Energy Conservation Building Code

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Psi Energy Pvt. Ltd.

2017.03.24

Radisson Blu Hotel

Guwahati

An Excerpt…

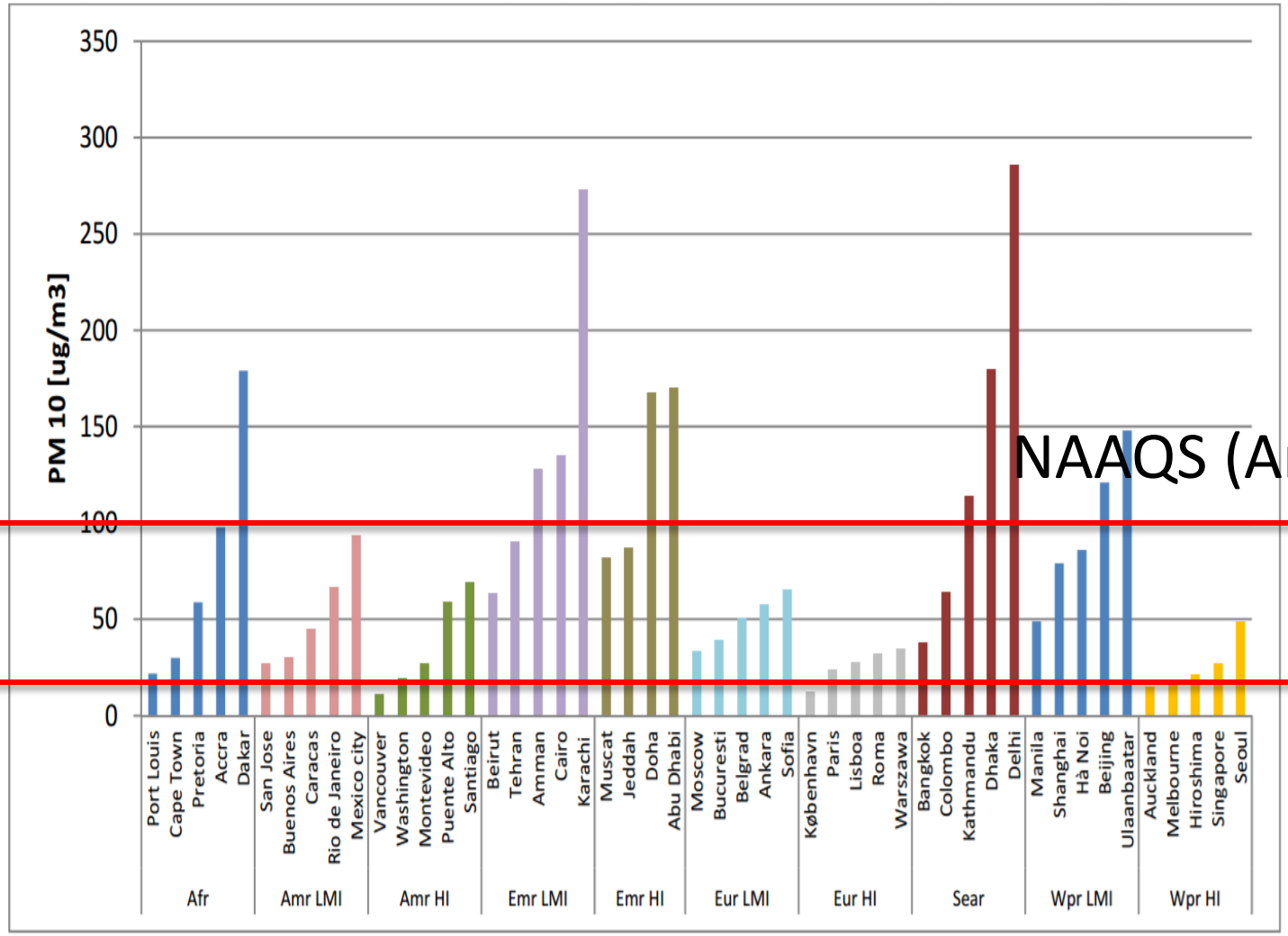
- The built up area in Indian cities will expand exponentially in the coming decade. The new built-up area will be several times more than the current built-up area…
    - From an expert business analysis report
- Mercedez, Audi and BMW dominated the luxury car market in 2015. Affluent Indians will continue to hanker for their dream machines in the next financial year too, experts say…
    - From a major, national news paper

Please notice the vocabulary

“WILL”

The faculty by which a person decides on and initiates action. "she has an iron will”. Synonyms: determination, firmness or fixity of purpose, resolve, resoluteness, purposefulness, single-mindedness, drive, commitment, dedication, doggedness, tenacity

Figure 3: *PM_{10} levels for selected cities by region, for the last available year in the period 2008-2012.*

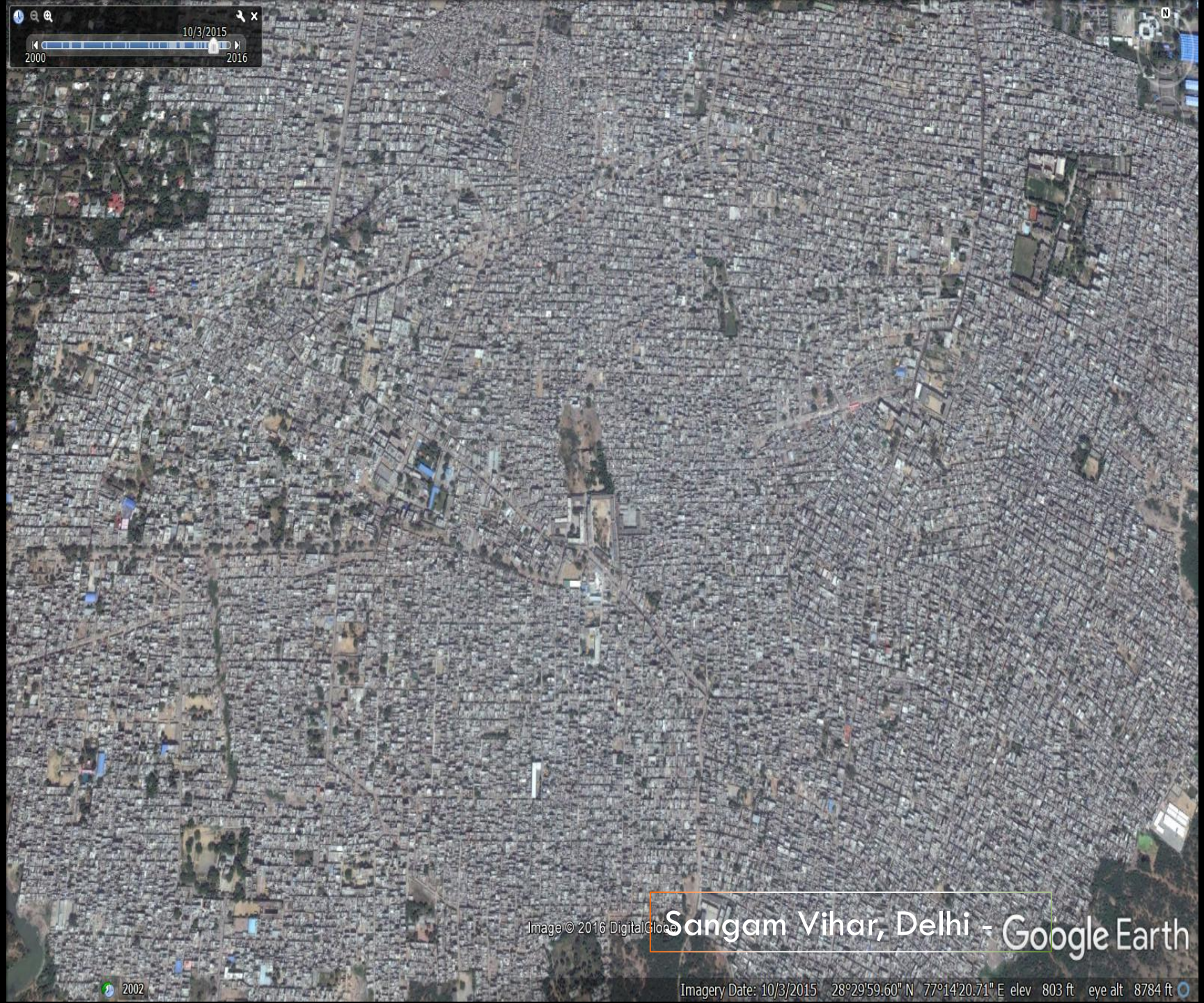


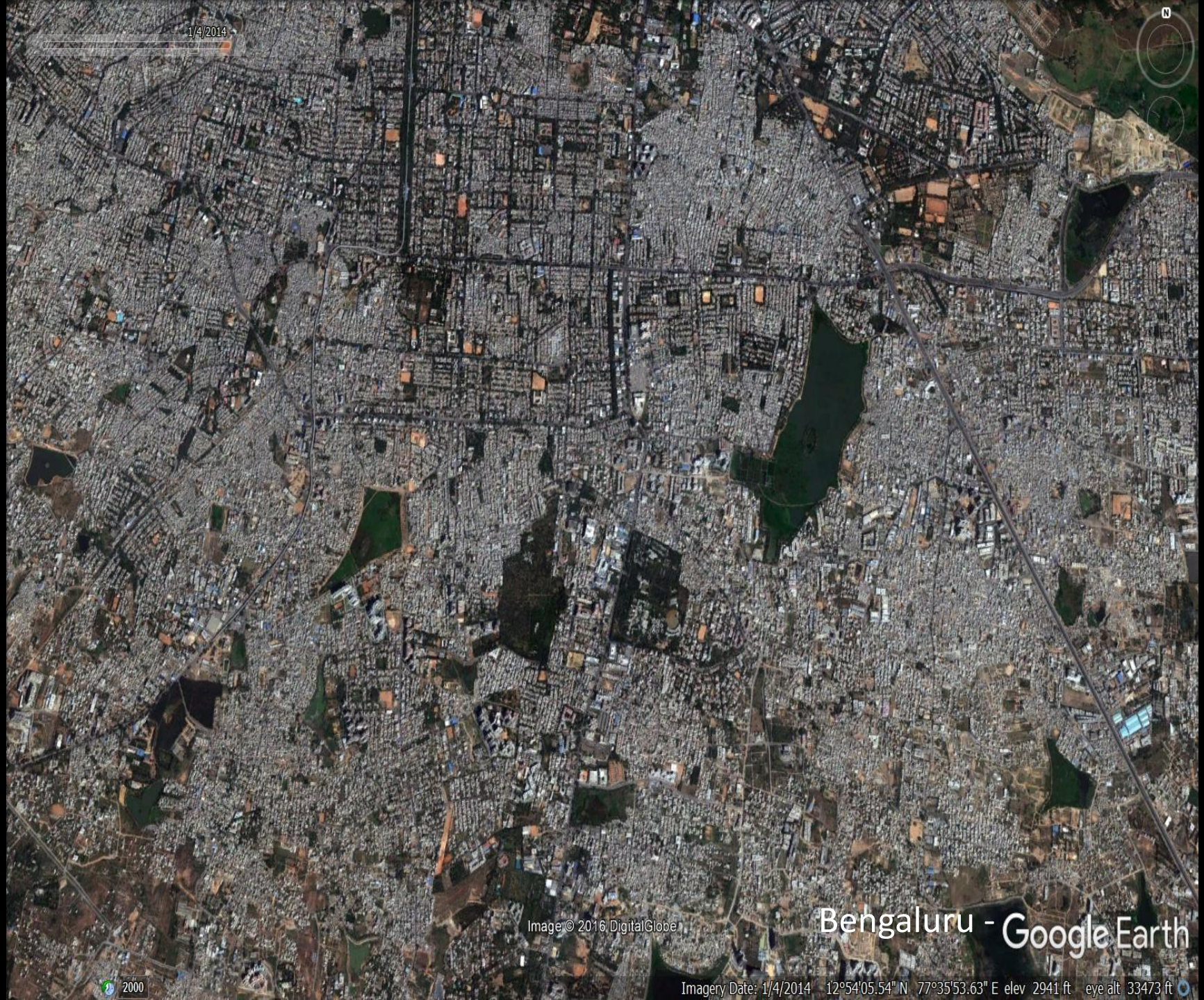
PM_{10}: Fine particulate matter of 10 microns or less; Afr: Africa; Amr: America; Emr: Eastern Mediterranean; Eur: Europe; Sear: South-East Asia; Wpr: Western Pacific; LMI: Low- and middle-income; HI: high-income.

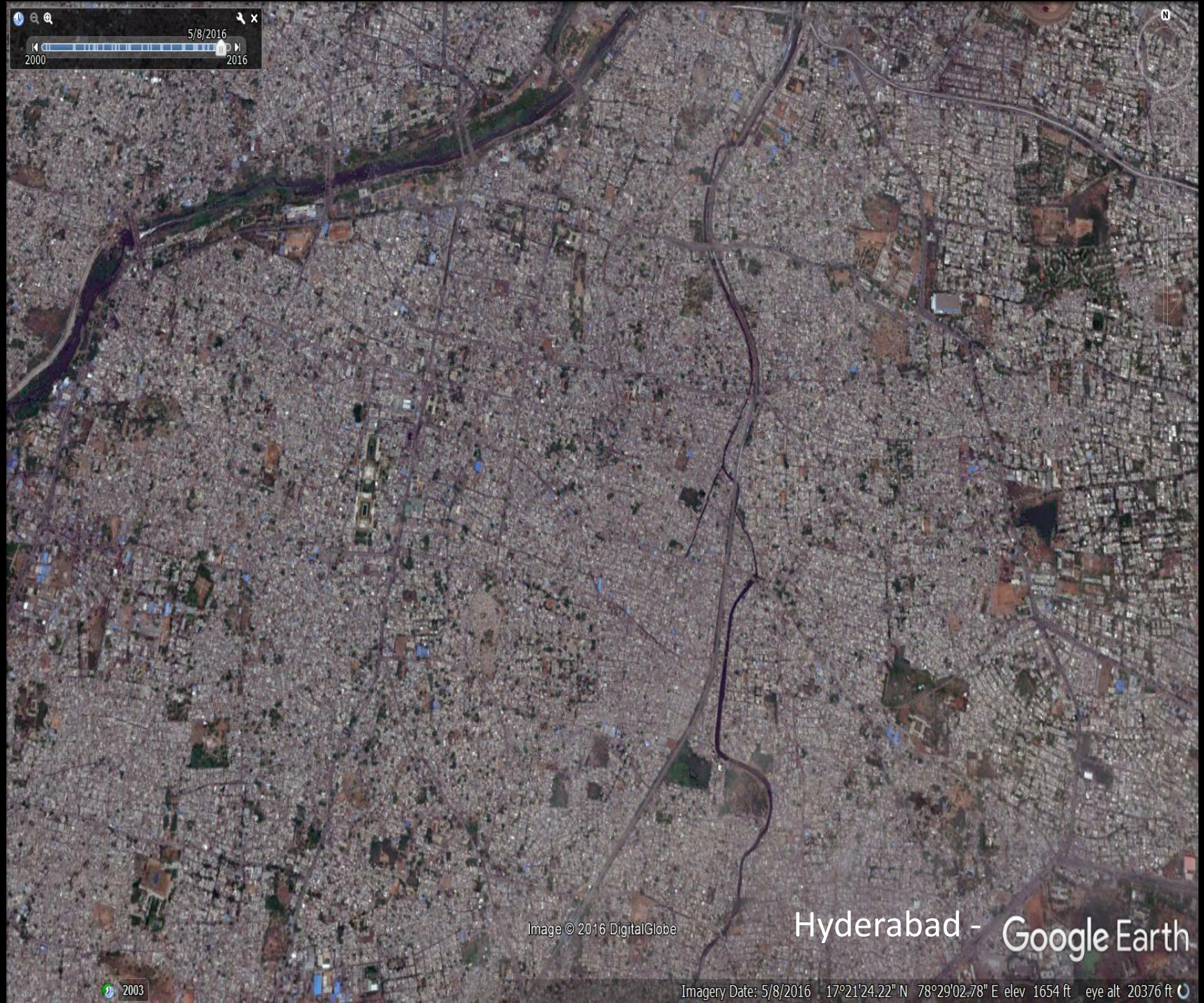
World Health Organization

Image Source: The Hindustan Times

Image Source: Flickr | Rajarshi MITRA | The Flood gates have opened | CC-BY-2.0


10/3/2015
2000
2016
Image © 2016 DigitalGlobe
Sangam Vihar, Delhi - Google Earth
2002
Imagery Date: 10/3/2015 28°29'59.60" N 77°14'20.71" E elev 803 ft eye alt 8784 ft


1/4/2014
N
Image © 2016 DigitalGlobe
Bengaluru - Google Earth
2000
Imagery Date: 1/4/2014 12°54'05.54" N 77°35'53.63" E elev 2941 ft eye alt 33473 ft


5/8/2016
2000
2016
Image © 2016 DigitalGlobe
Hyderabad - Google Earth
2003
Imagery Date: 5/8/2016 17°21'24.22" N 78°29'02.78" E elev 1654 ft eye alt 20376 ft

So, reiterating…

- "The built-up area in Indian cities will expand phenomenally in the coming decade. The new construction will be several folds more than the current size of the built-up area"
  - » From a report by a major business house

WERE YOUR ANCESTORS SUSTAINABLE?

HAVE ANY OF YOU EVERY DESIGNED AN INEFFICIENT BUILDING OR SYSTEM?

THEN WHERE IS THE PROBLEM?

It is important to marry the concepts in the NBC and other BIS codes with the ECBC for best results in your buildings.

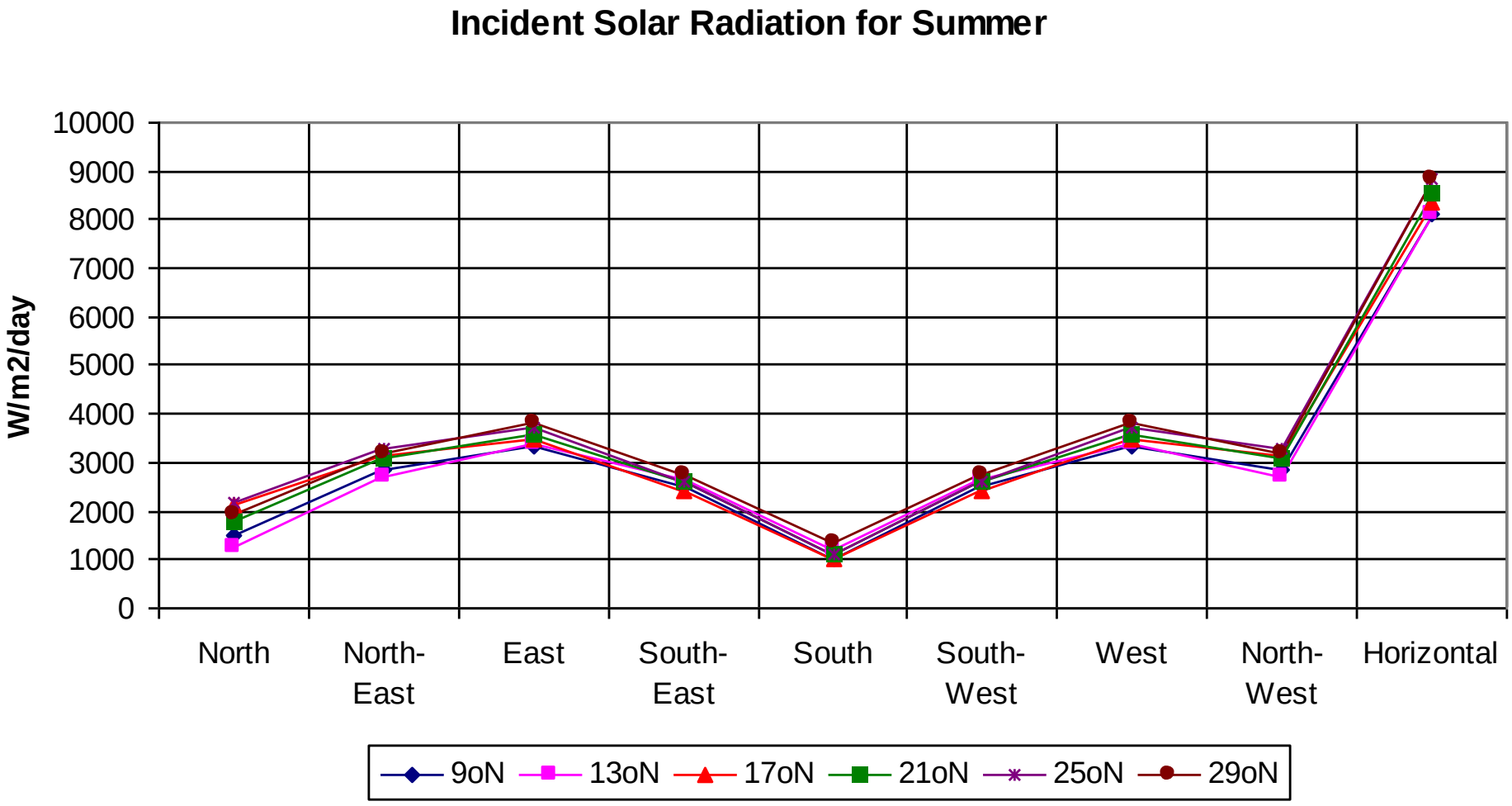
INESCAPABLE LOGIC – BEFORE ECBC

Table 3 Total Solar Radiation (Direct plus Diffused) Incident on Various Surfaces of Buildings in W/m2/day for Summer and Winter Seasons (Clause 3.4.1)

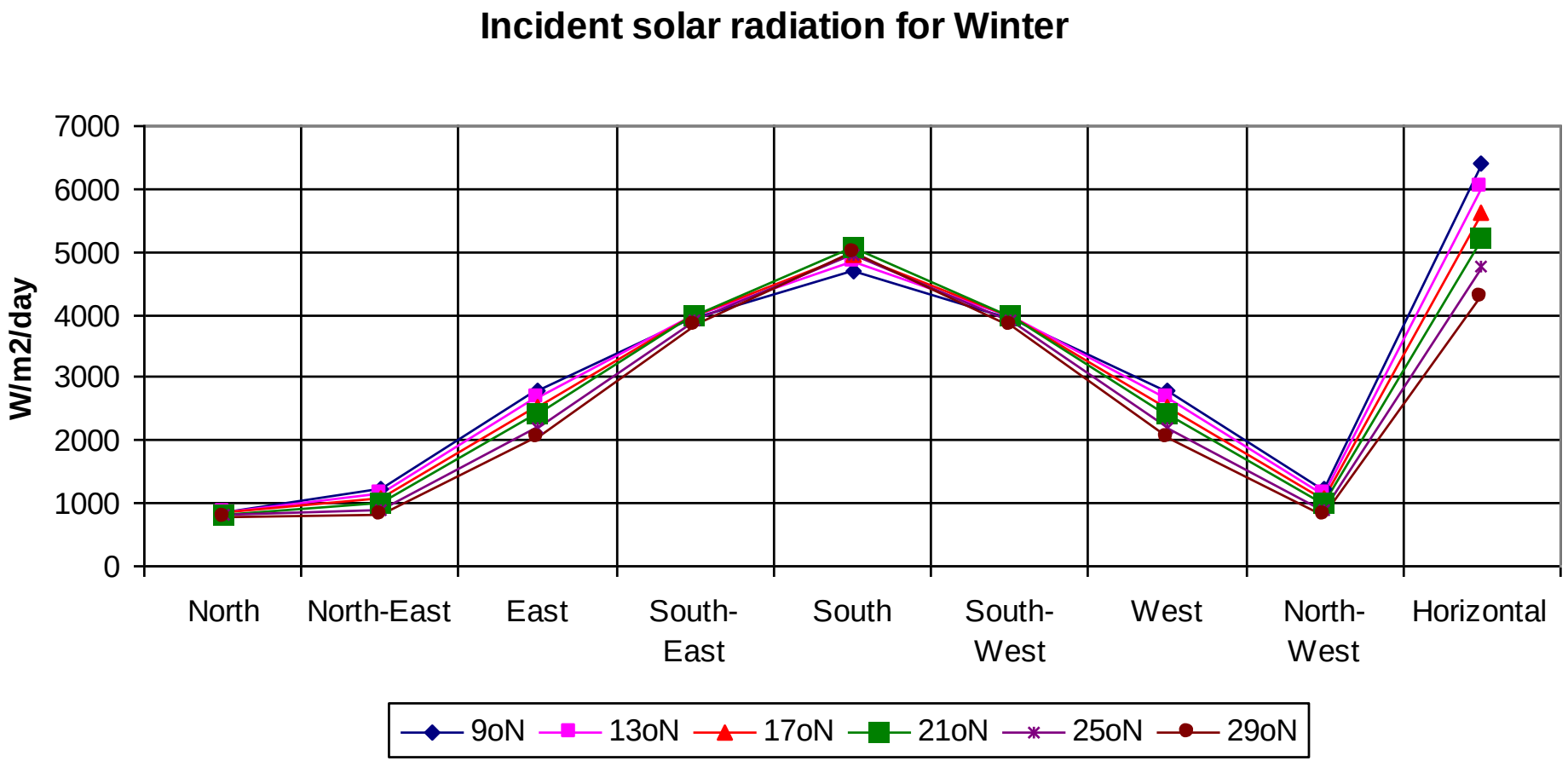
Orientation		Latitude					
		9oN	13oN	17oN	21oN	25oN	29oN
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
North	Summer	1494	1251	2102	1775	2173	1927
	Winter	873	859	840	825	802	765
North-East	Summer	2836	2717	3144	3092	3294	3189
	Winter	1240	1158	1068	1001	912	835
East	Summer	3344	3361	3475	3598	3703	3794
	Winter	2800	2673	2525	2409	2211	2055
South-East	Summer	2492	2660	2393	2629	2586	2735
	Winter	3936	3980	3980	3995	3892	3818
South	Summer	1009	1185	1035	1117	1112	1350
	Winter	4674	4847	4958	5059	4942	4981
South-West	Summer	2492	2660	2393	2629	2586	2735
	Winter	3936	3980	3980	3995	3892	3818
West	Summer	3341	3361	3475	3598	3703	3794
	Winter	2800	2673	2525	2409	2211	2055
North-West	Summer	2836	2717	3144	3092	3294	3189
	Winter	1240	1158	1068	1001	912	835
Horizontal	Summer	8107	8139	8379	8553	8817	8863
	Winter	6409	6040	5615	5231	4748	4281

Source: Table-3, National Building Code-2005

Incident solar radiation in summer for India

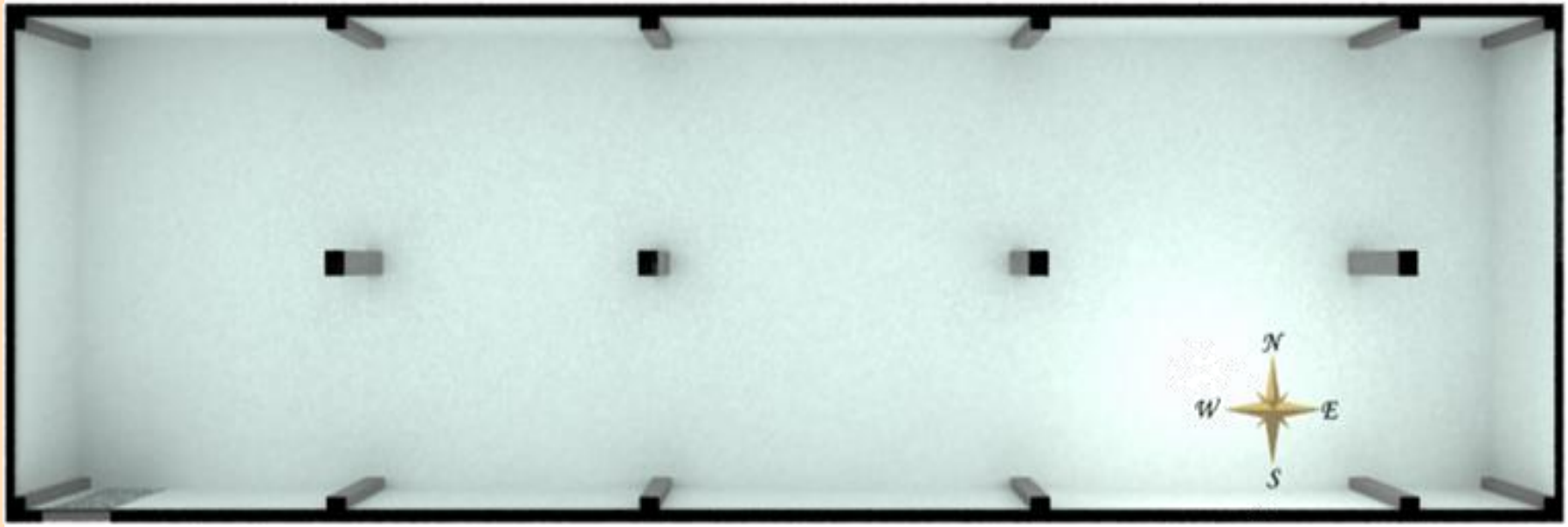


Incident solar radiation in winter for India



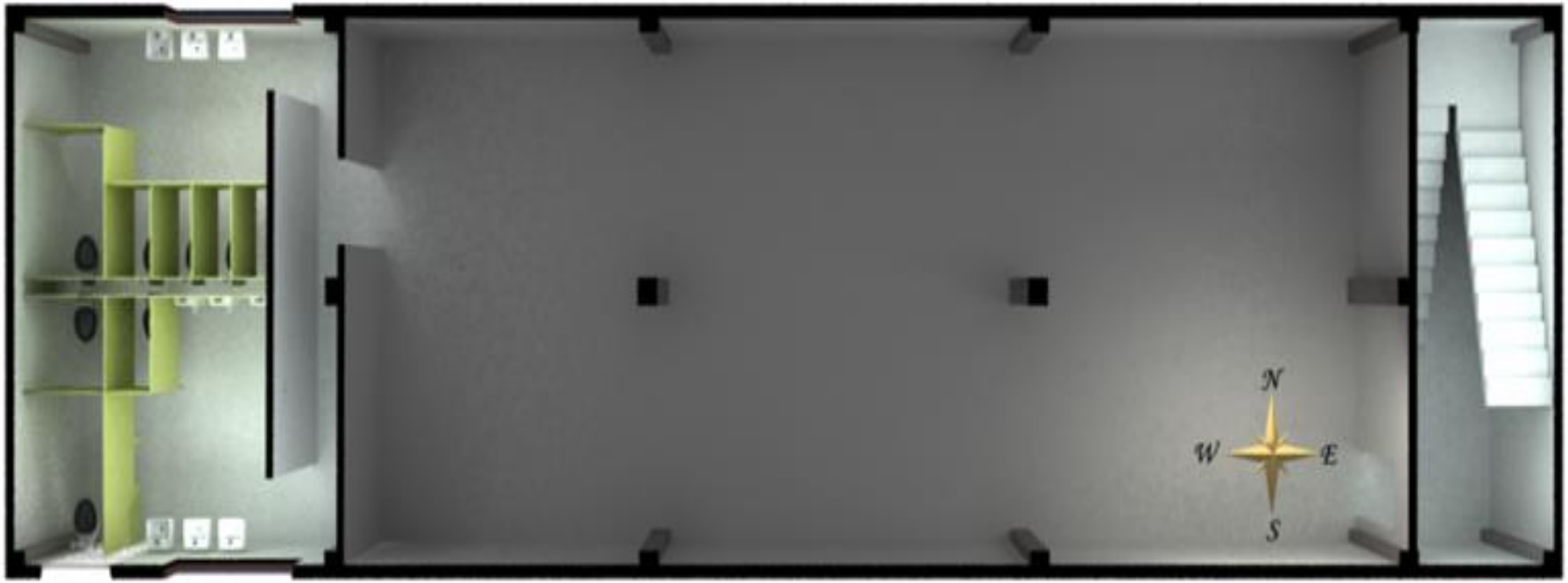
Optimize building orientation

- Orient major facades of your building along North and South



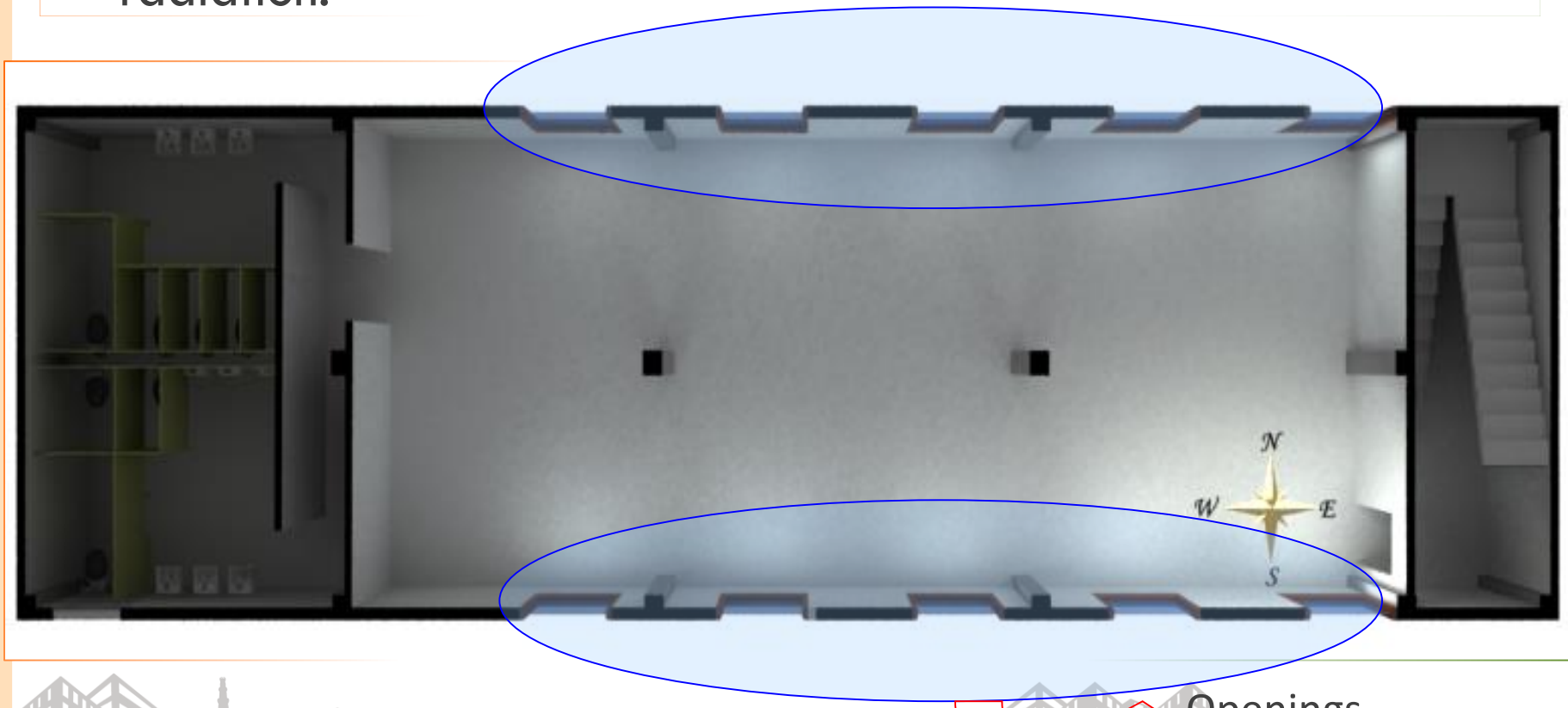
Buffer spaces along E & W

- Place the buffer spaces (such as- toilets, corridors, staircases, lifts and service areas etc.) along western and eastern facades.



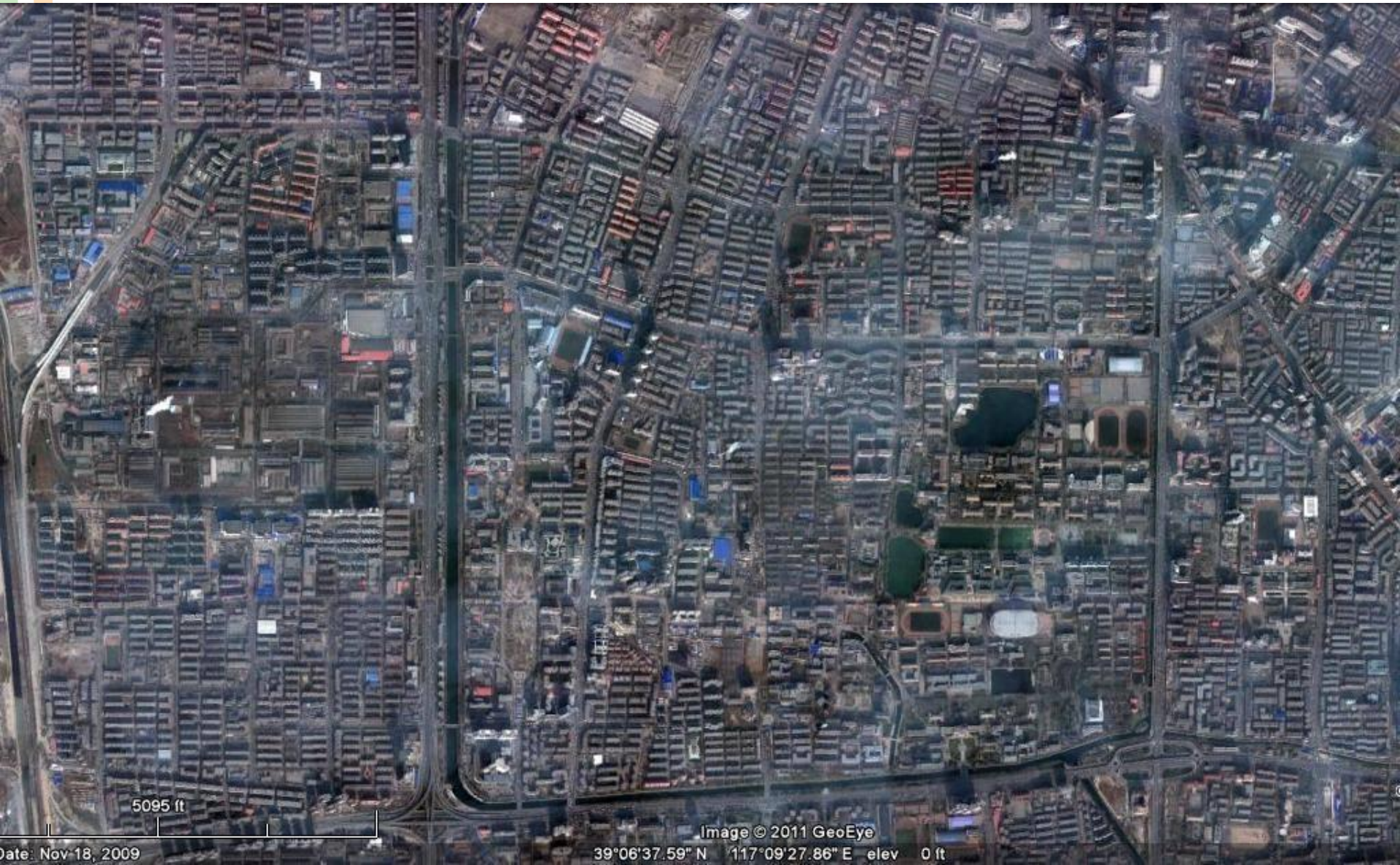
Maximum openings on N & S

- Maximum opening should be provided along the north and south facades to avail maximum daylight and minimum solar radiation.

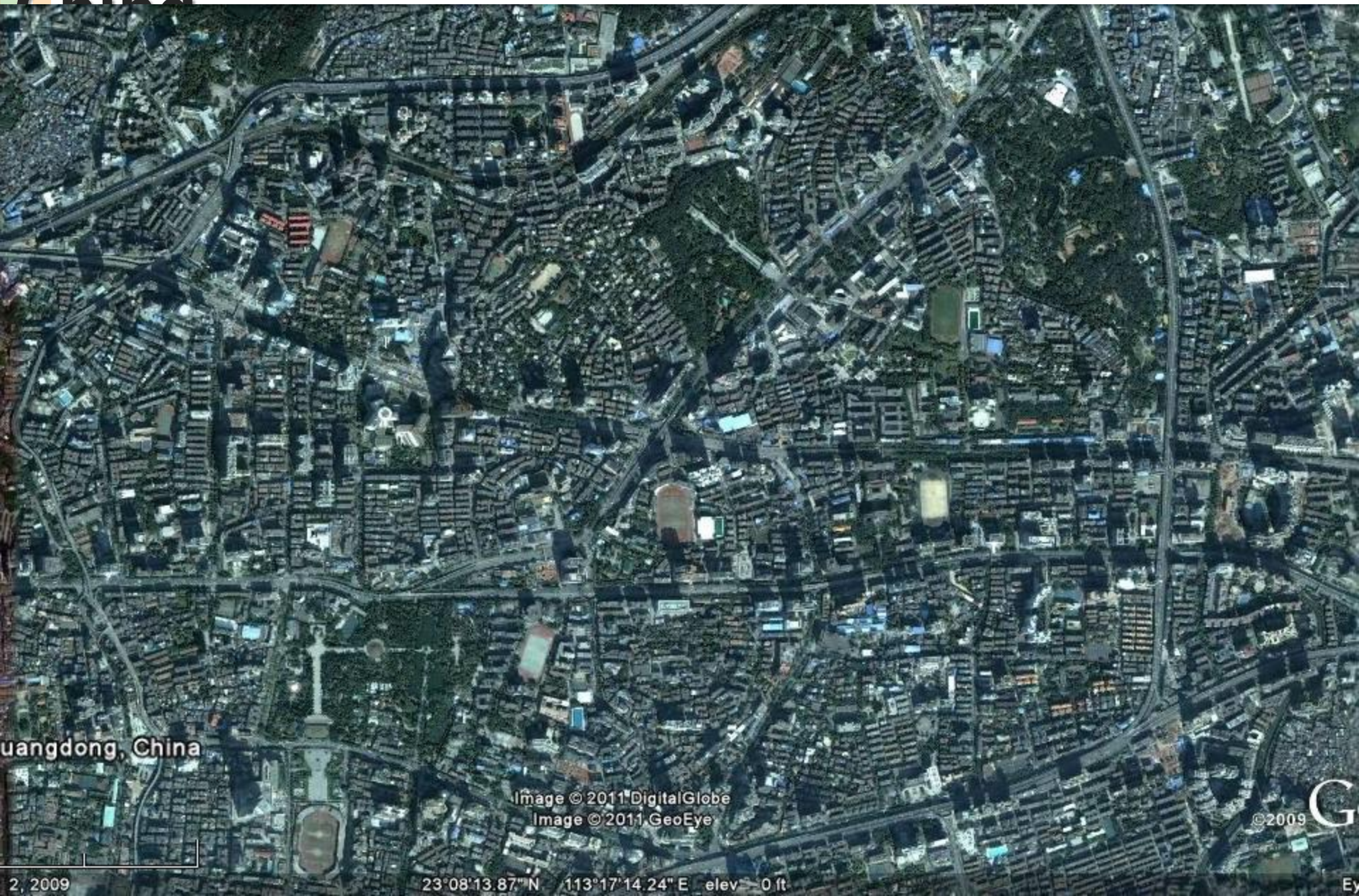


BUT ENTIRE CITIES CANT BE ORIENTED IN THE SAME DIRECTION BHAI!!!

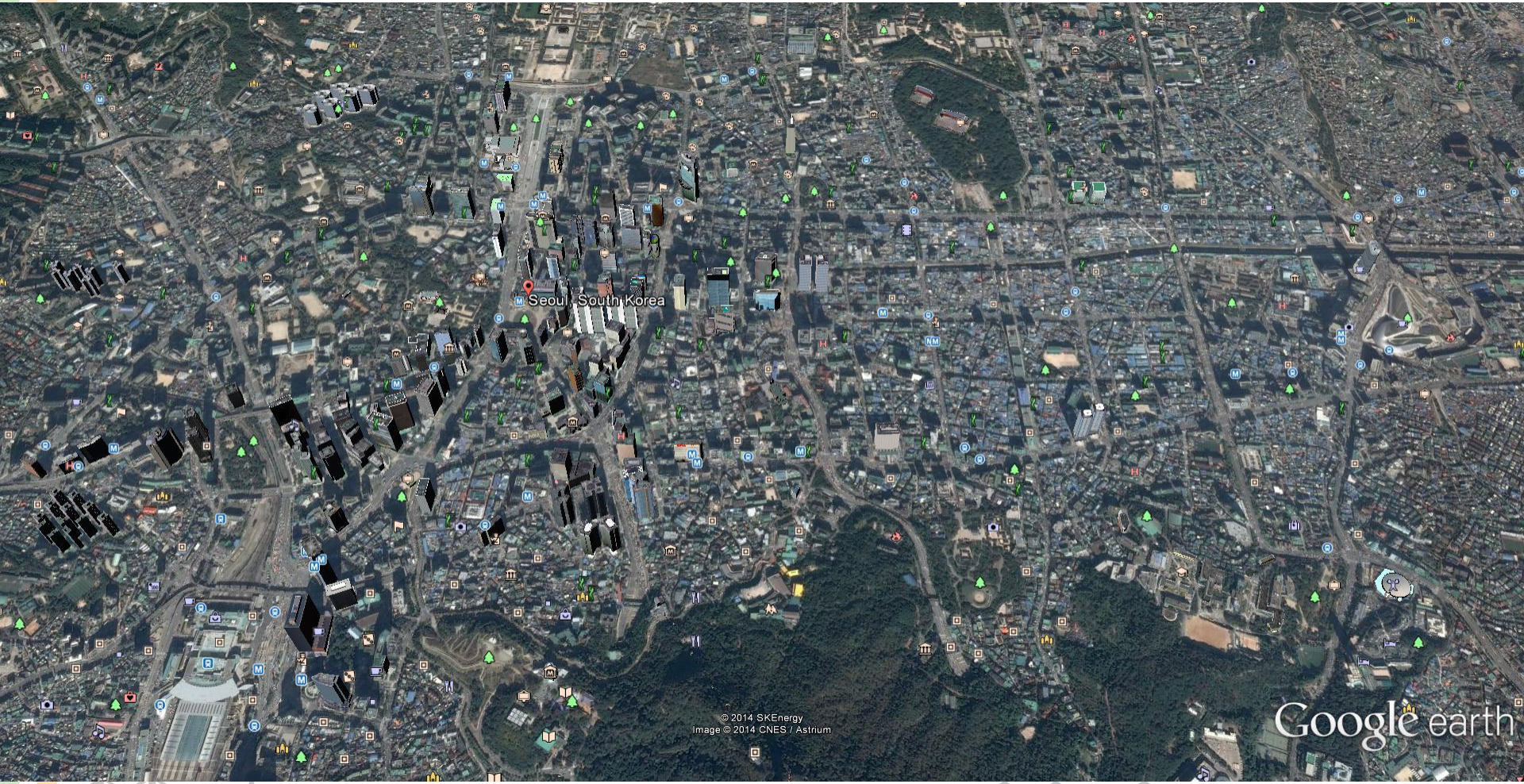
Google earth image of Tianjin - China



Google earth image of Guangzhou - China



Google Earth Image of Seoul, Korea



- The WWR (window to wall ratio) is limited to a maximum of 60% of gross wall area and the SSR (skylight to roof ratio) is limited to a maximum of 5% of gross roof area (as prescribed in Energy Conservation Building Code (ECBC)-2007).

SHGC Requirement for vertical fenestration & skylight

Climate	Maximum SHGC			
	WWR < 40%	40% < WWR < 60%	0% < SRR < 2%	2.1% < SRR < 5%
Composite	0.25	0.2	0.4	0.25
Hot and Dry	0.25	0.2	0.4	0.25
Warm and Humid	0.25	0.2	0.4	0.25
Moderate	0.4	0.3	0.61	0.4
Cold	0.51	0.51	0.61	0.4

13.1 Commitment

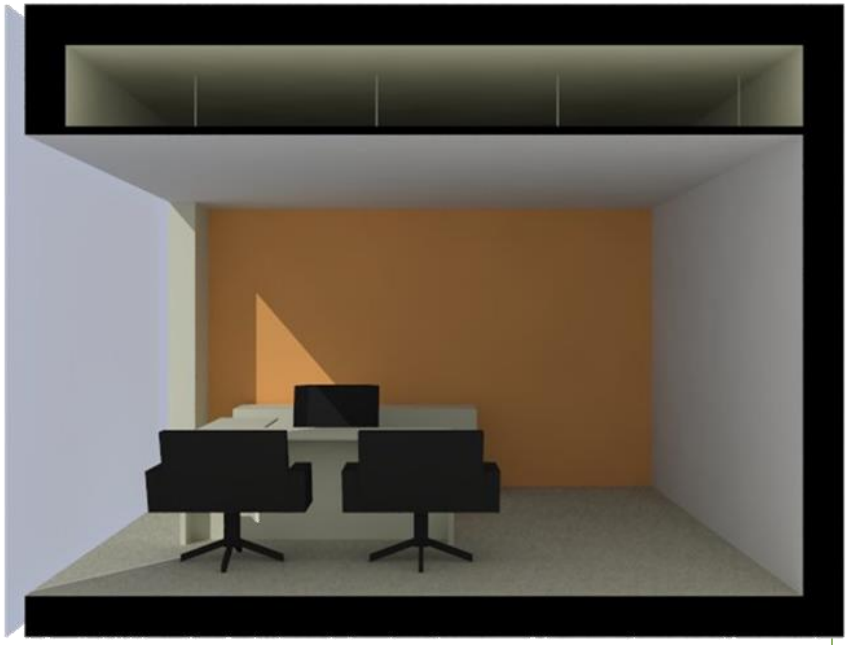
- 13.1.4 Ensure that the total day lighted area* (as defined in the Appendix-A of ECBC-2007) of the proposed building is ≥ 25% of the total living area* (areas listed in table-2, SP41); and achieve the recommended DF* (as prescribed in table-2, SP41) at the centre of the daylighted area or the average on the daylighted area in a design sky condition* (as recommended in Part-8 of National Building Code -2005) to fetch two mandatory points.

  - For every 25% increase in the total daylighted area upon the total living area shall fetch one additional point on each. This shall however be non mandatory.

- Note: The daylight clause is not mandatory for all other living spaces that are not listed in the table-2 (Sp41) however similar points can be awarded for respective daylighted area as mentioned above and DF can be decided based on project specific daylight requirement.

Window Wall Ratio

- Window-Wall-Ratio (WWR) : The Window Wall Ratio refers to the ratio of the total fenestration area to the gross wall area.
- ECBC in a prescriptive approach recommends a maximum WWR of 60%.



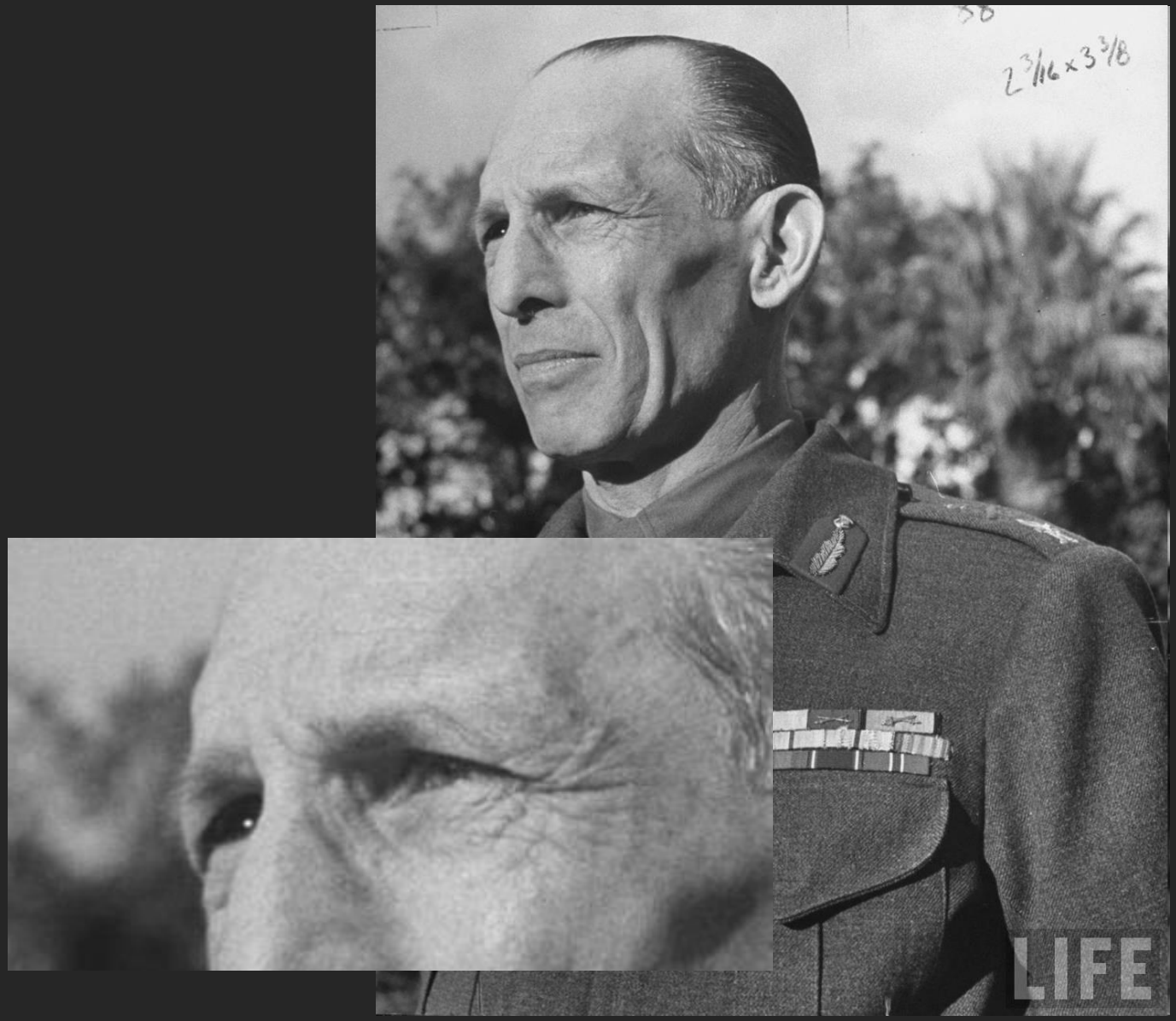
The portion of the glazing which lets in light is same in both cases. This is why WWR is important. The rest of the glass does not contribute to daylight, only permits more heat inside.

Window to Wall Ratio in Nature…

- Most recommendations in the ECBC follow simple logic
- Not following the ECBC is impossible for an intelligent engineer/architect/client

- In other words
  - Any rational architect / engineer / consultant will instinctively follow the ECBC
  - Whether he/she consciously knows it or not.
- Let's examine instinct for a bit…

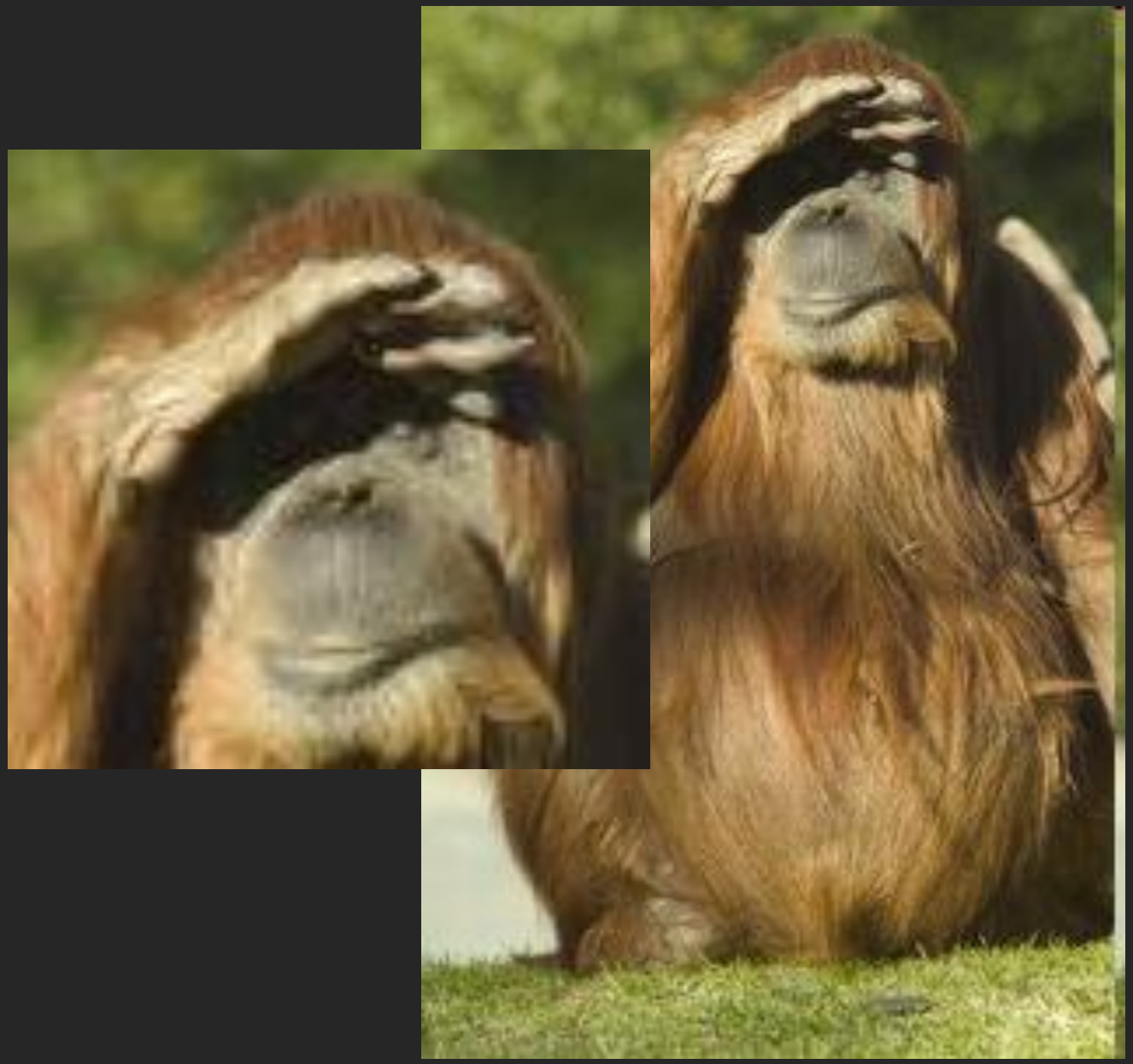
http://lh6.ggpht.com/__2tJjrIFCs8/RoCs2VAI9XI/AAAAAAAAAko/bYxoTHdv4iQ/Me%20Shading%20Eyes%20in%20Cinque%20Terre.jpg



Caption:King George II squinting his eyes from the sun. (Photo by John Phillips//Time Life Pictures/Getty Images)
http://www.gstatic.com/hostedimg/cef2c6feda04a57d_large

http://farm3.static.flickr.com/2469/3917233084_6ba0cc4c36.jpg

Even Animals Know Better...

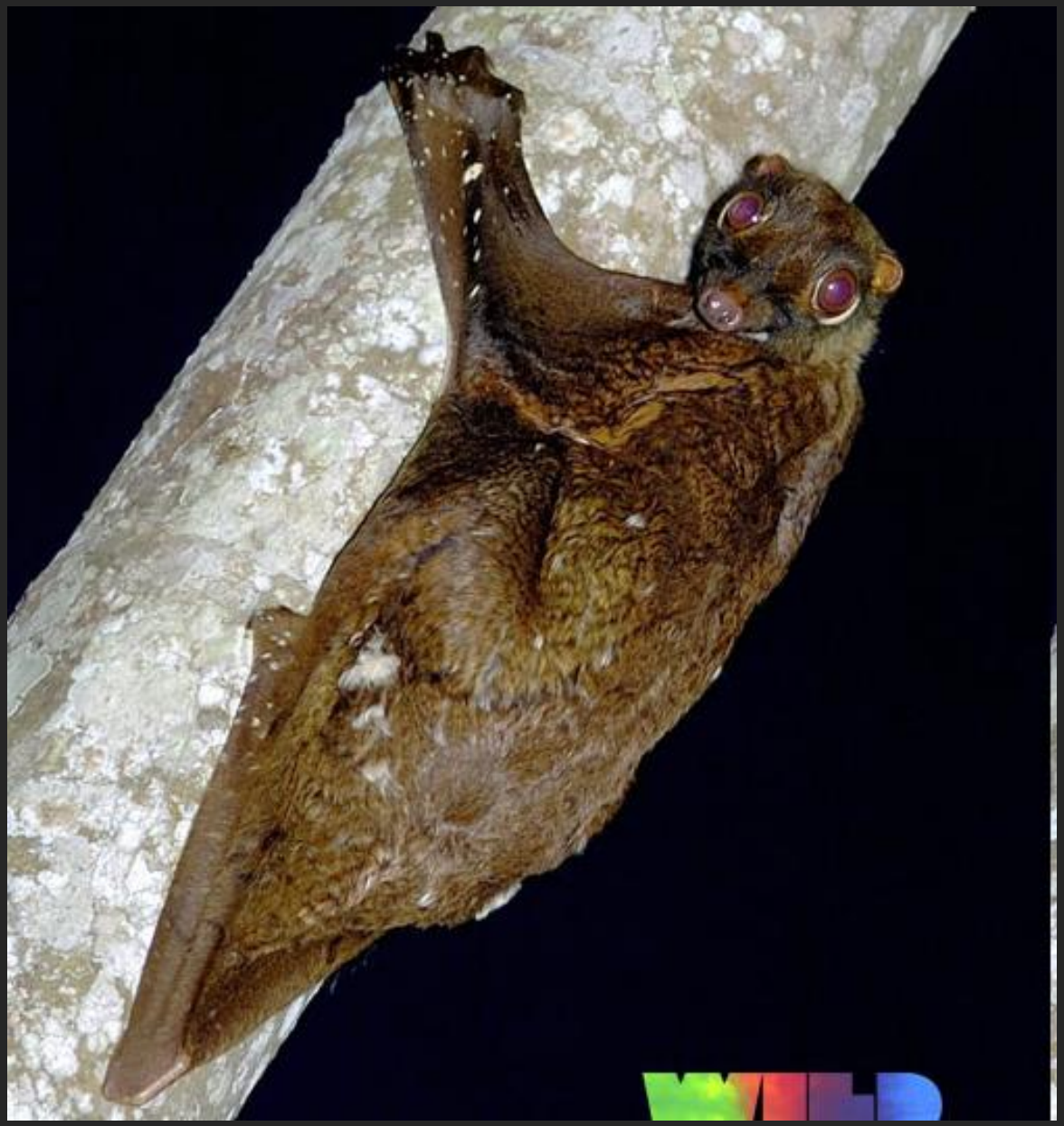


http://www.best-of-web.com/PICTURES/free_images/cute_old_fat_orangutan_shading_its_eyes_and_keeping_an_eye_out_for_trouble_0001-0404-1218-2437_SMU.jpg

Large Window to Wall Ratio in Nature…

http://nocturnal-animals.com/wp-content/uploads/2010/03/tarsier_nocturnal_animals.jpg

http://nocturnal-animals.com/wp-content/uploads/2010/06/redeyedtreefrog.jpg



http://daddu.net/wp-content/uploads/2010/02/Colugo-climbing.jpg

http://www.spin4suggies.com/images/pict3899_yc4p.jpg

So what is the cheapest option?

Is it shading?

- Is it external shading?
- Is it internal shading?

- Is it glazing?
  - Is it regular glazing?
  - Is it high-performance glazing?

National Building Code

PSI
PARTNERSHIPS FOR SUSTAINABLE INDIA

Current Market Practice

http://cdn.koimoi.com/wp-content/new-galleries/2012/08/Salman-Khan-in-Bodyguard-Ready-Dabangg.jpg

ECBC recommendation

http://jkhgroup.com/flben4.jpg

http://3.bp.blogspot.com/-H8o_1AGLuws/UgnyWvAdINI/AAAAAAAABOw/tGsuh7iy730/s1600/WP_20130812_009.jpg

http://img401.imageshack.us/img401/6743/dlfgurgaonnamitrustagisjf6.jpg


सभागृह
AUDITORIUM

Orientation

Shading (projection factors, effective SHGC)

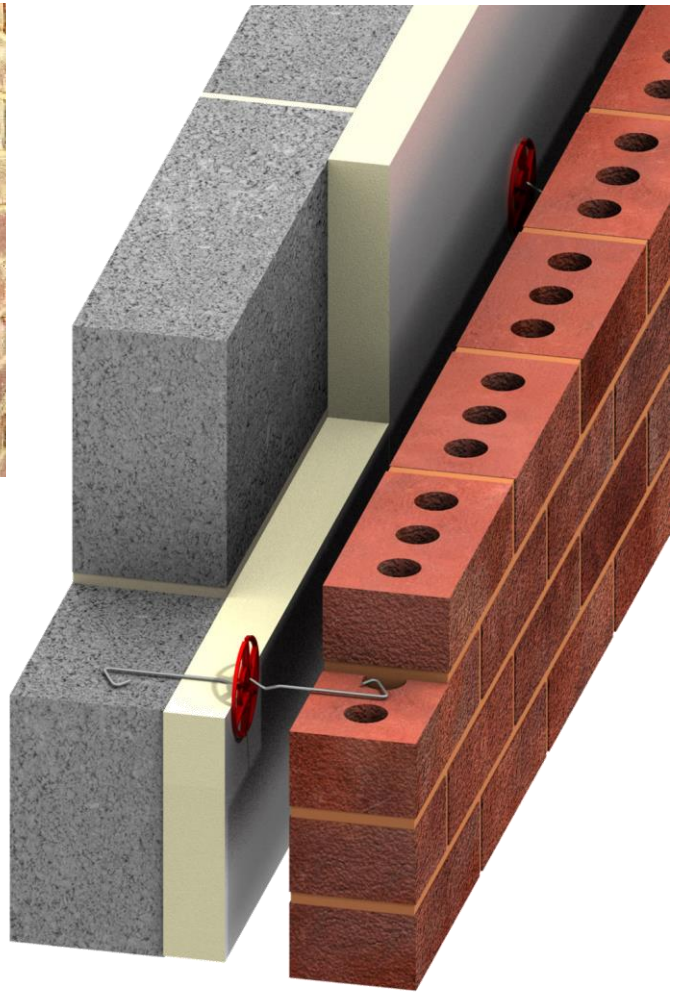
Visible Light Transmission

CRI, etc.

ENVELOPE OPTIMIZATION


Hard Shell Layer
Insulation Layer
Wind Layer
Wool Base Layer

Various insulation scenarios



U-value thresholds specified in the ECBC

GLASS

Climate	Max. U-factor ($W/m^2/^oC$)
Composite	3.3

WALLS

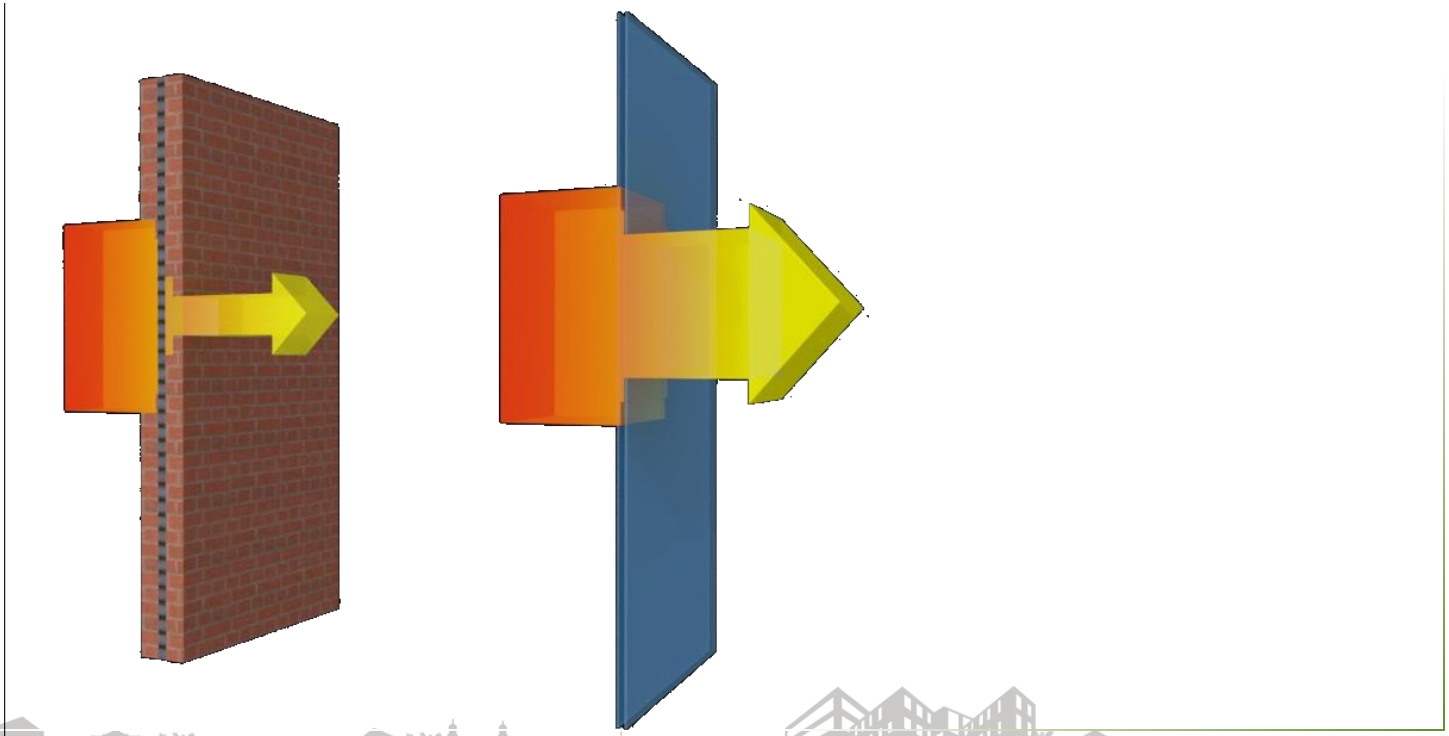
Climate	Max U-factor ($W/m^2/^oC$)
Composite	0.44

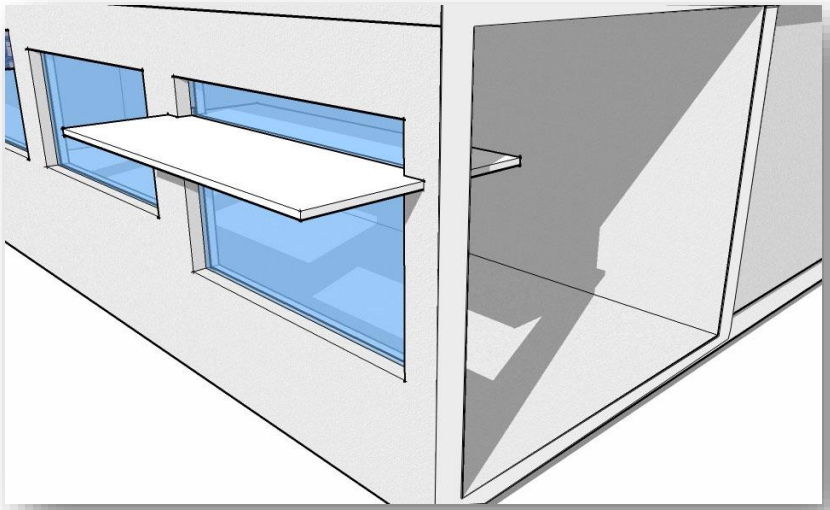
ROOFS

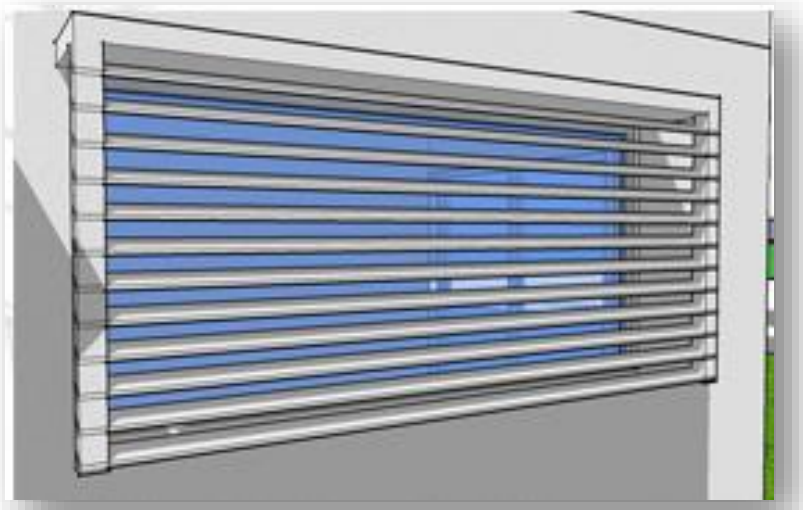
Climate	Max U-factor ($W/m^2/^oC$)
Composite	0.44

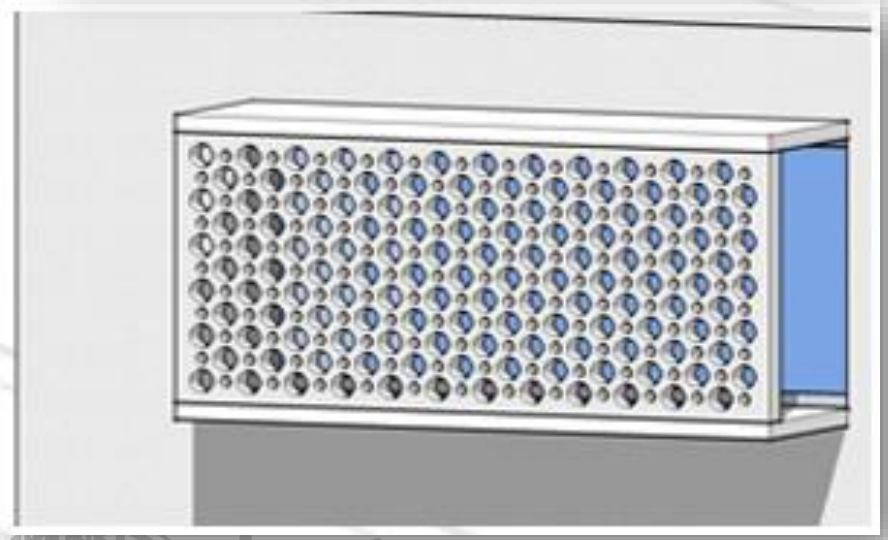
- Even some of the most energy efficient glass available in the market has U-value ranging from 1.4-1.9 W/sq.m.oC.

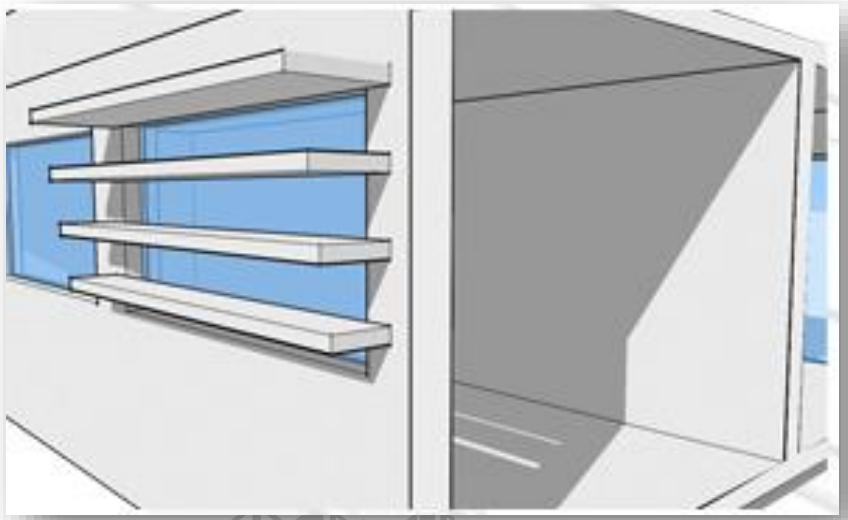
- That means even some of the best available glass allows 3-4 times more heat transfer as compared to a well-insulated wall.











HVAC

Chiller Efficiencies

Air Cooled Chiller

Water Cooled Chiller

Centrifugal

Screw

Size of chiller	COP
Less than 150 TR	2.9
Greater than equal to 150 TR	3.05

Size of chiller	COP
Less than 150 TR	5.8
>=150 TR < 300 TR	5.8
>= 300 TR	6.3

Size of chiller	COP
Less than 150 TR	4.7
>=150 TR < 300 TR	5.4
>= 300 TR	5.75

Some case studies we will share

- School Near Pondicherry
- School in Bhutan
- Government Building, Bhuvaneswar, Odisha

Project 2 - School in Bhutan

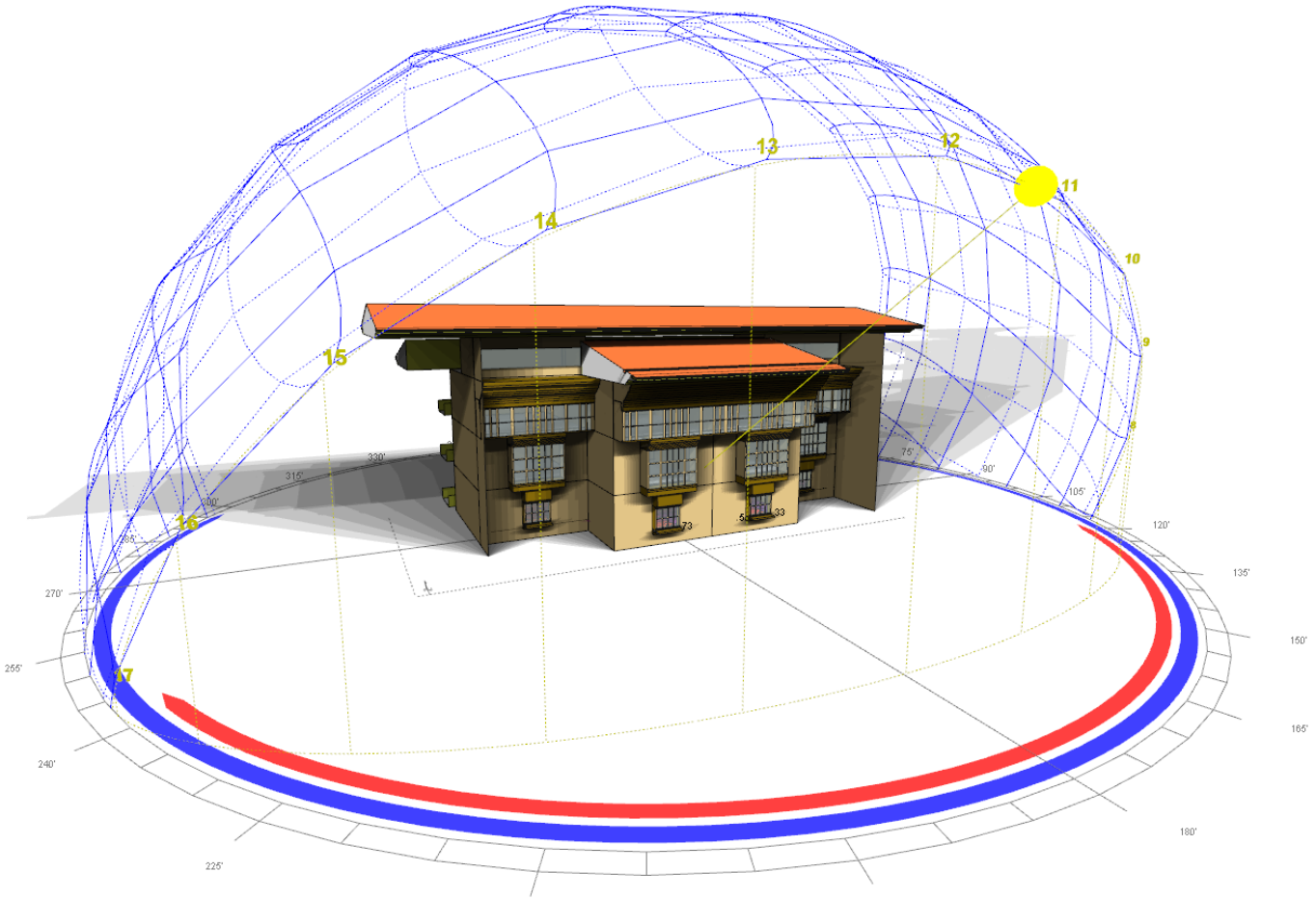
COLD (Cloudy/Sunny) CLIMATE ZONE	
Thermal Requirements	Physical Manifestation
Reduce Heat Loss	
Decrease exposed surface area	Orientation and shape of building. Use of trees as wind barriers
Increase thermal resistance	Roof insulation, wall insulation and double glazing
Increase thermal capacity (Time lag)	Thicker walls
Increase buffer spaces	Air locks/Lobbies
Decrease air exchange rate	Weather stripping and reducing air leakage
Increase surface absorptive	Darker colours
Promote Heat Gain	
Reduce shading	Walls and glass surfaces
Trapping heat	Sun spaces/green houses/Trombe walls etc.

Cold climate			
Parameters	**Conventional buildings**	**Low Energy Buildings**	**ECBC Compliant Buildings**
Operational Schedule	24 hr operating building	Daytime (10 hr operating) occupied, 5 Days Working, with every second Saturday as holiday	Daytime (10 hr operating) occupied, 5 Days with heating system working for 24 hrs and 7 Days
Design Features	long facades East-West	Long façade are south west and north east	Longer facades are north-south cardinal directions
	Building Envelope Details:	Building Envelope Details:	Building Envelope Details:
	Walls U Value: 0.352W/m2/k	Walls U Value: 2.7 W/m2/k	Walls U Value: 1.92 W/m2/k
	Roof U Value: 0.605 W/m2/k	Roof U Value: 2.6 W/m2/k	Roof U Value: 3.72 W/m2/k
	Glass U Value: 4.3 W/m2/k	Glass U Value: 5.8 W/m2/k	Glass U Value: 2.8 W/m2/k
	Glass SHGC Value: 0.89	Glass SHGC Value: 0.87	Glass SHGC Value: 0.45
Lighting system Features	No daylight integration	Daylight and Artificial lighting integration	Daylight and Artificial lighting integration
	No Lighting Controls	No Lighting Controls	No Lighting Controls
	Lighting power density is in the range of 12.4 W/m2	Lighting power density is less than 7.65 W/m2	Lighting power density is less than 8.7 W/m2
	Visual comfort was maintained as per National building code-2005 Standard	Visual comfort was partly maintained as per National Building Code-2005 standard	Visual comfort was partly maintained as per National Building Code-2005 standard
Air conditioning system Features	No natural ventilation or passive cooling techniques.	Circulation areas are naturally ventilated	No natural ventilation or passive cooling techniques.
	HVAC system used is convective heating system with electrical hot water boilers.	HVAC system used is convective heating system with electrical hot water boilers.	HVAC system used is radiant floor heating system with electrical hot water boilers.
	% of AC area to built up area is above 80%.	% of AC area to built up area is 100%	% of AC area to built up area is 81%
	Thermal comfort was maintained as per National building code-2005 standard	Thermal comfort was maintained as per National building code-2005 standard	Thermal comfort was maintained as per National building code-2005 standard
Energy Performance	Air conditioning Performance Index lies from 297 kWh/m2/year	Air conditioning Performance Index lies from 70 kWh/m2/year	Air conditioning Performance Index lies from 97 kWh/m2/year

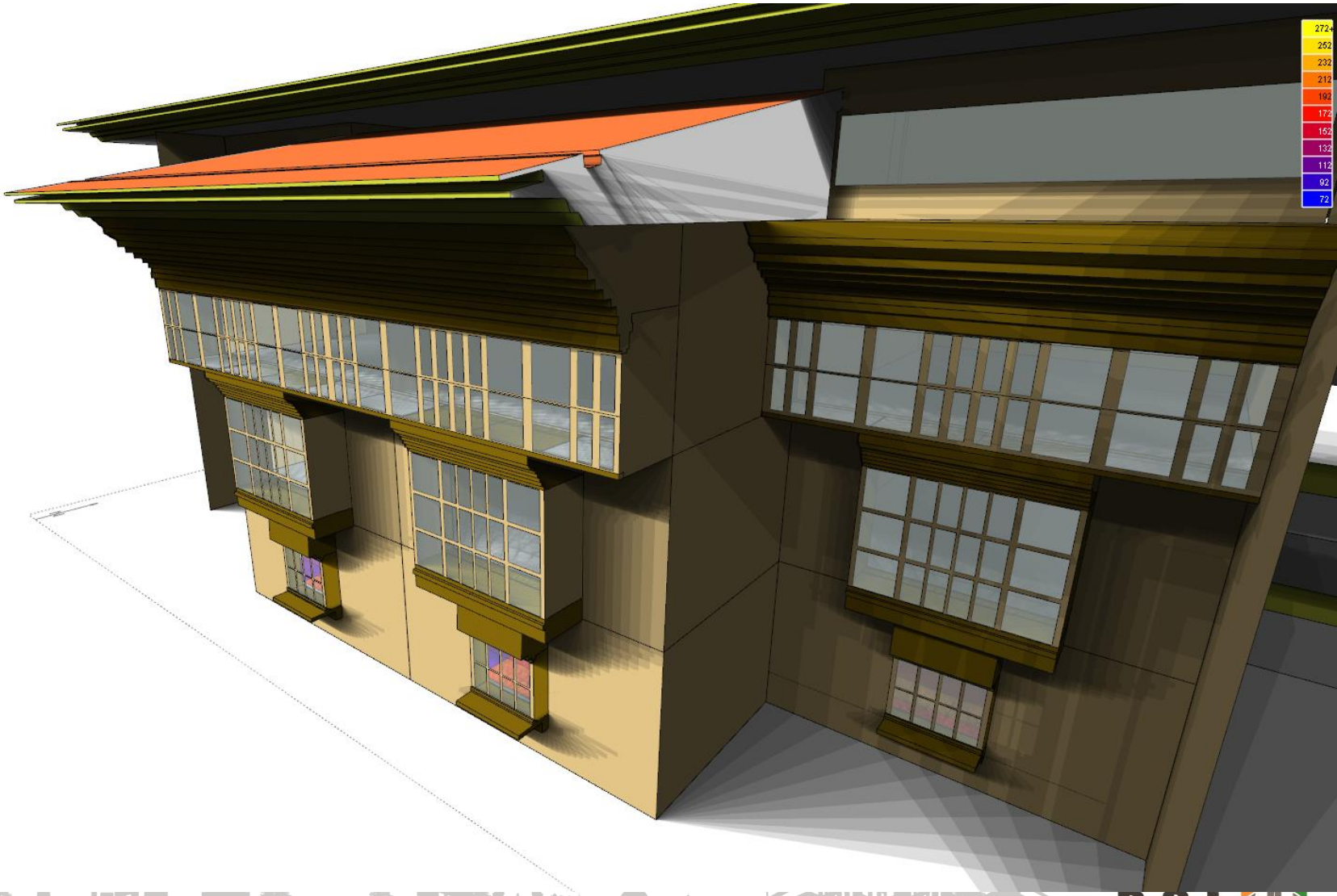
Building Typologies

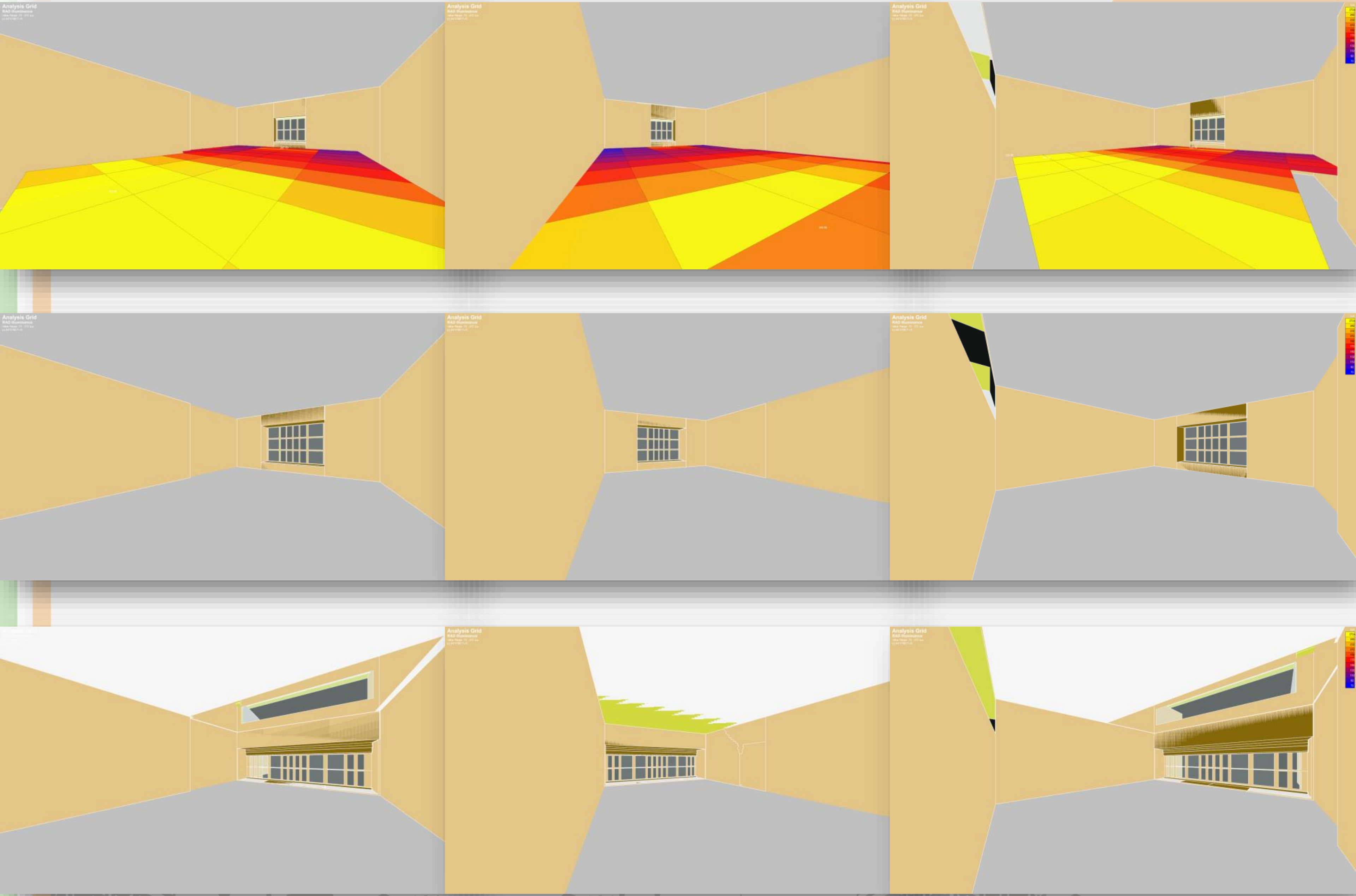
- Academic
- Administrative
- Dining
- Residential
- Sports and recreation
- Dormitory

Sample block - academic

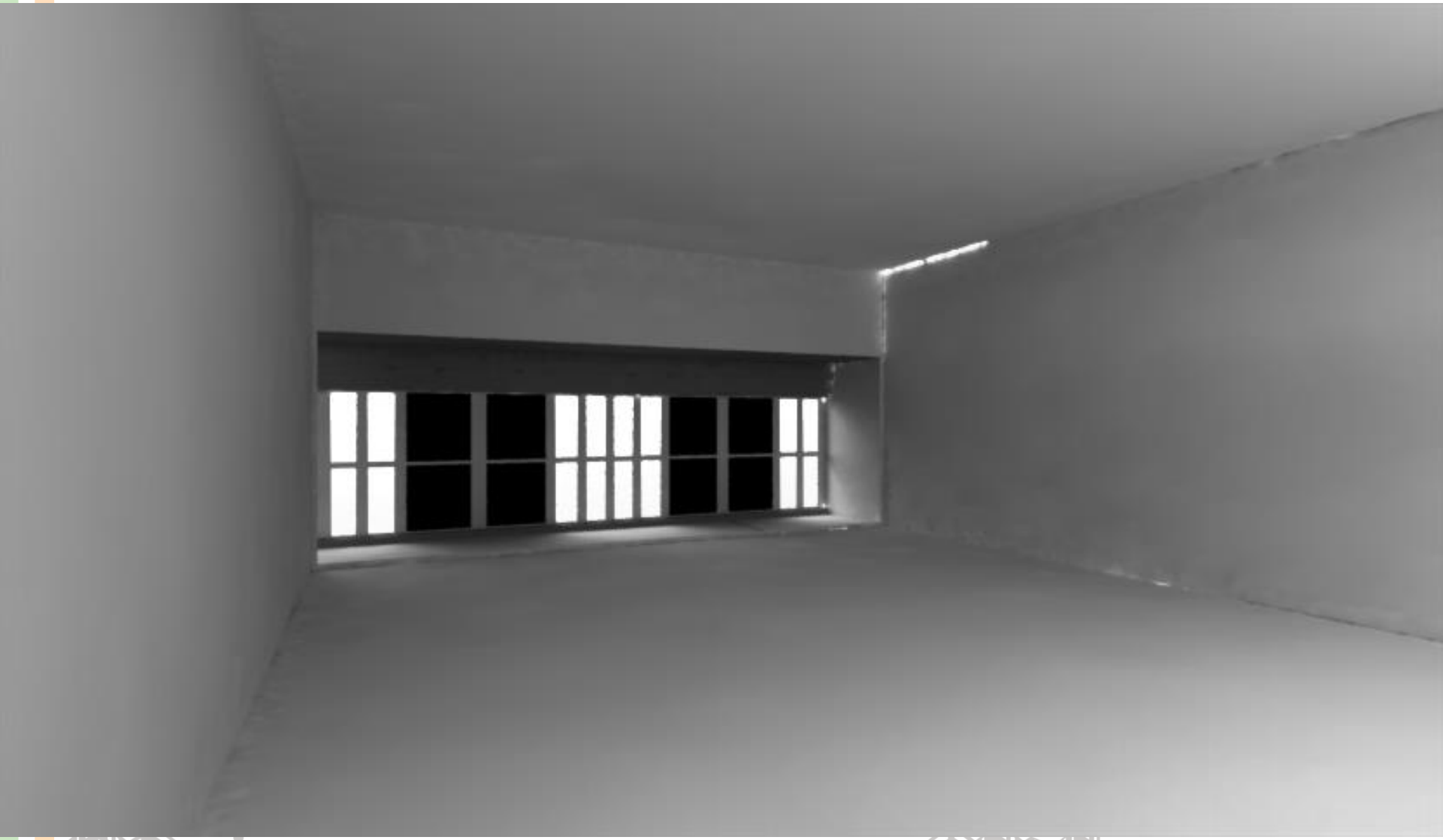


Analysis Grid
RAD Illuminance
Value Range: 72 - 272 Lux
(c) ECOTECT v5

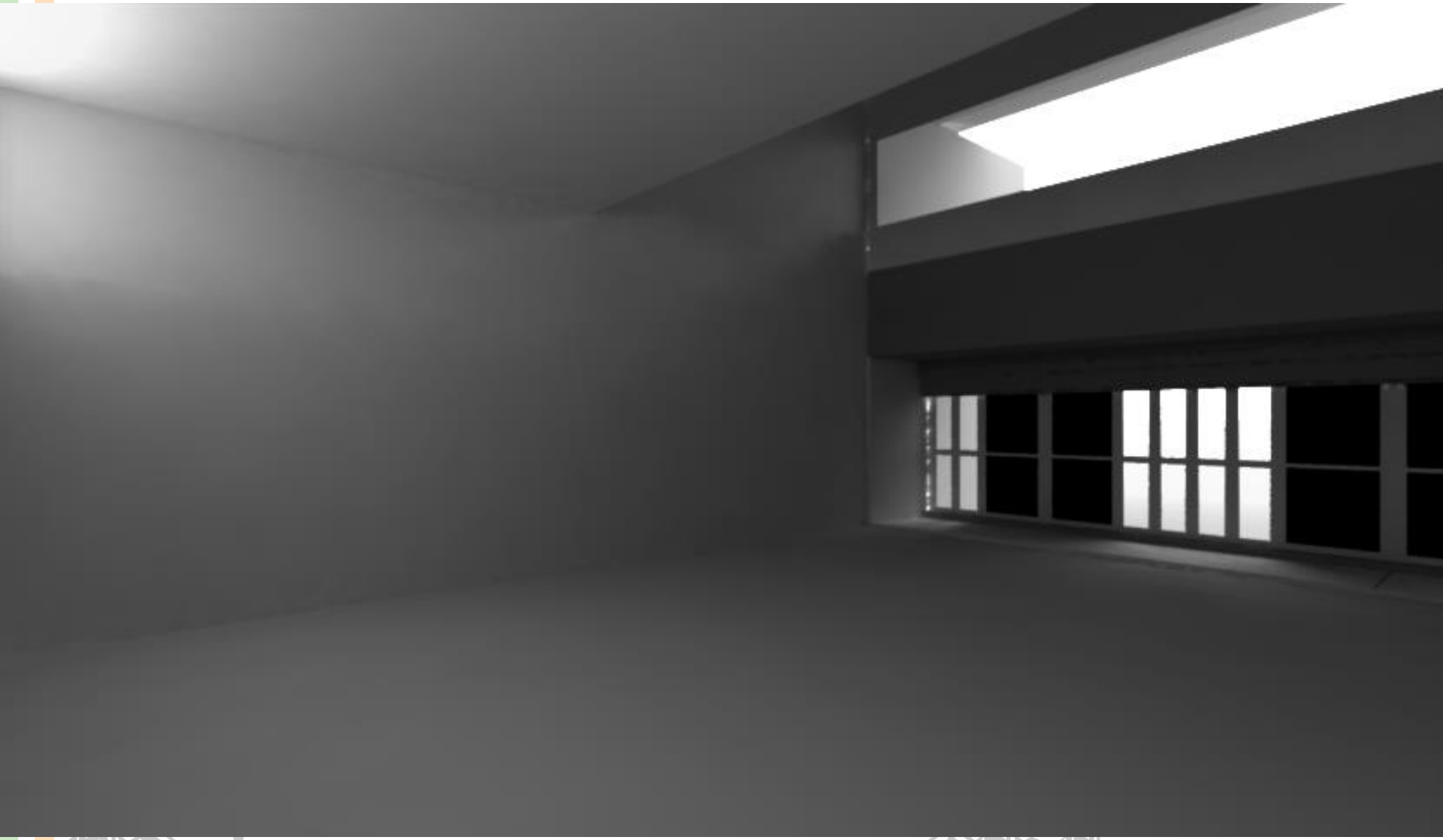



Analysis Grid
RAD Illuminance

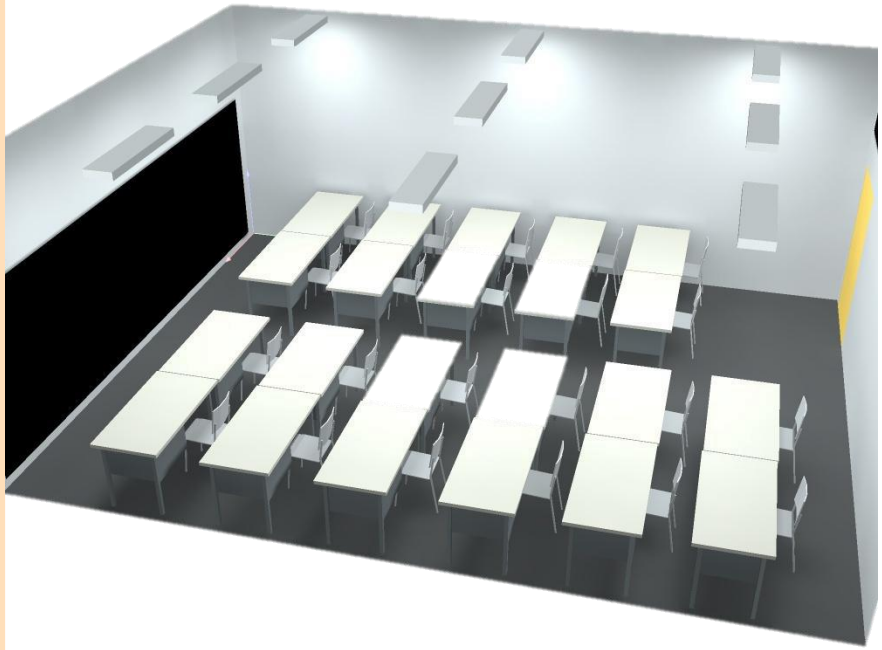
Classroom Middle Floor

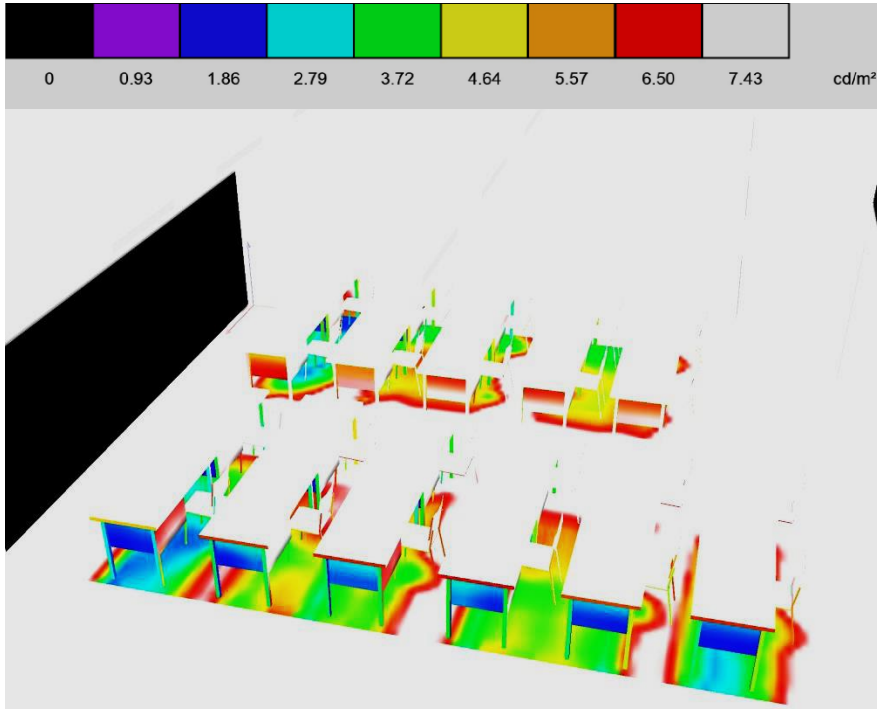


Classroom Top Floor



Classroom Middle Floor Artificial Lighting

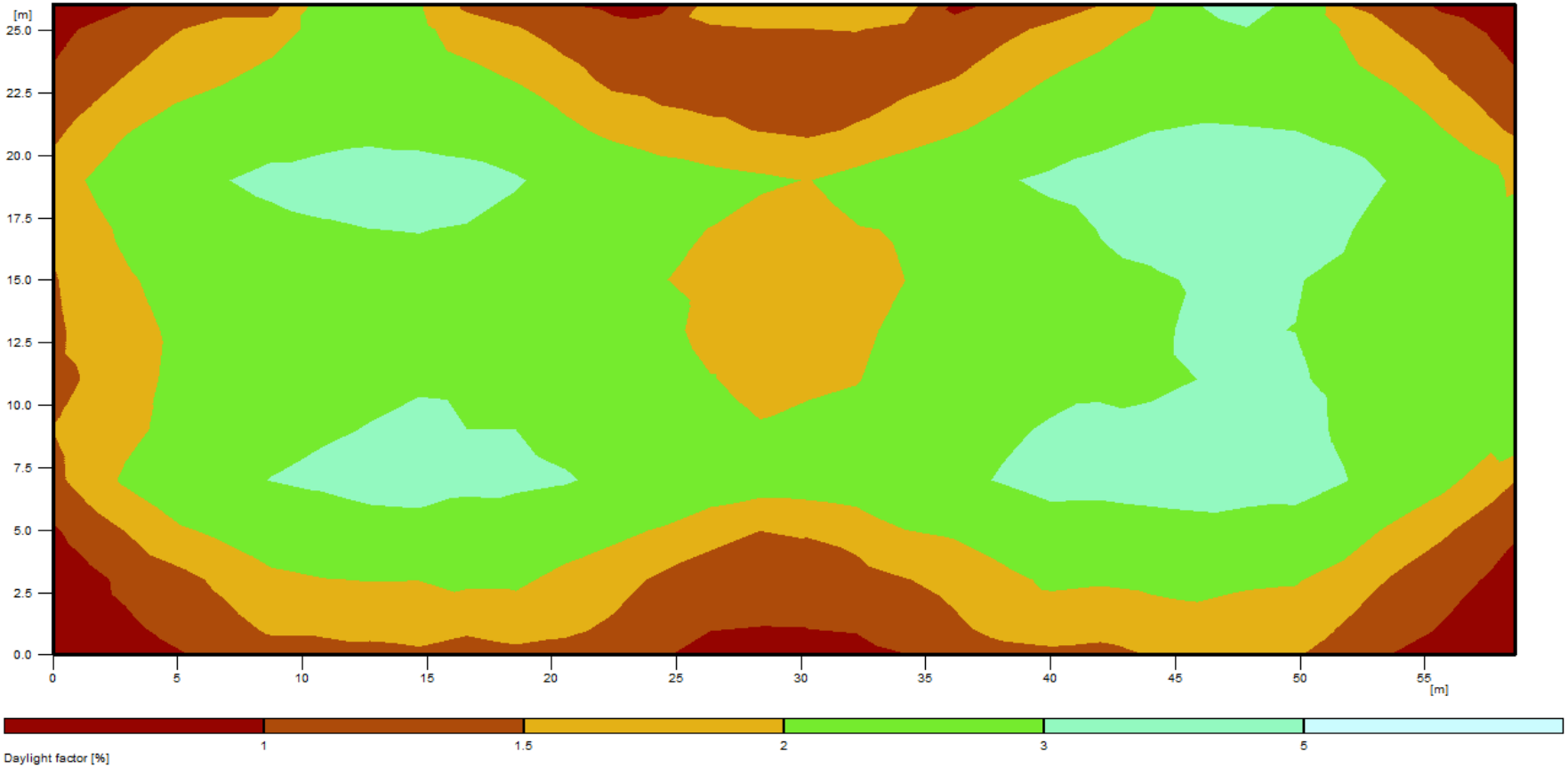




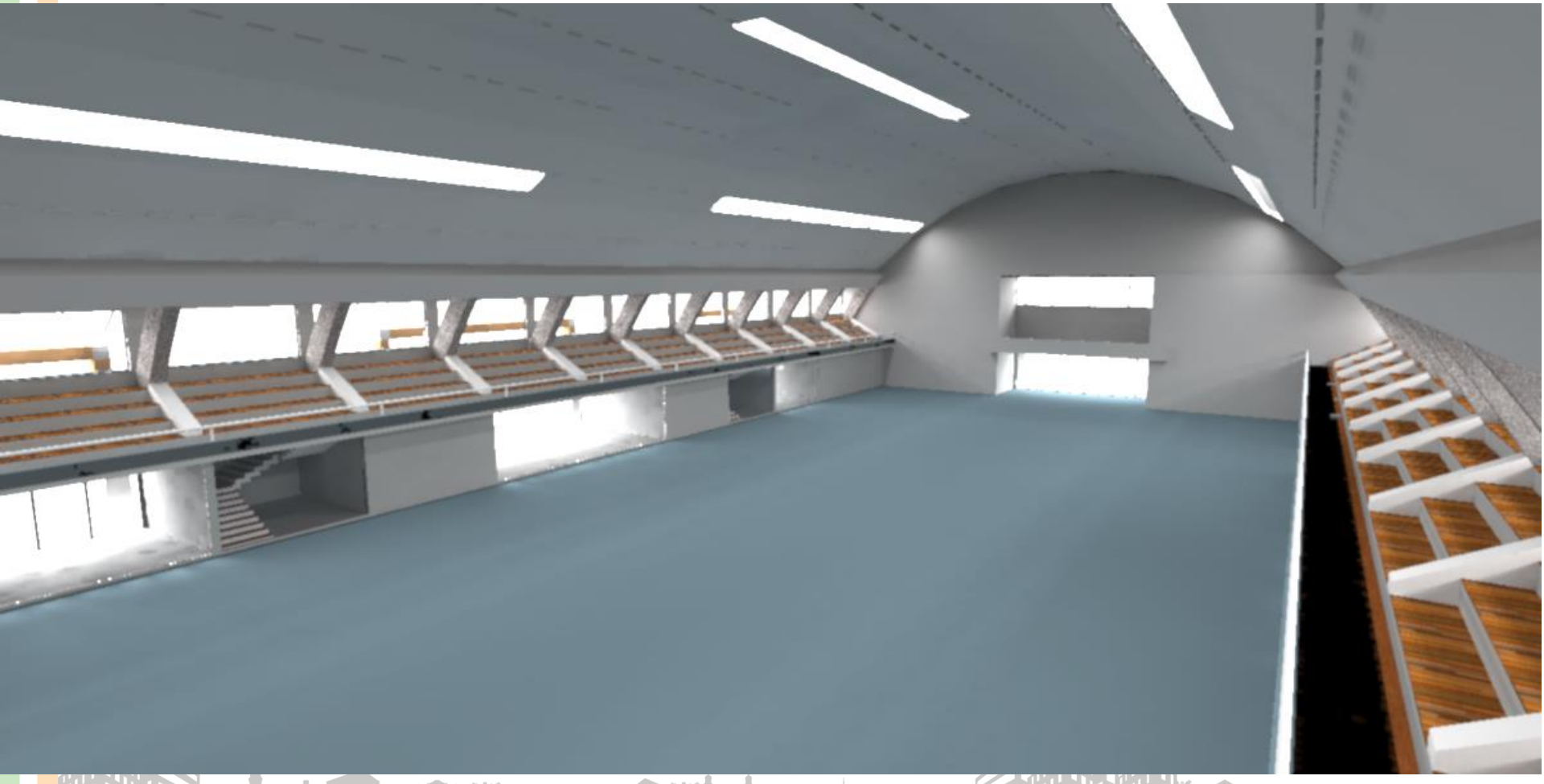
Average Luminance: 21 fc ; LPD: 7 W/m2

Multipurpose hall - Sports and recreation with 5% Skylight

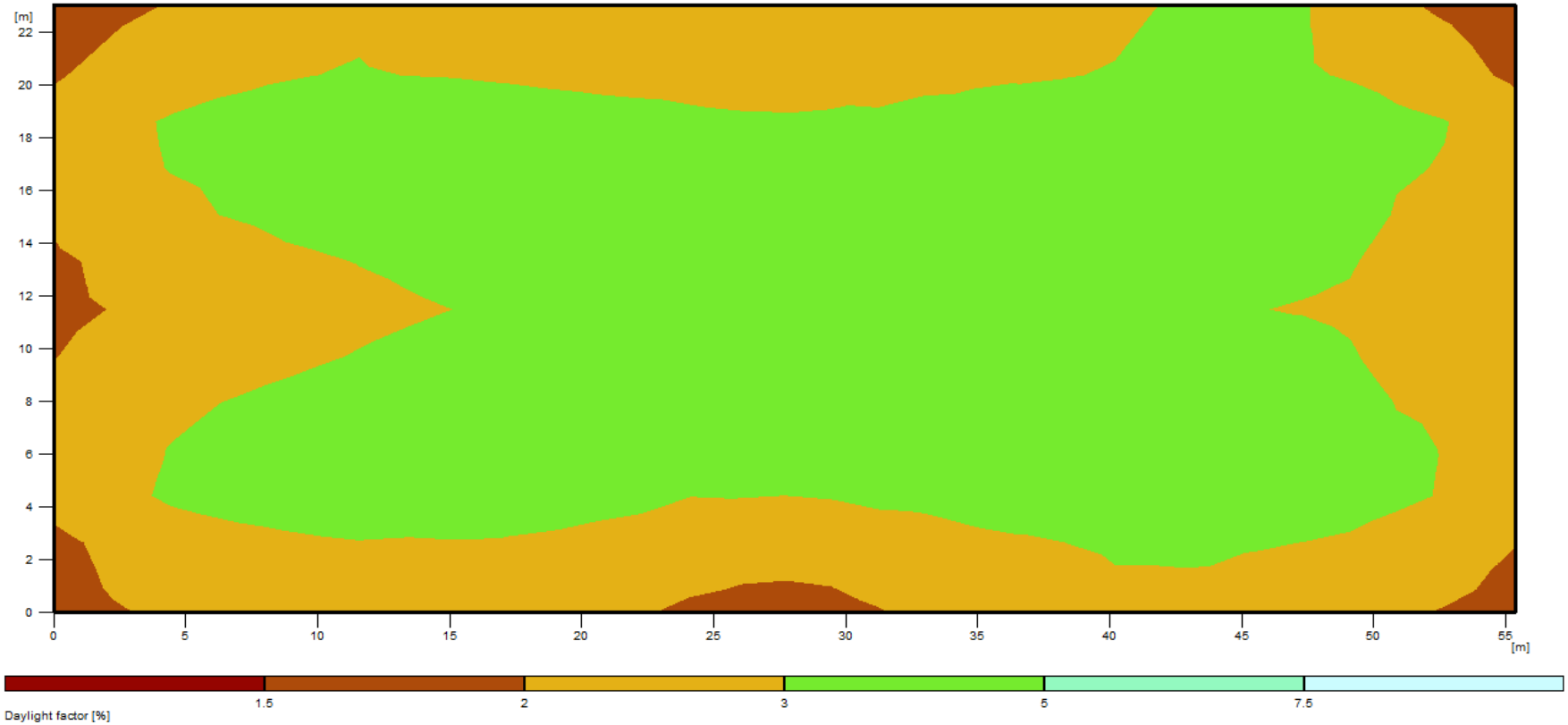
Multipurpose hall - Sports and recreation with 5% Skylight Daylight



Multipurpose hall - Sports and recreation with 5% Skylight Daylight

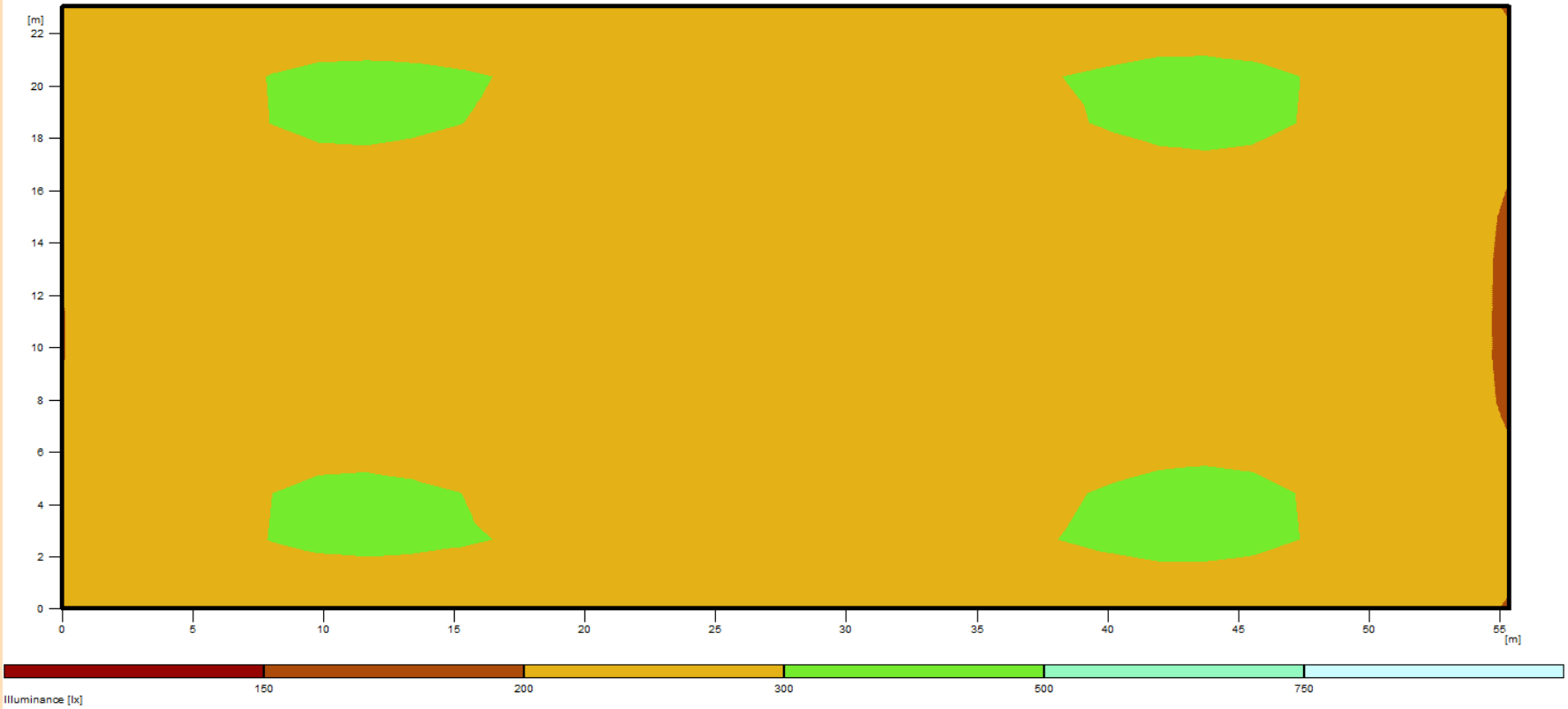


Multipurpose hall - Sports and recreation with 5% Skylight Daylight



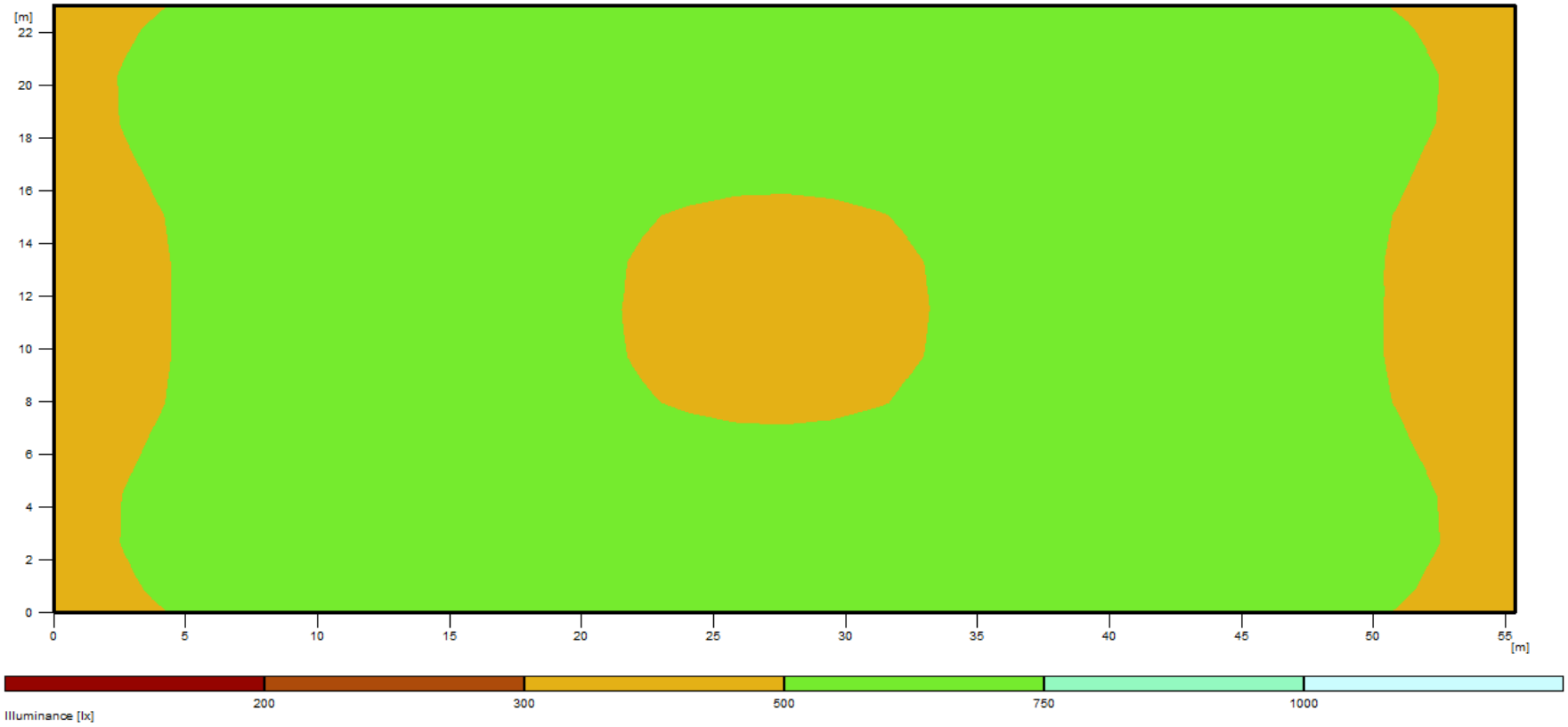
Multipurpose hall – Sports and recreation
Artificial Light (half lamps on)

Multipurpose hall - Sports and recreation
Artificial Light (half lamps on)



Multipurpose hall - Sports and recreation Artificial Light (all lamps on for competitions)

Multipurpose hall - Sports and recreation Artificial Light (all lamps on for competitions)



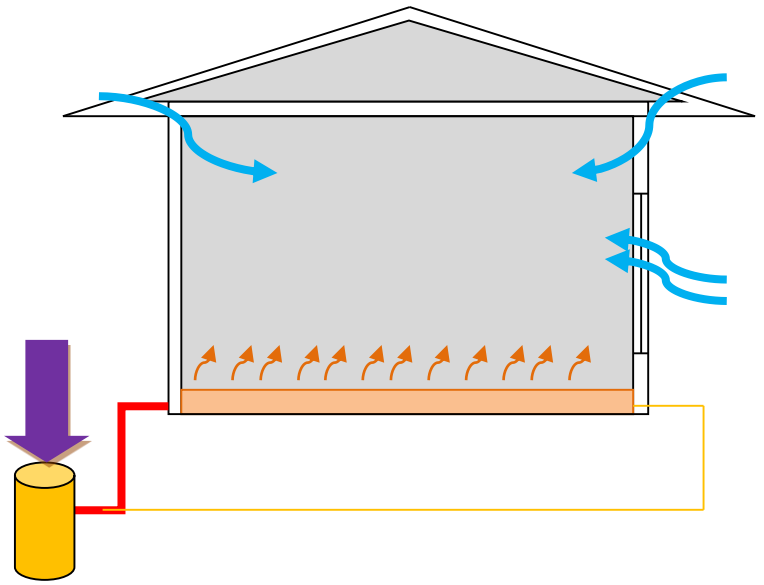
Envelope Academic block

- ECBC
  - Walls
    - U-Value – 0.352 W/m^2K
  - Roof
    - U-Value – 0.409 W/m^2K
  - Glazing
    - U-value – 1.42 W/m^2K
    - SHGC – 0.51 (WWR 40%)

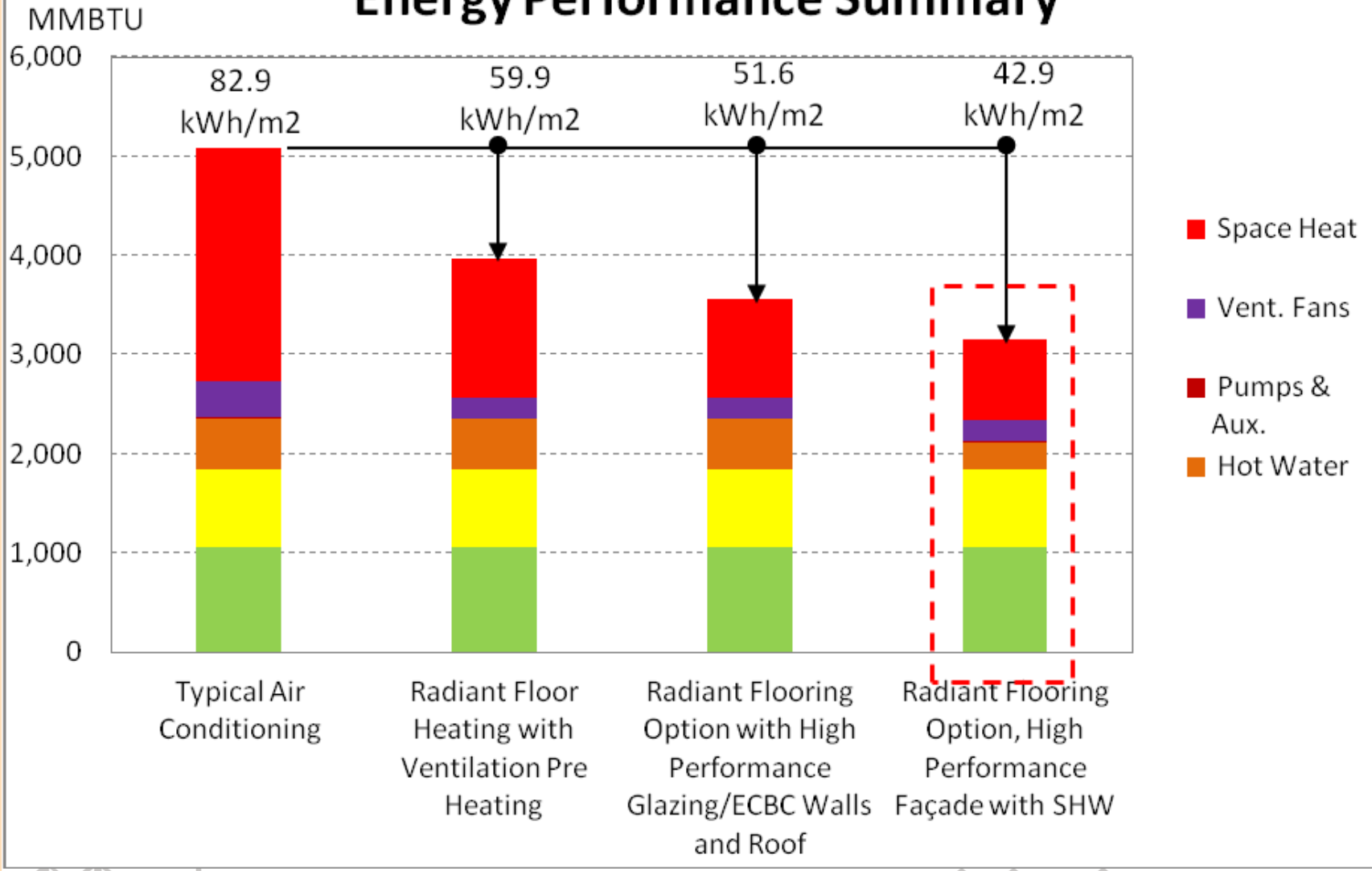
- ECBC+
  - Walls
    - U-Value – 0.352 W/m2K
  - Roof
    - U-Value – 0.409 W/m2K
  - Glazing
    - U-value – 1.42 W/m2K
    - SHGC – 0.51 (WWR 40%) With low-e on the no #3 surface

HVAC System

- Radiant Floor Heating without Ventilation.
- Building relies on infiltration through open window/doors etc. for ventilation.



Energy Performance Summary



The Buddhist Institute, Martam, Sikkim

Submitted to:
Team Design Workshop

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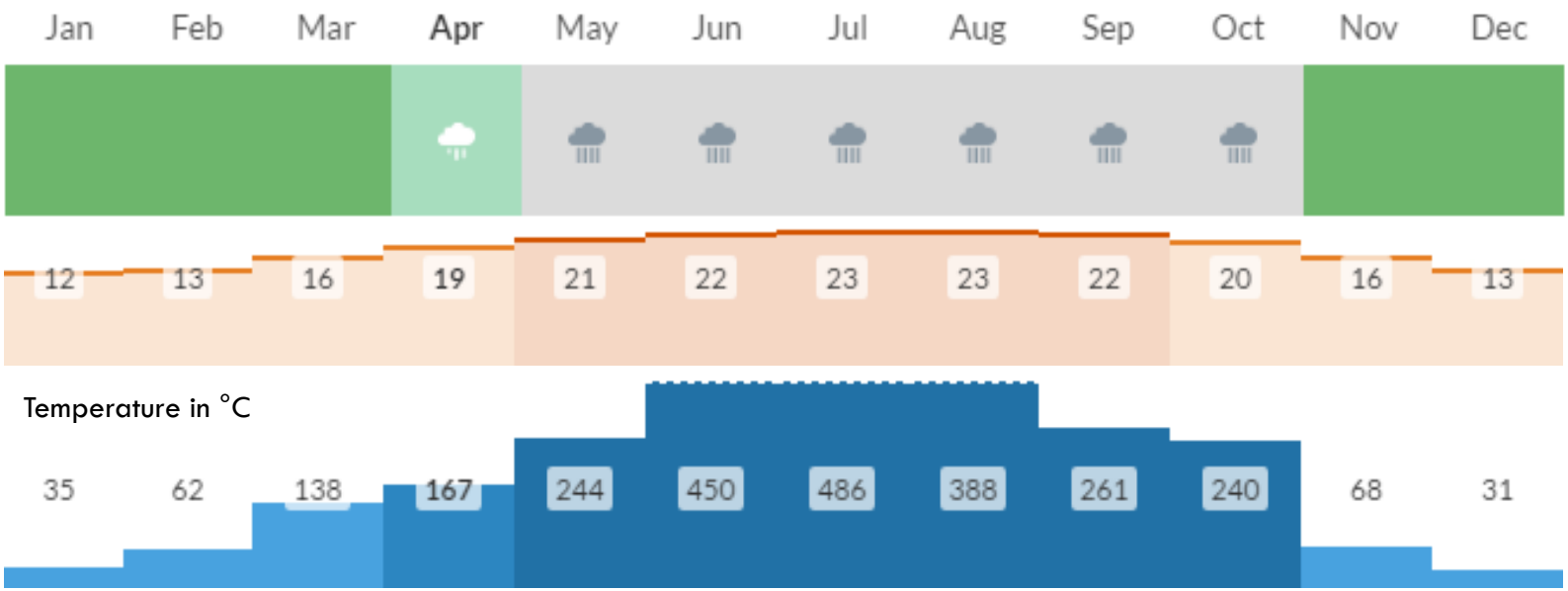
COLD (Cloudy/Sunny) CLIMATE ZONE	
Thermal Requirements	Physical Manifestation
Reduce Heat Loss	
Decrease exposed surface area	Orientation and shape of building. Use of trees as wind barriers
Increase thermal resistance	Roof insulation, wall insulation and double glazing
Increase thermal capacity (Time lag)	Thicker walls
Increase buffer spaces	Air locks/Lobbies
Decrease air exchange rate	Weather stripping and reducing air leakage
Increase surface absorptive	Darker colours
Promote Heat Gain	
Reduce shading	Walls and glass surfaces
Trapping heat	Sun spaces/green houses/Trombe walls etc.


Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
12
13
16
19
21
22
23
23
22
20
16
13
Temperature in °C
35
62
138
167
244
450
486
388
261
240
68
31

Cold climate

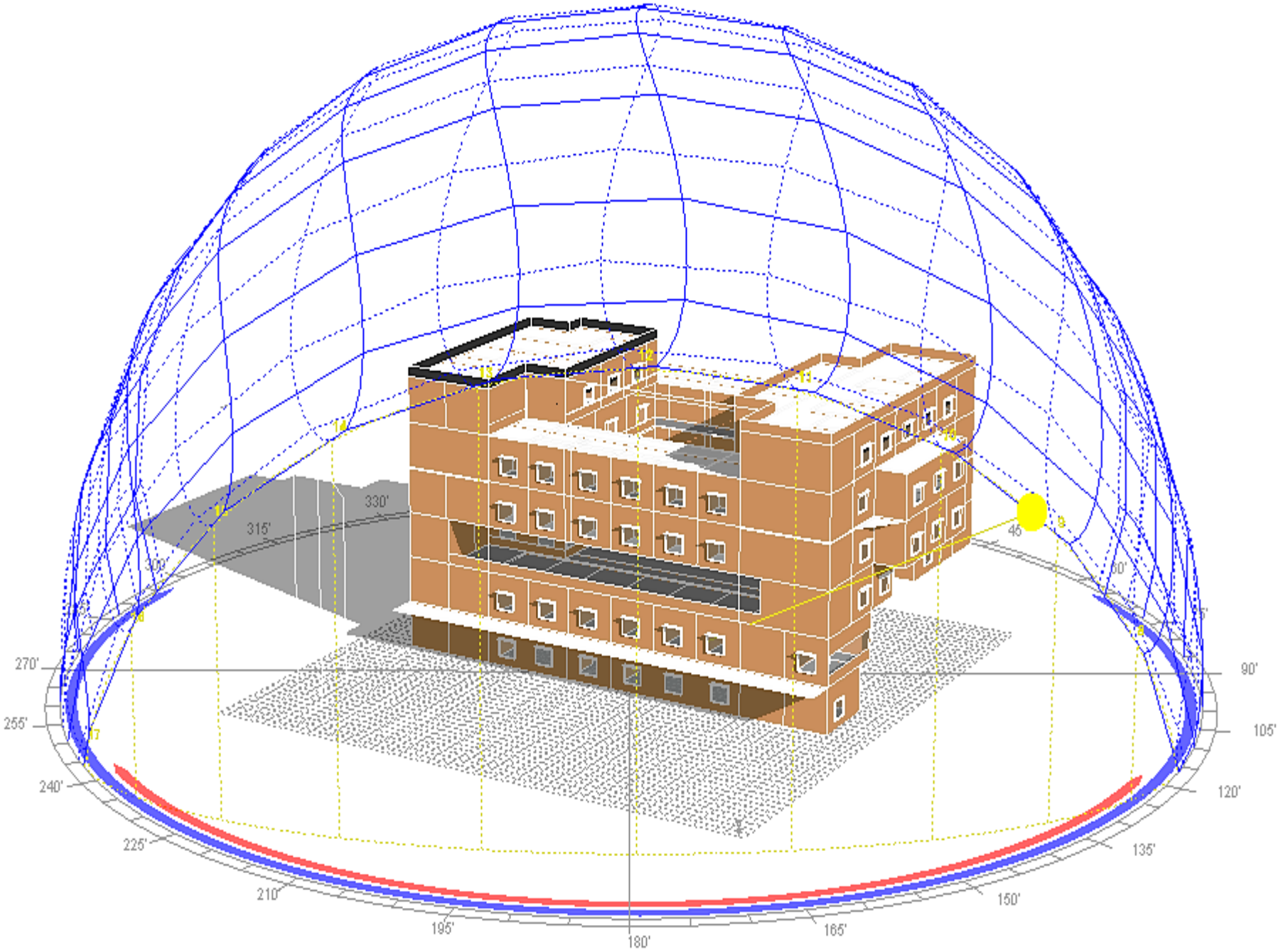
Parameters	Conventional buildings	Low Energy Buildings	ECBC Compliant Buildings
Operational Schedule	24 hr operating building	Daytime (10 hr operating) occupied, 5 Days Working, with every second Saturday as holiday	Daytime (10 hr operating) occupied, 5 Days with heating system working for 24 hrs and 7 Days
Design Features	Long facades East-West	Long façade are south west and north east	Longer facades are north-south cardinal directions
	Building Envelope Details:	Building Envelope Details:	Building Envelope Details:
	Walls U Value: 0.352W/m2/k	Walls U Value: 2.7 W/m2/k	Walls U Value: 1.92 W/m2/k
	Roof U Value: 0.605 W/m2/k	Roof U Value: 2.6 W/m2/k	Roof U Value: 3.72 W/m2/k
	Glass U Value: 4.3 W/m2/k	Glass U Value: 5.8 W/m2/k	Glass U Value: 2.8 W/m2/k
	Glass SHGC Value: 0.89	Glass SHGC Value: 0.87	Glass SHGC Value: 0.45
Lighting system Features	No daylight integration	Daylight and Artificial lighting integration	Daylight and Artificial lighting integration
	No Lighting Controls	No Lighting Controls	No Lighting Controls
	Lighting power density is in the range of 12.4 W/m2	Lighting power density is less than 7.65 W/m2	Lighting power density is less than 8.7 W/m2
	Visual comfort was maintained as per National building code-2005 Standard	Visual comfort was partly maintained as per National Building Code-2005 standard	Visual comfort was partly maintained as per National Building Code-2005 standard
Air conditioning system Features	No natural ventilation or passive cooling techniques.	Circulation areas are naturally ventilated	No natural ventilation or passive cooling techniques.
	HVAC system used is convective heating system with electrical hot water boilers.	HVAC system used is convective heating system with electrical hot water boilers.	HVAC system used is radiant floor heating system with electrical hot water boilers.
	% of AC area to built up area is above 80%	% of AC area to built up area is 100%	% of AC area to built up area is 81%

Spatial Typologies

Academic
Administrative
Dining & Kitchen
Residential
Dormitory

Builtup Area (Sq. M.)

Basement I	336.6
Basement II	434.8
Ground Floor	1131.4
First Floor	996.5
Second Floor	1084.4
Third Floor	713.5


330'
315'
45
270'
255'
240'
225'
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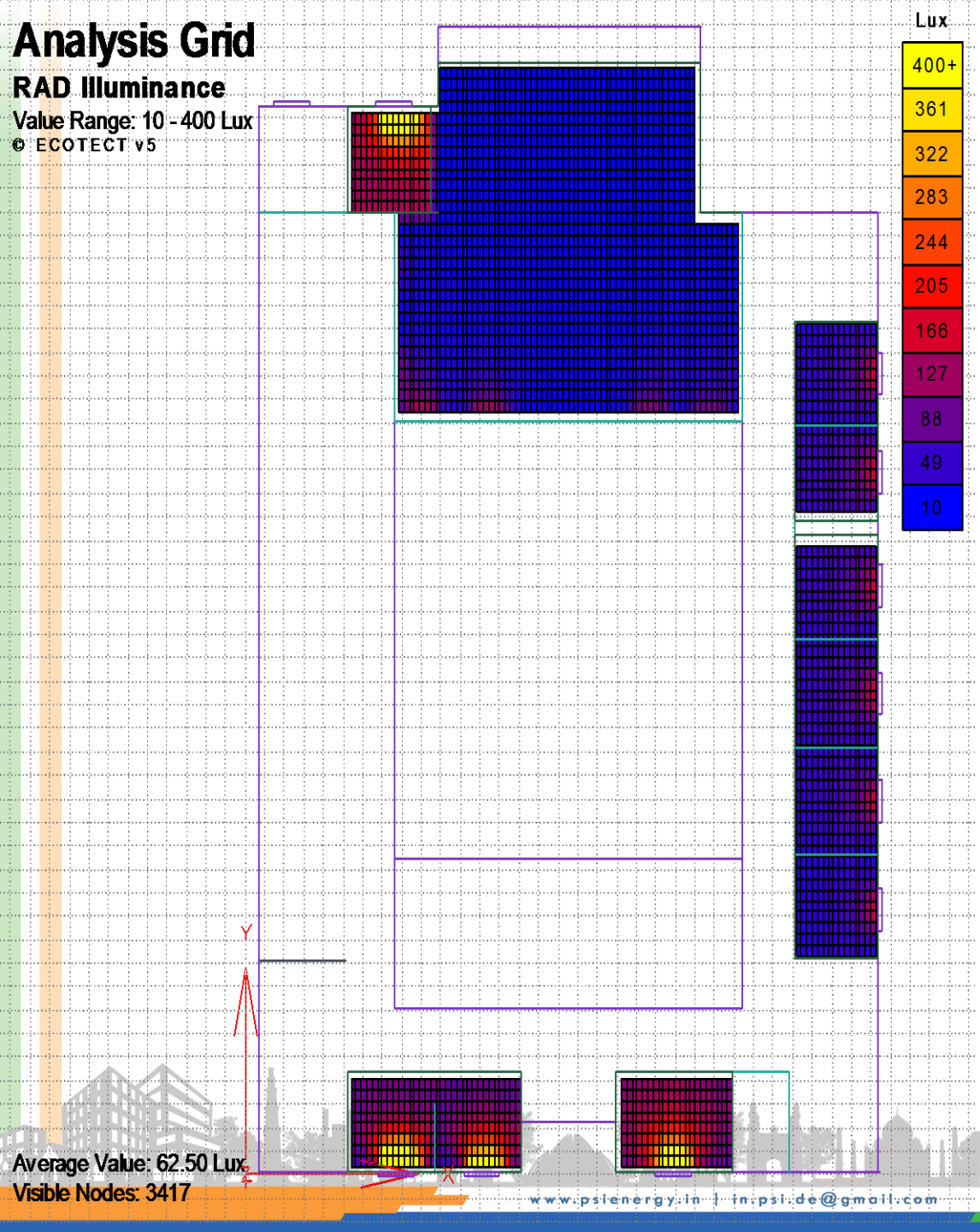
195'
180'
165'
150'
135'
120'
105'
90'



Ground Floor

Avg. Daylight Factor = 0.78

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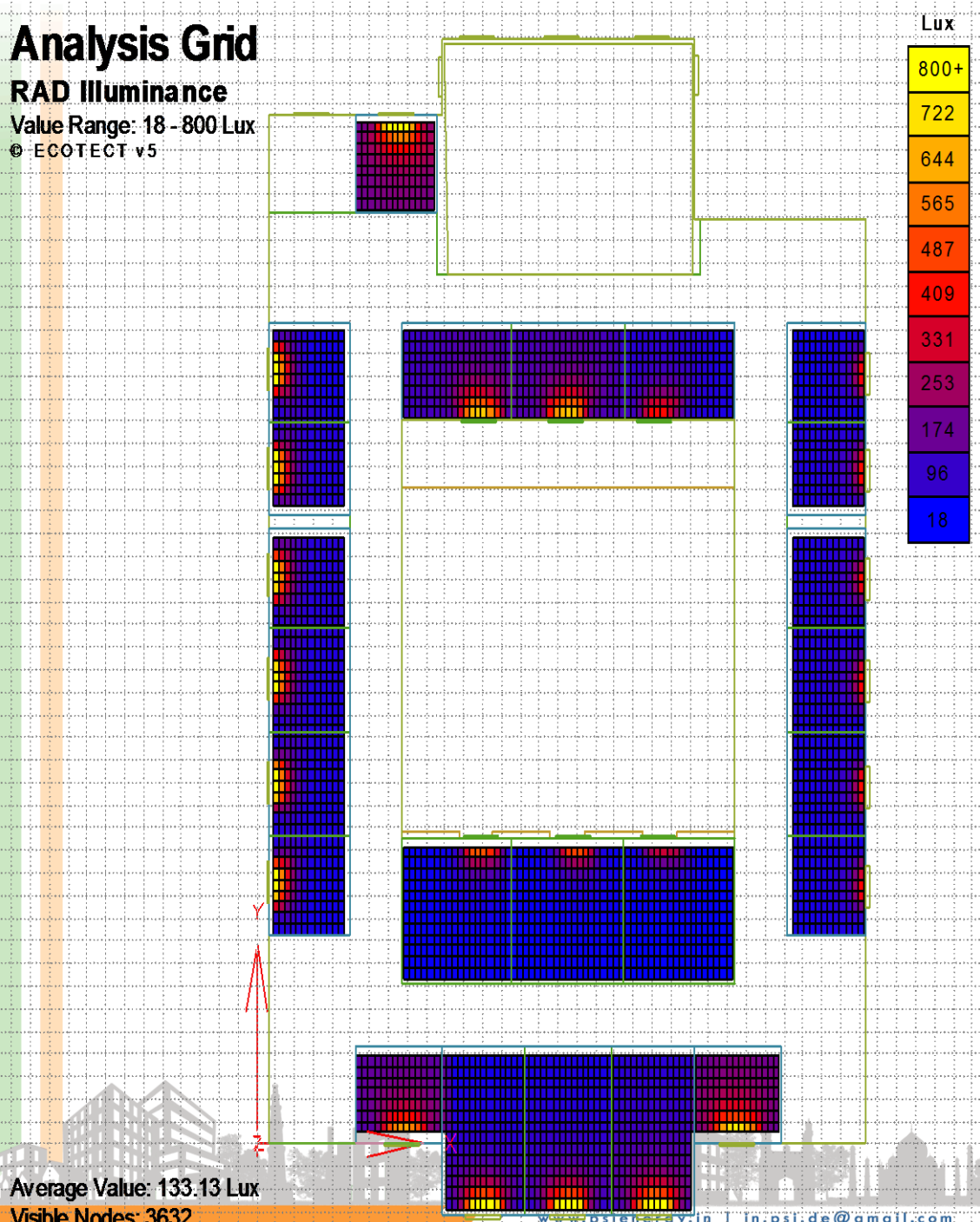

First Floor

Avg. Daylight Factor = 1.66

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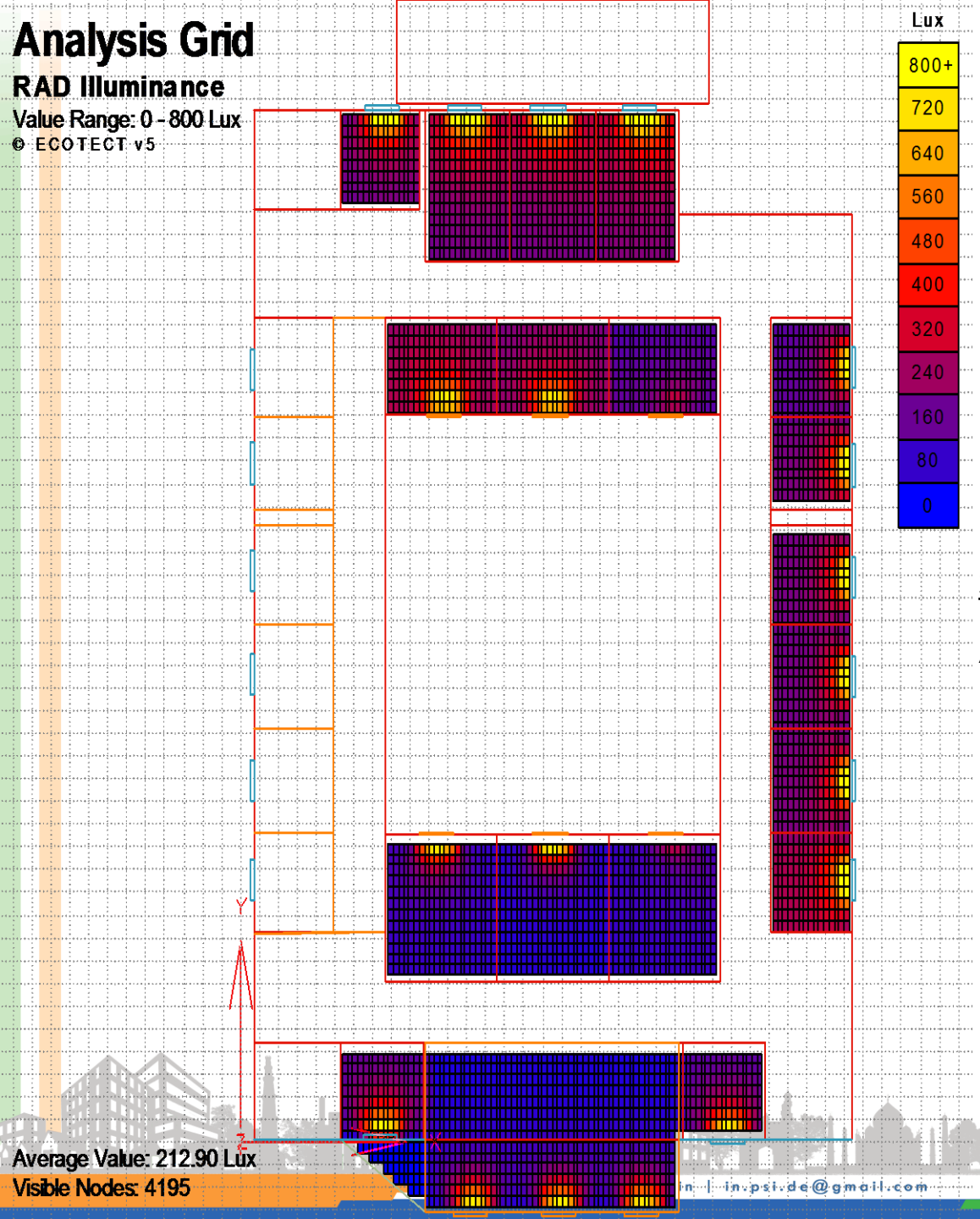

Second Floor

Avg. Daylight Factor = 2.66

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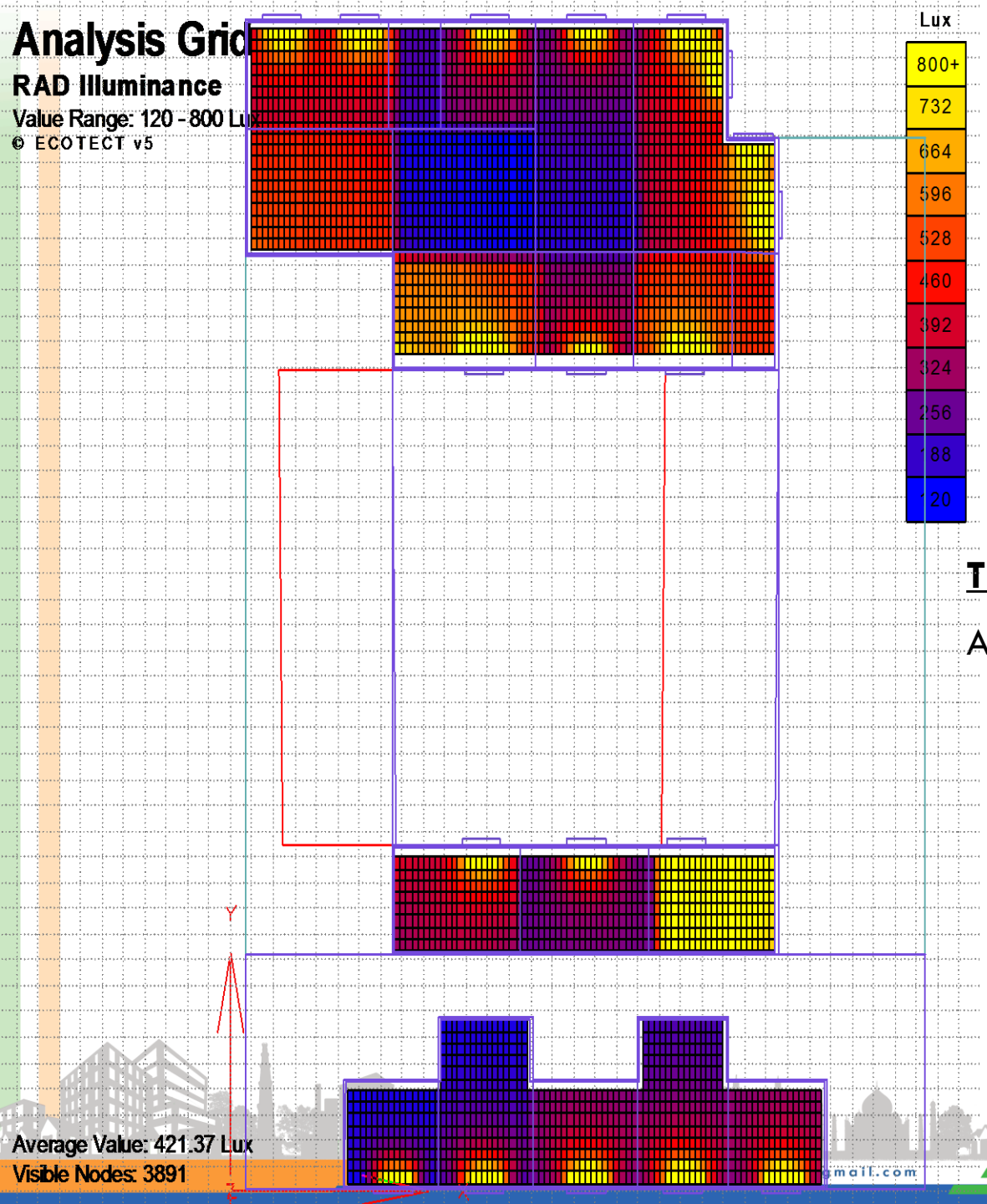

Third Floor

Avg. Daylight Factor = 5.26

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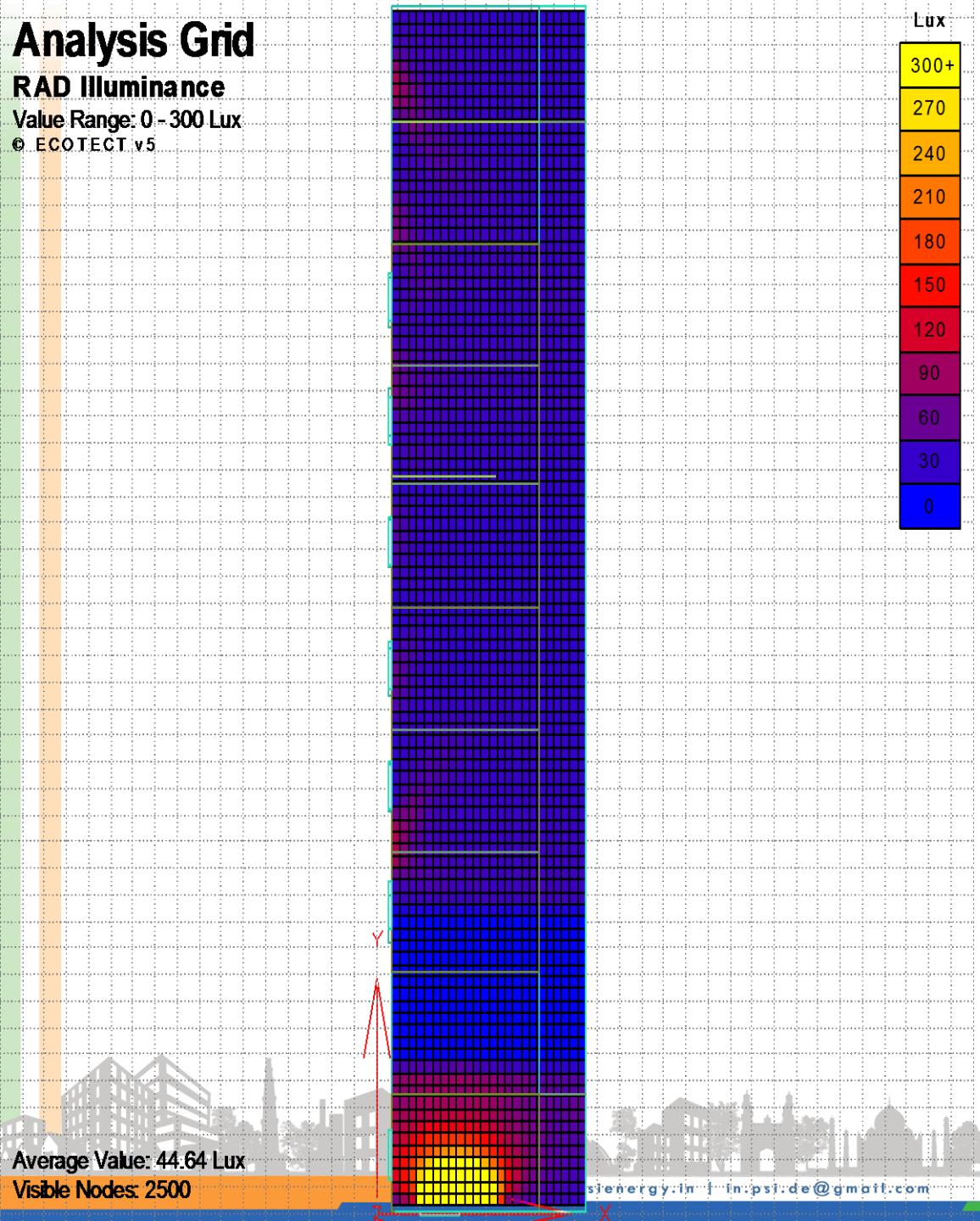
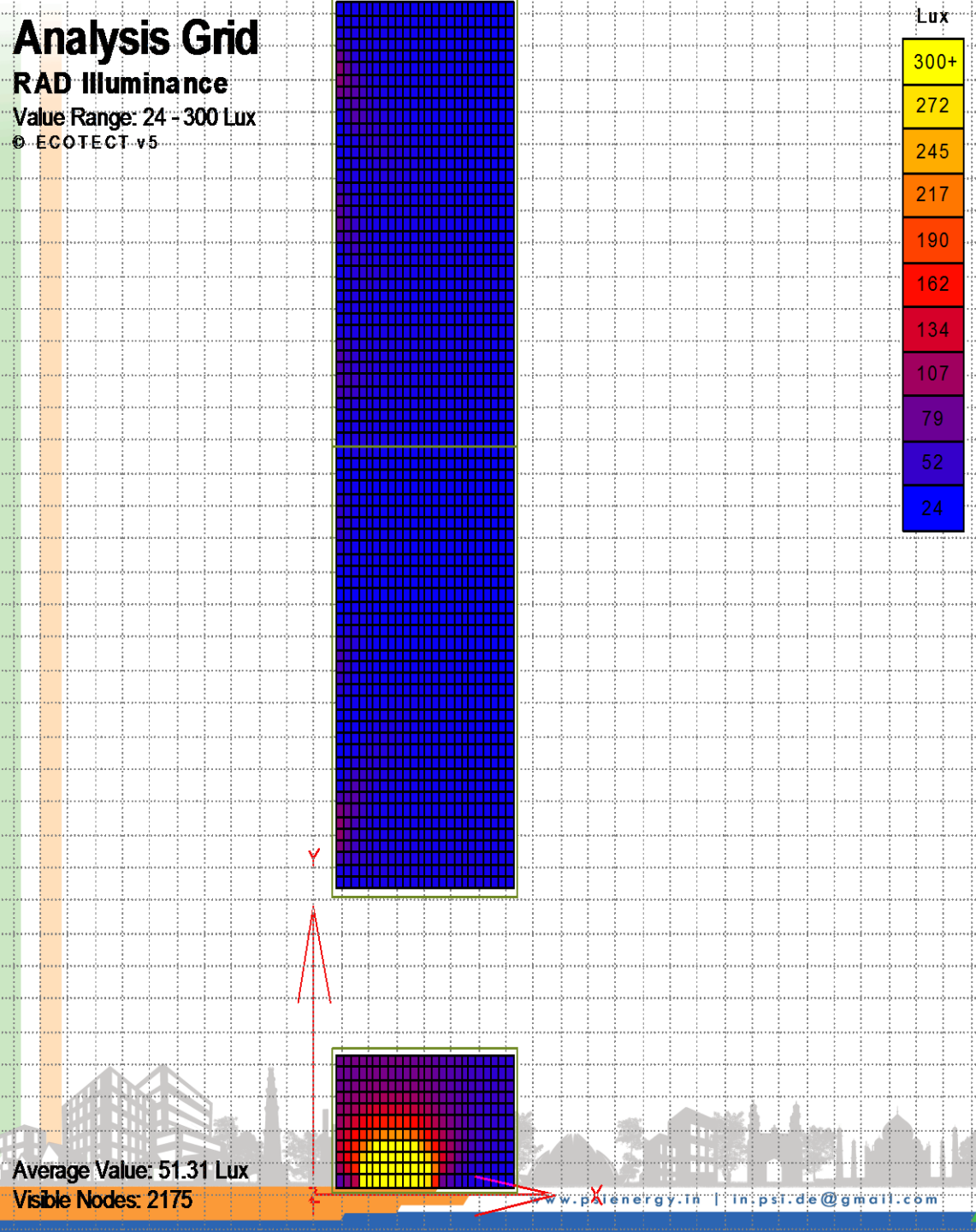


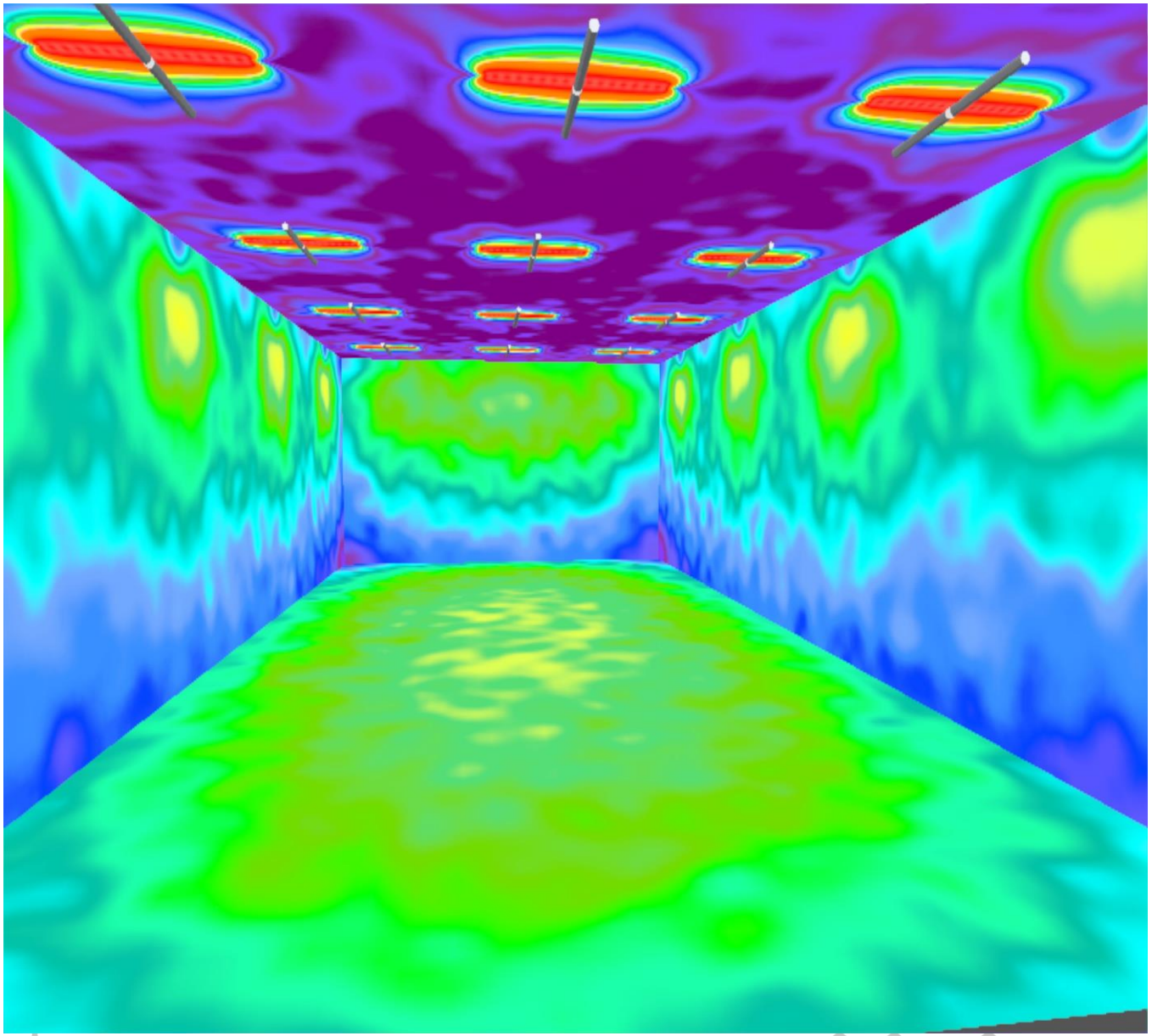
Basement 1

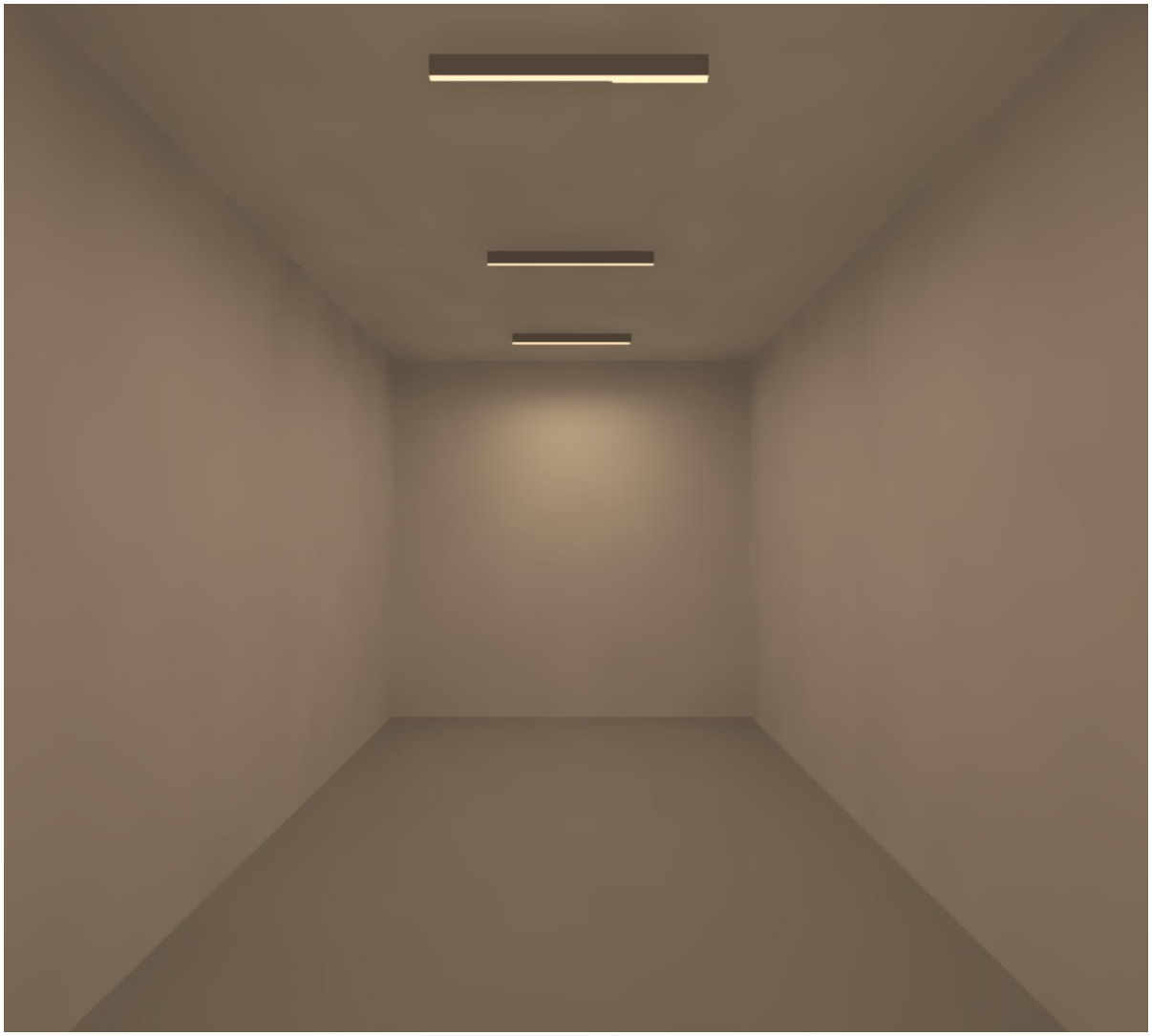
Avg. Daylight Factor = 0.58

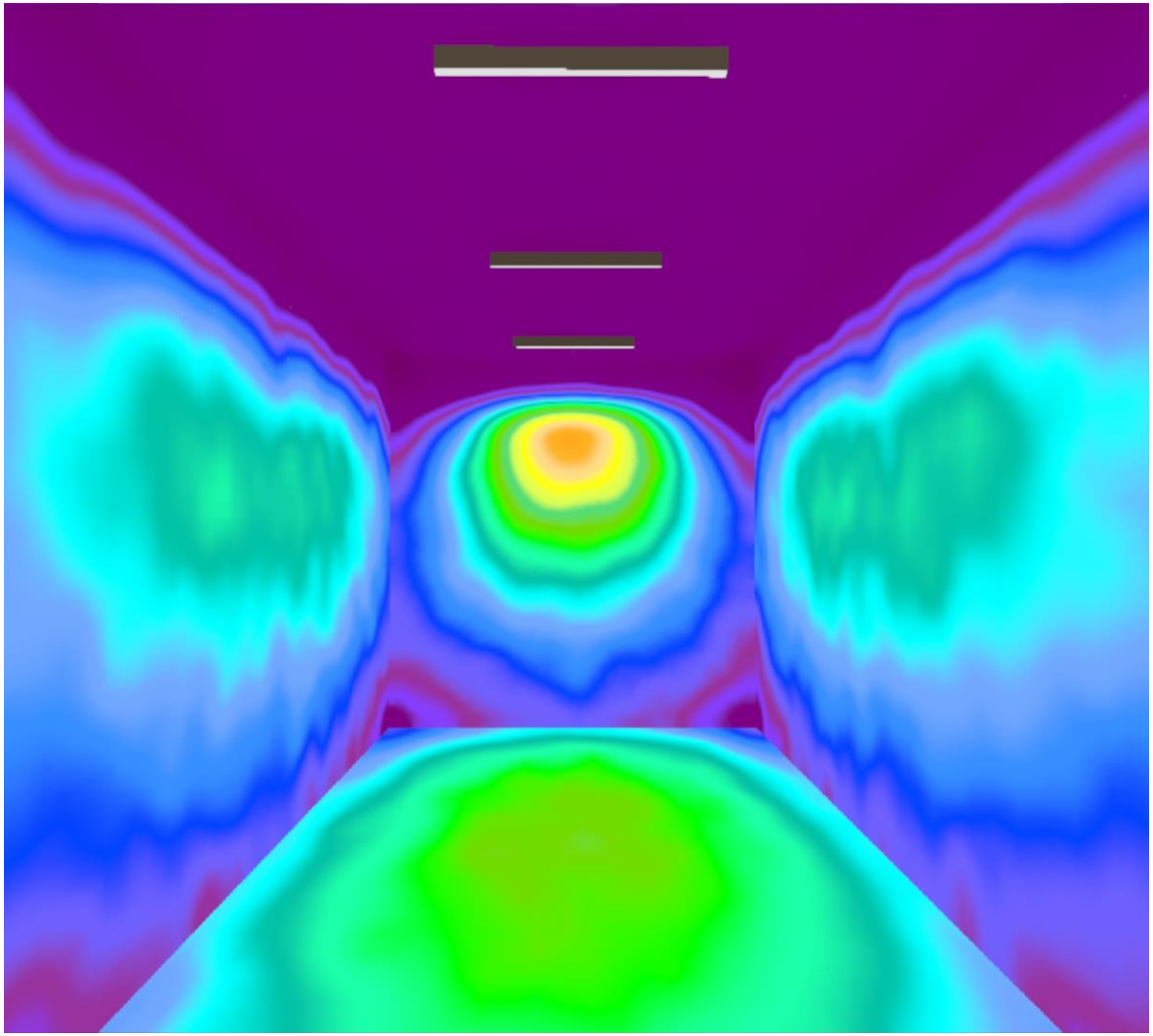


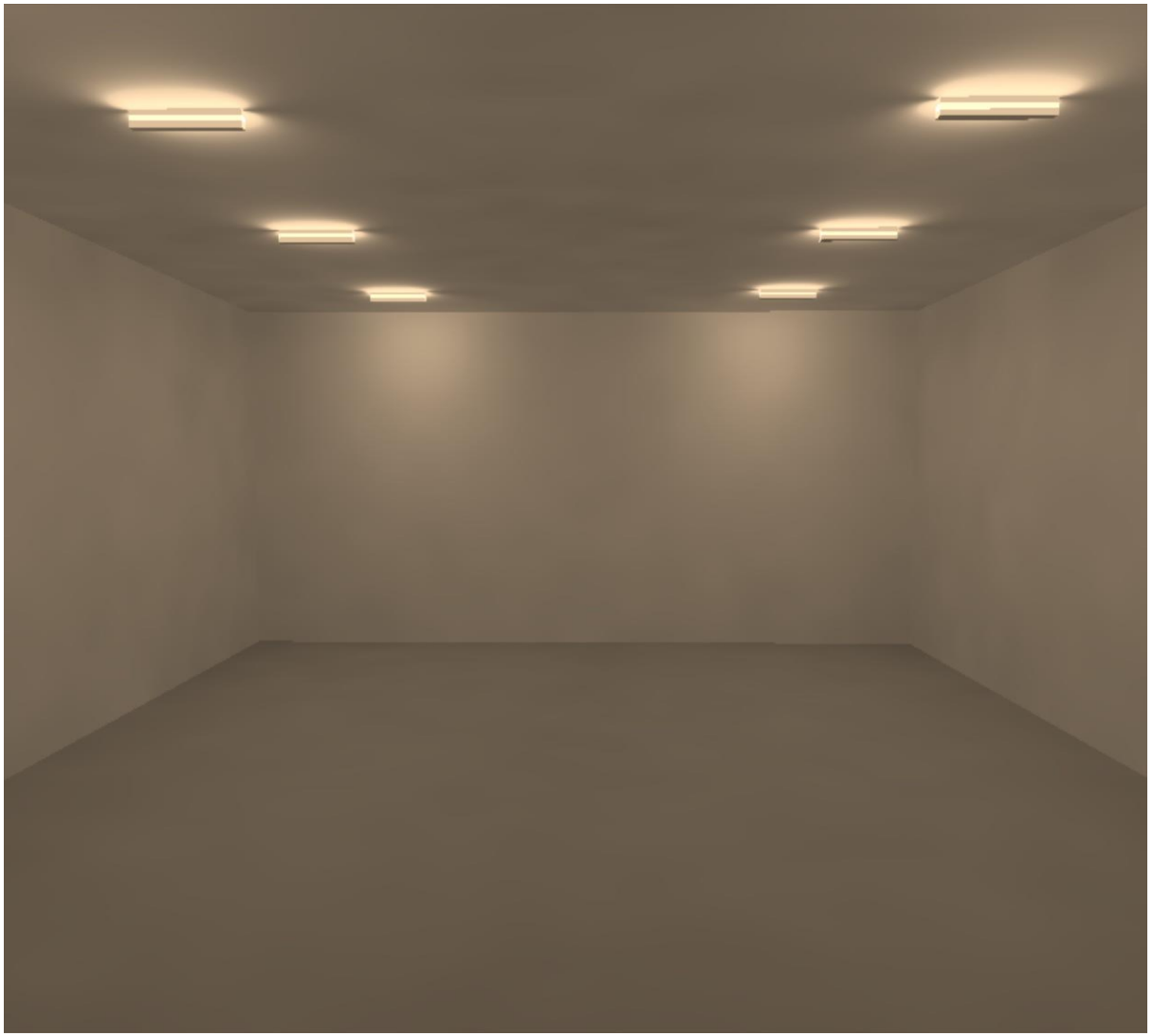
Basement 2

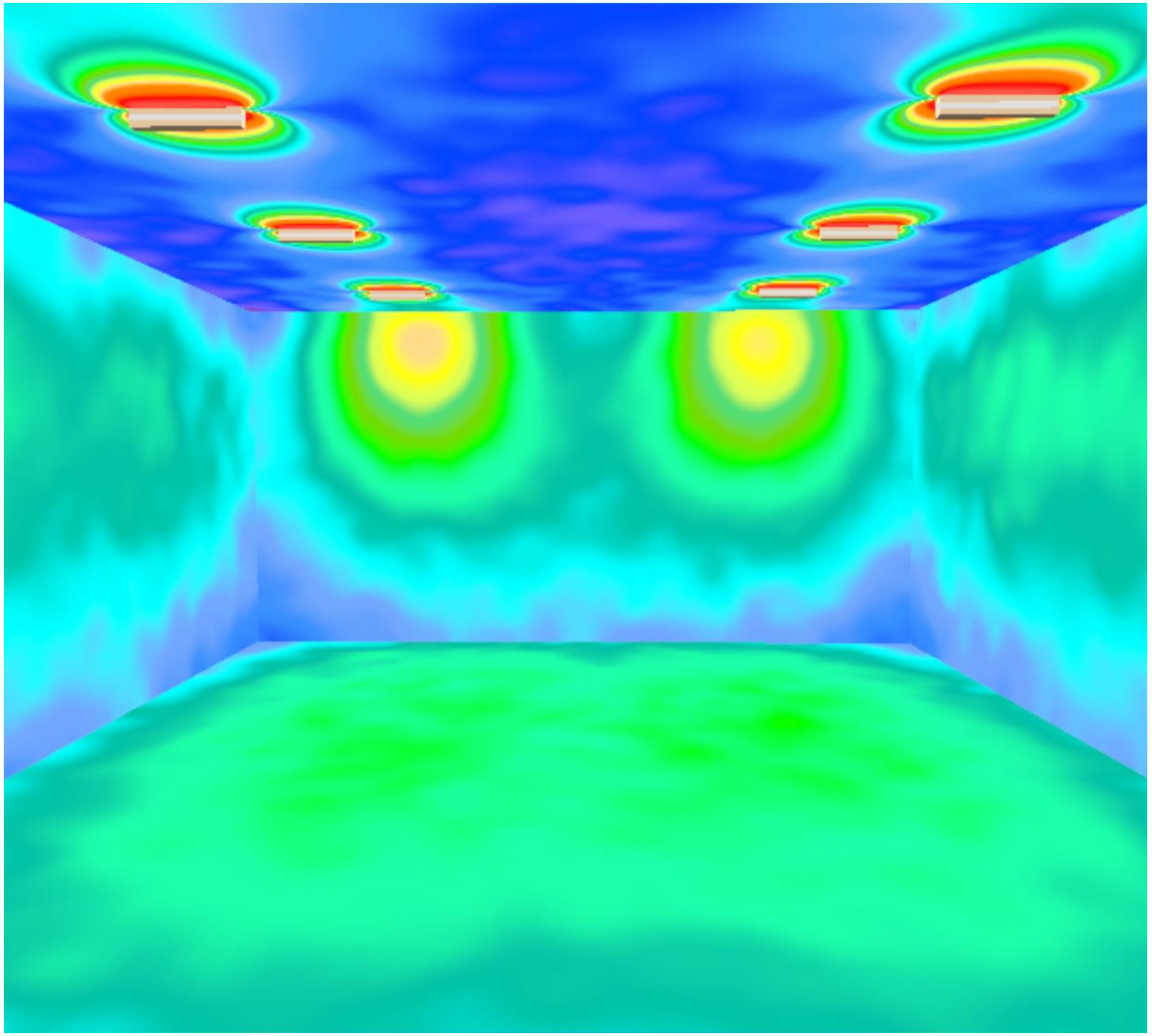
Avg. Daylight Factor = 0.64











Total EPI * Area	189590.04
Total Area	9049.53
Average EPI	20.95
BENCHMARK EPI (12 Hour)	50
Reduction from Benchmark	58

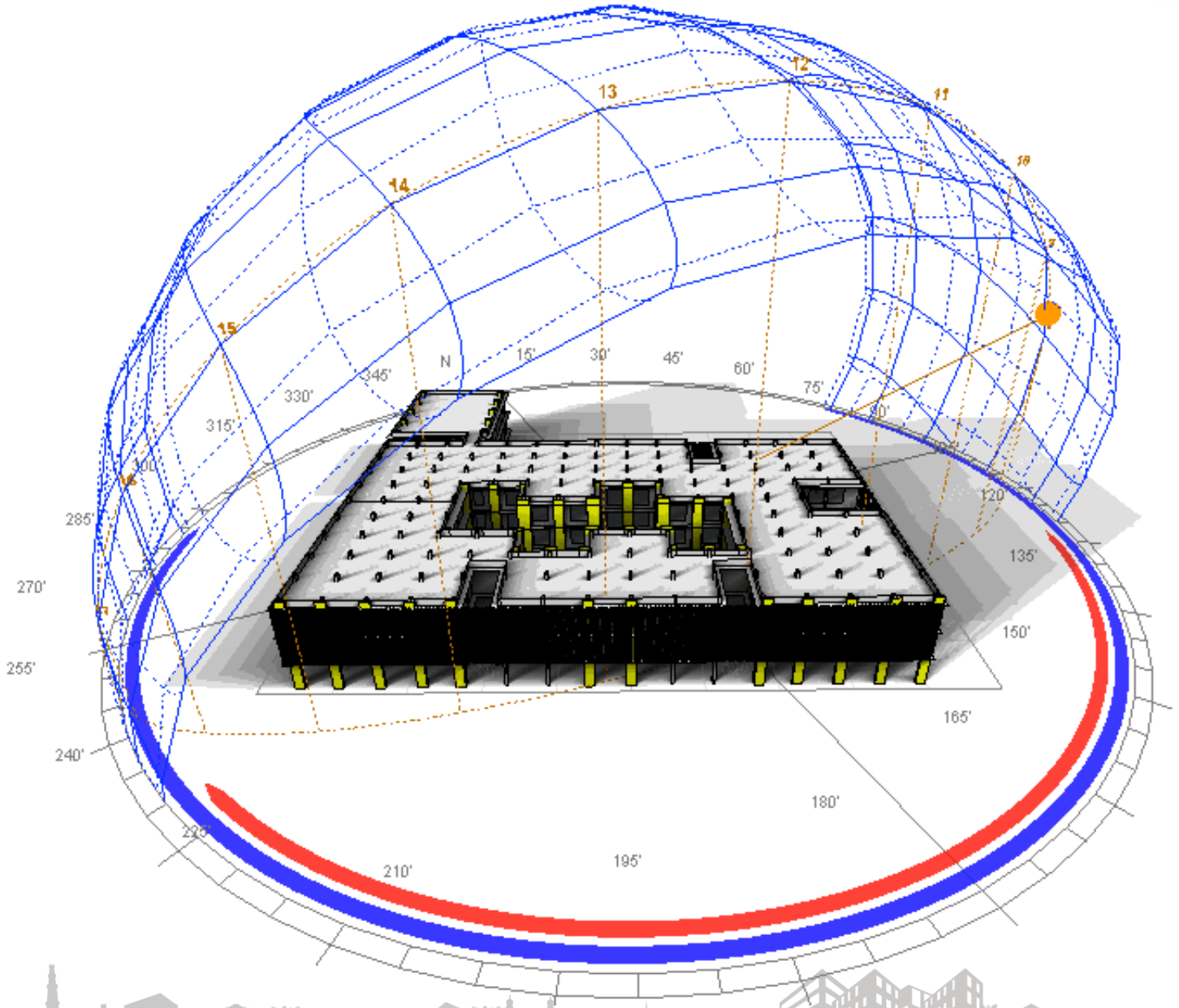
ECBC

- Walls
  - U-Value – 0.352 W/m2K
- Roof
  - U-Value – 0.409 W/m2K
- Glazing
  - U-value – 1.42 W/m2K
  - SHGC – 0.51 (WWR 40%)

Project3 – Government Building, Odisha

WARM AND HUMID CLIMATE ZONE	
Thermal Requirements	Physical Manifestation
Reduce Heat Gain	
Decrease exposed surface area	Orientation and shape of building
Increase thermal resistance	Roof insulation and wall insulation
Reflective surface of roof	
Increase buffer spaces	Balconies and verandas
Increase shading	Walls, glass surfaces protected by overhangs, fins and trees
Increase surface reflectivity	Pale color, glazed china mosaic tiles, etc.
Reduce solar heat gain	Use glazing with lower SHGC and provide shading for windows.
Minimize glazing in East and West	
Promote Heat Loss	
Increase air exchange rate (Ventilation throughout the day)	Ventilated roof construction. Courtyards, wind towers and
arrangement of openings	
Decrease humidity levels	Dehumidifiers/desiccant cooling

Source: Nayak and Prajapati (2006). Handbook of Energy Conscious Building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13
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15'
30'
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60'
75'
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345'
330'
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270'
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240'
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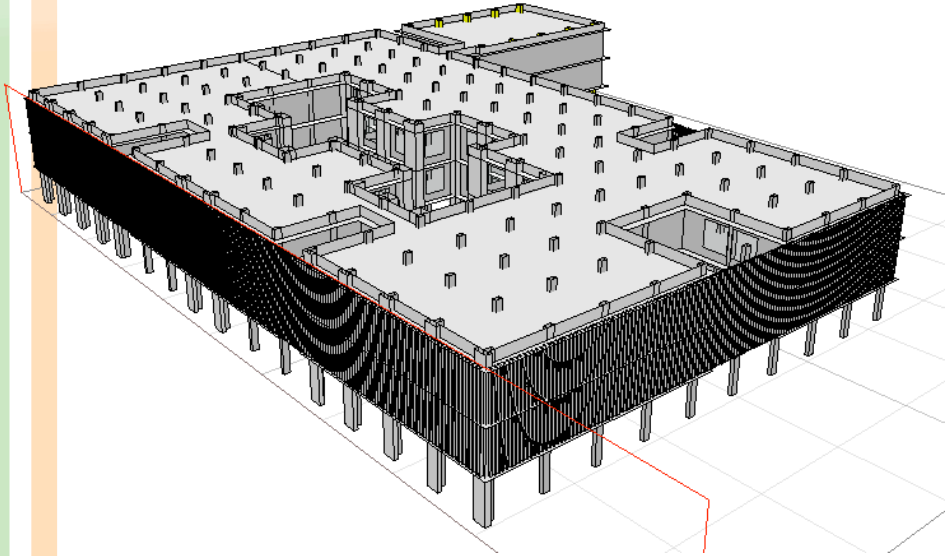
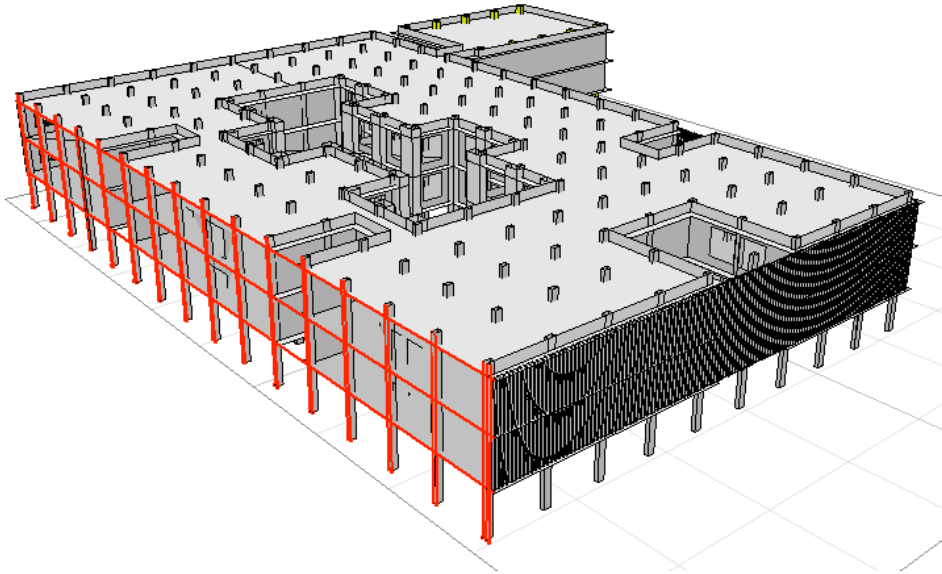
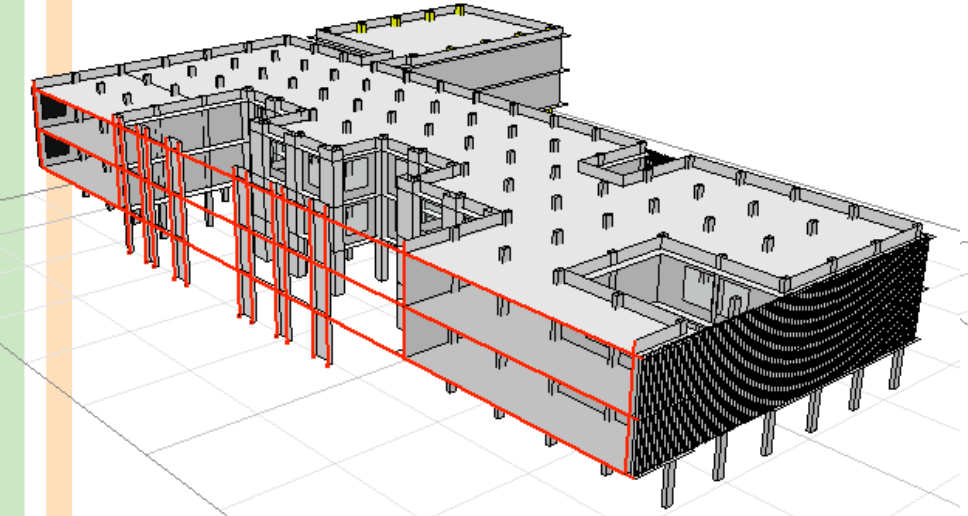
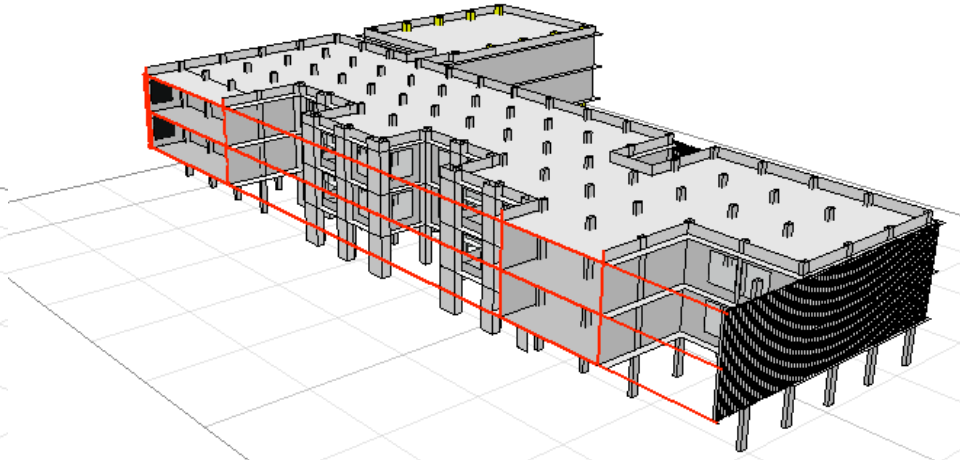
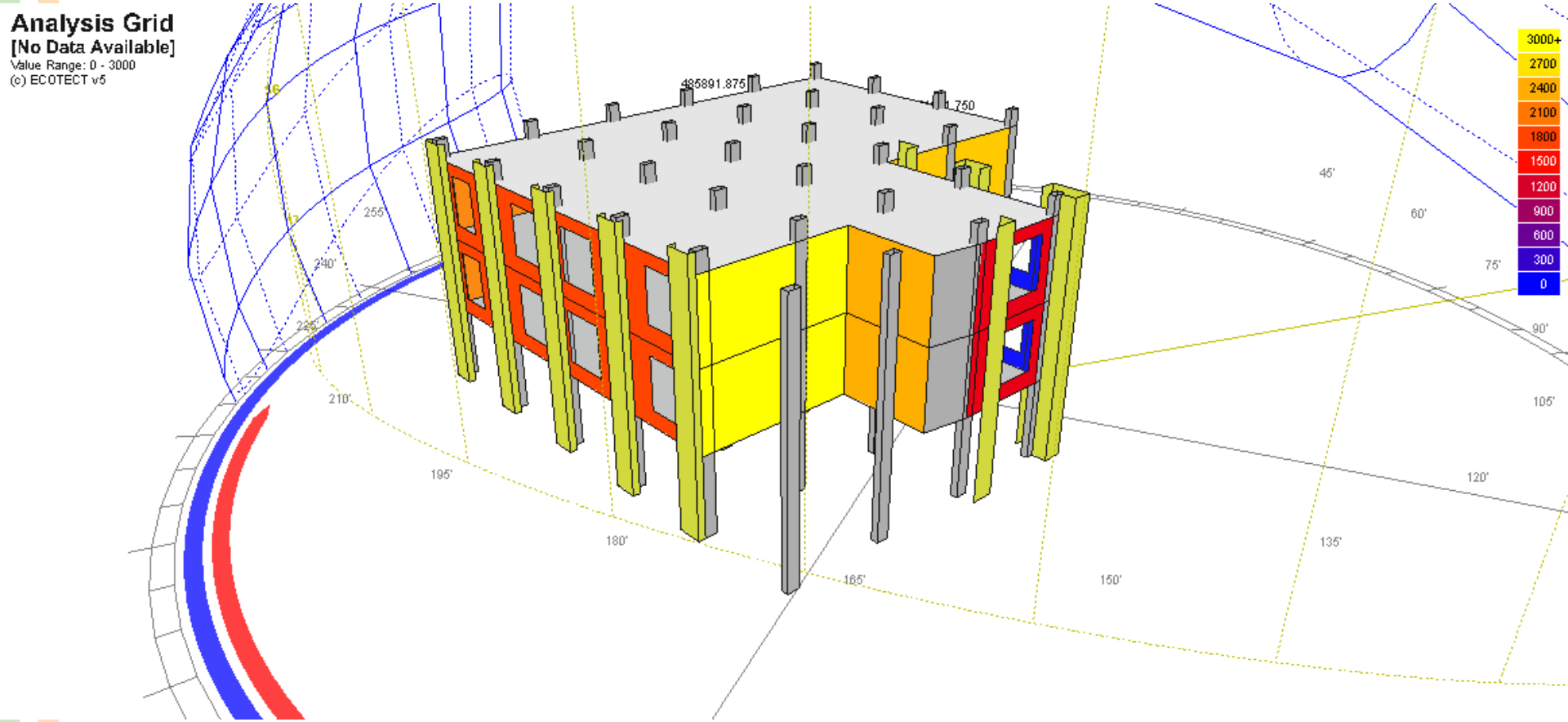
135'
150'
165'
180'
195'
210'







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750
3000+
2700
2400
2100
1800
1500
1200
900
600
300
0
45'
60'
75'
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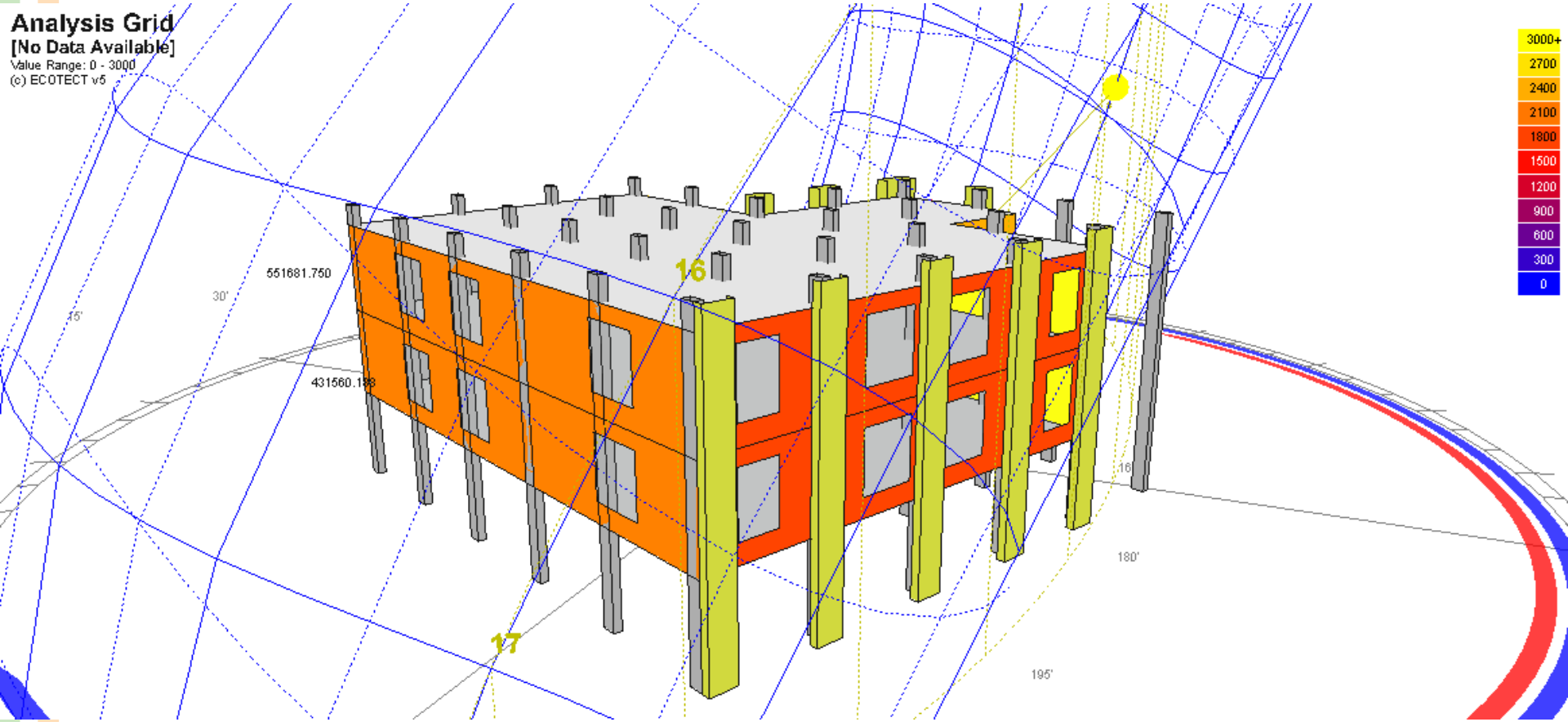
120'
135'
150'
165'
180'
195'
210'
225'
240'
255'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(c) ECOTECT v5
3000+
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551681.750
431560.188
30'
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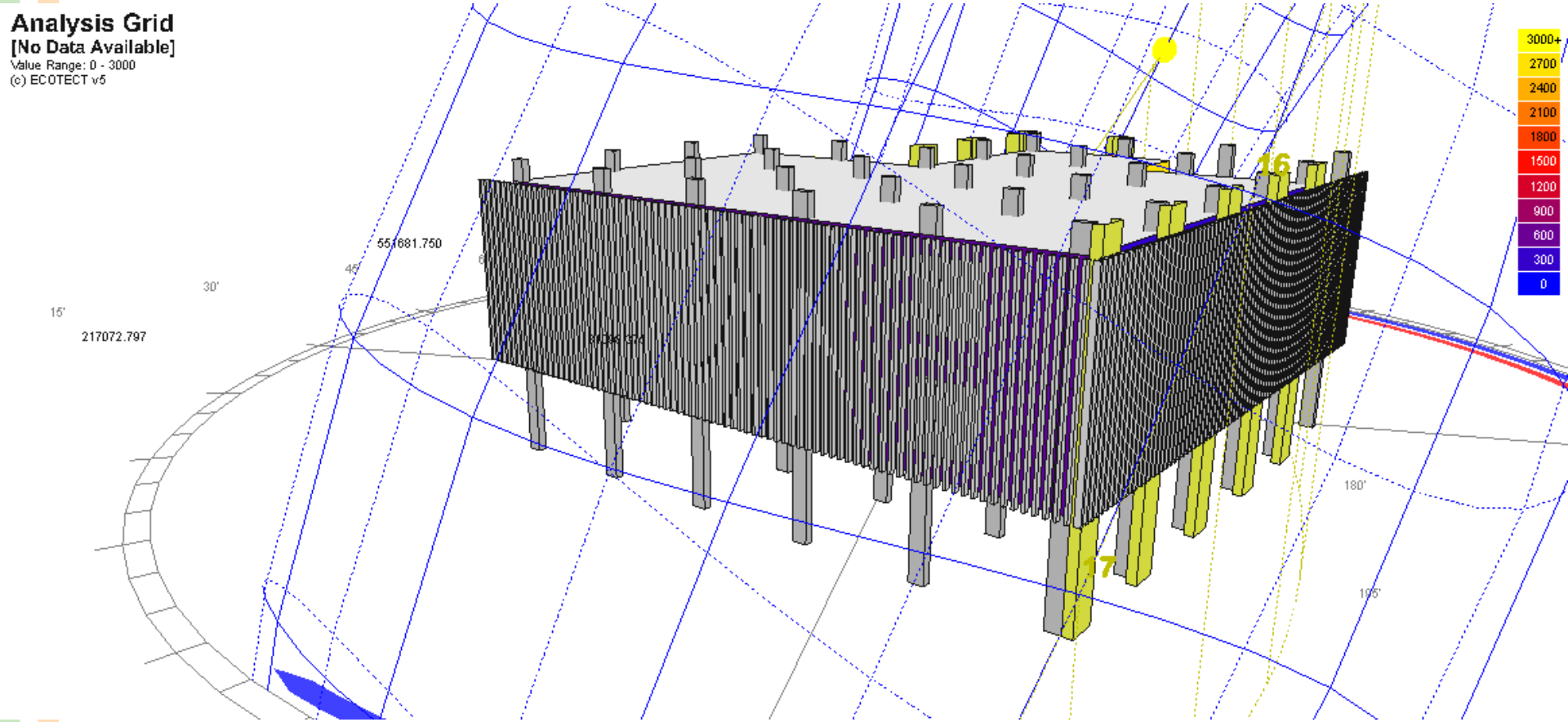
180'
195'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3000+
2700
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2100
1800
1500
1200
900
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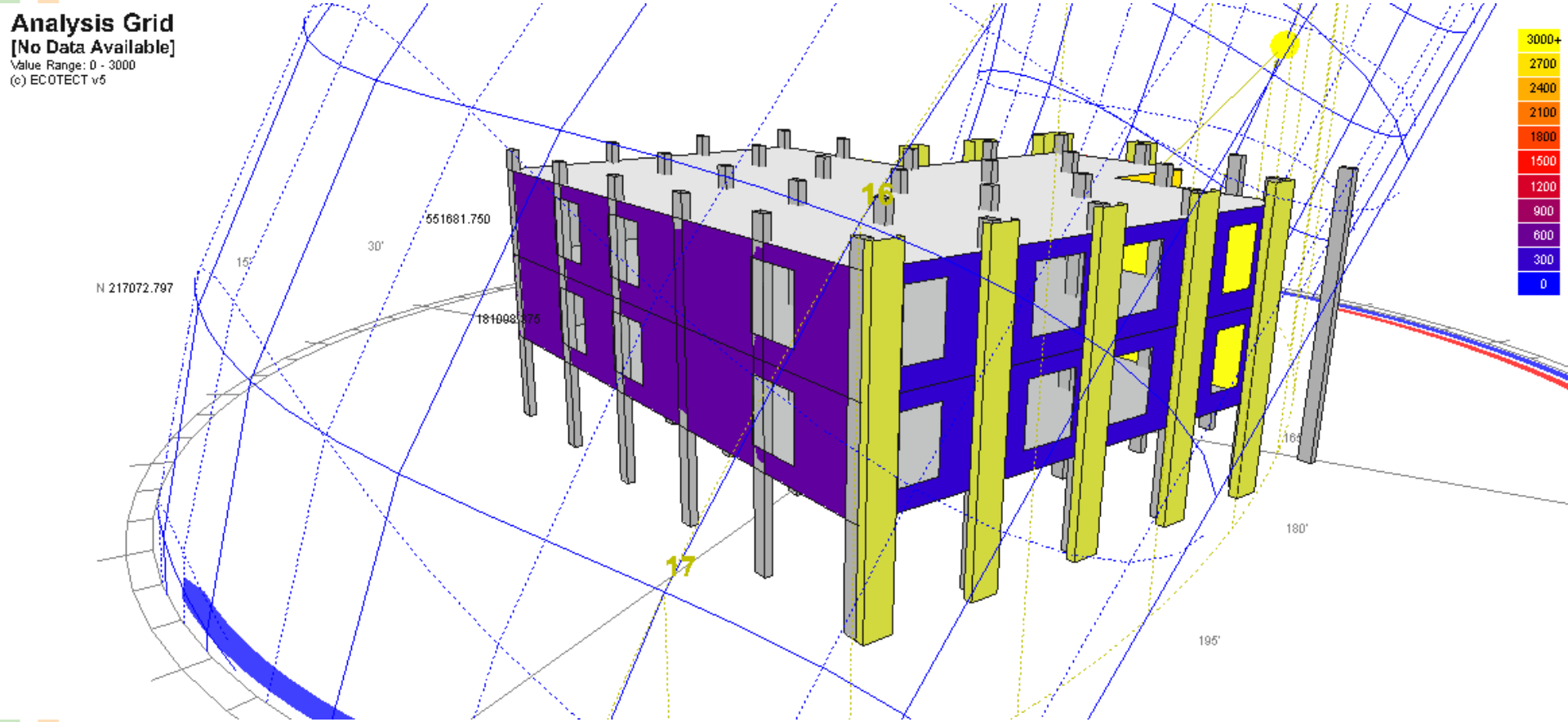
0
551681.750
217072.797
30'
15'
45'
180'
16
17


Analysis Grid
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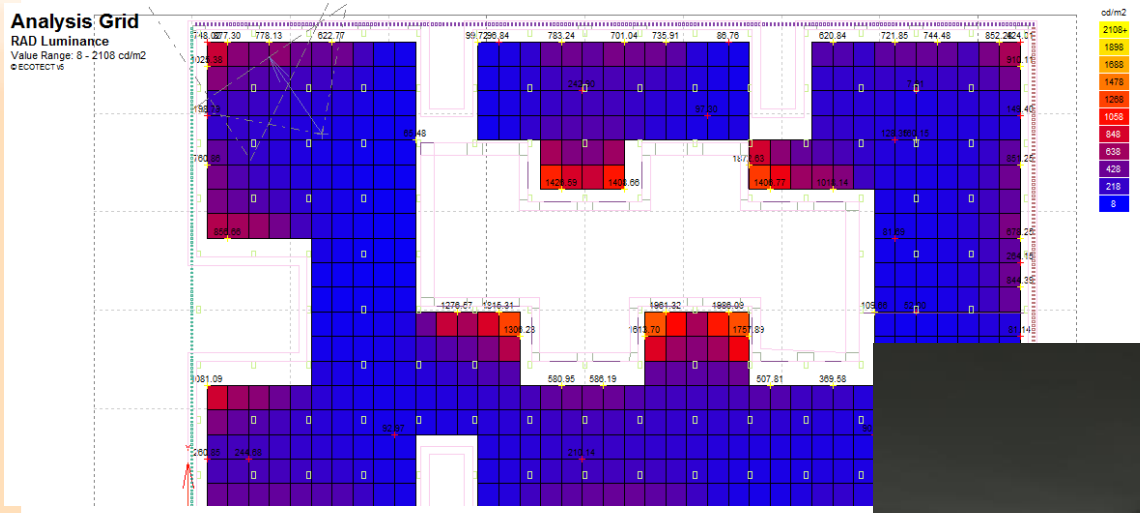
Value Range: 0 - 3000
(c) ECOTECT v5
3000+
2700
2400
2100
1800
1500
1200
900
600
300
0
551681.750
N 217072.797
30'
15'
16
17
180'
195'


Analysis Grid
RAD Luminance
Value Range: 8 - 2108 cd/m2
© ECOTECT v5
cd/m2
2108+
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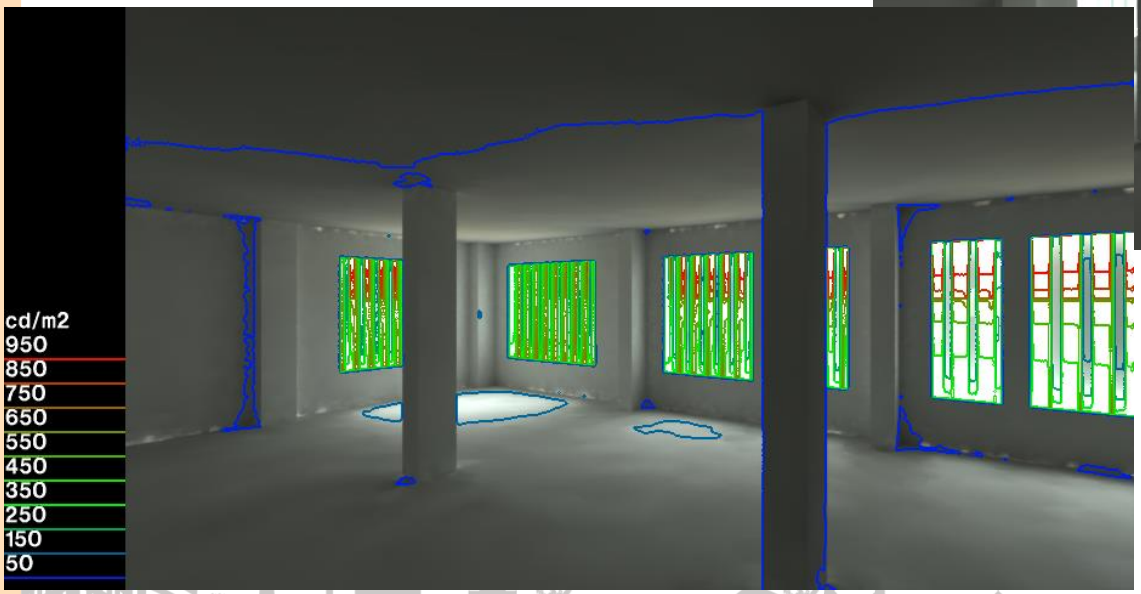
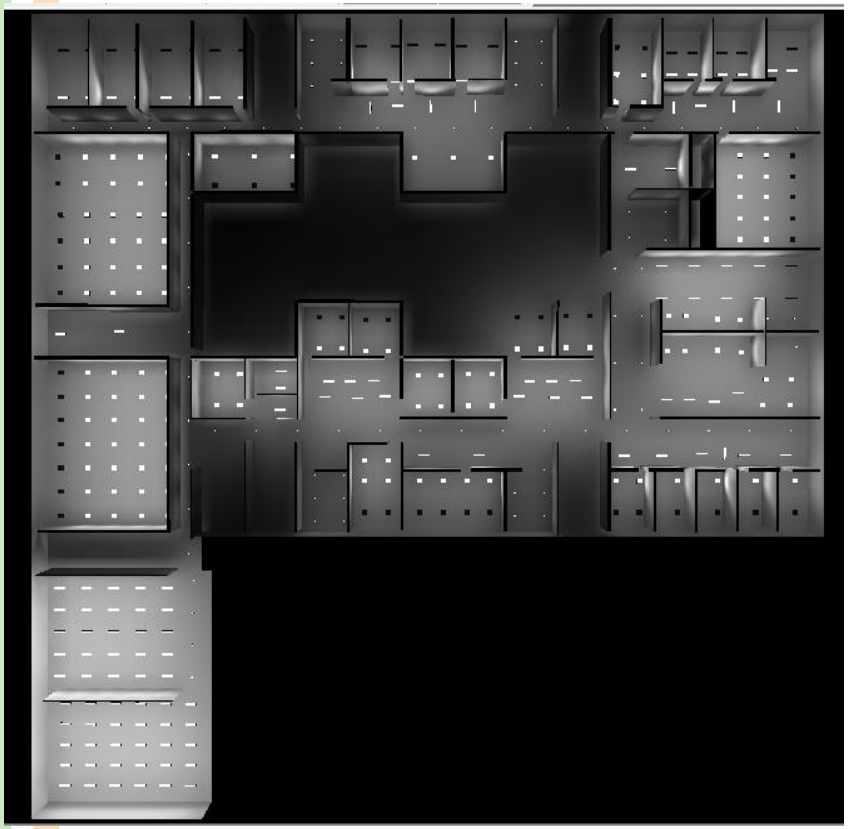
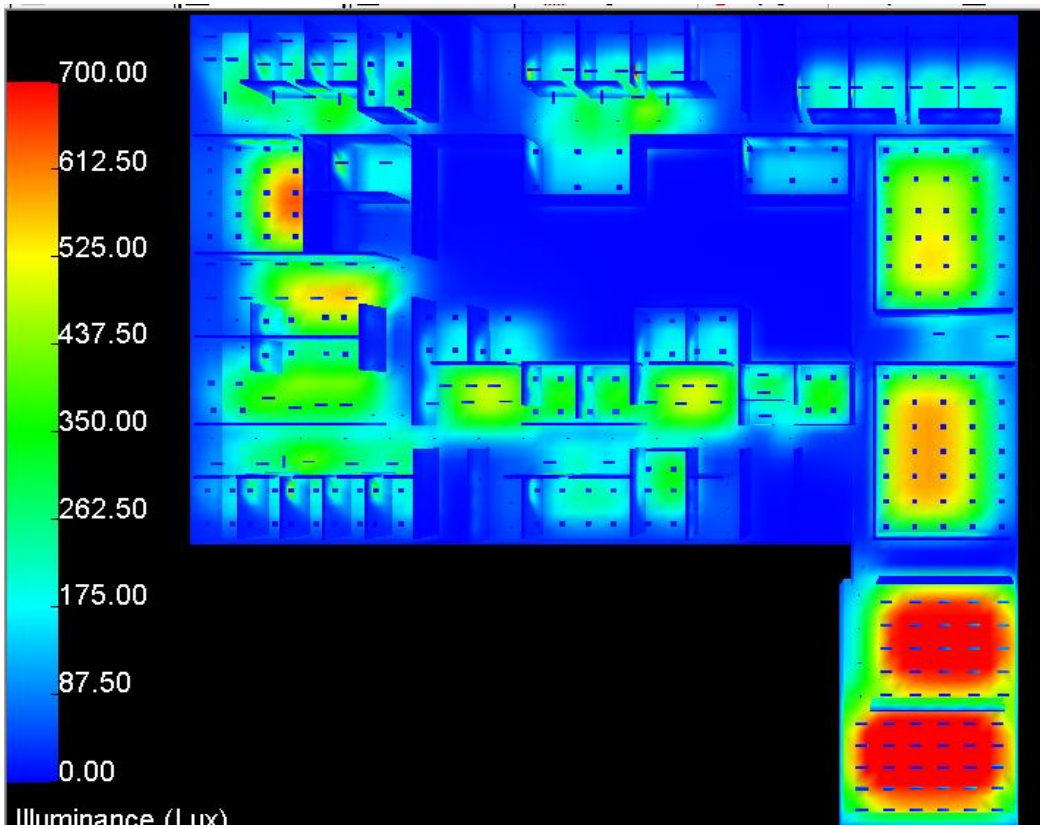
1688
1478
1268
1058
848
638
428
218
8


cd/m2
950
850
750
650
550
450
350
250
150
50

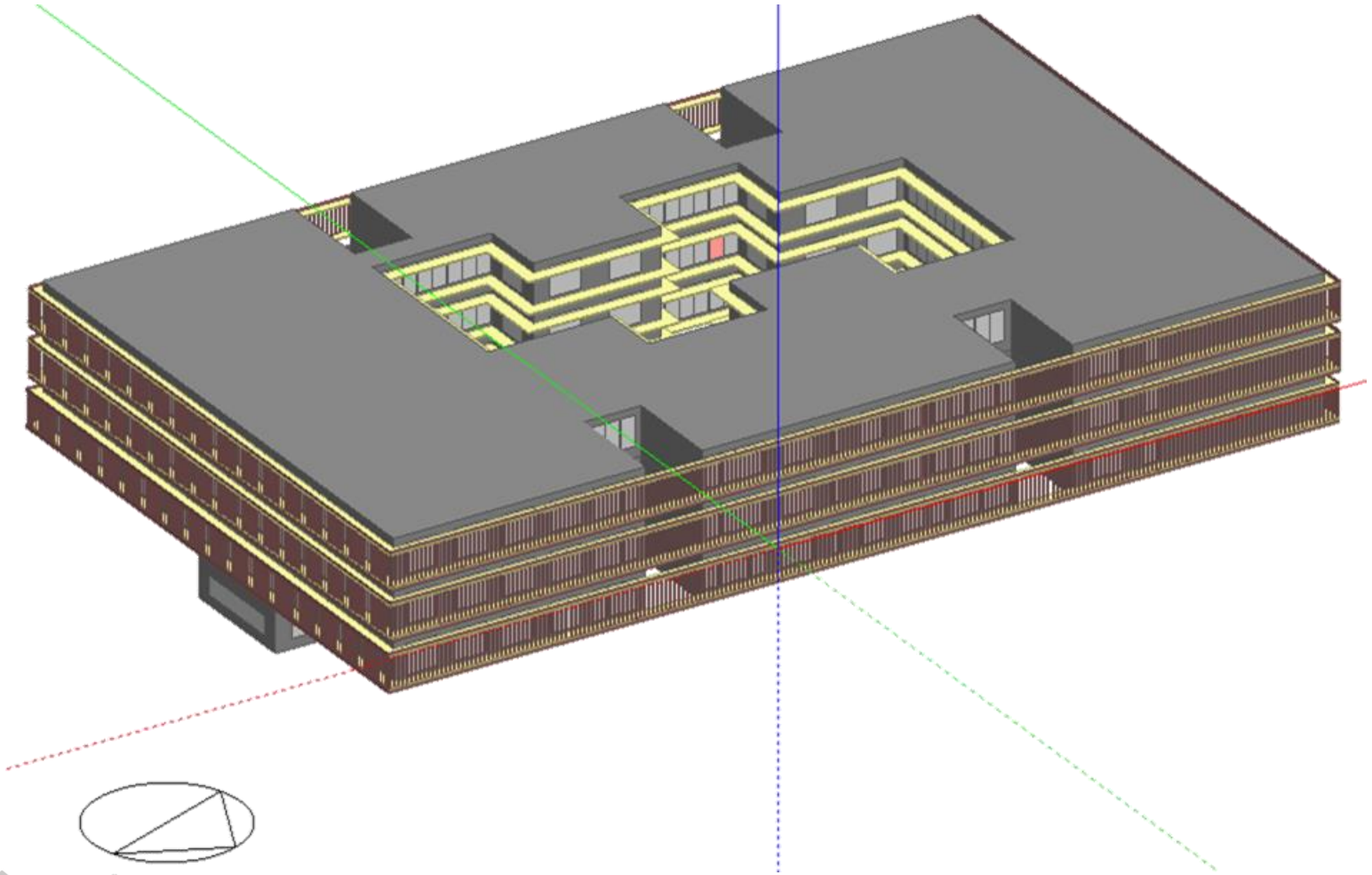
Day Light and Artificial lighting





Lighting Levels : 300 -500 lux (As per NBC 2005)

Lighting power density : 4 W/m2 more efficient than ECBC 2007



Envelope Optimisation

- ECBC
  - Walls
    - U-Value – 0.440 W/m^{2}K
  - Roof
    - U-Value – 0.409 W/m^{2}K
  - Glazing
    - U-value – 3.3 W/m^{2}K
    - SHGC – 0.25 (WWR 40%)

- ECBC+
  - Walls
    - U-Value – 1.2 W/m^{2}K
    - Shaded
  - Roof
    - U-Value – 0.6 W/m^{2}K
    - Green Roof over RCC slab
  - Glazing
    - U-value – 1.7 W/m^{2}K
    - SHGC – 0.25 (WWR 40%) by shaded clear glass

Thermal comfort with Natural Ventilation and Ceiling Fans

- '*Comfort model for non conditioned spaces with wind speed*', as per the NBC 2005

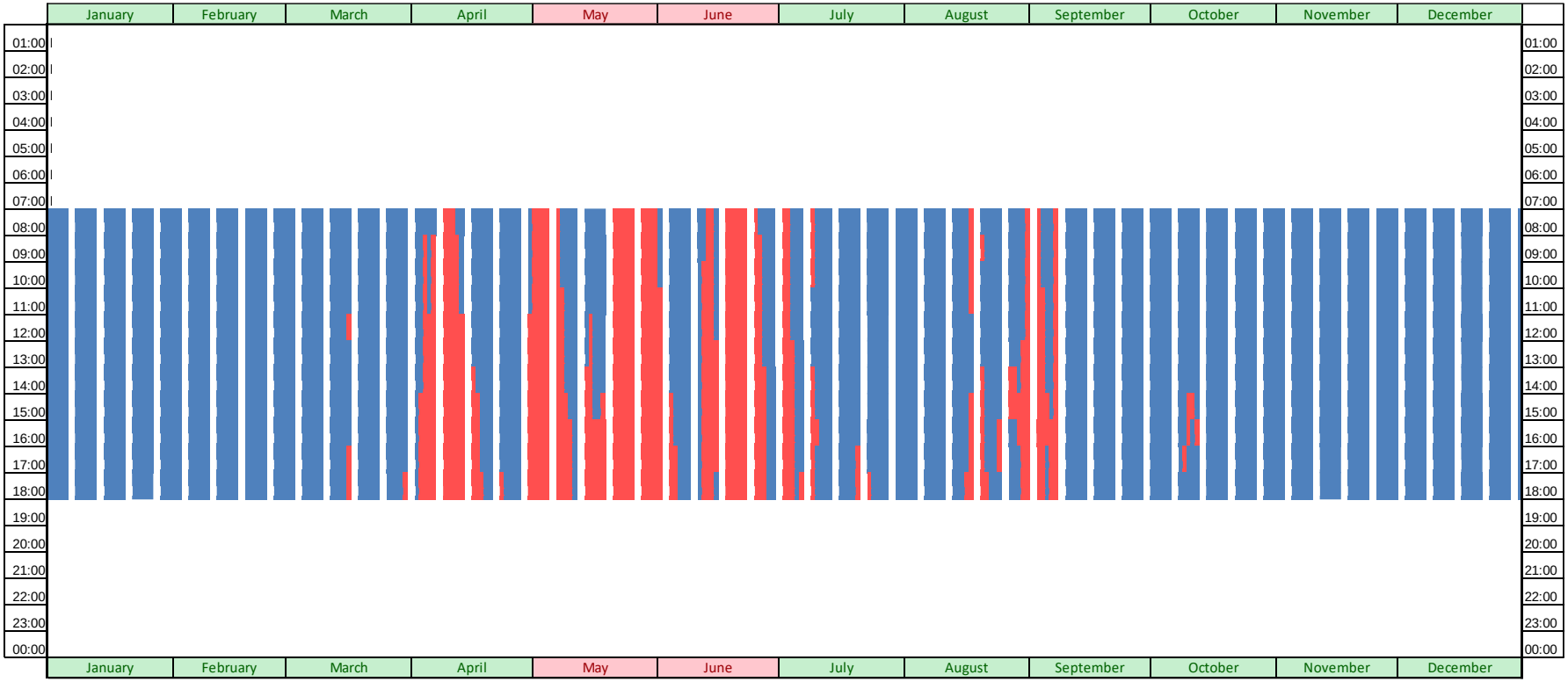
Table 3 Comfort conditions for non-air conditioned spaces

Dry bulb temperature °C	Relative humidity (percentage)						
	30	40	50	60	70	80	90
30	–	–	–	–	–	–	–
31	–	–	–	–	–	0.06	0.23
32	–	–	–	0.09	0.29	0.6	0.94
33	–	0.04	0.24	0.6	1.04	1.85	2.1
34	0.15	0.46	0.94	1.6	2.26	3.05	–
35	0.68	1.36	2.10	3.05	–	–	–
36	1.72	2.70	–	–	–	–	–

Source: NBC - 2005, BIS, Part 8, Building services; Section 1, Tables 10

Discomfort Chart – occupied hours

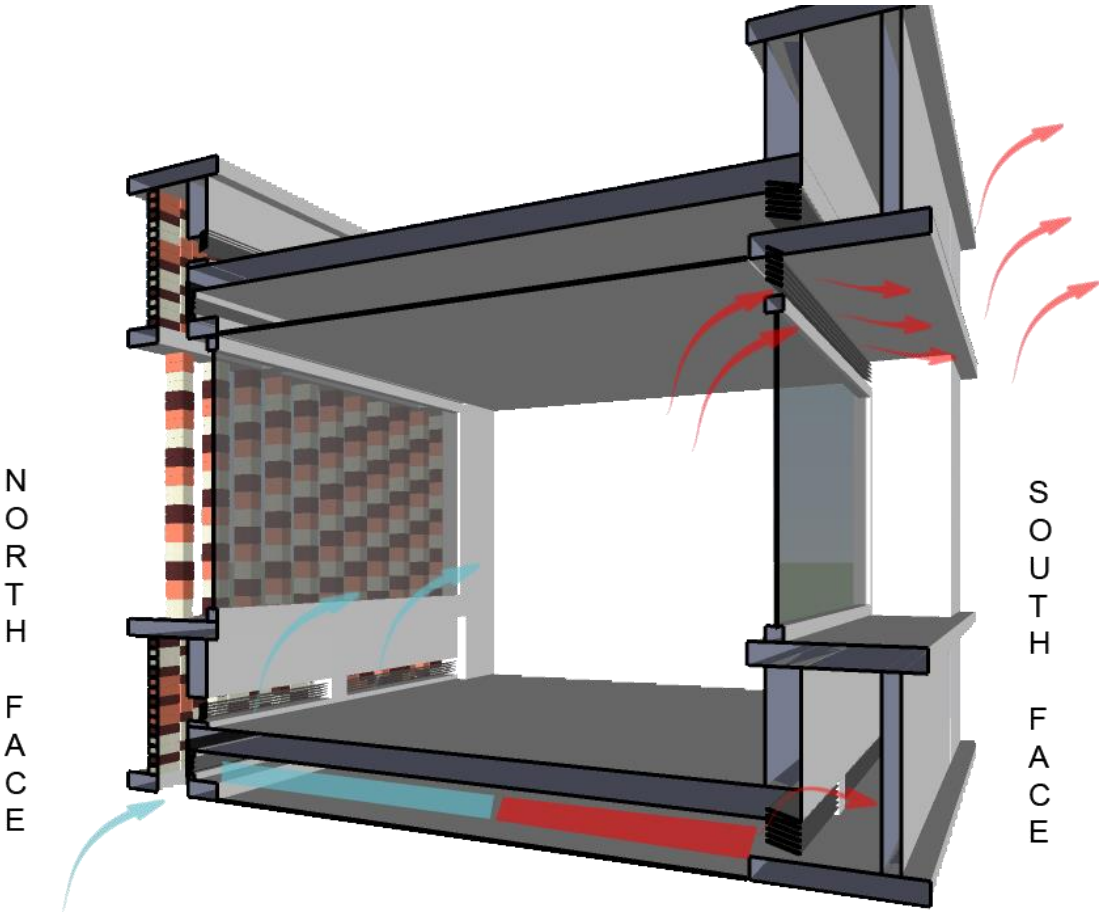
Hours of Discomfort Minimum	Percentage Discomfort
547	21.04%



X-Axis – Days of the Year; Y-Axis – Time of the day;

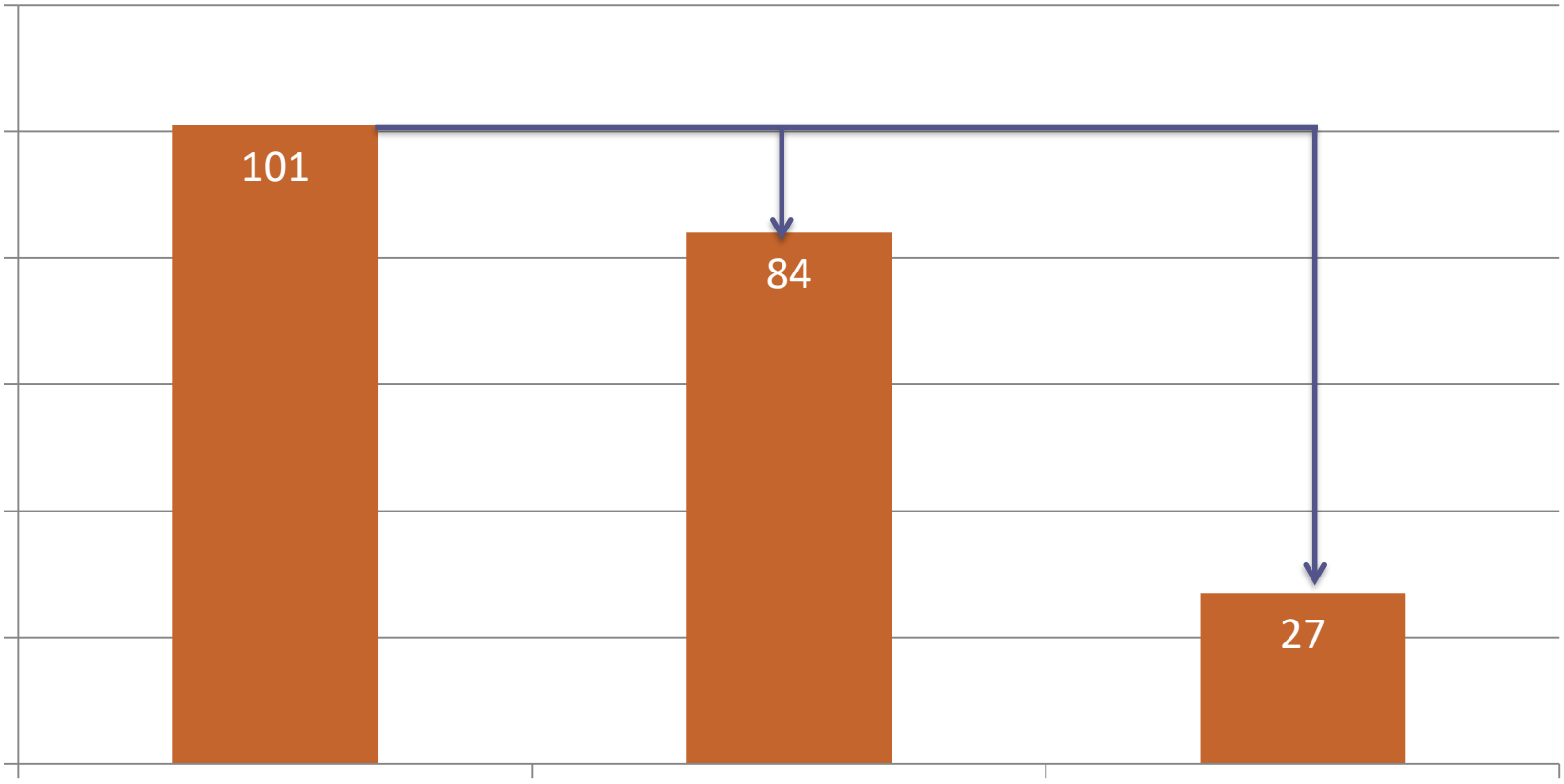
Red – Discomfort Hours; Blue – Comfortable hours; White areas Unoccupied hours

System



- Natural ventilation with night purging
- HVAC system yet to be designed

Summary



Cumulative impact of all ECMs

Conventional Building	Building with ECMs
Cooling Demand (TR) Reduction	45%
Electrical Load (kW) Reduction	59%
Energy Consumption (kWh) Reduction	43%
Efficient Envelope, Lighting and HVAC System	Variable Incremental Cost
Reduction in electrical load by 59%	Variable Reduced Cost
Downsizing of cooling system by 45%	

4.3% Reduction in Overall Costs

Source: TERI, http://high-performancebuildings.org/

Energy efficient building = Solar passive building + ECBC compliance

ECBC Compliance:

- Insulation
- High Performance glass
- Controls
- Efficient electrical , mechanical and lighting systems

Incremental cost: 15%

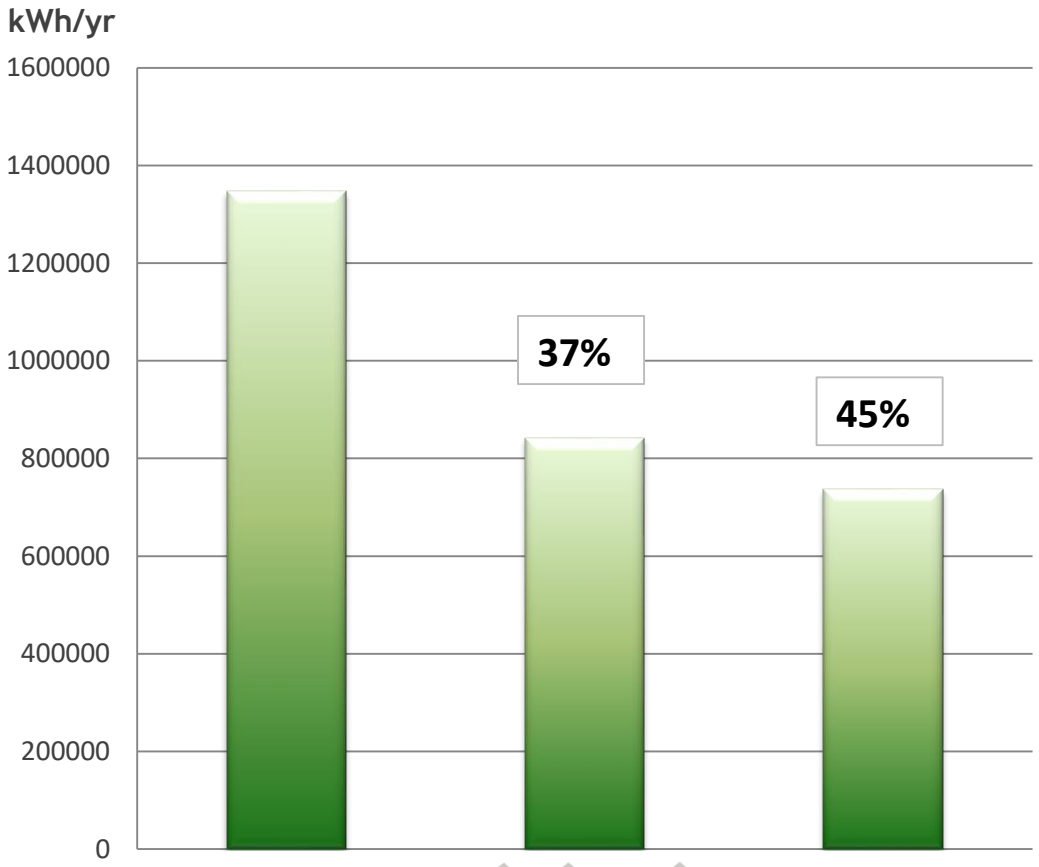
Payback period < 5 years

Compliance with NBC + ECBC

- Passive principles (shading, orientation, controlled glass area)
- Higher indoor design conditions (higher by 1 deg C)
- Optimized lighting design

No further incremental cost

Payback period: < 4 years



http://www.architecturetravelwriter.com/wp-content/uploads/2011/08/HVAC-and-windows-view-of-NREL.jpg

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THANK YOU FOR YOUR LISTENING