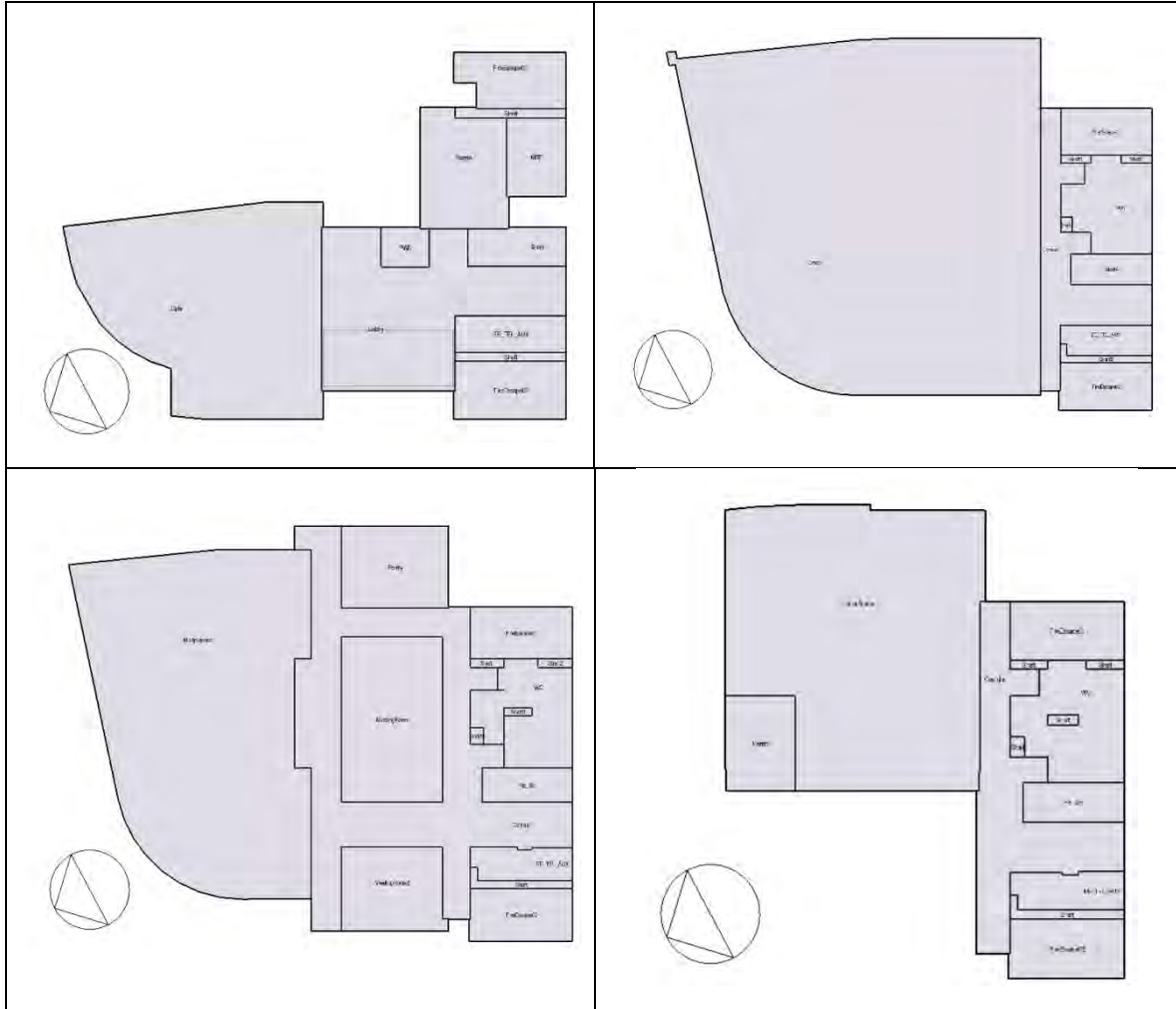


Figure 3: Some of the DesignBuilder Plan Views for the Model

2 BASELINE BUILDING DESCRIPTION

2.1 Baseline Area

The ASHRAE Baseline Model has the same number of floors and identical conditioned floor area as the Proposed Design.

2.2 Climate Data

The project's climate zone is Climate Zone 1A. The weather data file used in the simulations is the "MDV_MALE_SWERA.435550_EPW" weather data file. A plot of the dry bulb and wet bulb temperatures from the climate data is given in Figure 3.

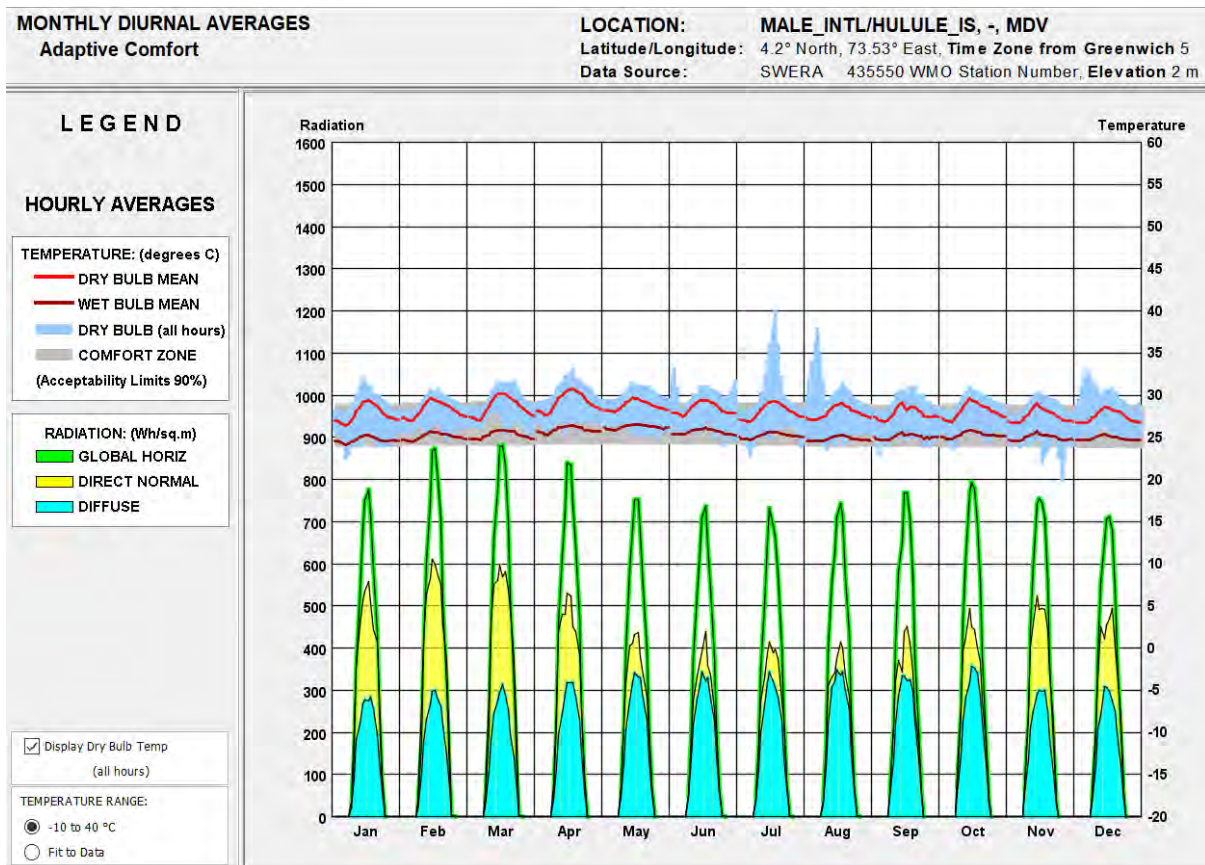


Figure 4: Ambient Dry Bulb and Wet Bulb Temperatures

2.3 Baseline Building Fabric

The ASHRAE/IESNA Standard 90.1-2013 describes a hypothetical code-compliant baseline building which shall be used as a reference point for the building benchmarking. It requires calculation of baseline energy consumption by rotating the building from its original orientation to 90°, 180°, and 270° and the respective annual energy consumptions for each orientation shall be averaged to compute the reference energy consumption. The baseline building is modelled such, that it does not shade itself.

ASHRAE/IESNA Standard 90.1-2013 specifically mandates minimum performance criterion for the building envelope, lighting system and HVAC system. Table 2 below lists the building envelope/fabric minimum performance specifications for baseline design specific to climate zone 1A as per ASHRAE classification.

Table 1: Baseline Building Envelope/Fabric Minimum Performance Specifications

	Subject Component	Detail of Performance Criteria as per ASHRAE/IESNA Standard 90.1-2013
Building Envelope	Roof	The roof space of the building is to be compliant with: $U = 0.273 \text{ W/m}^2\text{K}$
	Exposed Floor	The exposed floor of all the space of the building is to be compliant with: $U = 1.986 \text{ W/m}^2\text{K}$
	Walls	Walls above grade are to be compliant with: $U = 0.705 \text{ W/m}^2\text{K}$
	Slab-on-Grade Floor	Slab-on-Grade floor of building is to be compliant with: $F = 1.264 \text{ W/m}^2\text{K}$ ($U \sim 0.400 \text{ W/m}^2\text{K}$)
	Fenestration	For $\leq 40\%$ window to wall ratio, the glazing requirements are: $U_{\text{windows}} = 3.69 \text{ W/m}^2\text{K}$ $\text{SHGC}_{\text{all}} = 0.25$ Shading – No

***Source: Table 5.5 Building Envelope requirements of ASHRAE 90.1 2013 standard**

The glazing distribution in the Baseline model is determined in accordance with ASHRAE 90.1 Appendix G protocols. The rules are outlined in Table 4.

Table 2: ASHRAE Baseline Glazing Distribution

Proposed Design Façade Glazing Percentage	Baseline Model Façade Glazing Percentage
< 40%	= Proposed Design
> 40%	= 40%

Based on the architectural drawings, the Proposed Design has almost equal to 34% façade glazing; therefore, the Baseline Model’s window to wall ratio was defined as 34% based on ASHRAE 90.1-2013 Appendix G requirements.

2.4 Baseline Building HVAC and Lighting System

Baseline HVAC system description is specified in ASHRAE 90.1-2013 Appendix G section as Systems 6: Packaged VAV with PFP Boxes type for this type building.

Table 3: Baseline Building HVAC System Min. Performance Specifications

HVAC System	Systems/Plants	Detail of Performance Criteria as per ASHRAE/IESNA Standard 90.1-2013
	Baseline Primary HVAC System	System 8—VAV with PFP boxes for Building Occupied Spaces
	Primary HVAC System-Heating	Electric Resistance
	Primary HVAC System-Cooling	Water cooled centrifugal chiller with VSD control Performance Value: COP:5.18, IPLV:8.00 (defined in ASHRAE 90.1-2013 Table 6.8.1.3)
	Ventilation System	Minimum outdoor air flow rates were defined according to ASHRAE 62.1-2013 standard requirements Exhaust air energy recovery is modeled with 50% efficiency as required by G3.1.2.11

***Source: Baseline HVAC system description as specified in Table G3.1.1-3 & G3.1.1-4 of Appendix G ASHRAE 90.1 – 2013 standard**

The baseline lighting power density is defined as space-by-space method in Table 5 below:

Table 4: Baseline Building Lighting System Minimum Performance Specifications

		Detail of Performance Criteria as per ASHRAE/IESNA Standard 90.1-2013
Lighting System	Space Type	
	Interior	<p>The baseline building lighting power allowance for overall interior spaces is 8.72 W/m².</p> <p>Space by Space LPD Value</p> <p>Parking: 2.1 W/m²</p> <p>Electrical/Mechanical Room: 4.6 W/m²</p> <p>Storage: 6.8 W/m²</p> <p>Prayer Room: 6.9 W/m²</p> <p>Cafeteria: 7.0 W/m²</p> <p>Corridor: 7.1 W/m²</p> <p>Stairs: 7.4 W/m²</p> <p>Breakroom: 7.9 W/m²</p> <p>Main Entry Lobby: 9.7 W/m²</p> <p>Restroom: 10.6 W/m²</p> <p>Office: 12.0 W/m²</p> <p>Meeting Room: 13.3 W/m²</p> <p>Multipurpose: 13.3 W/m²</p>

***Source: Baseline lighting system description as specified in TABLE 9.6.1 'Lighting Power Densities Using the Space by Space Method' of ASHRAE 90.1 – 2013 standard**

Appendix G of Standard 90.1-2013 requires that the energy analysis done by using the Building Performance Rating Method must include all the energy costs within and associated with the building project. The baseline building that complies with Appendix G to Standard 90.1-2013 shall have a default process energy cost which should be at least 25% of the total energy cost for the baseline building. Therefore, interior equipment power density values were entered to related section of energy model input files as 17.0 W/m² for all occupiable spaces in both cases.

Table 5: Baseline Building Interior Equipment Performance Specifications

		Detail of Performance Criteria as per ASHRAE/IESNA Standard 90.1-2013
Receptacle	Space Type	
	Interior	Interior equipment (receptacle equipment) power densities for all occupiable spaces in both cases is 17 W/m ² .

2.5 Schedules

In performing computer simulations of buildings, schedules/profiles need to be defined and assigned to parameters such as:

- ❖ Occupancy / People
- ❖ HVAC Plant Operation
- ❖ Internal Lighting
- ❖ Internal Equipment
- ❖ Infiltration
- ❖ Thermostat Setpoints

In defining these schedules, a usage percentage is allocated on an hourly basis, covering all 24 hours of a day and accounting for every single day of the year. Schedules/profiles used in the computer simulations are based on those stated in ASHRAE 90.1 Appendix G, and the same schedules/profiles are used in all the computer simulations. Representative schedule of office occupancy is shown in Appendix of this report.

3 PROPOSED DESIGN DESCRIPTION

The proposed design simulation parameters are described in the following tables 6 and 7:

Table 6: Proposed Building Envelope/Fabric Performance Specifications

Building Envelope/Fabric	Subject Component	Detail of Technical Specifications
	Roof	The roof space of the building is to be compliant with: $U = 0.554 \text{ W/m}^2\text{K}$
	Exposed Floor	The exposed floor of all the space of the building is to be compliant with: $U = 1.986 \text{ W/m}^2\text{K}$
	Walls	Walls above grade are to be compliant with: $U = 0.705 \text{ W/m}^2\text{K}$
	Slab-on-Grade Floor	Slab-on-Grade floor of building is to be compliant with: $F = 1.264 \text{ W/m}^2\text{K}$ ($U \sim 0.400 \text{ W/m}^2\text{K}$)
	Fenestration	For $\leq 40\%$ window to wall ratio, the glazing requirements are: $U_{\text{windows}} = 1.8 \text{ W/m}^2\text{K}$ $\text{SHGC}_{\text{all}} = 0.32$ Shading – Yes

Table 7: Proposed Building HVAC System Performance Specifications

HVAC	Systems/Plants	Detail of Performance Criteria
	HVAC System Description (Plant Side)	The central plant houses two air cooled screw chiller with VSD control.
	HVAC System Description (Zone Side)	There are three different type fan coil units (Ceiling Cassette, Ceiling Concealed FCU, Wall Mounted) in conditioned zones.
	HVAC System Description (Air Side)	There was no air handling unit to meet fresh air requirement of zones in mechanical plans. Because of this reason it was modeled six AHUs to required provide outdoor air rates. Each office space has one HRV (HRV-01/02/03/04/05) and one AHU (AHU-01) is available to provide fresh air for common occupied areas in building such as cafeteria, meeting rooms, multipurpose and corridors.

	<p>Outdoor air flow rates have been calculated based on ASHRAE 62.1.2013 requirements. Fan powers of AHU and HRVs were calculated according to ASHRAE 90.1-2013 Table G3.1.2.10 and Section 6.5.3.1.1. Calculations are provided in annex of this report.</p> <p>Heat recovery effectiveness values for all AHUs have been defined as 70%.</p>
--	------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------

The proposed design lighting power density is defined as space-by-space method in Table 8 below:

Table 8: Proposed Building Lighting System Performance Specifications

LPD	Space Type	Detail of Performance Criteria
	Interior	<p>The proposed building lighting power allowance for overall interior spaces is 6.54 W/m².</p> <p><u>Space by Space LPD Value</u></p> <p>Parking: 1.575 W/m² Electrical/Mechanical Room: 3.45 W/m² Storage: 5.1 W/m² Prayer Room: 5.175 W/m² Cafeteria: 5.25 W/m² Corridor: 5.325 W/m² Stairs: 5.55 W/m² Breakroom: 5.925 W/m² Main Entry Lobby: 7.275 W/m² Restroom: 7.95 W/m² Office: 9.0 W/m² Meeting Room: 9.975 W/m² Multipurpose: 9.975 W/m²</p>

The proposed building interior equipment performance specifications if defined in Table 9 below:

Table 9: Proposed Building Interior Equipment Performance Specifications

Receptacle Equipment	Space Type	Detail of Performance Criteria as per ASHRAE/IESNA Standard 90.1-2013
	Interior	Interior equipment (receptacle equipment) power densities for all occupiable spaces in both cases is 17 W/m ² .

4 BREEAM BEST PRACTICE DESIGN DESCRIPTION

The BREEAM Best Practice design simulation parameters are described in the following tables:

Table 10: BREEAM Best Practice Building Envelope/Fabric Performance Specifications

Building Envelope/Fabric	Subject Component	*Detail of Technical Specifications
	Roof	The roof space of the building is to be compliant with: $U = 0.273 \text{ W/m}^2\text{K}$
	Exposed Floor	The exposed floor of all the space of the building is to be compliant with: $U = 1.986 \text{ W/m}^2\text{K}$
	Walls	Walls above grade are to be compliant with: $U = 0.705 \text{ W/m}^2\text{K}$
	Slab-on-Grade Floor	Slab-on-Grade floor of building is to be compliant with: $F = 1.264 \text{ W/m}^2\text{K}$ ($U \sim 0.400 \text{ W/m}^2\text{K}$)
	Fenestration	For $\leq 40\%$ window to wall ratio, the glazing requirements are: $U_{\text{windows}} = 1.8 \text{ W/m}^2\text{K}$ $\text{SHGC}_{\text{all}} = 0.32$ Shading – Yes

* BREEAM Best Practice Building U values are different from performance values shown in above table according to Guidance Note GN25. However, project climate zone is 1A, demands are much higher than proposed building when using building envelope performance values defined in Guidance Note GN25. Because of this reason building envelope performance values kept same as Proposed Building as required building fabric section of "Further guidance on BREEAM best practice specification".

Table 11: BREEAM Best Practice Building HVAC System Performance Specifications

HVAC	Systems/Plants	Detail of Performance Criteria
	HVAC System Description (Plant Side)	The central plant houses two air cooled screw chiller with VSD control. Air cooled chiller efficiency value has been entered as 3.5 that is defined Table 2 of Guidance Note GN25.
	HVAC System Description (Zone Side)	Same as Proposed Building (FCUs in occupied zones). Terminal unit SFP has been modeled with 0.5 W/l/s.
	HVAC System Description (Air Side)	<p>System is same as Proposed Building but performance values are different as follows;</p> <p>Central ventilation unit SFP has been modeled with 1 W/l/s, Heat recovery effectiveness has been modeled with 75% efficiency</p> <p>There was no air handling unit to meet fresh air requirement of zones in mechanical plans.</p>

The BREEAM Best Practice design lighting power density is defined as space by space method in Table 8 below:

Table 12: BREEAM Best Practice Building Lighting System Performance Specifications

LPD	Space Type	Detail of Performance Criteria
	Interior	<p>The BREEAM best practice building lighting power allowance for overall interior spaces is 4.28 W/m².</p> <p>Lighting luminaire has been taken as 65 lm/Watt as required in Table 2 of Guidance Note GN25. EN 12464-1:2011 standard was used to define lux values of each zone type. Additionally, 10% improvement has been added to reflect occupancy and daylight control effect on lighting design.</p> <p>Space by Space LPD Value</p> <p>Parking: 1.04 W/m² Electrical/Mechanical Room: 2.77 W/m² Storage: 1.38 W/m² Prayer Room: 2.77 W/m² Cafeteria: 2.77 W/m² Corridor: 1.38 W/m² Stairs: 1.38 W/m² Breakroom: 2.77 W/m² Main Entry Lobby: 2.77 W/m² Restroom: 2.77 W/m² Office: 6.92 W/m² Meeting Room: 6.92 W/m² Multipurpose: 6.92 W/m²</p>

Table 13: BREEAM Best Practice Building Interior Equipment Performance Specifications

Receptacle Equipment	Space Type	Detail of Performance Criteria as per ASHRAE/IESNA Standard 90.1-2013
	Interior	<p>Interior equipment (receptacle equipment) power densities for all occupiable spaces in both cases is 17 W/m².</p>

5 BASELINE vs PROPOSED SYSTEM COMPARISON

Systems	Baseline Building	Proposed Building	BREEAM Best Practice Building
Fenestration Window to Wall Ratio	%33.64	%33.64	%33.64
Heating/Cooling System	VAV with parallel fan power boxes and reheat	Central air-cooled screw chillers with fan coil units in zones	Central air-cooled screw chillers with fan coil units in zones
Cooling System Performance Values	Water cooled centrifugal chiller with VSD control COP: 5.18, IPLV: 8.00	Air cooled screw chiller with VSD control COP: 2.87, IPLV: 4.76	Air cooled screw chiller with VSD control COP: 3.5, IPLV: 5.81
Heating System Performance Values	Electric resistances with 1.0 efficiency value	Electric resistances with 1.0 efficiency value	Electric resistances with 1.0 efficiency value
Ventilation System	VAV with parallel fan power boxes and reheat	DOAS units with heat recovery units (%70 efficiency) and heating/cooling coils	DOAS units with heat recovery units (%75 efficiency) and heating/cooling coils
*Total Outdoor Air Flow Rate	16,442 m ³ /h	17.800 m ³ /h	17.800 m ³ /h
**Total Fan Power	Parallel Fan Power Boxes: 14.11 kW, VAV Units: 54.72 kW,	Fan Coils: 19.78 kW, AHU Units: 15.32 kW,	Fan Coils: 23.29 kW, AHU Units: 9.88 kW,

Systems	Baseline Building	Proposed Building	BREEAM Best Practice Building
Fan Type and Maximum Air Flow Rates	PIU: Constant Volume, 18.99 m ³ /s VAV: Variable Volume, 37.38 m ³ /s	FCU: On/Off, 46.59 m ³ /s AHU: Constant Volume, 9.9 m ³ /s	FCU: On/Off, 46.59 m ³ /s AHU: Constant Volume, 9.9 m ³ /s
***Pump Type and Power	Primary Cooling Circulation Pump: Variable Speed, 4.1 kW Secondary Cooling Circulation Pump: Variable Speed, 4.1 kW Cooling Tower Circulation Pump: Variable Speed, 10.6 kW DHW Pump: Variable Speed, 0.1 kW	Cooling Circulation Pump: Variable Speed, 29.8 kW DHW Pump: Variable Speed, 0.1 kW	Cooling Circulation Pump: Variable Speed, 29.8 kW DHW Pump: Variable Speed, 0.1 kW
****Lighting Power Density (W/m²) Values	LPD values were specified based on ASHRAE 90.1-2013 Table 9.6.1 for each zone type	LPD values are %25 much lower than Baseline Building LPD values	LPD values have been determined based on 65 lm/watt criteria that is defined in Appendix B section of Guidance Note GN25. Additionally, occupancy control and daylight control effect have been added with 10% improvement.
*****PV System	There is no renewable energy production	Solar panel system capacity is 18.24 kW.	On site electric generation should be

Systems	Baseline Building	Proposed Building	BREEAM Best Practice Building
		Energy produced by proposed solar panel system per year is 23,965.9 kWh.	$\%50 \times \text{Roof Area} \times 120$ kWh/m ² according to Guidance Not GN25. Because of this reason 21,160 kWh electricity generation from PV system has been subtracted from energy model total end use results. (Roof area taken as 350 m ²)

*Total outdoor air flow rates were defined according to ASHRAE 62.1-2013. Calculations are provided in appendix of this report.

** Fan powers of AHU and HRVs were calculated according to ASHRAE 90.1-2013 Table G3.1.2.10 and Section 6.5.3.1.1. Calculations are provided in appendix of this report.

***Baseline Building pump performance values were modeled based on ASHRAE 90.1-2013 Appendix G requirements. Proposed and BREEAM Best Practice Building pump capacity was taken from mechanical schedule provided by design team. Pump capacities and performance values are provided in appendix of this report.

****Lighting power density values for each building are provided in appendix of this report.

*****Information about electricity generation from PV system in Proposed Building is taken from "Solar Feasibility Report 2021-05-13" document that includes capacity of PV system and annual electricity production value.

6 RESULTS

This report presents the energy savings results from analysis of the differences between proposed design and the code-compliant baseline developed using the Performance Rating Method as defined in ASHRAE/IESNA Standard 90.1-2013.

A computer simulation was performed to demonstrate these achievements and analyses the results of energy efficiency measures applied in the project. Assuming that the building envelope and systems are designed to maximize energy performance, computer simulation model is used to assess the energy performance and identify the most cost-effective energy efficiency measures.

As required by ASHRAE/IESNA Standard 90.1-2013, the code compliant baseline building model was generated and simulations were run for different orientations of the building (0, 90°, 180°, 270°) Average of these four performance results were computed and determined as baseline building energy performance. Following table represents a comparison of average baseline building energy performance and the proposed annual energy consumption output for Green Offices project generated by EnergyPlus:

Table 14: Comparison of Baseline, Proposed and BREEAM Best Practice Buildings Energy Consumption (kWh) by End Use

End Uses	Baseline Building (ASHRAE 90.1-2013 Appendix G)	Proposed Building without PV System	Proposed Building with PV System	BREEAM Best Practice Building
	Electricity (kWh)	Electricity (kWh)	Electricity (kWh)	Electricity (kWh)
Heating	776.86	0.00	0.00	278.02
Cooling	311,194.14	459,054.00	459,054.00	408,803.20
Interior Lighting	148,145.90	111,109.43	111,109.43	72,682.10
Interior Equipment	288,671.39	288,671.39	288,671.39	288,671.39
Exterior Equipment	8,376.01	8,376.01	8,376.01	8,376.01
Fans	195,534.49	76,513.14	76,513.14	48,469.21
Pumps	131,660.21	117,951.17	117,951.17	87,222.16
Heat Rejection	71,484.16	0.00	0.00	0.00
Water Systems	20,365.66	20,364.06	20,364.06	20,367.13
Renewables	0.00	0.00	-23,965.90	-21,159.60
Total End Uses	1,176,208.82	1,082,039.20	1,058,073.30	913,709.62
Total Savings	-	8.0%	10.0%	22.3%

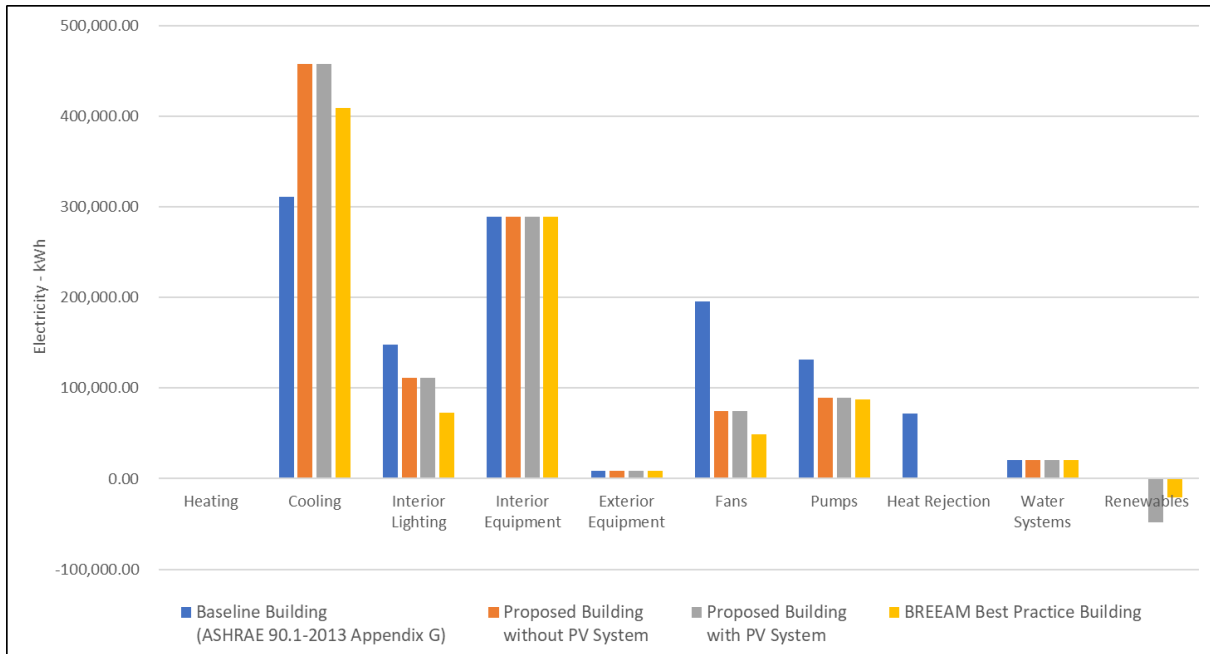


Figure 5: Comparison Chart of Baseline vs. Proposed Building

7 ENERGY PERFORMANCE AND COMPLIANCE

The table below presents the key performance indicators resulting from an analysis of the differences between the baseline building, proposed building and BREEAM best practice building.

Table 15: ENE01 Key Performance Indicators with Renewable Energy Production

Ene01 Key Performance Indicators				
Notional building energy demand	1,048,596.47	MJ/year	175.67	MJ/m ² /year
Actual building energy demand	511,007.61	MJ/year	85.61	MJ/m ² /year
Best practice building energy demand	641,748.29	MJ/year	107.51	MJ/m ² /year
Notional building primary energy consumption	2,437,104.68	kWh/year	408.29	kWh/m ² /year
Actual building primary energy consumption	2,192,327.88	kWh/year	367.28	kWh/m ² /year
Best practice primary energy consumption	1,893,206.33	kWh/year	317.17	kWh/m ² /year
Notional building emission rate	1,366,754.65	kgCO ₂ /year	228.97	kgCO ₂ /m ² /year
Actual building emission rate	1,229,481.17	kgCO ₂ /year	205.97	kgCO ₂ /m ² /year
Best practice emission rate	1,061,730.58	kgCO ₂ /year	177.87	kgCO ₂ /m ² /year

Table 16: ENE01 Key Performance Indicators without Renewable Energy Production

Ene01 Key Performance Indicators				
Notional building energy demand	1,048,596.47	MJ/year	175.67	MJ/m ² /year
Actual building energy demand	511,007.61	MJ/year	85.61	MJ/m ² /year
Best practice building energy demand	641,748.29	MJ/year	107.51	MJ/m ² /year
Notional building primary energy consumption	2,437,104.68	kWh/year	408.29	kWh/m ² /year
Actual building primary energy consumption	2,241,985.22	kWh/year	375.60	kWh/m ² /year
Best practice primary energy consumption	1,893,206.33	kWh/year	317.17	kWh/m ² /year
Notional building emission rate	1,366,754.65	kgCO ₂ /year	228.97	kgCO ₂ /m ² /year
Actual building emission rate	1,257,329.55	kgCO ₂ /year	210.64	kgCO ₂ /m ² /year
Best practice emission rate	1,061,730.58	kgCO ₂ /year	177.87	kgCO ₂ /m ² /year

Note: Primary energy conversion factor for electricity has been taken as 2.072 and CO₂ emission conversion factor has been taken as 1.162.

According to energy model analysis results, 9 points can be taken for BREEAM ENE01 credit as shown below BREEAM ENE01 calculation tool results.

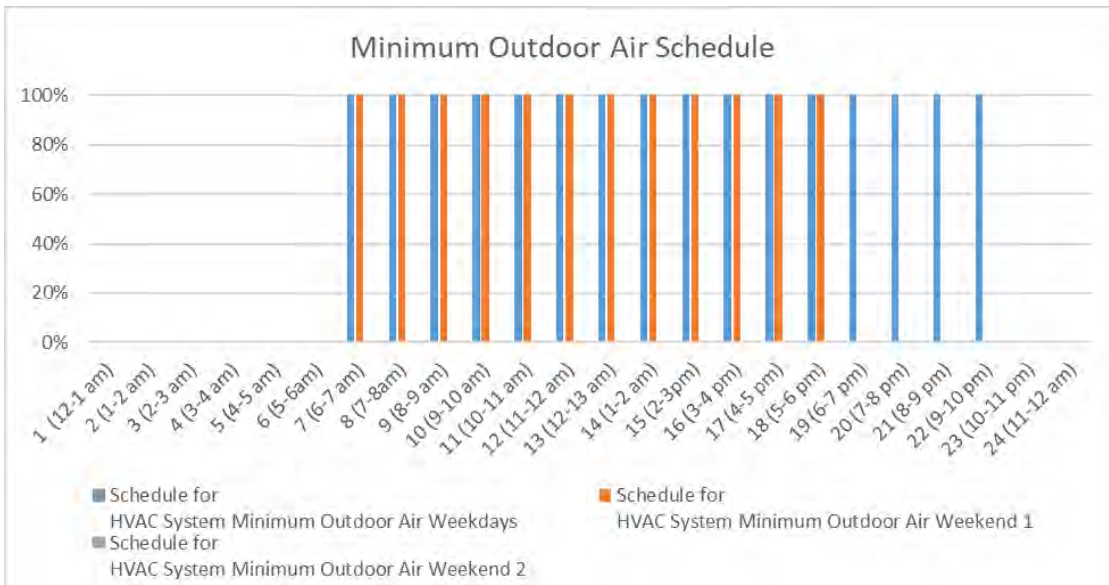
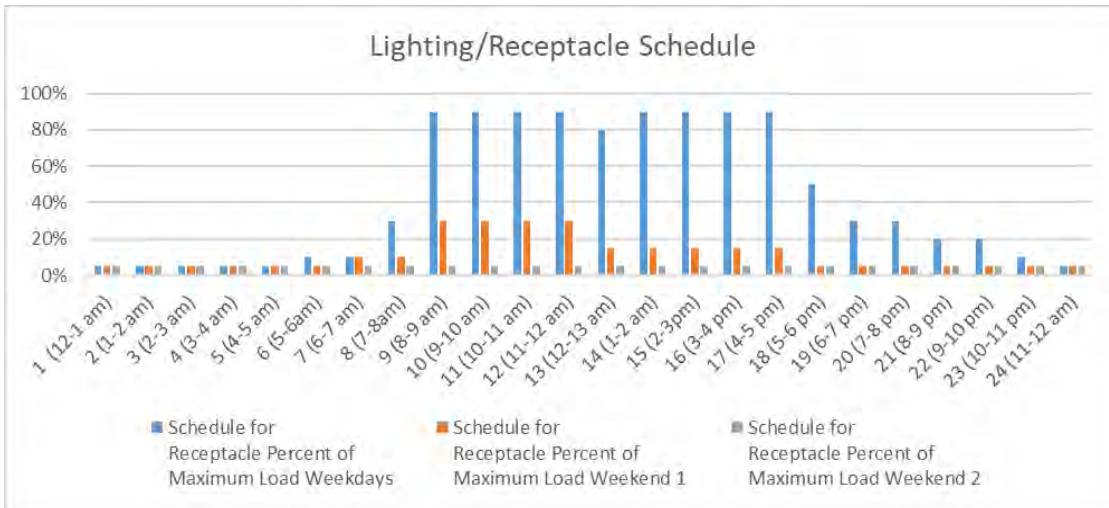
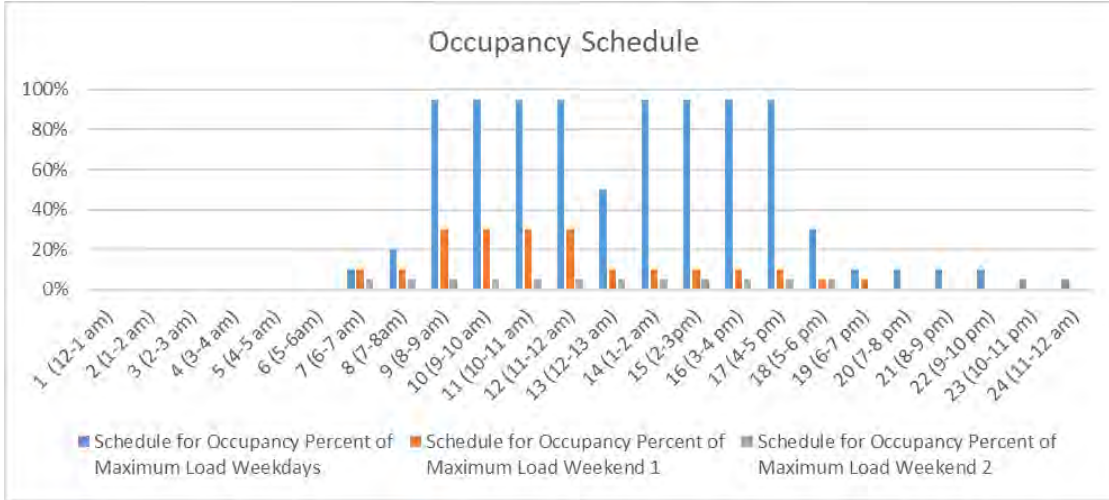
Building Score	
Actual Bdg Emission Rate improvement over Notional Building	10.040000000000006 %
Demand Energy Performance Ratio (EPR)	0.9052
Consumption Energy Performance Ratio (EPR)	0.4906
CO2 Energy Performance Ratio (EPR)	0.3189
Overall Building Energy Performance Ratio (EPRNC)	0.5715

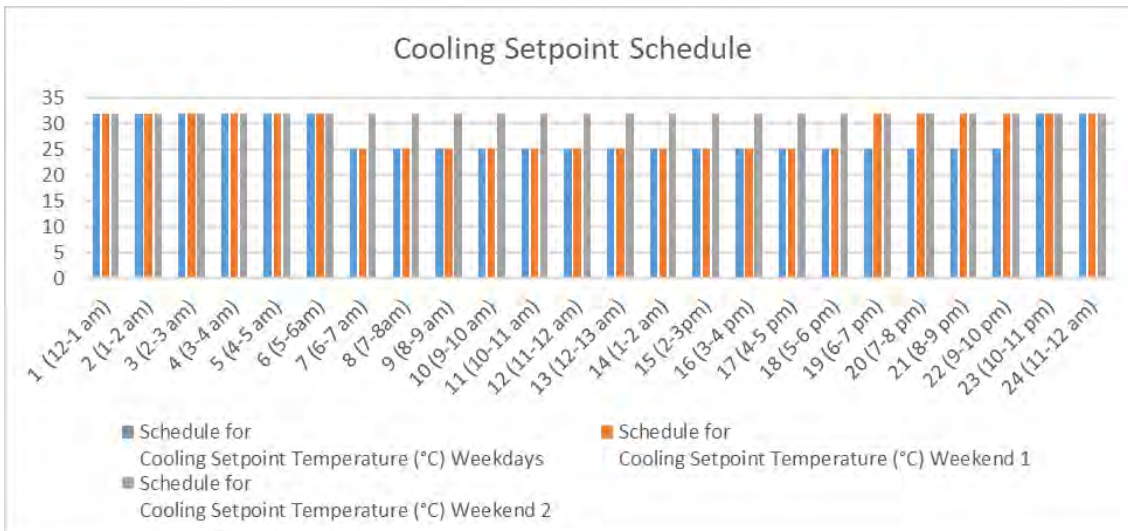
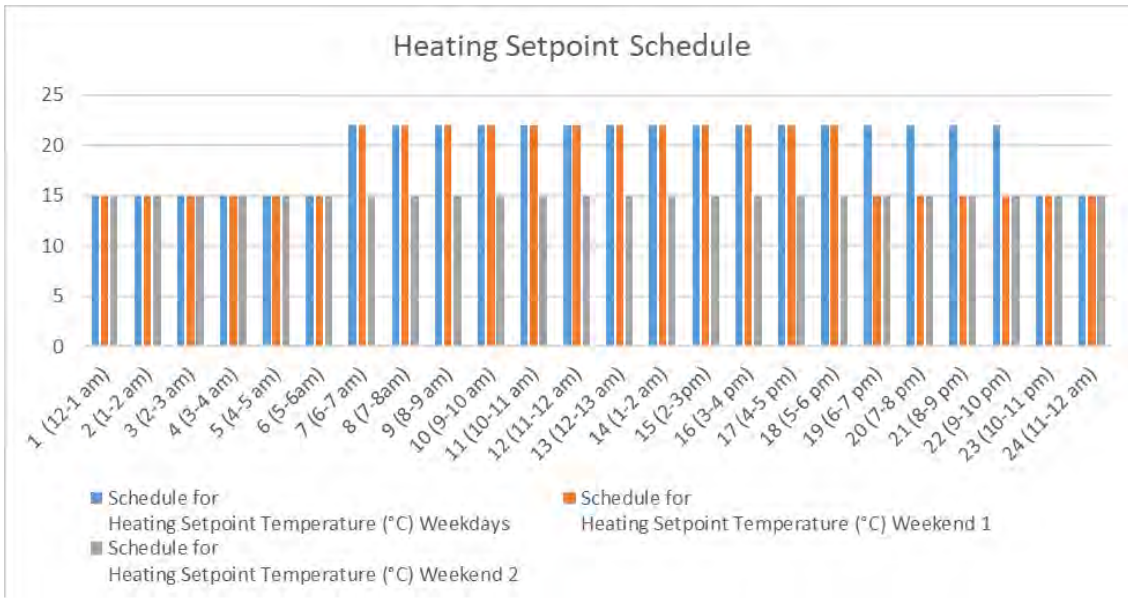
Credits available	15	Credits awarded	9
Exemplary credits available	4	Exemplary credits awarded	0
Minimum Standard	Excellent		

Figure 6: BREEAM ENE01 Building Score with Renewable Energy Production

APPENDIX

SCHEDULES





ASSUMPTIONS AND CALCULATIONS

Occupancy Values and Outdoor Air Flow Rates

Baseline Building, Proposed Building and BREEAM Best Practice Building outdoor air flow rates were calculated based on ASHRAE 62.1-2013 standard. Also occupancy values were taken from standard default values for each zone type as shown below tables. Please see the below table that includes zone by zone outdoor air flow rate calculations for Baseline Building.

ASHRAE 62.1-2013 VENTILATION CONTROL TABLE										
FLOOR	Zone	Zone	Occupancy	Area	Design Air Flow	Occupancy (based on Project Design Values)	Ez	Ev	Vot	Complies
Number	Number	Description	Category	m ²	m ³ /h	#			m ³ /h	w / A62.1
GF	G12	Cafe	Cafeteria / fast food dining	129.40	2800	130	0.80	1.00	2,747	YES
GF	G03	Lobby	Main entry lobbies	79.40	200	8	0.80	1.00	197	YES
GF	G08	Admin	Office space	29.40	100	2	0.80	1.00	62	YES
GF	G09/G10	MRF	Computer (not printing)	13.70	100	1	0.80	1.00	30	YES
F01	112	Cafe	Cafeteria / fast food dining	66.50	1500	67	0.80	1.00	1,415	YES
F01	104	MDF	Computer (not printing)	5.90	100	1	0.80	1.00	19	YES
F01	106/107	TELCO	Computer (not printing)	13.80	100	1	0.80	1.00	30	YES
F01	108	Security Room	Office space	20.50	100	2	0.80	1.00	50	YES
F03	311/312/313/314	Prayer Room	Places of religious worship	55.60	900	67	0.80	1.00	829	YES
F03	303	Corridor	Corridors	48.00	100	0	0.80	1.00	65	YES
F03	315	Office	Office space	448.00	900	23	0.80	1.00	364	YES
F04	403	Corridor	Corridors	46.40	100	0	0.80	1.00	63	YES
F04	411	Office	Office space	498.40	1000	25	0.80	1.00	954	YES
F05	503	Corridor	Corridors	46.40	100	0	0.80	1.00	63	YES
F05	511	Office	Office space	498.40	1000	25	0.80	1.00	954	YES
F06	603	Corridor	Corridors	46.40	100	0	0.80	1.00	63	YES
F06	611	Office	Office space	498.40	1000	25	0.80	1.00	954	YES
F07	703	Corridor	Corridors	46.40	100	0	0.80	1.00	63	YES
F07	711	Office	Office space	498.40	1000	25	0.80	1.00	954	YES
F08	816/817/818	Multipurpose	Multi-purpose assembly	239.50	3600	288	0.80	1.00	3,563	YES
F08	803	Corridor	Corridors	130.00	200	0	0.80	1.00	176	YES
F08	814	Meeting Room2	Conference / meeting	30.30	300	16	0.80	1.00	221	YES
F08	813/815	Meeting Room	Conference / meeting	58.90	500	30	0.80	1.00	417	YES
F08	811	Pantry	Occupiable storage rooms for dry materials	31.20	100	1	0.80	1.00	53	YES
F09	911	Pantry	Occupiable storage rooms for dry materials	18.50	100	1	0.80	1.00	36	YES
F09	912	Indoor Space	Breakrooms (office buildings)	183.00	1600	92	0.80	1.00	1,529	YES
F09	903	Corridor	Corridors	53.50	100	0	0.80	1.00	72	YES
				Total Area	Total Supplied Fresh Air	Total Peak Occupancy			Total Required Fresh Air	IEQp1
				3,834	17,800	830			16,442	27
										27
										YES

Fan Powers

Fan powers in Baseline Building were calculated according to ASHRAE 90.1-2013 requirements shown in below snapshots.

TABLE 6.5.3.1-1 Fan Power Limitation ^a			
	Limit	Constant Volume	Variable Volume
Option 1: Fan system motor nameplate kW	Allowable nameplate motor kW	$kW \leq L/S_G \cdot 0.0017$	$kW \leq L/S_G \cdot 0.0024$
Option 2: Fan system input kW	Allowable fan system input kW	$kW_I \leq L/S_G \cdot 0.0015 + A$	$kW_I \leq L/S_G \cdot 0.0021 + A$

a. where
 L/S_G – maximum design supply airflow rate to conditioned spaces served by the system in litres per second
 kW – maximum combined motor nameplate kW
 kW_I – maximum combined fan input kW
 A – sum of $(PD \times L/S_D/65,0000)$
 where
 PD – each applicable pressure drop adjustment from Table 6.5.3.1-2 in Pa.
 L/S_D – the design airflow through each applicable device from Table 6.5.3.1-2 in litres per second

TABLE 6.5.3.1-2 Fan Power Limitation Pressure Drop Adjustment	
Device	Adjustment
Credits	
Fully ducted return and/or exhaust air systems	125 Pa (535 Pa for laboratory and vivarium systems)
Return and/or exhaust airflow control devices	125 Pa
Exhaust filters, scrubbers, or other exhaust treatment	The pressure drop of device calculated at fan system design condition
Particulate Filtration Credit: MERV 9 through 12	125 Pa
Particulate Filtration Credit: MERV 13 through 15	225 Pa
Particulate Filtration Credit: MERV 16 and greater and electronically enhanced filters	Pressure drop calculated at 2× clean filter pressure drop at fan system design condition
Carbon and other gas-phase air cleaners	Clean filter pressure drop at fan system design condition
Biosafety cabinet	Pressure drop of device at fan system design condition
Energy recovery device, other than coil runaround loop	$(550 \times \text{Energy Recovery Effectiveness}) - 125$ Pa for each airstream
Coil runaround loop	150 Pa for each airstream
Evaporative humidifier/cooler in series with another cooling coil	Pressure drop of device at fan system design condition
Sound attenuation section (fans serving spaces with design background noise goals below NC35)	38 Pa
Exhaust system serving fume hoods	85 Pa
Laboratory and vivarium exhaust systems in high-rise buildings	60 Pa/30 m of vertical duct exceeding 25 m
Deductions	
Systems without central cooling device	150 Pa
Systems without central heating device	75 Pa
Systems with central electric resistance heat	50 Pa

Please see the below table that includes fan powers and air flow rates for Baseline, Proposed and BREEAM Best Practice Buildings.

BREEAM Best Practice Building Fans					
Fan Name	Type	Delta Pressure [pa]	Max Air Flow Rate [m3/s]	Rated Electric Power [W]	Rated Power Per Max Air Flow Rate [W-s/m3]
GROUND FLOOR:ADMIN FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.38	188.89	500.00
GROUND FLOOR:MRF FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.38	188.89	500.00
GROUND FLOOR:LOBBY FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.70	351.39	500.00
GROUND FLOOR:CAFE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	1.89	944.44	500.00
FIRST FLOOR:SECURITY ROOM FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.19	94.44	500.00
FIRST FLOOR:TELCO FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.38	188.89	500.00
FIRST FLOOR:MDF FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.19	94.44	500.00
FIRST FLOOR:CAFE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	1.13	566.67	500.00
THIRD FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.35	175.69	500.00
THIRD FLOOR:PRAYER ROOM FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.76	377.78	500.00
THIRD FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	5.67	2,833.33	500.00
4TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.35	175.69	500.00
4TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	6.42	3,211.11	500.00
5TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.35	175.69	500.00
5TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	6.42	3,211.11	500.00
6TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.35	175.69	500.00
6TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	6.42	3,211.11	500.00
7TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.35	175.69	500.00
7TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	6.42	3,211.11	500.00
8TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	1.05	527.08	500.00
8TH FLOOR:MEETING ROOM 2 FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.38	188.89	500.00
8TH FLOOR:MEETING ROOM FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.76	377.78	500.00
8TH FLOOR:PANTRY FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.38	188.89	500.00
8TH FLOOR:MULTIPURPOSE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	2.11	1,054.17	500.00
9TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.35	175.69	500.00
9TH FLOOR:PANTRY FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	0.19	94.44	500.00
9TH FLOOR:INDOOR SPACE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	300.00	2.27	1,133.33	500.00
HRV04 AHU EXTRACT FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV04 AHU SUPPLY FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV01 AHU EXTRACT FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV01 AHU SUPPLY FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV02 AHU EXTRACT FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV02 AHU SUPPLY FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV03 AHU EXTRACT FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV03 AHU SUPPLY FAN	Fan:ConstantVolume	700.00	0.28	277.78	1,000.00
HRV05 AHU EXTRACT FAN	Fan:ConstantVolume	700.00	0.25	250.00	1,000.00
HRV05 AHU SUPPLY FAN	Fan:ConstantVolume	700.00	0.25	250.00	1,000.00
AHU01 AHU EXTRACT FAN	Fan:ConstantVolume	700.00	3.58	3,583.33	1,000.00
AHU01 AHU SUPPLY FAN	Fan:ConstantVolume	700.00	3.58	3,583.33	1,000.00

Proposed Building Fans					
Fan Name	Type	Delta Pressure [pa]	Max Air Flow Rate [m3/s]	Rated Electric Power [W]	Rated Power Per Max Air Flow Rate [W-s/m3]
GROUND FLOOR:ADMIN FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.70	0.38	127.00	336.17
GROUND FLOOR:MRF FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.70	0.38	127.00	336.17
GROUND FLOOR:LOBBY FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	0.70	730.00	1,038.73
GROUND FLOOR:CAFE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	1.89	635.01	336.18
FIRST FLOOR:SECURITY ROOM FAN COIL UNIT SUPPLY FAN	Fan:OnOff	174.71	0.19	55.00	291.18
FIRST FLOOR:TELCO FAN COIL UNIT SUPPLY FAN	Fan:OnOff	174.70	0.38	110.00	291.17
FIRST FLOOR:MDF FAN COIL UNIT SUPPLY FAN	Fan:OnOff	174.71	0.19	55.00	291.18
FIRST FLOOR:CAFE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.70	1.13	380.99	336.17
THIRD FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	0.35	365.00	1,038.73
THIRD FLOOR:PRAYER ROOM FAN COIL UNIT SUPPLY FAN	Fan:OnOff	174.71	0.76	220.01	291.18
THIRD FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	5.67	1,905.04	336.18
4TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	0.35	365.00	1,038.73
4TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	6.42	2,159.04	336.18
5TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	0.35	365.00	1,038.73
5TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	6.42	2,159.04	336.18
6TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	0.35	365.00	1,038.73
6TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	6.42	2,159.04	336.18
7TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	0.35	365.00	1,038.73
7TH FLOOR:OFFICE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	6.42	2,159.04	336.18
8TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	207.75	1.05	365.01	346.25
8TH FLOOR:MEETING ROOM 2 FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.70	0.38	127.00	336.17
8TH FLOOR:MEETING ROOM FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.71	0.76	254.01	336.18
8TH FLOOR:PANTRY FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.70	0.38	127.00	336.17
8TH FLOOR:MULTIPURPOSE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	623.24	2.11	2,190.00	1,038.73
9TH FLOOR:CORRIDOR FAN COIL UNIT SUPPLY FAN	Fan:OnOff	1,869.72	0.35	1,095.00	3,116.20
9TH FLOOR:PANTRY FAN COIL UNIT SUPPLY FAN	Fan:OnOff	174.71	0.19	55.00	291.18
9TH FLOOR:INDOOR SPACE FAN COIL UNIT SUPPLY FAN	Fan:OnOff	201.70	2.27	761.98	336.17
HRV04 AHU EXTRACT FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV04 AHU SUPPLY FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV01 AHU EXTRACT FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV01 AHU SUPPLY FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV02 AHU EXTRACT FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV02 AHU SUPPLY FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV03 AHU EXTRACT FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV03 AHU SUPPLY FAN	Fan:ConstantVolume	1,092.52	0.28	433.54	1,560.74
HRV05 AHU EXTRACT FAN	Fan:ConstantVolume	1,083.85	0.25	387.09	1,548.35
HRV05 AHU SUPPLY FAN	Fan:ConstantVolume	1,083.85	0.25	387.09	1,548.35
AHU01 AHU EXTRACT FAN	Fan:ConstantVolume	1,082.86	3.58	5,543.22	1,546.94
AHU01 AHU SUPPLY FAN	Fan:ConstantVolume	1,082.86	3.58	5,543.22	1,546.94

Baseline Building Fans					
Fan Name	Type	Delta Pressure [pa]	Max Air Flow Rate [m3/s]	Rated Electric Power [W]	Rated Power Per Max Air Flow Rate [W-s/m3]
GROUNDFOOR:ADMIN PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.18	130.47	742.33
GROUNDFOOR:MRF PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.07	55.53	742.33
GROUNDFOOR:LOBBY PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.80	446.81	742.33
GROUNDFOOR:CAFE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.76	566.66	742.33
FIRSTFLOOR:SECURITYROOM PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.12	90.22	742.33
FIRSTFLOOR:TELCO PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.08	62.06	742.33
FIRSTFLOOR:MDF PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.05	39.34	742.33
FIRSTFLOOR:CAFE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.51	378.51	742.33
THIRDFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.36	270.84	742.33
THIRDFLOOR:PRAYERROOM PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.37	274.39	742.33
THIRDFLOOR:OFFICE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	2.72	2,020.48	742.33
4THFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.31	226.86	742.33
4THFLOOR:OFFICE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	2.14	1,591.36	742.33
5THFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.29	214.99	742.33
5THFLOOR:OFFICE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	2.04	1,512.88	742.33
6THFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.29	211.95	742.33
6THFLOOR:OFFICE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	2.01	1,490.31	742.33
7THFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.28	209.66	742.33
7THFLOOR:OFFICE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	1.98	1,471.49	742.33
8THFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.70	518.42	742.33
8THFLOOR:MEETINGROOM2 PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.23	168.18	742.33
8THFLOOR:MEETINGROOM PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.21	159.35	742.33
8THFLOOR:PANTRY PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.16	121.01	742.33
8THFLOOR:MULTIPURPOSE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	1.13	841.33	742.33
9THFLOOR:CORRIDOR PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.46	338.87	742.33
9THFLOOR:PANTRY PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.11	81.53	742.33
9THFLOOR:INDOORSPACE PARALLEL PIU SUPPLY FAN	Fan:ConstantVolume	445.40	0.83	613.51	742.33
AIR LOOP AHU EXTRACT FAN	Fan:VariableVolume	879.88	1.58	2,312.77	1,466.47
AIR LOOP AHU SUPPLY FAN	Fan:VariableVolume	879.88	1.58	2,312.77	1,466.47
AIR LOOP 1 AHU EXTRACT FAN	Fan:VariableVolume	881.98	0.72	1,053.93	1,469.96
AIR LOOP 1 AHU SUPPLY FAN	Fan:VariableVolume	881.98	0.72	1,053.93	1,469.96
AIR LOOP 2 AHU EXTRACT FAN	Fan:VariableVolume	879.45	3.37	4,932.96	1,465.74
AIR LOOP 2 AHU SUPPLY FAN	Fan:VariableVolume	879.45	3.37	4,932.96	1,465.74
AIR LOOP 3 AHU EXTRACT FAN	Fan:VariableVolume	878.51	2.45	3,586.29	1,464.19
AIR LOOP 3 AHU SUPPLY FAN	Fan:VariableVolume	878.51	2.45	3,586.29	1,464.19
AIR LOOP 4 AHU EXTRACT FAN	Fan:VariableVolume	879.17	2.33	3,410.62	1,465.28
AIR LOOP 4 AHU SUPPLY FAN	Fan:VariableVolume	879.17	2.33	3,410.62	1,465.28
AIR LOOP 5 AHU EXTRACT FAN	Fan:VariableVolume	877.08	2.29	3,352.08	1,461.80
AIR LOOP 5 AHU SUPPLY FAN	Fan:VariableVolume	877.08	2.29	3,352.08	1,461.80
AIR LOOP 6 AHU EXTRACT FAN	Fan:VariableVolume	876.46	2.26	3,308.17	1,460.76
AIR LOOP 6 AHU SUPPLY FAN	Fan:VariableVolume	876.45	2.26	3,308.13	1,460.75
AIR LOOP 7 AHU EXTRACT FAN	Fan:VariableVolume	877.57	2.33	3,410.63	1,462.62
AIR LOOP 7 AHU SUPPLY FAN	Fan:VariableVolume	877.56	2.33	3,410.60	1,462.60
AIR LOOP 8 AHU EXTRACT FAN	Fan:VariableVolume	878.75	1.36	1,990.75	1,464.59
AIR LOOP 8 AHU SUPPLY FAN	Fan:VariableVolume	878.75	1.36	1,990.75	1,464.59

Performance Values of Pumps

Baseline Building pump performance values were modeled based on ASHRAE 90.1-2013 Appendix G requirements as shown below snapshots.

G3.1.3.10 Chilled-Water Pumps (Systems 7, 8, and 11). The baseline building design pump power shall be 349 kW/1000 L/s. Chilled-water systems with a cooling capacity of 11,148 m² or more shall be modeled as primary/secondary systems with variable-speed drives on the secondary pumping loop. Chilled-water pumps in systems serving less than 11,148 m² cooling capacity shall be modeled as a primary/secondary systems with secondary pump riding the pump curve. For computer room systems using System 11 with an integrated water-side economizer, the baseline building design primary chilled-water pump power shall be increased 80 kW/1000 L/s for flow associated with the water-side economizer.

The tower shall be controlled to maintain a 21°C leaving water temperature where weather permits, floating up to leaving water temperature at design conditions. The baseline building design condenser-water pump power shall be 310 kW/1000 L/s. For computer room systems using System 11 with an integrated water-side economizer, the baseline building design condenser water-pump power shall be increased 80 kW/1000 L/s for flow associated with the water-side economizer. Each chiller shall be modeled with separate condenser water and chilled-water pumps interlocked to operate with the associated chiller.

Proposed and BREEAM Best Practice Building pump capacity was taken from mechanical schedule provided by design team.

Please see the below table that includes pump capacities, control types and performance values for Baseline, Proposed and BREEAM Best Practice Buildings.

Baseline Building Pumps						
	Type	Control	Head [pa]	Water Flow [m³/s]	Electric Power [W]	Power Per Water Flow Rate [W-s/m³]
CHW LOOP 1 SUPPLY PUMP	Pump:VariableSpeed	Intermittent	122,499.00	0.02	4,156.18	174,500.00
CHW LOOP SUPPLY PUMP	Pump:ConstantSpeed	Intermittent	122,499.00	0.02	4,156.18	174,500.00
DHW LOOP SUPPLY PUMP	Pump:VariableSpeed	Intermittent	179,352.00	0.00	9.10	255,487.18
CONDENSER LOOP SUPPLY PUMP	Pump:ConstantSpeed	Intermittent	217,620.00	0.03	10,614.08	310,000.00

Proposed Building Pumps						
	Type	Control	Head [pa]	Water Flow [m³/s]	Electric Power [W]	Power Per Water Flow Rate [W-s/m³]
CHW LOOP SUPPLY PUMP	Pump:VariableSpeed	Intermittent	640,354.53	0.03	29,840.00	912,185.94
DHW LOOP SUPPLY PUMP	Pump:VariableSpeed	Intermittent	179,352.00	0.00	9.10	255,487.18

BREEAM Best Practice Building Pumps						
	Type	Control	Head [pa]	Water Flow [m³/s]	Electric Power [W]	Power Per Water Flow Rate [W-s/m³]
CHW LOOP SUPPLY PUMP	Pump:VariableSpeed	Intermittent	556,393.45	0.04	29,840.00	792,583.26
DHW LOOP SUPPLY PUMP	Pump:VariableSpeed	Intermittent	179,352.00	0.00	9.10	255,487.18

Lighting Power Density Values

Baseline Building's lighting power density values (W/m^2) were taken from ASHRAE 90.1-2013 Table 9.6.1 for each zone type.

Proposed Building's lighting power density values (W/m^2) have been determined with %25 improvement according to lighting power density values in ASHRAE 90.1-2013 Table 9.6.1.

BREEAM Best Practice Building's lighting power density values have been determined based on 65 lm/watt criteria that is defined in Appendix B section of Guidance Note GN25. Additionally, occupancy control and daylight control effect have been added with 10% improvement according to lighting power density values.

Please see the below table that includes LPD values for Baseline, Proposed and BREEAM Best Practice Buildings.

Zone Category	Zone Area [m ²]	Baseline Building LPD [W/m ²]	Proposed Building LPD [W/m ²]	EN 12464-1:2011 Lux Values for Zone Types	BREEAM Best Practice Building LPD with Daylight and Occupancy Controls [W/m ²]
Parking	999.71	2.10	1.58	75	1.04
Elec_Mech_Tec	397.35	4.60	3.45	200	2.77
Storage	49.73	6.80	5.10	100	1.38
Prayer Room	55.62	6.90	5.18	200	2.77
Cafeteria	195.99	7.00	5.25	200	2.77
Corridor	417.06	7.10	5.33	100	1.38
Stairs	395.90	7.40	5.55	100	1.38
Breakroom	182.97	7.90	5.93	200	2.77
Main Entry Lobby	79.39	9.70	7.28	200	2.77
Restroom	216.54	10.60	7.95	200	2.77
Office	2,491.62	12.00	9.00	500	6.92
Meeting Room	89.15	13.30	9.98	500	6.92
Multipurpose Room	239.53	13.30	9.98	500	6.92

Interim Certificate: Design Stage

The assessment of:

N2-32 Green Office Building
Bageechaa Hingun
Hulhumalé
11538
Maldives

has been carried out according to Technical Manual:

BREEAM International New Construction 2016

Office

Shell and Core

and based on the Assessment Report produced by:

Altensis Construction Energy Ltd

has achieved a score of **63.2%**

Very Good



Certificate Number: **BREEAM-0089-1655**

Issue: **01**

BRE Global Limited is accredited by UKAS. The assessment process is certified by BRE Global Limited in accordance with the requirements of Scheme Document SD123

22 December 2021

Date of Issue

Signed for BRE Global Ltd., Catherine Butcher

AIDEA

Architect

Housing Development Corporation Ltd.

Developer

Epoch Associates Pvt Ltd

Design Review

Muge Emen

BREEAM Accredited Professional

Housing Development Corporation Ltd.

Client for the Assessment

Emre Ilicali

Licensed Assessor

EI01

Assessor Number

AIDEA

Building Services & MEP Engineers

Epoch Associates Pvt Ltd

Building Services & MEP Review



SD123 Cert. No. BREEAM-0089-1655

This certificate is issued to the Licensed Assessor Organisation named above based on their application of the assessment process in accordance with Scheme Document SD123.

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Interim Certificate Number: BREEAM-0089-1655

Issue: 01

**N2-32 Green Office Building
Bageechaa Hingun
Hulhumalé
11538
Maldives**

Assessed for: Housing Development Corporation Ltd.

by: Altensis Construction Energy Ltd
Assessor Company

Emre Ilicali

EI01

Licensed Assessor

Assessor Number

BREEAM International New Construction 2016

Office

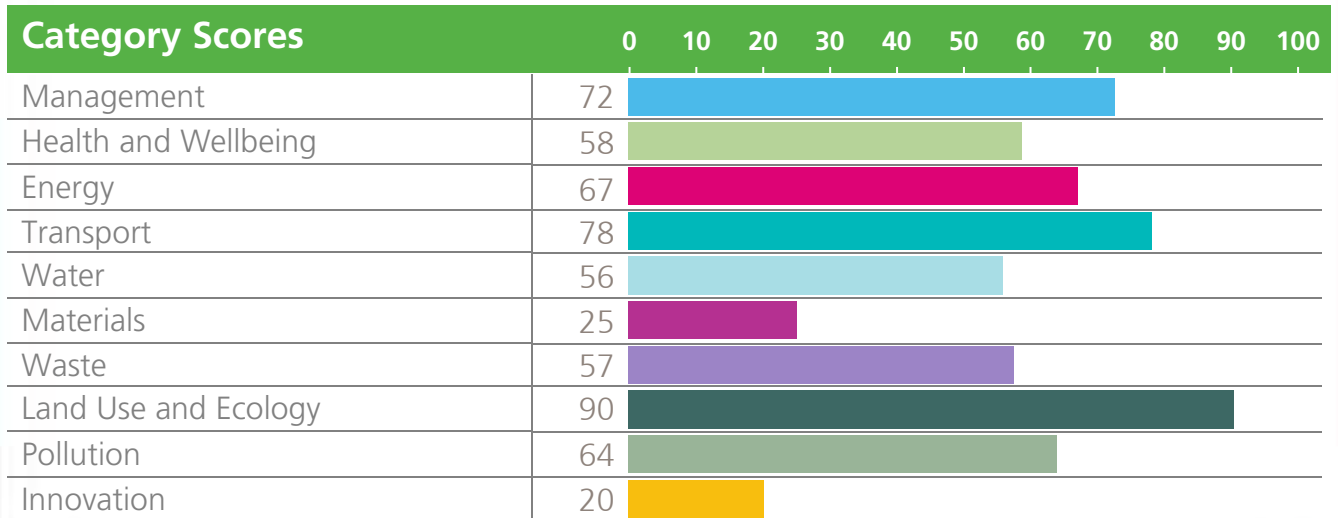
Shell and Core

Overall Score: 63.2%

Rating: Very Good



Category Scores



C Butcher

Signed for BRE Global Ltd., Catherine Butcher

22 December 2021

Date of Issue



SD123 Cert. No. BREEAM-0089-1655

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