Tutors: Prof. Zhou Huan, zouhuan@tsinghua.edu.cn
Team: Chia Hui Yen
Solo work

THE FOREST

Building Performance:
The Forest Community Center Environment Optimization

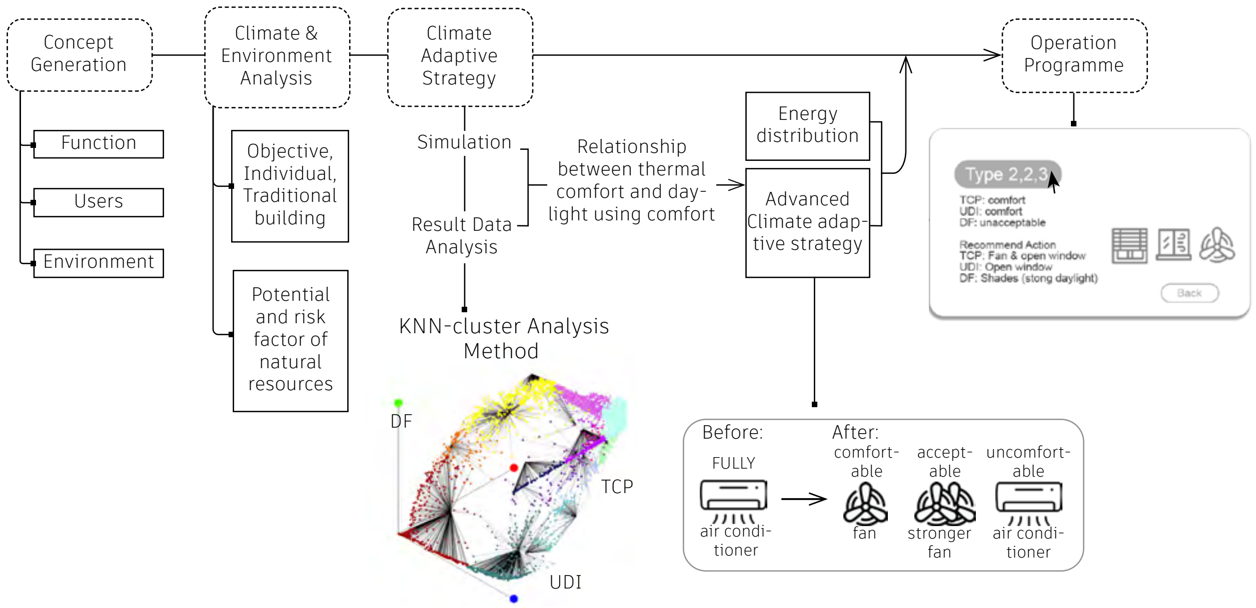
_Climate adpative design, Programme design

July 2023 - September 2023

Introduction

This project is located in Kuala Lumpur, Malaysia, within a tropical climate zone. Through a comprehensive analysis of the local climate, we have simulated responses tailored to the intense sunlight and abundant daylight conditions. The objective is to explore a balance between thermal comfort and effective utilization of natural light in the tropical climate. The project employs different climate-responsive strategies for various sections of the building to minimize the overall energy consumption.

Concept — Climate & Building Energy Analysis, Strategies — Operation



Concept Generation

1 Devide portion of spaces for tourist to discover local arts and crafts and a chilling place for the local passby by their dynamic flows.

2 Based on the consideration of climate adaptation, extract the form of Malay House and create an open space for market at ground floor and enclosed space for museum at upper floor.

3 Create gap between the module of exibition to improve the natural ventilation. Also, open up at as main passway.

4 For the ground floor, input a certain number of flexible module and create an free, public atmosphere of local market.

5 Lastly, lay a specific designed-roof on top, shaded the whole museum from sun-rays.

Climate & Building Energy Analysis, Strategies

1. Site Characteristic Analysis and Climate Adaptive Analysis

Analysis site characteristic from Objective factor (weather) and Individual factor (clothes, activities, and local standards), take traditional building adaptive s strategies as references.

Objective factor: Weather

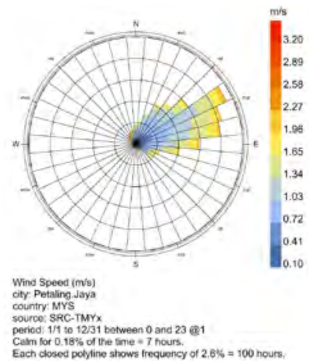
Factors of wind & sun towards thermal comfort

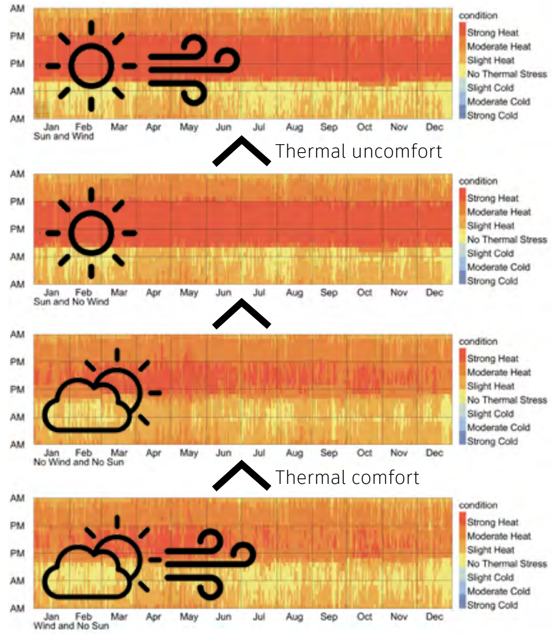
Limted wind energy and strong solar energy.

PMV factors are humid

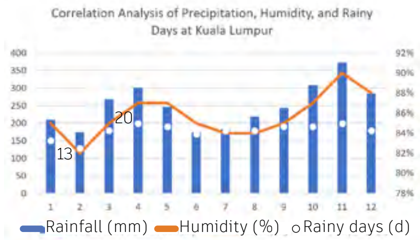
Therefore, strategy should focus on shading and maximise use of solar power, by installing BIPV system.

Wind Rose:





Rain & Humidity



According to research, the predominant influence of outdoor climate on the thermal comfort of occupants in naturally ventilated buildings, with optimal comfort temperatures determined by average outdoor temperatures.
Besides, the significant impact of relative humidity on indoor thermal comfort, necessitating strategies to maintain optimal humidity levels through effective air circulation and heat dissipation.

Result:
Wind & no sun> No wind & No Sun> Sun &Wind >Sun & no wind

Individual factor

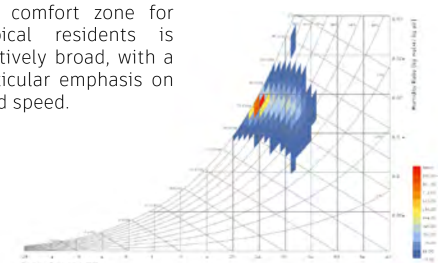
1. Clo rate
Clo rate are wide range: 0.2 to 0.5

2. Metabolism Rate
Activies in community center are wide range:

NORMAL STANDARD

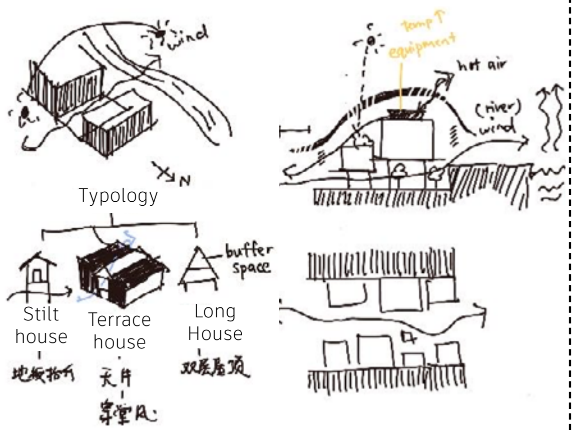
3. Malaysia standards

The comfort zone for tropical residents is relatively broad, with a particular emphasis on wind speed.



Traditional Buildings Typology for reference

Based on typology of traditional architecture, developed a series of climate adaptive method to apply on "the Forest building", method covered air flow (natural ventilation), daylight usage, water reuse, electricity from solar panel and material selection.



Conclusion:

Environmental Factors:

Wind: *Low potential for use.*
Sun: *High impact on thermal comfort, High potential for use*
Rainwater: *High potential for use.*
Humidity: *Negative influence on thermal comfort.*
River: *Risk of flooding, but potential for use.*

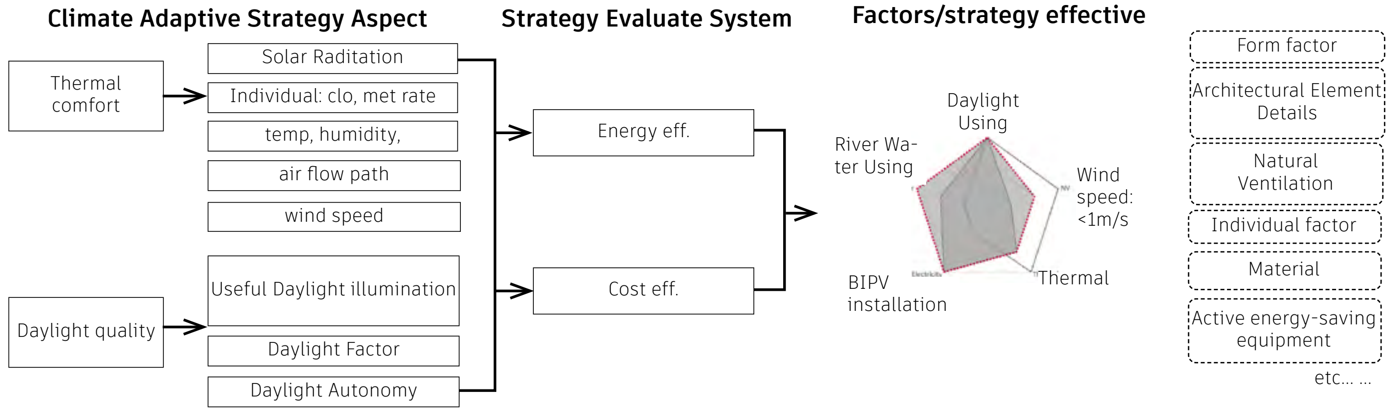
Individual Factors:

Metabolism Rate: *Wide and diverse range.*
Clothing Rate (Clo): *Restricted.*

These factors collectively contribute to the overall evaluation of thermal comfort and environmental suitability.

Balancing daylight levels with solar heat gain is essential in tropical climates. Daylight may lead to increased heat gain, impacting thermal comfort.

Climate Adaptive Strategy Aspect — Strategy Evaluate System — Factors/strategy effective



Reference:
1. International Organization for Standardization. (2005). ISO 7730: Moderate Thermal Environments - Determination of the PMV and PPD Indices and Specification of the Conditions for Thermal Comfort.
2. Jones, P. (2009). Thermal comfort factors in hot and humid regions: Malaysia.

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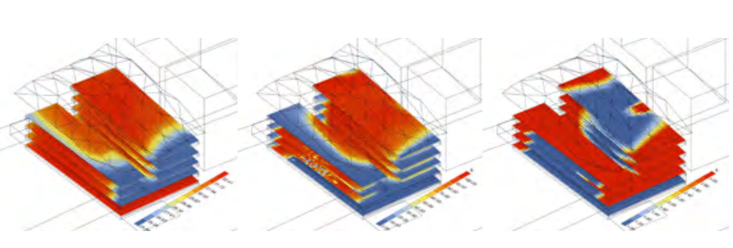
2. Relationship between Daylight and Thermal Comfort

(1) Problem: Thermal and Daylight Simulation

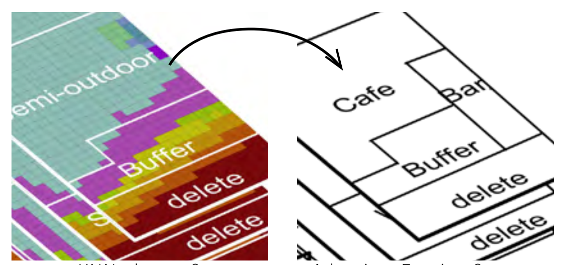
Go throught daylight and thermal simulation with the basic elements like floor area, roof top and surrounding buildings, in order to develop further startegy. From the simulation result, we can seethe trend of daylight useful i (UDI) and thermal comfort is different sometimes even invert, UDI and DA is positively related. DF is irregular.



Themal comfort percentage (TCP) — Useful daylight illuminance (UDI) — Daylight Factor (DF)

(2) Optimization Process:

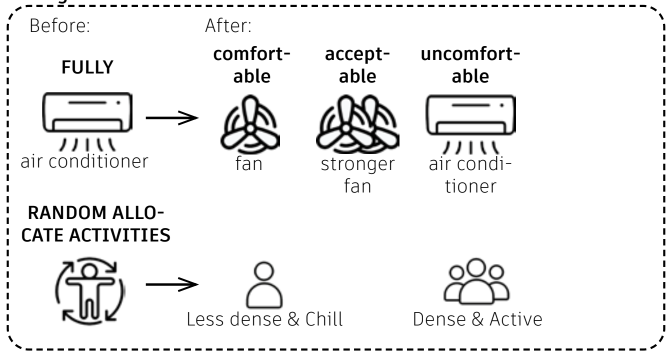
Classify thermal and lighting considerations by KNN-cluster Analysis Method to 3*3*3=27 Types, to derive suitable activities and design strategies tailored to climate conditions.



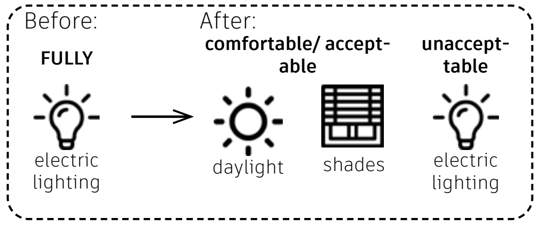
KNN-cluster & Visualization — Adaption: Funtion & strategies

(3) Result:

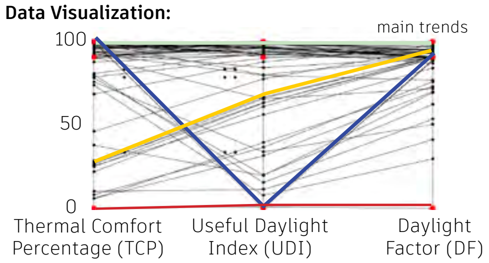
Strategies for thermal comfort:

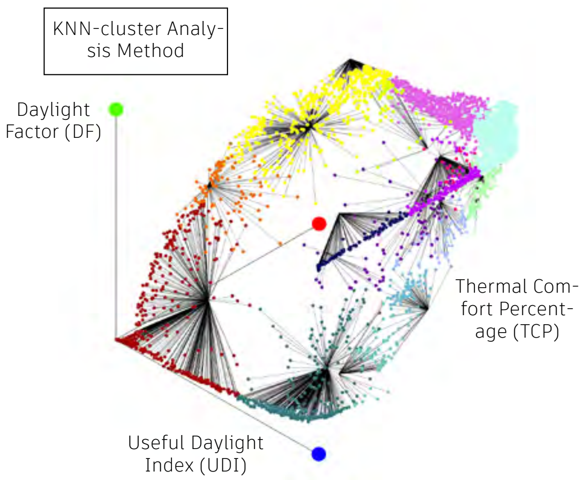


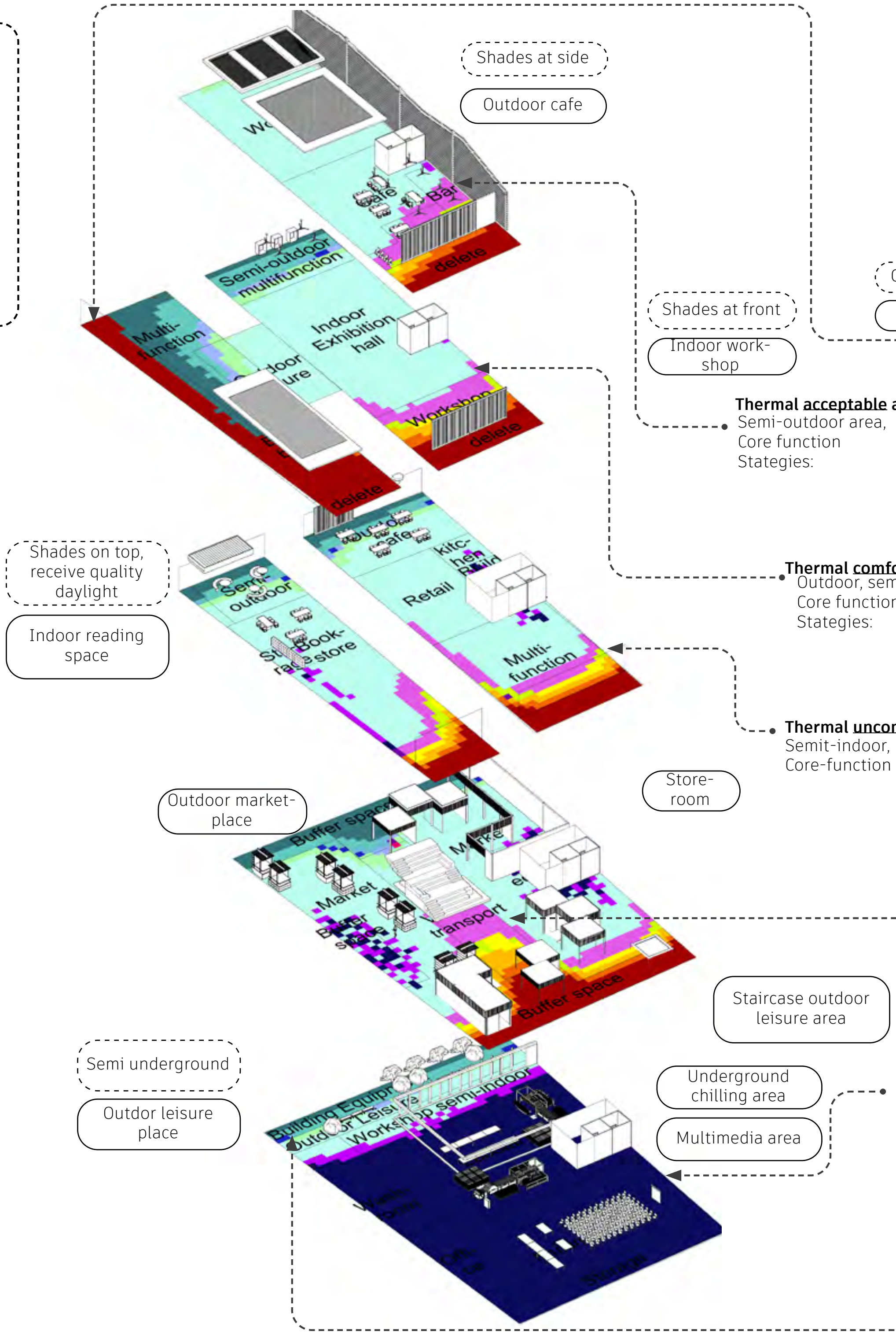
Strategies for Daylight usage:



Data Visualization:

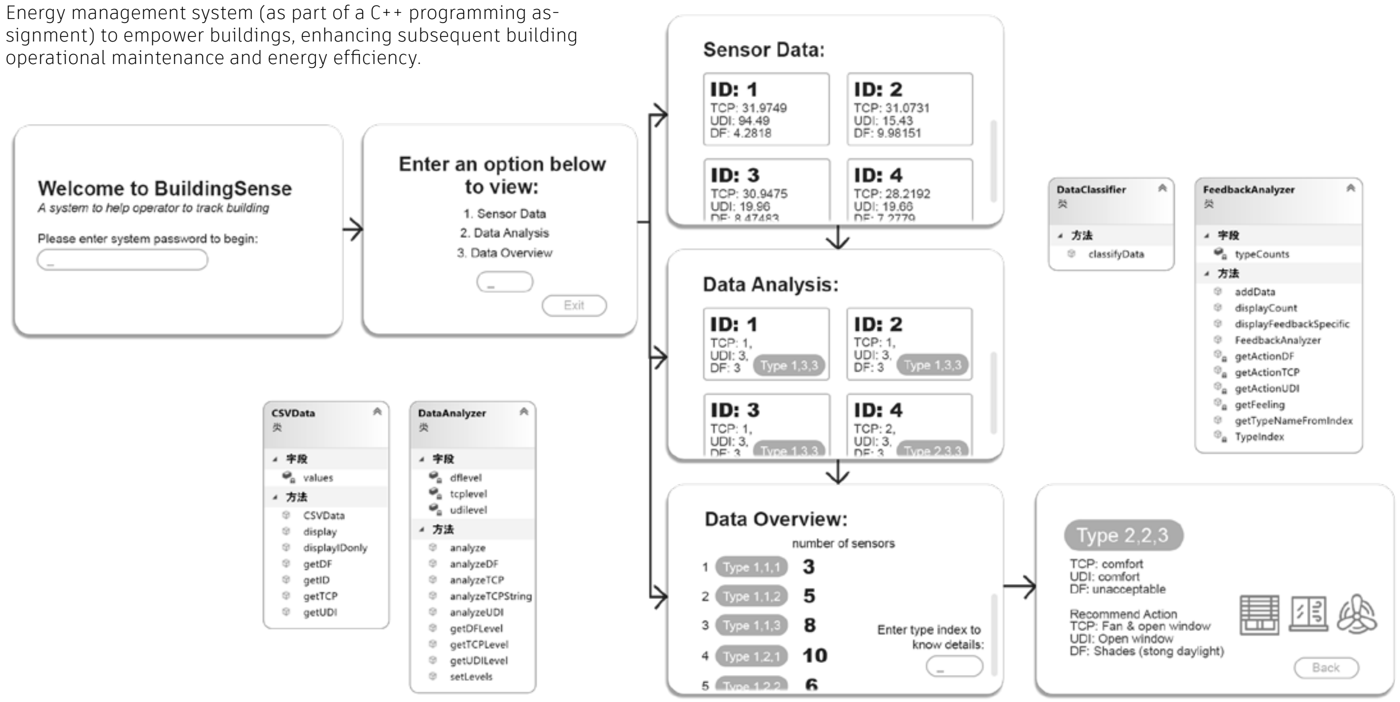


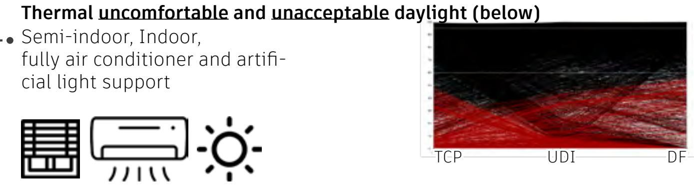


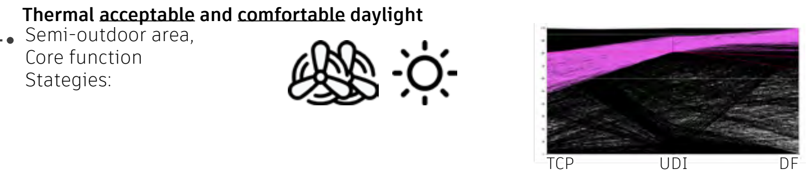


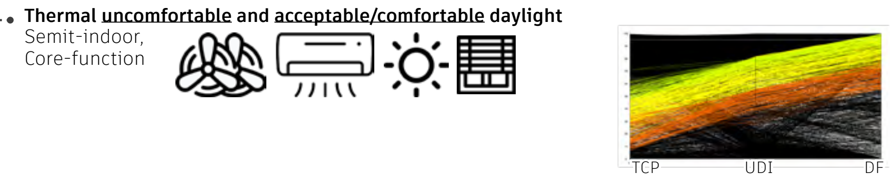
(4) Operation

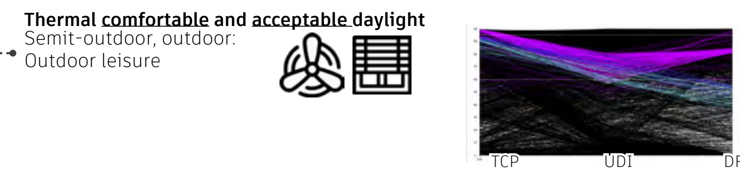
Energy management system (as part of a C++ programming assignment) to empower buildings, enhancing subsequent building operational maintenance and energy efficiency.

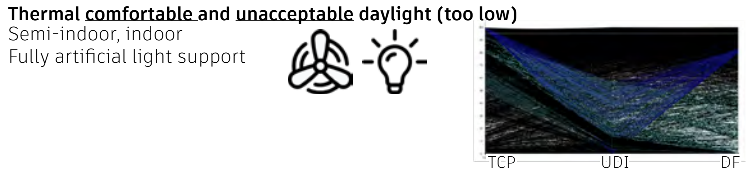


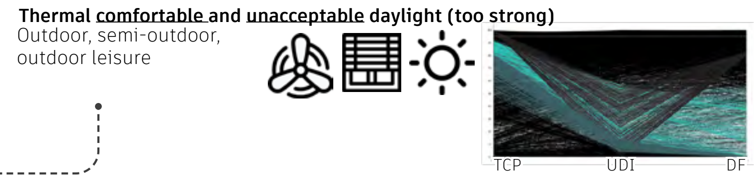












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The view of main hall of museum


Main Hall

To amphasize the local environment, the space of museum is opened up and to lead in nature and tropical environment. Also applied climate adaptive design by implated natural ventilation system in the building.

A specific-designed roof with islamic pattern is to cover up the open space.

Enclosed exibition/studios modules are implanted under the roof. Ground floor are the flexible, small unit modules, the upper floors are the larger exibition halls and studios.

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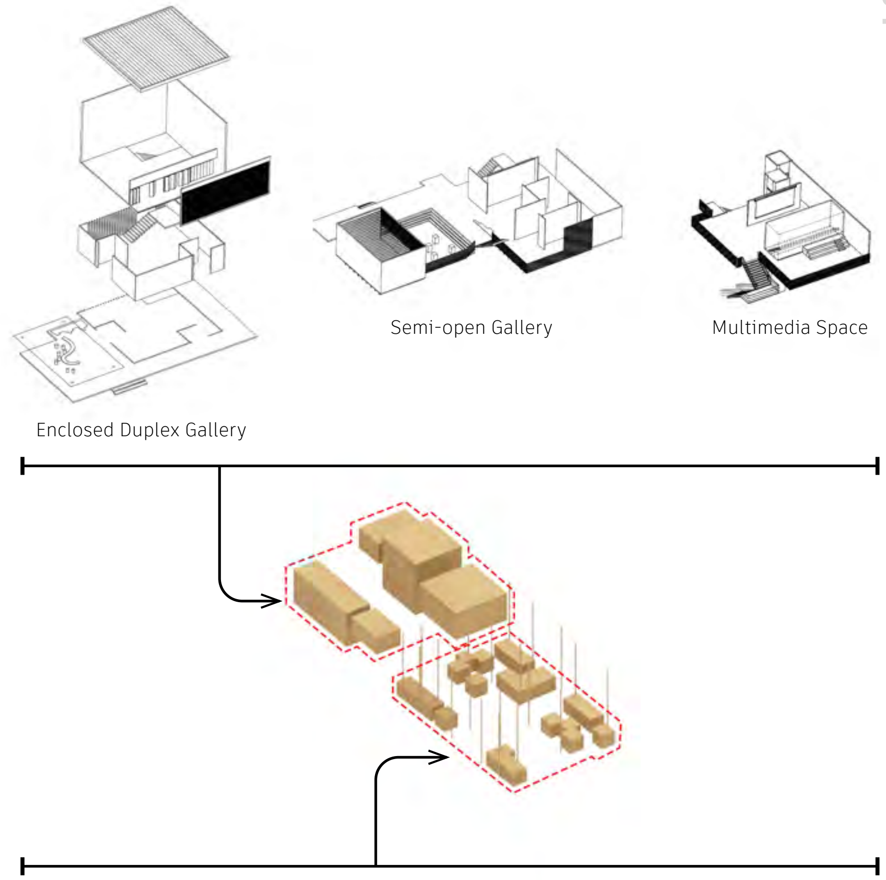


Art Market Entrance

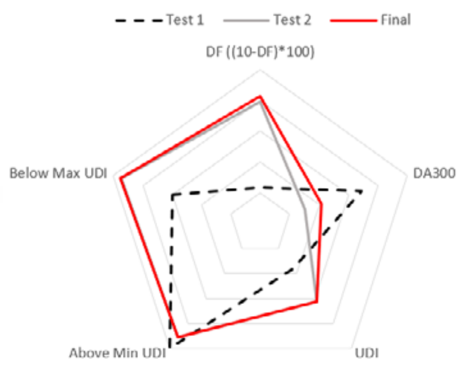

Main Entrance

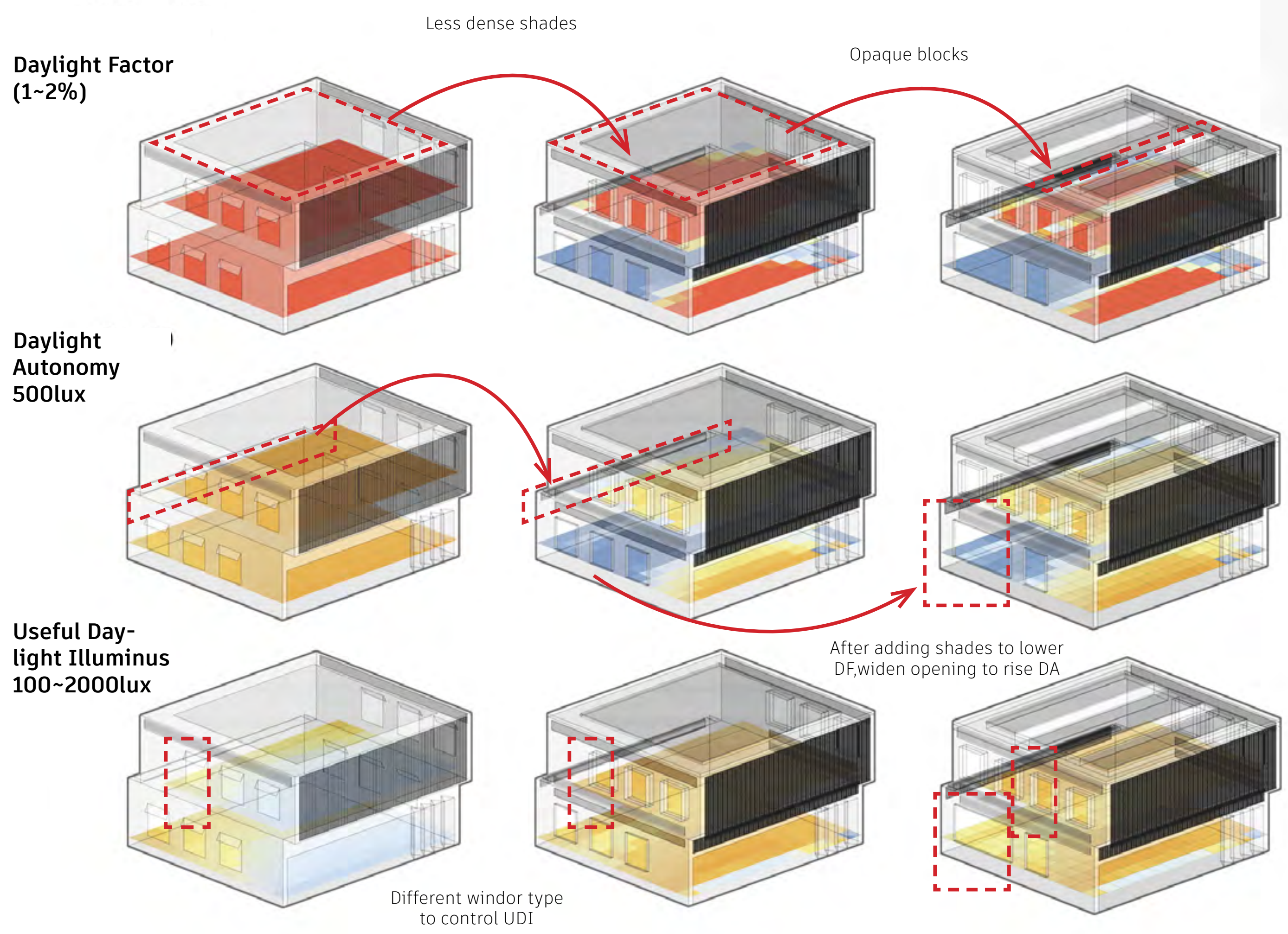
3. Indoor Daylight Simulation and Optimization

Examining daylight quality in one of the semi-indoor areas (core-function box) serves as an illustrative example. This box operates with natural air and occasional air conditioning based on the time of day.

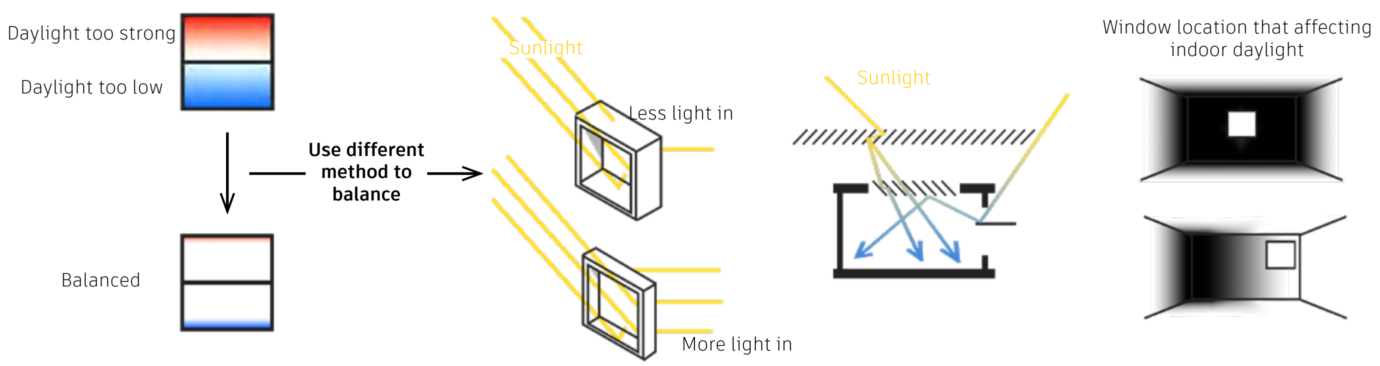
In our simulation, we used Daylight Factor (DF), Daylight Autonomy (DA), and Useful Daylight Illuminance (UDI) as indicators to enhance the lighting design. Given Malaysia's abundant sunlight, we set a 500 lux threshold (DA500). Effective Natural Illuminance Levels (UDI in lux), representing comfortable indoor lighting, fell within 100-2000 lux per the Malaysian standard MS2680. MS2680-2017 mandates a daylight factor for living spaces not below 2%.

Ultimately, adjusting roof shades, window types, depth, window-to-floor ratio, and placement increased effective DF from 23.4 to 82.5, reduced DA from 68.76 to 41.8, and improved UDI from 36.27 to 62.2. In inadequately lit areas, electrical lighting supplemented the design.

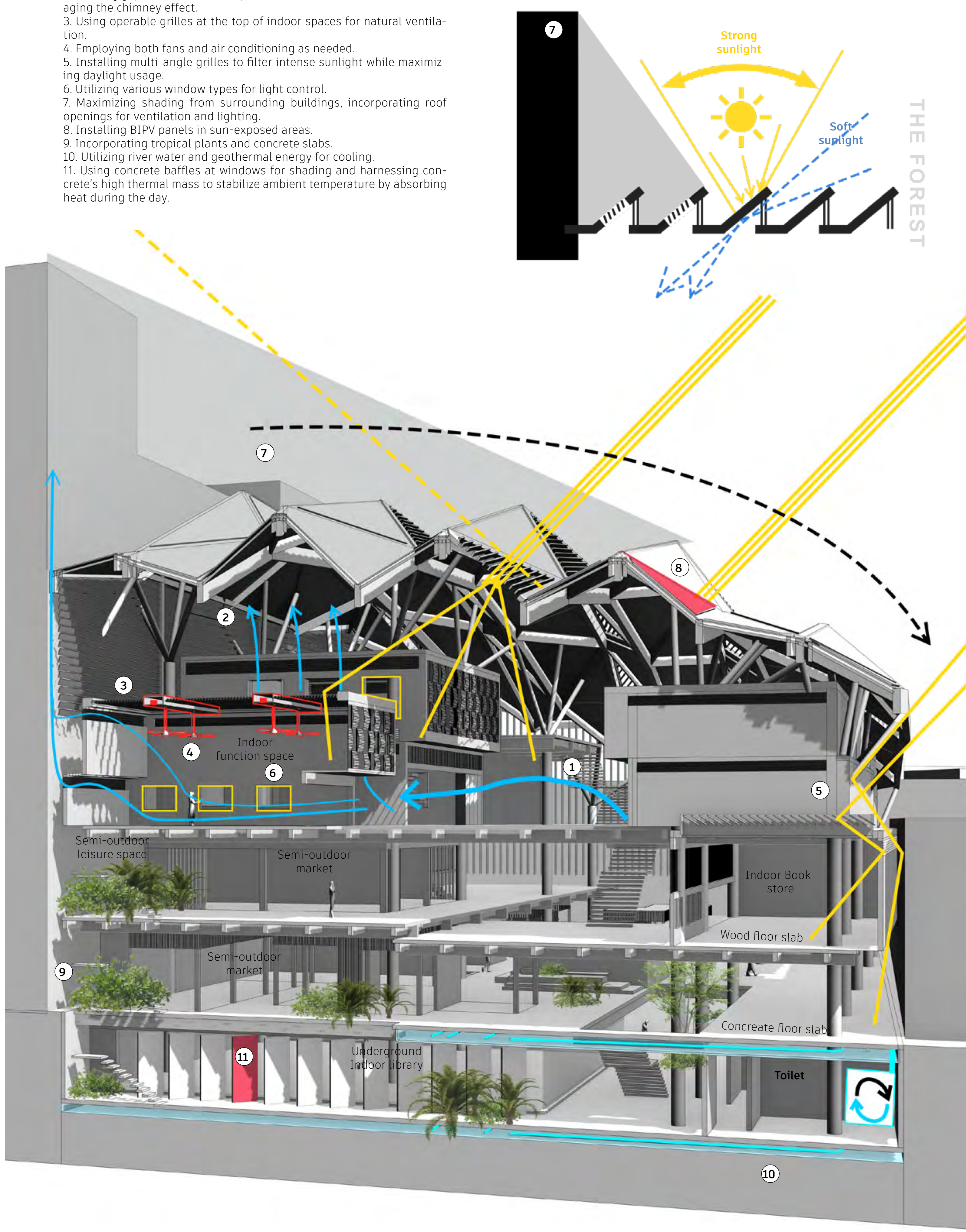




Strategies:



1. Implementing a well-ventilated atrium with full height.
2. Creating gaps between indoor spaces for efficient air circulation, leveraging the chimney effect.
3. Using operable grilles at the top of indoor spaces for natural ventilation.
4. Employing both fans and air conditioning as needed.
5. Installing multi-angle grilles to filter intense sunlight while maximizing daylight usage.
6. Utilizing various window types for light control.
7. Maximizing shading from surrounding buildings, incorporating roof openings for ventilation and lighting.
8. Installing BIPV panels in sun-exposed areas.
9. Incorporating tropical plants and concrete slabs.
10. Utilizing river water and geothermal energy for cooling.
11. Using concrete baffles at windows for shading and harnessing concrete's high thermal mass to stabilize ambient temperature by absorbing heat during the day.

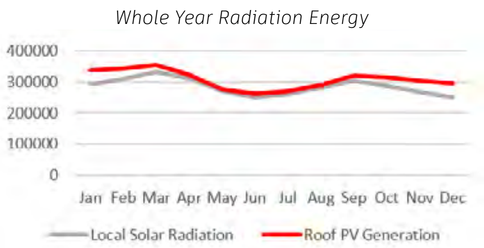


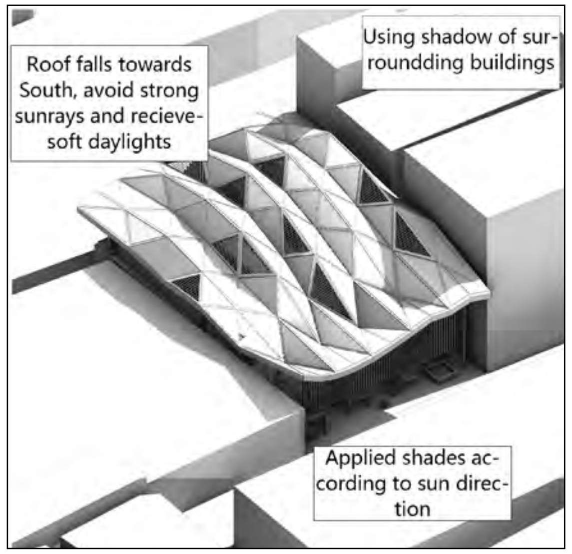
4. Strategy and Evaluate System

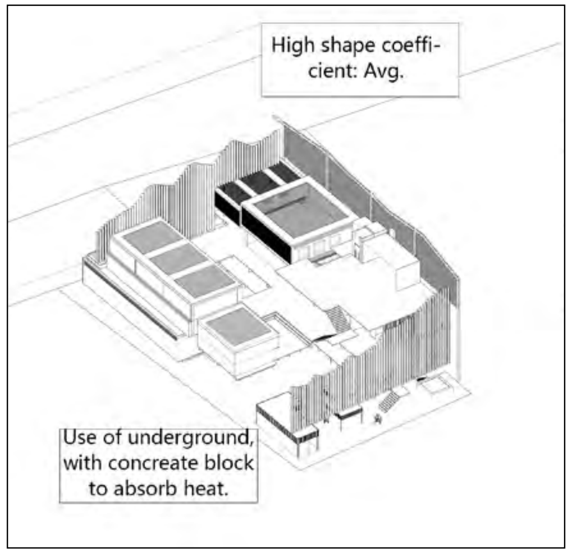
Based on typology of traditional architecture, developed a series of climate adaptive method to apply on "the Forest building", method covered air flow (natural ventilation), daylight usage, water reuse, electricity from solar panel and material selection.

(1) Thermal and Daylight adaptive strategy

Daylight Comfort Strategy: Employing the shadows cast by surrounding buildings, the roof slopes towards the south, mitigating exposure to intense sunlight while welcoming ample daylight. Shades have been strategically applied based on the direction of the sun.
Thermal Comfort Strategy: Embracing a high form factor, we leverage the use of underground spaces with concrete blocks to absorb and manage heat effectively.

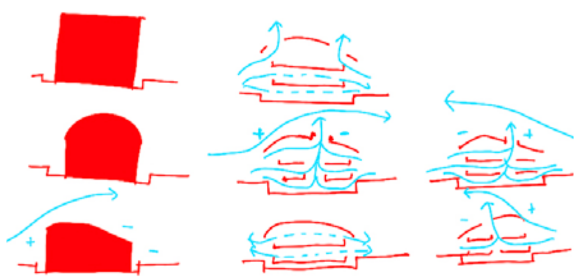


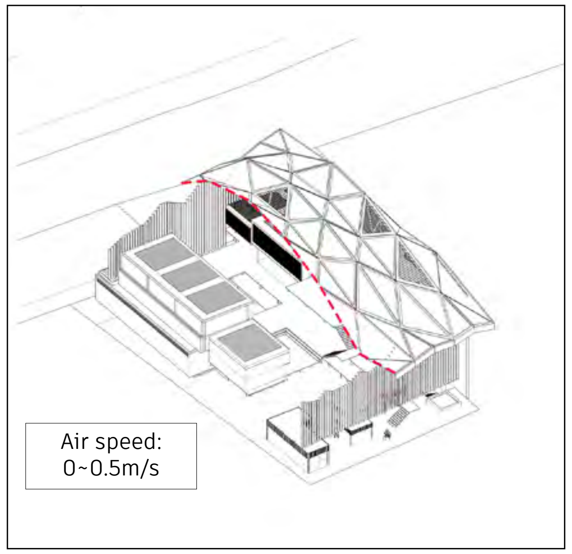




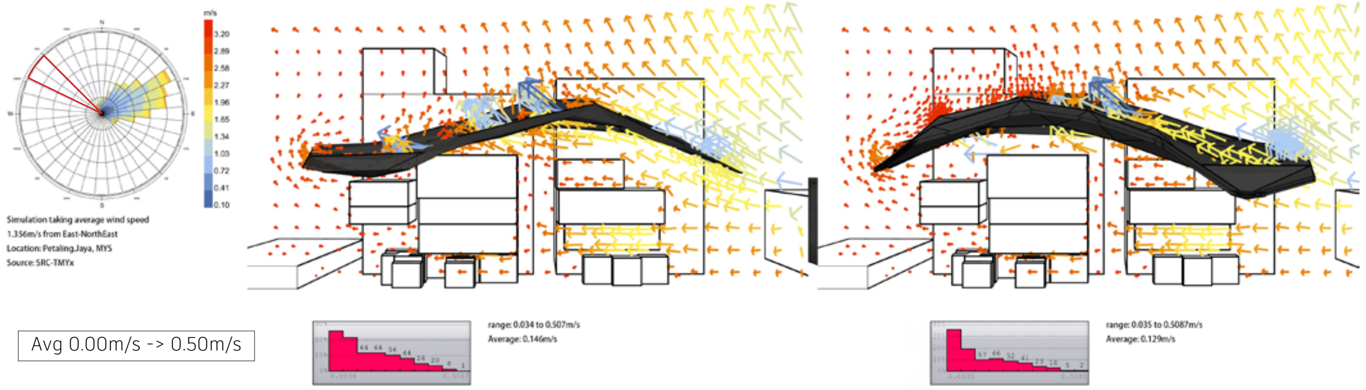
(2) Natural Ventilation

Enhanced form factor coincides with the creation of a central avenue, allowing for cross-ventilation. Gaps are intentionally left between function boxes, with openings at the top facilitating the release of rising hot air, thus generating a chimney effect.





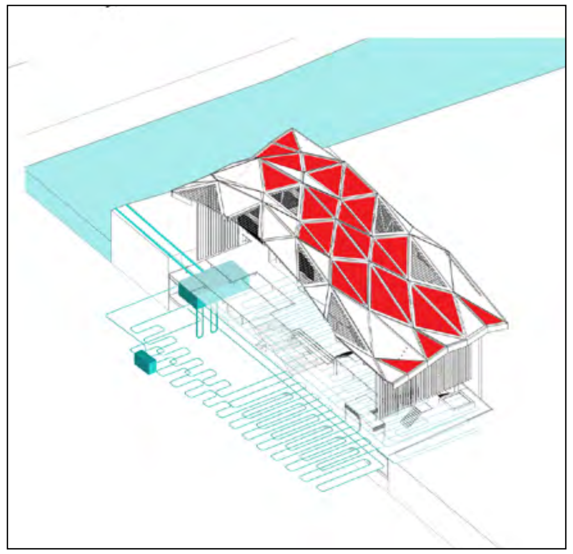
Roof Design : Maximise Air Flow



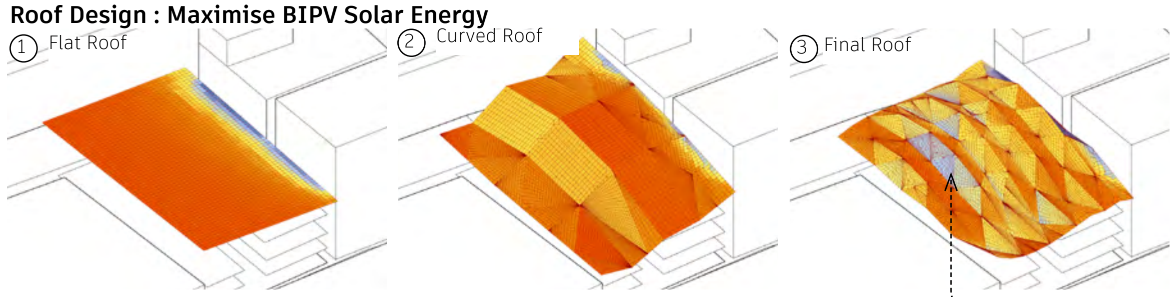
(3) Active strategy of climate adaptive design: BIPV Solar Energy & River water reuse

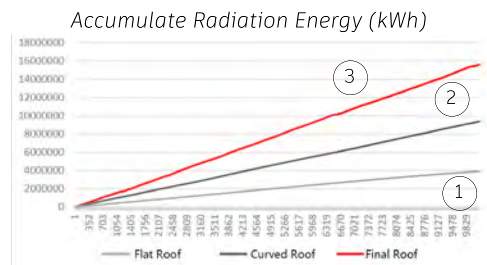
The building making efficient use of natural resources for cooling, shading, and energy generation.
The roof, equipped with BIPV panels, is meticulously designed to maximize radiation absorption while strategically creating openings to allow for ventilation. Through the introduction of river water underground, a cooling system is established, serving as an air conditioning heat sink between the floors.

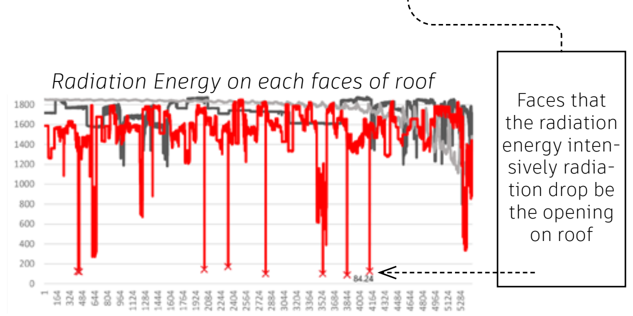
	Area (m2)	Solar irradiance (kWh/sqm/year)	Total radiaton received per year	Annual electricity production (kWh)	Total Price Saved per year
Roof	1699	122705	2804000	420600	RM299,013.05



Roof Design : Maximise BIPV Solar Energy







Cooling system:

Using river water as cooling medium, transfer water to underground to undergo cooling, and transfer it to builing as cooling medium, cooling the air in building.