# Building Simulation 2023 Student competition

Xin ZHOU
Southeast University, China

2023/02/08

IBPSA-China Tongji University Tsinghua University

# BS 2023 Student competition

## Simulation, design and optimization of a nearly net zero carbon emission building

**Modelling competition panel**

**(in alphabetic order)**

Mary Myla Andamon

Eleonora Brembilla

Francesca Cappelletti

Christina Hopfe

Jianlin LIU

Wei TIAN

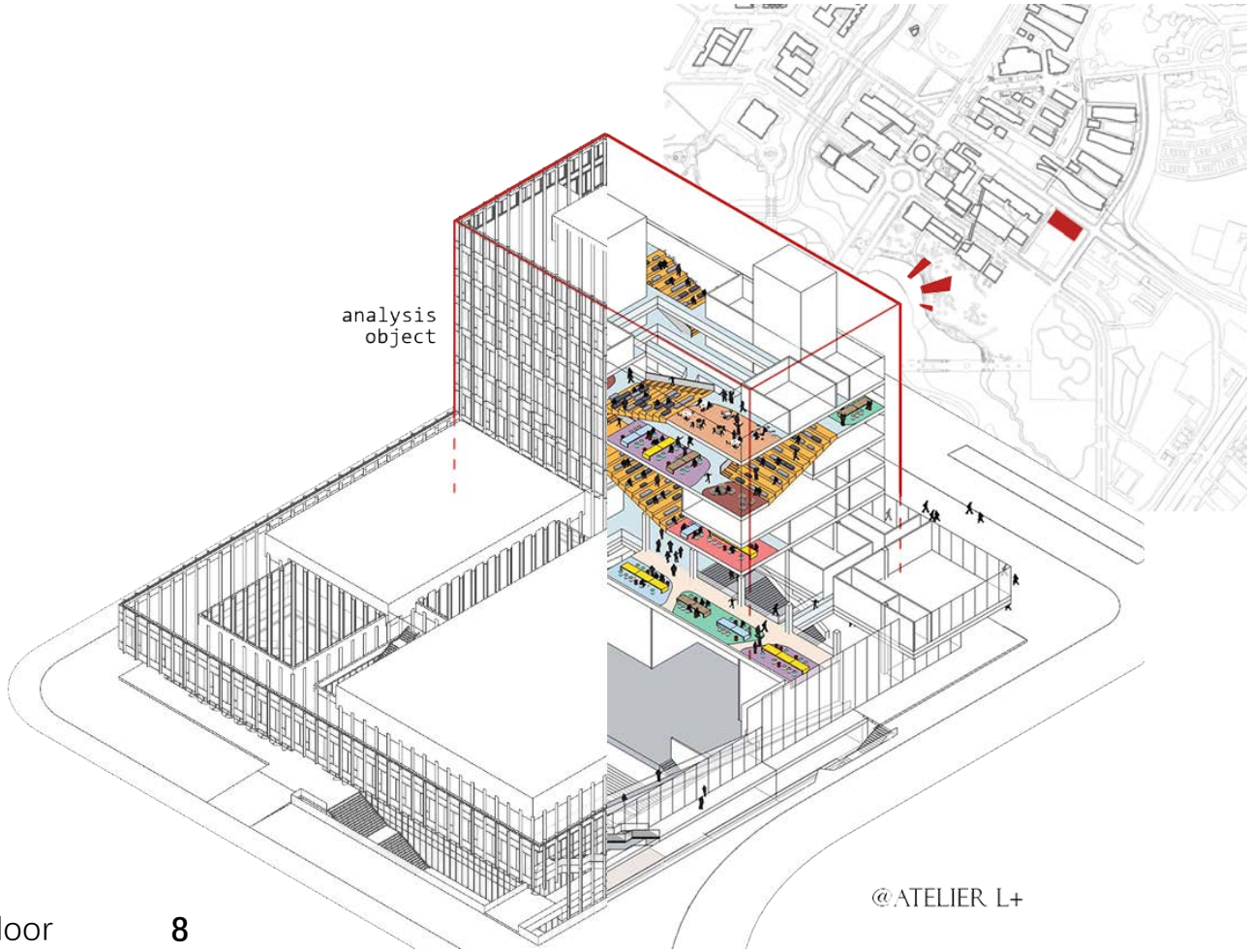
Zhun YU

Xin ZHOU

Detailed Information:https://bs2023.org/competition

# 01 Tasks

https://bs2023.org/competition




Floor 8
Latitude N **31.284°**
Longitude E **121.217°**
Azimuth **35.18°**

Student Activity Center
Jiading campus, Tongji University

For this year's competition, the aim of this exercise is to use computer simulation to **design and optimize a nearly net zero carbon emission building**

**NOTICE:**

- **Only the carbon in the operation phase**

√


- **Only electric equipment is allowed in this building**

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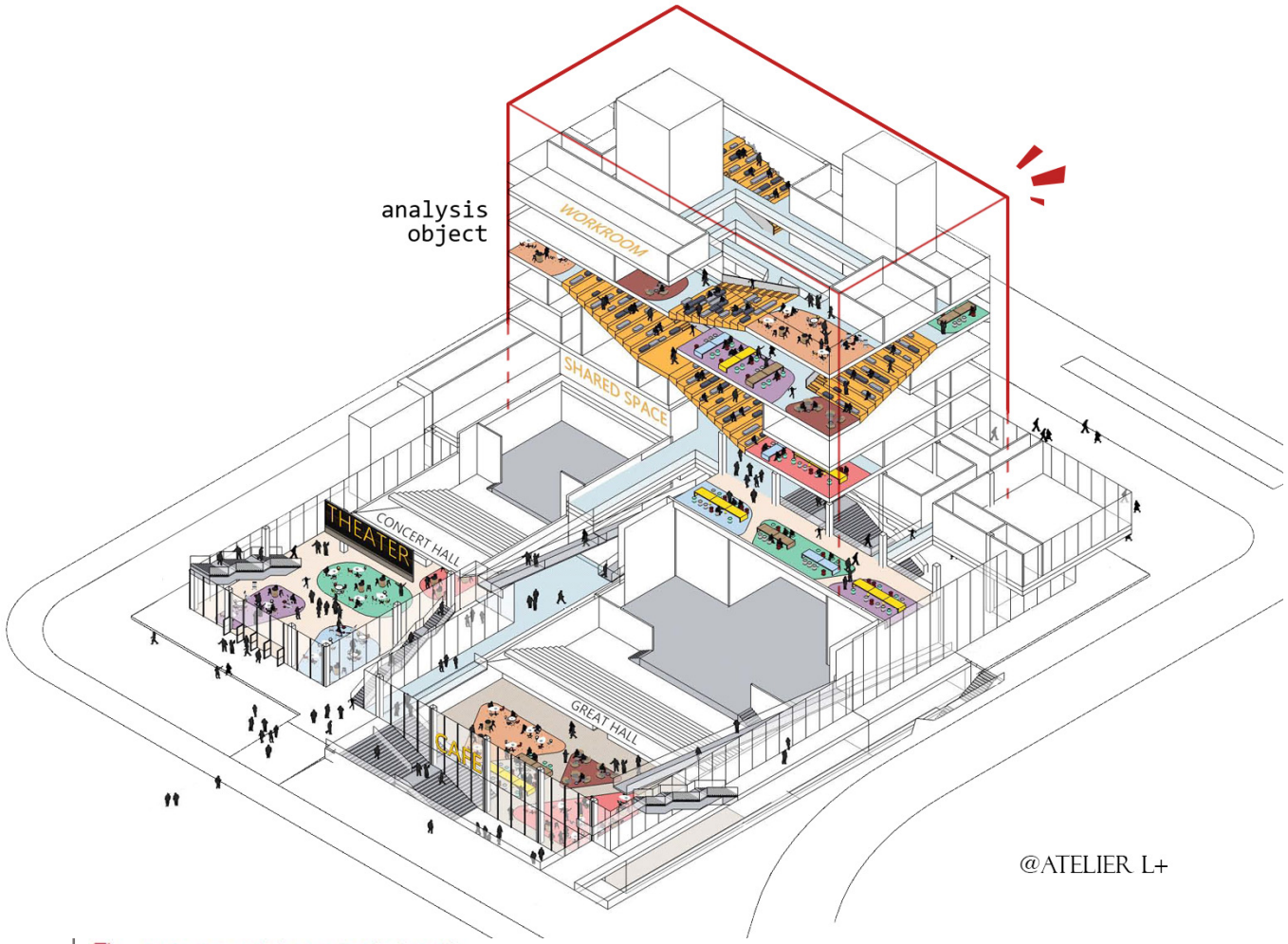
# 01 Tasks




DOCUMENT

- Competition_brief.pdf
- Building_floorplan.dwg (AC2018)
- CHN_SH_Shanghai.583620_CSWD.zip

Entrants are expected to assess the carbon emissions of the building during the operation, by means of appropriate models and metrics and to apply strategies to minimize carbon emission caused by cooling, heating, lighting and plug load, whilst providing comfortable conditions.

For carbon reduction:

**Active measures**

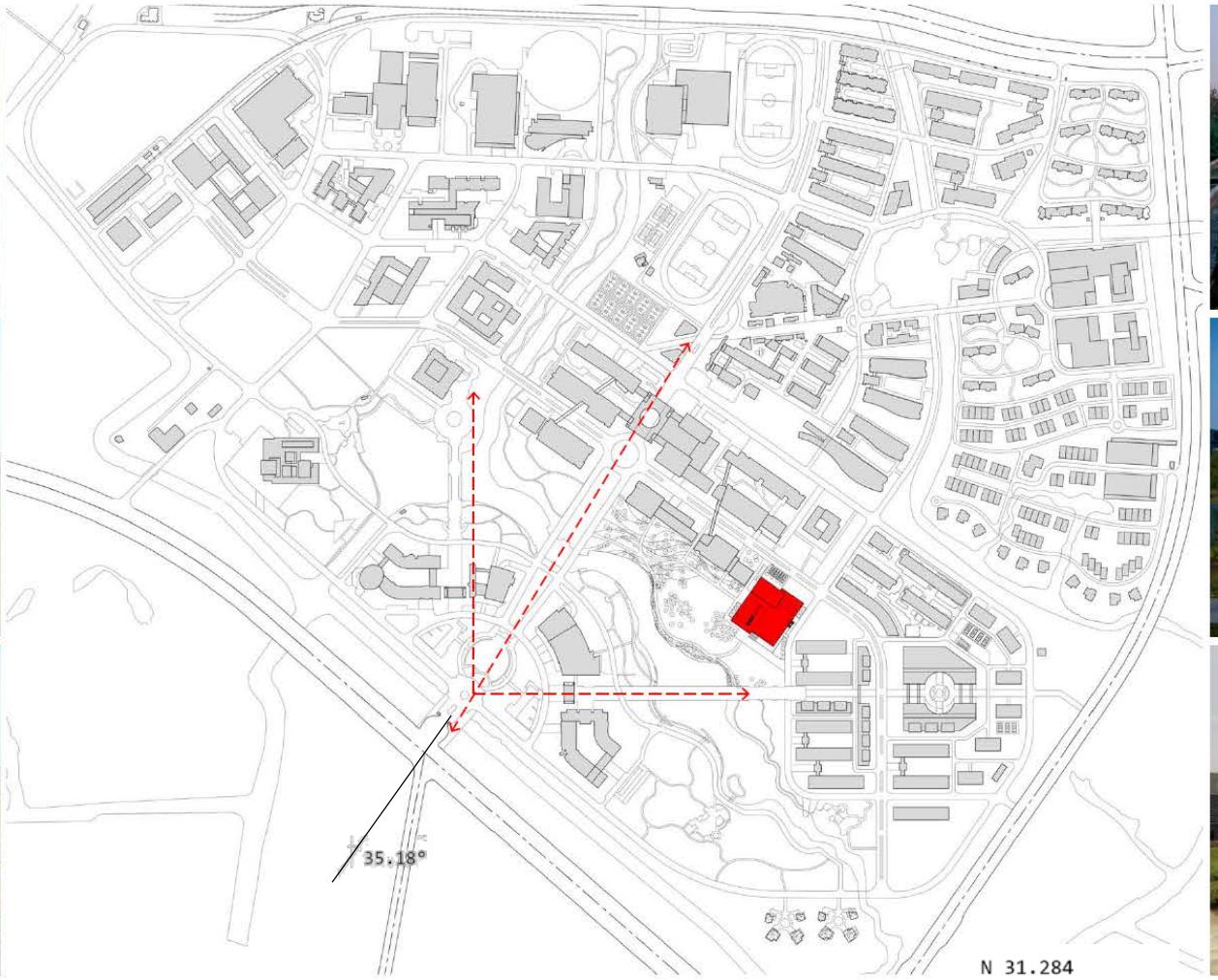
- photovoltaic
- battery storage
- charging pile
- ice storage
- ……

**Passive measures**

- fluctuating room temperature
- thermal storage in walls
- controllable lighting
- other demand side management

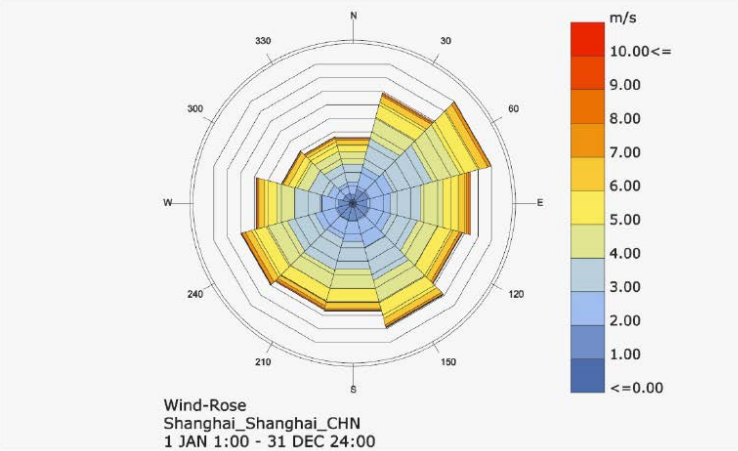
# building for analysis

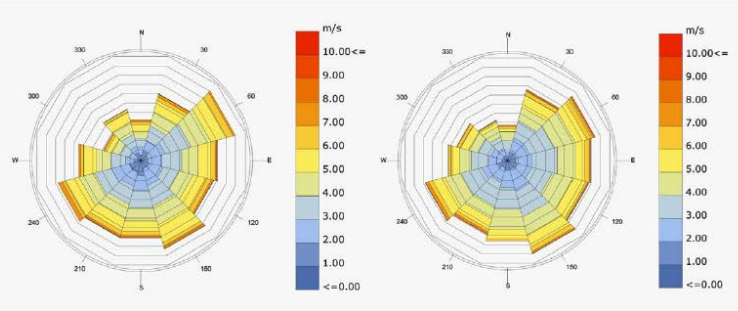




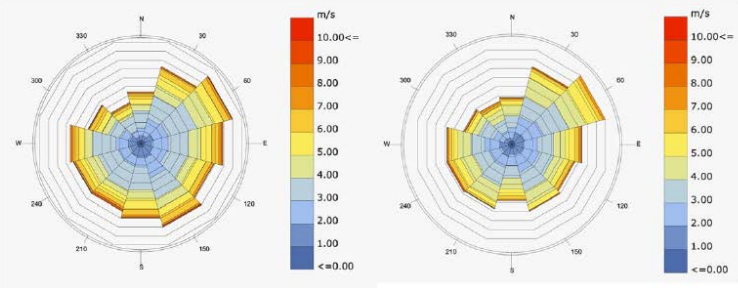

# 02 building for analysis

Shanghai meteorological data



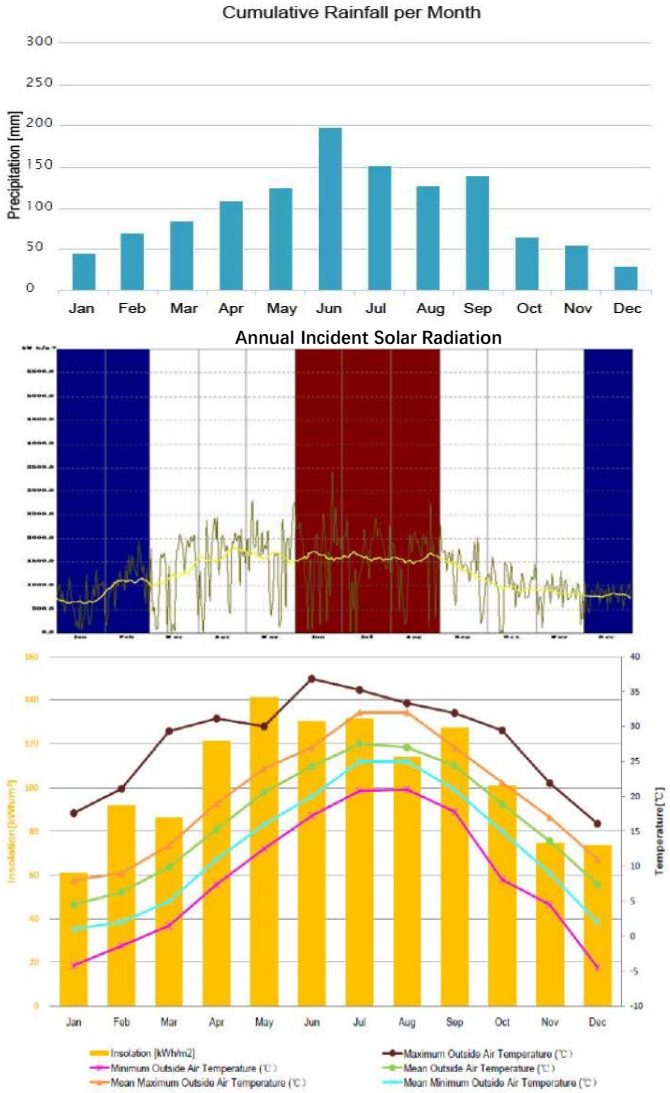



Spring Summer



Autumn Winter

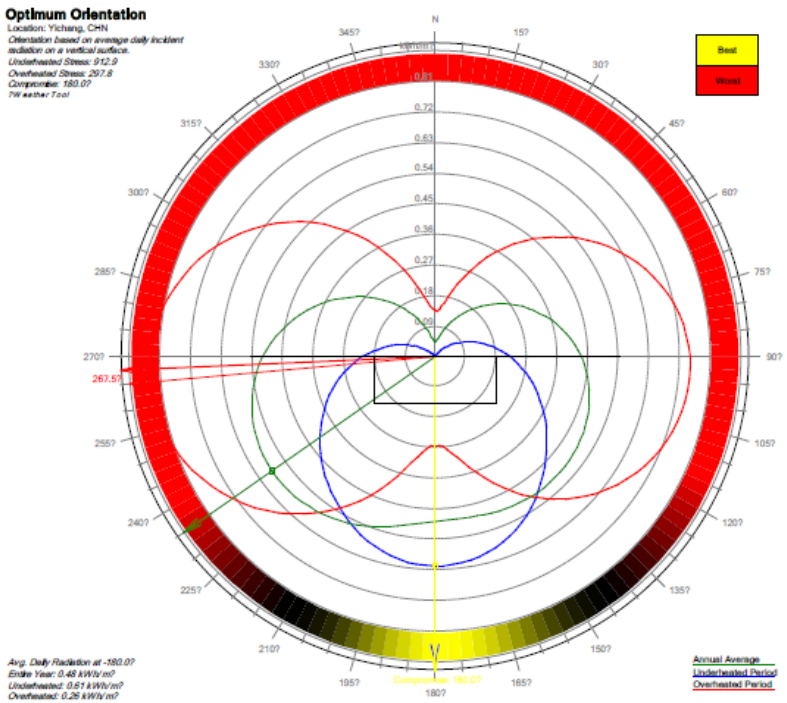
Natural ventilation design in transition seasons to optimize the performance



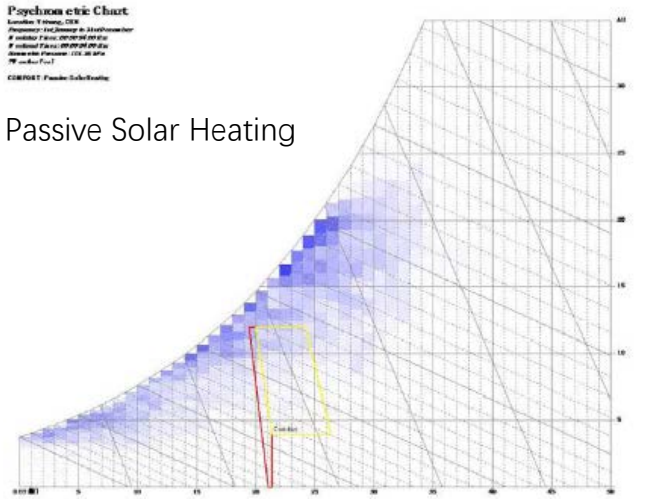

Fair and relative even solar radiation distribution over the year along with moderate temperature

# 02 building for analysis

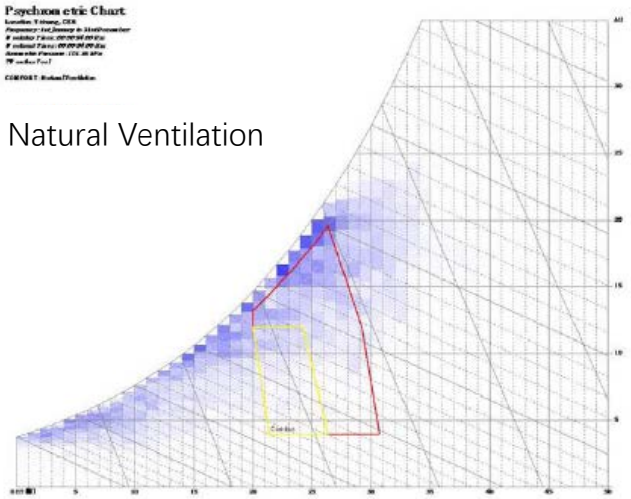
Shanghai meteorological data



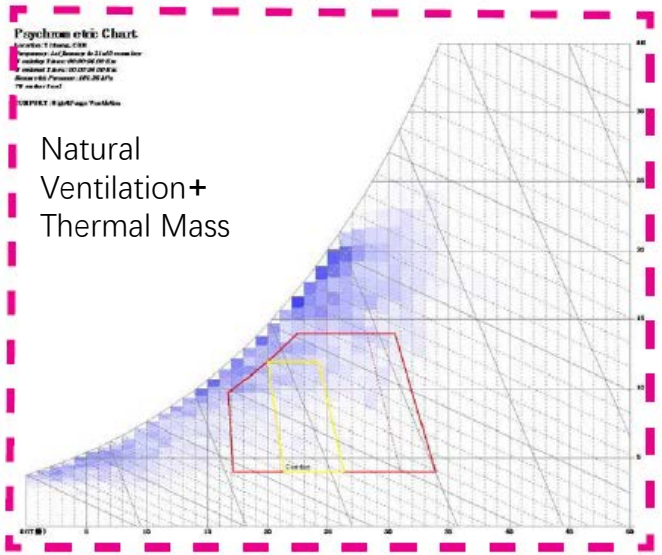

Fair and relative even solar radiation distribution over the year along with moderate temperature



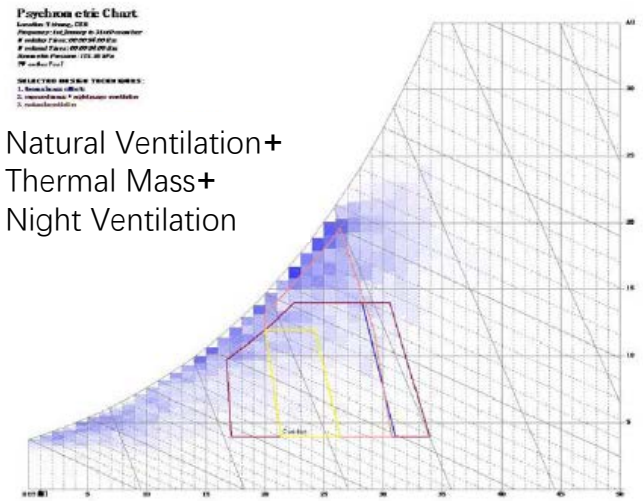

Passive Solar Heating




Natural Ventilation



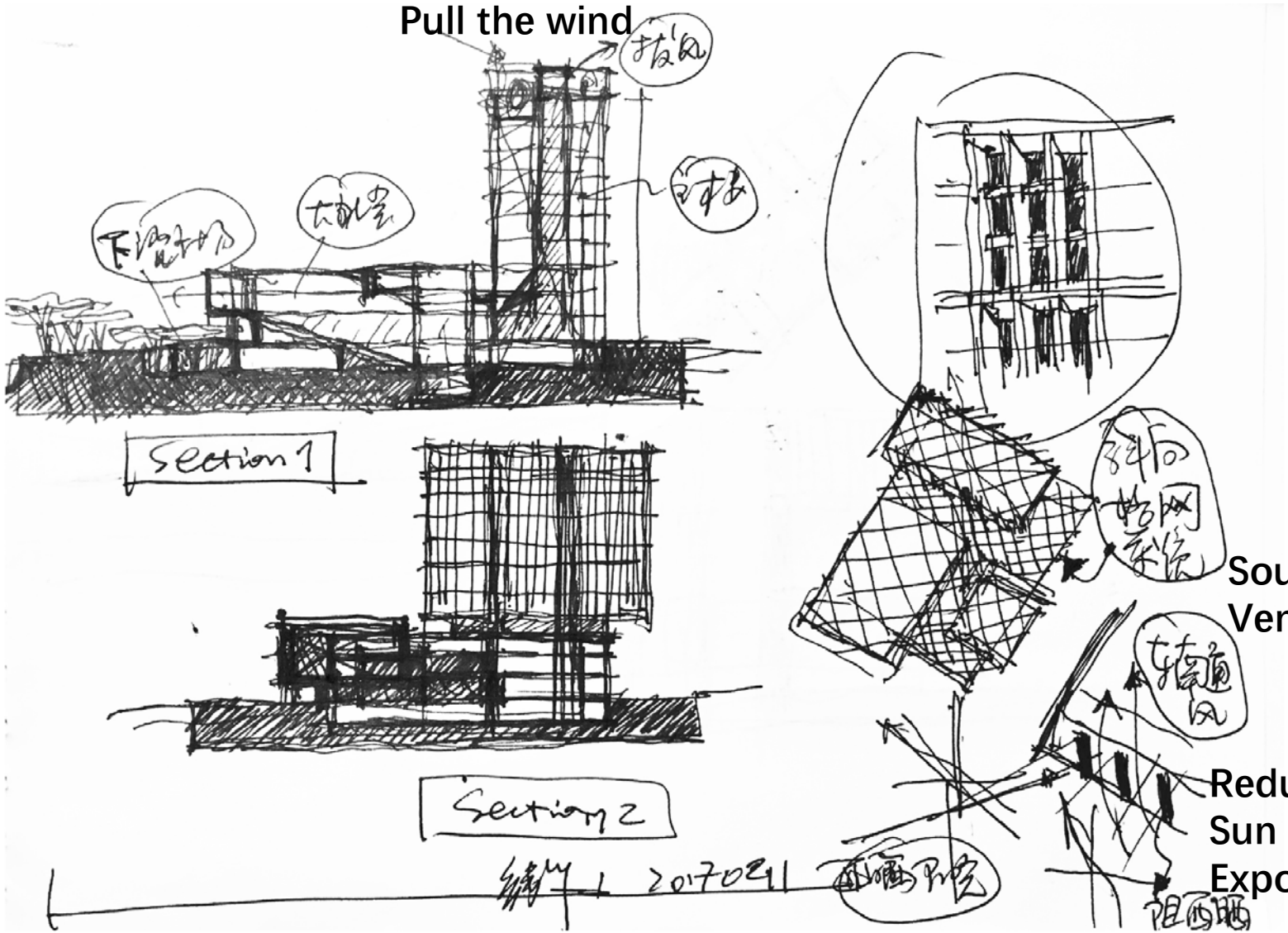

Natural Ventilation+ Thermal Mass




Natural Ventilation+ Thermal Mass+ Night Ventilation

# building for analysis



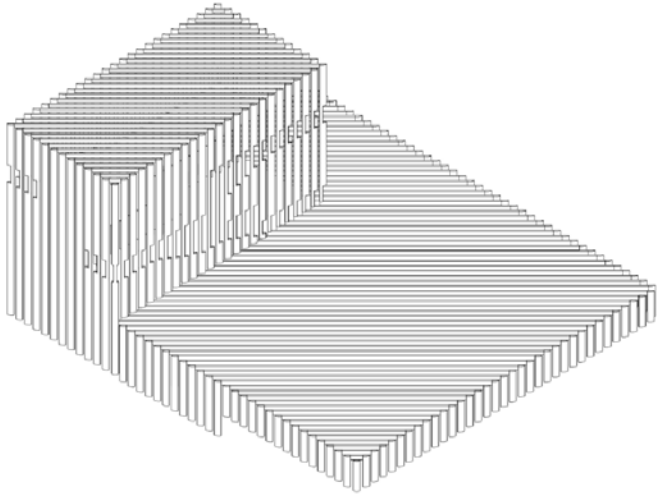


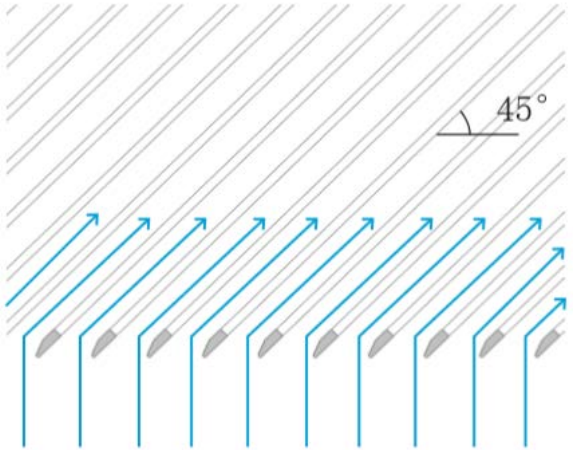

**Southeast Ventilation**

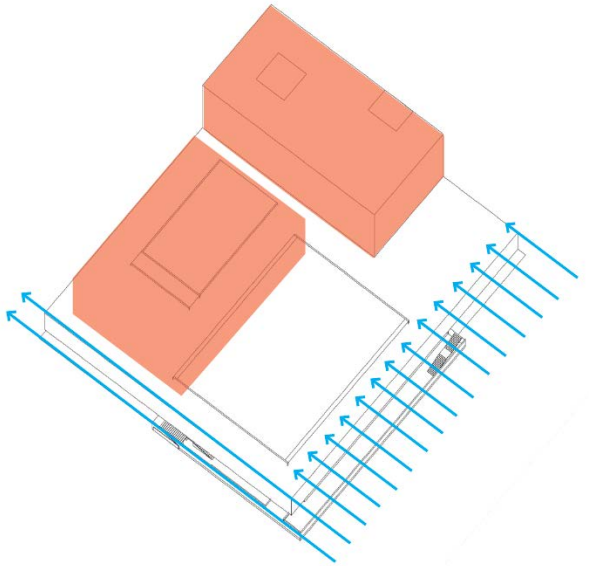
**Reduce Sun Exposure**

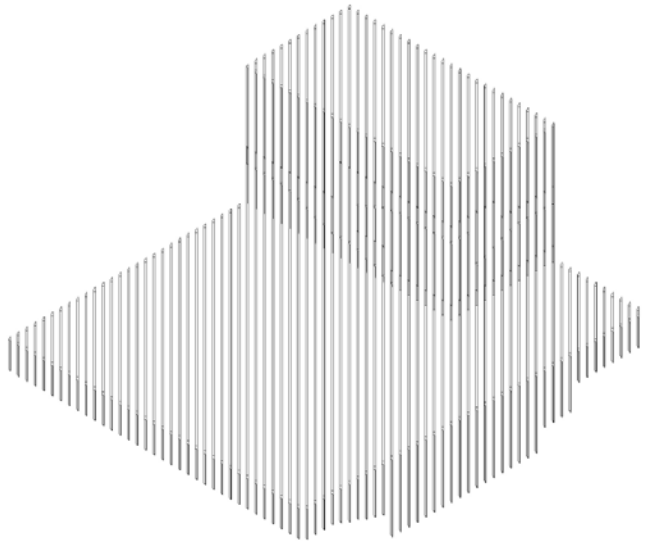
- High efficiency
- Energy saving
- Land saving

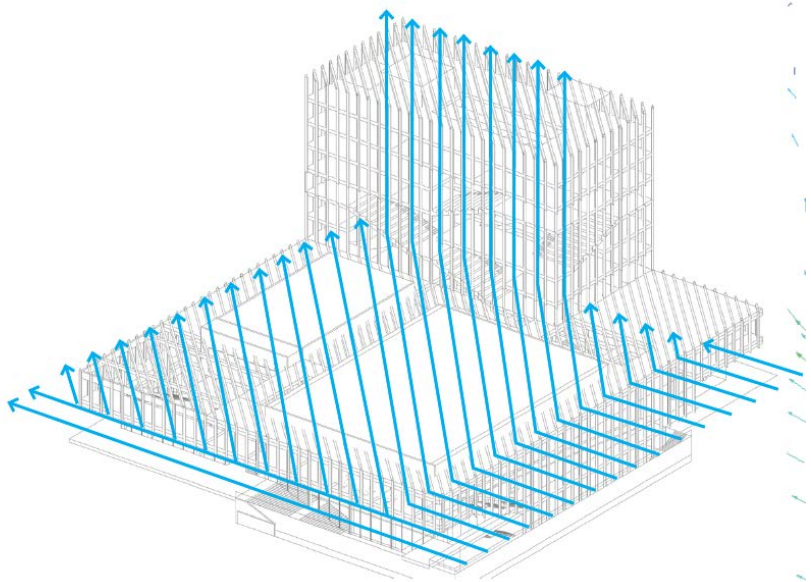
# 02 building for analysis

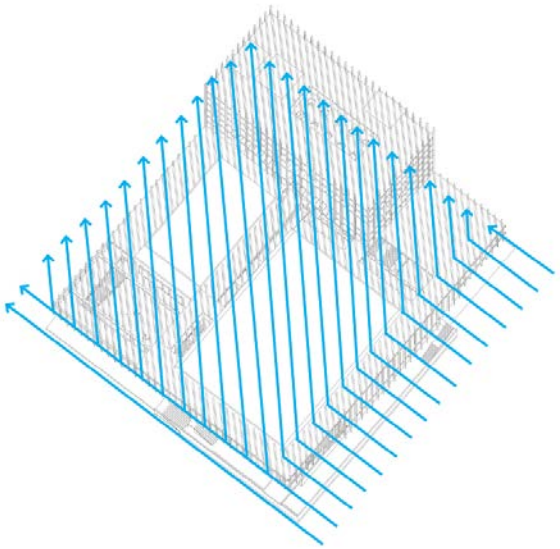




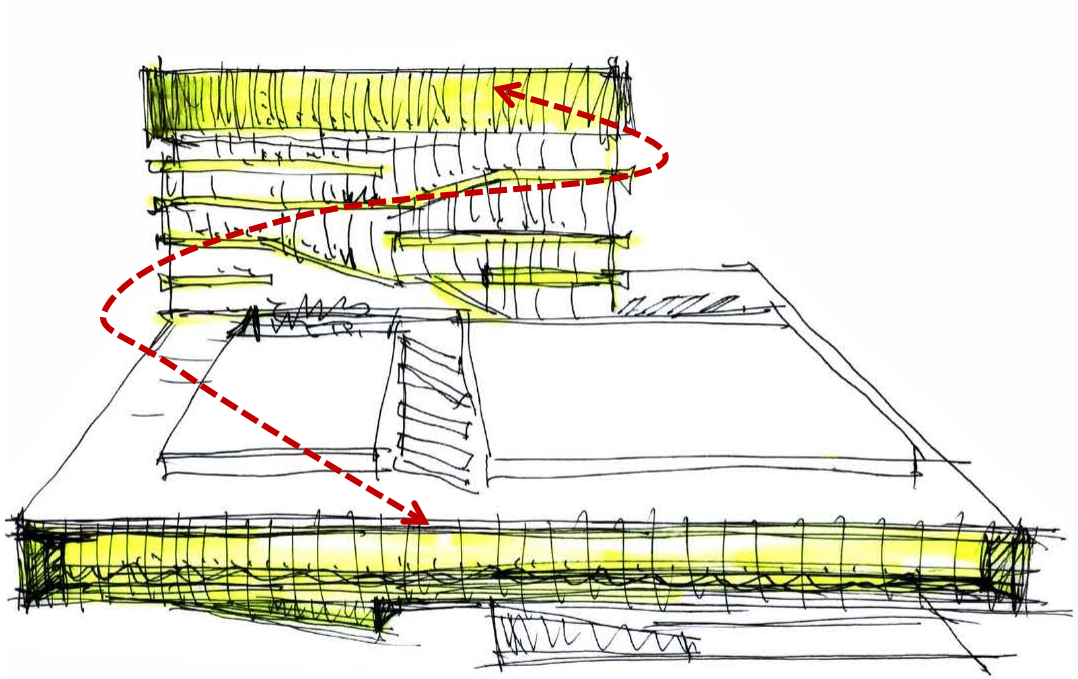



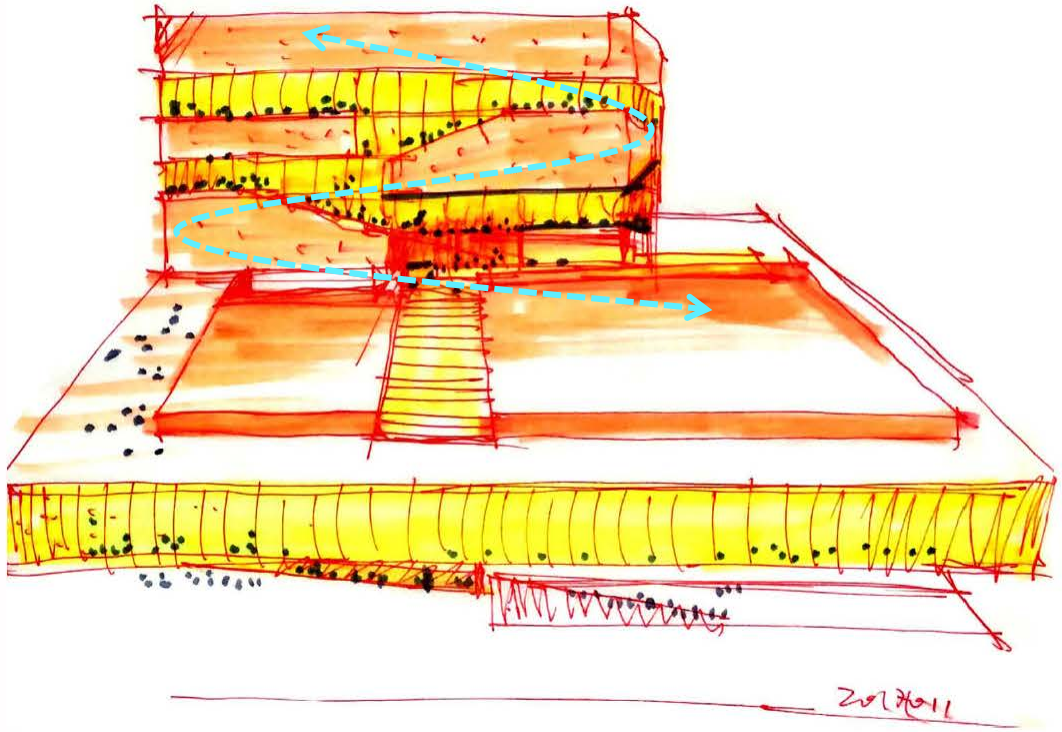




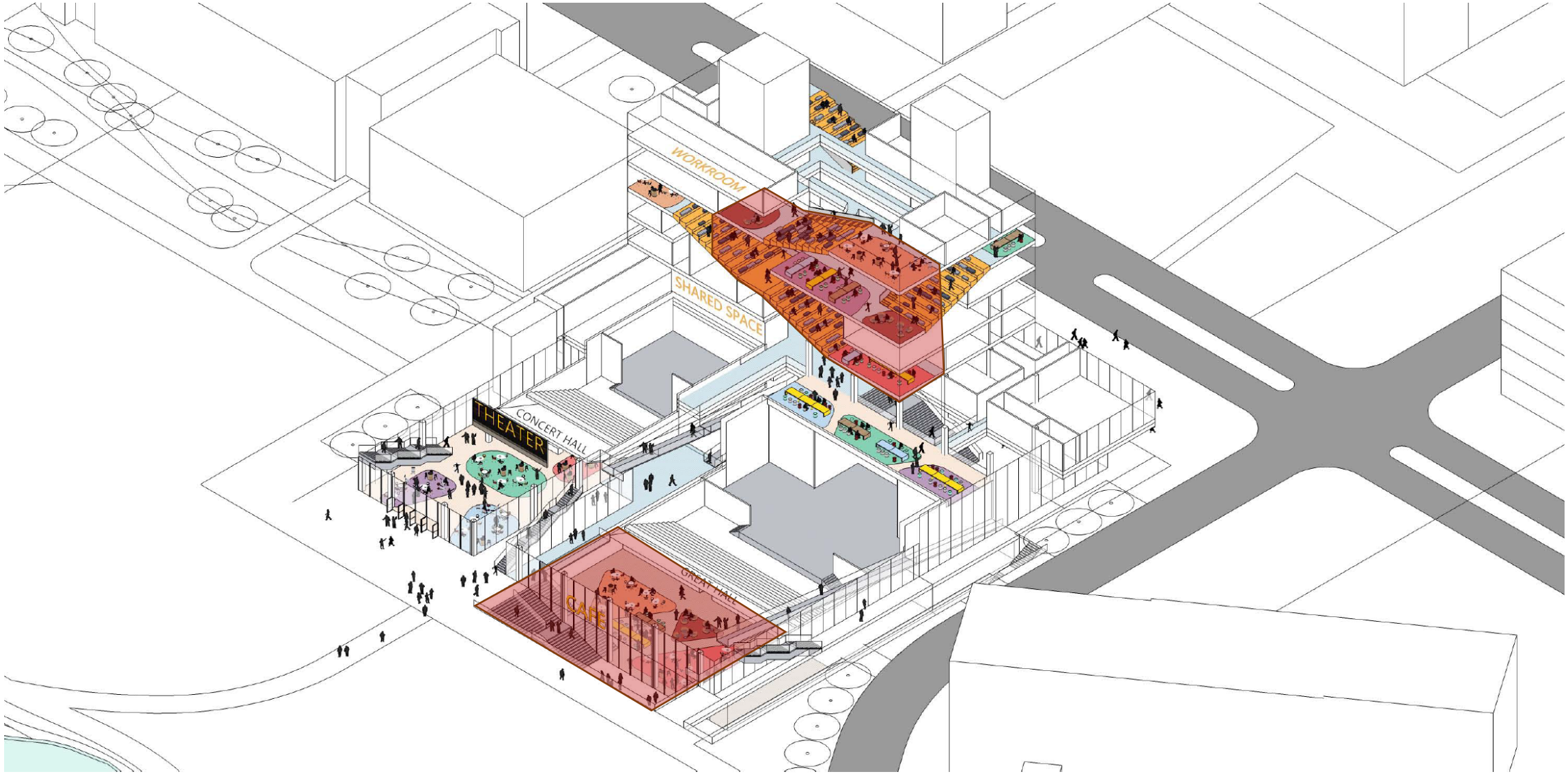


# 02 building for analysis



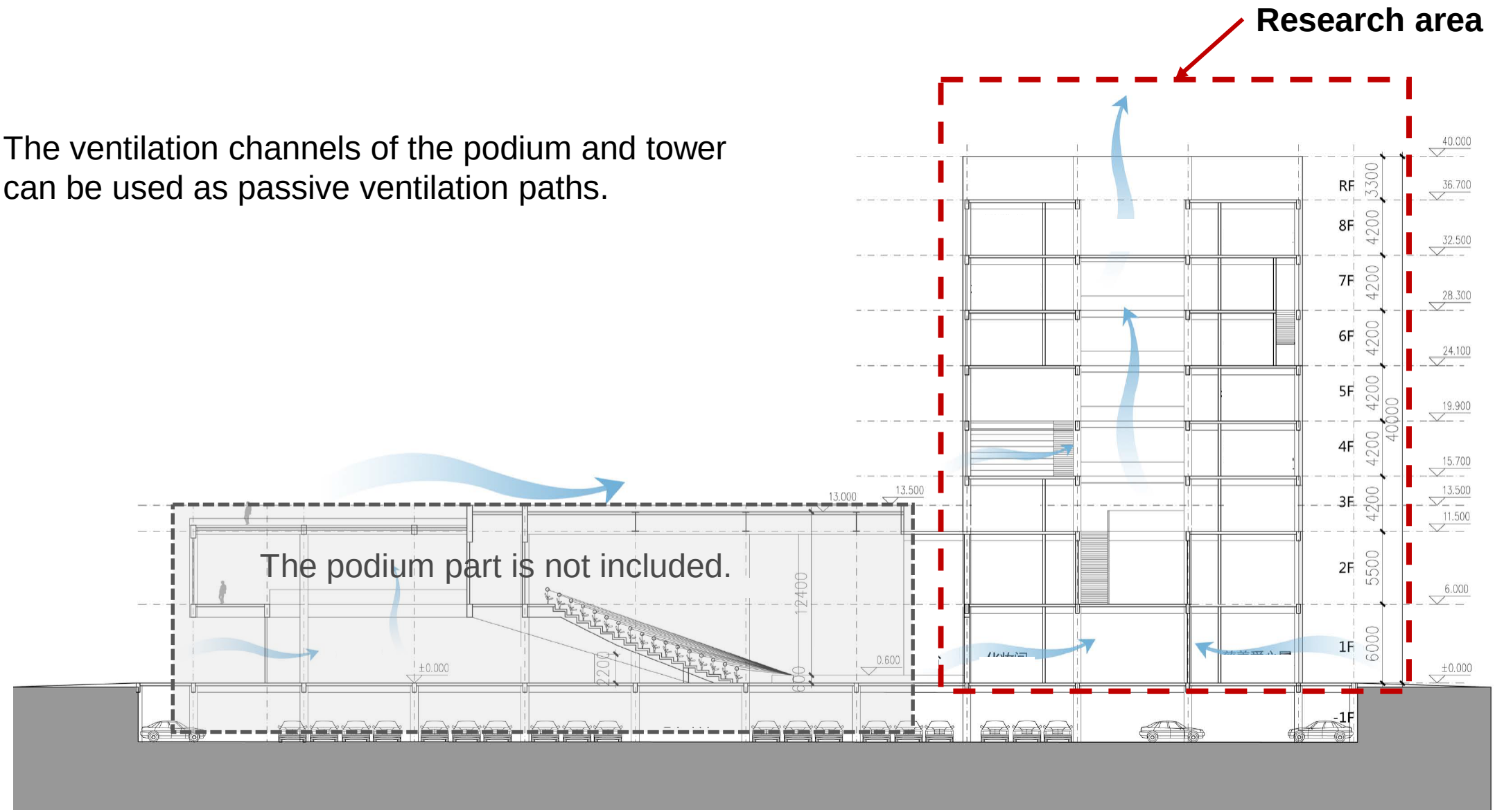


# 02 building for analysis



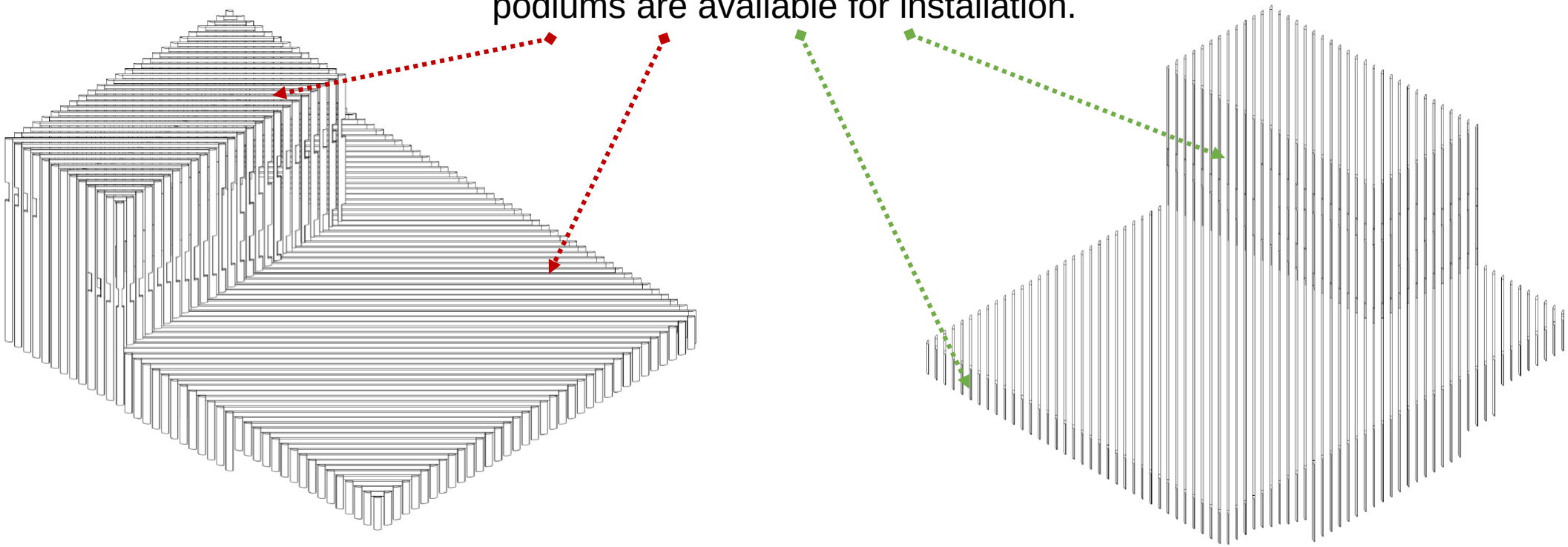
# 02 building for analysis

The ventilation channels of the podium and tower can be used as passive ventilation paths.



# 02 building for analysis

Roofs and elevations of towers and podiums are available for installation.



Both active and passive measures to reduce carbon emission from heating, cooling, lighting and plug loads during operation should be taken into consideration.

# Provided inputs and constraints



Entrants are free to choose the design for all aspects of the building envelope, if these meet the local Standard

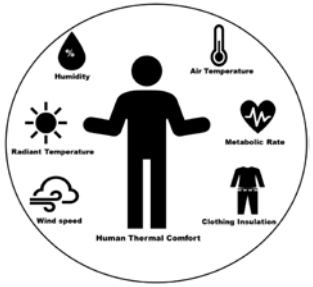
| | | **Area constraints** | | **Conductivity constraints W/( m·K)** | **Shading factor SC （East, West, South/North）** |
|---|---|---|---|---|---|
| **Transparent envelope** | External windows | Window-to-wall ratio (WWR) for Single façade for each orientation | ≤0.4 | ≤2.0 | ≤0.40/0.50 |
| | | | >0.4 & ≤0.5 | ≤2.0 | ≤0.35/0.45 |
| | | | >0.5 & ≤0.7 | ≤1.8 | ≤0.30/0.40 |
| | | | >0.7 | ≤1.5 | ≤0.25/0.35 |
| | Translucent Roof | Less than 20% of the total roof area | | ≤2.2 | ≤0.30 |
| **Non-transparent envelope** | External walls | | | ≤0.8 | |
| | Roof | | | ≤0.5 | |
| **Interior materials** | Transparent door | | | <3.5 | |
| | Non-transparent door | | | <2.5 | |
| | Internal wall | | | ≤2.0 | |
| | Internal floor | | | ≤2.0 | |

the Green Design Standard for Public Buildings in Shanghai (DGJ 08-2143-2021& DGJ 08-107-2015)

# 03 Provided inputs and constraints

**Weather**

The data set of typical weather year (TMY) in Shanghai is provided in the EPW format




**Comfort conditions**

All spaces are to be maintained between 18°C and 26°C when occupied. There are no requirements on unoccupied hours and humidity.

**Geometry**

Floor plans of the building showing room layout and dimensions as well as building sections are provided in the Appendix A of the Briefing document. These plans must be followed exactly and rooms may not be rearranged.

# 03 Provided inputs and constraints

## Occupancy densities, Ventilation & Illumination requirements

| | **Assembly Hall, Multi-function Room, Conference Room** | **Office** | **Lobby, Four-season hall, Over hall** | **Restroom, Lavatory** |
|---|---|---|---|---|
| **Occupancy density PF (pers./$m^2$)** | 0.6 | 0.12 | 0.01 | 0.05 |
| **Ventilation requirement (occupancy period) ($m^3$/(h·person))** | ≥12 | 30 | 10 | 8 ACH of exhaust air |
| **Minimum Room illumination (lux)** | 300 | 300 | 50 | 50 |

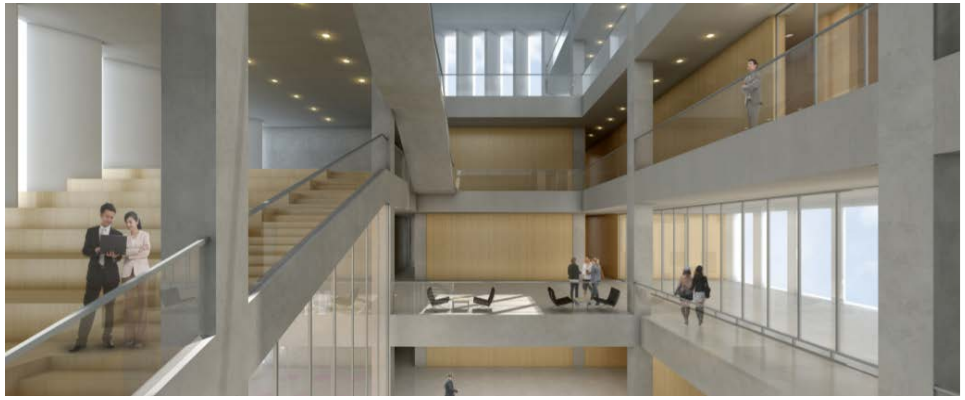
- The requirement for ventilation in the table may be ignored as a demand controlled ventilation system can ensure that the $CO_2$ will never rise above 1000ppm

- Minimum illumination levels can be used to reduce the prescriptive lighting energy by doing a lighting design calculation and daylight dependent control

# 03 Provided inputs and constraints

## Internal heat gains and schedules

### Office for example



| Name | Heat gains due to people(W/person) | | Heat gains due to lighting($W/m^2$) | Heat gains due to equipment($W/m^2$) |
|---|---|---|---|---|
| | Sensible | Latent | | |
| **Heat gains** | 61 | 68.4 | 4.5 | 200 |

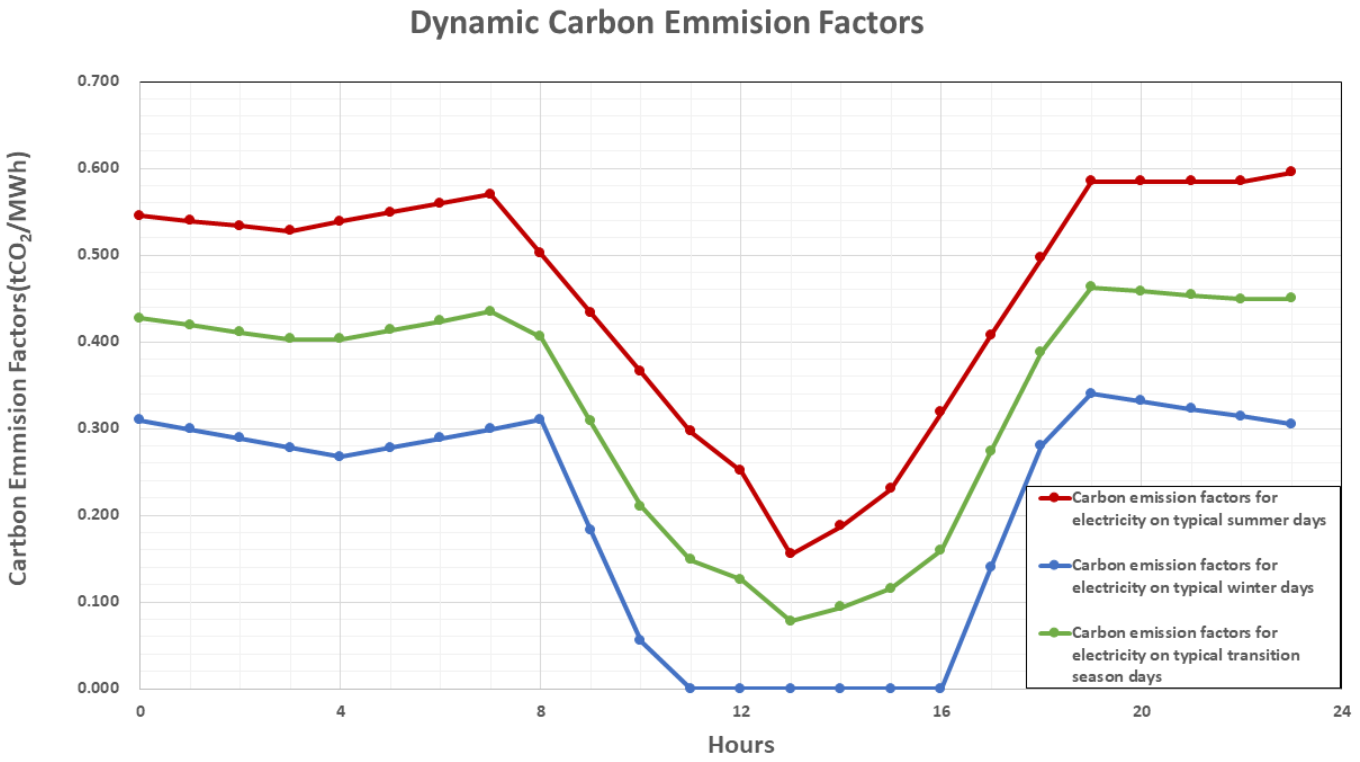
- Internal heat gains and schedules of occupants and equipment are mandatory.
- If daylight controls as applied, internal heat gains and schedules of lighting can be adjusted but need to meet the required illumination levels.

| Hours | Occupancy ratio of people | | Occupancy ratio of lighting | | Occupancy ratio of equipment | |
|---|---|---|---|---|---|---|
| | Monday-Friday | Saturday-Sunday | Monday-Friday | Saturday-Sunday | Monday-Friday | Saturday-Sunday |
| **0** | 0 | 0 | 0 | 0 | 0 | 0 |
| **1** | 0 | 0 | 0 | 0 | 0 | 0 |
| **2** | 0 | 0 | 0 | 0 | 0 | 0 |
| **3** | 0 | 0 | 0 | 0 | 0 | 0 |
| **4** | 0 | 0 | 0 | 0 | 0 | 0 |
| **5** | 0 | 0 | 0 | 0 | 0 | 0 |
| **6** | 0 | 0 | 0 | 0 | 0 | 0 |
| **7** | 0 | 0 | 0 | 0 | 0 | 0 |
| **8** | 0.1 | 0 | 0.1 | 0 | 0.1 | 0 |
| **9** | 1 | 0 | 1 | 0 | 1 | 0 |
| **10** | 1 | 0 | 1 | 0 | 1 | 0 |
| **11** | 0.9 | 0 | 0.9 | 0 | 0.9 | 0 |
| **12** | 0.3 | 0 | 0.3 | 0 | 0.3 | 0 |
| **13** | 0.9 | 0 | 0.9 | 0 | 0.9 | 0 |
| **14** | 1 | 0 | 1 | 0 | 1 | 0 |
| **15** | 1 | 0 | 1 | 0 | 1 | 0 |
| **16** | 1 | 0 | 1 | 0 | 1 | 0 |
| **17** | 1 | 0 | 1 | 0 | 1 | 0 |
| **18** | 0 | 0 | 0 | 0 | 0 | 0 |
| **19** | 0 | 0 | 0 | 0 | 0 | 0 |
| **20** | 0 | 0 | 0 | 0 | 0 | 0 |
| **21** | 0 | 0 | 0 | 0 | 0 | 0 |
| **22** | 0 | 0 | 0 | 0 | 0 | 0 |
| **23** | 0 | 0 | 0 | 0 | 0 | 0 |

# 03 Provided inputs and constraints

Dynamic carbon emission factors is provided in **Appendix E**, which can be used to convert the hourly electricity consumption to hourly carbon emissions.

$$\text{Dynamic carbon emission factor} = \frac{\text{Total instantaneous carbon emissions}}{\text{Total electricity of the whole grid}}$$




Note:
Summer: July to September;
Winter: January to February, December;
Transition season: March to June, October to November

# 04 Non-restricted inputs

**Inputs that the design teams may decide to vary include:**

- Shading
- Daylight controls
- Complete HVAC system (air-side, water-side, etc)
- Renewable energy
- Battery

# 05 Evaluation and judging criteria

- The key factors influencing the judges' decision will be **accurate and intelligent use of building simulation and adequate use of performance metrics**. It will not account for any site specific interventions outside of the building footprint.

- Entrants will be judged on the **design feasibility, carbon emission performance and robustness** of proposal to include all parameters and input, while providing a **salient solution that is achievable**.

Competition submissions can be **either individual or group submissions**. In case of group entries, a group leader should be nominated as corresponding person, and the total number of team members cannot exceed four.

# 06 Deliverable Report

**a.** Title page, including author(s) name(s), affiliation(s), and contact details
**b.** Executive Summary (maximum of 1 page)
**c.** Contents
**d.** Nomenclature
**e.** Introduction
**f.** Building and energy system design
    1) Explanation of options considered and decision process(es)
**g.** Modelling methods employed
    1) Explanation of modelling techniques used to evaluate $CO_2$ emissions, Energy Cost Measures and HVAC system selection
**h.** Modelling assumptions
**i.** Results
    1) Ensure all graphs provided are legible and concise to support overall results.
    2) Additional graphics can be included in Appendix.
**j.** Conclusions
**k.** References (if required)
**l.** Appendix (if required)

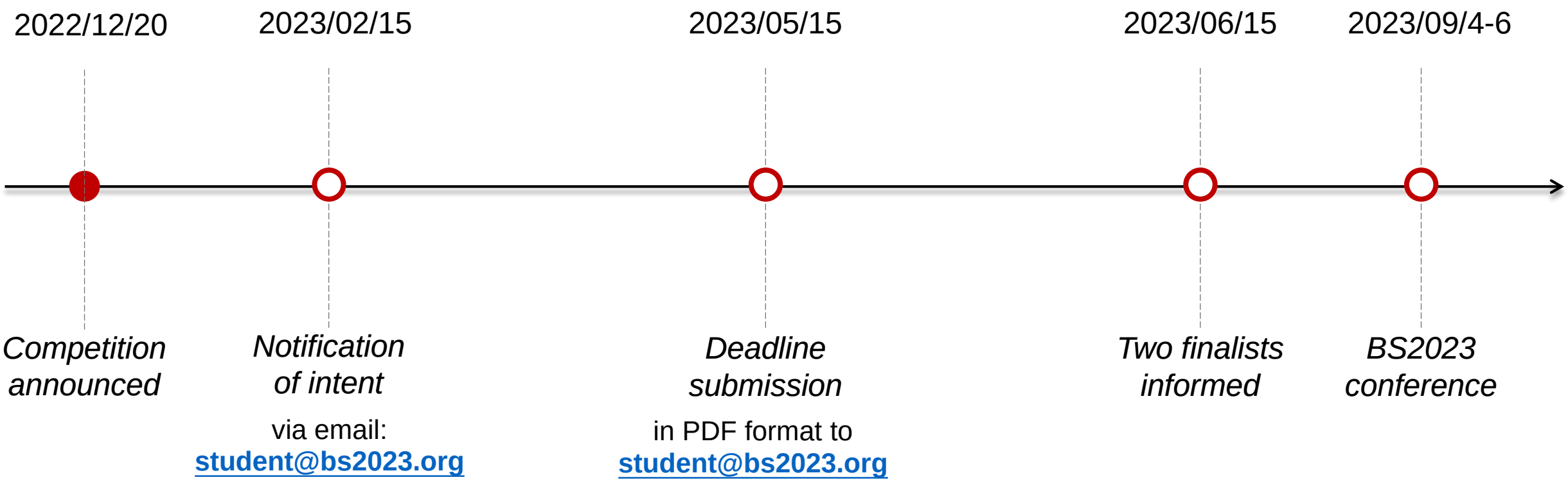
Note: The deliverable report should not exceed 20 pages excluding references and the annex section

# 07 Enrollment and notification of finalists

| | |
|---|---|
| **Enrollment** | • All entrants must be enrolled as students (PhD, MSc, BSc or equivalent) at the time of submission (i.e. May 15th 2023). Entrants must upload the following documents, as a proof of their 'student' status:<br>• 1) A bonafide letter on the university/institute letterhead from the supervisor or faculty-in-charge<br>• 2) Photocopy of the student ID provided by the university/institute<br>• Entrants who fail to submit these documents will be disqualified. Please note that in the case of group entries, each member must submit these documents. |
| **Notification of finalists** | • The two finalists will be notified by June 1$^{ST}$, 2023 and will receive free registration to BS2023 plus up to US $2000 (per group) in reimbursed travel expenses.<br>• The two finalists will be expected to attend the Building Simulation 2023 conference and to prepare a short presentation and produce a poster for display at BS2023.<br>• Poster requirements and travel/registration information for the finalists will be provided at that time.<br>• Based on the conference presentation and poster, an overall winner will be selected and announced at the conference. |

# 08 Student competition

**Key dates**



# 08 Student competition

**Queries**

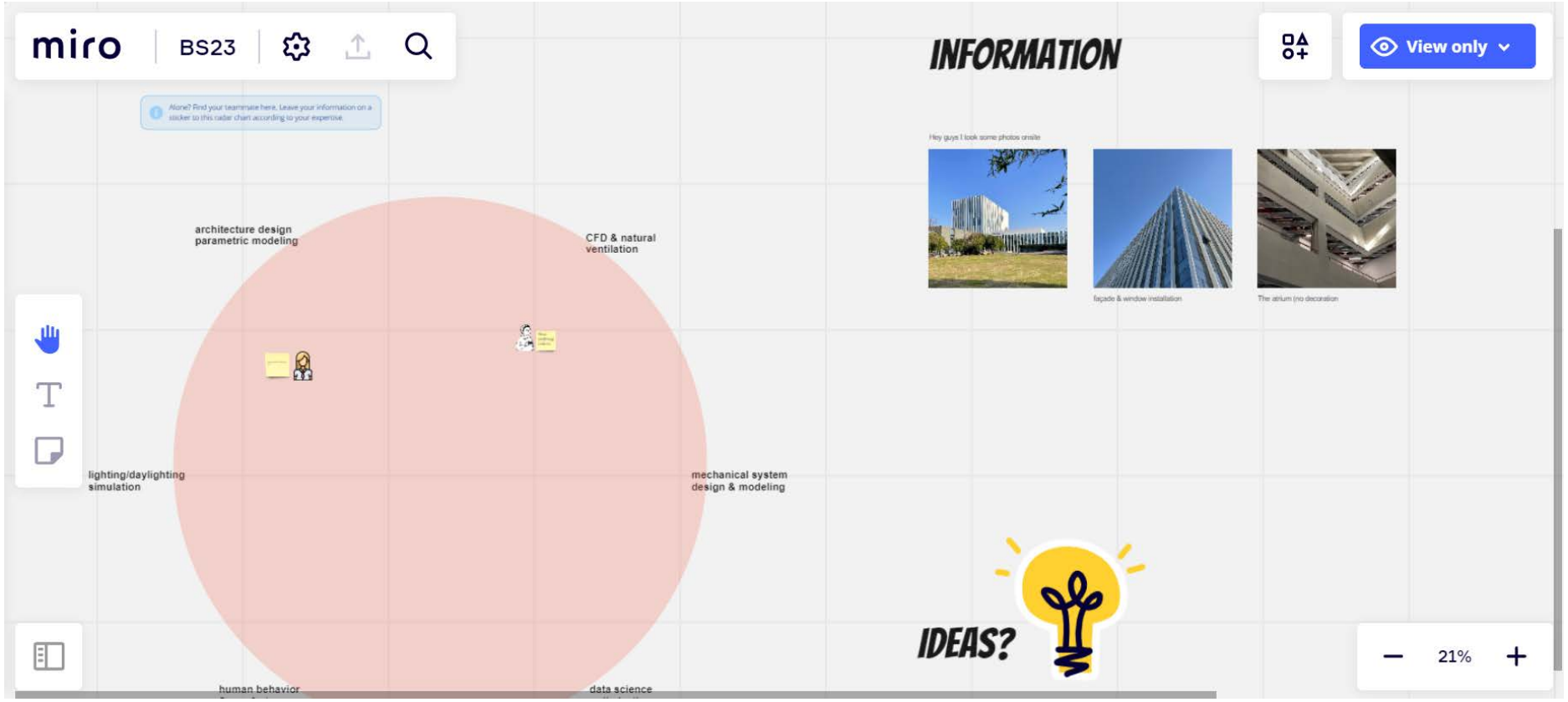
- If you require any further information, please contact us at the following e-mail:

  **student@bs2023.org**

- Please use email for correspondence and try to make your question as concise as possible.
- All questions and responses will be posted on the Student Competition section of the BS2023 website. Please check first that your query has not already been answered.

# 08 Student competition

**miro board for team cooperation**



# Building Simulation 2023 Student competition

# Thank you !

**If you have any questions, please contact us at the following e-mail: student@bs2023.org.**