THE HONG KONG POLYTECHNIC UNIVERSITY
香港理工大學

Climate-based Daylight Modeling for Energy Efficient Building Design

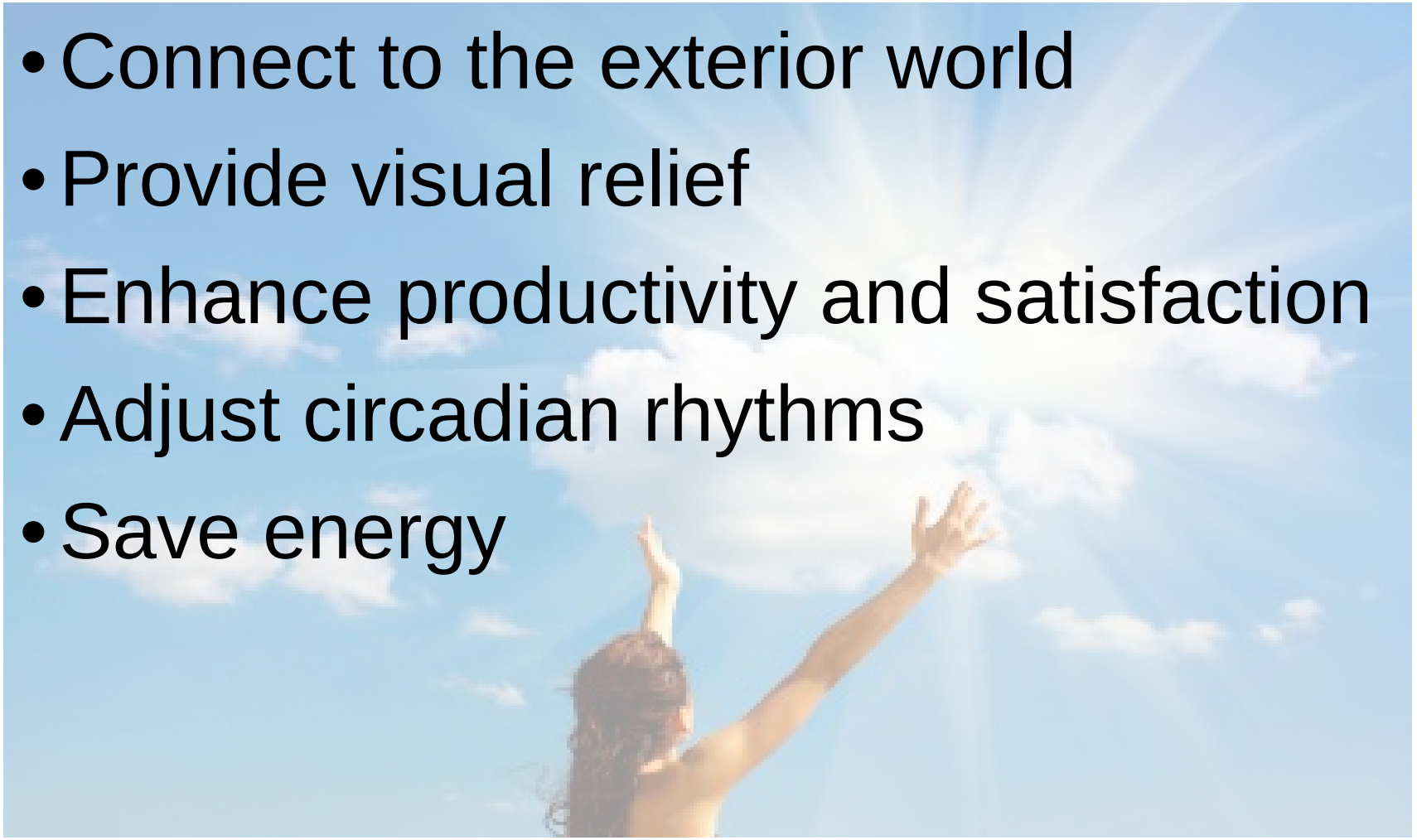
Technical Talk on Energy Engineering
- Challenges and Opportunities
December 10th, 2016

Minchen(Tommy) Wei, PhD
Assistant Professor
Dept. of Building Services Engineering
The Hong Kong Polytechnic University

minchen.wei@polyu.edu.hk

Daylight is beneficial to us

Daylight is beneficial to us



- Connect to the exterior world
- Provide visual relief
- Enhance productivity and satisfaction
- Adjust circadian rhythms
- Save energy

What is regarded as a good daylighting design in Hong Kong?

Building Ordinance (Cap 123F, reg 30)

"Every room used for habitation or for the purposes of an office or as a kitchen shall be provided with natural lighting and ventilation".

http://www.legislation.gov.hk

What is regarded as a good daylighting design in Hong Kong?

Building Department (APP-130):

Room of domestic building	Vertical Daylight Factor (VDF) (measurement taken on the centre of the window pane)
Habitable Room	8%
Kitchen	4%

http://www.bd.gov.hk

What is regarded as a good daylighting design in Hong Kong?

BEAM 4/04 and 5/04

"1 credit… where the average daylight factor is at least 0.5% for all normally occupied spaces."

"2 credits where the average daylight factor in all normally occupied spaces is at least 1%".

"3 credits where the average daylight factor in all normally occupied spaces is at least 2%."

What is regarded as a good daylighting design in Hong Kong?

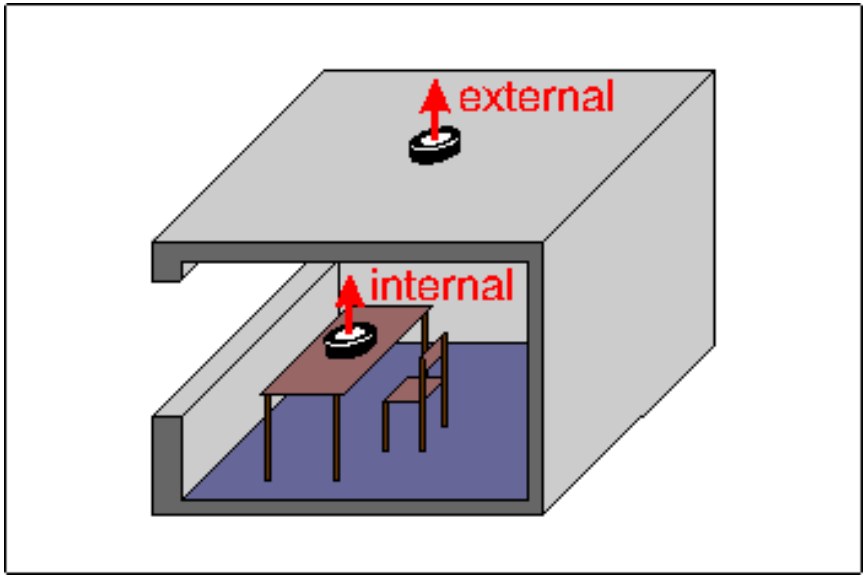
BEAM Plus for New Buildings V1.2

"1 credit where at least 80% of the floor area in all normally occupied spaces is adequately lit with an average daylight factor of 1%."

"2 credits here at least 95% of the floor area in all normally occupied spaces is adequately lit with an average daylight factor of 1%".

What is daylight factor (DF)?

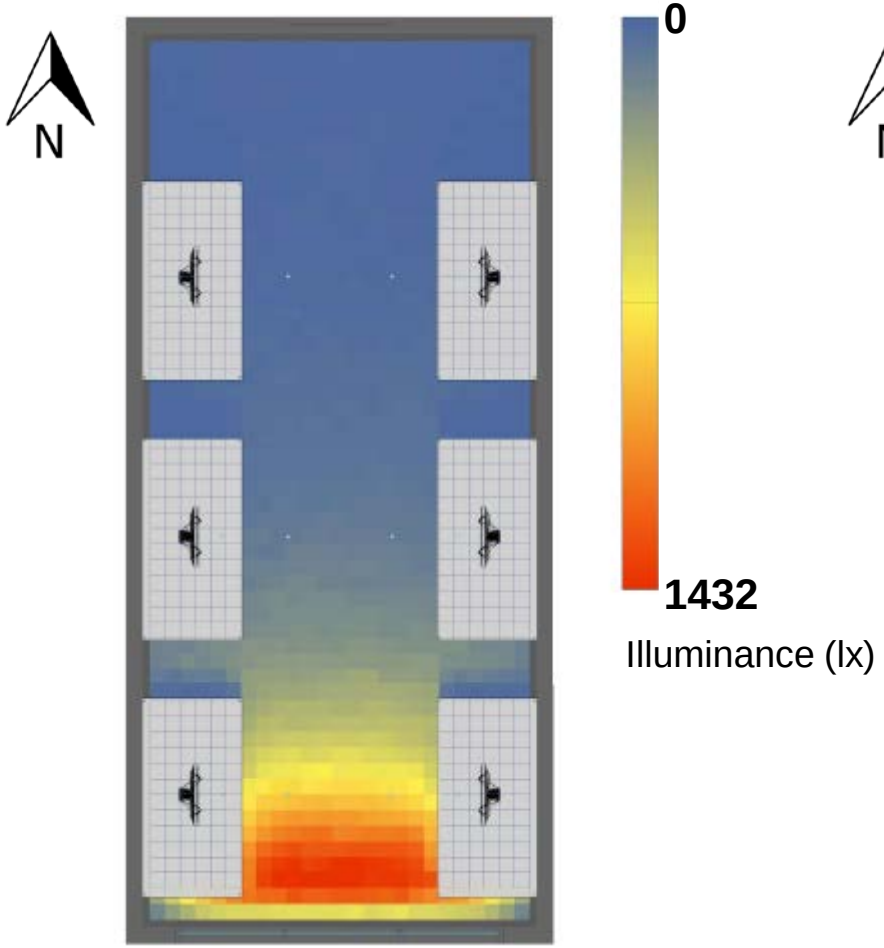
- DF is the ratio of light level (i.e., illuminance) at a given point due to daylight of an overcast sky to the light level on a horizontal plane due to an unobstructed overcast sky.



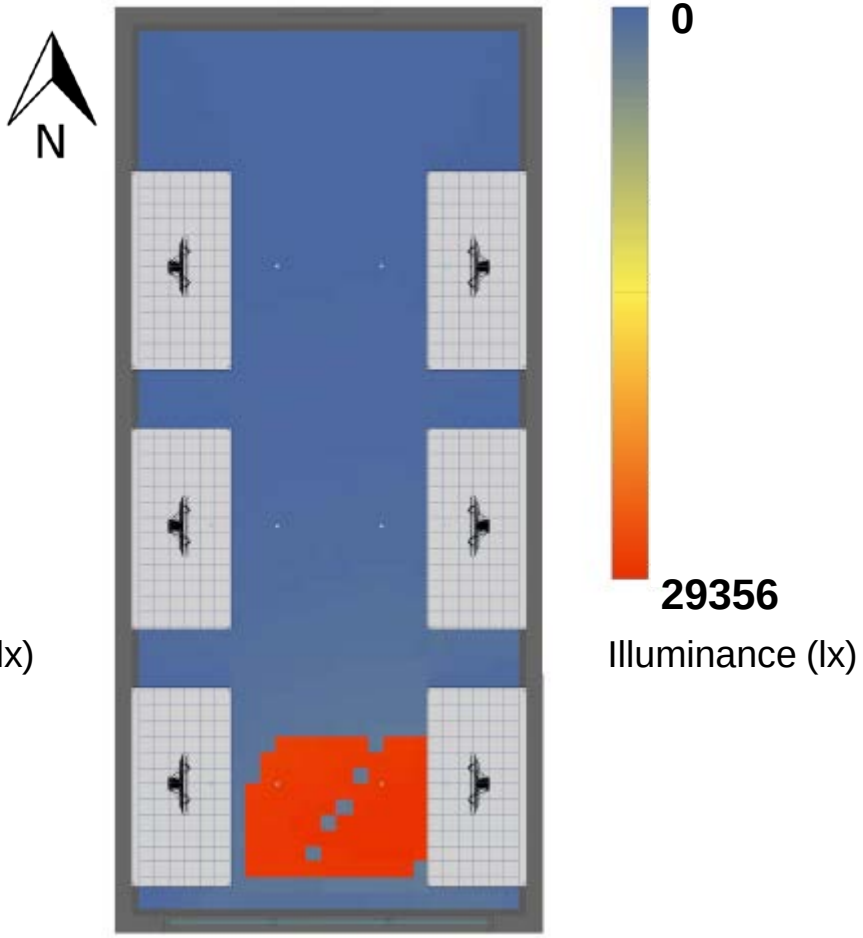
Limitations of DF

1. Overcast sky does not consider sun

Overcast Sky



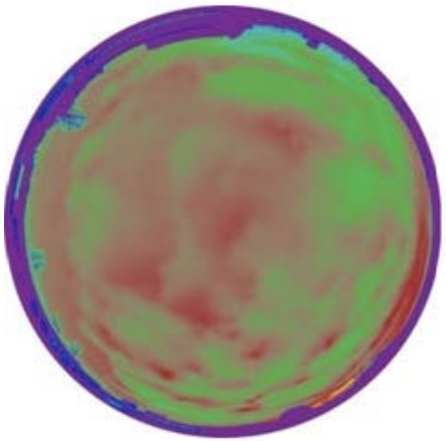
Clear Sky



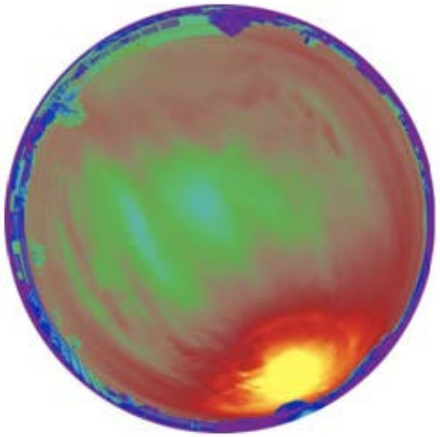
Limitations of DF

1. Overcast sky does not consider sun

Overcast Sky



Clear Sky

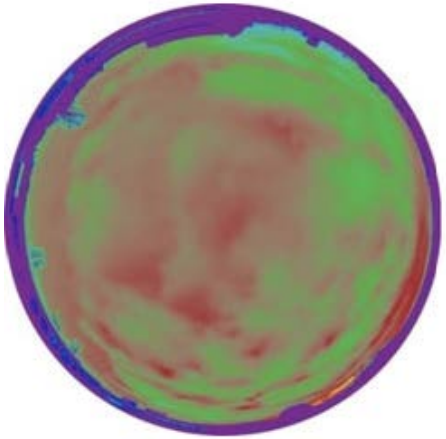


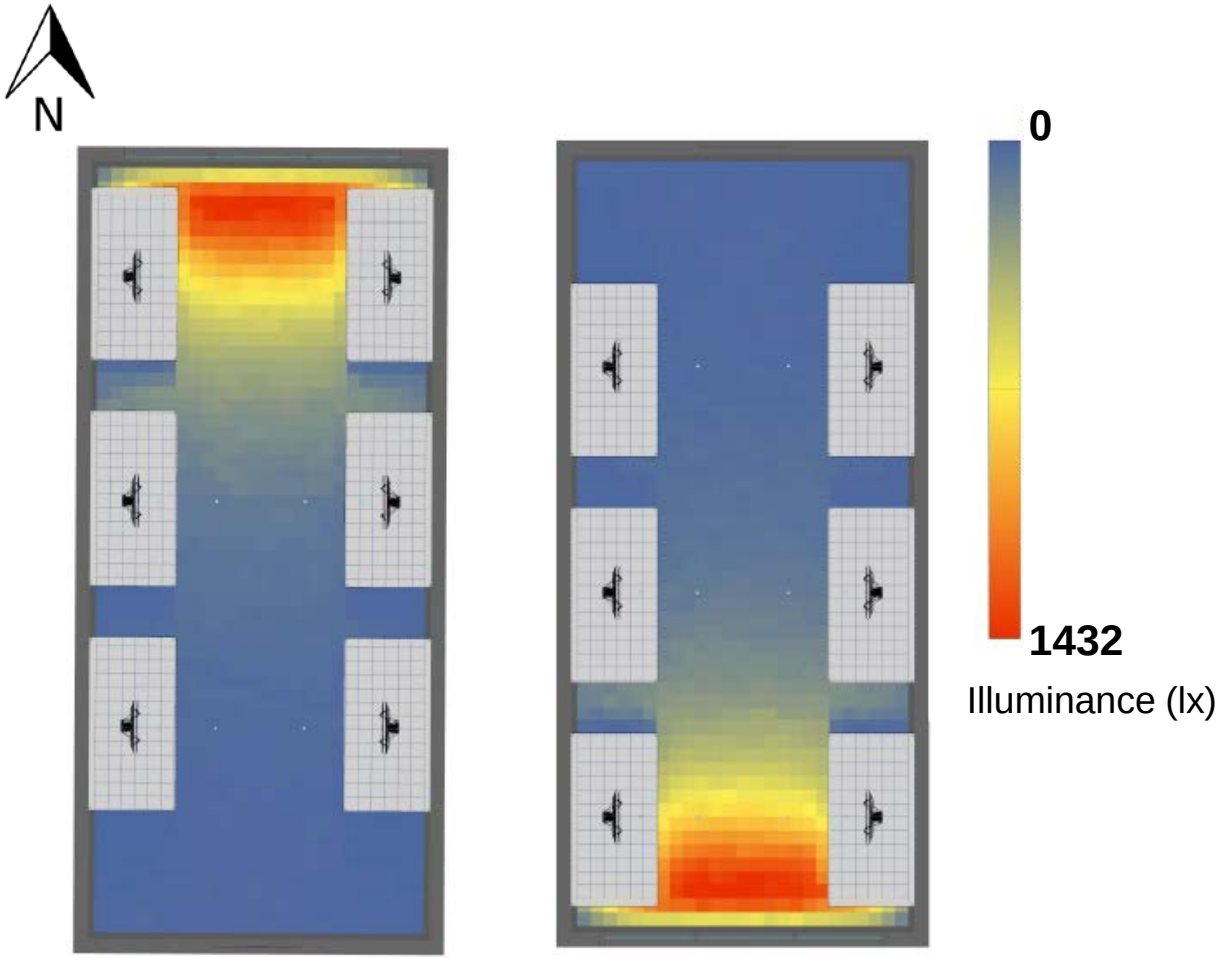
Luminance

Limitations of DF

2. Orientation does not matter

Overcast Sky

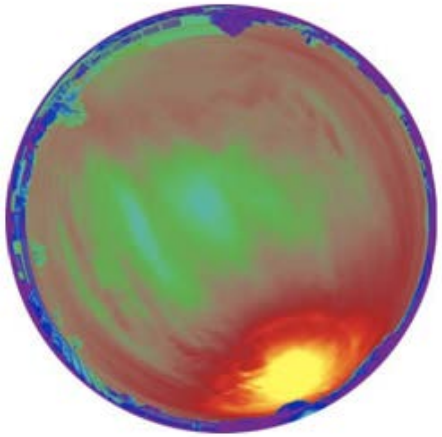


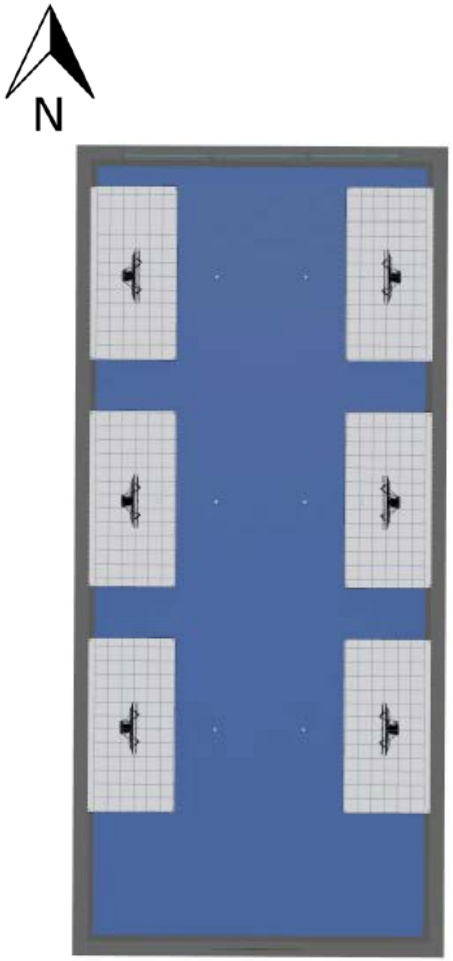


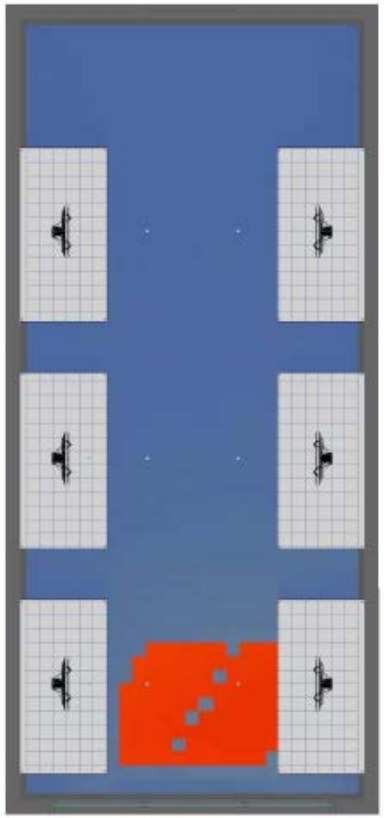
Limitations of DF

2. Orientation does not matter

Clear Sky

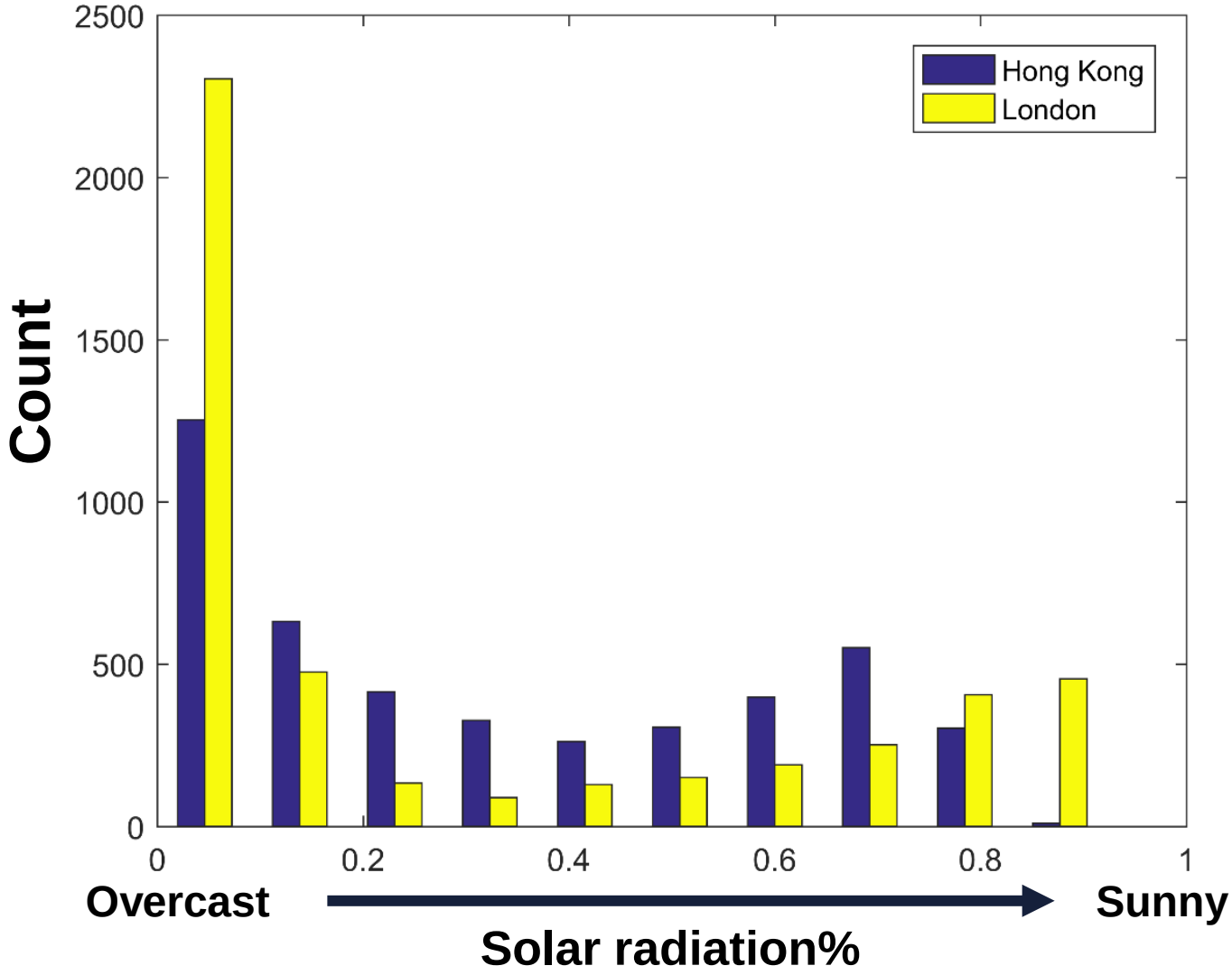






Illuminance (lx)

Overcast sky is more common in London



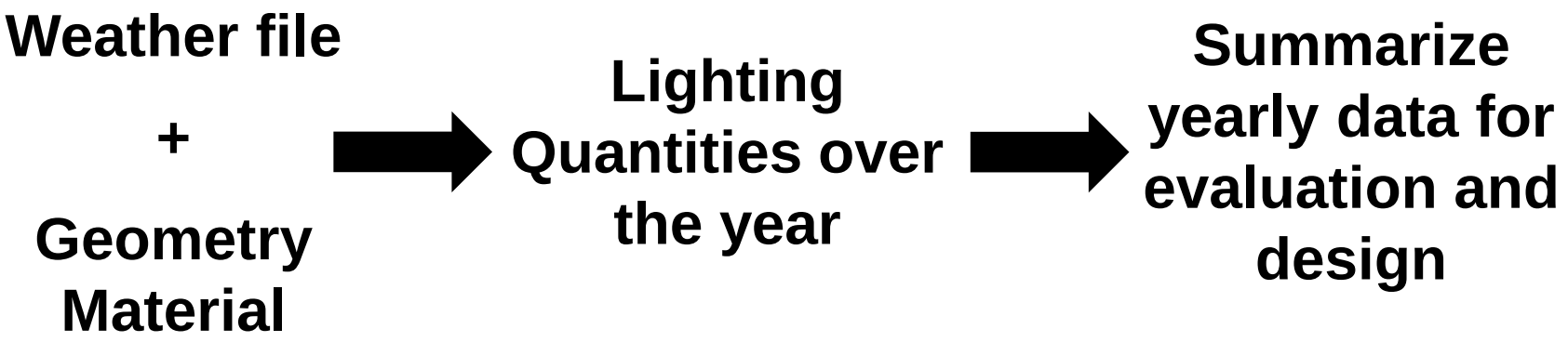
Sun, sky, and reflections should be considered throughout the year.

Sun, sky, and reflections should be considered throughout the year.

Climate-Based Daylight Modelling

- CBDM is the prediction of lighting quantities (e.g., illuminance and luminance) using sun and sky conditions that are derived from standard meteorological datasets.

Climate-Based Daylight Modelling



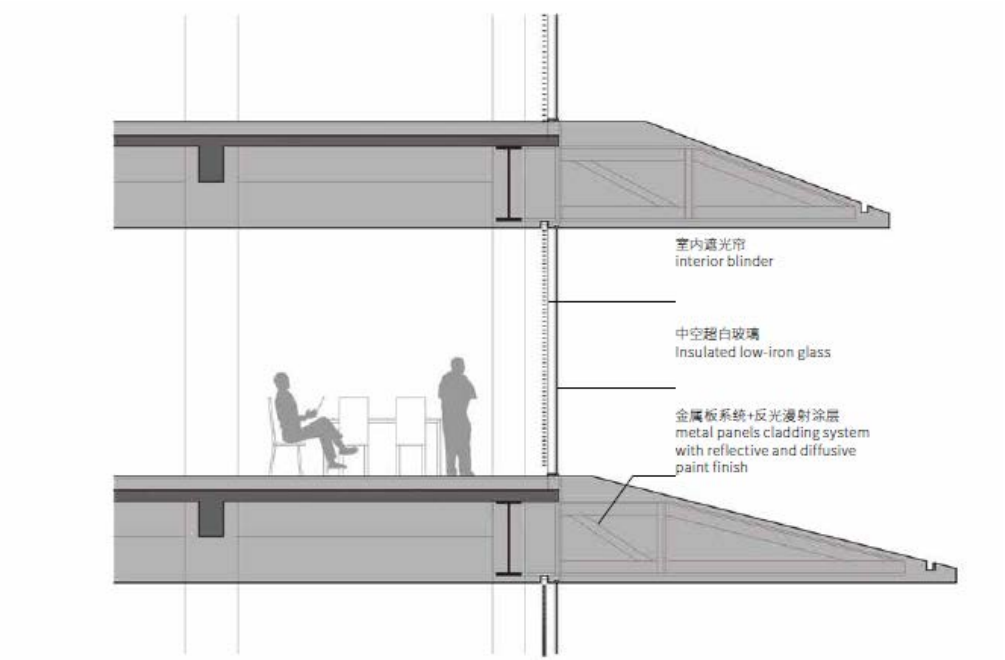
CBDM Measures

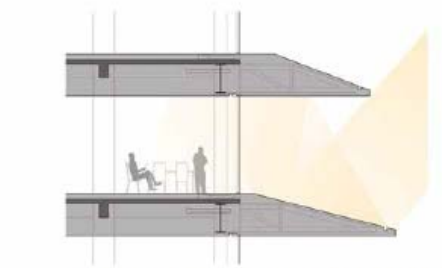
- Characterizing each point
  - Daylight Autonomy (DA)
  - Continuous Daylight Autonomy (cDA)
  - Useful Daylight Illuminance (UDI)
- Characterizing the entire space
  - Spatial Daylight Autonomy (sDA)
  - Annual Sunlight Exposure (ASE)

} **LEED**

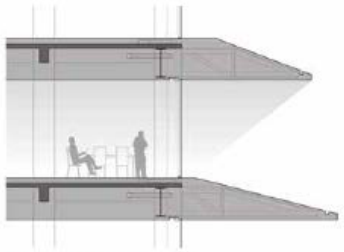
Real Project in China

Overhangs were designed



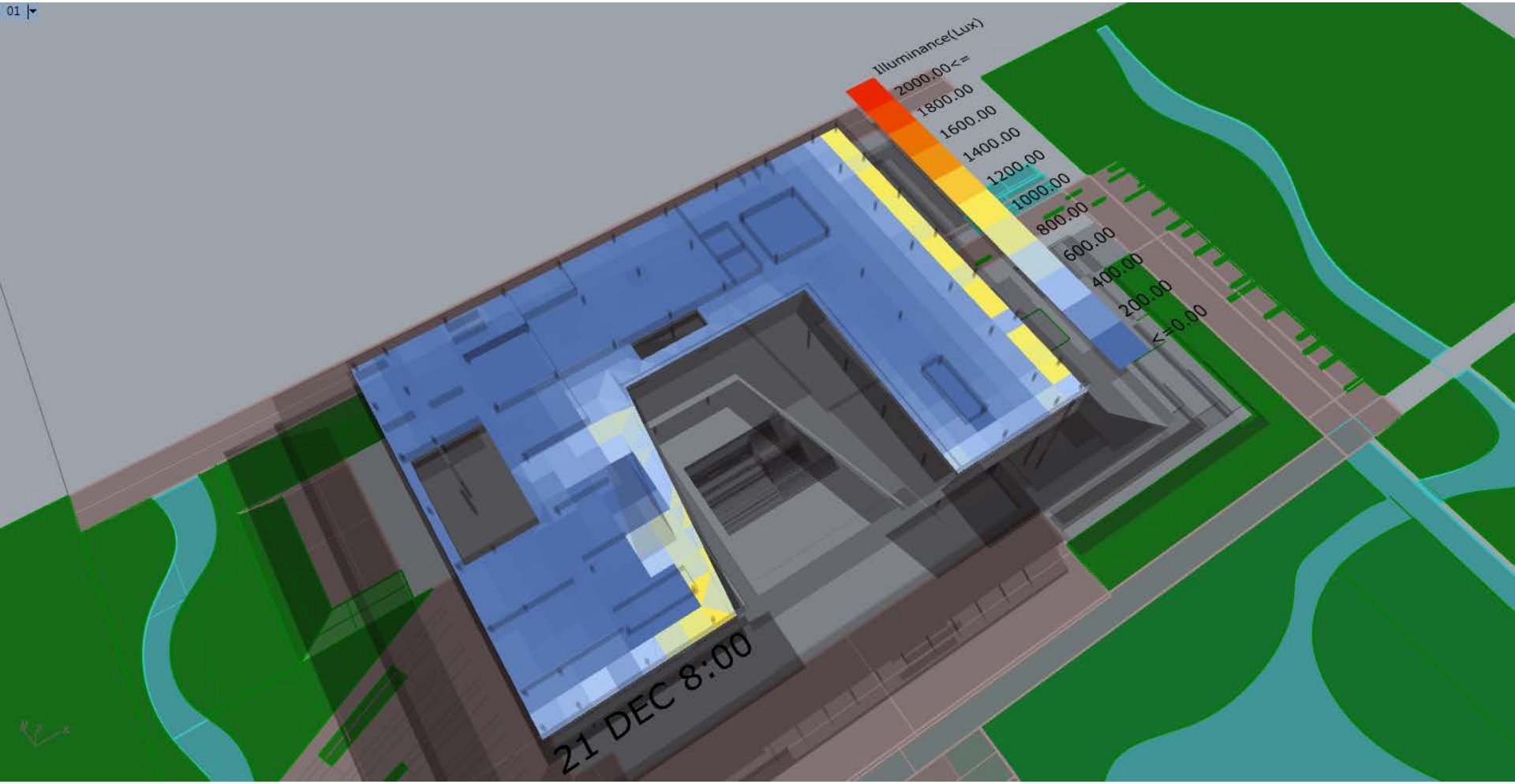


倾斜的屋檐轮廓将阳光反射入室内，为阅读空间制造柔和的自然采光。
Angled canopies produce diffusing effect of perimeter light into the reading space without glare.

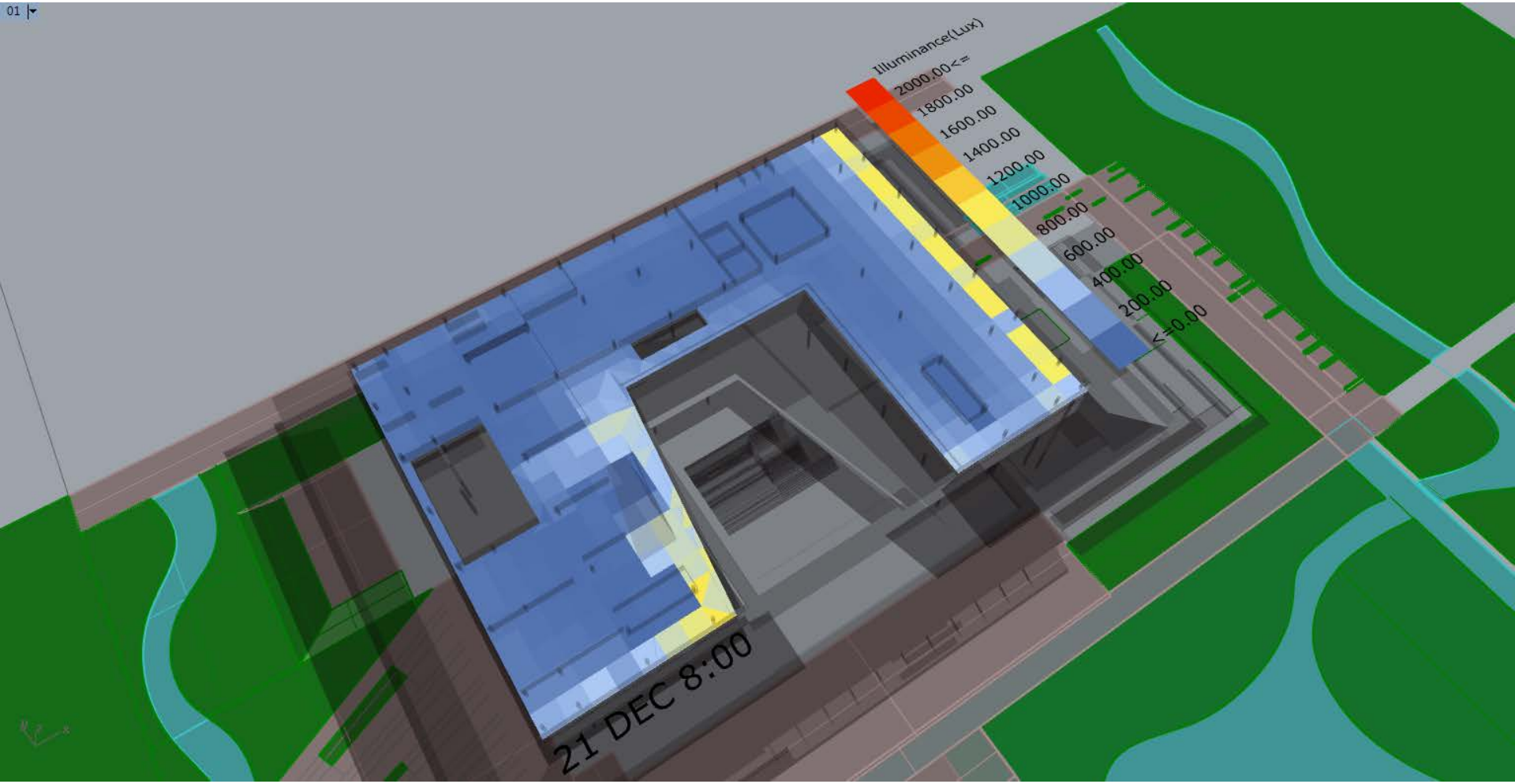


延伸的屋檐有效的为室内遮阳
Extensive canopies shade interior space effectively.

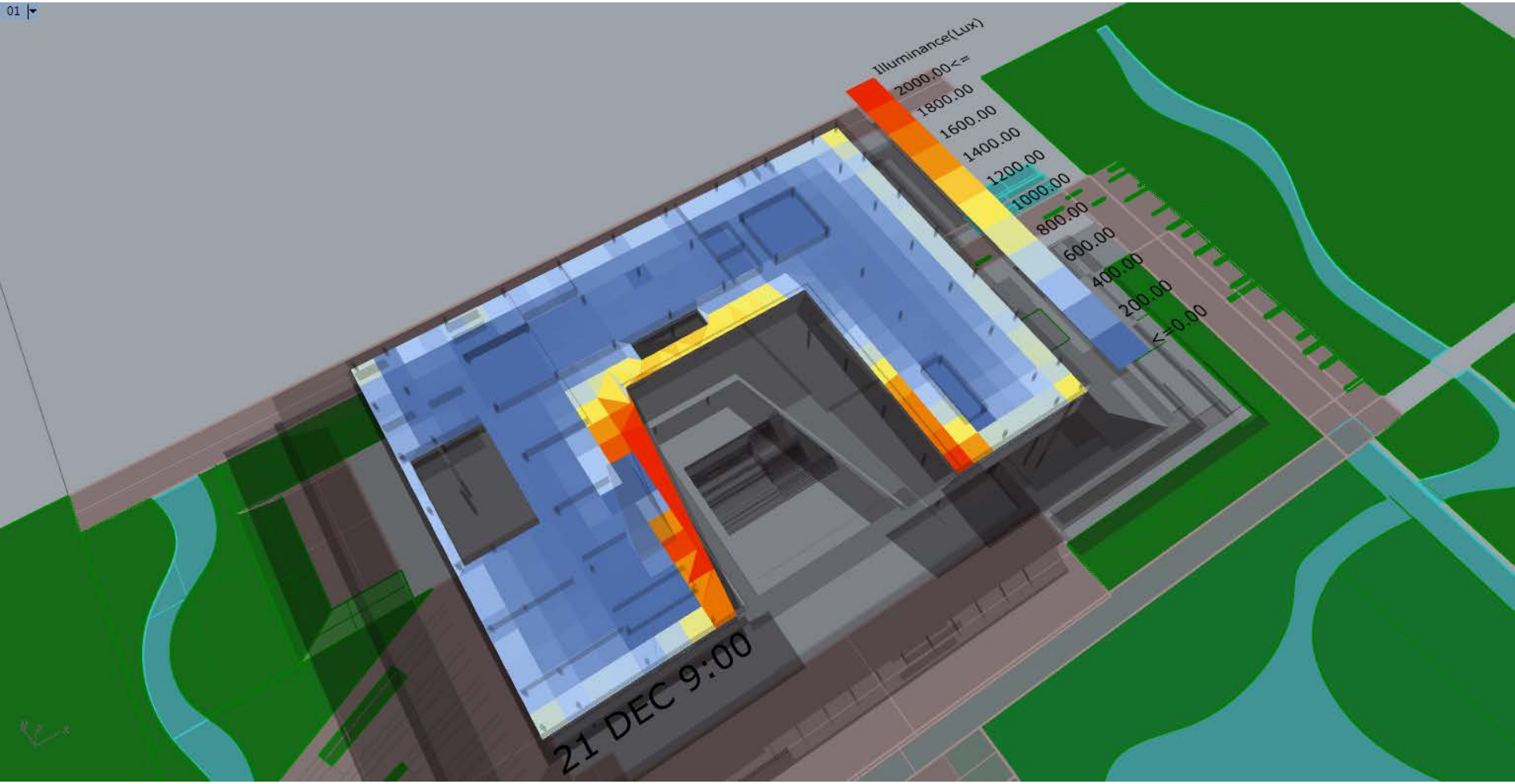
Hourly simulation as conducted



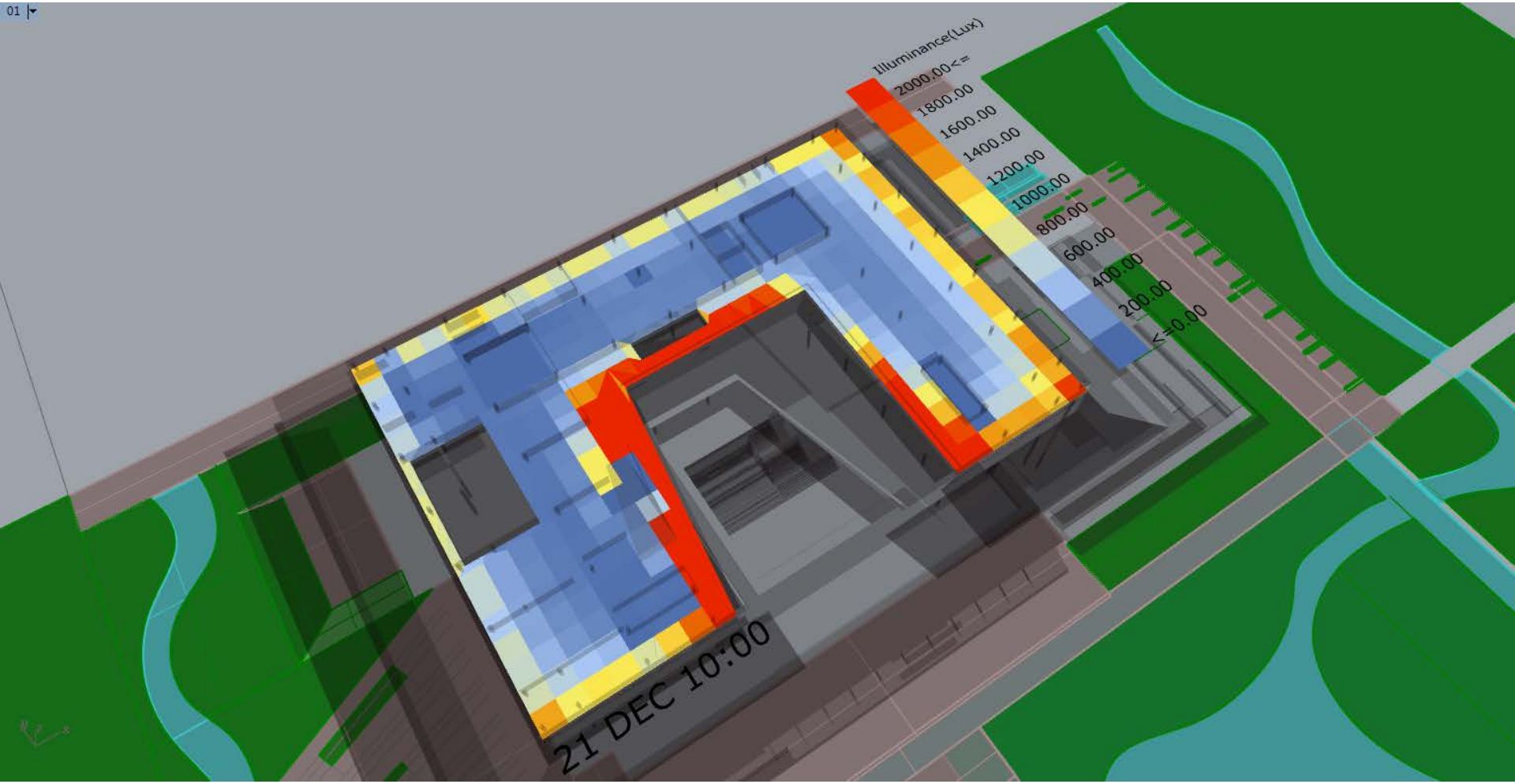
Dec 21st 8AM


01
Illuminance(Lux)
2000.00<=
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
<=0.00
21 DEC 8:00

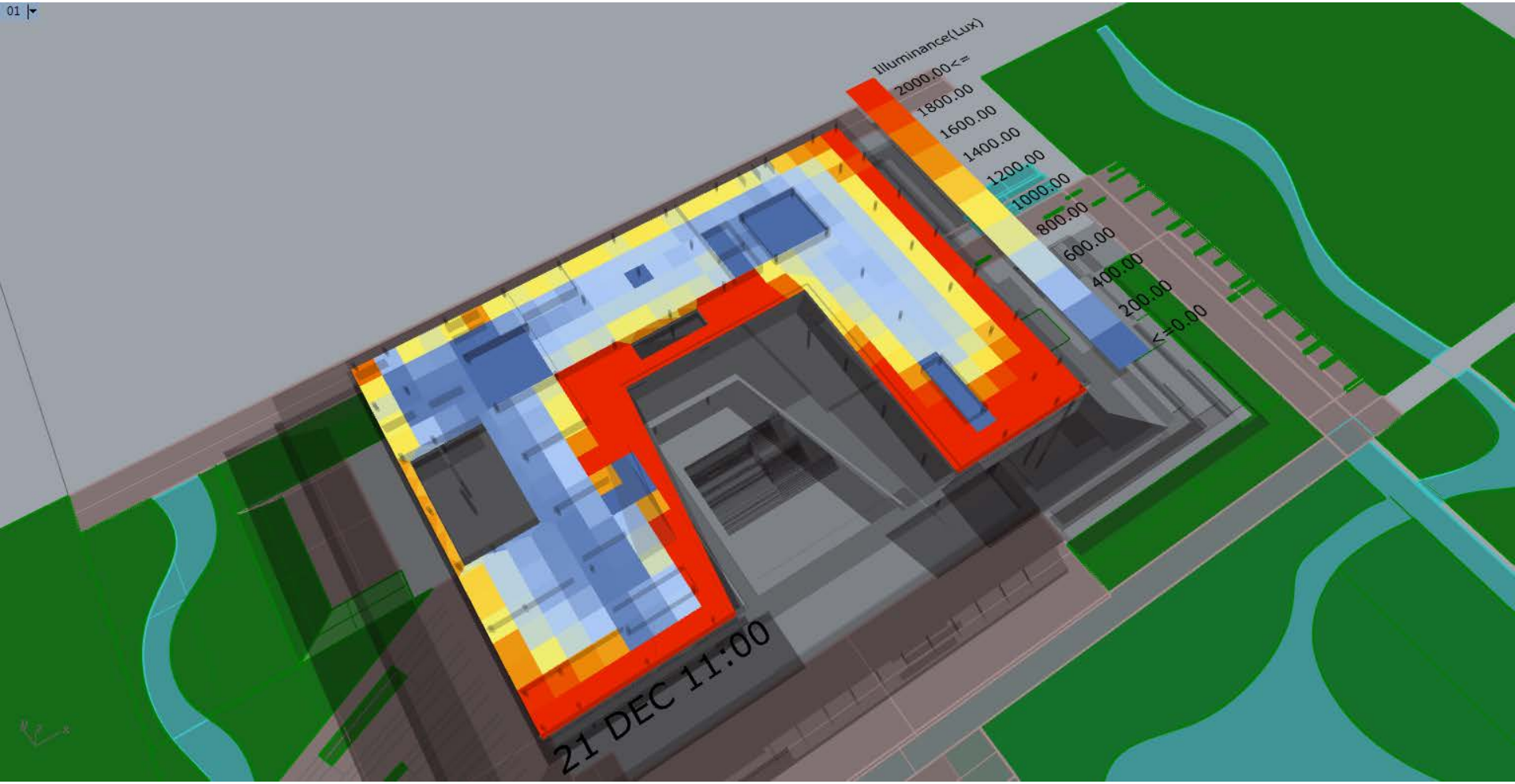
Dec 21st 9AM


01
Illuminance(Lux)
2000.00<=
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
<=0.00
21 DEC 9:00

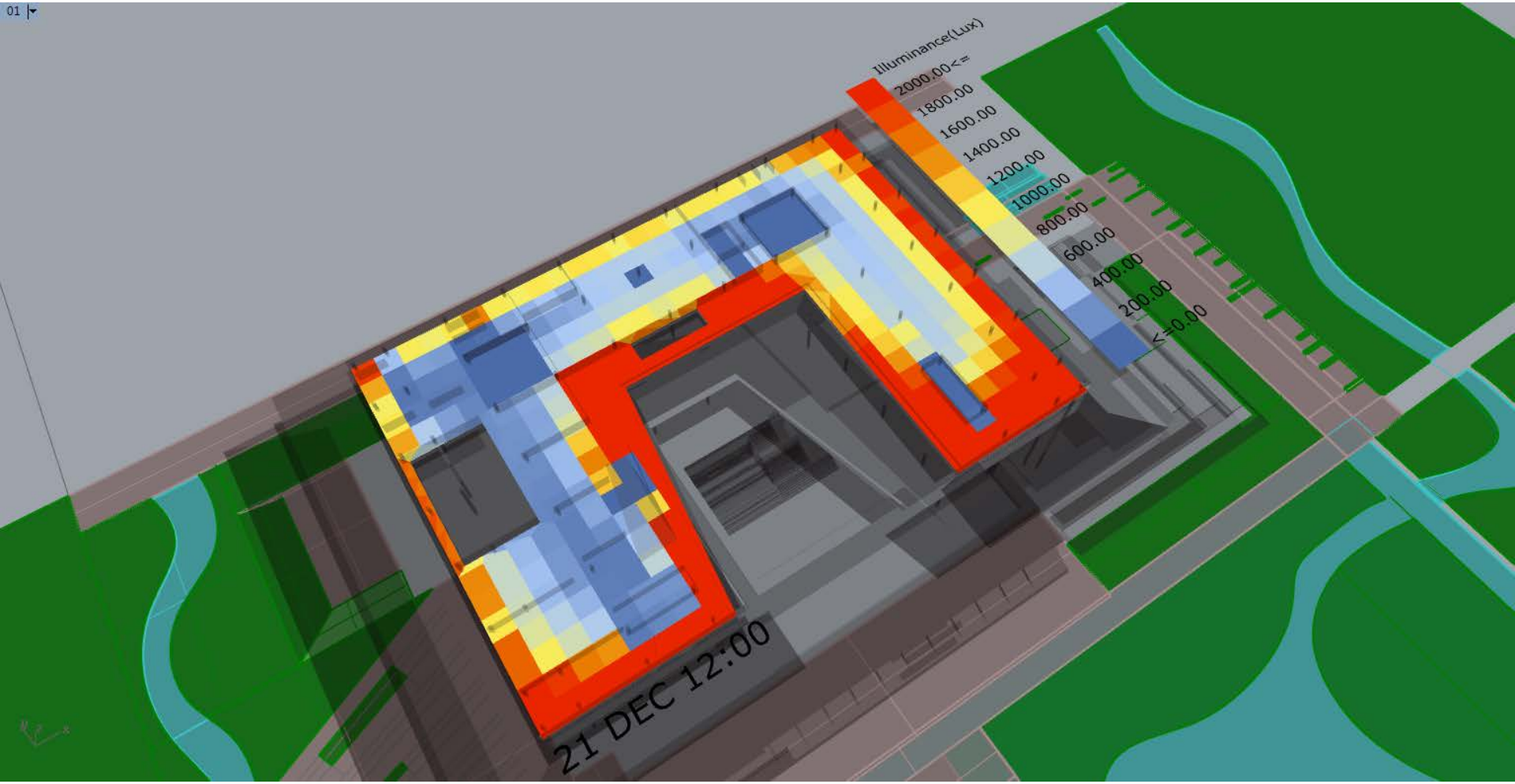
Dec 21st 10AM



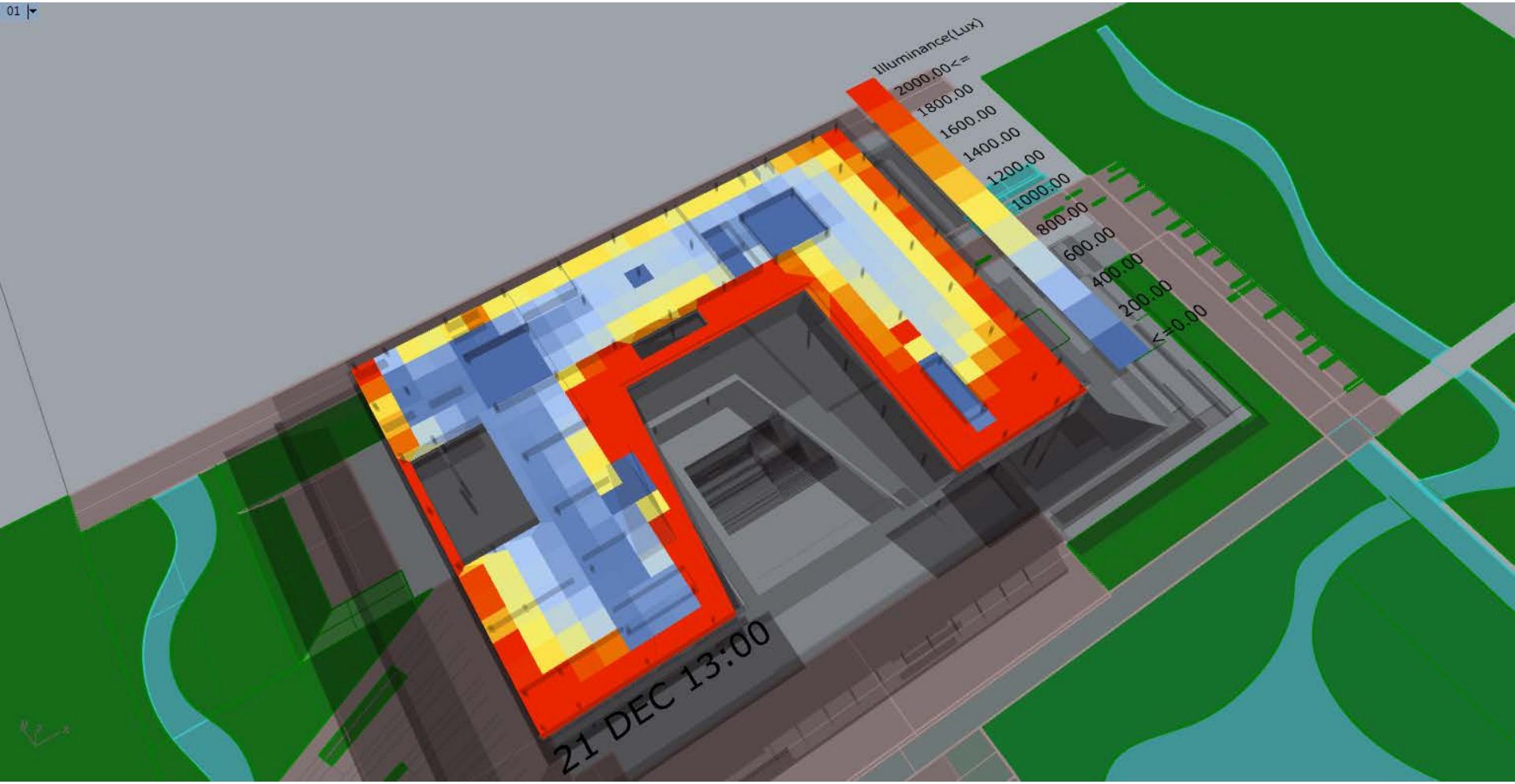
Dec 21st 11AM



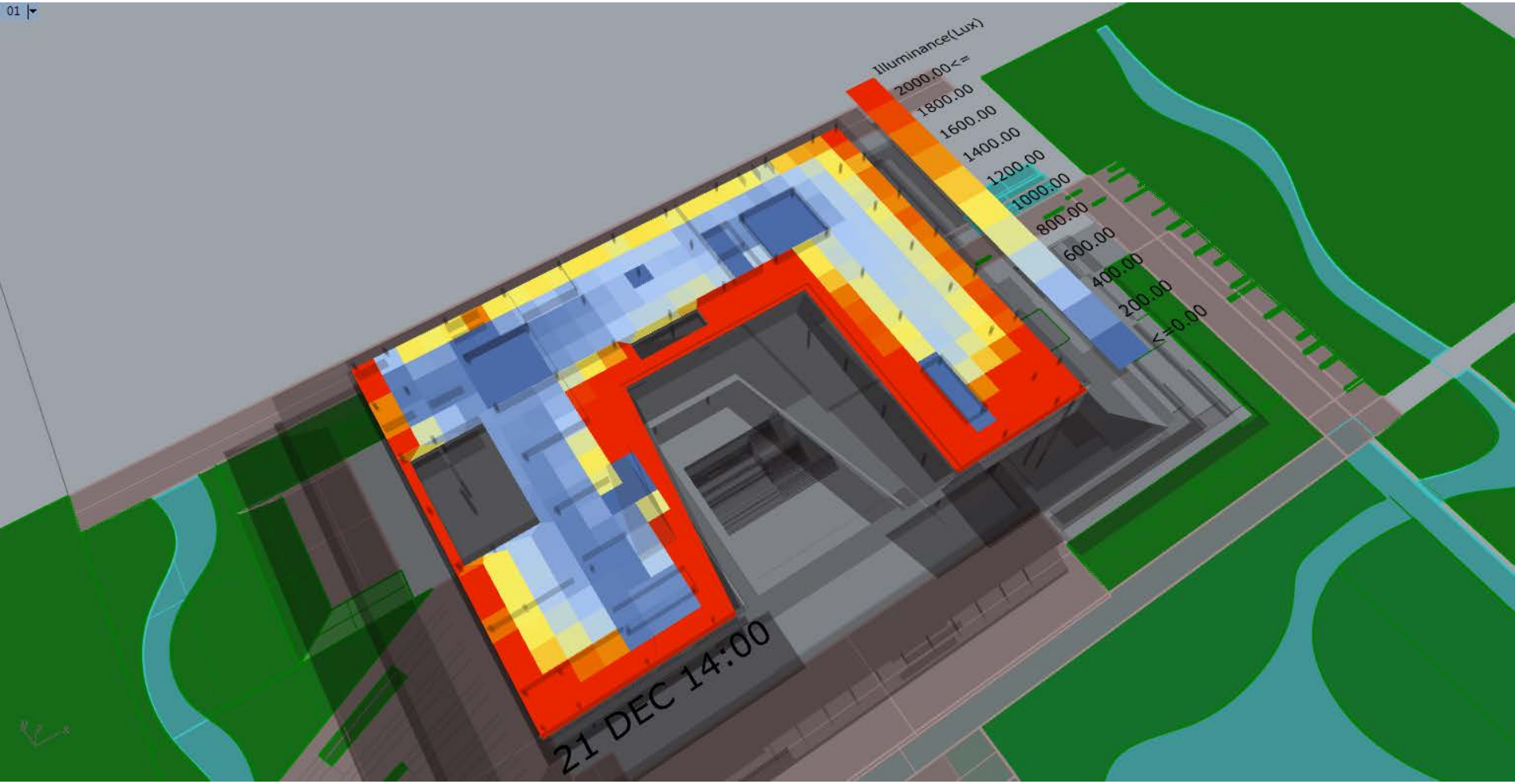
Dec 21st 12PM



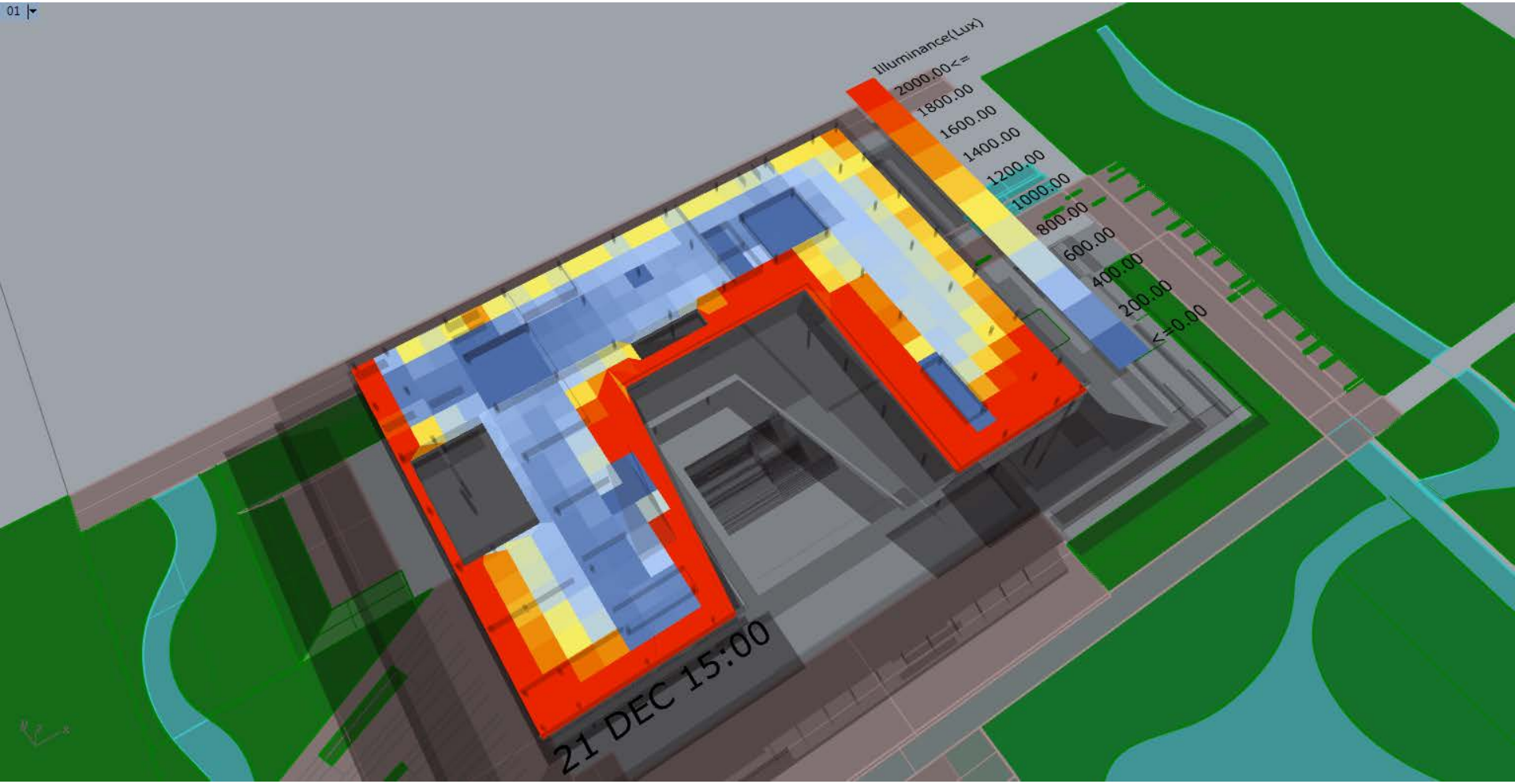
Dec 21st 1PM


01
Illuminance(Lux)
2000.00<=
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
<=0.00
21 DEC 13:00

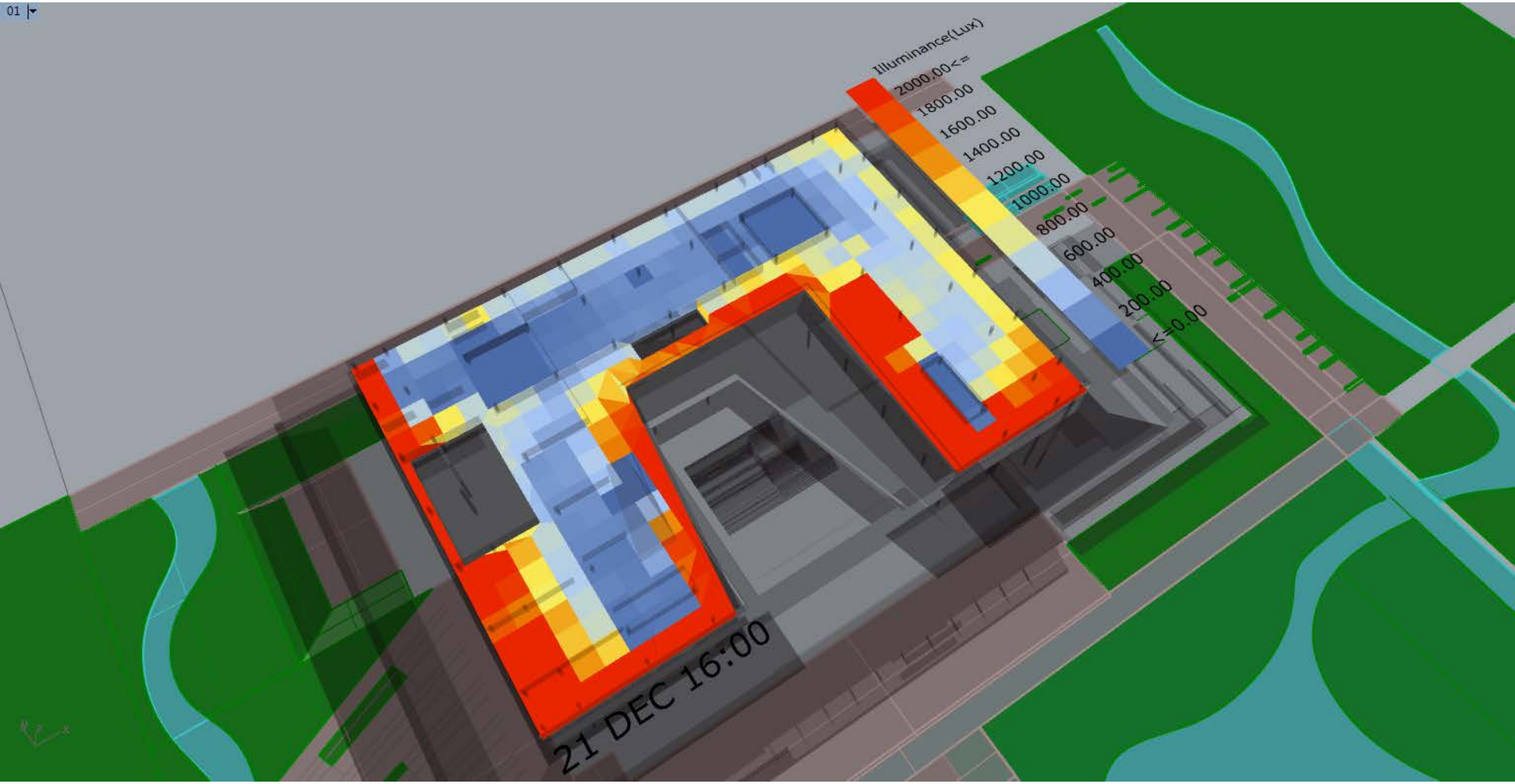
Dec 21st 2PM


01
Illuminance(Lux)
2000.00<=
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
<=0.00
21 DEC 14:00

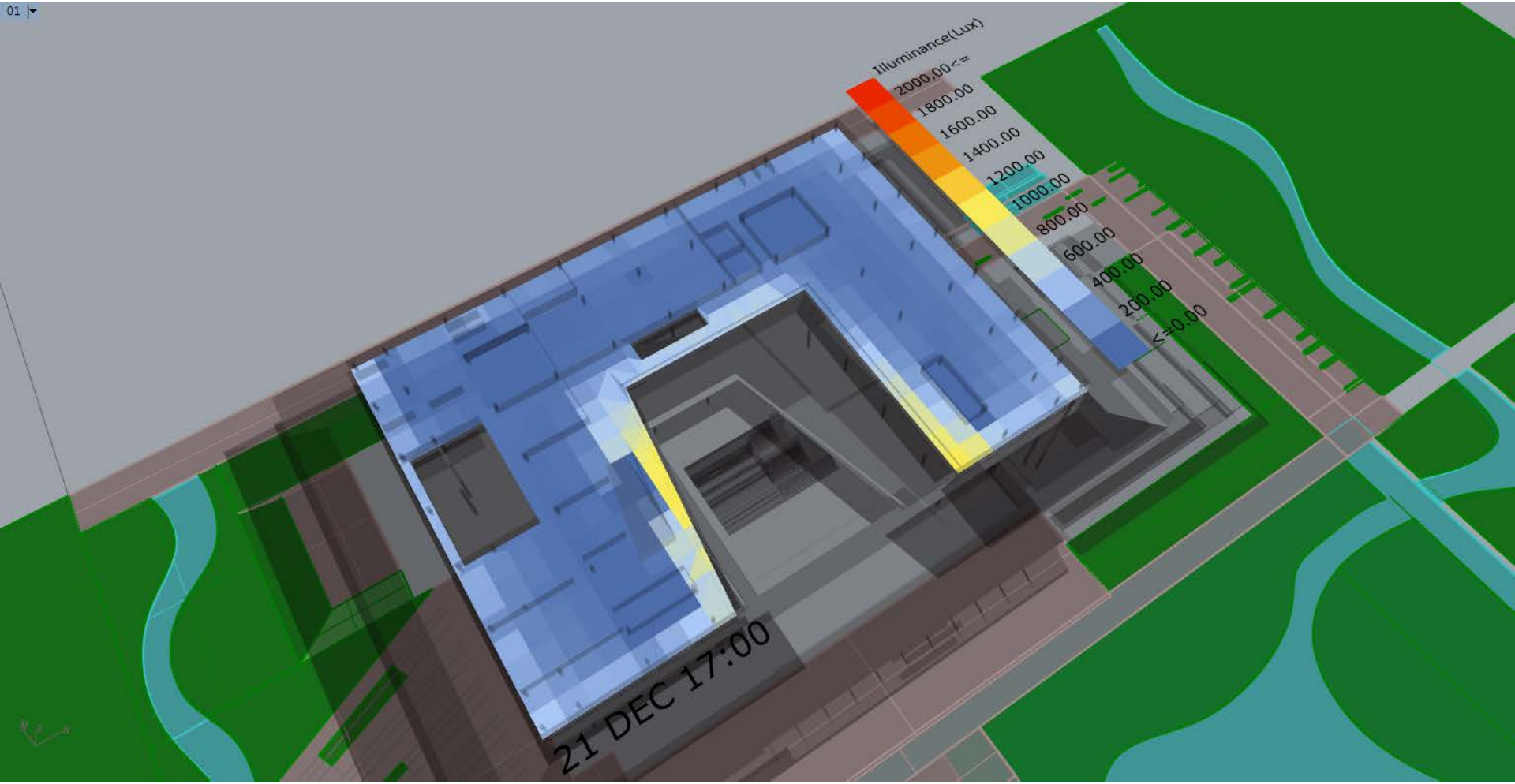
Dec 21st 3PM


01
Illuminance(Lux)
2000.00<=
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
<=0.00
21 DEC 15:00

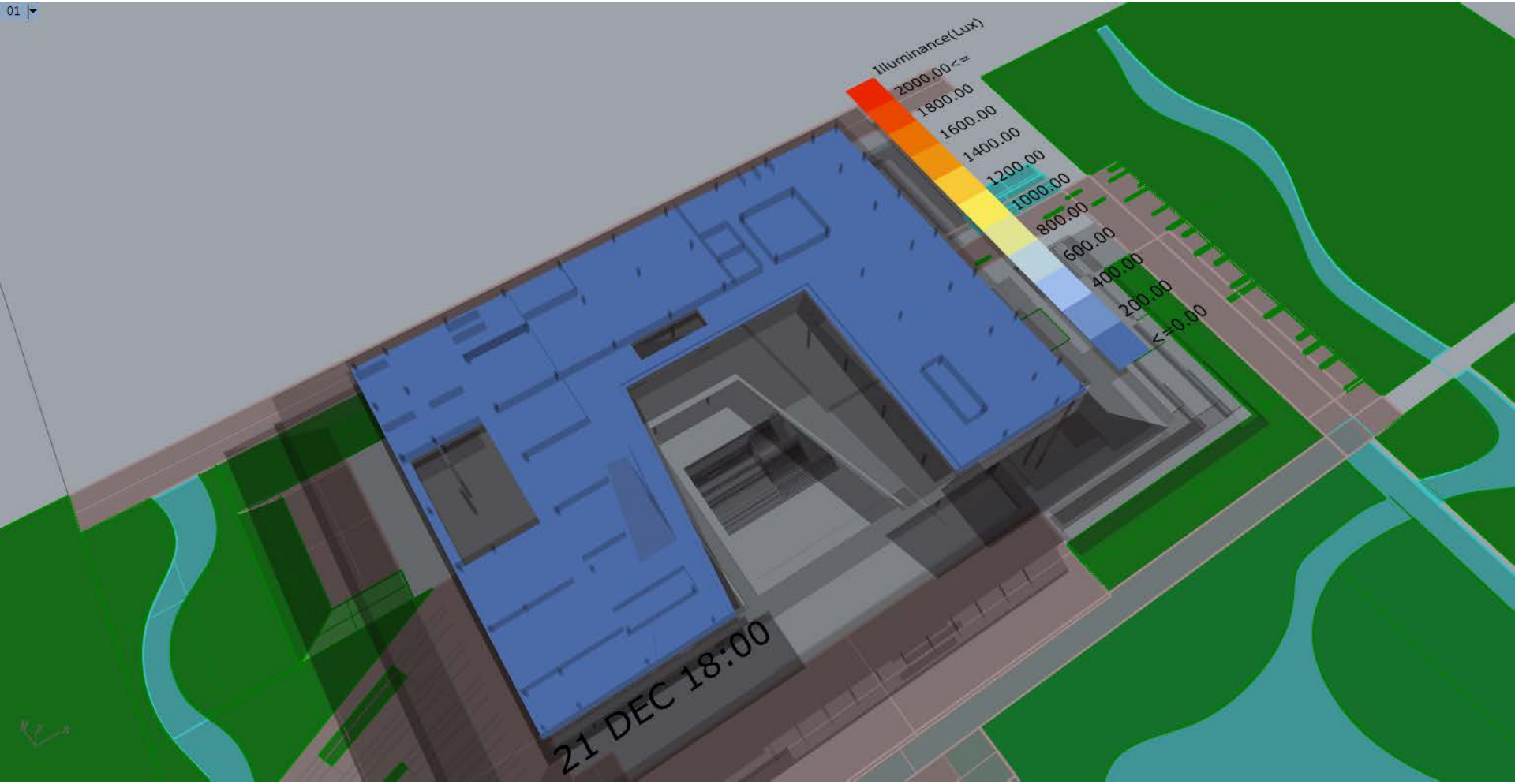
Dec 21st 4PM


01
Illuminance(Lux)
2000.00<=
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
<=0.00
21 DEC 16:00

Dec 21st 5PM

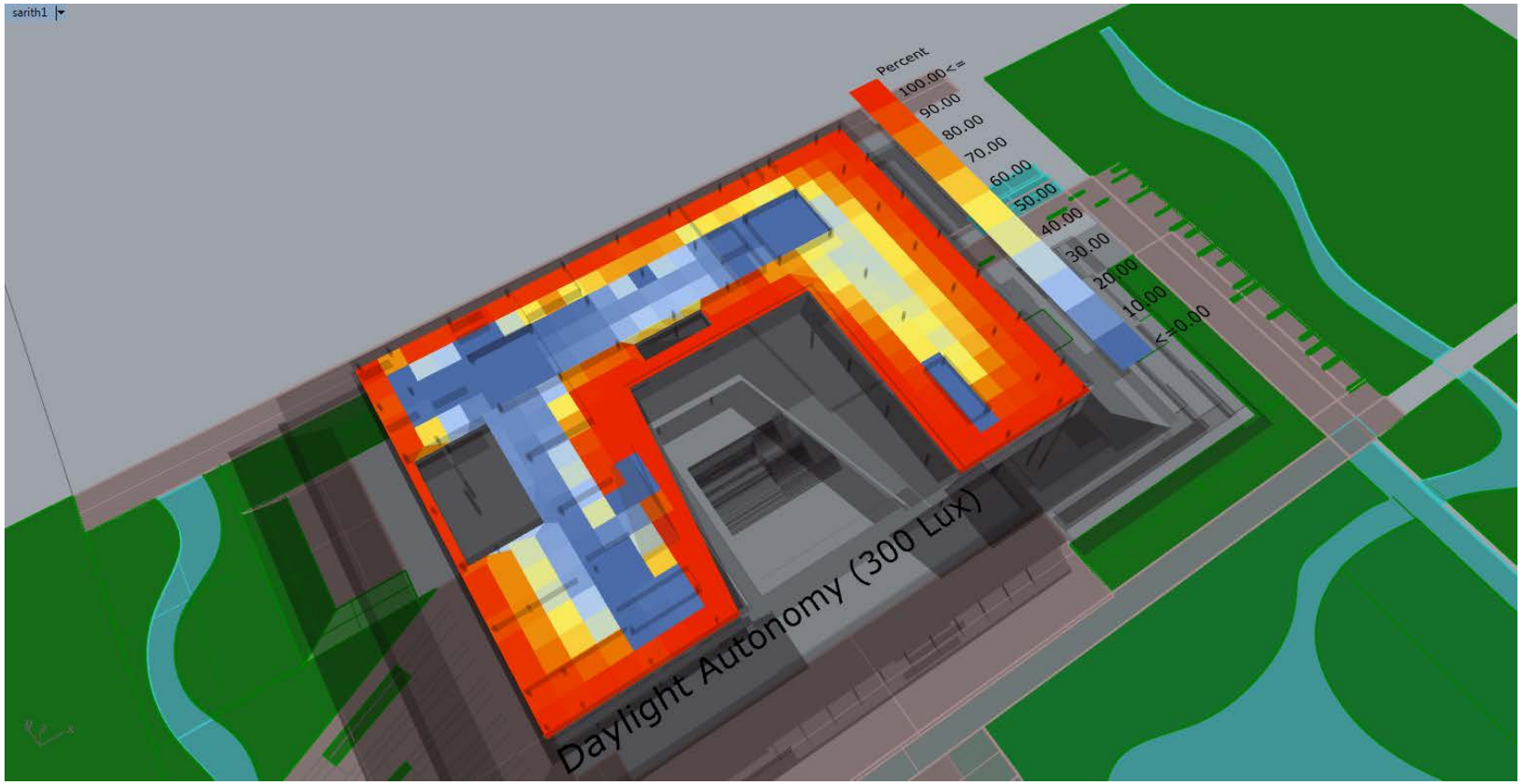

01
Illuminance(Lux)
2000.00<=
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
<=0.00
21 DEC 17:00

Dec 21st 6PM


01
Illuminance(Lux)
2000.00<=
1800.00
1600.00
1400.00
1200.00
1000.00
800.00
600.00
400.00
200.00
<=0.00
21 DEC 18:00

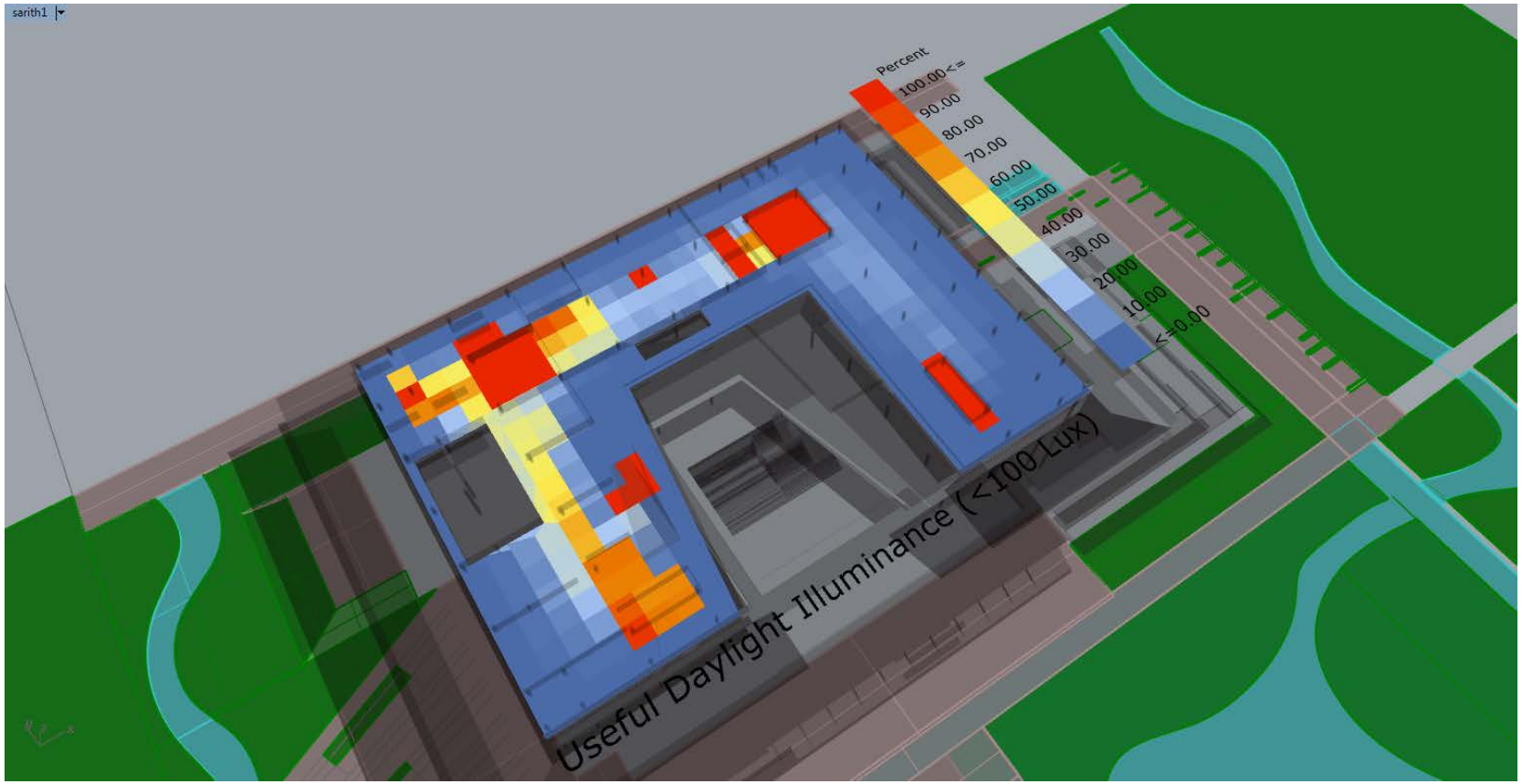
Daylight Autonomy (DA)

Percentage of the time meets target light level



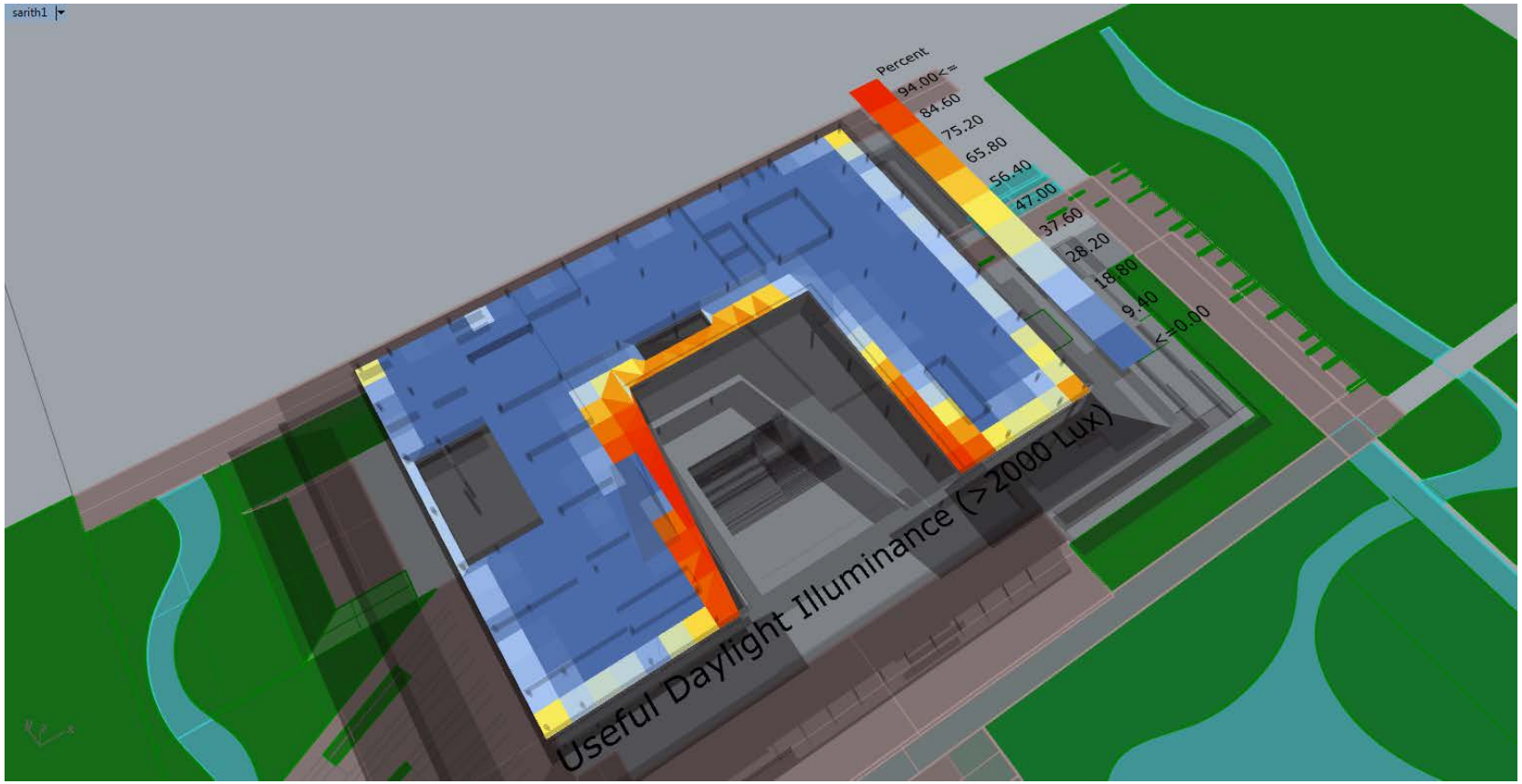
Separate electric lighting in different zones and estimate potential energy savings

Useful Daylight Illuminance
a. < 100 lux



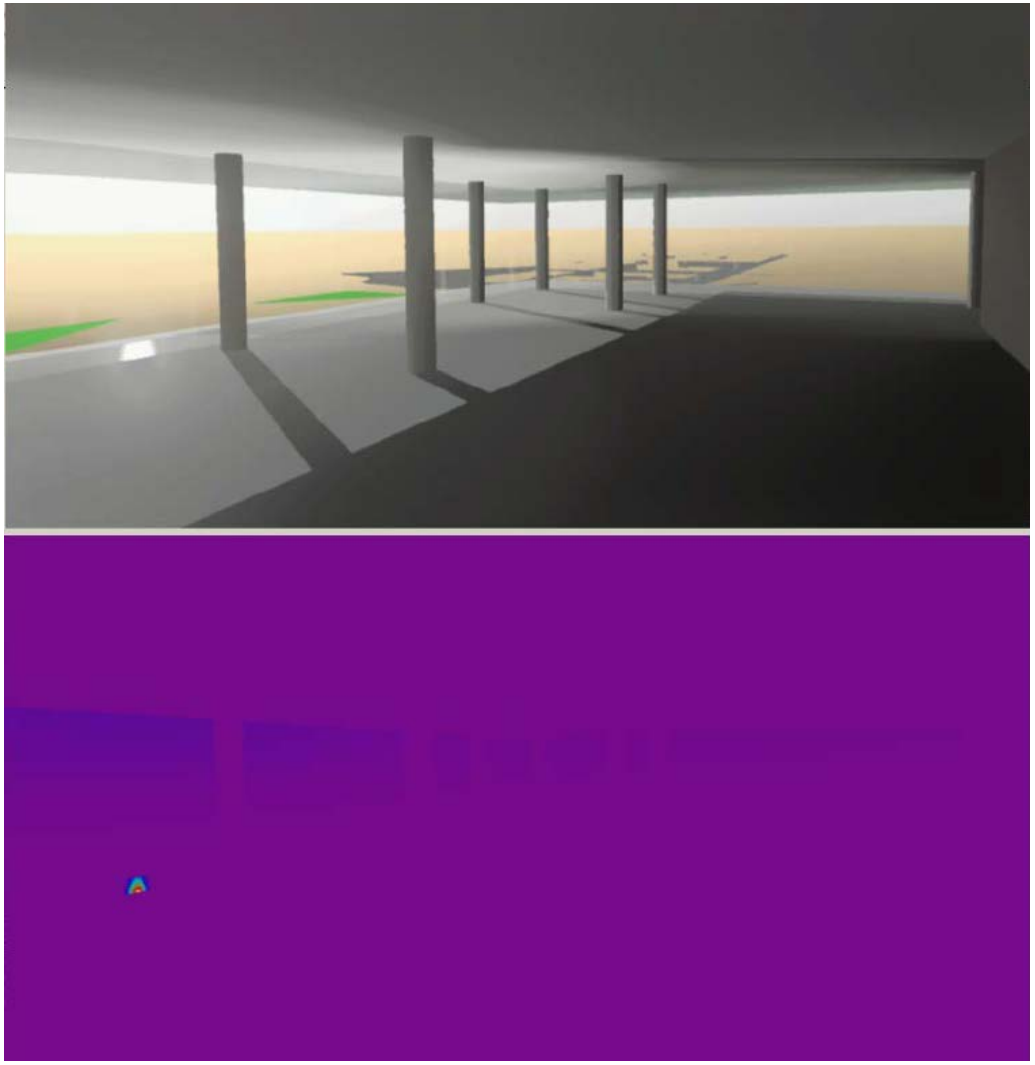
Identify areas have to have electric lighting

Useful Daylight Illuminance
b. > 2000 lux



Consider about shading devices

Identify extremely bright spot due to reflections.



Future trends of CBDM

- Estimate daylight quality for health
- Integrate control system/strategies into simulation
- Model human behavior to estimate energy saving
- Enhance simulation speed and accuracy

Thank you!

Minchen(Tommy) Wei, PhD
Assistant Professor
Dept. of Building Services Engineering
The Hong Kong Polytechnic University
Hung Hom, Hong Kong
Email: minchen.wei@polyu.edu.hk