Best Practices to design energy efficient buildings

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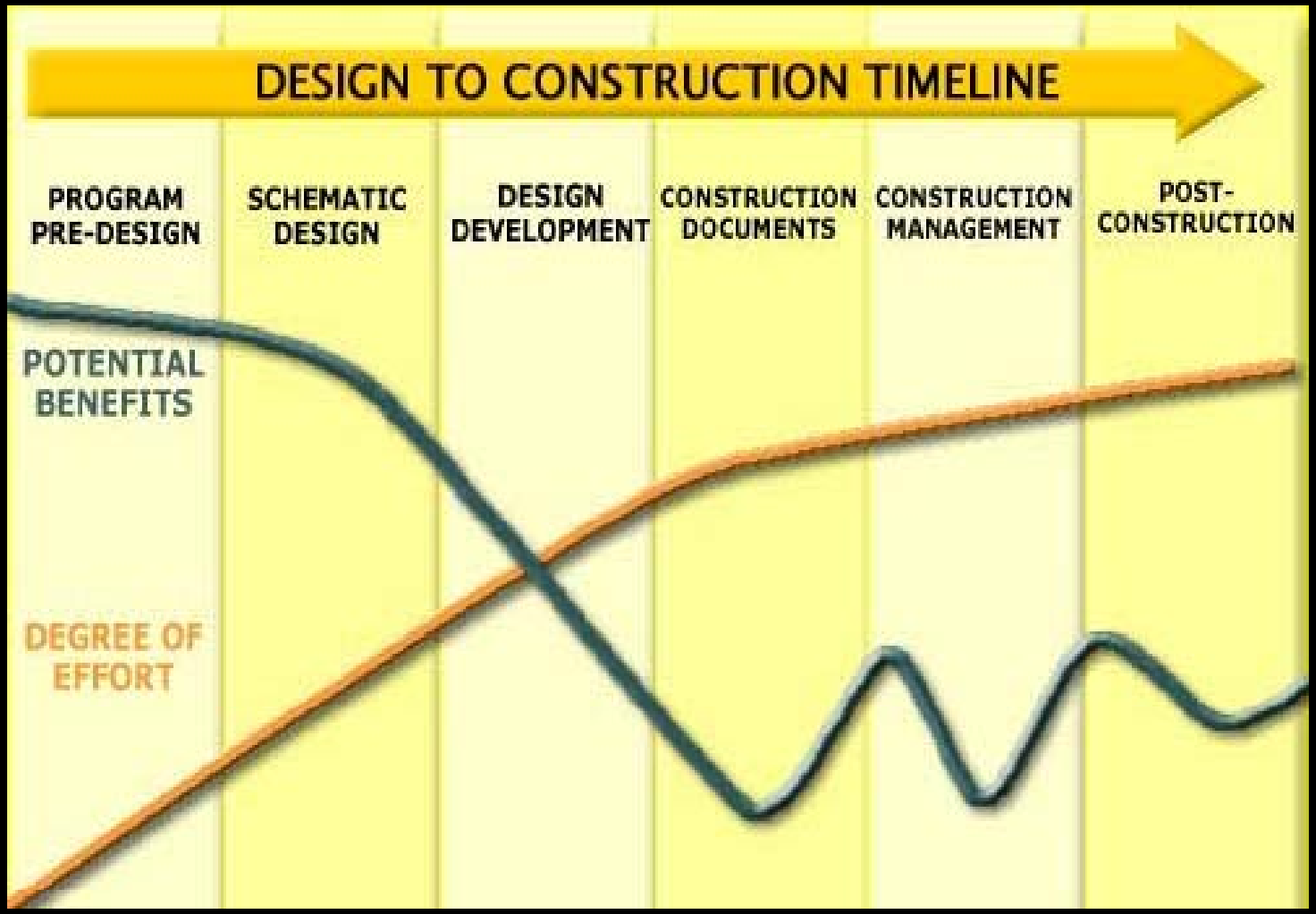
Simulation tools for building design

- Advanced computer tools exist to model whole building and building systems
- Computer simulation models are most commonly used for optimizing:
  - Concept Design
  - Façade Systems & Day-lighting
  - Interior Lighting
  - Energy
  - HVAC Design
- Simulation is key to integrated design

Integrated Design for Sustainability



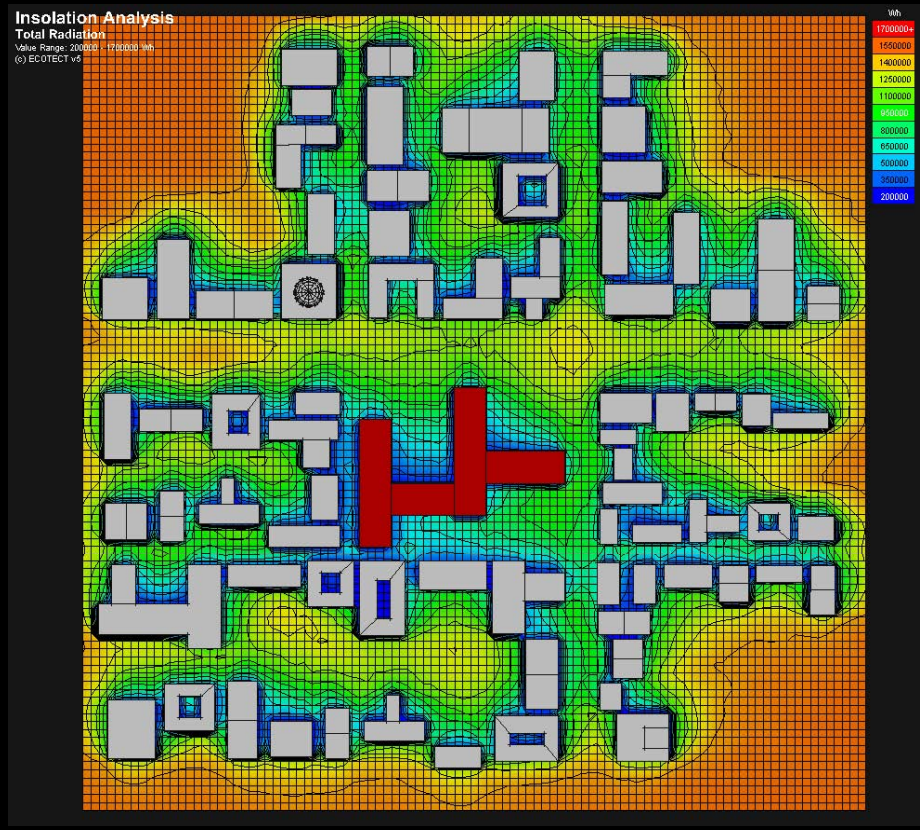
Optimize

Concept Design

Optimize Concept Design

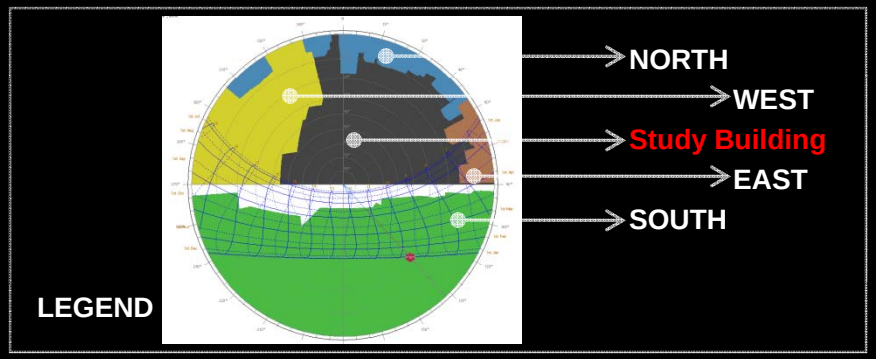
SITE Insolation Analysis

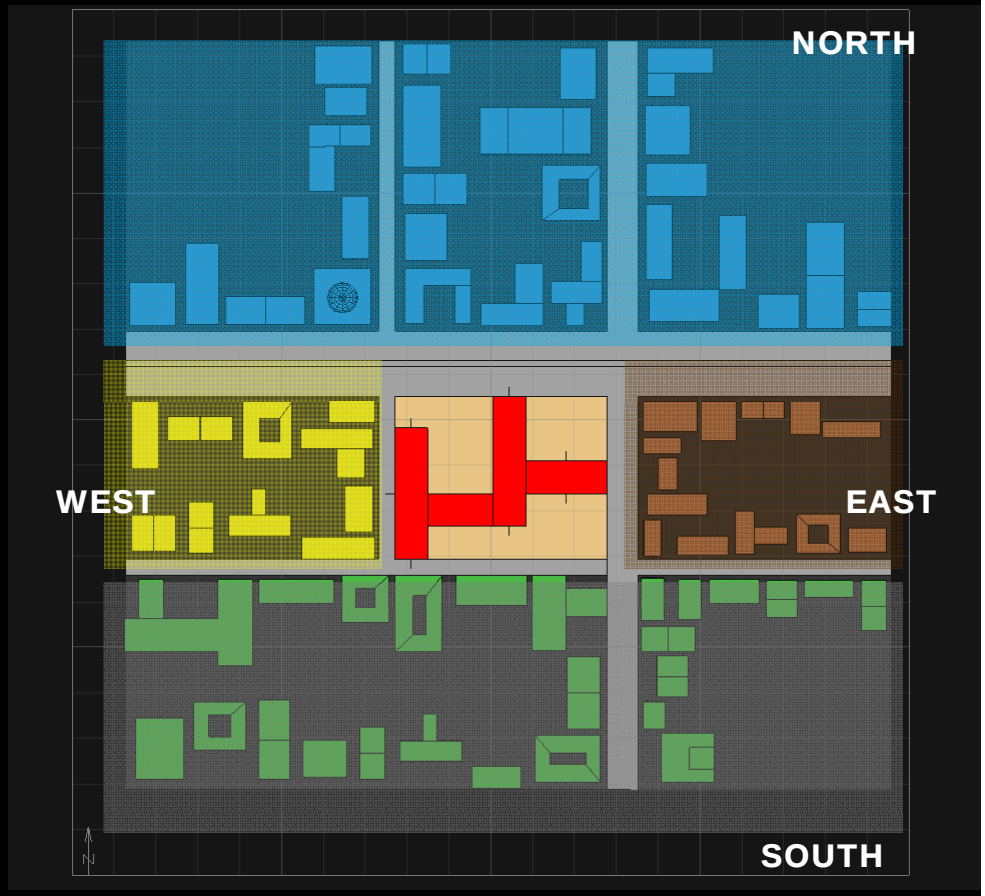
- Identifying heat islands,
- potentials for mutual shading,
- macro and micro level zoning possibilities and
- impact of closed or open built forms.

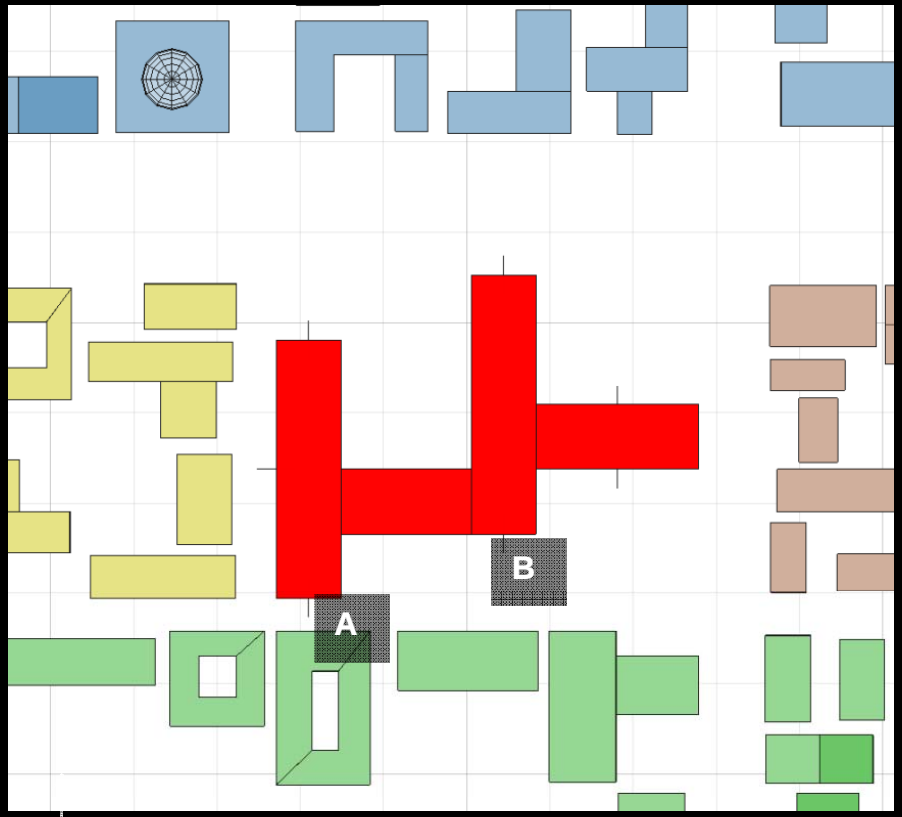


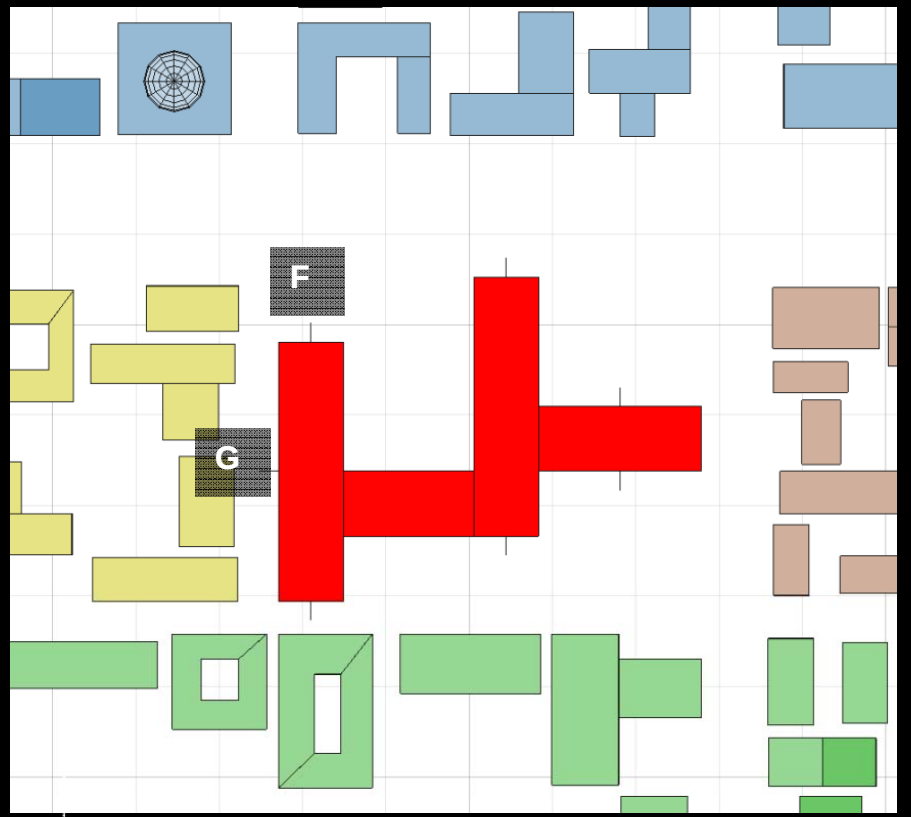
Optimize Concept Design

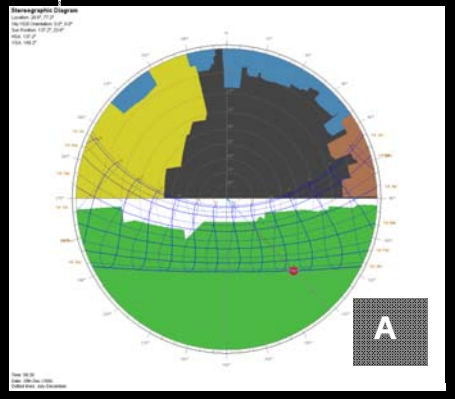
- Identify mutual shading from the existing development around the site.

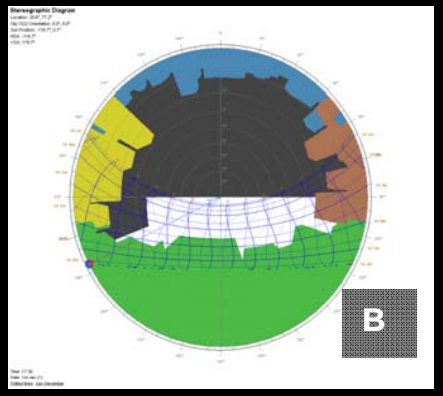





A
B


F
G


A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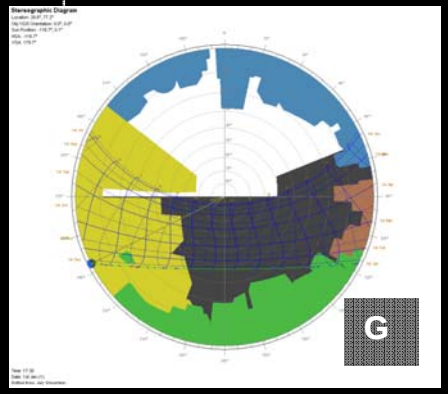
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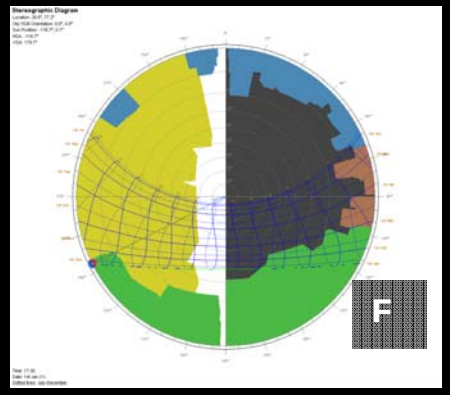

F

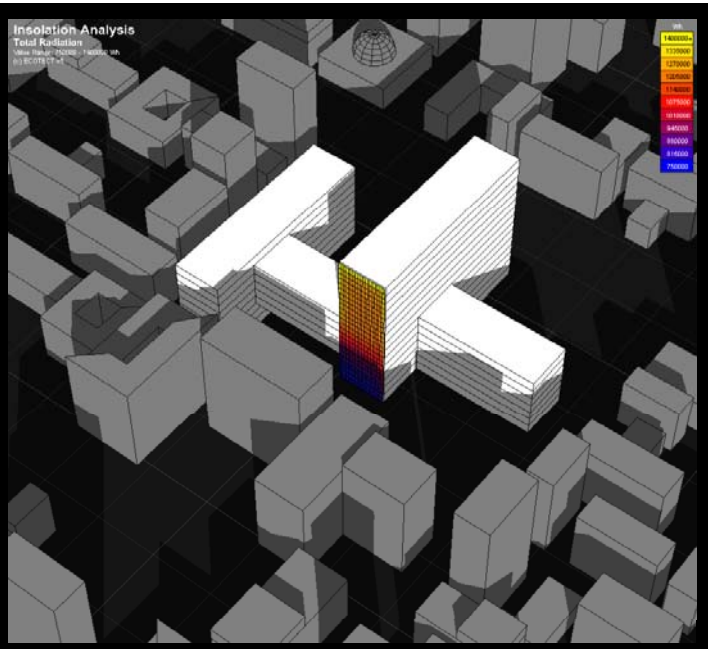
Optimize

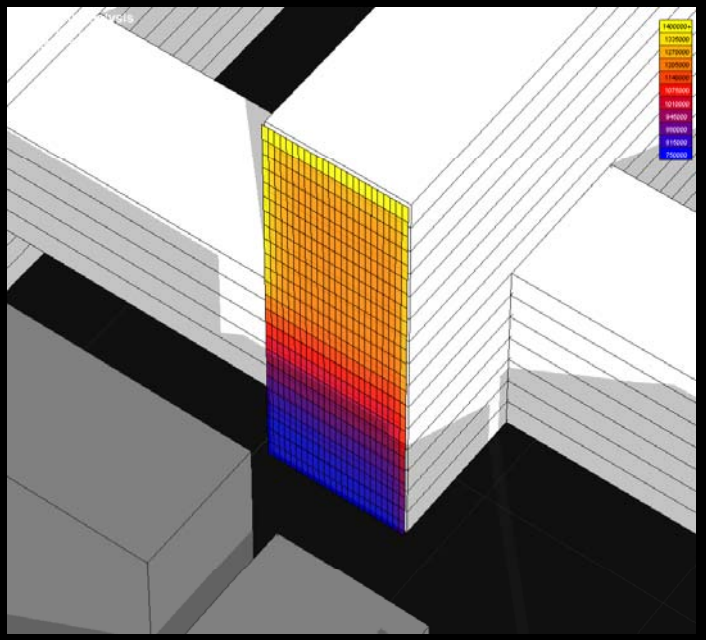
Façade Systems

Façade insolation

Due to variant solar Insolation on the façade, the same façade can be designed for different specifications from bottom to top.

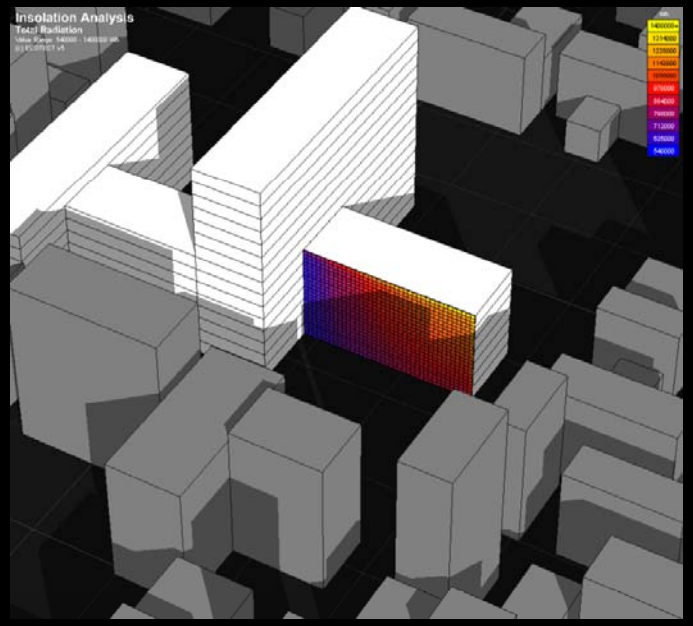
Window Types - Single Glazing or Double Glazing can be indentified based on the insolations on the façade.

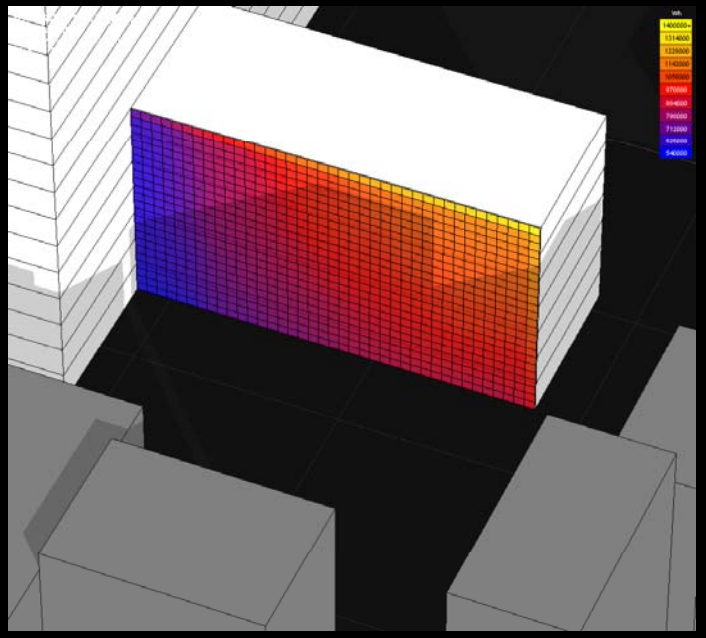




Façade insolation

- Fenestration area and percentage – Vision Area V/S Spandrel Area.
- Organization of regularly occupied spaces.
- Organization of air conditioned and non air conditioned zones.





Envelope Material Selection

Opaque Elements	Nonresidential		Residential		Semiheated	
	Assembly Maximum	Insulation Min. R-Value	Assembly Maximum	Insulation Min. R-Value	Assembly Maxi-mum	Insulation Min. R-Value
Roofs						
Insulation Entirely above Deck	U-0.063	R-15.0 ci	U-0.063	R-15.0 ci	U-1.282	NR
Metal Building	U-0.065	R-19.0	U-0.065	R-19.0	U-1.280	NR
Attic and Other	U-0.034	R-30.0	U-0.027	R-38.0	U-0.614	NR
Walls, Above-Grade						
Mass	U-0.580	NR	U-0.151[a]	R-5.7 ci[a]	U-0.580	NR
Metal Building	U-0.113	R-13.0	U-0.113	R-13.0	U-1.180	NR
Steel-Framed	U-0.124	R-13.0	U-0.124	R-13.0	U-0.352	NR
Wood-Framed and Other	U-0.089	R-13.0	U-0.089	R-13.0	U-0.292	NR
Wall, Below-Grade						
Below-Grade Wall	C-1.140	NR	C-1.140	NR	C-1.140	NR
Floors						
Mass	U-0.322	NR	U-0.322	NR	U-0.322	NR
Steel-Joist	U-0.350	NR	U-0.350	NR	U-0.350	NR
Wood-Framed and Other	U-0.282	NR	U-0.282	NR	U-0.282	NR
Slab-On-Grade Floors						
Unheated	F-0.730	NR	F-0.730	NR	F-0.730	NR
Heated	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.	F-1.020	R-7.5 for 12 in.
Opaque Doors						
Swinging	U-0.700		U-0.700		U-0.700	
Non-Swinging	U-1.450		U-1.450		U-1.450	

Wall Window Ratio:

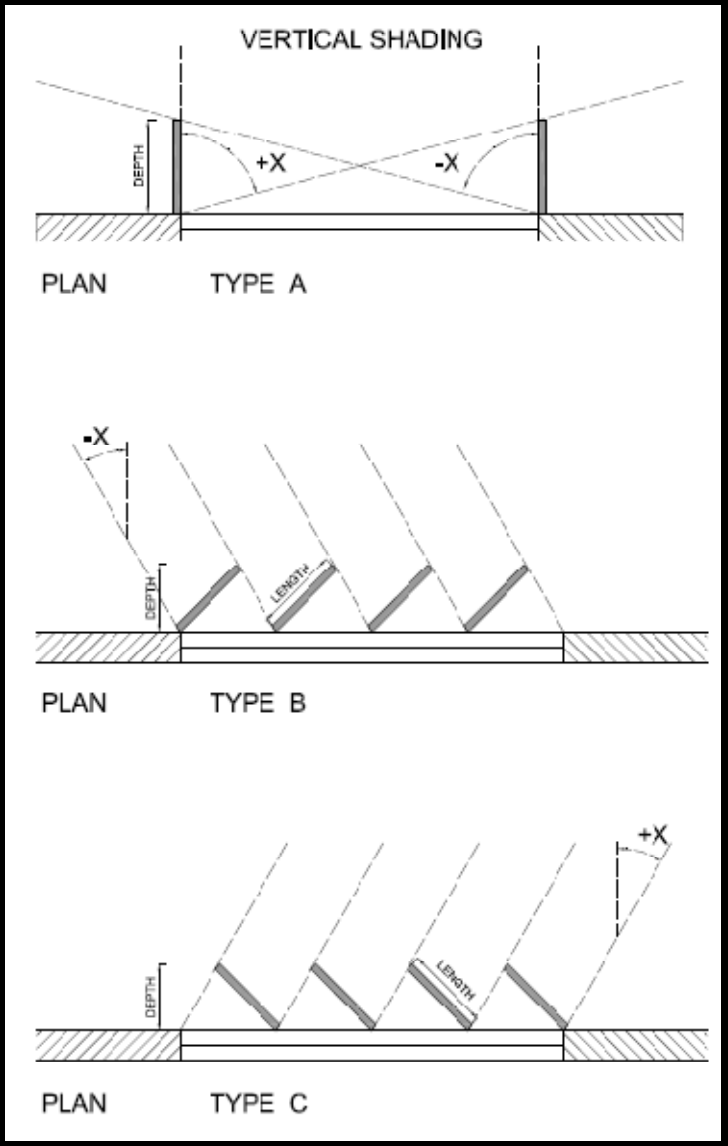
Fenestration	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)	Assembly Max. U (Fixed/ Operable)	Assembly Max. SHGC (All Orientations/ North-Oriented)
Vertical Glazing,% of Wall						
0-10.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
10.1-20.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
20.1-30.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.61	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
30.1-40.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.44	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.25 $SHGC_{north}$-0.44	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-NR $SHGC_{north}$NR
40.1-50.0%	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.19 $SHGC_{north}$-0.33	U_{fixed}-1.22 U_{oper}-1.27	$SHGC_{all}$-0.19 $SHGC_{north}$-0.33	U_{fixed}-0.98 U_{oper}-1.02	$SHGC_{all}$-NR $SHGC_{north}$NR
Skylight with Curb, Glass,% of Roof						
0-2.0%	U_{all}-1.98	$SHGC_{all}$-0.36	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.98	$SHGC_{all}$-0.19	U_{all}-1.98	$SHGC_{all}$-0.16	U_{all}-1.98	$SHGC_{all}$-NR
Skylight with Curb, Plastic,% of Roof						
0-2.0%	U_{all}-1.90	$SHGC_{all}$-0.34	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-0.27	U_{all}-1.90	$SHGC_{all}$-NR
Skylight without Curb, All,% of Roof						
0-2.0%	U_{all}-1.36	$SHGC_{all}$-0.36	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR
2.1-5.0%	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-0.19	U_{all}-1.36	$SHGC_{all}$-NR

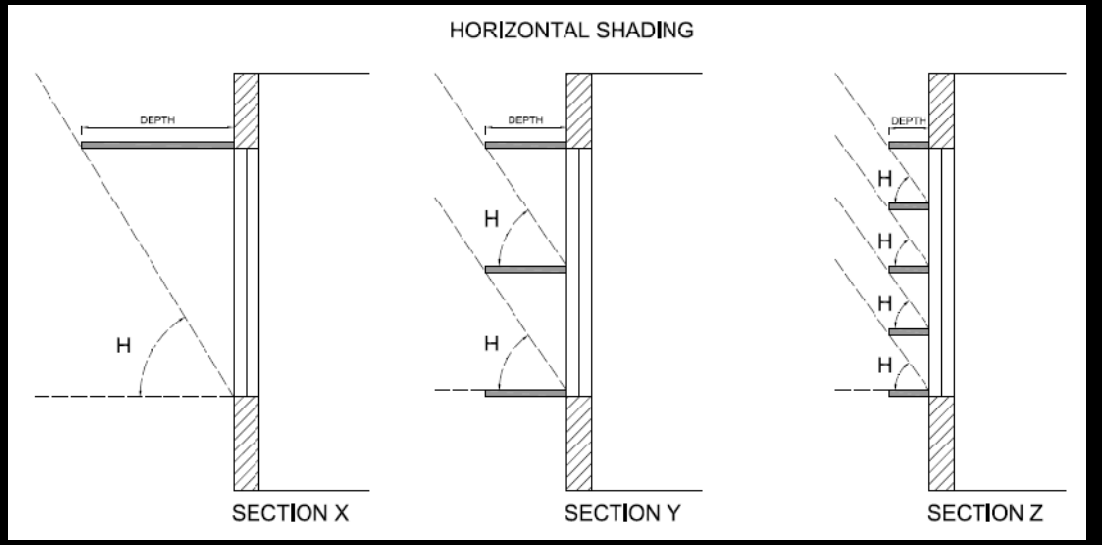
[a]Exception to A3.1.3.1 applies.

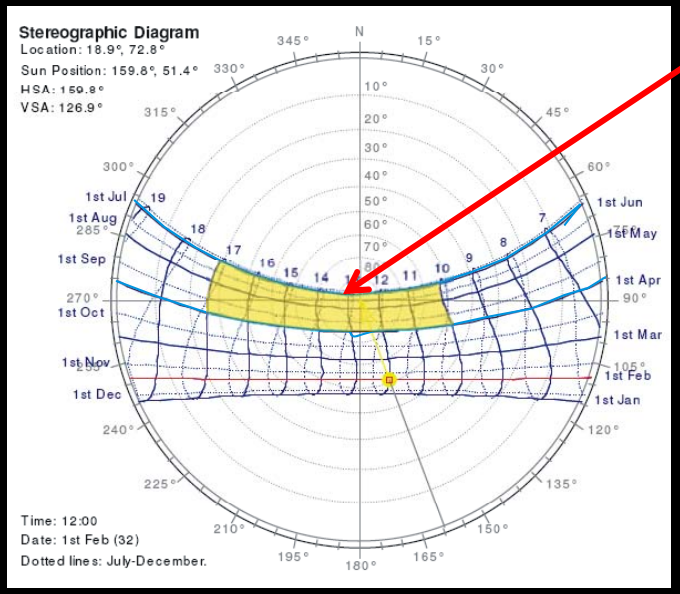
Optimize

Day-lighting

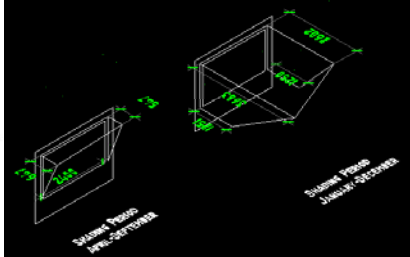
Shading Design Options

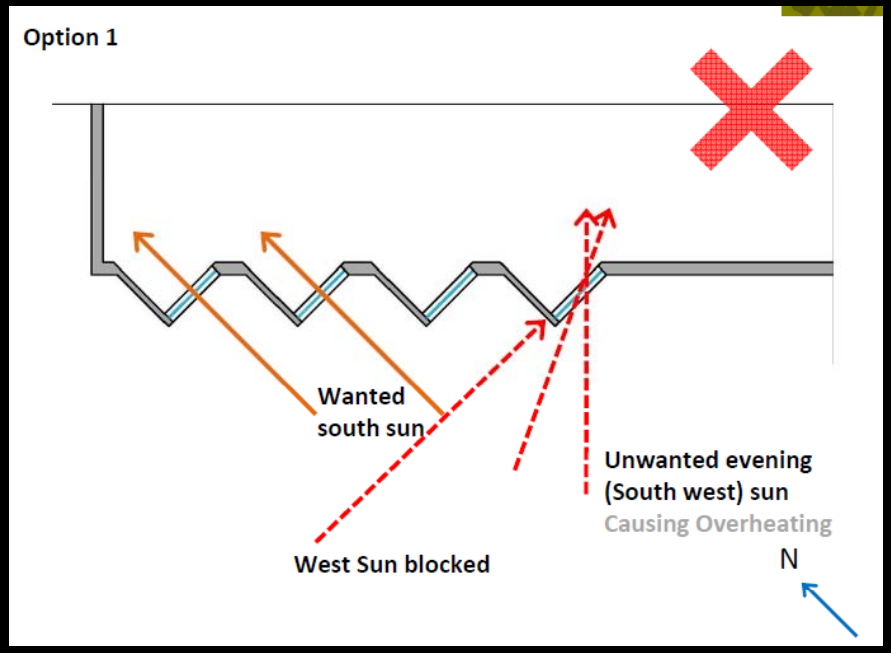


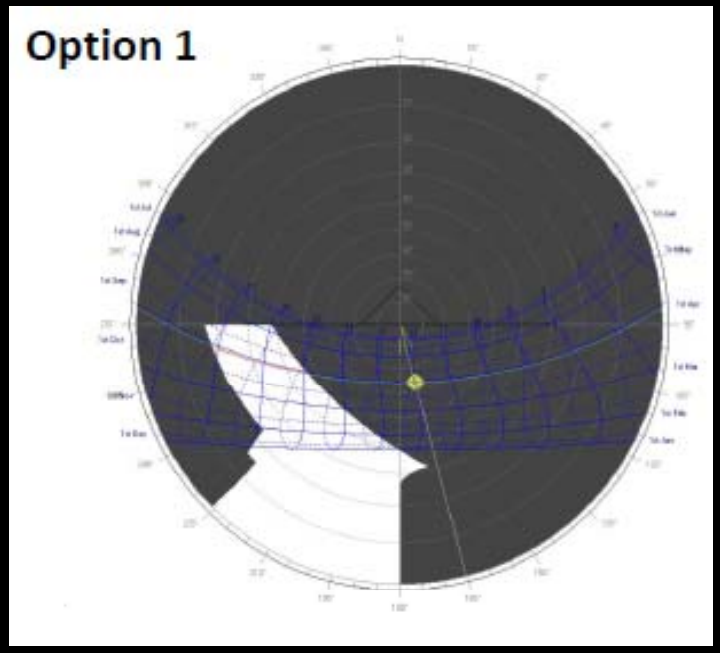


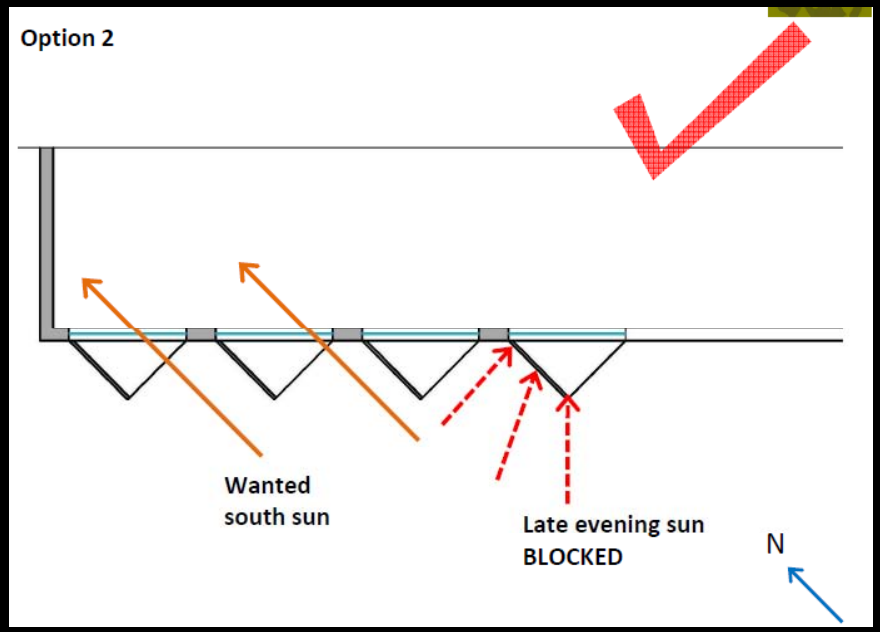


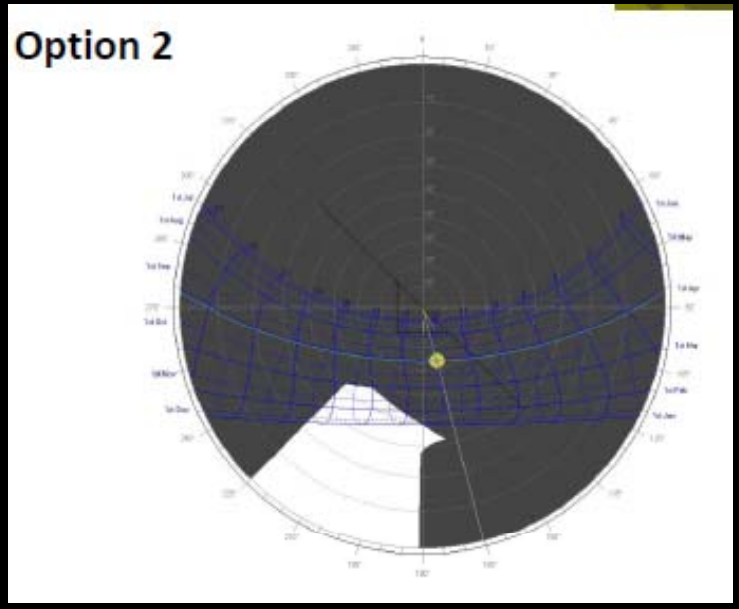
Shaded Time Zone









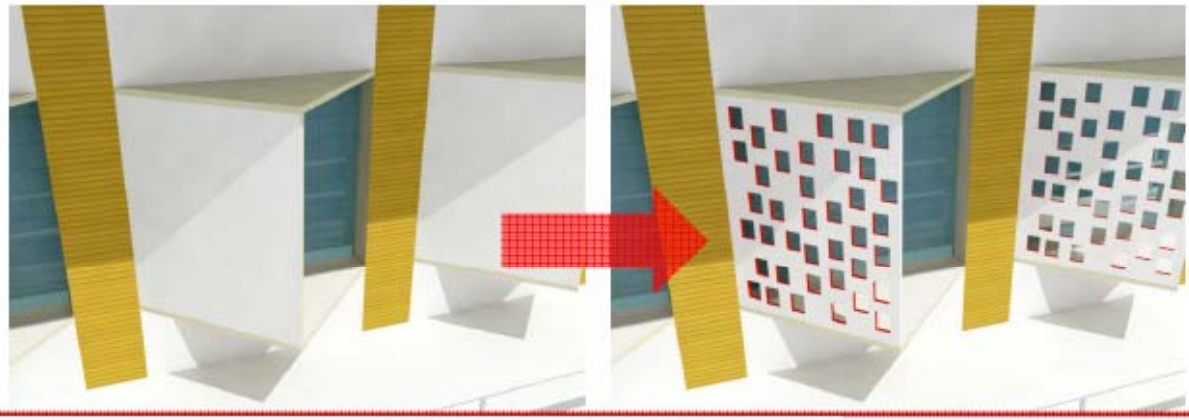


FRONT FAÇADE - SOUTH WEST FACADE

FRONT FAÇADE - SOUTH WEST FACADE

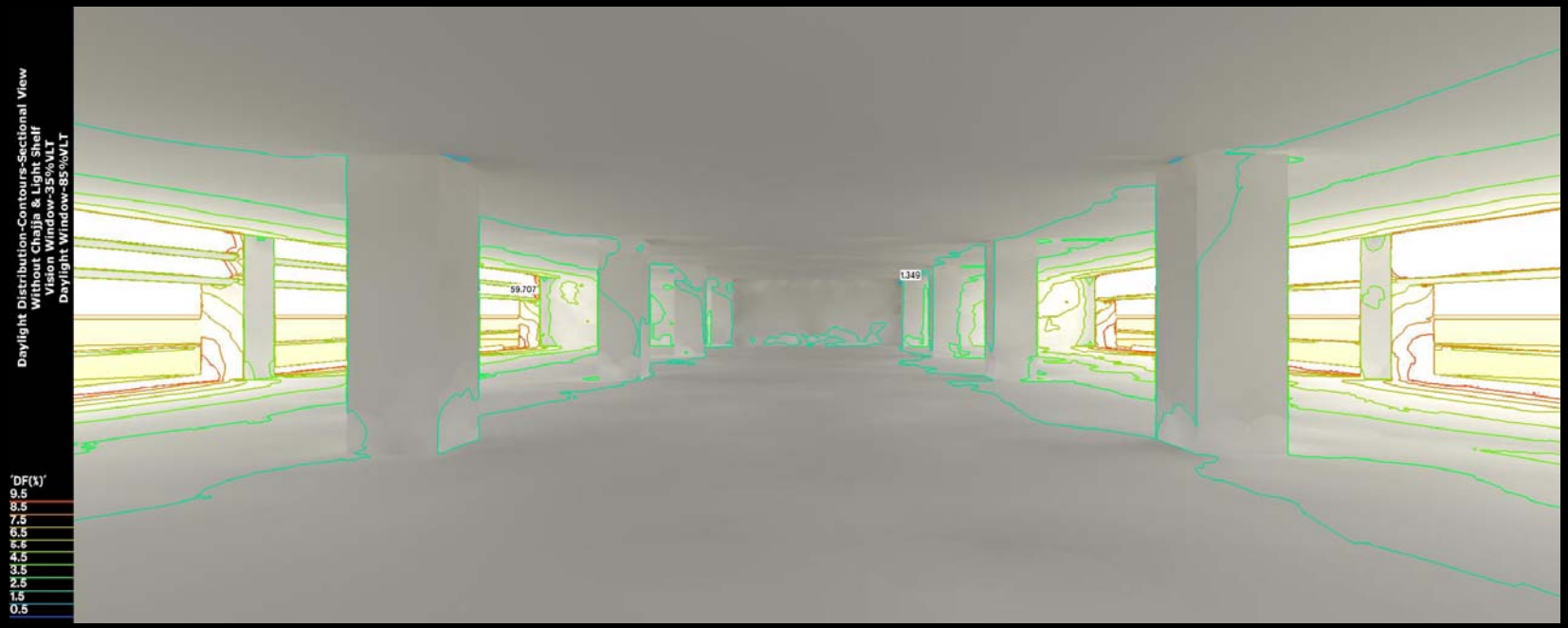
Final - Exploring a sub-option

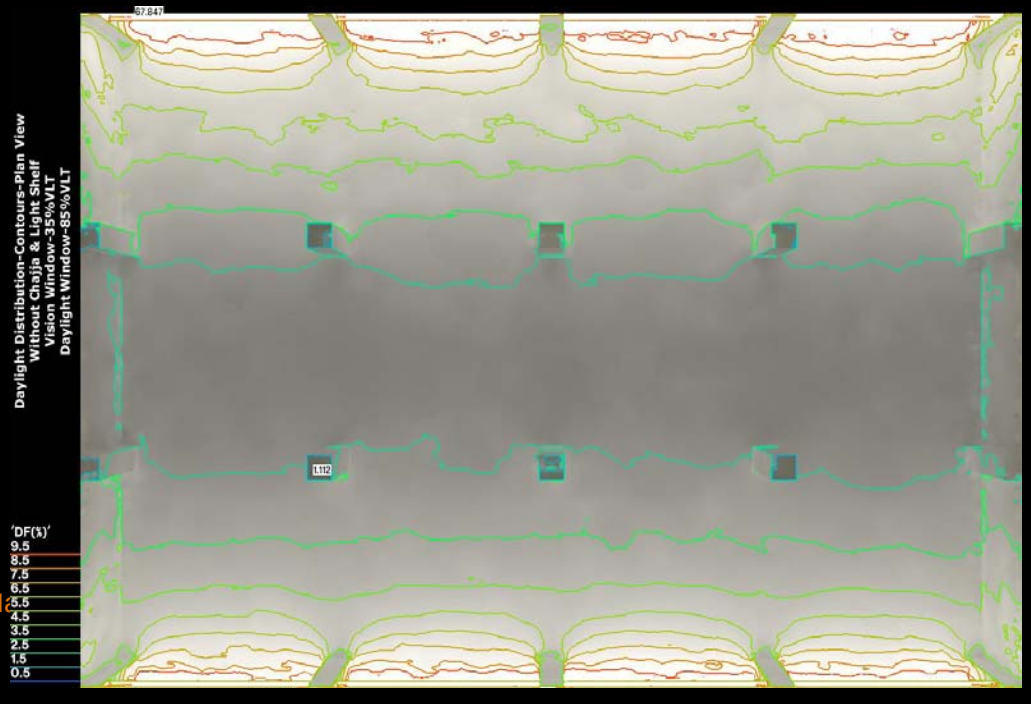
For better viewing abilities from interior spaces, the west wall can be treated as jaalis (gysum). This will allow minimum harsh sun to enter the spaces.



Examples of Jalli:

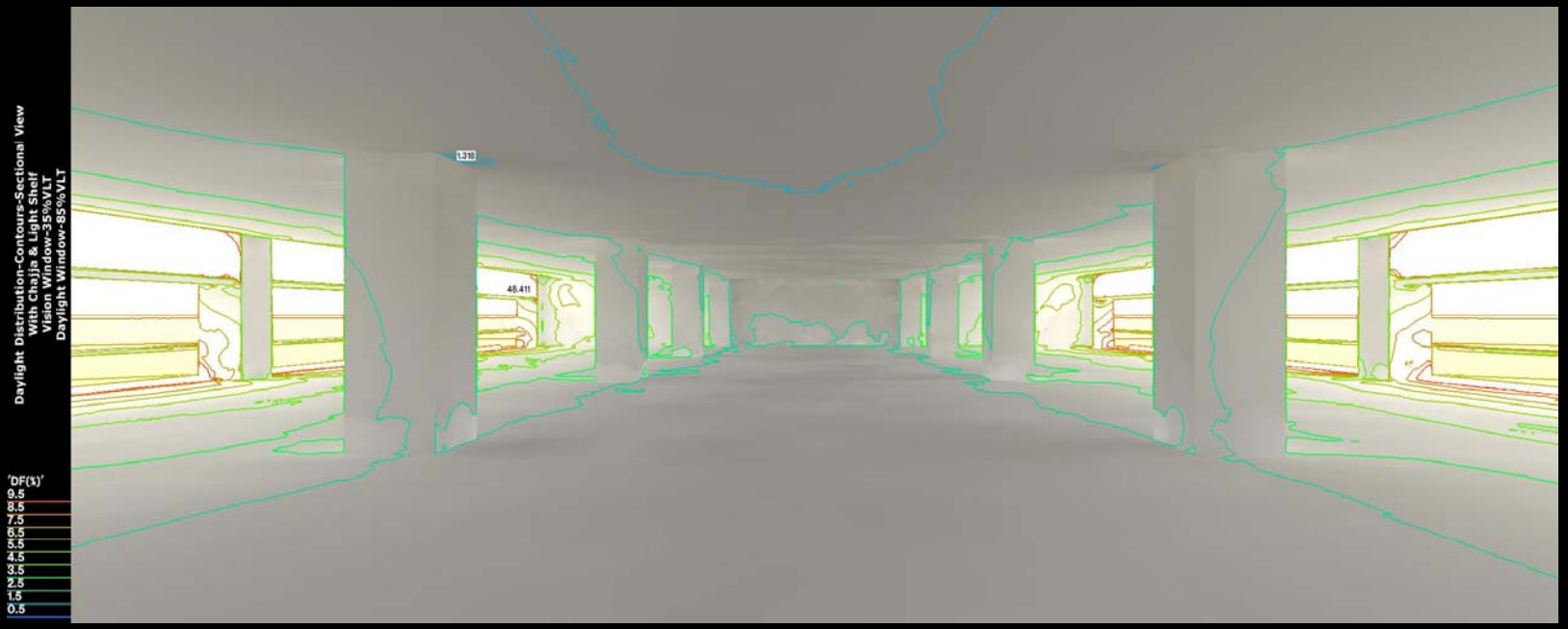
Recently used in Lodi hotel Delhi

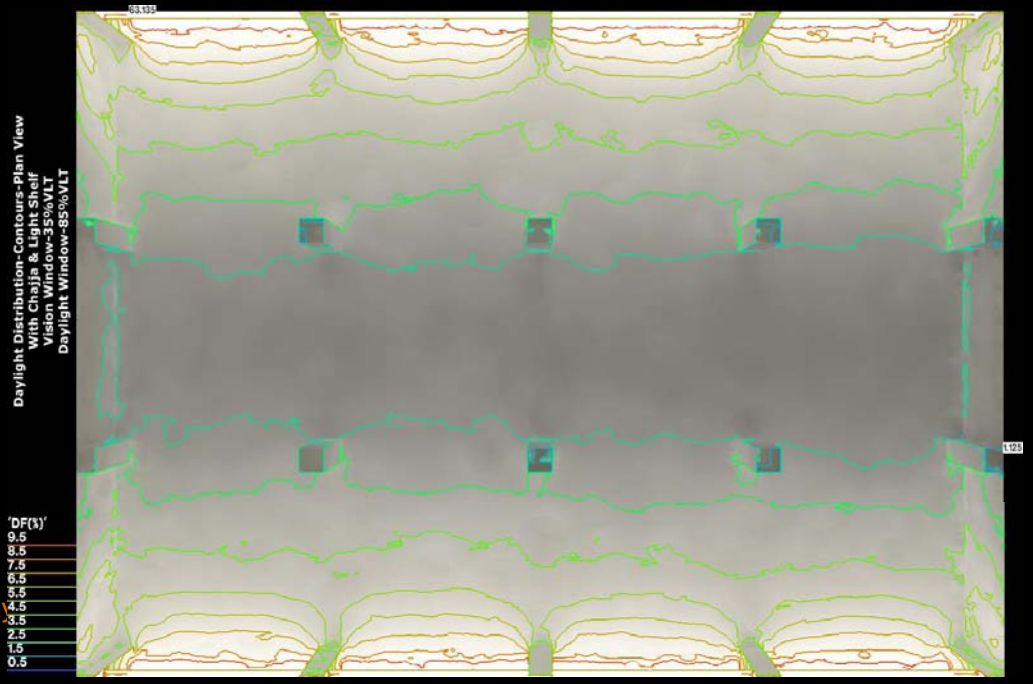




Daylight Factor Distribution

Without Overhang





Daylight Factor Distribution

With Overhang

Optimize

Interior Lighting

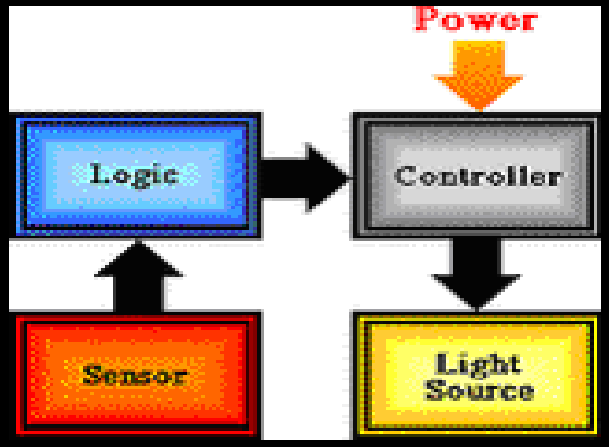
Optimize Interior Lighting

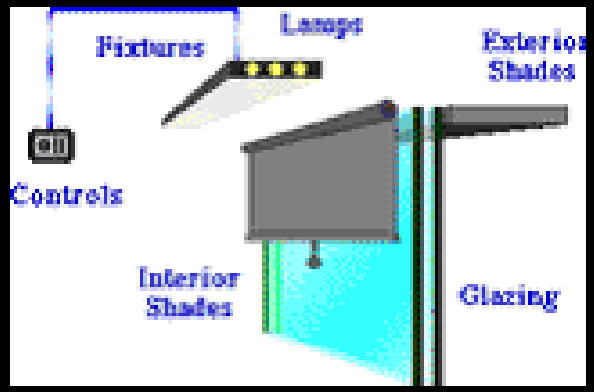
Daylight Controls

- regulate the level of illumination provided by electric lights in response to the presence of natural daylight

- a sensing device (photocell or photosensor) that monitors either the total/available light level in the space

- Control module that then switches or dims the electric lighting to maintain the needed illumination with minimal energy use.





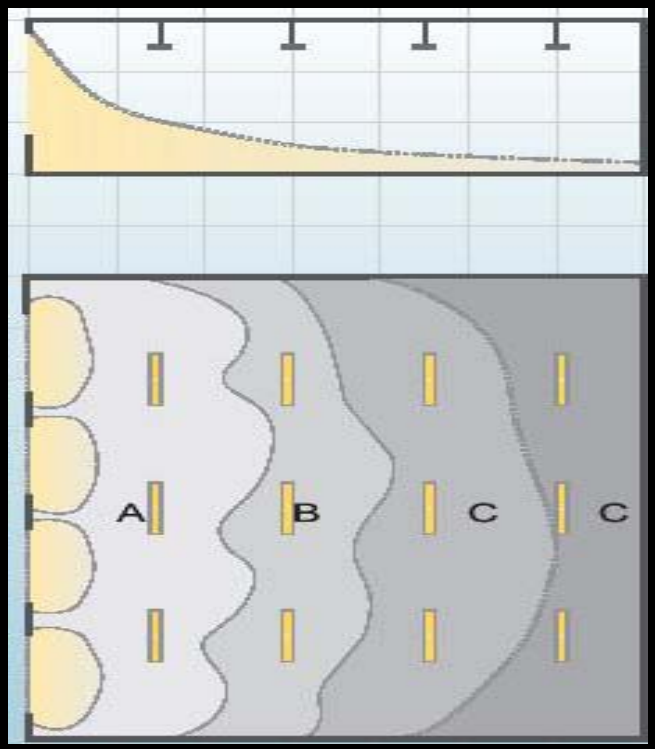
Optimize Interior Lighting

Integrated Lighting design

A experiences the most daylight and is turned off or dimmed first

B is controlled second

C receives the least daylight and is left at full power to maintain wall brightness



An integrated electric lighting scheme should deliver electric light to the same surfaces as the daylight in order to minimize changes in room surface brightness

Energy Modeling & Analysis

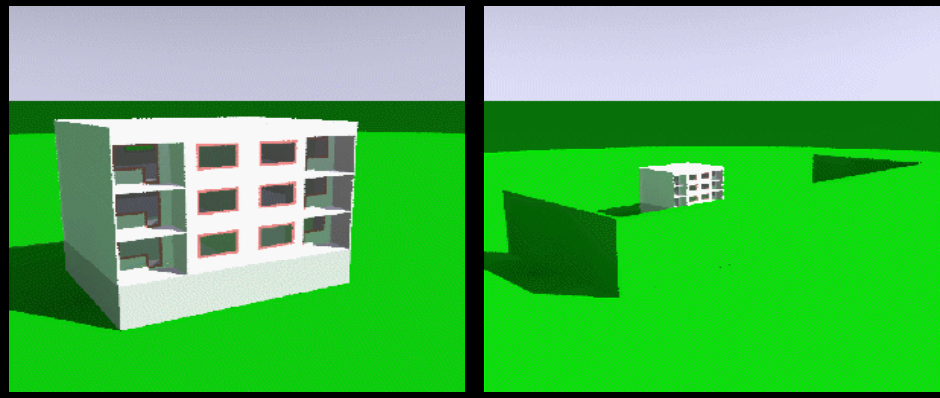
Simulation of ECMs

Developing Thermal Specification

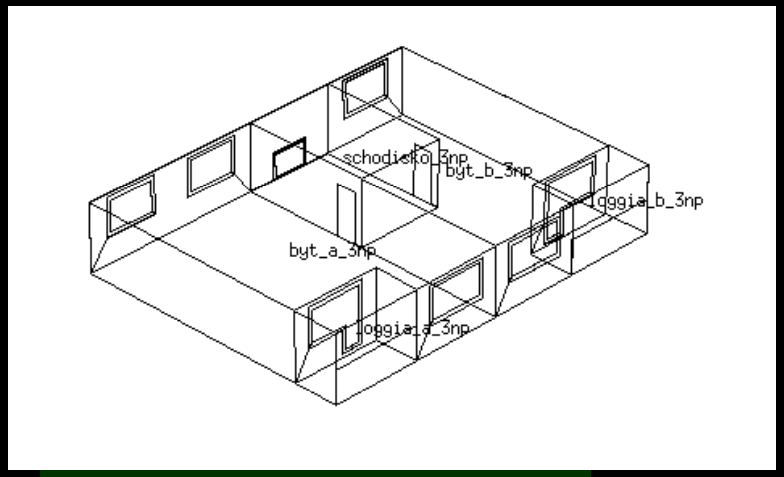
Glazing Analysis

Analysis of a housing complex

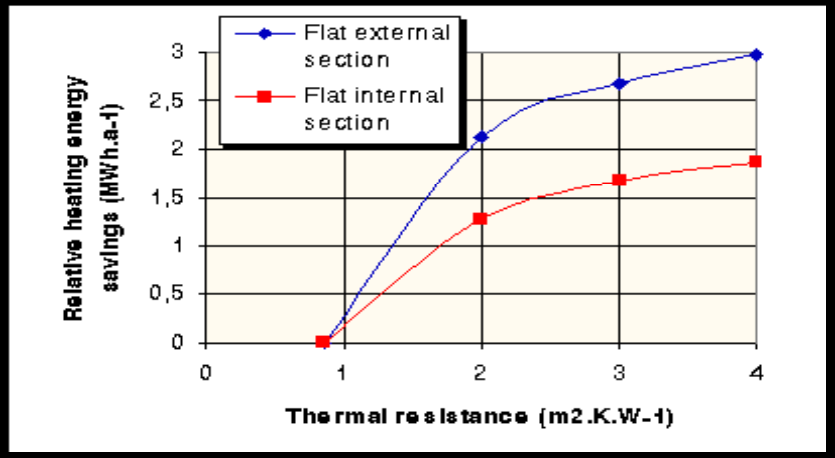
1. Actual Building



2. Simulation Input

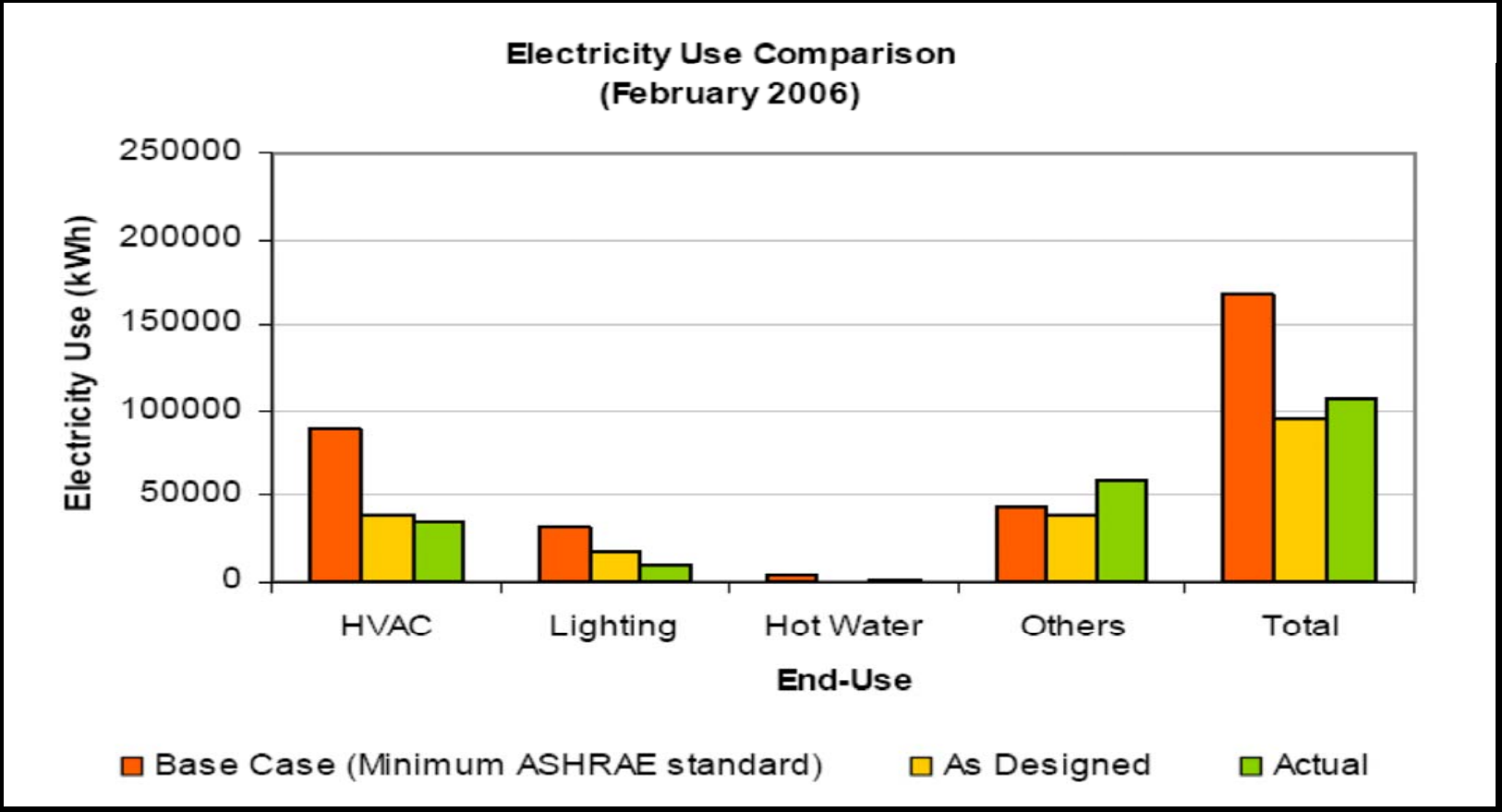


3. ECM Analysis

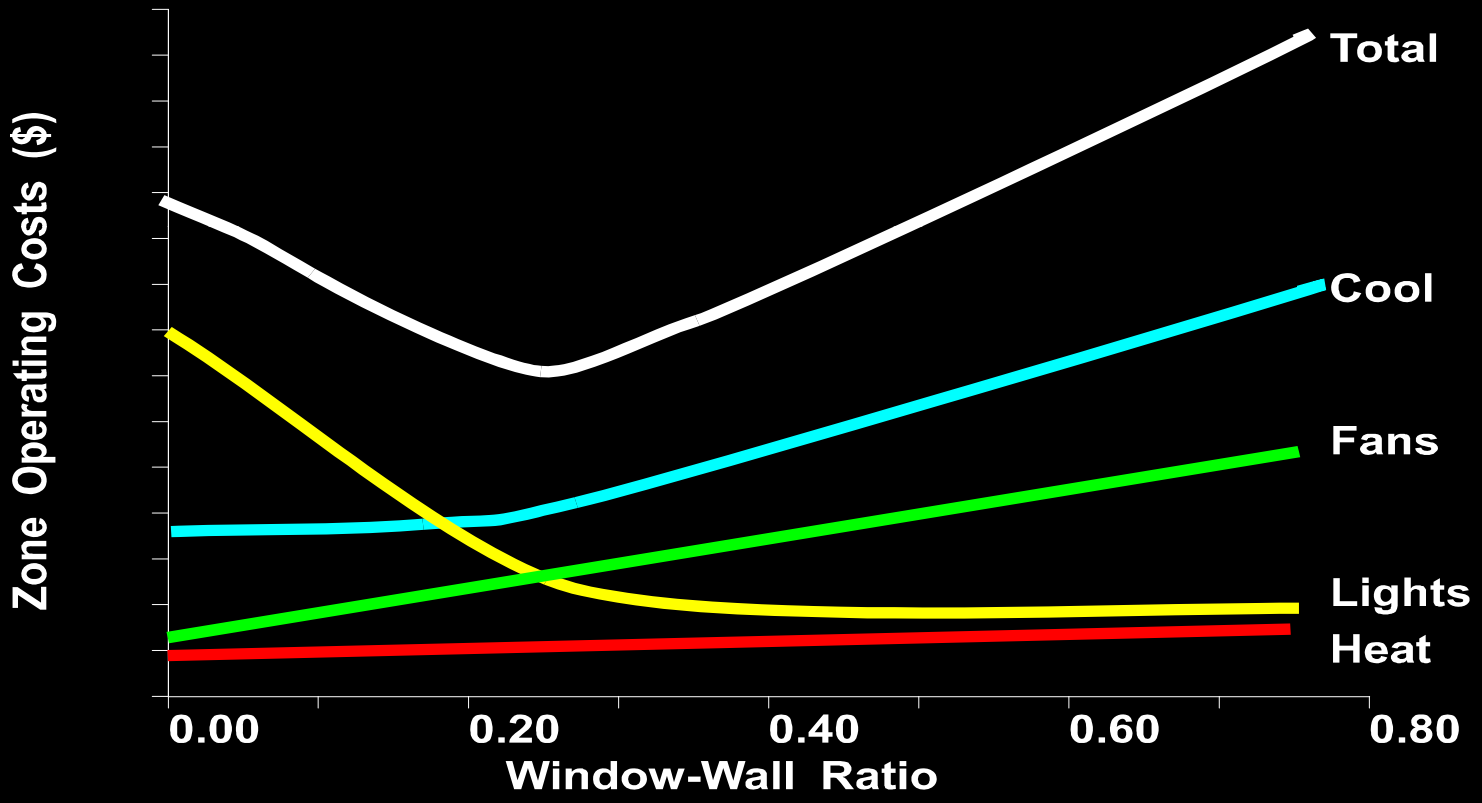


4. Output/Results

Energy Analysis



Optimizing glazing area

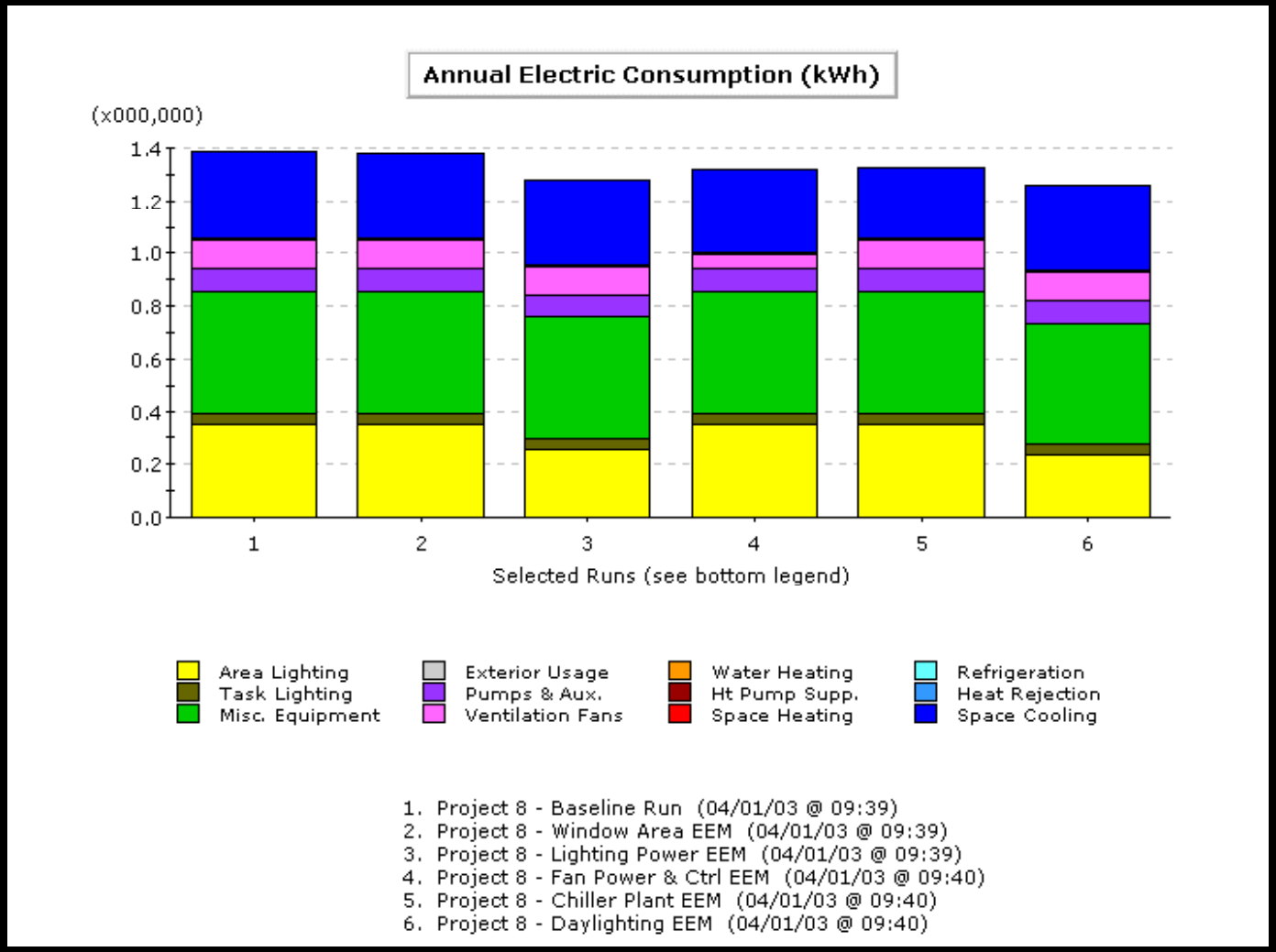


Note: South Orientation, Double Green Glass, Warm Coastal Climate

Glass Selection Analysis

Glazing Type	Total HVAC Energy Use (kWh)	HVAC Energy Cost (Rs/Yr)#	Energy/Cost Savings over Base Case (%)	Incremental Cost of Glass (Rs)	Simple Payback Period (Yrs)
Antelio Emerald	4,534,687	22673435	-	-	-
Deep green-ST408	4,075,159	20375795	10%	3899091	1.7
Aquamarine-ST420	4,204,361	21021805	7%	3899091	2.4
Blue Green-ST436	4,325,001	21625005	5%	3899091	3.7
Single-ST420	4,328,556	21642780	5%	2042381	2.0
Single-ST436	4,428,799	22143995	2%	2042381	3.9

Energy analysis

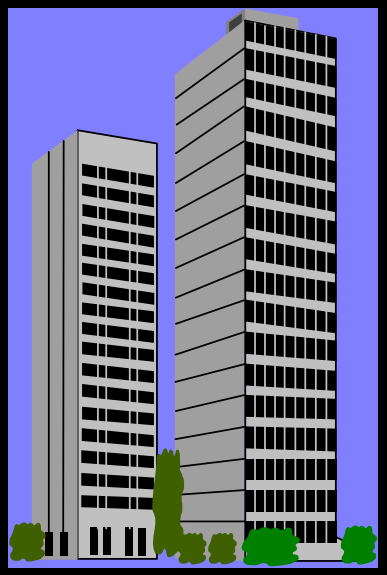


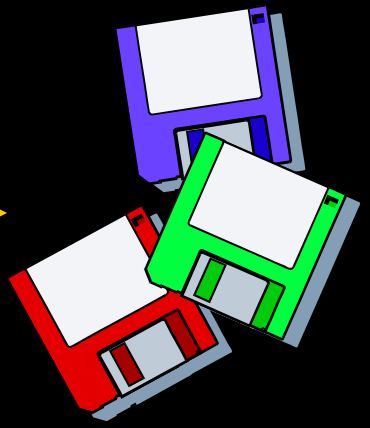
Energy analysis results for an office building

Energy Savings Analysis Results

S.No	Alternative	Areas ft2	incremental Unit Cost	total Cost	Payback (yrs)	Total (Kwh)	% Savings over ASHRAE Base case	Total Energy Cost (Rs)	Energy Cost Savings over Typical bldg (Rs)
1	Typical building					840,632	-57.1%	4,203,160	
2	Ashrae base case					534,987		2,674,935	1,528,225
3	Roof high albedo	39856	0	-	0.0	521,654	2.5%	2,608,270	1,594,890
4	Roof R 30 in	45000	120	5,400,000	3.4	519,028	3.0%	2,595,140	1,608,020
5	AAC wall	80000	35	2,800,000	1.7	508,143	5.0%	2,540,715	1,662,445
6	Cavity Wall 2 in ins	80000	90	7,200,000	4.2	499,350	6.7%	2,496,750	1,706,410
7	Ind Cavity Wall 3 in ins	80000	110	8,800,000	5.1	492,942	7.9%	2,464,710	1,738,450
8	Single Glass U=1	8000	600	4,800,000	3.1	528,761	1.2%	2,643,805	1,559,355
9	Double Glass U=0.5	8000	800	6,400,000	4.1	526,189	1.6%	2,630,945	1,572,215
10	Combined case				0.0	361,744	32.4%	1,808,720	2,394,440

Weather data





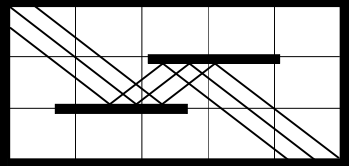
Building description

- physical data
- design parameters

Simulation tool

Simulation outputs

- energy consumption (MWh)
- energy demands (kW)
- environmental conditions



blast

EnergyPlus

DOE-2

Solar-5

ESP-r

ENER-WIN©
Hourly Energy Simulation Program for Buildings

Building Energy Simulation Software

TRNSYS

Carrier

E-20-II & HAP

HOT2000

TRANE

TRACE 600

ADELINE

Tas

HVAC design

- Evaluation of system type options
- System Sizing
- Controls
- Optimization
- Integrated Building Management System