20.307
Toward Carbon-Neutral Architecture and Urban Design

Lead Instructor

Naree Phinyawatana
Zheng Kai

The course teaches a working understanding of how to design, construct, and operate sustainable architecture and urban design developments and projects toward achieving carbon neutral on all aspects. Students will develop an understanding of a building's relationship to its site's natural systems; the building enclosure's ability to mitigate outdoor conditions; passive systems for conditioning and lighting; mechanical heating, cooling and ventilation strategies; lighting and daylighting opportunities; site and building water cycles; and health and well-being, and advanced building and environmental system simulation through a series of lectures and workshops.

Case studies will be introduced based on the lecture themes. Topics are discussed based on the physical laws that govern the exchange of energy between building and environment and how they relate to human comfort. The ability and confidence in making both quantitative and qualitative statements about building performance will help students in integrating these considerations into their future architecture and urban design work. Ultimately students will be able to understand the impact of their design decisions on building performance to mitigate the carbon footprint.

Workshops throughout the semester will be a series of design exercise and environmental design studies as well as calculations, which will serve as supporting documents for the final carbon-neutral project at the end of the semester.

Learning Objectives

After successful completion of the subject, students will be able to:

- Describe fundamental knowledge and concepts of sustainable design, carbon footprint, carbon emissions, low-carbon design strategies, and zero-carbon design calculations.
- Classify and discuss carbon-neutral architecture and urban design concepts, methods and strategies.
- Assess and criticize the carbon footprint generated through the selection of design strategies, construction materials, and building systems pertaining to carbon-neutral architecture and urban design.
- Illustrate a thorough technical knowledge of carbon-neutral architecture and urban design strategies.
- Select carbon offset strategies based on their consequences related to building energy, comfort and environmental impacts.
- Apply and integrate technical knowledge within designs of carbon-neutral architectural projects.

Measurable Outcomes

Achievement of the Learning Objectives will be measured in terms of the student's ability to:

- Participate in in-class laboratory exercises, design studies, and calculations.
- Complete short homework assignments focused on implementation of topics and methods communicated in lecture classes and laboratory sessions.
- Present selected case studies of real projects through discussion and analytical computational analysis.
- Compare different carbon-neutral architecture and urban design types and strategies using simulation tools to predict thermal comfort, daylight availability, energy consumption, water consumption and reclamation, and embodied energy of materials as part of design homework assignments.
- Design, simulate, analyse, and document a final architecture and urban design project through the application of quantitative measures such as environmental performance simulations, water use, and embodied energy accounting that were learned through homework assignments mentioned in the previous MO.
- Produce a written report documenting the features and analysis of a final carbon-neutral architecture and urban design project.

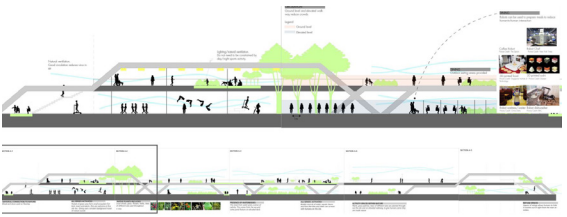
2020 - Smart City and Pandemic Ready

Because of the recent COVID-19 pandemic, the course content expands to cover design strategies to serve as preventative measures against COVID-19 as well as to focus on Singapore Smart Nation initiatives. With these two special topics, selected case studies have been chosen to represent exemplar innovative developments around the world including Jurong Lake Garden (Singapore), Woven City (Japan), Hudson Yard (USA) and Barangaroo (Australia).

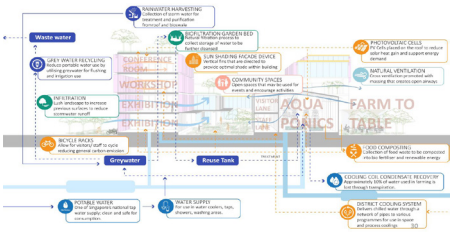
Final Project

The final projects demonstrate all key sustainability strategies that students have been learning throughout the semester. For this year, students work in groups on four separate sites in Singapore. Each site will be the upcoming innovative and smart districts to support the course focus on Smart City and Pandemic Ready.

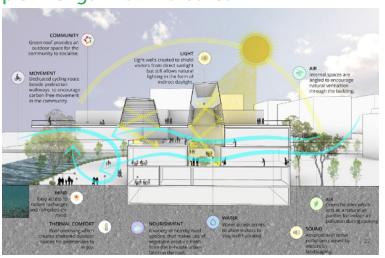
Group 1 - Punggol Digital District

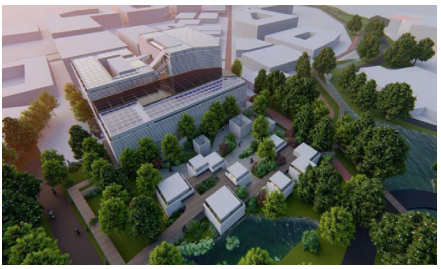


Group 2 - Sungei Kadut District



Group 3 - Tengah Town District





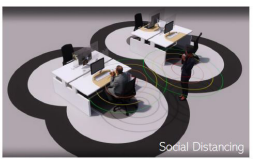
Group 4 - Jurong Innovation District

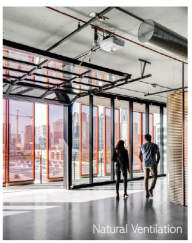
The course also includes a simple exercise for students to think creatively on pragmatic strategies to be incorporated to be ready for future pandemic events through various programs including office, supermarket, school and shopping mall. The submissions demonstrate on students' understanding of the past norm, present (COVID-19) norm, and the soon new norm that we will have to adapt and adjust our lives to the post COVID-19 environment.

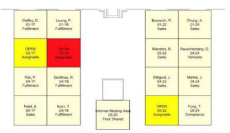
2025

Spaces:
- Designated isolation rooms
- Natural ventilation
- Reconfigurable flexible spaces
- Shift in circulation and program arrangement
- Hygiene stations
- 'Contactless' devices
- Incorporate elements from hospital design

Actions:
- Seat tracking
- Identify essential workers
- Rethink density to prioritize physical distancing
- Video conferencing
- Practice good hygiene







2025 Supermarket

Team Members :

Ho Zhi Yuan	1002404
Wong Shu Miin Naomi	1003109
Tan Shao Xuan	1002054
Sally Tan Jie Ying	1002389
Xiao Yiming	1002256
Zhu Wentao	1002356

Supermarket Layout

Beyond displaying and selling packaged food, supermarkets will start investing in on-site food production. These indoor farms will be displayed in supermarkets to give shoppers a better understanding of where their food comes from. Interactive screens will also allow customers to check and compare the nutritional value, the carbon footprint etc. of their food while they browse the aisles.

Food Demand

People are more concerned about their food safety and health. Organic food items as well as plant-based foods have grown in popularity as they are deemed. Consumers are also looking into options of having their produced grown in their own homes, where they know what goes into what they eat.

Human traffic

Supermarkets are tailored for purchasing of only perishable products for shoppers to visit and purchase, while other products are typically ordered online and delivered directly to houses. As such, there is a significant decrease in number of typical customers. Instead, people look to delivery services for such purchases, thus the majority of people visiting supermarkets are delivery personnel.

Operation Model

Priority Shopping Hours will continue. Some supermarkets may convert into self-pick-up for customers or collaborate with other merchant for online delivery.

Online Grocery

Supermarket will be transformed into warehouse setting. Contactless delivery for all grocery shopping with the help of autonomous vehicles.

2025: The post COVID-19 situation will see a rise in implementation of technology and robots to redefine the shopping experience for consumers such that social interactions can be safe.

Elevator - non-contact lift buttons.

Shopping - avatars for virtual shopping.

Maintenance - autonomous disinfection robots.

Restaurants - social distancing pod for dining-in.

Entrances - sanitizer tunnel.

Punggol Digital District - Redefining Retail

Punggol Digital District is a 50ha masterplan located in the north of Punggol and is planned to be the next generation smart and integrated digital district. This group focuses on "Redefining Retail" for this innovative district of Singapore. The project proposal comprises of retail, digital platform and active outdoor areas.

The current retail scene of Singapore consists of large air conditioned shopping malls with mainly physical retail spaces and services. More than just having retail spaces, the project creates an enhanced retail experience of the future that focuses on incorporating the digital and outdoor aspect to retail. Additionally, this new retail prototype experience will be fully functioned as an open outdoor park along the waterfront of Punggol Digital District. All activities will be connected in a single mobile app.

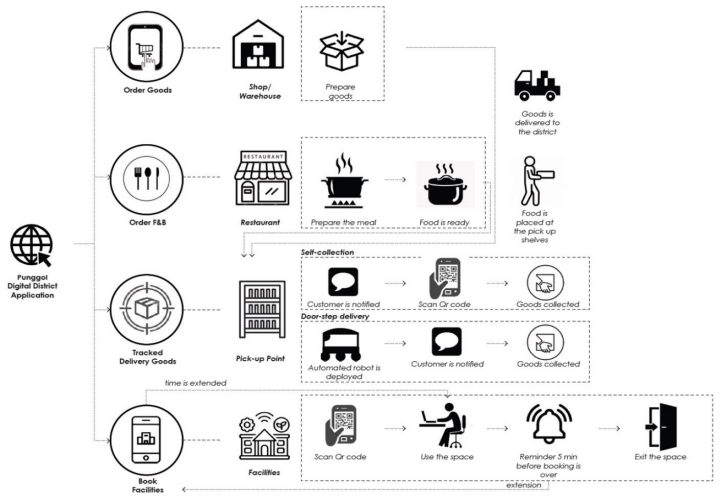
Students

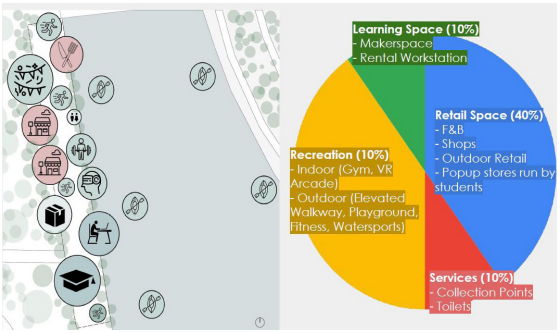
Toh Sing Ru
Ong Li Wen Anjelica
Fang Zixin
Kyaw Htet Paing
Clarissa Maharani Hartanto
Samanta Tang

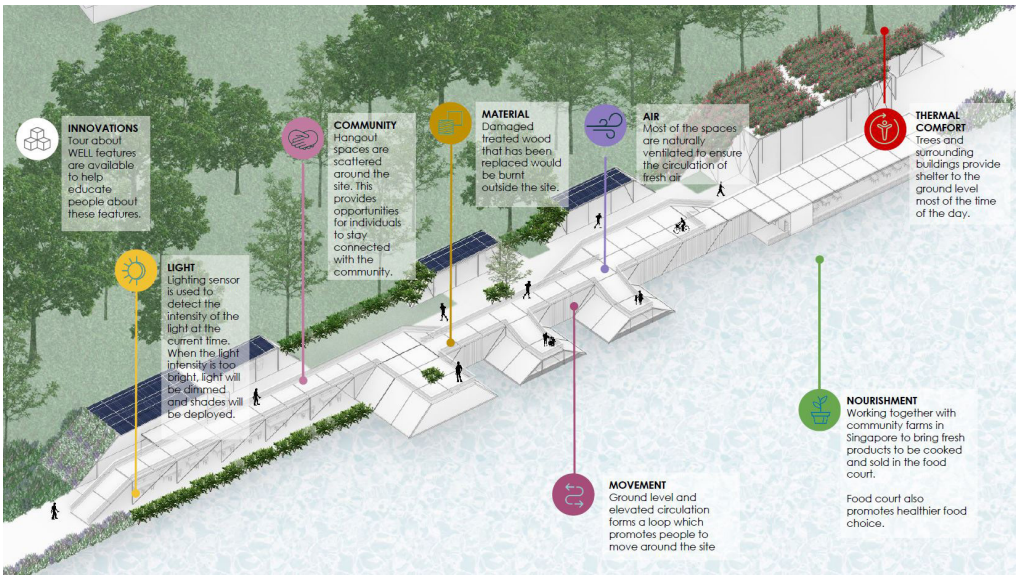
PROGRAM DETAILS

PROGRAM ZONING
The site is loosely divided into three main zones: 1. work/learn zone will be nearer to the SIT and JTC campus and consists of the learning 2. play zone consisting of retail and recreation zone (play) 3. live zone for events and retail

DIGITALLY-CONNECTED PROGRAMS ON SITE
In line with the masterplan for the site to be a smart and integrated digital district, we hoped to focus on the digital aspect of our site by connecting all the programs within a single mobile application, the Punggol Digital District App.

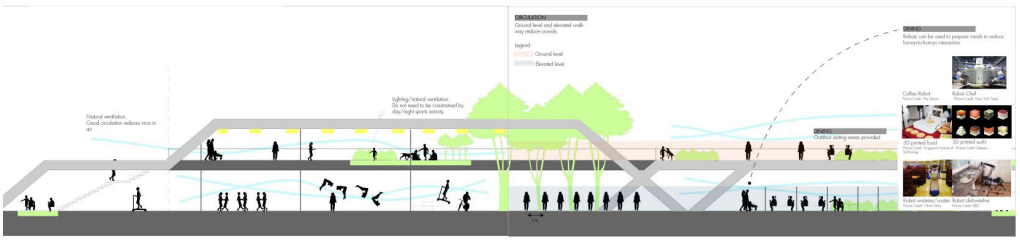


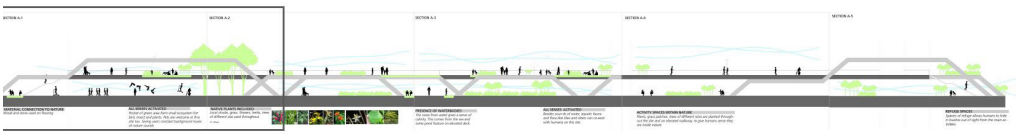




PANDEMIC: COVID Ready

In the light of COVID, the project looks at several measures in which measures could be implemented in times of pandemic.





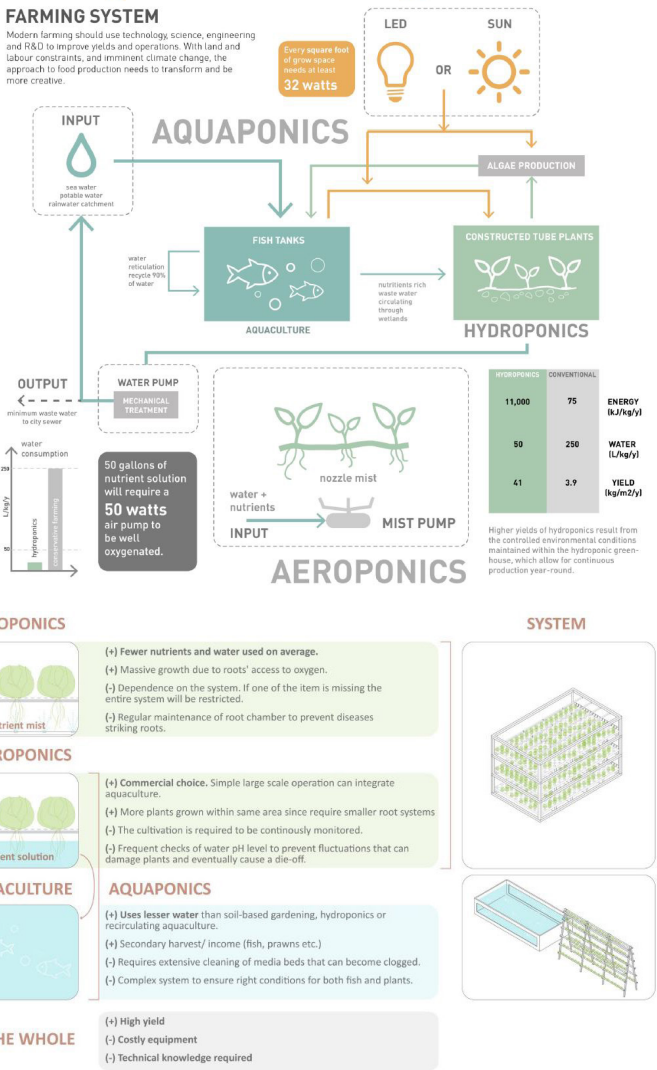
Sungei Kadut District - The Future of Food

Sungei Kadut District will be transformed into an eco-district that embodies the concept of live, work and play. The district will welcome new growth industries such as agri-tech to seize new economic opportunities.

This group develops a mixed use development that will support the goal "30 by 30 - 30% of home-grown food goal by 2030." The project has a vision to provide food for 200 people daily on-site with urban farming and R&D labs as well as education facilities and exhibit spaces for showcasing innovative farming techniques.

Specialty Program Background

High Density Vertical Farming

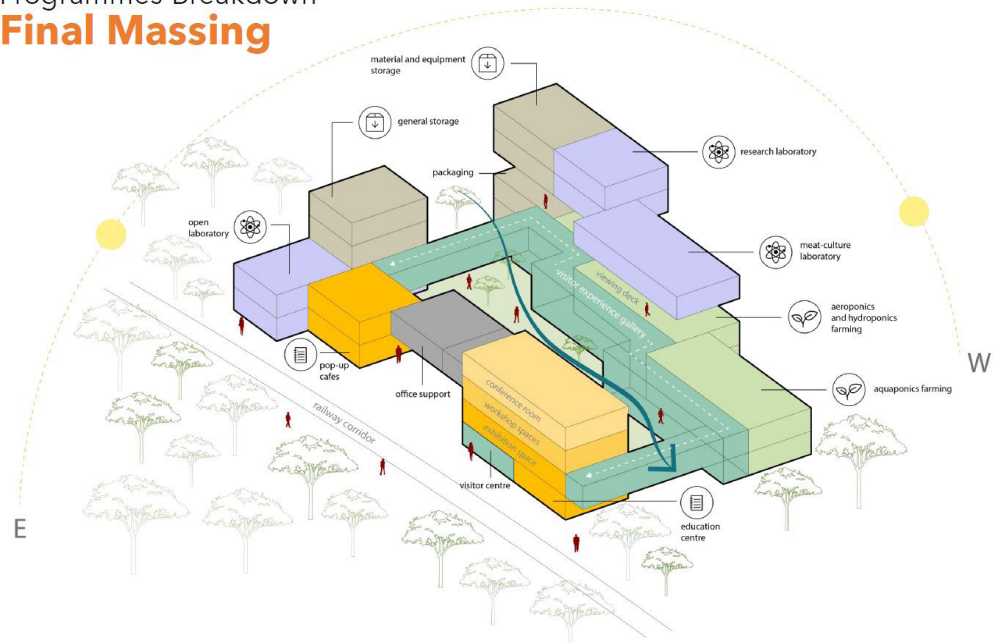


Students

Jennifer Gautama
Lim Hui Yee
Tan Zhi Wei
Michelle Gouw
Lim Jin-En Clarissa

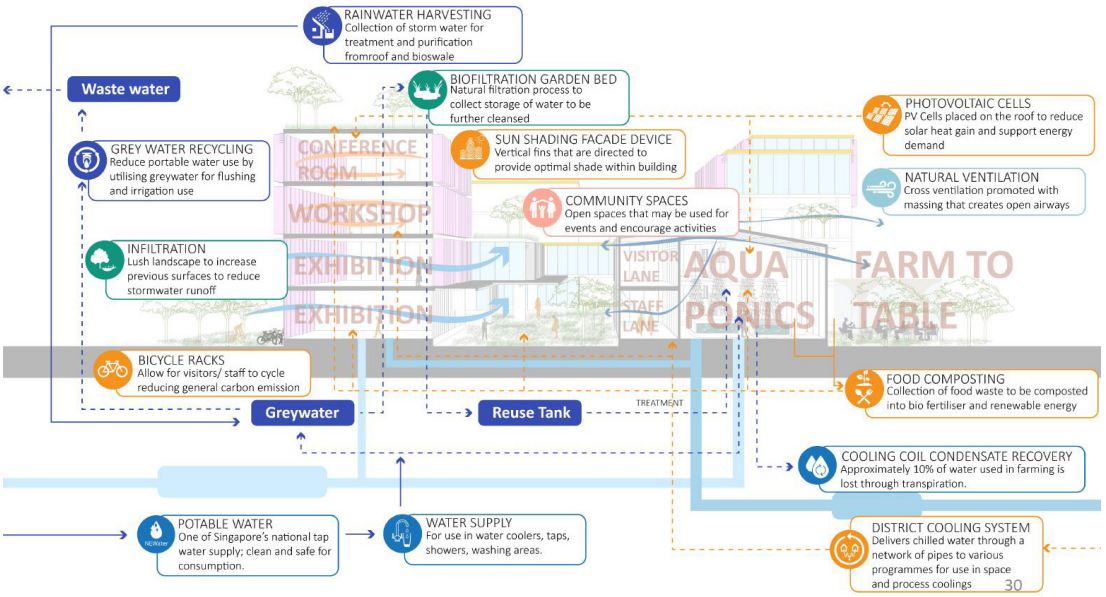
Programmes Breakdown

Final Massing



Eco Systems

Overall



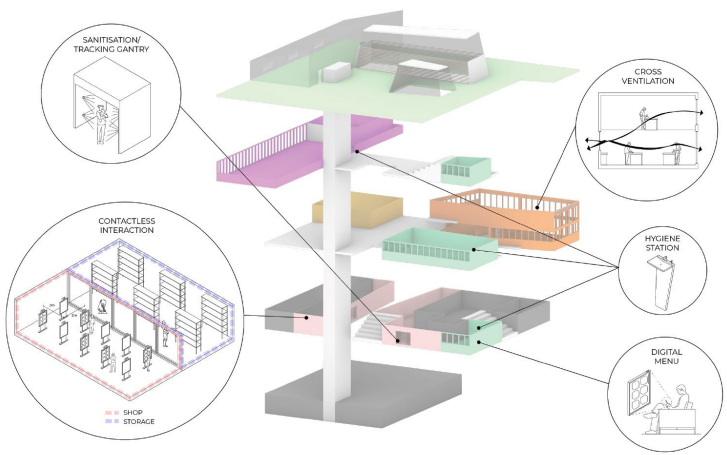
Tengah District - SuperCC

Tengah District will be Singapore's first smart and sustainable next-generation HDB town, with green features and smart technologies. The development of Tengah will provide new homes and workspaces in the Western region of Singapore and compliment Jurong Innovation District.

This group develops a mixed use development that will support the goal "30 by 30 - 30% of home-grown food goal by 2030." The project has a vision to provide food for 200 people daily on-site with urban farming and R&D labs as well as education facilities and exhibit spaces for showcasing innovative farming

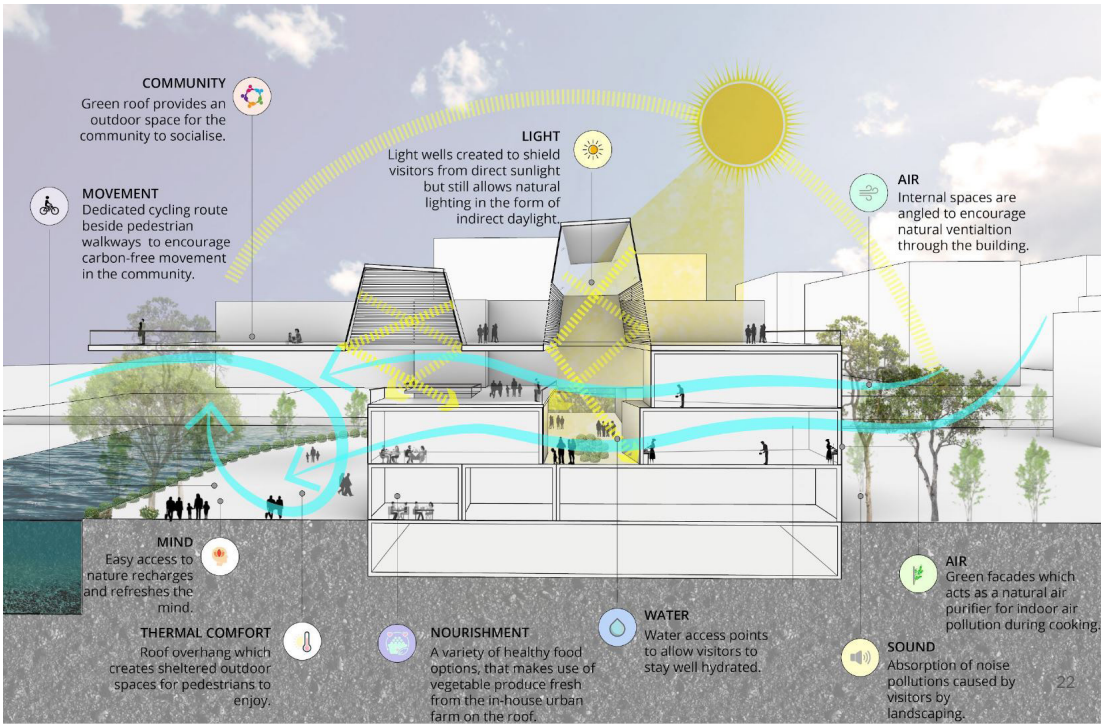
Programmes: Complementing Residential Living

Pandemic Mitigation Strategy



Students

Lim Xin Yan
Chin Kee Ting
Jane Cher
Song Tingxuan
Goh Min Rui
Anirudh Rathi


COMMUNITY
Green roof provides an outdoor space for the community to socialise.
MOVEMENT
Dedicated cycling route beside pedestrian walkways to encourage carbon-free movement in the community.
LIGHT
Light wells created to shield visitors from direct sunlight but still allows natural lighting in the form of indirect daylight.
AIR
Internal spaces are angled to encourage natural ventialtion through the building.
MIND
Easy access to nature recharges and refreshes the mind.
THERMAL COMFORT
Roof overhang which creates sheltered outdoor spaces for pedestrians to enjoy.
NOURISHMENT
A variety of healthy food options, that makes use of vegetable produce fresh from the in-house urban farm on the roof.
WATER
Water access points to allow visitors to stay well hydrated.
AIR
Green facades which acts as a natural air purifier for indoor air pollution during cooking.
SOUND
Absorption of noise pollutions caused by visitors by landscaping.
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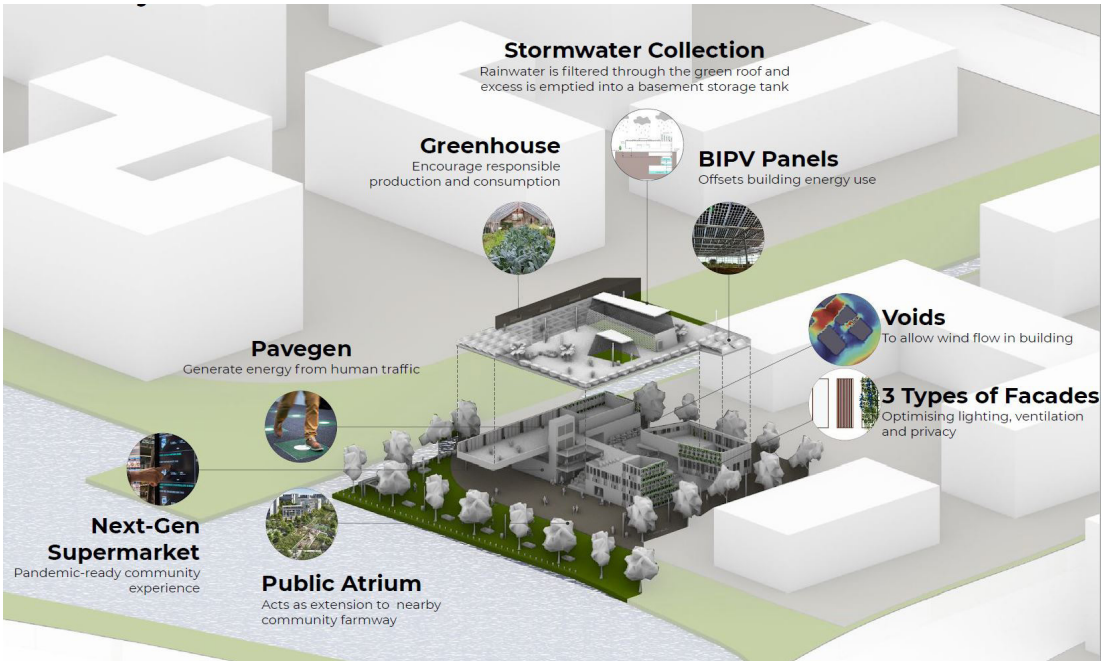

Stormwater Collection
Rainwater is filtered through the green roof and excess is emptied into a basement storage tank
Greenhouse
Encourage responsible production and consumption
BIPV Panels
Offsets building energy use
Voids
To allow wind flow in building
3 Types of Facades
Optimising lighting, ventilation and privacy
Pavegen
Generate energy from human traffic
Next-Gen Supermarket
Pandemic-ready community experience
Public Atrium
Acts as extension to nearby community farmway

Jurong Innovation District - SERIS Campus

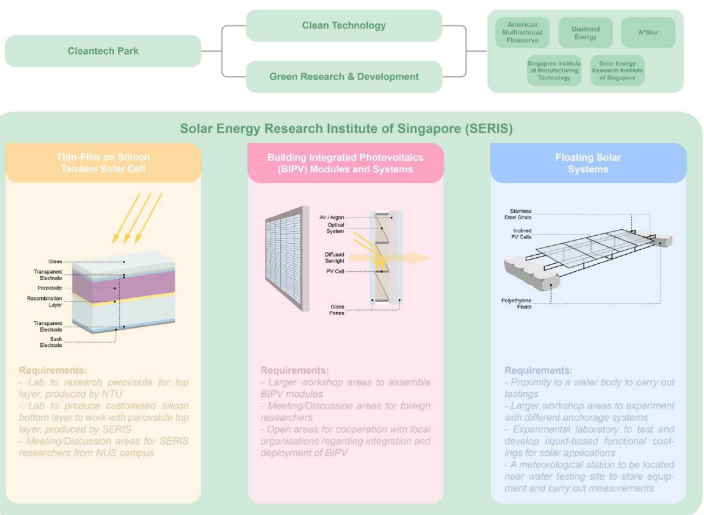
Jurong Innovation District will be a vibrant ecosystem for advanced manufacturing, livable and sustainable industrial district of the future. It will also be a home to thriving industry-academia collaborations that will lead new paradigm for manufacturing and R&D programs.

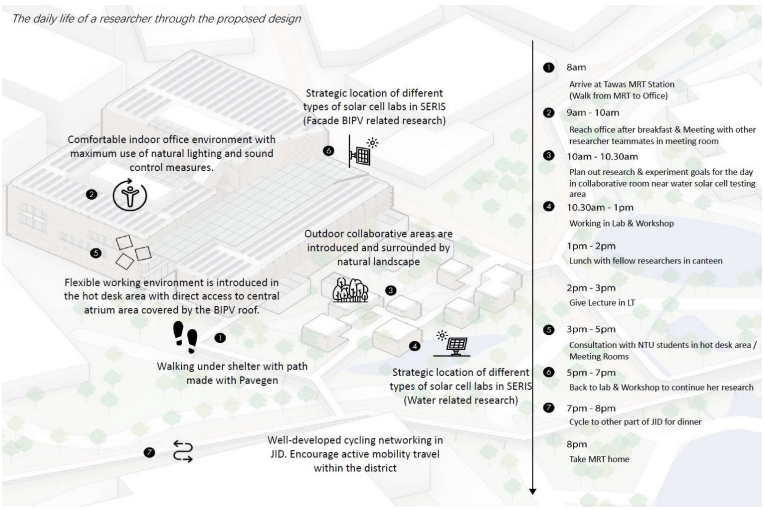
This group designs the project for a selected client "SERIS - Solar Energy Research Institute of Singapore" who has been the innovative leader in R&D on solar cell technologies. The program comprises of office, R&D, labs and workshop areas. Various in-development technologies has been implemented on the project as a test bed for SERIS.

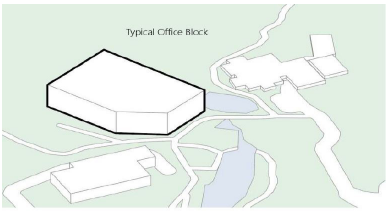
Students

Ho Zhi Yuan
Wong Shu Min Naomi
Tan Shao Xuan
Zhu Wentao
Sally Tan Jie Ying
Xiao Yiming

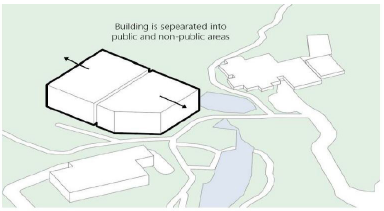
Targeted Site & Tenant



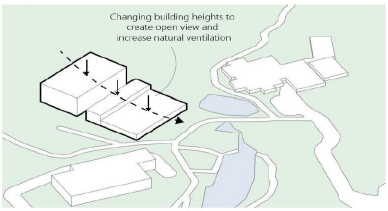




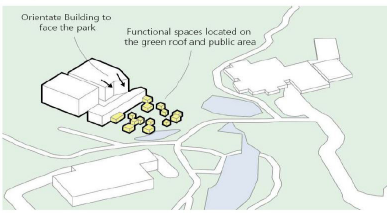
Step 1



Step 2



Step 3



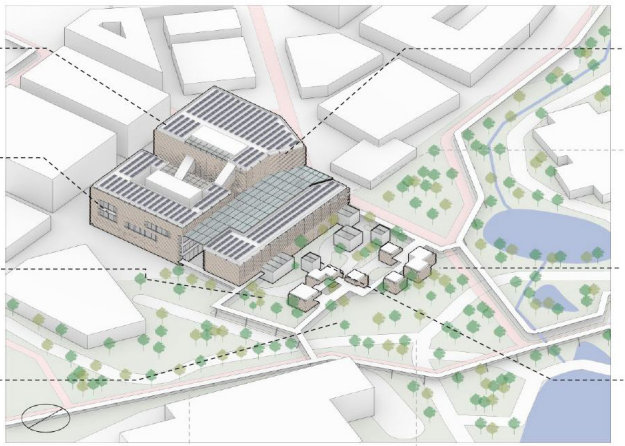
Step 4

Renewable Energy
Strong emphasis on the use of solar cell technologies

Smart Operation
Smart lighting Control

Urban Harmony
High Green Ratio & The integration between greenery & workspace

Social Benefit
Creating privately owned public spaces (POPS) within an office building



Daylight Control
Indoor daylight control via façade design

Food Preparation
Wide range of healthy food choices available in the F&B Area

Access to nature
Seamless connection to Jurong Eco Park

Community Access & Engagement
Collaborative spaces, atrium space & courtyard are provided for gathering

Active Commuter

Site Planning & Selection

Maximize the use of natural lighting within the building

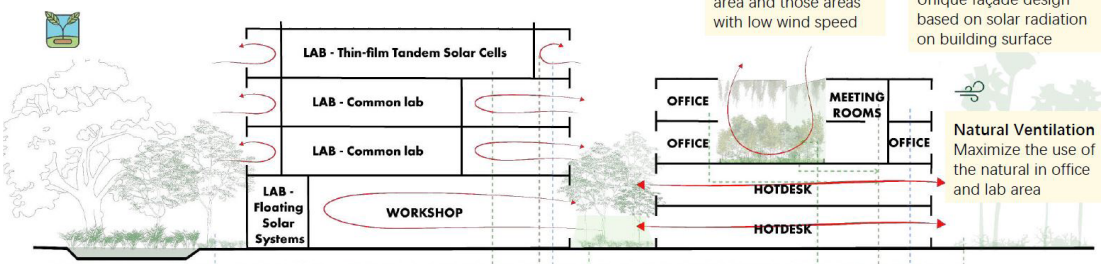
Community Garden
Providing different types of the communal space in office and collaborative space

Solar Energy (SERIS)
Implementation of different types of solar energy. This building serves as a test bed for SERIS solar cell research

Urban Green
Forming green connection to Jurong Eco Park and creating new office environment in a natural environment

Ventilation System
Mixed ventilation systems has implemented to lab area and those areas with low wind speed

Sun shading Façade Design
Unique façade design based on solar radiation on building surface



Natural Ventilation
Maximize the use of the natural in office and lab area

Water Recycling System
Collection of rainwater for greenery.