INTRODUCTION TO BUILDING SIMULATION

Shreshth Nagpal

SPECTRAL





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ASHRAE

LEED-NC CERTIFIED 2005
U.S. GREEN BUILDING COUNCIL
LEADERSHIP IN ENERGY & ENVIRONMENTAL DESIGN

indian green building council

GRIHA

architecture 2030

Living Building Challenge
www.cascadiagbc.org/lbc

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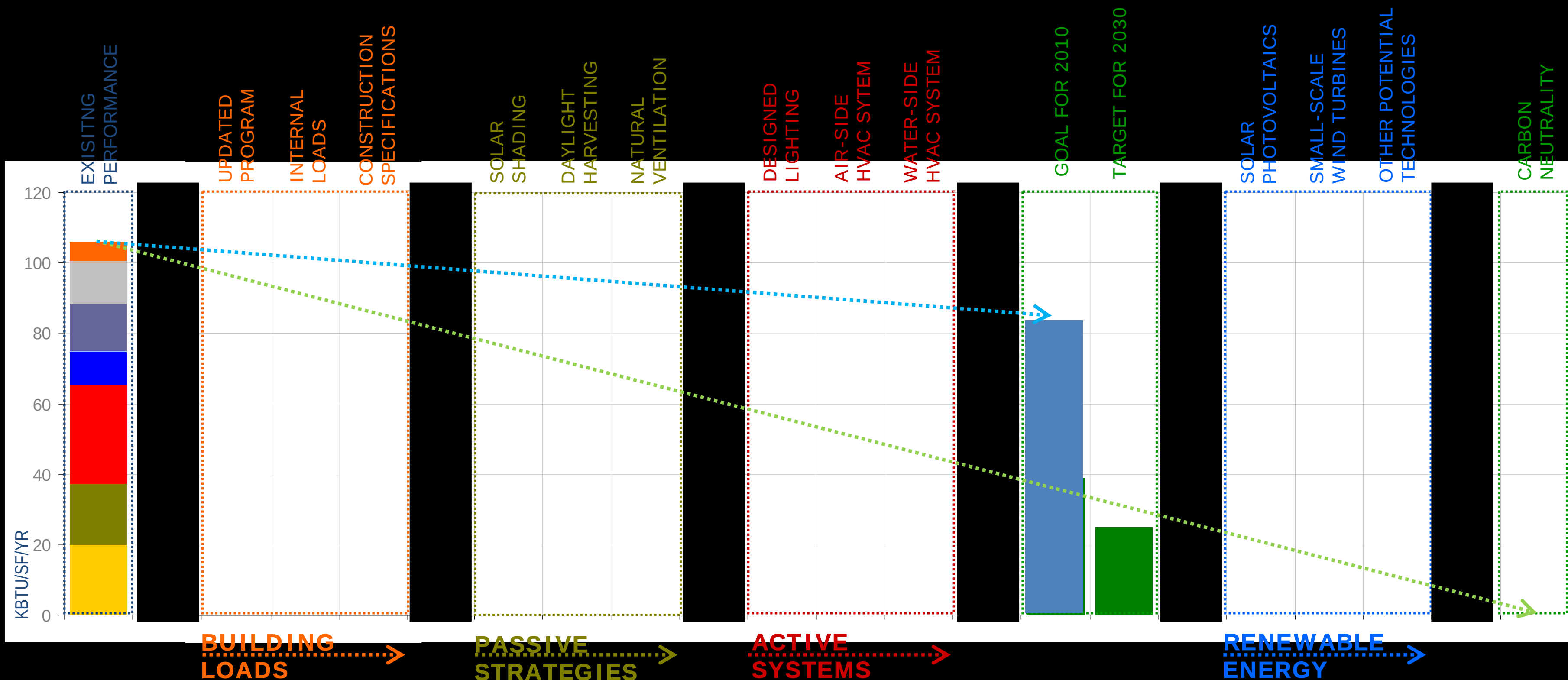
EXISITNG PERFORMANCE
UPDATED PROGRAM
INTERNAL LOADS
CONSTRUCTION SPECIFICATIONS
SOLAR SHADING
DAYLIGHT HARVESTING
NATURAL VENTILATION
DESIGNED LIGHTING
AIR-SIDE HVAC SYTEM
WATER-SIDE HVAC SYSTEM
GOAL FOR 2010
TARGET FOR 2030
SOLAR PHOTOVOLTAICS
SMALL-SCALE WIND TURBINES
OTHER POTENTIAL TECHNOLOGIES
CARBON NEUTRALITY
KBTU/SF/YR
120
100
80
60
40
20
0
BUILDING LOADS
PASSIVE STRATEGIES
ACTIVE SYSTEMS
RENEWABLE ENERGY

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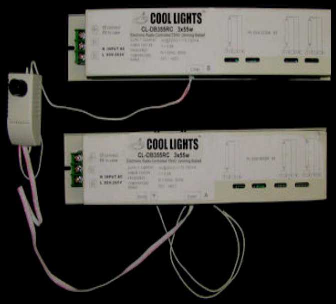

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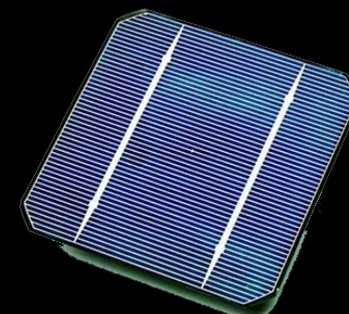

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ecotect

BERKELEY LAB

WIS
Advanced Window Information System

Radiance
Synthetic Imaging System

Airpak
.fluent.com

eQUEST

EnergyPlus

ies

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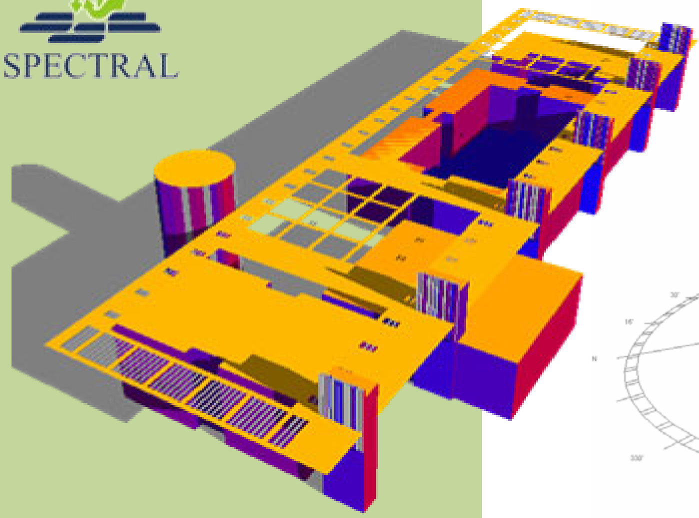
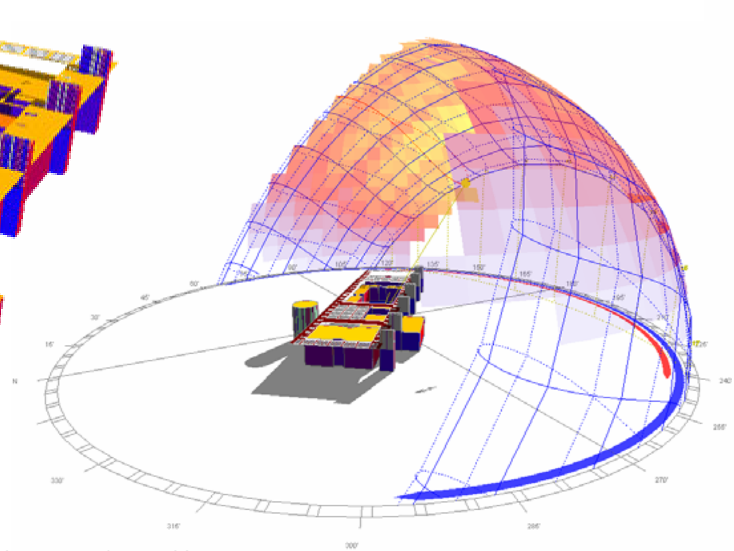
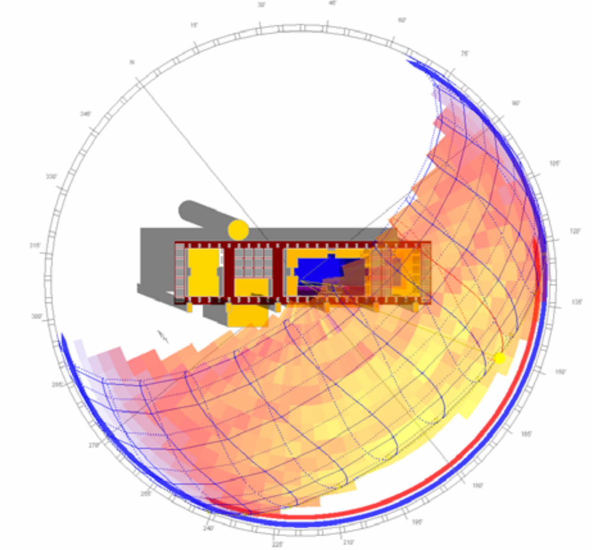


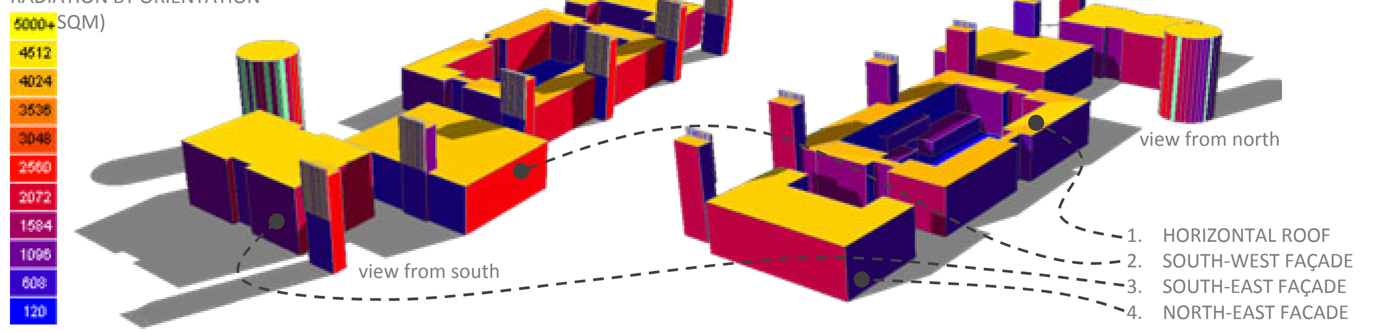


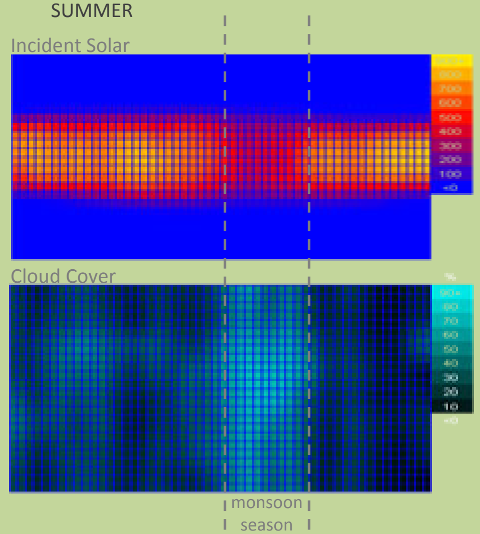


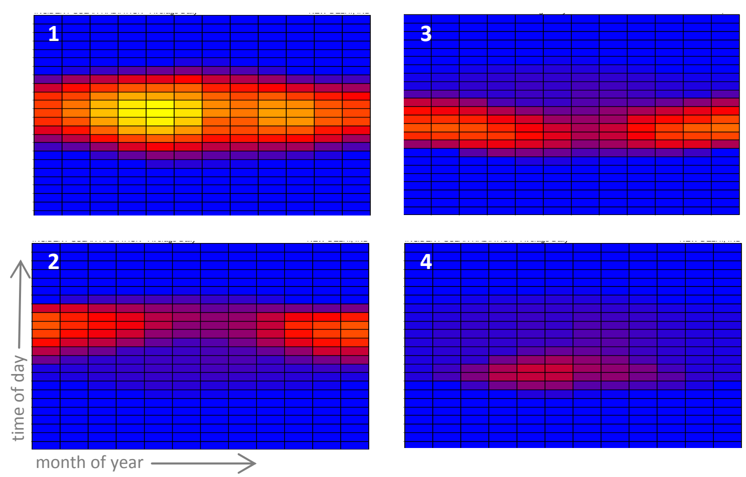
SITE CLIMATE DATA

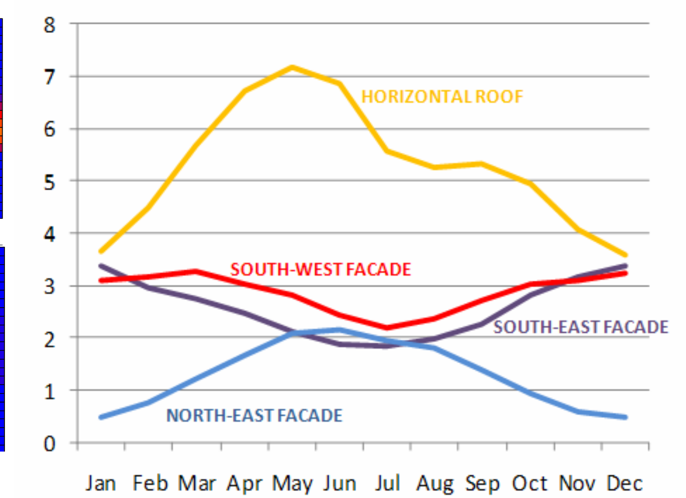
- LONGITUDE -76.47 E
- LATITUDE – 30.44 N
- ALTITUDE - 304-365 METERS ABOVE MSL
- MONSOON - JULY TO SEPTEMBER
- TEMPERATURE –
  WINTER - MIN. 1* C - 16* C (NOV. – JAN.)
  SUMMER – MIN. 27* C – 44* C (APRIL – JULY)
- WIND DIRECTION - FROM NORTH WEST TO SOUTH EAST IN WINTER & REVERSE IN SUMMER

AVERAGE DAILY INCIDENT SOLAR RADIATION BY ORIENTATION









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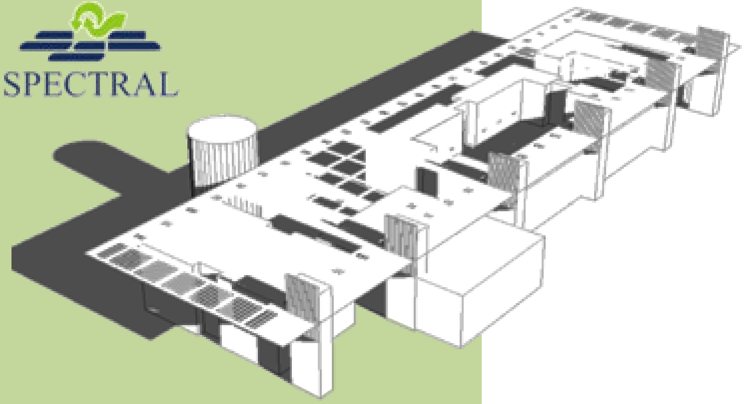


BUILDING PERFORMANCE ANALYSIS

1. The solar radiation analysis on the previous page clearly shows that roof surfaces receive the maximum average daily radiation through the year followed by the south-west facades.

2. The energy use characterization of a baseline design building defined by performance parameters mandated by ASHRAE standard 90.1-2004 illustrates that envelope loads result in almost half of the total cooling energy requirements of the building.

3. Daylight level analysis for both outdoor and indoor spaces illustrates that there may be potential discomfort conditions caused due to excessive radiation and high contrast situations.

To optimize the performance of the building, the design intent should be directed towards the following aspects:

•Reduction in direct solar radiation incident on building surfaces – especially during summers.

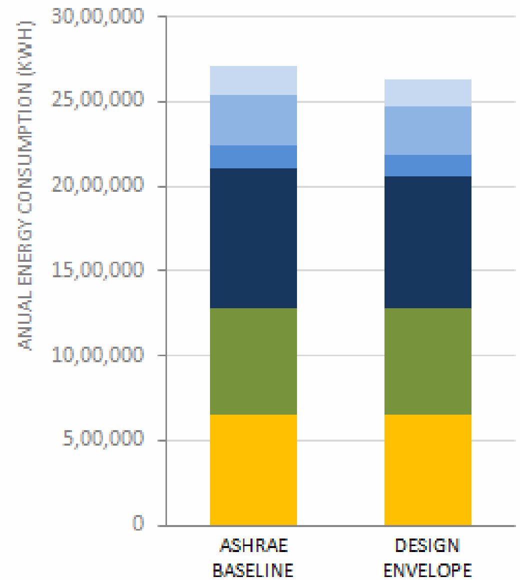
•Glare control and maximum visual comfort in both indoor and outdoor spaces throughout the year.

•Optimum daylight availability in regularly occupied spaces for maximum part of the year.

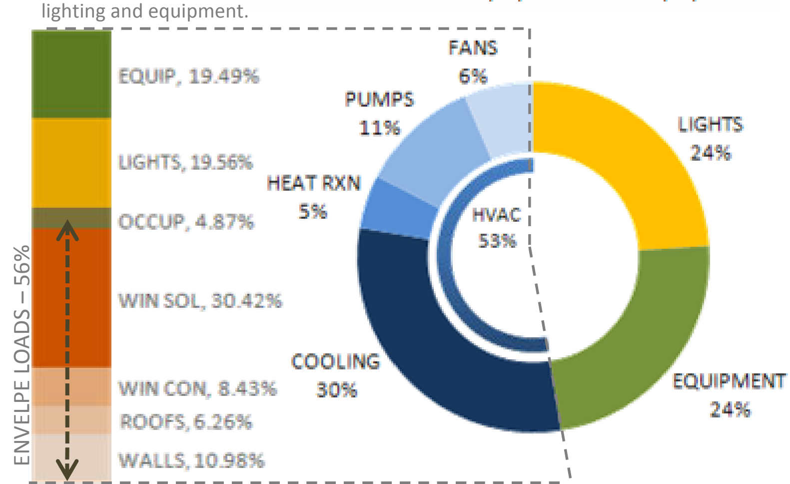
The chart on the right presents the annual energy use breakdown by end use and illustrates that half of the building energy is consumed by HVAC end uses comprising of Cooling, Heat Rejection, Pumping and Ventilation Fans.

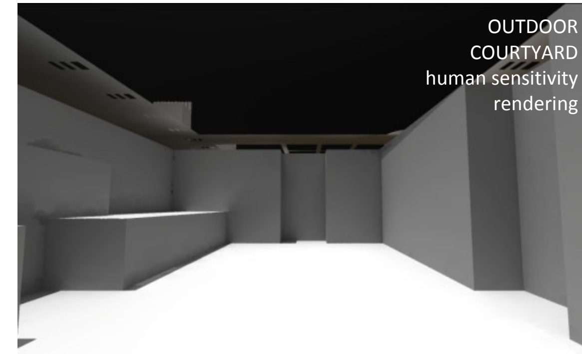
Further Cooling load breakdown, as shown below, also suggests that 56% of the cooling load in the project is directly affected by the design of the building envelope. The rest is caused by heat gain from internal loads such as lighting and equipment.

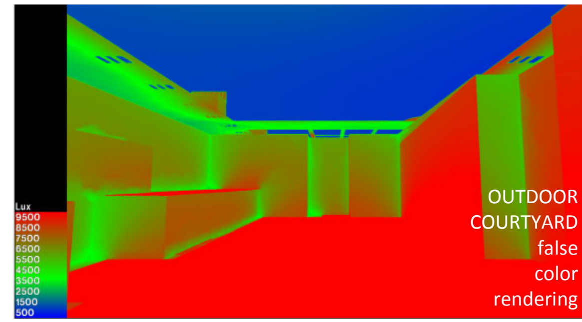
ENERGY USE CHARACTERIZATION FOR ASHRAE CASE AND COMPARISON WITH DESIGNED ENVELOPE

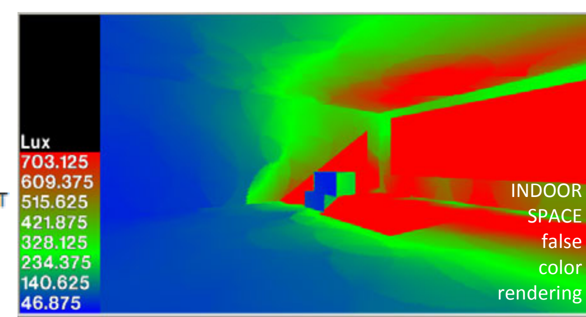


	ASHRAE BASELINE	DESIGN ENVELOPE
FANS	1,74,685	1,66,708
PUMPS	2,97,119	2,82,383
HEAT RXN	1,33,531	1,25,198
COOLING	8,17,294	7,74,625
EQUIPMENT	6,36,233	6,36,233
LIGHTS	6,50,151	6,50,151
TOTAL	27,09,013	26,35,298









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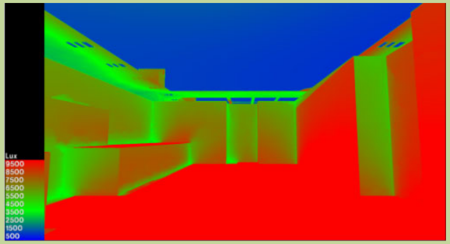
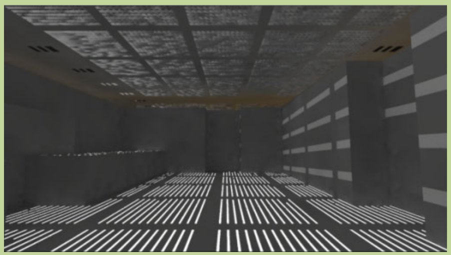
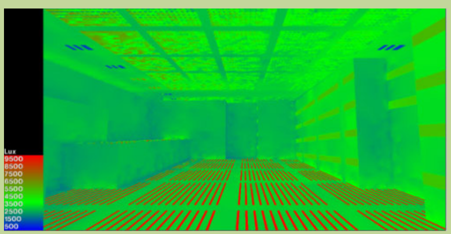
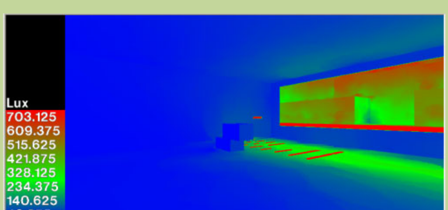
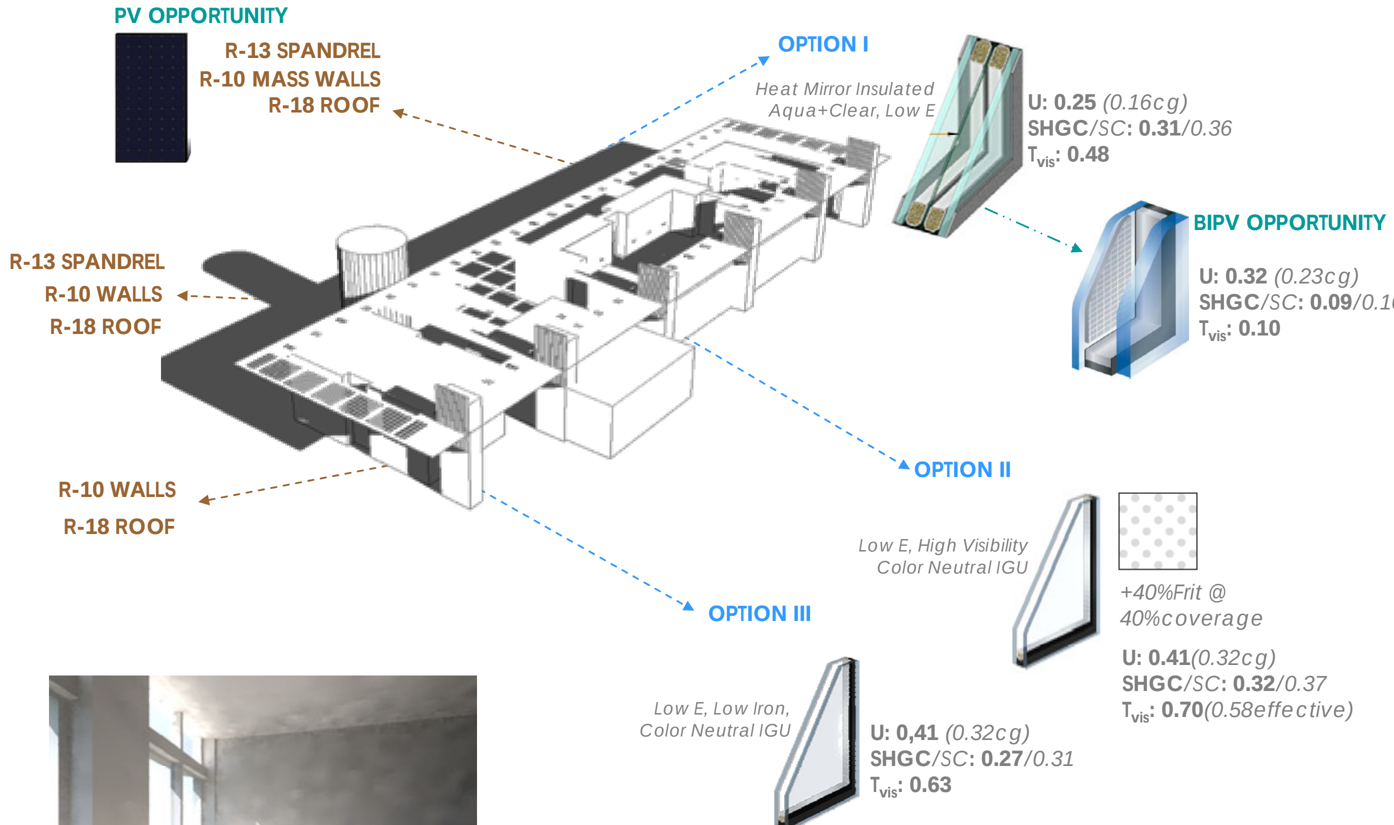
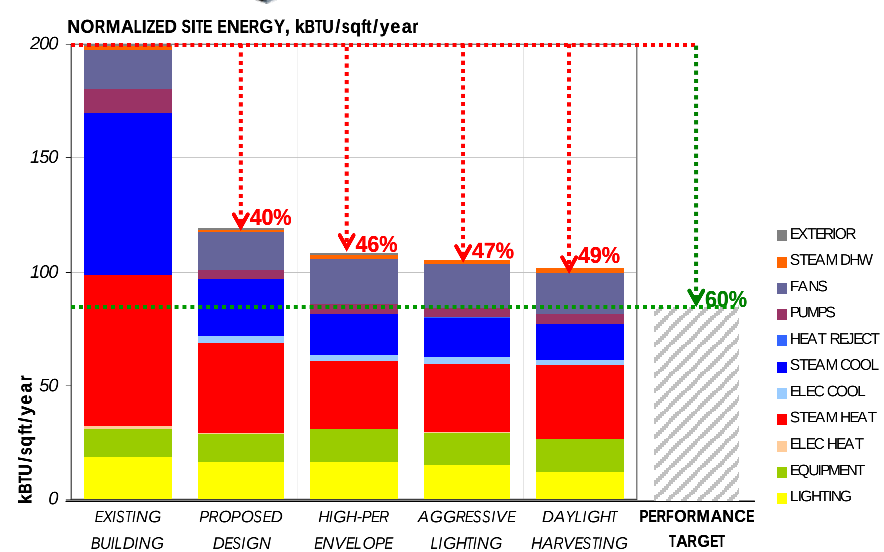







Lux
703.125
609.375
515.625
421.875
328.125
234.375
140.625
46.875


PV OPPORTUNITY
R-13 SPANDREL
R-10 MASS WALLS
R-18 ROOF
R-13 SPANDREL
R-10 WALLS
R-18 ROOF
R-10 WALLS
R-18 ROOF
OPTION I
Heat Mirror Insulated
Aqua+Clear, Low E
U: 0.25 (0.16cg)
SHGC/SC: 0.31/0.36
Tvis: 0.48
BIPV OPPORTUNITY
U: 0.32 (0.23cg)
SHGC/SC: 0.09/0.10
Tvis: 0.10
OPTION II
Low E, High Visibility
Color Neutral IGU
+40%Frit @
40%coverage
U: 0.41(0.32cg)
SHGC/SC: 0.32/0.37
Tvis: 0.70(0.58effective)
OPTION III
Low E, Low Iron,
Color Neutral IGU
U: 0,41 (0.32cg)
SHGC/SC: 0.27/0.31
Tvis: 0.63


NORMALIZED SITE ENERGY, kBTU/sqft/year
kBTU/sqft/year
200
150
100
50
0
40%
46%
47%
49%
60%
EXISTING BUILDING
PROPOSED DESIGN
HIGH-PER ENVELOPE
AGGRESSIVE LIGHTING
DAYLIGHT HARVESTING
PERFORMANCE TARGET
EXTERIOR
STEAM DHW
FANS
PUMPS
HEAT REJECT
STEAM COOL
ELEC COOL
STEAM HEAT
ELEC HEAT
EQUIPMENT
LIGHTING

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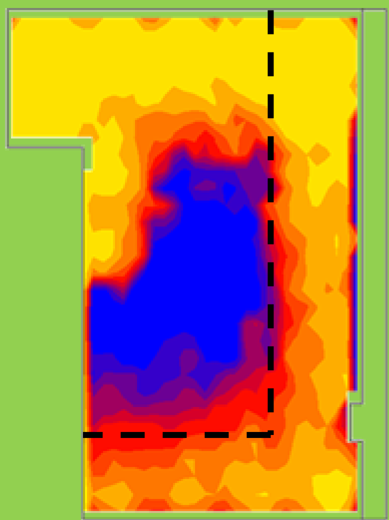
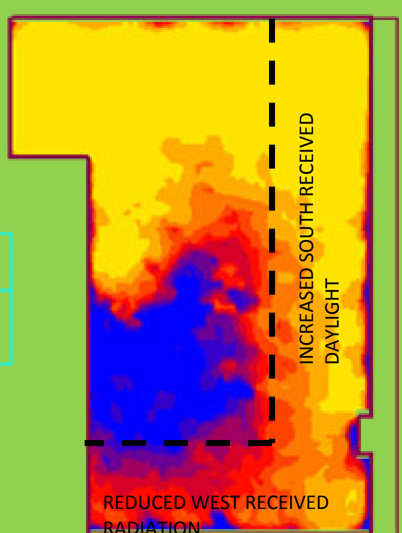
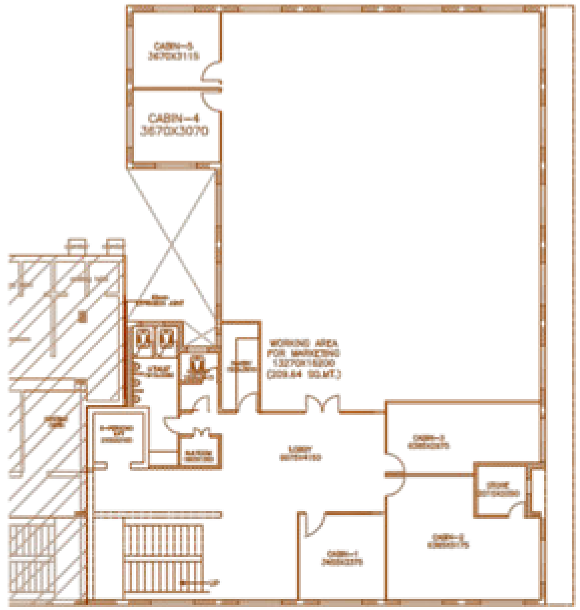
GREENEST BY DESIGN



DAYLIGHT AUTONOMY STUDY WITH
DESIGNED SOUTH AND WEST WALL DESIGN

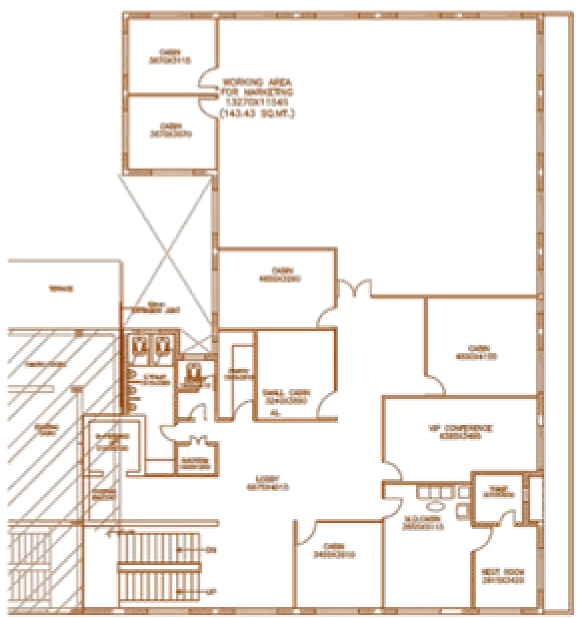


DAYLIGHT AUTONOMY STUDY WITH RECOMMENDED SOUTH AND WEST WALL DESIGN

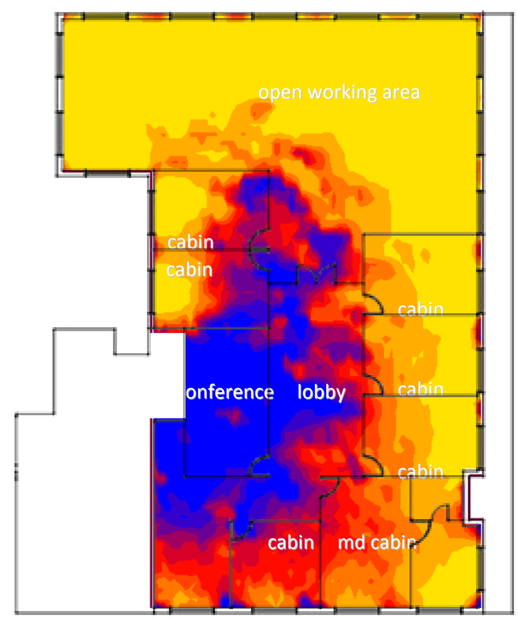


EXISTING LOWER FLOOR PLAN

RECOMMENDED LOWER FLOOR PLAN OPTION

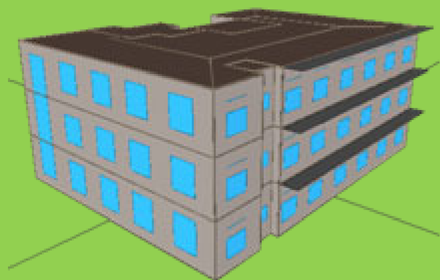


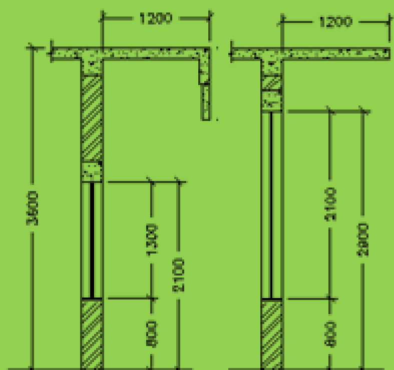
EXISTING UPPER FLOOR PLAN

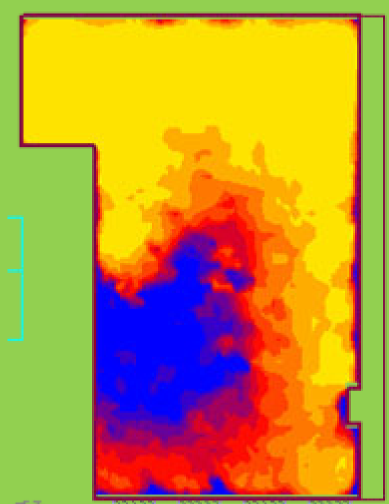


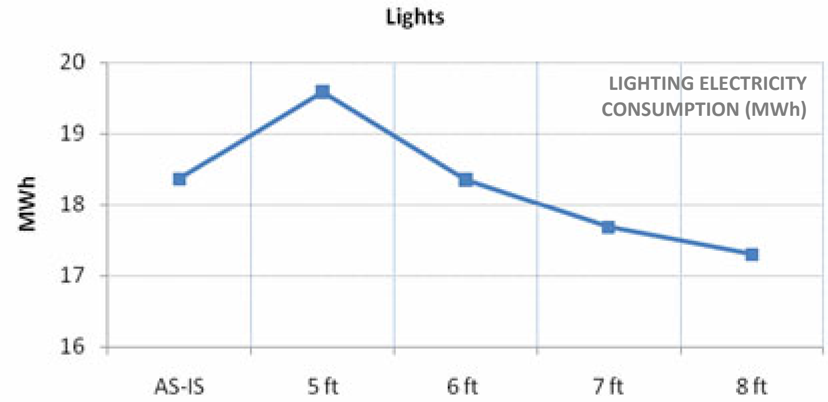
RECOMMENDED UPPER FLOOR PLAN OPTION

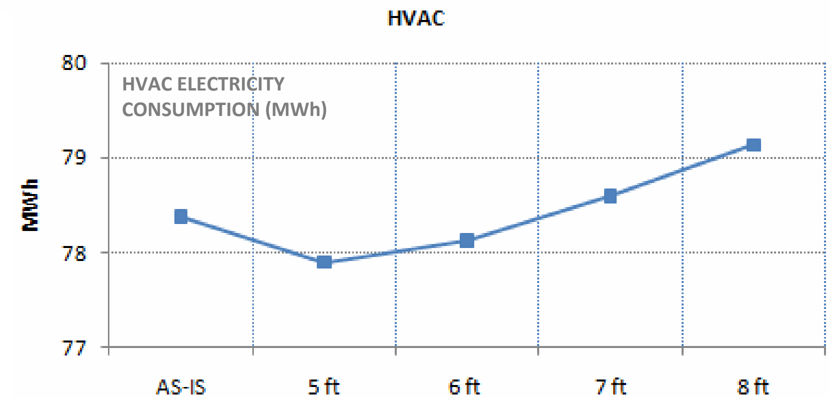
ENERGY CONSUMPTION WITH DIFFERENT WINDOW HEIGHTS

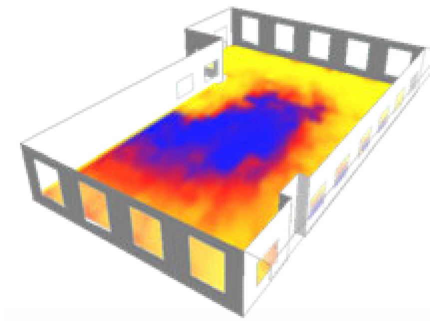


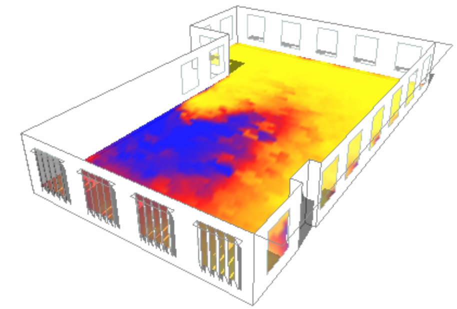












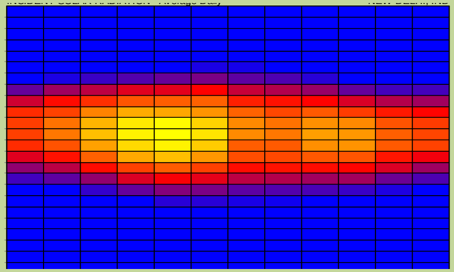
The graphs on the left illustrate the optimization analysis for appropriate window heights. As can be seen, as window height is reduced daylight levels reduce resulting in increased lighting consumption.

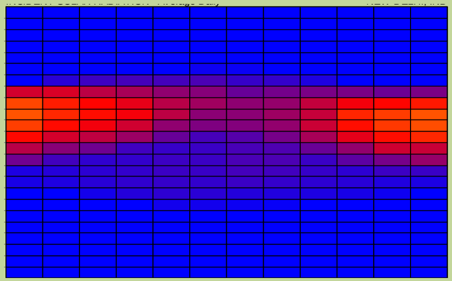
Although there is a reduction in thermal losses with reduced windows, there is an increase in cooling energy because of the lighting associated heat gains.

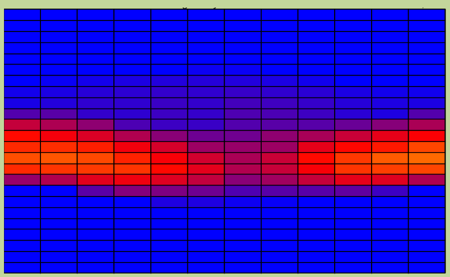
The trade-off between thermal performance and lighting performance was analyzed for various window heights to determine the optimum window size.

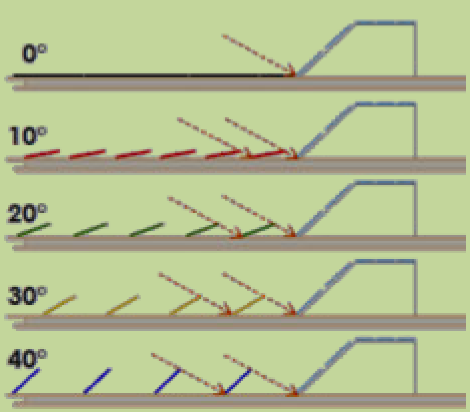
It was found that at window heights equal to 7’, there is minimum total energy consumption along with comfortable day light levels inside.

SPECTRAL





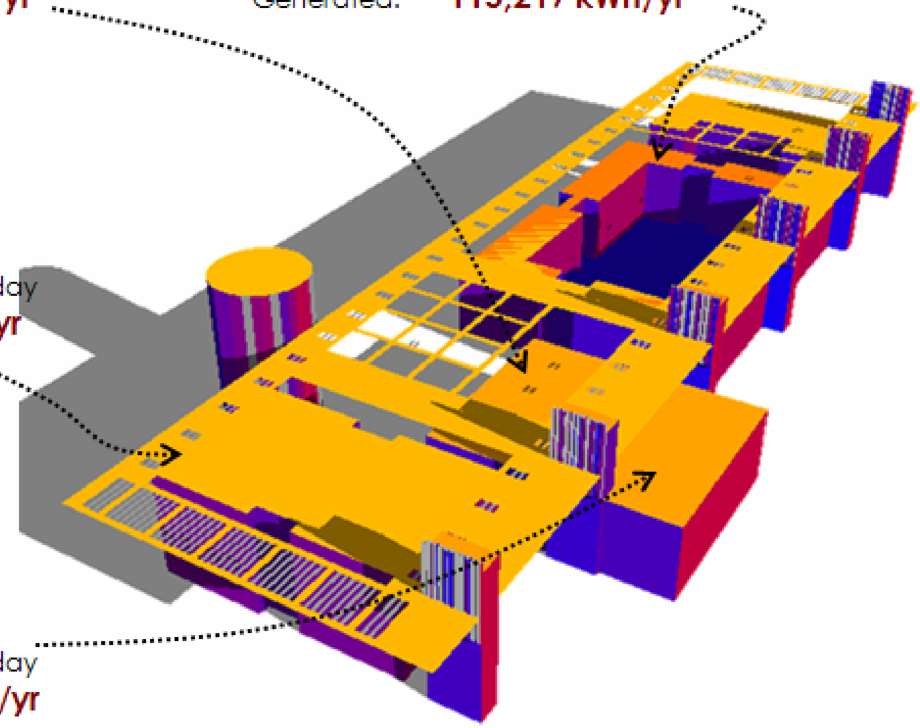




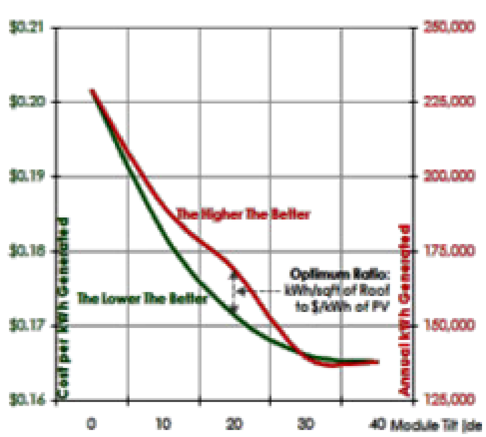
Area: 5787.8 sqft
Azimuth: 162deg
Altitude: 12.5deg
Incident: 5.07kWh/sqm/day
Generated: **115,901 kWh/yr**

Area: 6110.7 sqft
Azimuth: -108deg
Altitude: 12.5deg
Incident: 4.80kWh/sqm/day
Generated: **115,217 kWh/yr**

Area: 2234.55 sqft
Azimuth: -108deg
Altitude: 12.5deg
Incident: 4.80kWh/sqm/day
Generated: **42,132 kWh/yr**



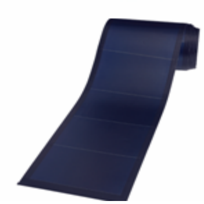
Area: 9763.75 sqft
Azimuth: -108deg
Altitude: 12.5deg
Incident: 4.80kWh/sqm/day
Generated: **184,096 kWh/yr**



High Efficiency p-Si
@ South Facing - Tilt Mounted

Framed Crystalline 4'x6'

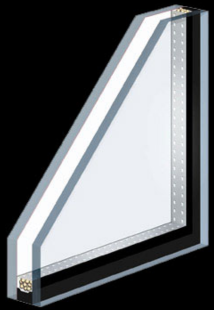
Nominal Power: 12W/sqft

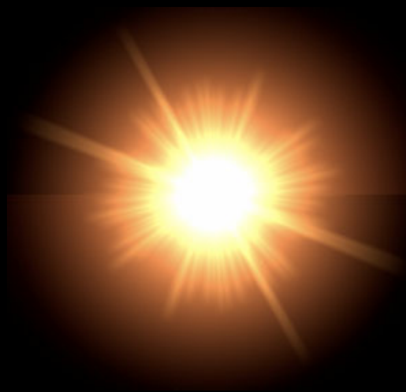


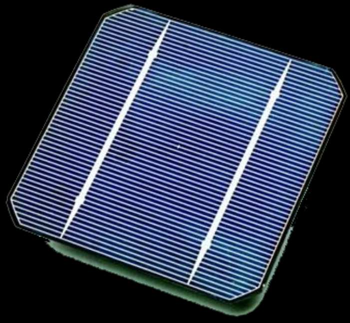
Low Efficiency a-Si
@ Horizontal - Roof Laminated

Opaque 0.1" thick Membrane

Nominal Power: 5.8W/sqft







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