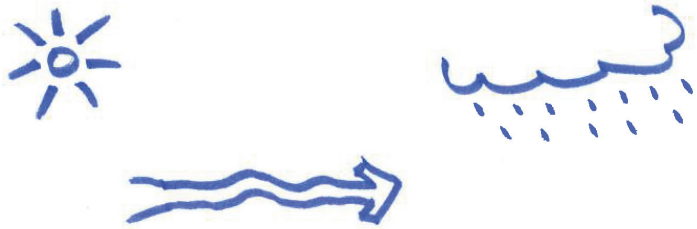
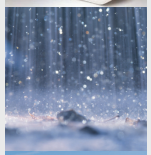


Climate Analysis

Temperature

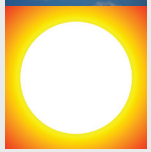
Humidity



Precipitation

Wind

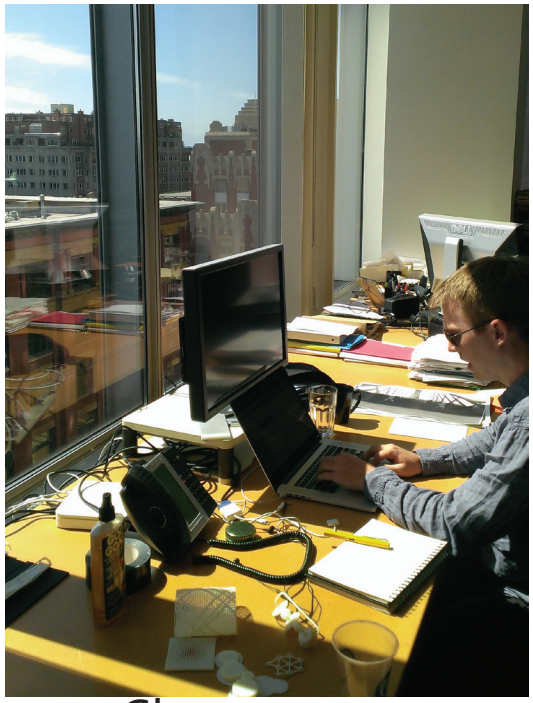
Cloud Cover



Solar Energy

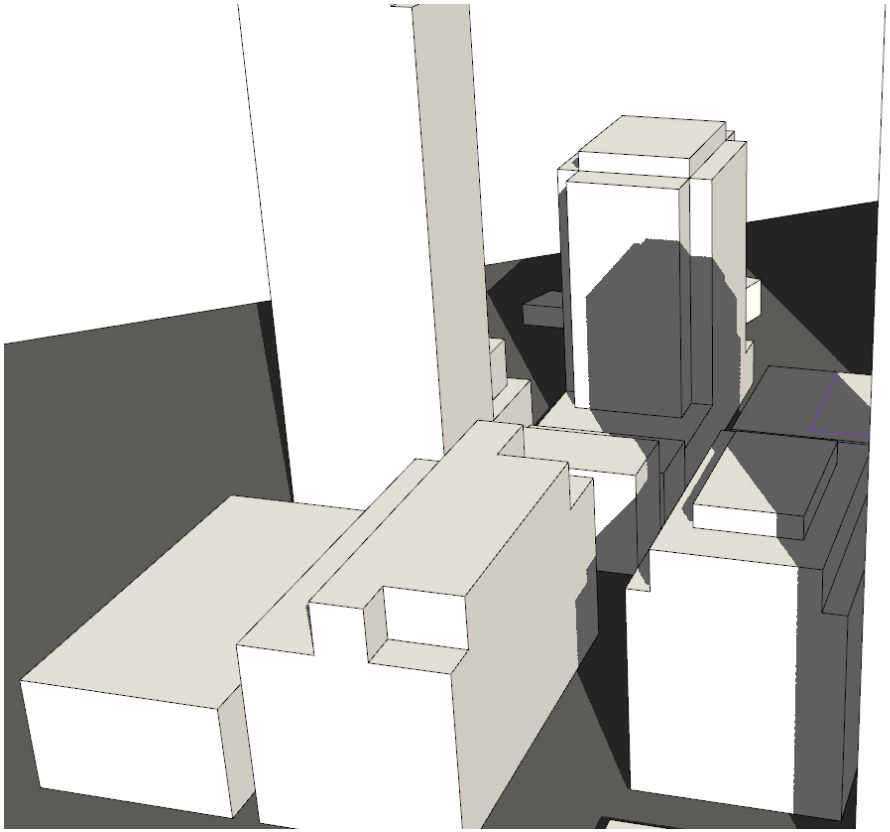
Daylighting uses solar angles,
cloud cover/precipitation,
and context.

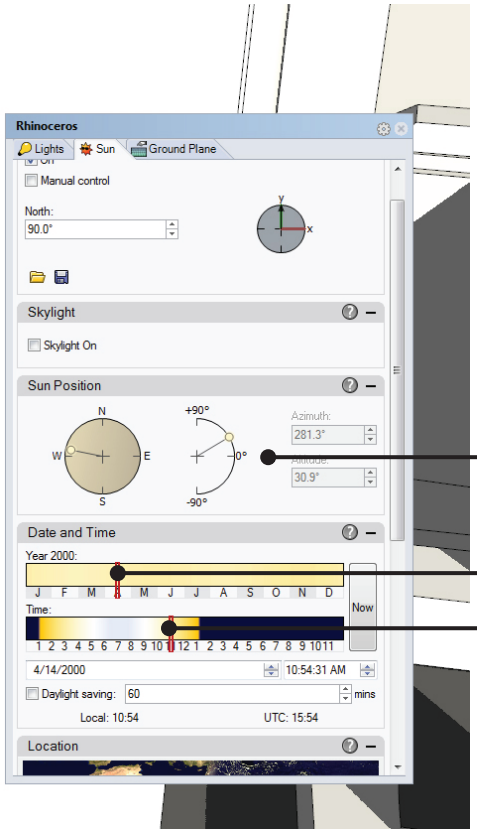
Daylight



Glare

Simple Daylight Analysis





North Angle

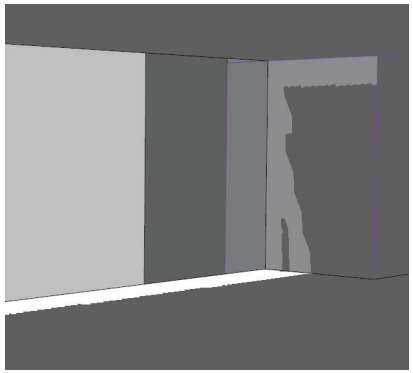
Month/Day

Hour

Dynamic Shadows using Latitude and Month/Day/Time

Pros:
- Quick and Easy
- Dynamic

Cons:
- Only shows direct sunlight
  (ie, no reflections)
- Produces no daylighting metrics
- Single Point in Time



Interior Shadow Analysis

advanced buildings
Energy performance solutions from NBI

Daylighting Pattern Guide

Home | Patterns | Using this Guide | About | DPG+E Development

Introduction

New Buildings Institute in partnership with the University of Idaho and University of Washington has developed a freely available interactive tool for the design of proven daylighting strategies in a variety of building types. Users will be introduced to the Daylighting Pattern Guide while exploring the inter-relationship of sky, site, aperture, and space planning. The guide uses a combination of built examples and advanced simulation to set the stage for substantial reductions in lighting power consumption and overall energy use through successful daylighting design.

Contributors

nbi new buildings institute

INTEGRATED idl DESIGN LAB boise + puget sound

University of Idaho College of Art and Architecture

BE COLLEGE OF BUILT ENVIRONMENTS

Learn more about our Contributors

 New Buildings Institute | Integrated Design Lab Boise | Integrated Design Lab Puget Sound | Login

Pattern 6: Courtyard Depth and Width

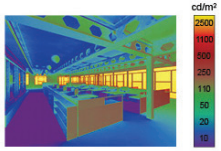
Eight Floors Below Courtyard Aperture

1 of 10

Slideshow

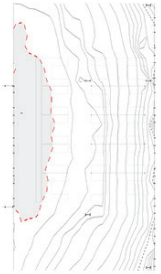
To Overview

At eight floors below the courtyard aperture, illuminance from the courtyard glazing is negligible. The false color image shows a substantial disparity between the brightness of surfaces at the courtyard side and the outside perimeter of the office area. However it does provide visual relief through views to the exterior. Again, since the floor plate is narrow, 85% of the floor area receives sufficient daylight to meet 300 lux of horizontal illumination.



85%
of floor area is above 300 lux

LUX
2000
300
200
100
0



Pattern 11: Toplighting (Classroom)

No Toplighting: Standard View Windows

1 of 25

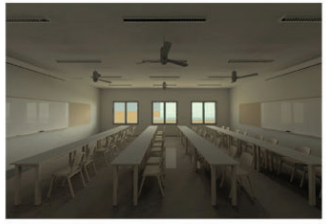
Slideshow

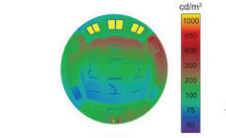
To Overview

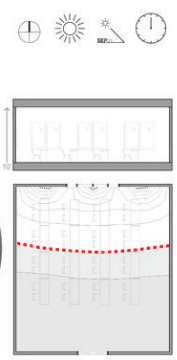
These data represent a common classroom design with three standard view windows along one façade. The floor area above 300 lux is 35%.

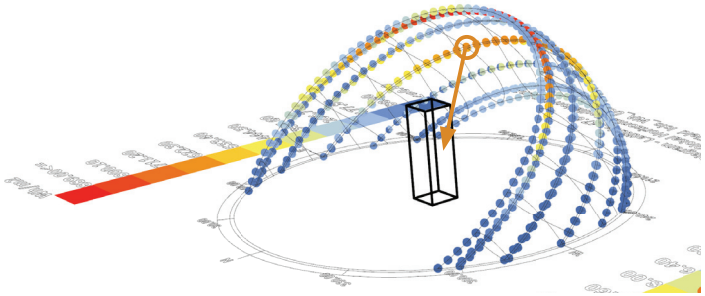
35%
of floor area is above 300 lux

LUX
2000
300
200
100
0

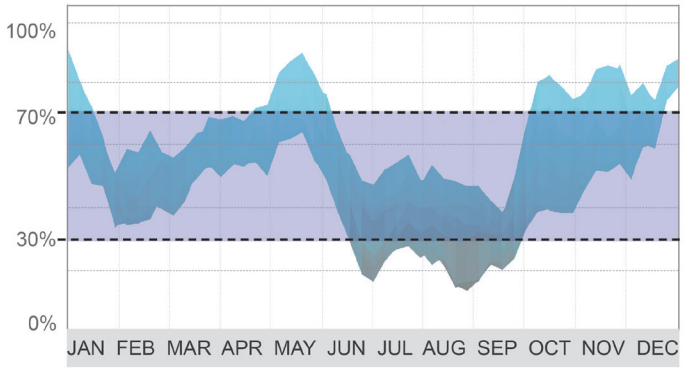








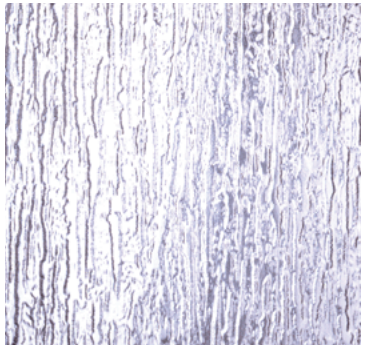
Sun Path
(Latitude, Solar Noon)



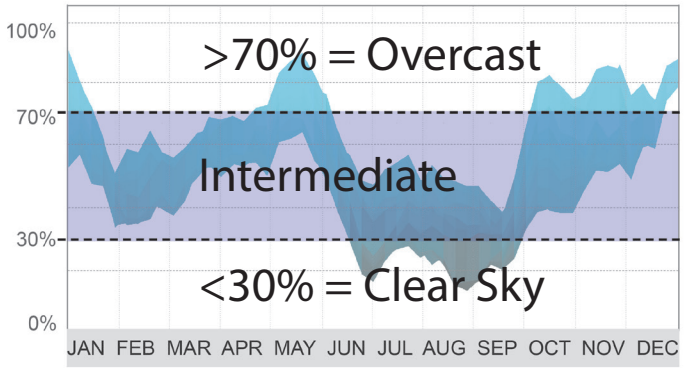
Cloud Cover

There is a better way.

Geometry



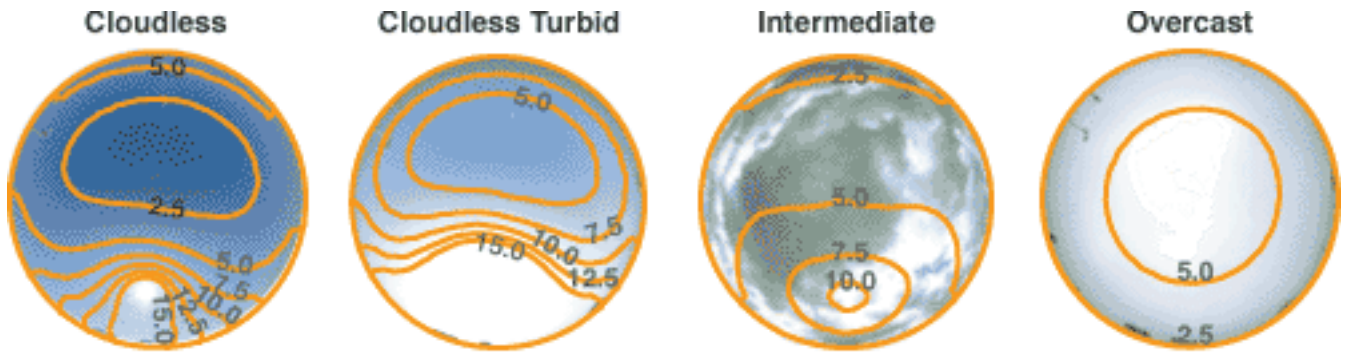
Material Properties
- Transparency
- Translucency
- Color
- Specularity



Cloud Cover

...becomes Sky Conditions
(ie, a Luminance map of the sky)

(you can see how this works in Ladybug/Honeybee)

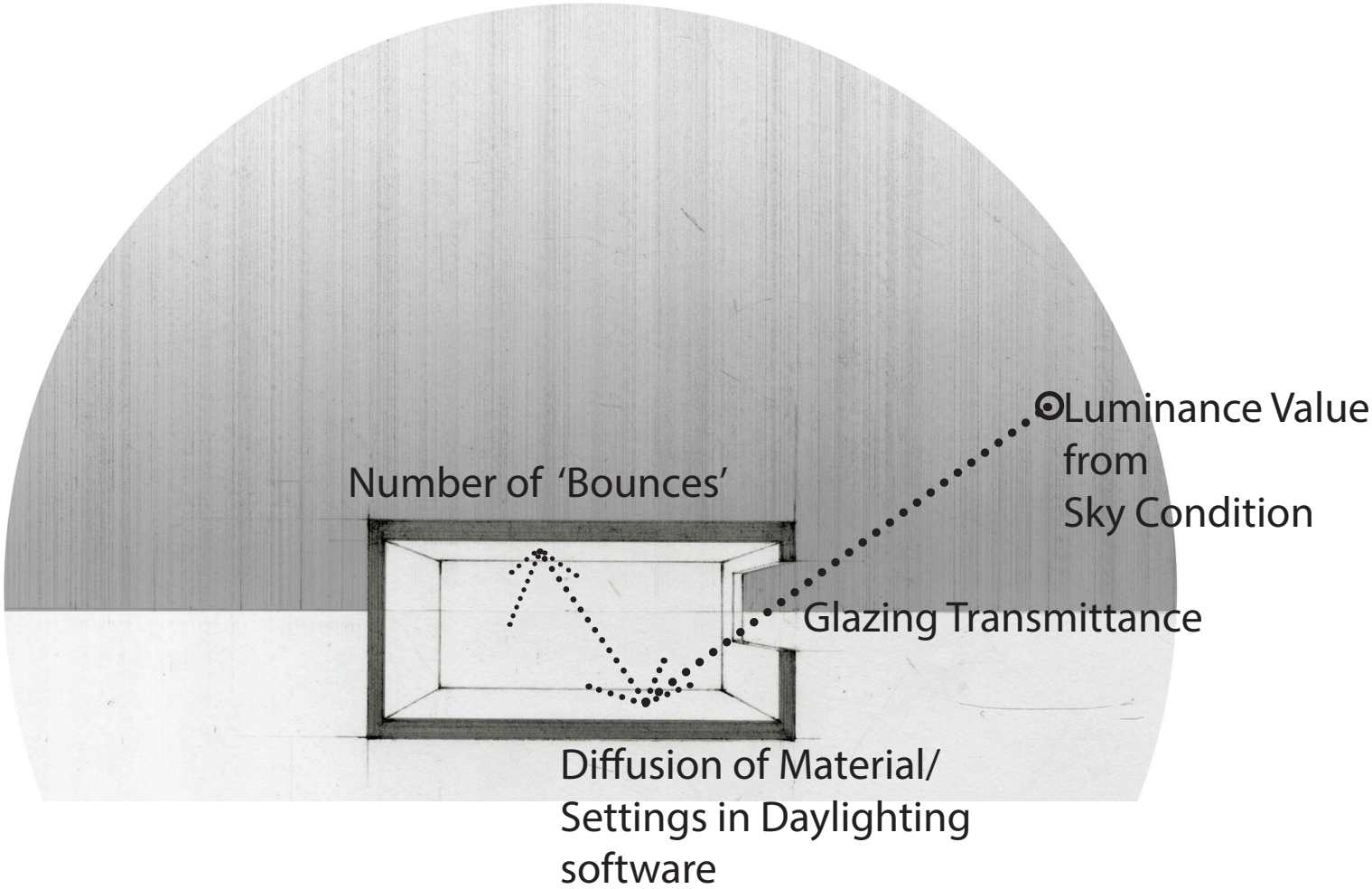


ASRC -CIE Luminance distribution for the four basic models (kcd/m^2)

...Sky Conditions

(ie, a Luminance map of the sky)

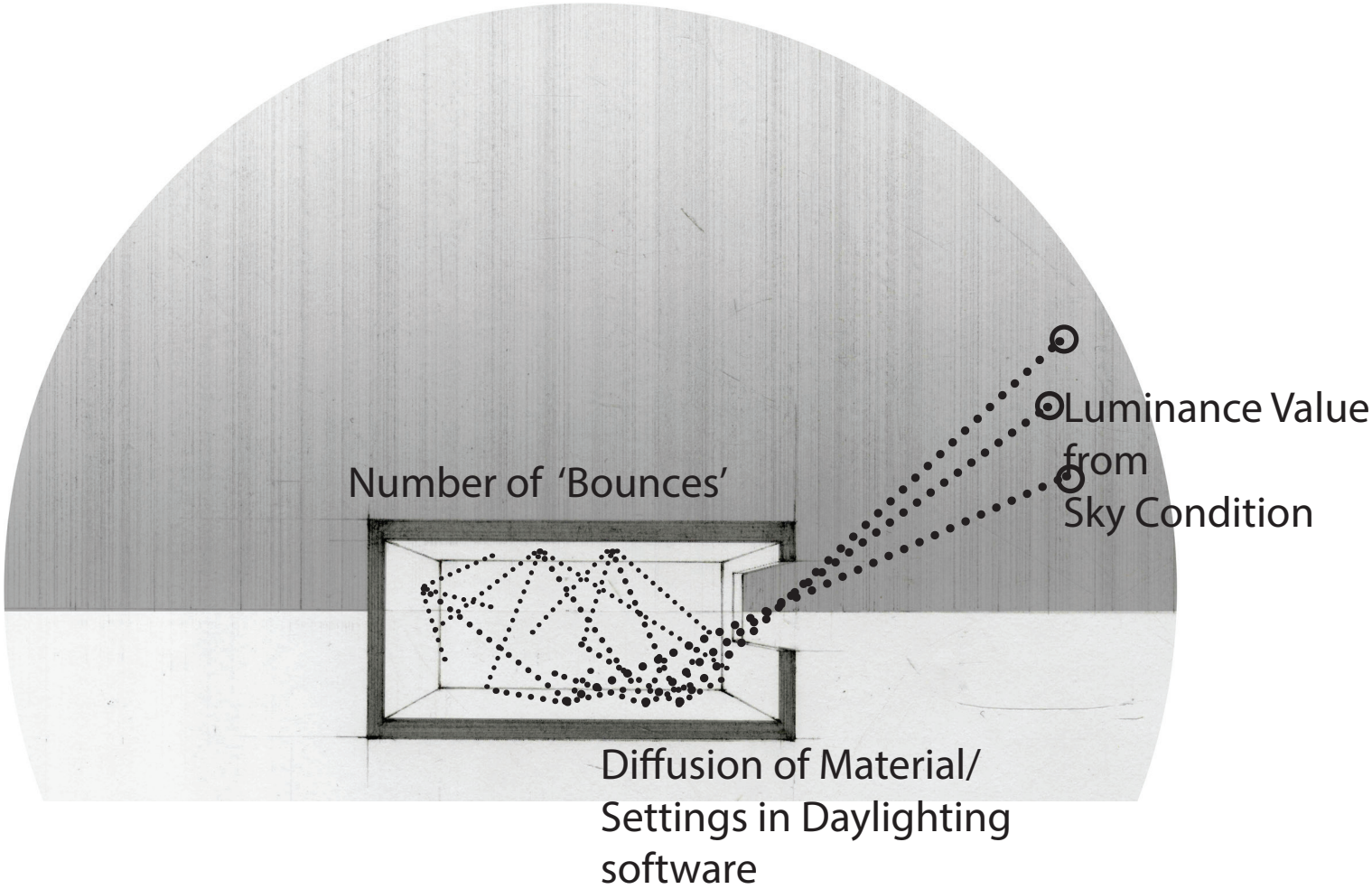
are used to simulate outdoor sky conditions.



...Sky Conditions

(ie, a Luminance map of the sky)

are used to simulate outdoor sky conditions.



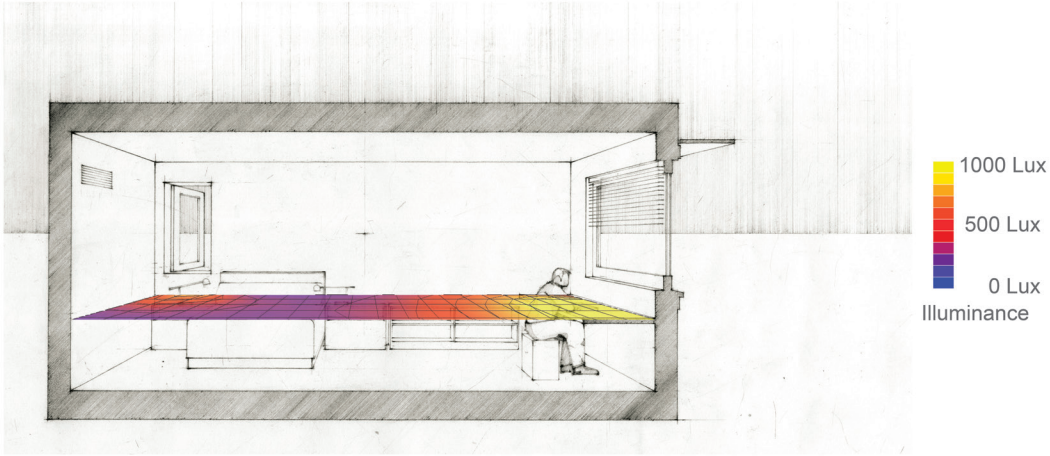
Now that we have all the pieces, we can choose the type of Daylight Analysis

Hint: You need to understand what question you are asking!

Are lighting levels appropriate for an office?
classroom
lab
ballroom
natatorium

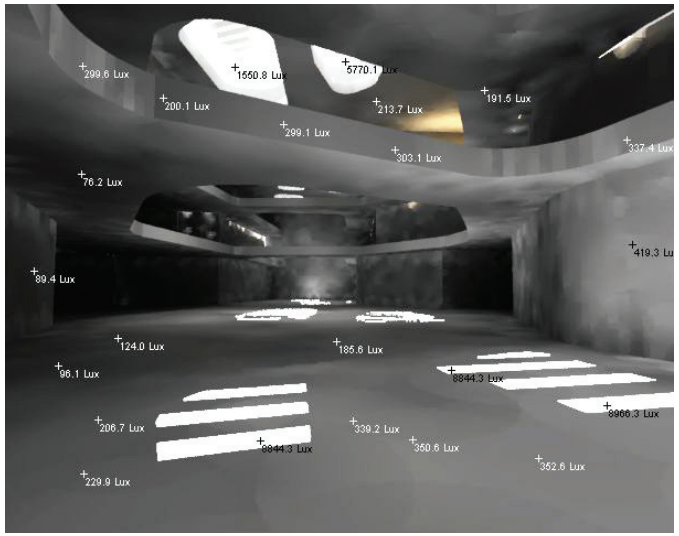
Which seasons is glare likely?
How much effect does a light shelf have on light balance within a space?
How much view is preserved with 96% dark shades deployed?
How often are shades likely to be deployed on the southeast facade?
How will a space feel in terms of lighting balance?
How much electric light is necessary to balance daylighting levels in the winter?
How does fritting affect the daylight levels?

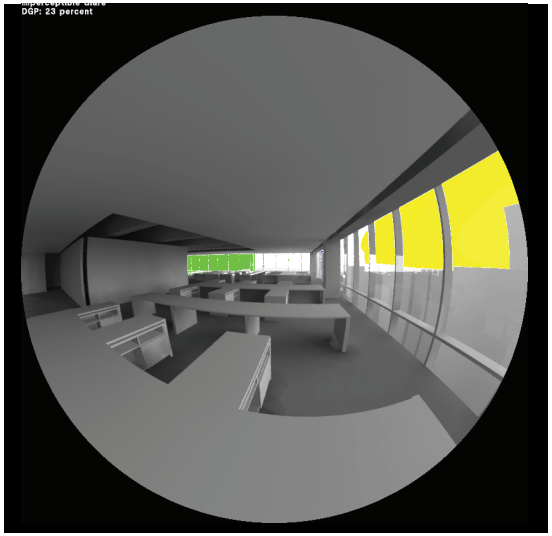
Two types of Analysis:



- Grid-Based (often work plane)

  used to determine lighting levels and balance





- 3d View

  used to look at lighting balance and potential glare

Two time-scales of Analysis:

2:08:11

Point-In-Time

often uses false color and shows specific lighting levels

simple to run, with detailed results

1999

Annual (Time-Step)

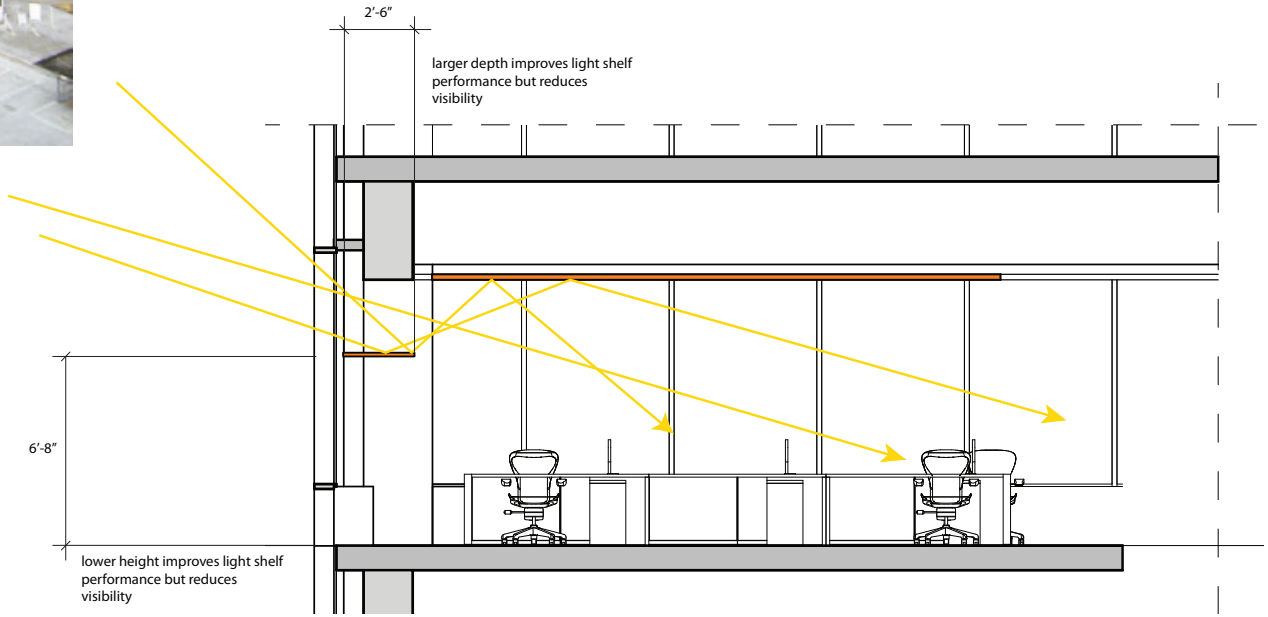
uses time-steps (1 hour, 15 minutes, 1 second)
uses averaged conditions

need to define occupancy, ie 7am-6pm.

LMN Offices, Seattle

Questions:

- Does a lightshelf provide adequate glare control?
- Where should desks be located based on daylighting levels?
- How much 'daylight autonomy' can we expect

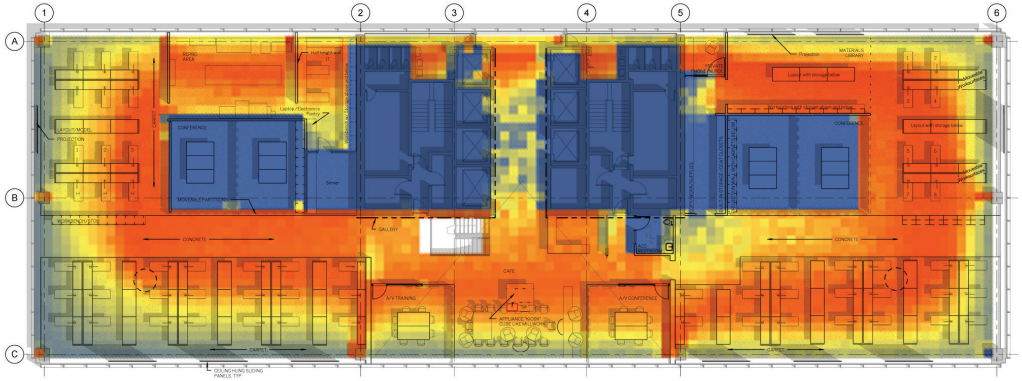


UDI : Useful Daylight Illuminance

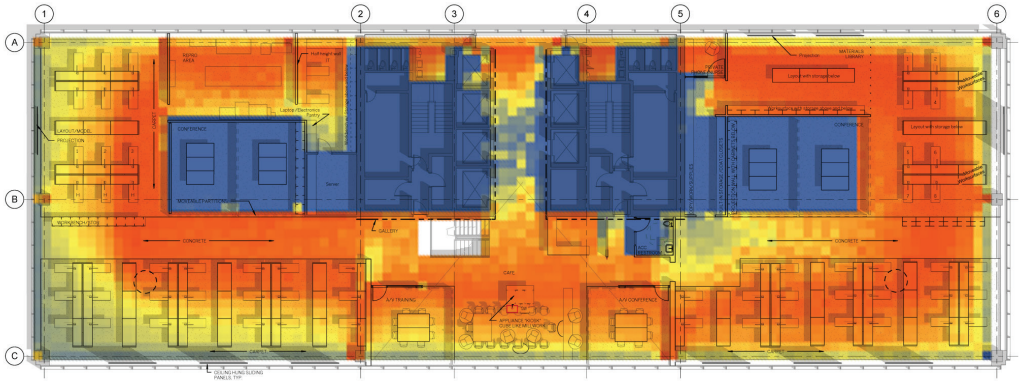
Questions:

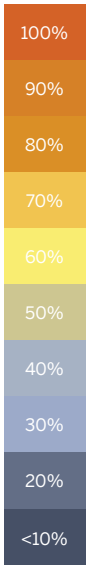
- Does a lightshelf provide adequate glare control?
- Where should desks be located based on daylighting levels?
- How much 'daylight autonomy' can we expect

No Light Shelf



With Light Shelf





100% means electric lights are, in theory, not necesary.

50% means half of the occupied hours lights may be completely off.

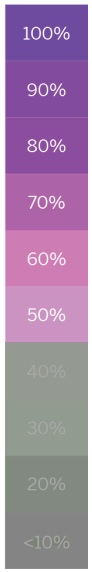
10% means electric lights are on nearly all occupied hours.

UDI : Useful Daylight Illuminance

Overlit Areas, % of occupied hours

0 fc — 10 fc — 200 fc — ++

underlit — useful daylight — overlit



100% means area receives 'too much' daylight all year

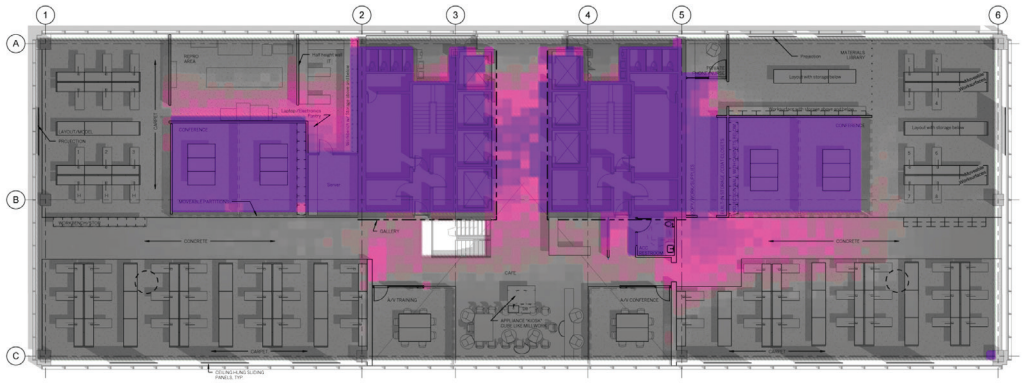
50% means half of the occupied hours receives too much daylight

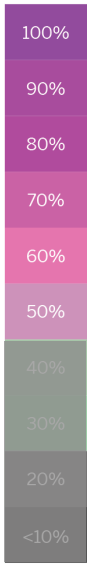
---

Underlit Areas, % of occupied hours

0 fc — 10 fc — 200 fc — ++

underlit — useful daylight — overlit





100% means area receives 'too little' daylight all year

50% means half of the occupied hours receives too little daylight.

Questions:

- Does a lightshelf provide adequate glare control?
- Where should desks be located based on daylighting levels?
- How much 'daylight autonomy' can we expect

Answers:

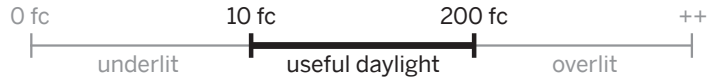
- No, additional measures necessary
- Near windows, but not too near.
- 54% of the year electric lights not necessary*

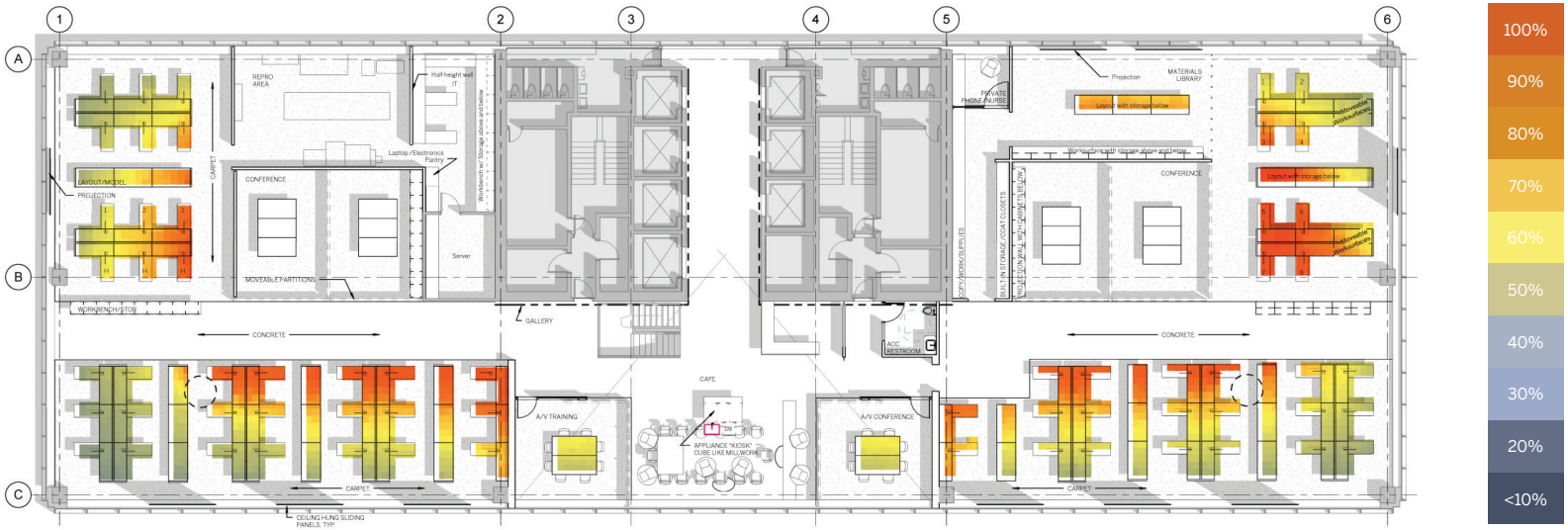
* automatic shades and dimming LEDs installed which were not assumed for these early studies. The shades operate in 5 zones based on photosensors.

USEFUL DAYLIGHT INDEX

WITH LIGHT SHELF WITHOUT SHADING (30" DEEP, 6'-8" FROM FLOOR)

USEFUL DAYLIGHT ILLUMINATION (UDI):
DAYLIGHTING ILLUMINANCE >10fc and <200fc
% OF OCCUPIED HOURS FOR THE YEAR





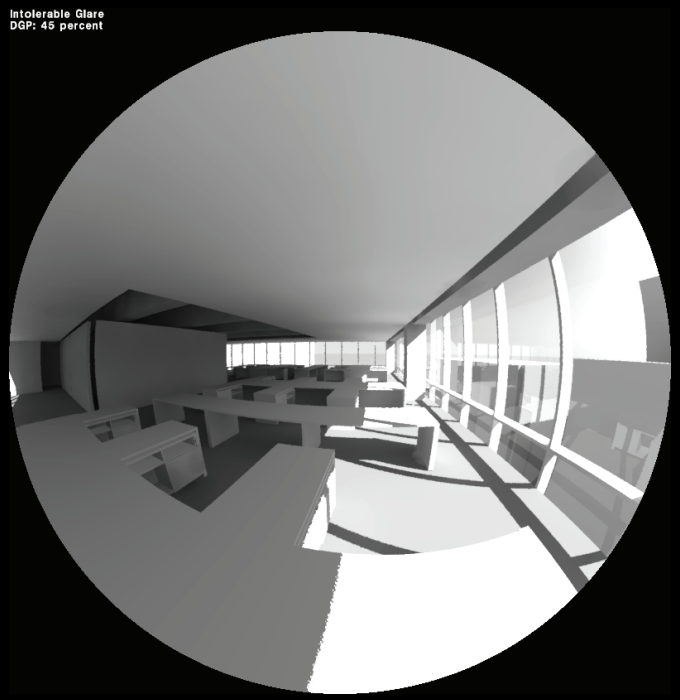
USEFUL DAYLIGHT 53.9% OF OCCUPIED TIME

GLARE STUDY FROM WORKSPACE 4W

IMPERCEPTIBLE GLARE: .35>DGP
PERCEPTIBLE GLARE: .4>DGP>.35
DISTURBING GLARE: .45>DGP>.4
INTOLERABLE GLARE: DGP>.45

Intolerable Glare
DGP: 48 percent

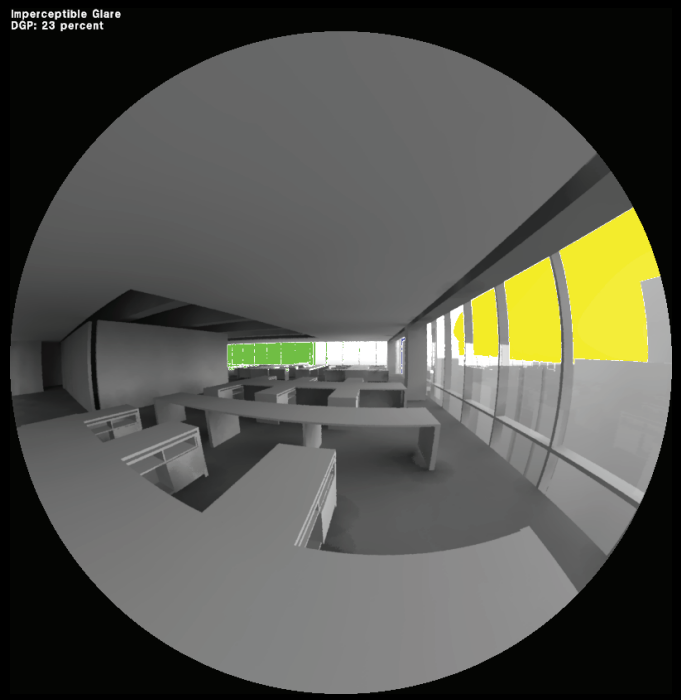
Intolerable Glare
DGP: 45 percent



SUMMER SOLSTICE, 4PM

EQUINOX, 4PM

Imperceptible Glare
DGP: 23 percent



WINTER SOLSTICE, 4PM

THERE ARE SEVERAL METHODS FOR MEASURING GLARE. THIS STUDY USES DGP (DAYLIGHT GLARE PROBABILITY). THIS USES DAYLIGHT SIMULATIONS COMBINED WITH LUMINANCE CONTRAST ASSESSMENTS.

CASE STUDY 1:
EAST PORTLAND COMMUNITY CENTER

EXISTING CONDITIONS

Completed 1997
Total area: 32,000 sf

Gym:	8,700 sf
Multipurpose:	2,698 sf
Classrooms:	1,664 sf
Dance:	1,700 sf
Senior lounge:	720 sf

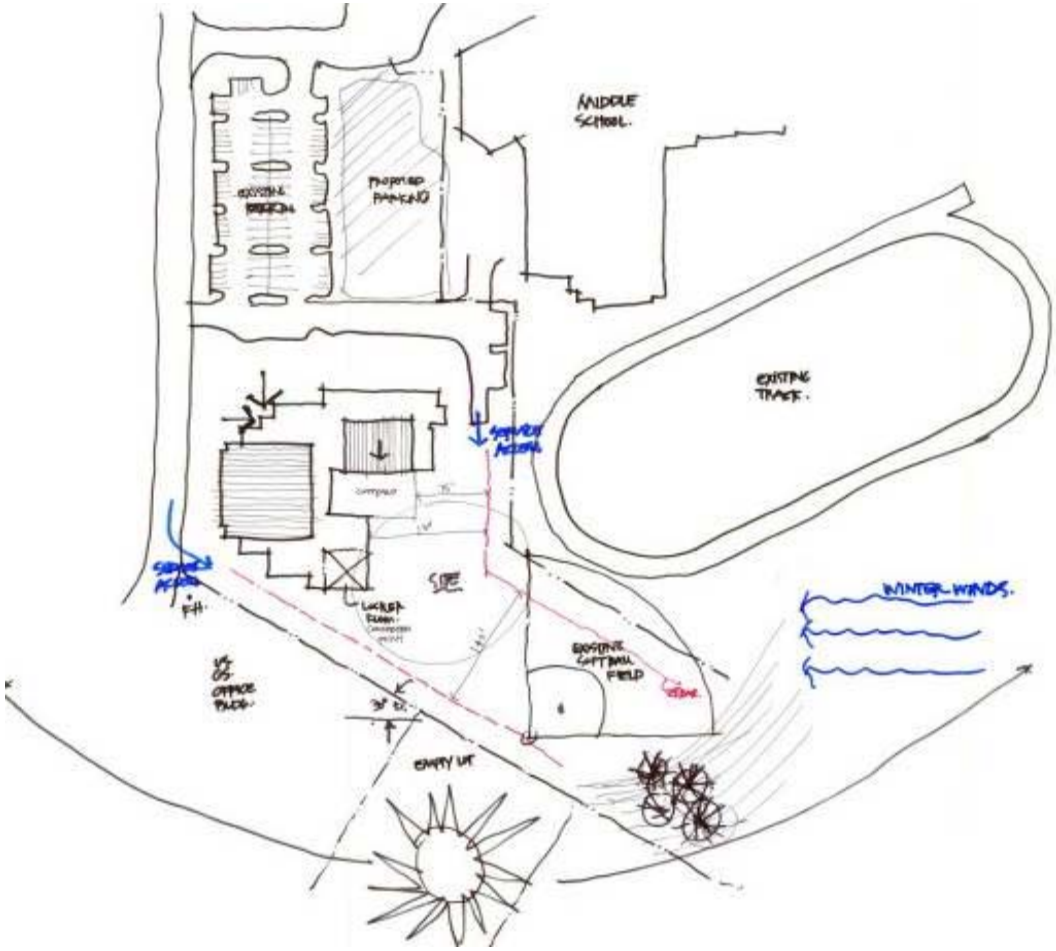
Existing Building

Reception desk

Courtyard

SITE
ANALYSIS

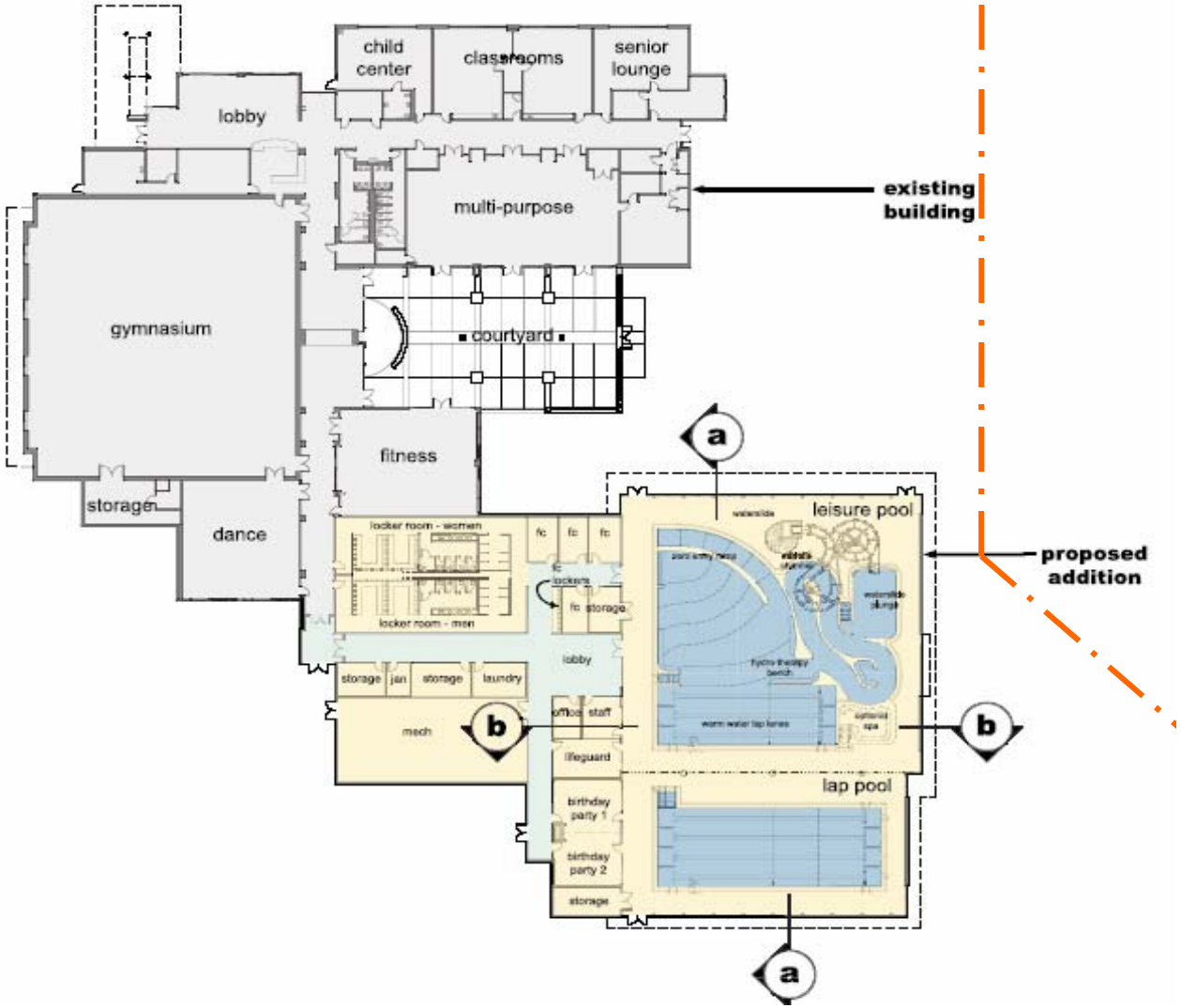
SOLAR PATHFINDER



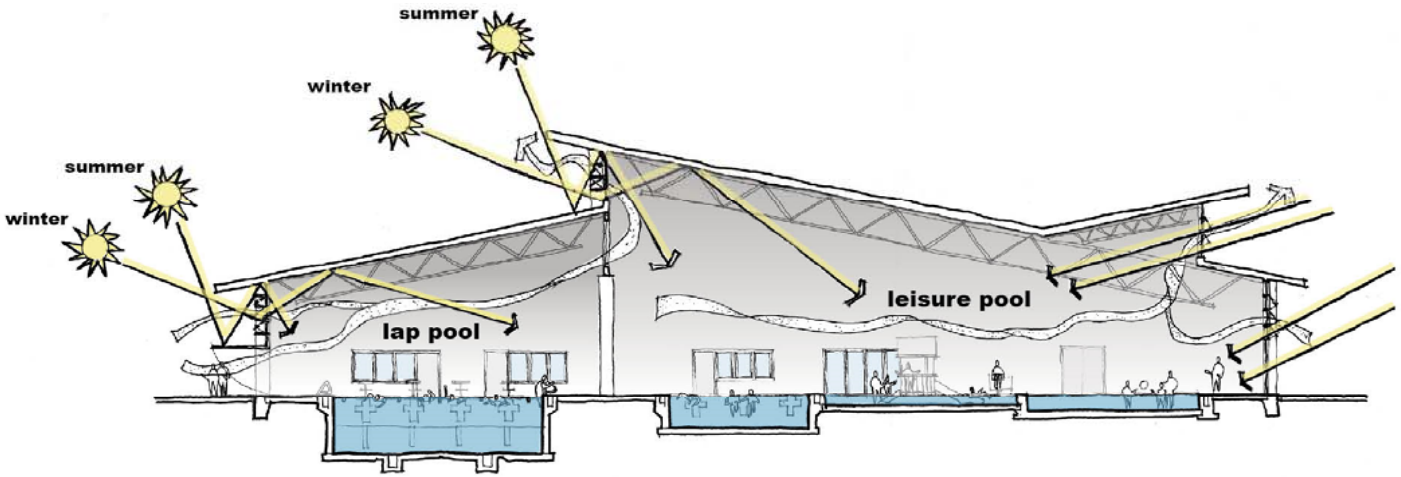
SITE ANALYSIS

SCHEMATIC
DESIGN

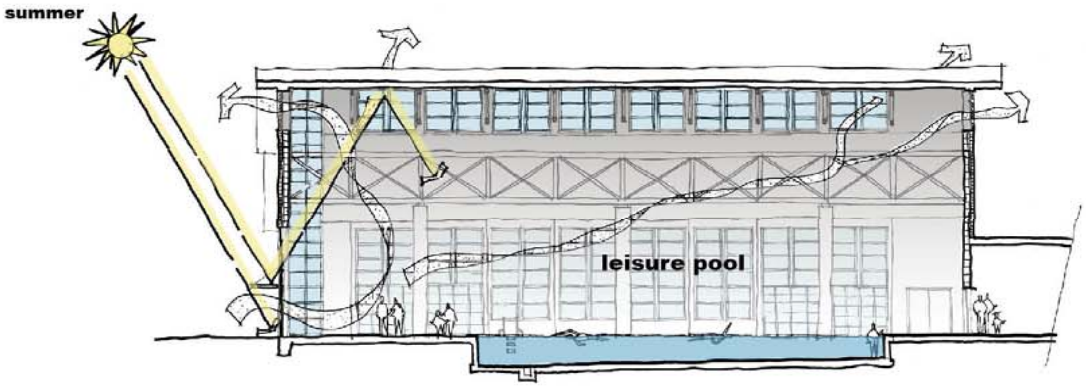
EXISTING BLDG AREA	31,658 sf
NEW ADDITION AREA	24,167 sf
Natatorium	14,860 sf
Lobby	720 sf
Additional locker room	784 sf
Birthday party rooms	710 sf
Family change rooms (6)	544 sf
Office	122 sf
Staff offices	182 sf
Lifeguard / first aid	379 sf
Laundry / storage	270 sf
Pool storage	375 sf
Custodial storage	264 sf
Mechanical	1,711 sf



SCHEMATIC DESIGN



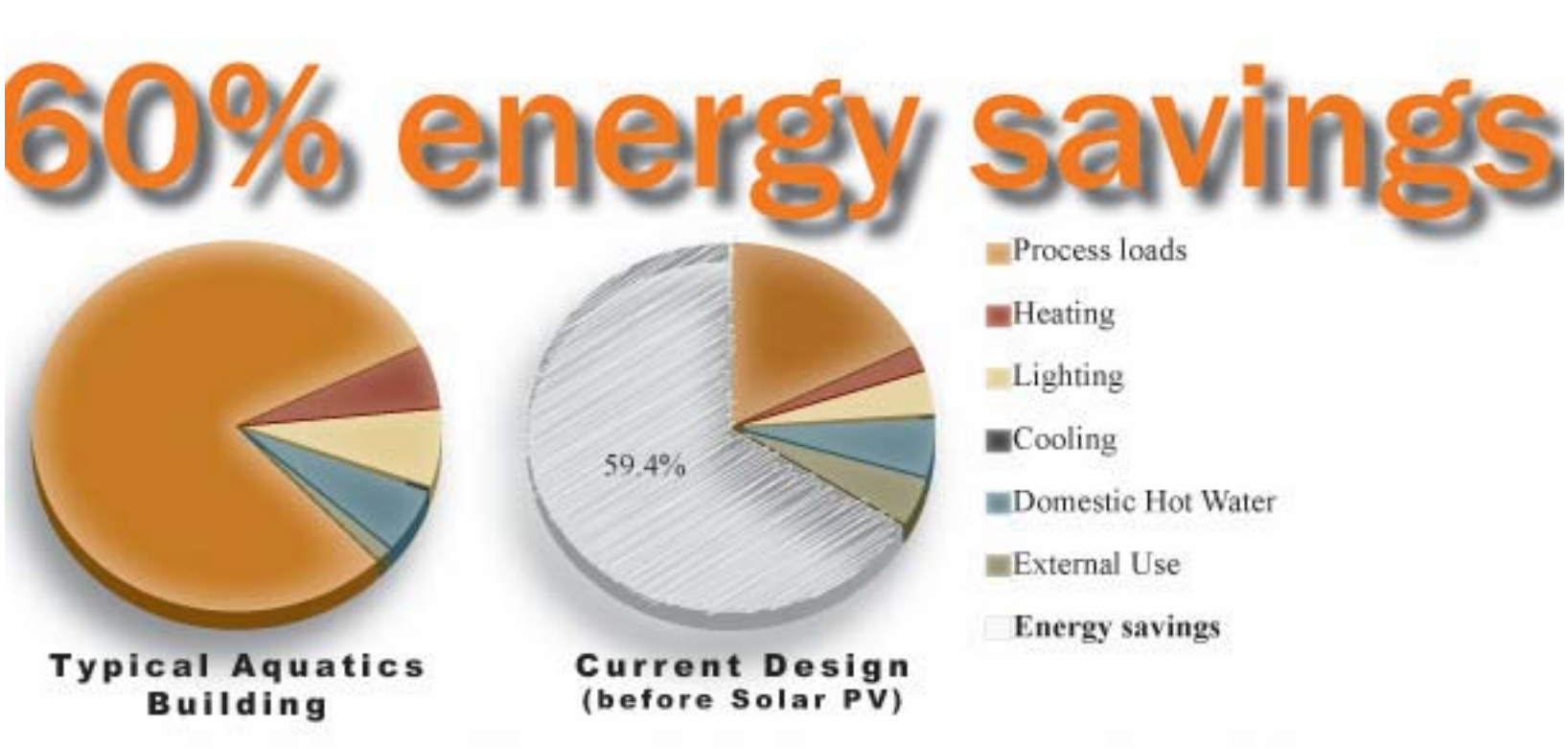
a north-south section



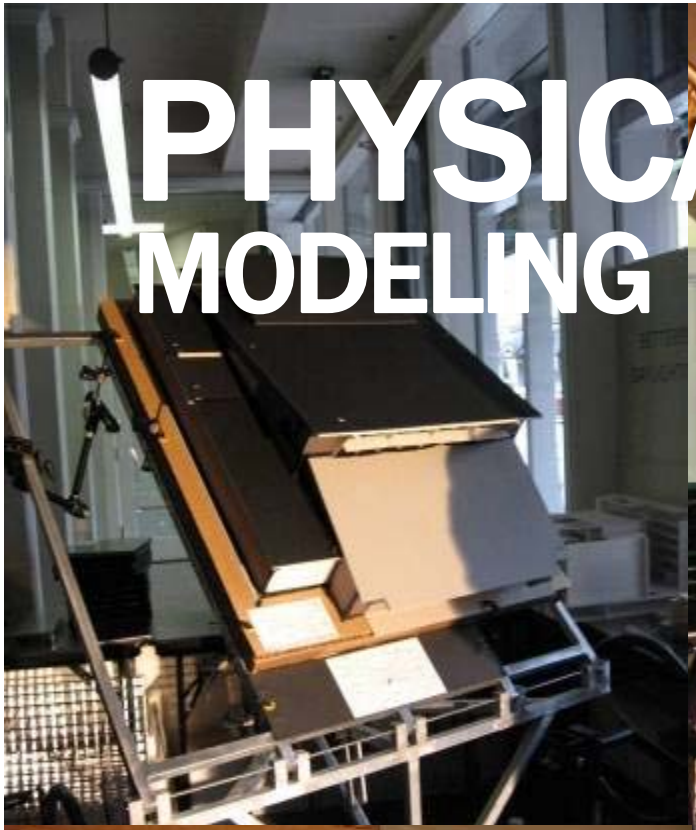
b west-east section

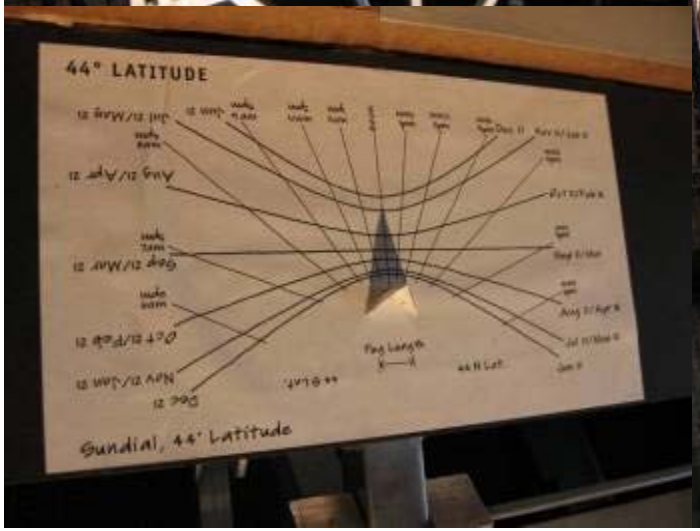
ENERGY SAVINGS

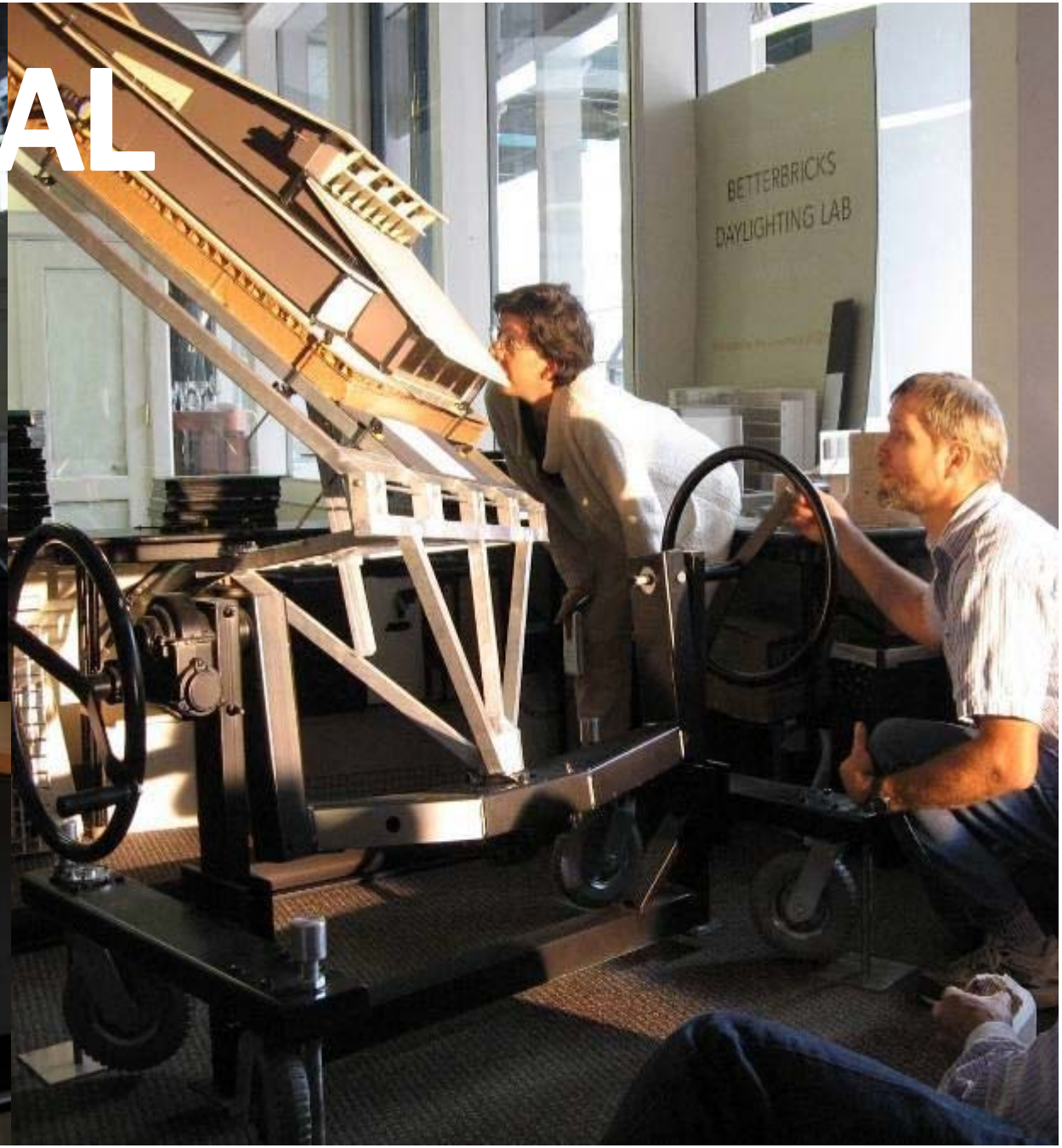
FROM BASELINE AQUATICS BUILDING

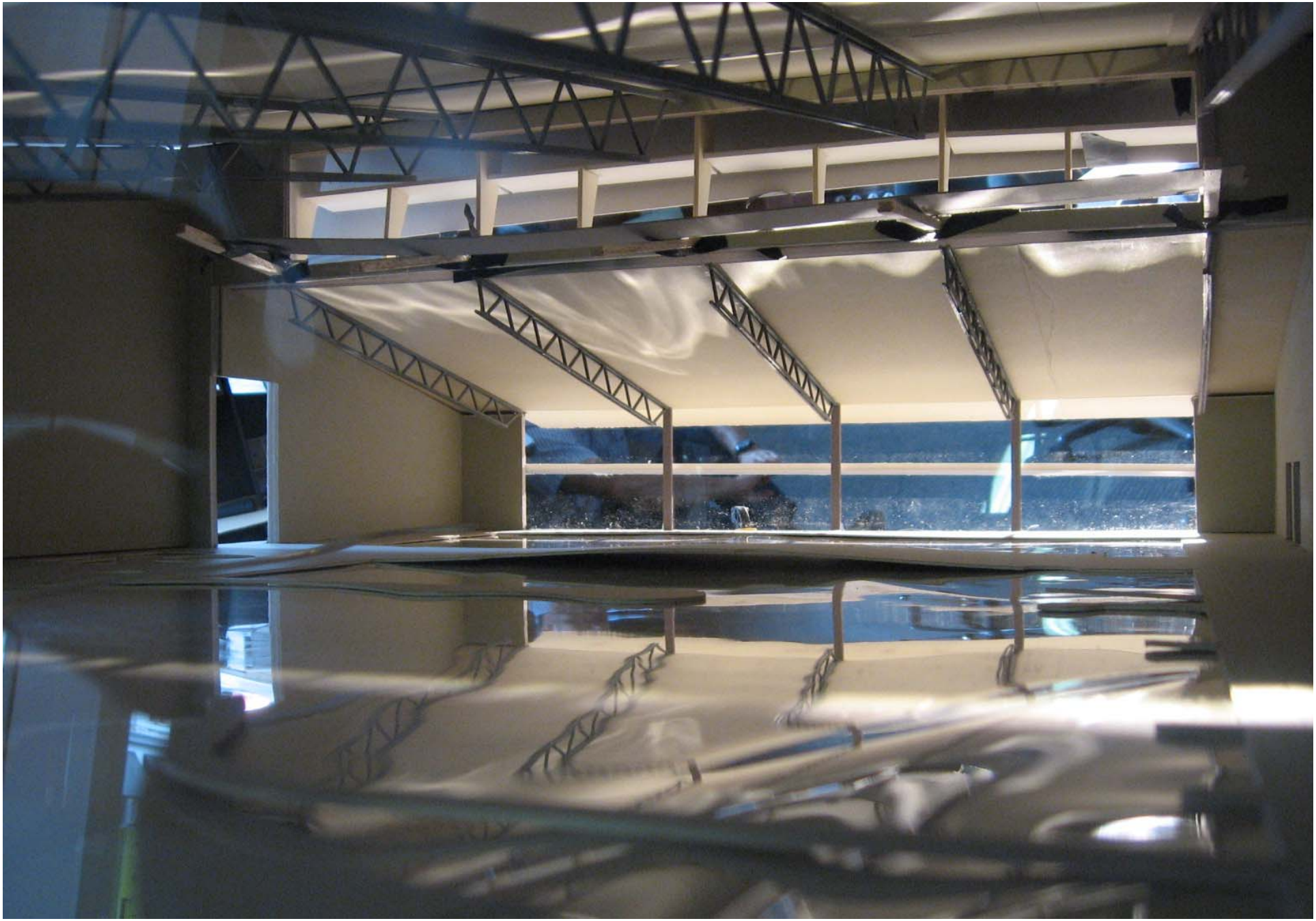


PHYSICAL MODELING



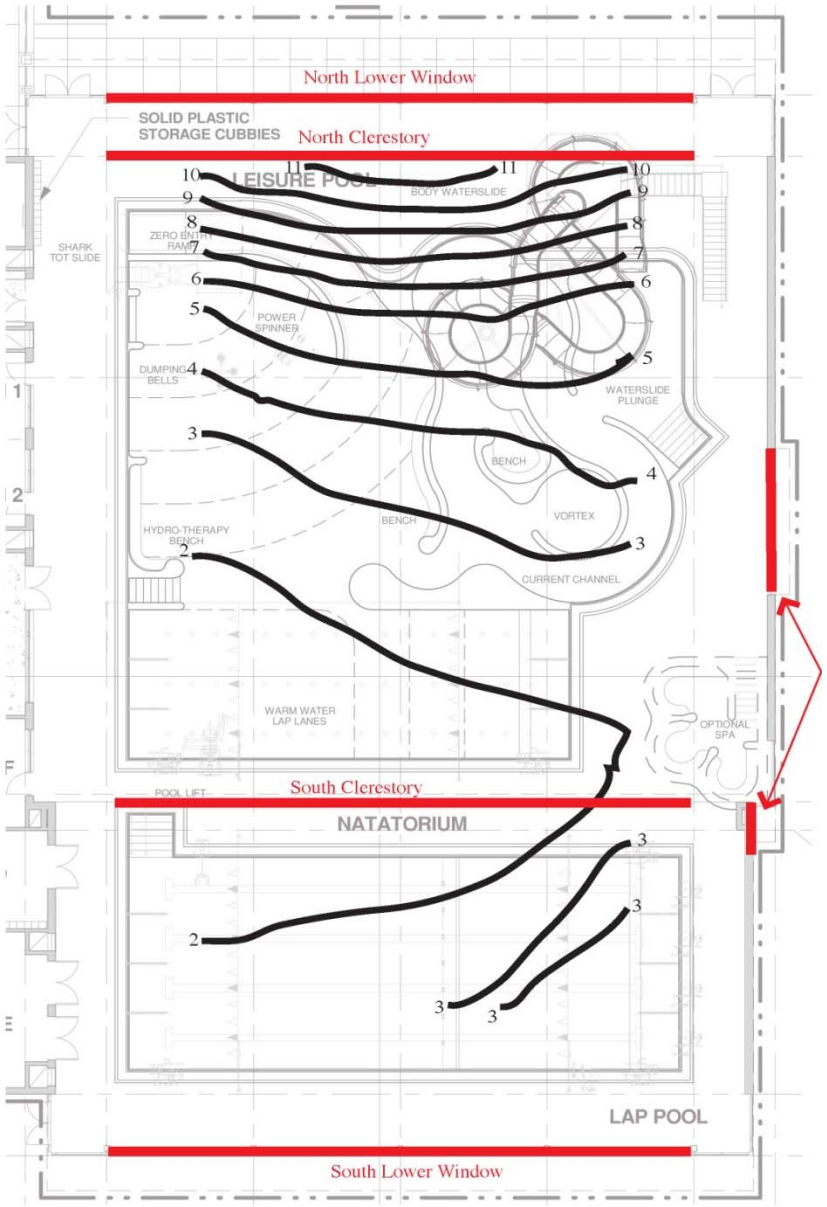






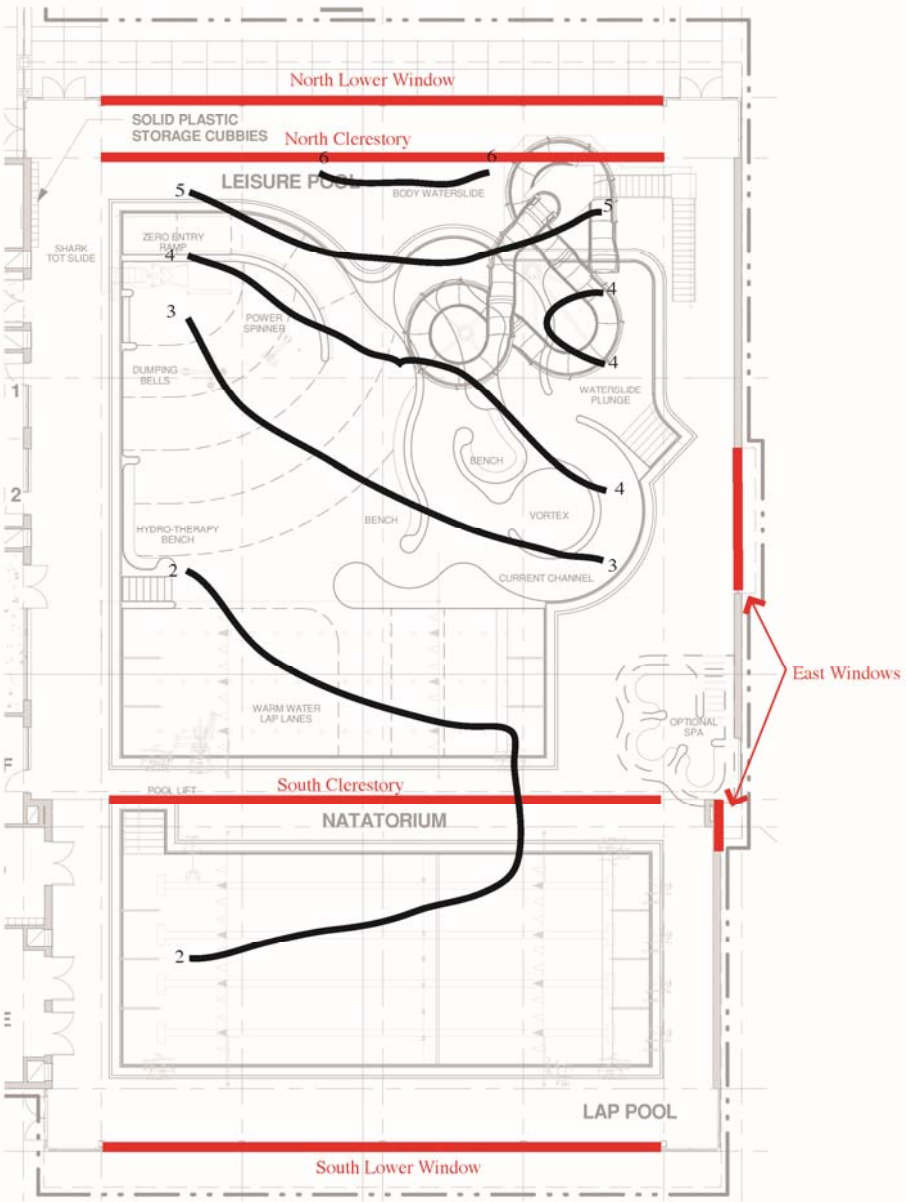
DRAFT 8/17/2006 10 AM

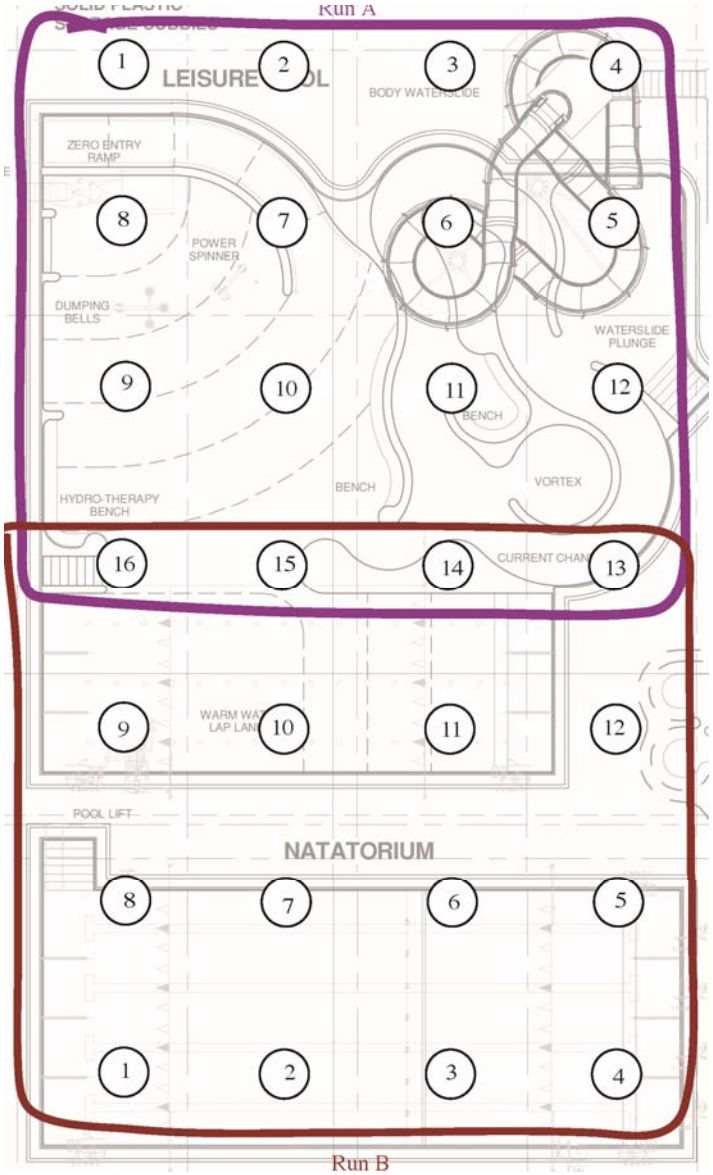
East Portland Community Center Aquatic Center



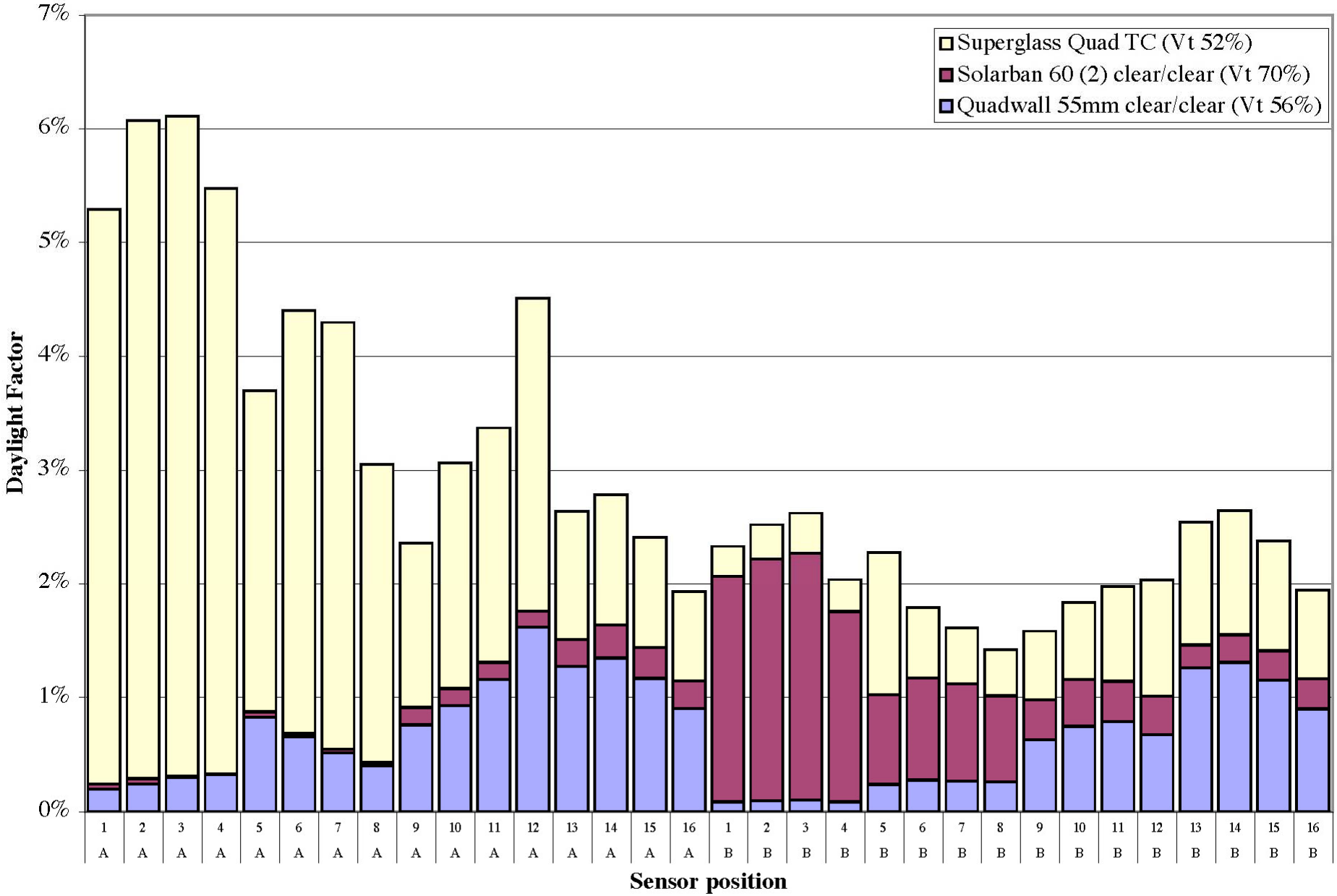
DRAFT 9/1/2006 4 PM Retested Model 8/31/2006

East Portland Community Center Aquatic Center




Run A
LEISURE POOL
BODY WATERSLIDE
ZERO ENTRY RAMP
POWER SPINNER
DUMPING BELLS
WATERSLIDE PLUNGE
BENCH
VORTEX
HYDRO-THERAPY BENCH
CURRENT CHAN
WARM WA
LAP LAN
POOL LIFT
NATATORIUM
Run B

East Portland Community Center Aquatic Center



PHYSICAL
MODELING

CONTINUOUS DIMMING ANALYSIS

DAYLIGHT FACTOR	4.1%
TARGET ILLUMINATION LEVEL	30 FC
MINIMUM DIMMING LEVEL	0%

% Electric Lighting On

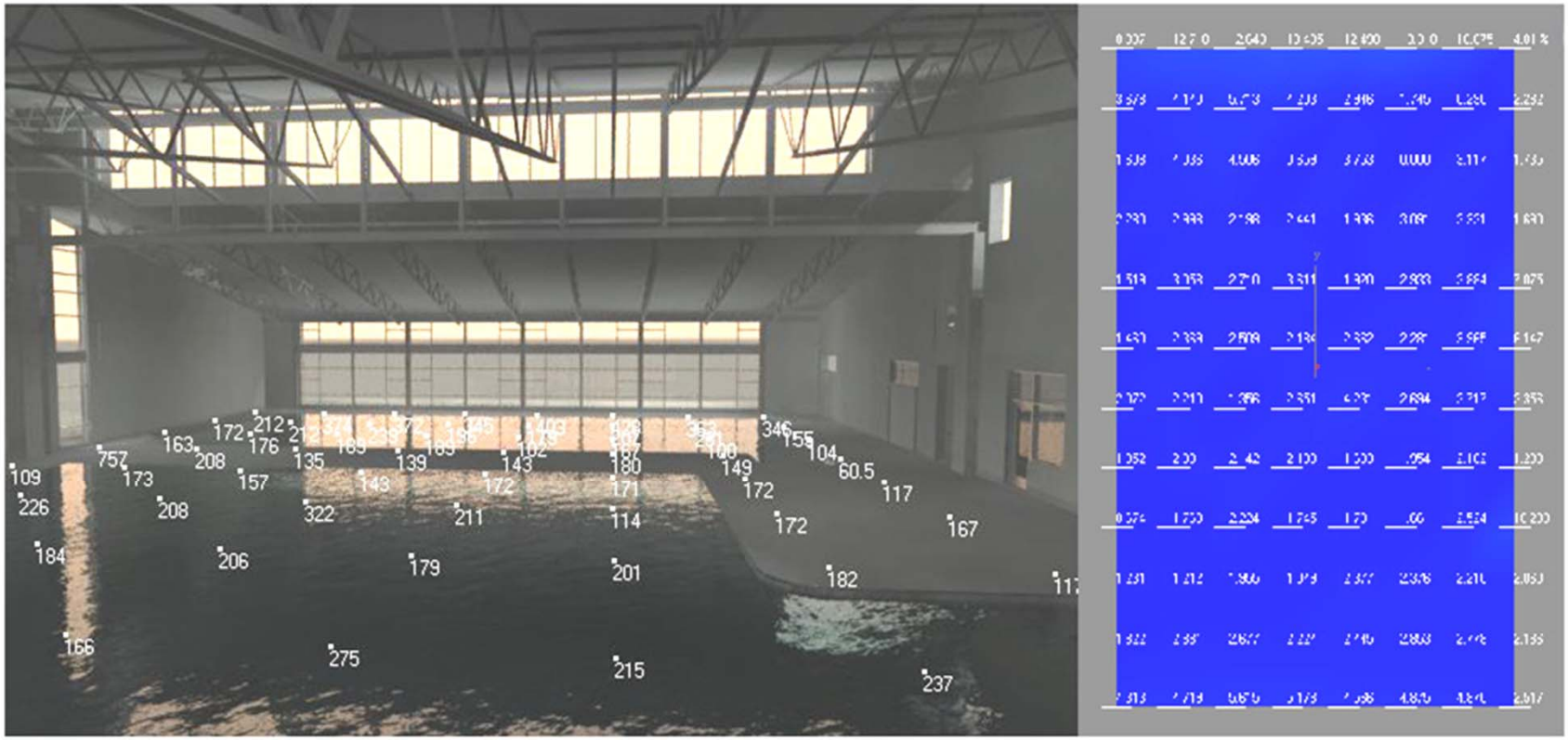
Clock time	Jan	Feb	Mar	*Apr	*May	*Jun	*Jul	*Aug	*Sep	*Oct	Nov	Dec
1 AM	100	100	100	100	100	100	100	100	100	100	100	100
2 AM	100	100	100	100	100	100	100	100	100	100	100	100
3 AM	100	100	100	100	100	100	100	100	100	100	100	100
4 AM	100	100	100	100	100	100	100	100	100	100	100	100
5 AM	100	100	100	100	100	100	100	100	100	100	100	100
6 AM	100	100	100	100	66	53	64	100	100	100	100	100
7 AM	100	78	40	47	29	23	28	46	97	100	100	100
8 AM	62	35	12	17	0	0	0	16	39	80	63	81
9 AM	33	11	0	0	0	0	0	0	11	36	33	42
10 AM	16	0	0	0	0	0	0	0	0	12	16	25
11 AM	3	0	0	0	0	0	0	0	0	0	4	15
12 PM	0	0	0	0	0	0	0	0	0	0	0	10
1 PM	3	0	0	0	0	0	0	0	0	0	4	15
2 PM	16	0	0	0	0	0	0	0	0	0	16	25
3 PM	33	11	0	0	0	0	0	0	0	0	33	42
4 PM	62	35	12	0	0	0	0	0	0	12	63	81
5 PM	100	78	40	0	0	0	0	0	11	36	100	100
6 PM	100	100	100	17	0	0	0	16	39	80	100	100
7 PM	100	100	100	47	29	23	28	46	97	100	100	100
8 PM	100	100	100	100	66	53	64	100	100	100	100	100
9 PM	100	100	100	100	100	100	100	100	100	100	100	100
10 PM	100	100	100	100	100	100	100	100	100	100	100	100
11 PM	100	100	100	100	100	100	100	100	100	100	100	100
12 AM	100	100	100	100	100	100	100	100	100	100	100	100

* months are adjusted for daylight savings time

	CONTINUOUS DIMMING	STEP DIMMING
AVERAGE % SAVED, DAYLIGHT HOURS	83	53
AVERAGE % SAVED, HOURS 6 THRU 21	62	40
AVERAGE % SAVED, HOURS 8 THRU 16	89	64

COMPUTER
MODELING

Computer-Generated Daylighting Analysis



COMPARISON

PHYSCIAL MODEL vs. COMPUTER

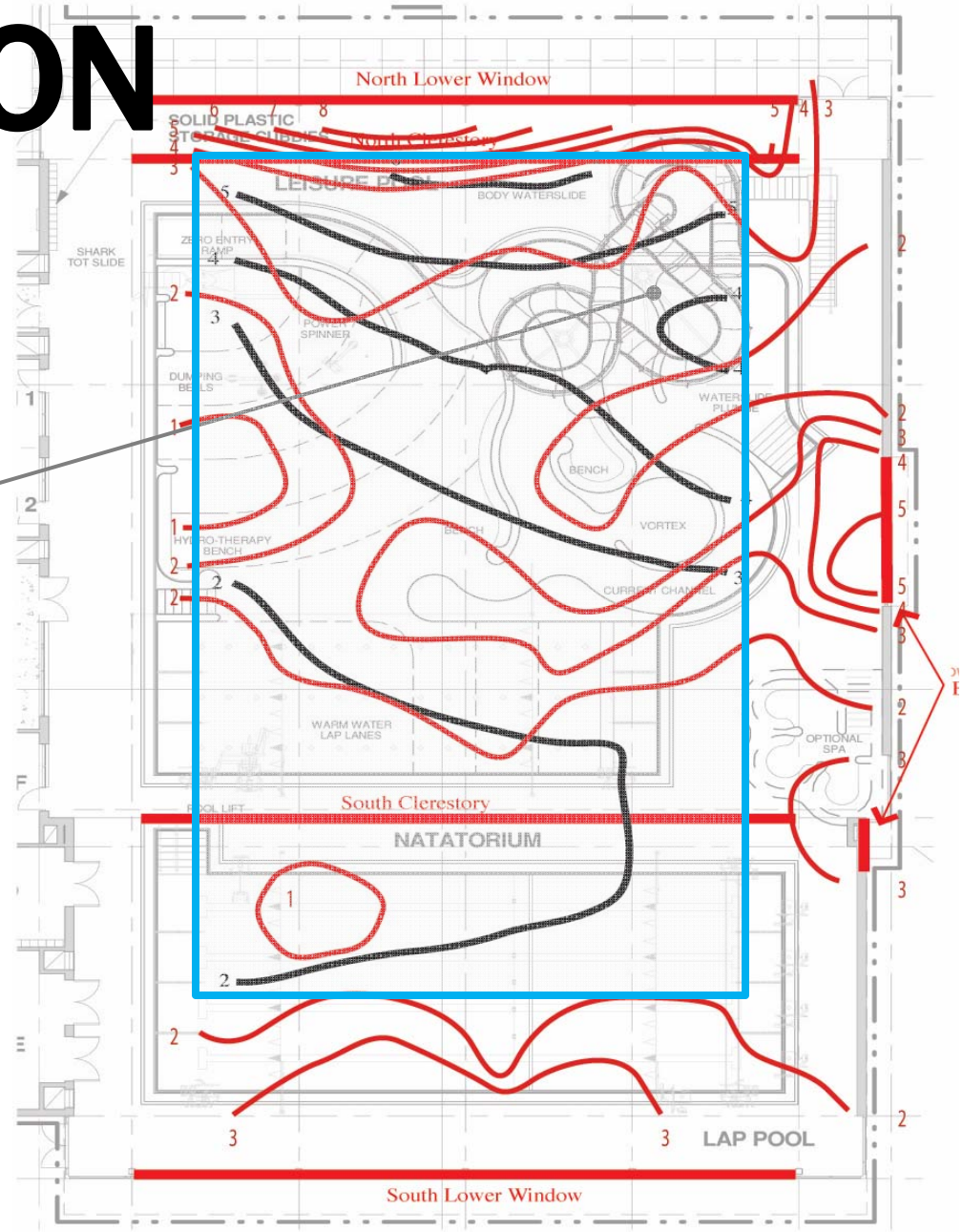
SLIDE
not in physical model

PHYSICAL MODEL

DF 2.6

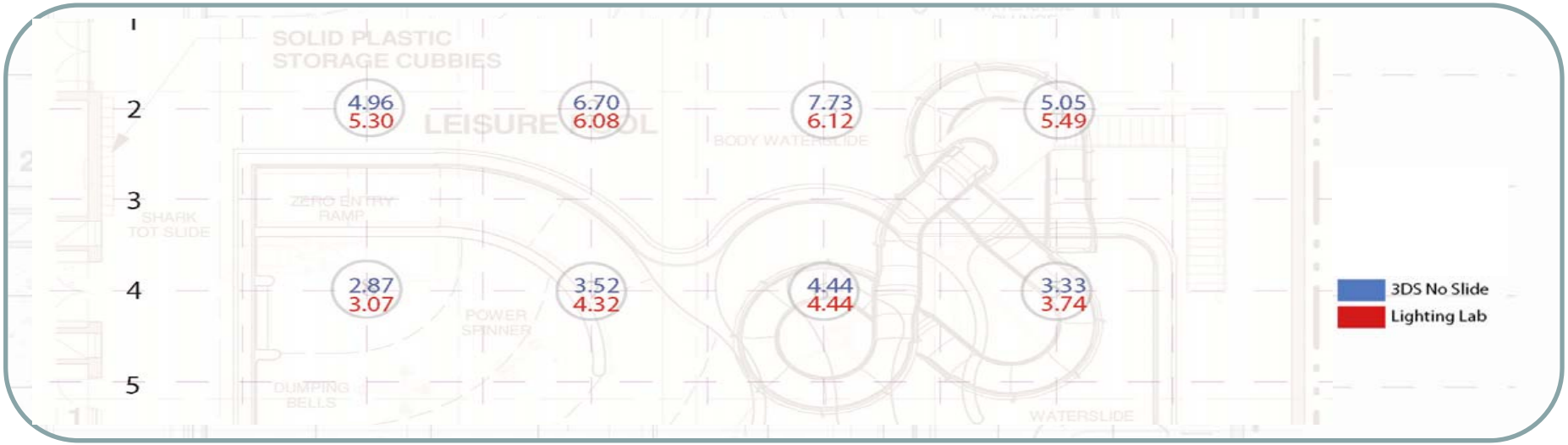
COMPUTER MODEL

DF 1.8



COMPARISON

PHYSCIAL vs. COMPUTER MODELING



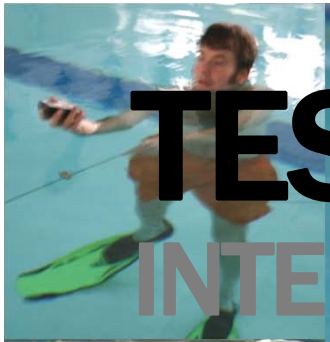
when slide removed from computer model we got better correlation between the two data sets.

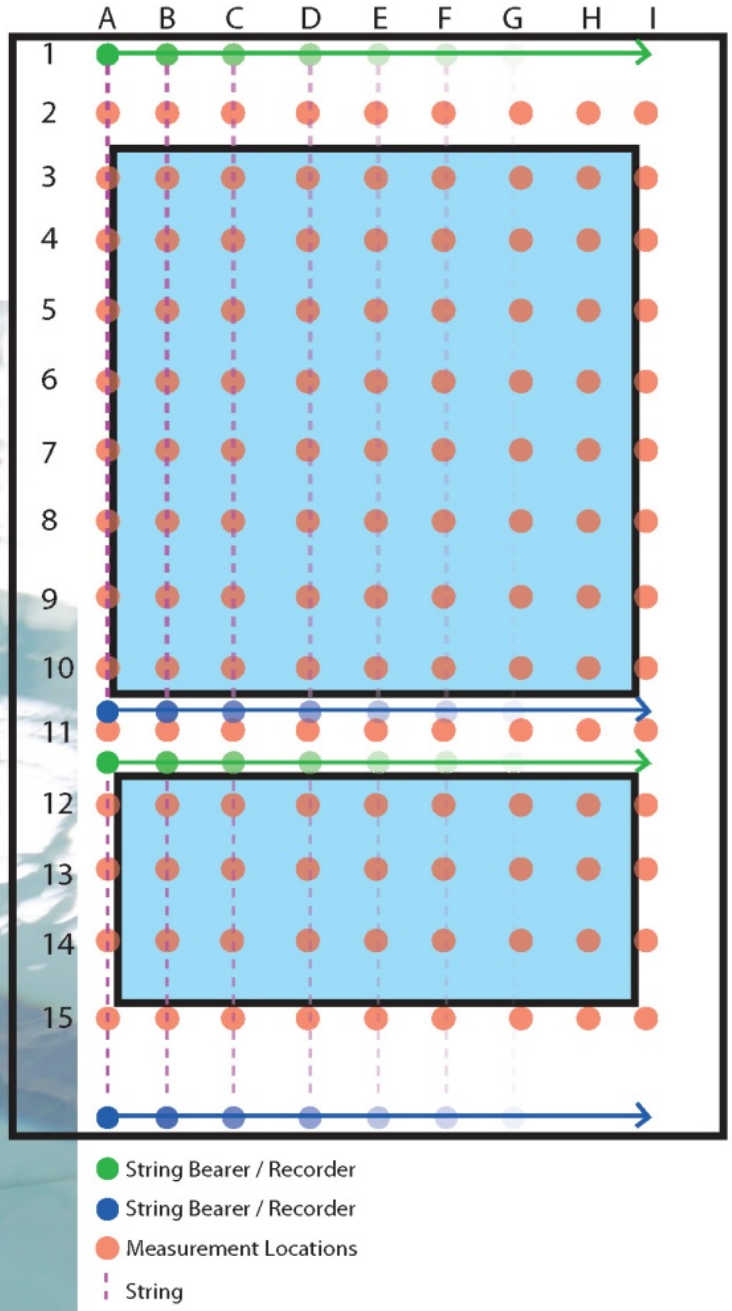
TESTING

EXTERIOR

TESTING

INTERIOR



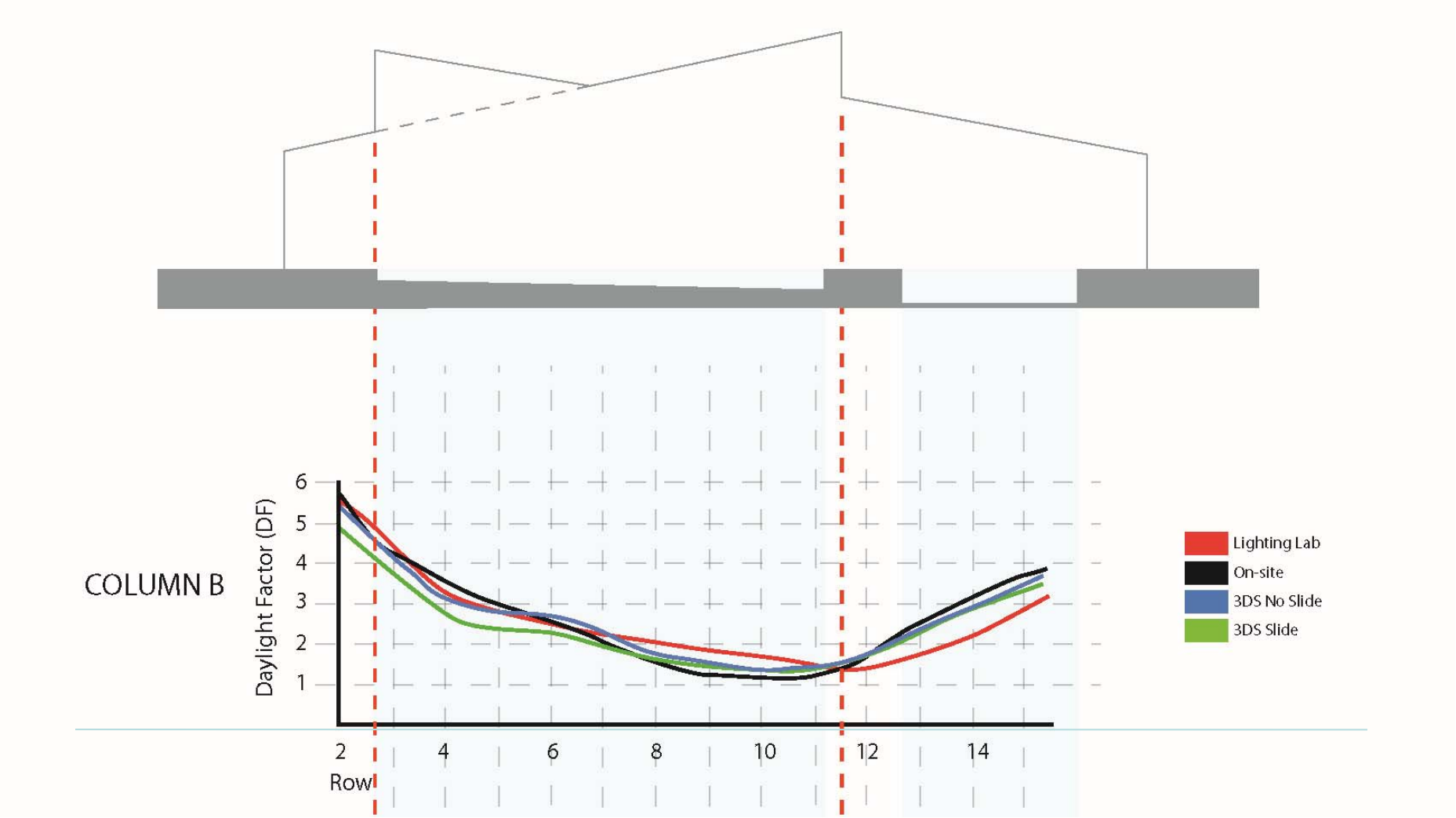


RESULTS

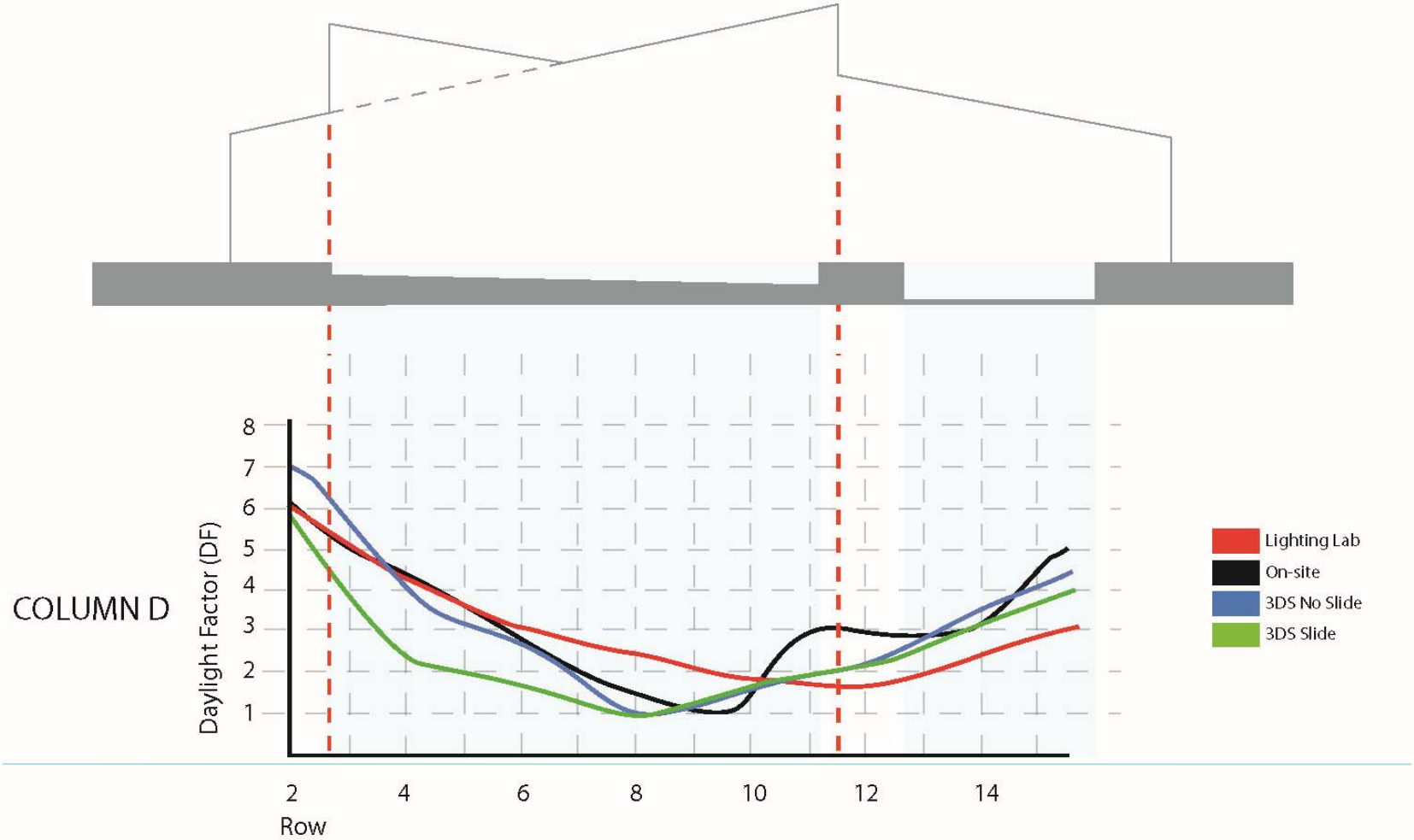
6	1.66 1.05 1.65	2.58 2.17 2.47 2.40	2.74 1.89 2.44	2.83 1.57 2.38 3.11	2.60 2.16 2.34	1.42 1.24 2.00 3.43	2.13 2.27 3.57	1.67 3.65 3.80 4.59	2.48 6.45 6.76
7	1.28 1.49 1.68	2.08 1.61 1.68	2.03 2.09 2.22	2.23 1.86 2.34	1.94 1.59 1.76	1.69 1.68 2.03	2.23 1.79 2.32	1.60 3.14 3.47	4.92 7.60 8.19
8	0.60 1.26 1.36	1.40 1.41 1.50 1.98	1.43 1.12 1.25	1.51 .93 1.00 2.43	1.61 2.08 2.06	1.61 1.55 1.72 2.70	0.23 1.73 2.10	1.93 2.29 2.71 2.60	1.13 2.51 2.71
9	0.62 1.49 1.63	1.19 1.45 1.49	1.49 1.40 1.48	1.95 1.77 1.99	1.70 1.99 2.01	1.87 2.16 2.30	1.69 1.31 1.37	1.93 1.57 2.14	1.16 1.83 2.15

On-site
3DS Slide
3DS No Slide
Lighting Lab

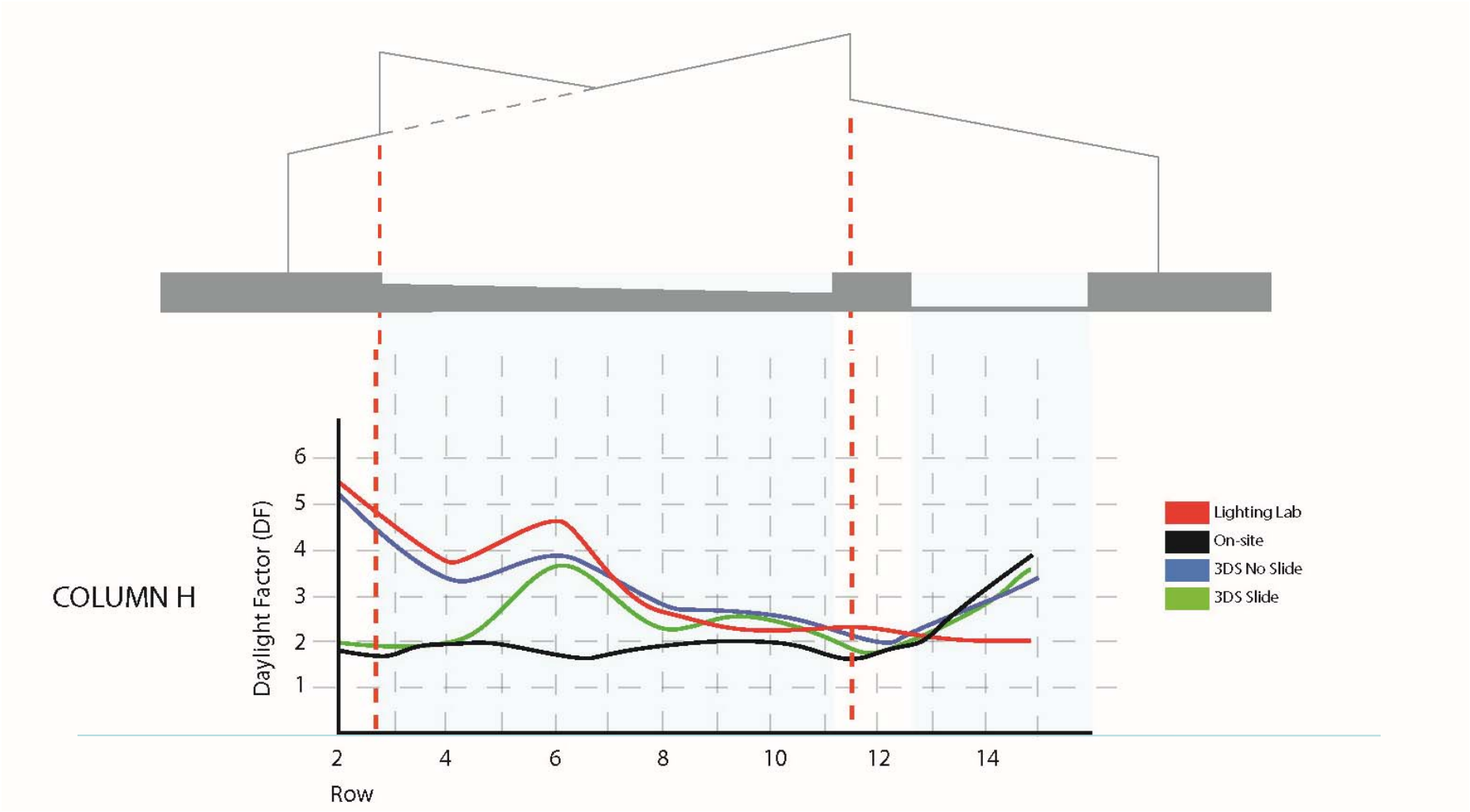
RESULTS


COLUMN B
Daylight Factor (DF)
6
5
4
3
2
1
2
4
6
8
10
12
14
Row
Lighting Lab
On-site
3DS No Slide
3DS Slide

RESULTS

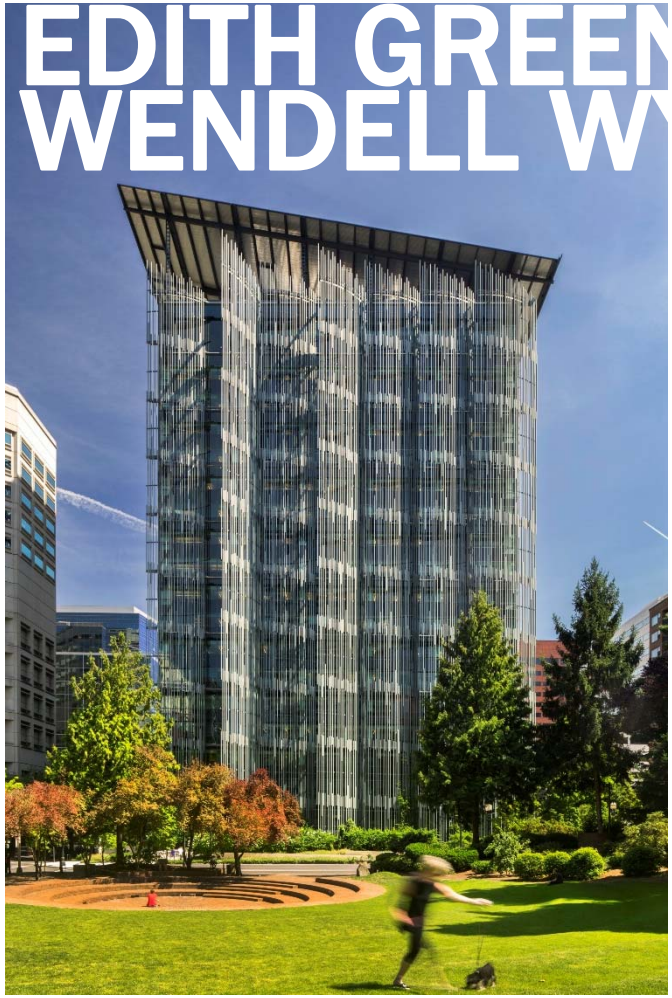

COLUMN D
Daylight Factor (DF)
8
7
6
5
4
3
2
1
2
4
6
8
10
12
14
Row
Lighting Lab
On-site
3DS No Slide
3DS Slide

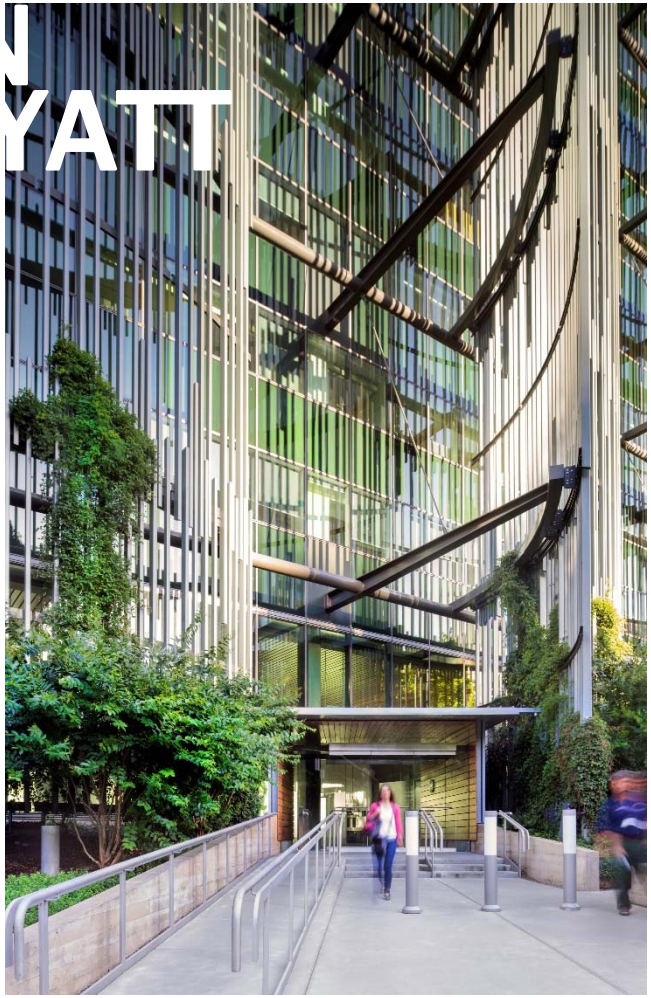
RESULTS

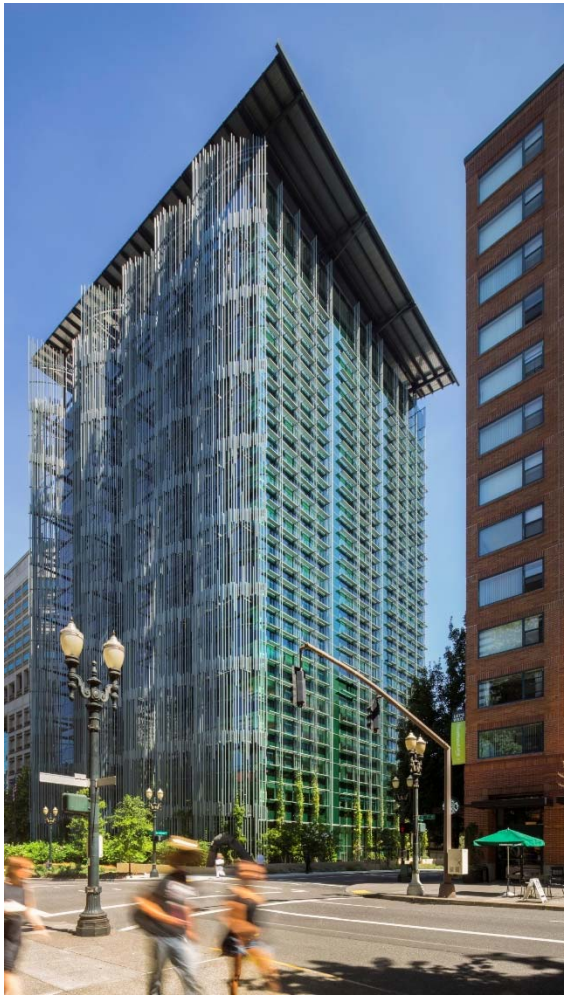

COLUMN H
Daylight Factor (DF)
6
5
4
3
2
1
2
4
6
8
10
12
14
Row
Lighting Lab
On-site
3DS No Slide
3DS Slide

ACTUAL
CONDITIONS

CASE STUDY 2:
EDITH GREEN WENDELL WYATT

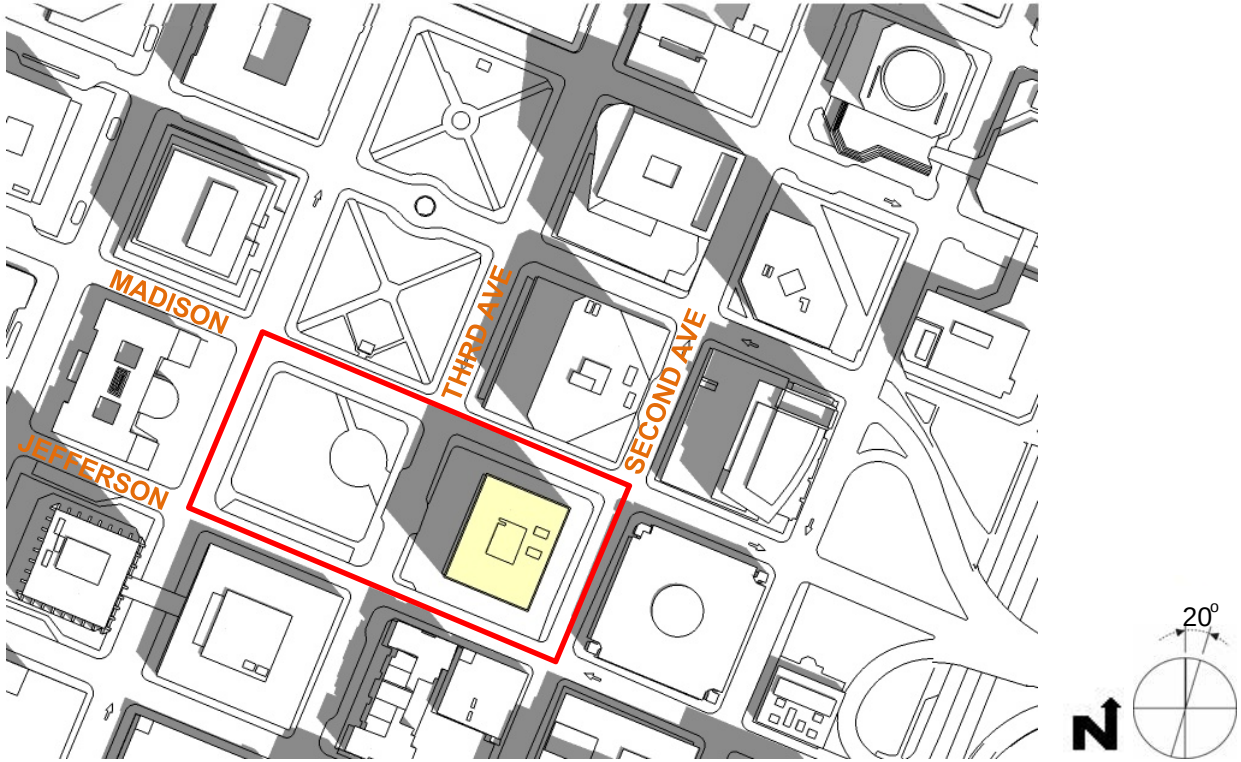






PROJECT

SITE



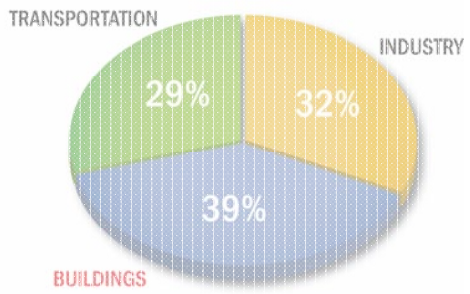
Transform a 512,400 square foot, 18-story, 1974 office building into a LEED Platinum cornerstone of GSA's green building portfolio.

BUDGET: $ 141,000,000

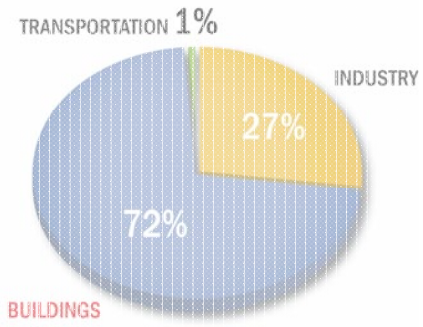
EISA

ENERGY INDEPENDENCE & SECURITY ACT

"To move the United States toward greater **energy independence & security**, to increase the production of clean renewable fuels, to protect consumers, to **increase the efficiency** of products, buildings & vehicles, to promote research on & deploy greenhouse gas capture & storage options, & to **improve the energy performance** of the Federal Government, & for other purposes."



U.S. ENERGY USE



U.S. ELECTRICITY USE

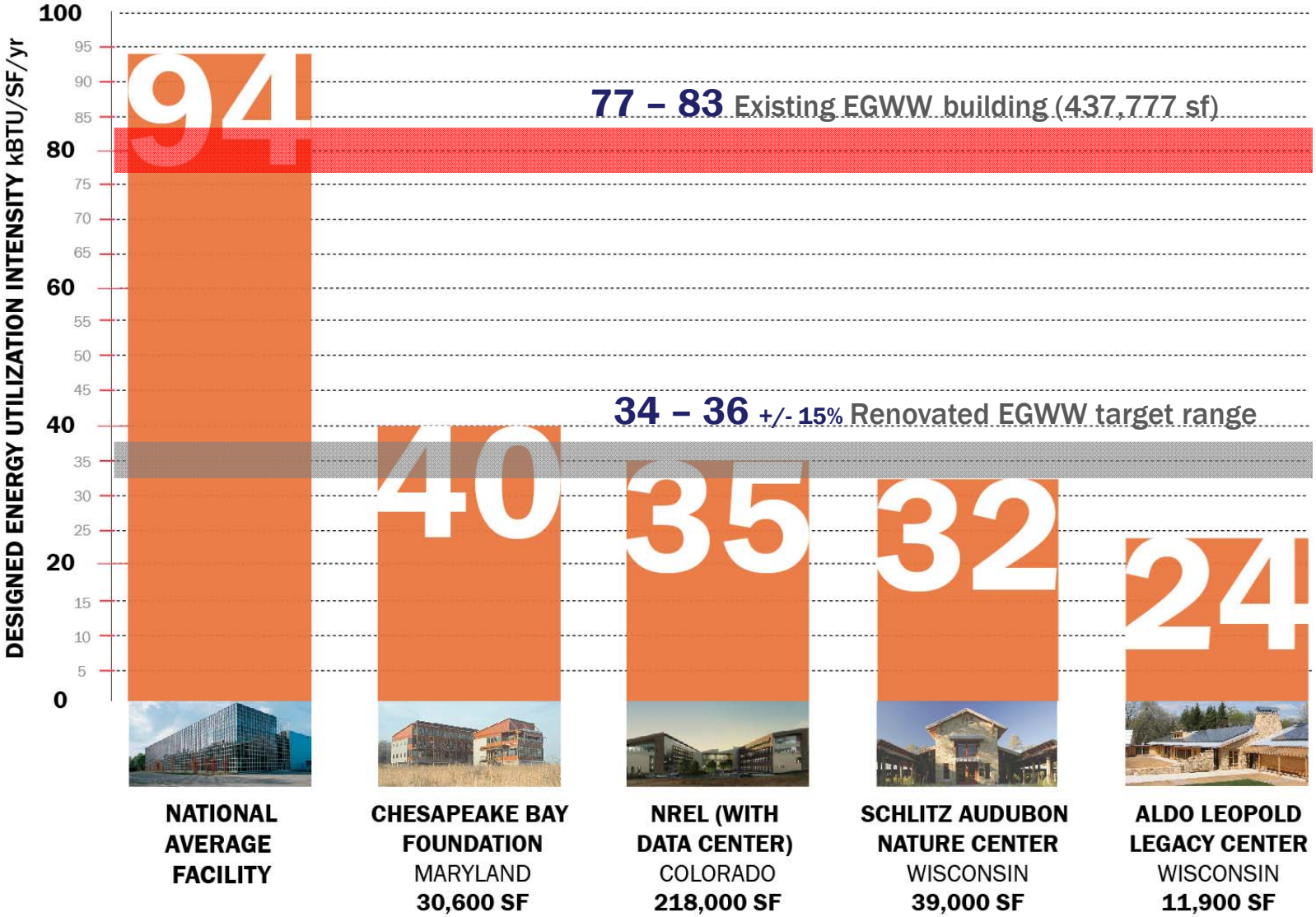
Source : Energy Information Administration Annual Energy Review 2008

MINIMUM PERFORMANCE

ARRA and EISA

Energy Star Requirements	Water Conservation Requirements	Energy Conservation Requirements	LEED Requirements
Score goal: 97	20% Indoor potable water reduction	55% Fossil fuel reduction	Gold Required
	50% Outdoor potable water reduction	30% Energy usage reduction	Platinum Goal
		30% Solar thermal	

ENERGY GOAL


DESIGNED ENERGY UTILIZATION INTENSITY kBTU/SF/yr
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
94
40
35
32
24
77 – 83 Existing EGWW building (437,777 sf)
34 – 36 +/- 15% Renovated EGWW target range
NATIONAL AVERAGE FACILITY
CHESAPEAKE BAY FOUNDATION
MARYLAND
30,600 SF
NREL (WITH DATA CENTER)
COLORADO
218,000 SF
SCHLITZ AUDUBON NATURE CENTER
WISCONSIN
39,000 SF
ALDO LEOPOLD LEGACY CENTER
WISCONSIN
11,900 SF

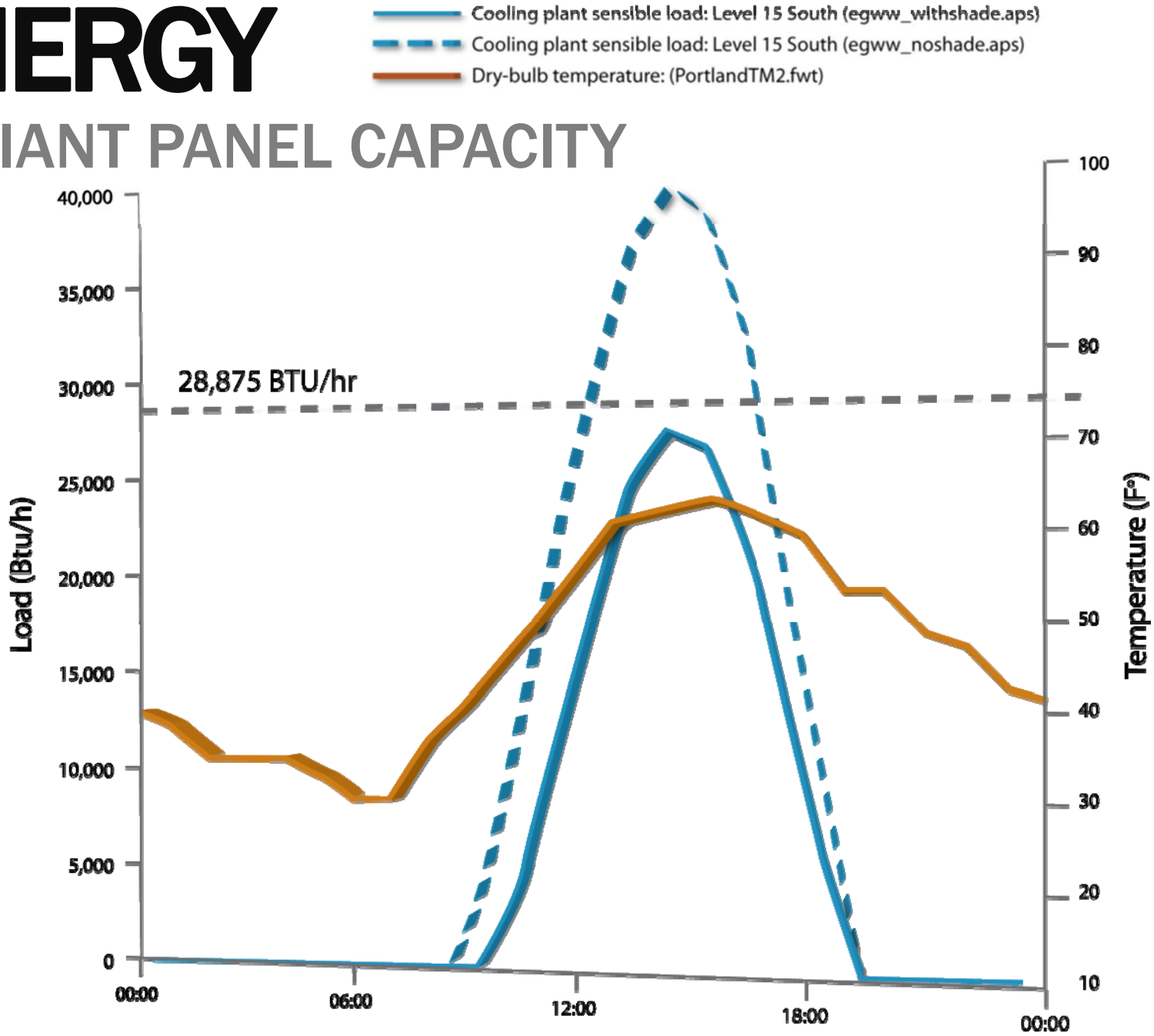
ENERGY CONSERVATION

MEASURES STUDIED

Energy Conservation Measures Recommended	Energy Saved
Radiant Heating & Cooling	11.0%
Shading Exterior - Fixed East / South fins - West fins	7.0%
Energy Efficient Lighting	6.0%
Glass U-value	2.7%
Wall U-value	2.2%
Glass Percentage	2.0%
Daylighting	2.0%

ENERGY

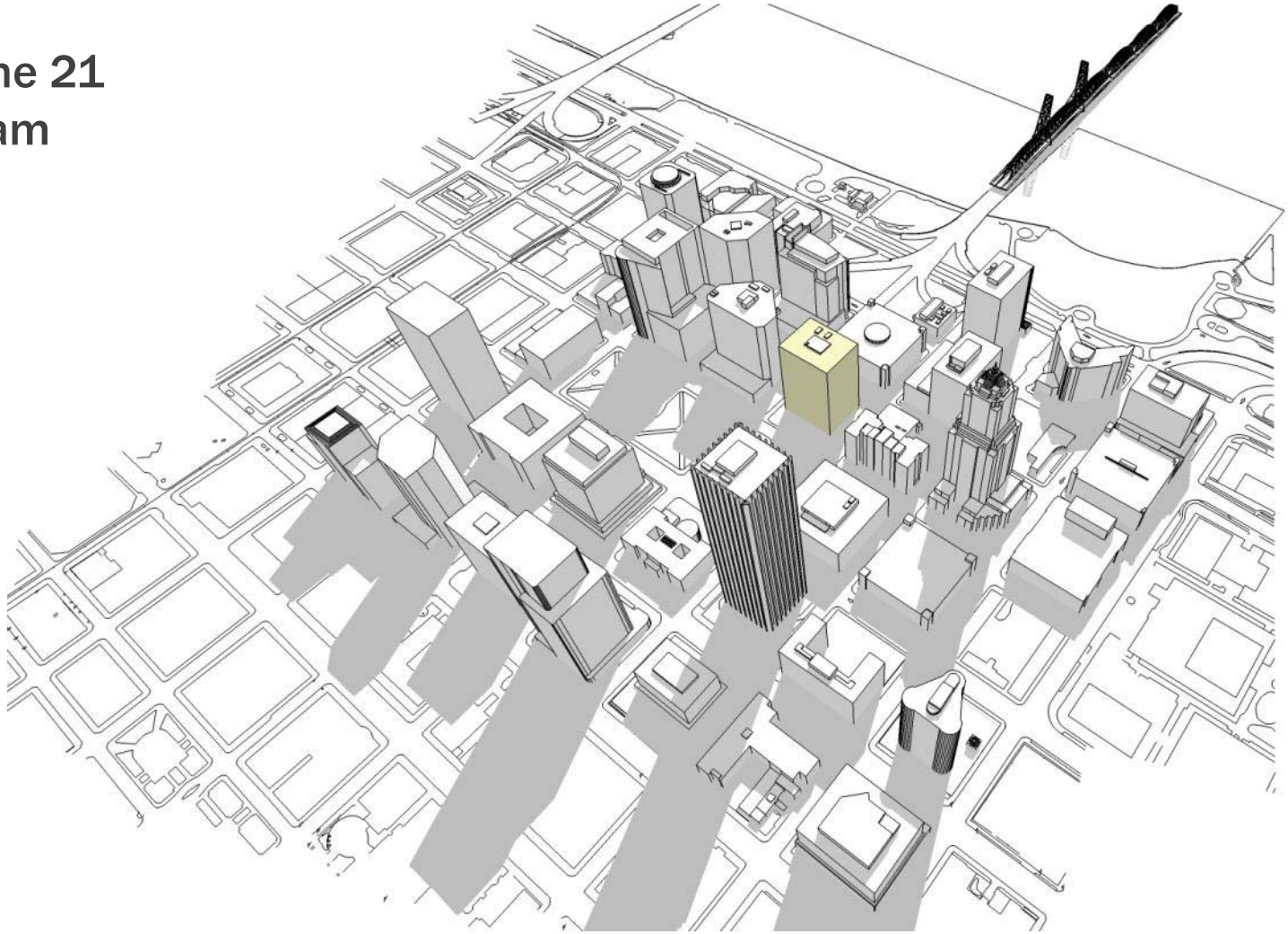
RADIANT PANEL CAPACITY



ENVELOPE STUDY

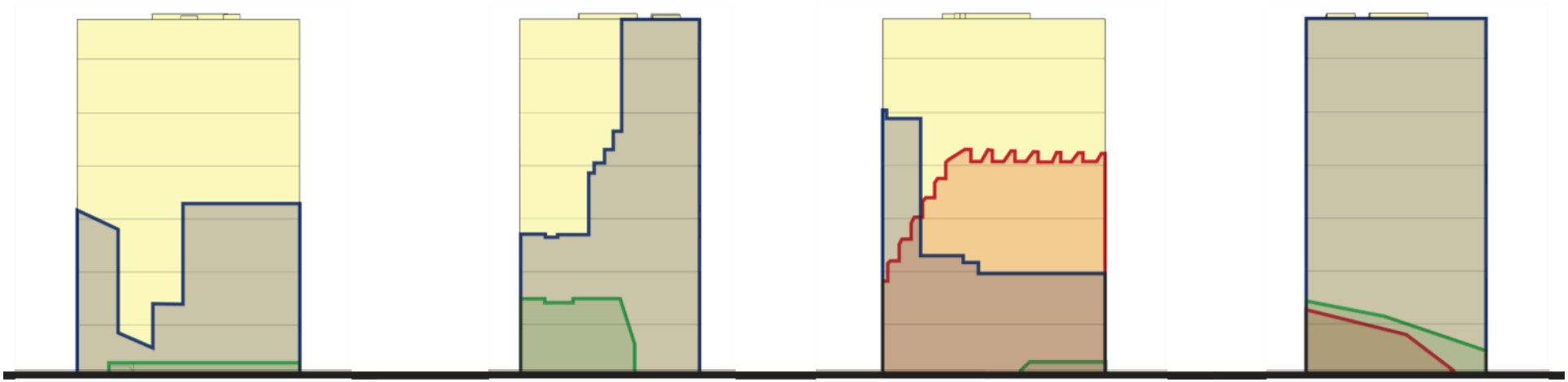
SURROUNDING BUILDINGS

June 21
8 am



ENVELOPE STUDY

SHADING FROM ADJACENT BUILDINGS



East Elevation
10 am

South Elevation
2 pm

West Elevation
4 pm

North Elevation
8 am

Shaded Area

March / September

June

December

ENVELOPE STUDY

SCOPE OF WORK

Thermal analysis

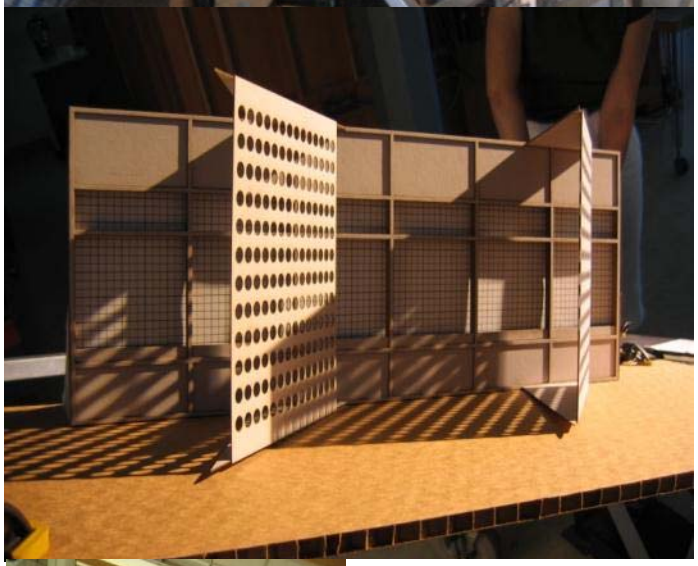
- Percentage glazing
- Shading

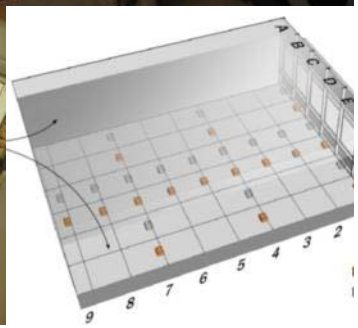
Daylight analysis

- Surrounding buildings shading
- Building integrated shading
- Interior light quality
- Energy savings

Ongoing Studies

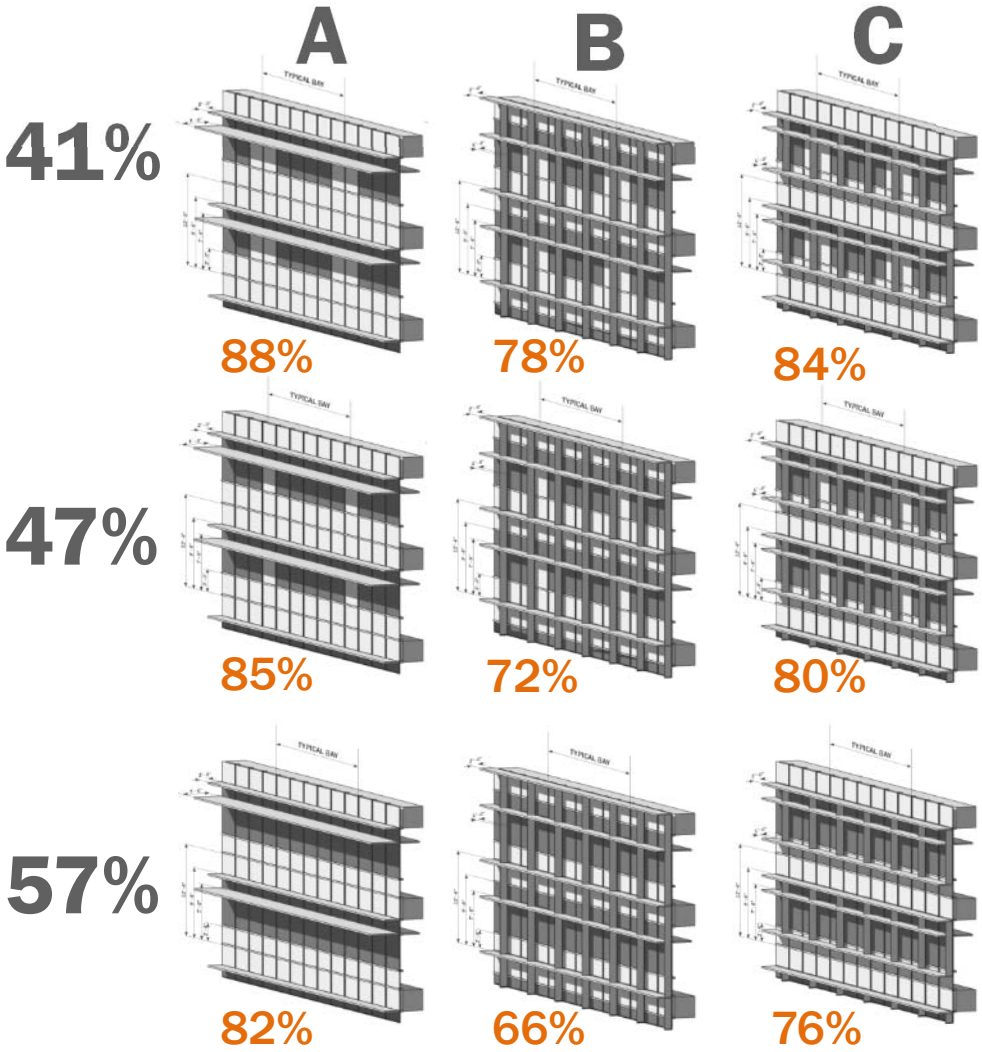
- Energy Sensitivity Analysis





SHADING STUDY

HELIDON TESTING

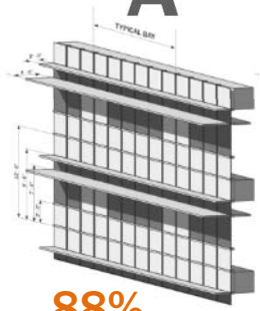


SHADING STUDY

HELIDON TESTING

A B C

41%

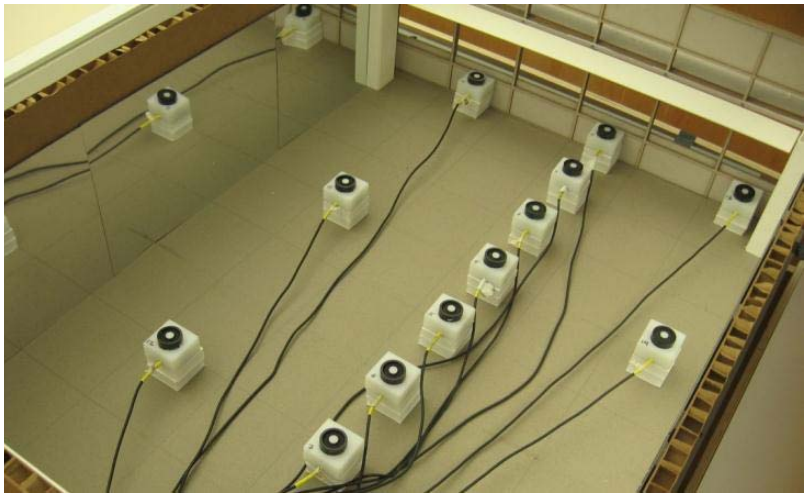


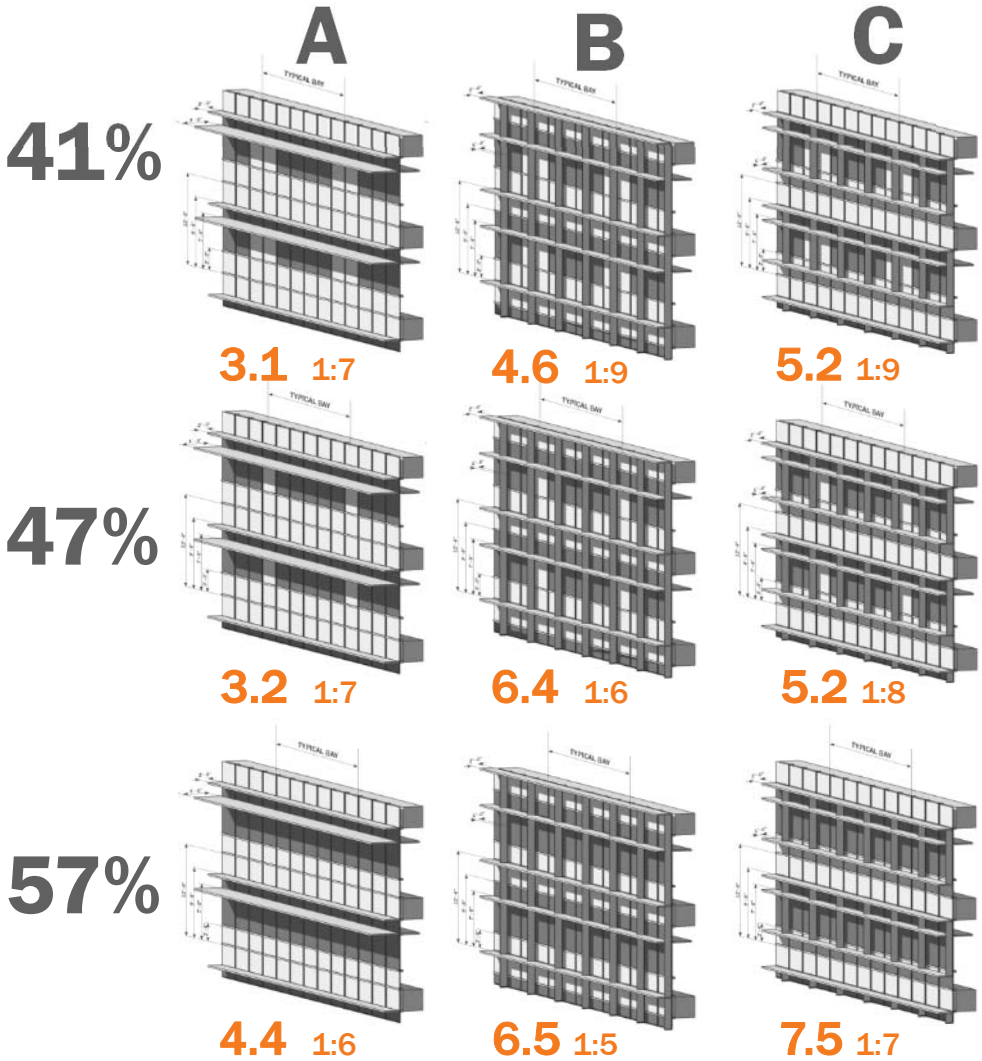
88%

47%

57%

DAYLIGHT STUDY



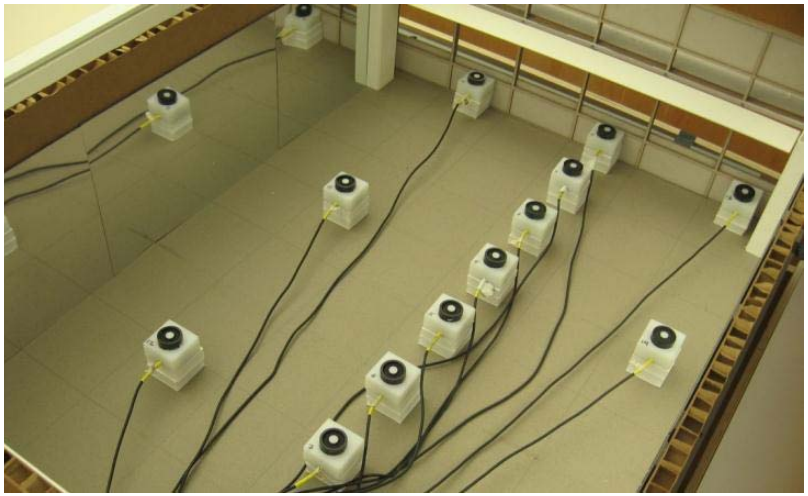


DAYLIGHT STUDY

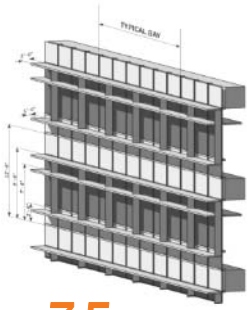
A B C

41%

47%



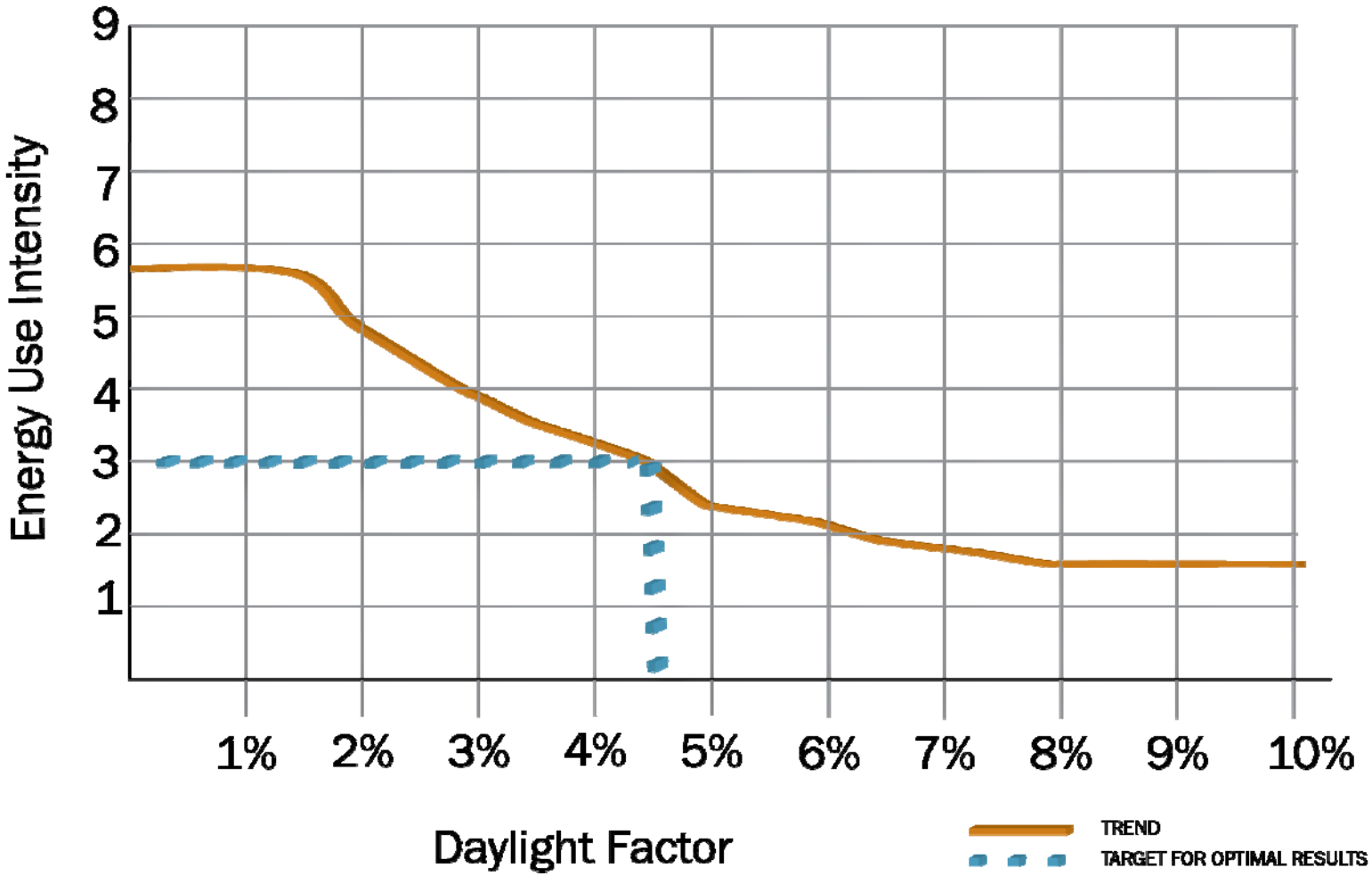
57%



7.5 1:7

DAYLIGHT STUDY

EUI RESULTS



DAYLIGHT STUDY

ENERGY SAVINGS

01:00	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
02:00	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
03:00	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
04:00	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
05:00	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
06:00	12%	12%	12%	12%	9%	8%	9%	12%	12%	12%	12%	12%
07:00	55%	45%	29%	32%	24%	21%	24%	31%	54%	55%	55%	55%
08:00	43%	30%	19%	21%	15%		15%	21%	32%	52%	43%	52%
09:00	31%	20%							19%	32%	31%	36%
10:00	23%									21%	23%	28%
11:00	17%										17%	22%
12:00	15%										15%	18%
13:00	15%										15%	19%
14:00	21%										21%	26%
15:00	32%										32%	37%
16:00	46%	32%	20%							20%	46%	56%
17:00	61%	51%	32%						18%	30%	61%	61%
18:00	55%	55%	55%	19%	14%		14%	18%	28%	46%	55%	55%
19:00	52%	52%	52%	30%	23%	20%	23%	30%	51%	52%	52%	52%
20:00	30%	30%	30%	30%	22%	19%	21%	30%	30%	30%	30%	30%
21:00	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%	23%
22:00	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%	16%
23:00	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%
24:00	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%	5%

times when
no electric lighting
is required to light the daylight zone of the building
(0'-16' from the window)

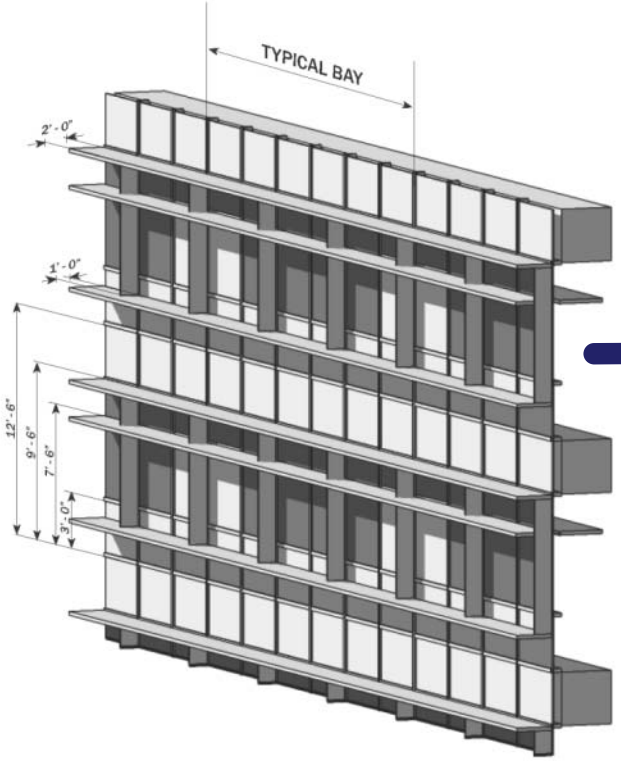
% = energy savings if lights are dimmed

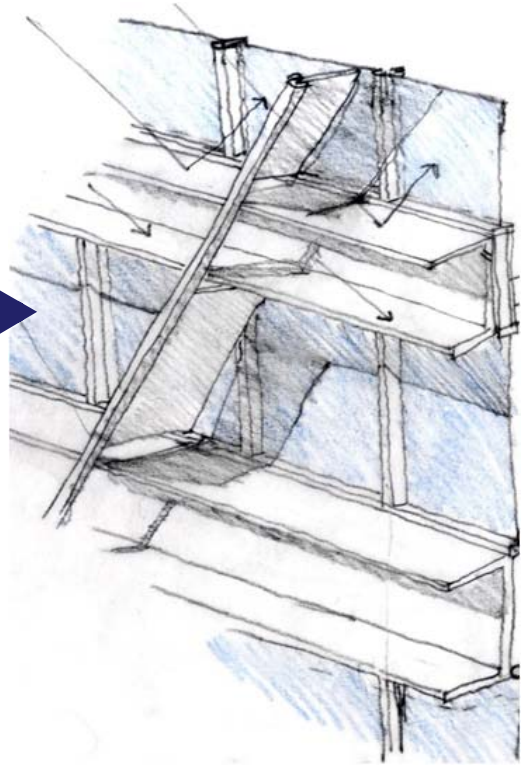
times when there is no daylight

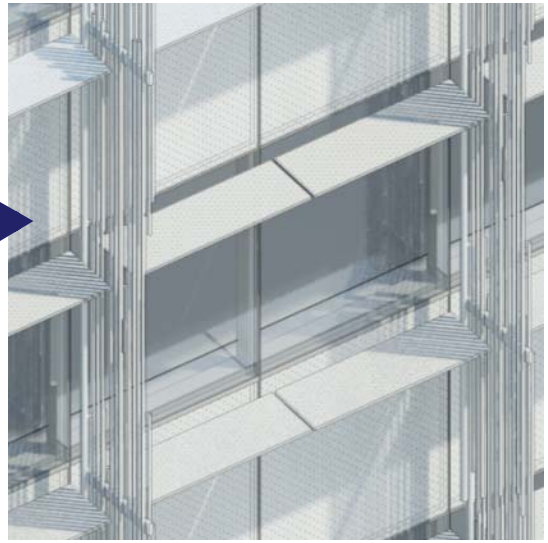
times when there is no electric power draw

DESIGN PROCESS

FROM STUDY TO DESIGN TO CONSTRUCTION



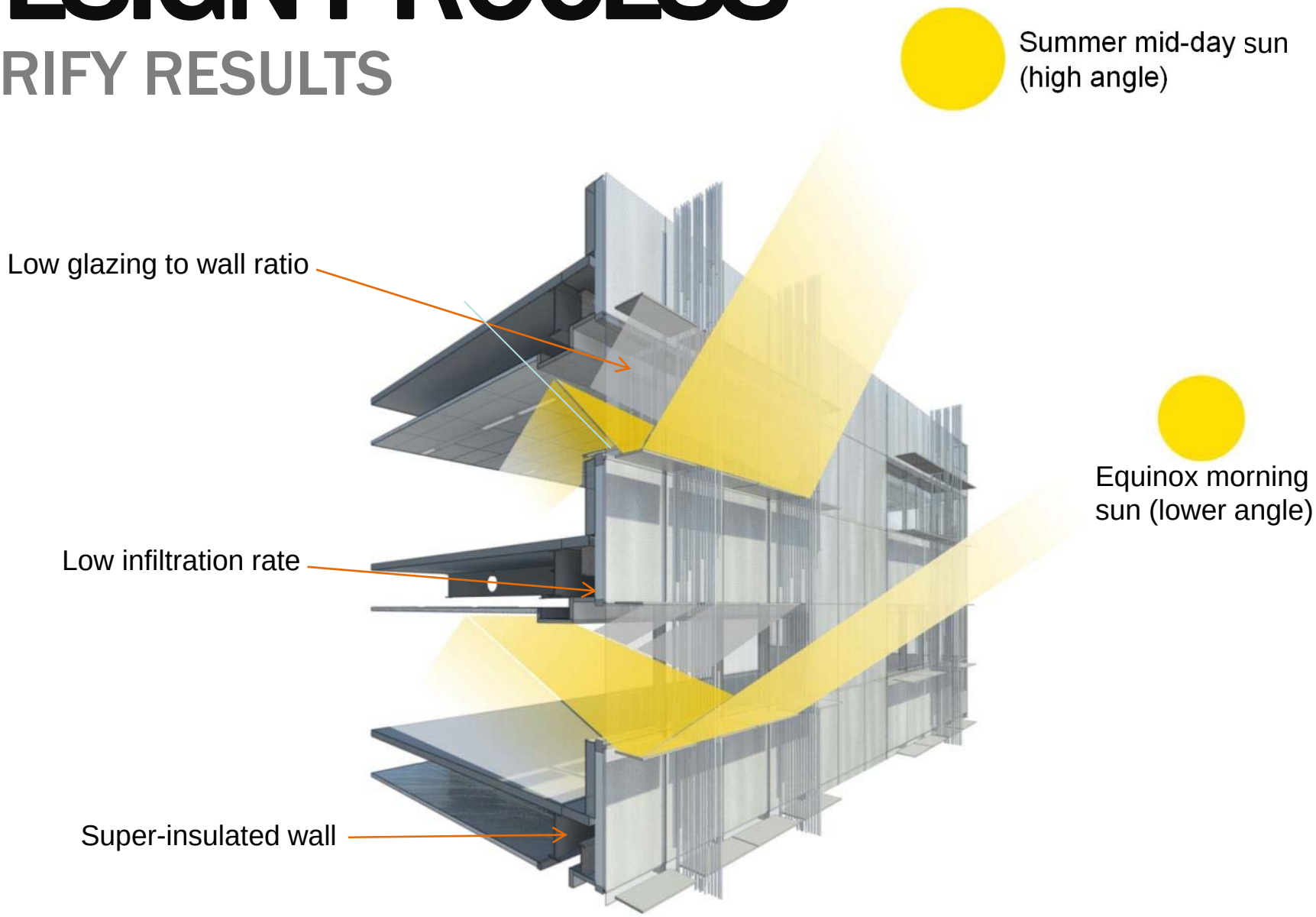




REEDS ON EAST FAÇADE

DESIGN PROCESS

VERIFY RESULTS



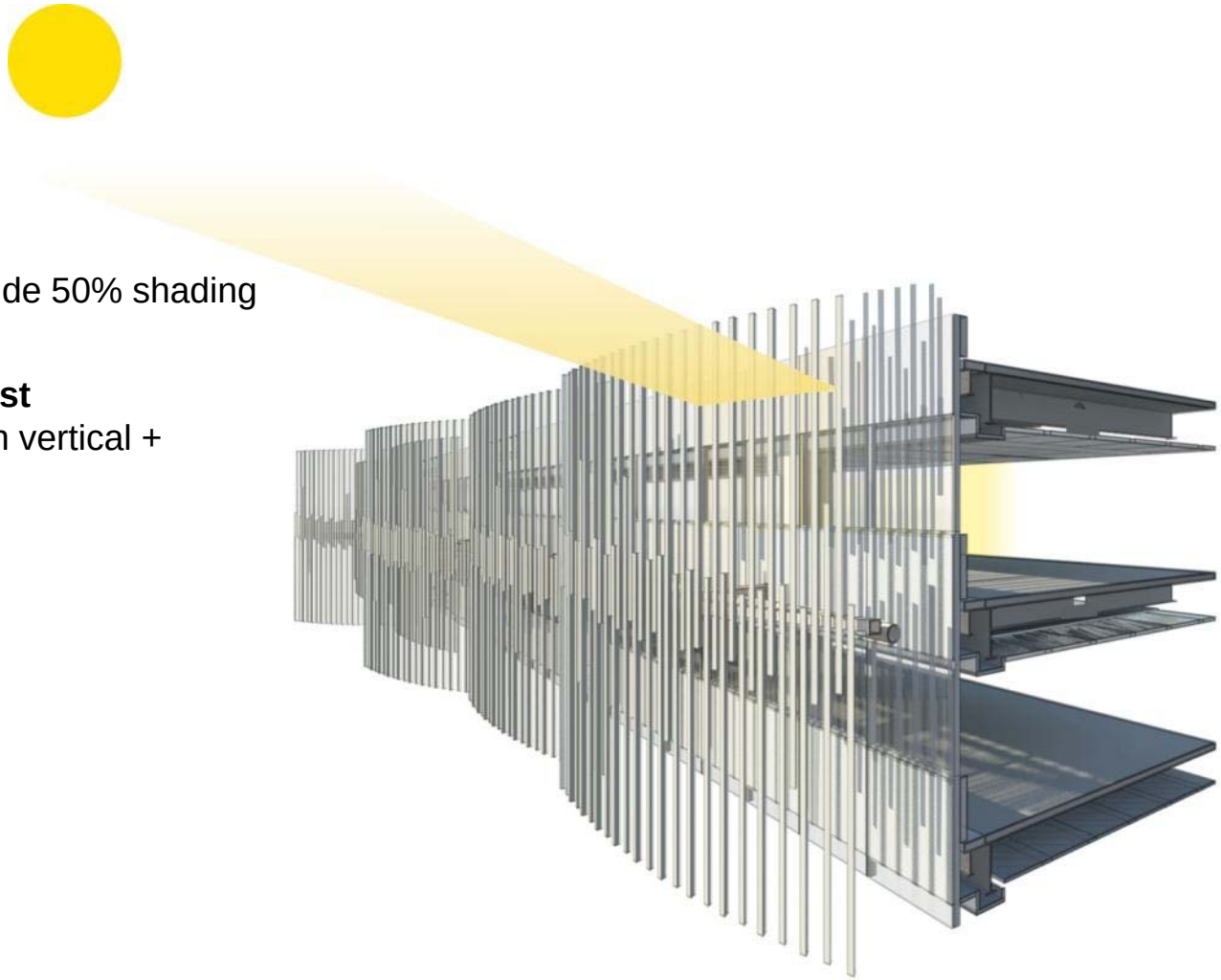
DESIGN PROCESS

WEST FACADE

West
Reeds provide 50% shading

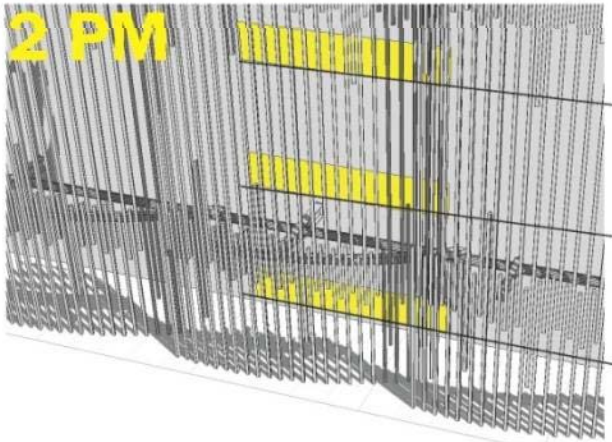
South & East
Combination vertical + horizontal

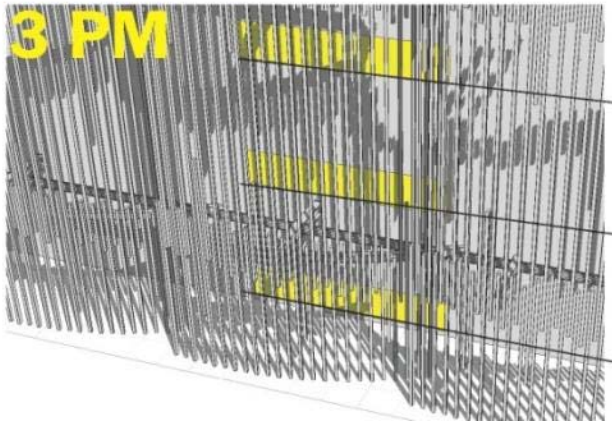
North
No shading



DESIGN PROCESS

WEST FACADE





	revised design
LEVEL 9 base design - 90%	95%
LEVEL 8 base design - 85%	82%
LEVEL 7 base design - 88%	91%
LEVEL 9 base design - 70%	61%
LEVEL 8 base design - 53%	58%
LEVEL 7 base design - 57%	66%

DESIGN PROCESS

CURTAIN WALL VISUAL MOCKUP

Daylighting: Solar Shading and Glare Control

Christopher Meek, AIA
Integrated Design Lab

Research Associate Professor
University of Washington
Department of Architecture
cmeek@uw.edu

@ the Bullitt Center

The Integrated Design Lab

The Discovery Commons

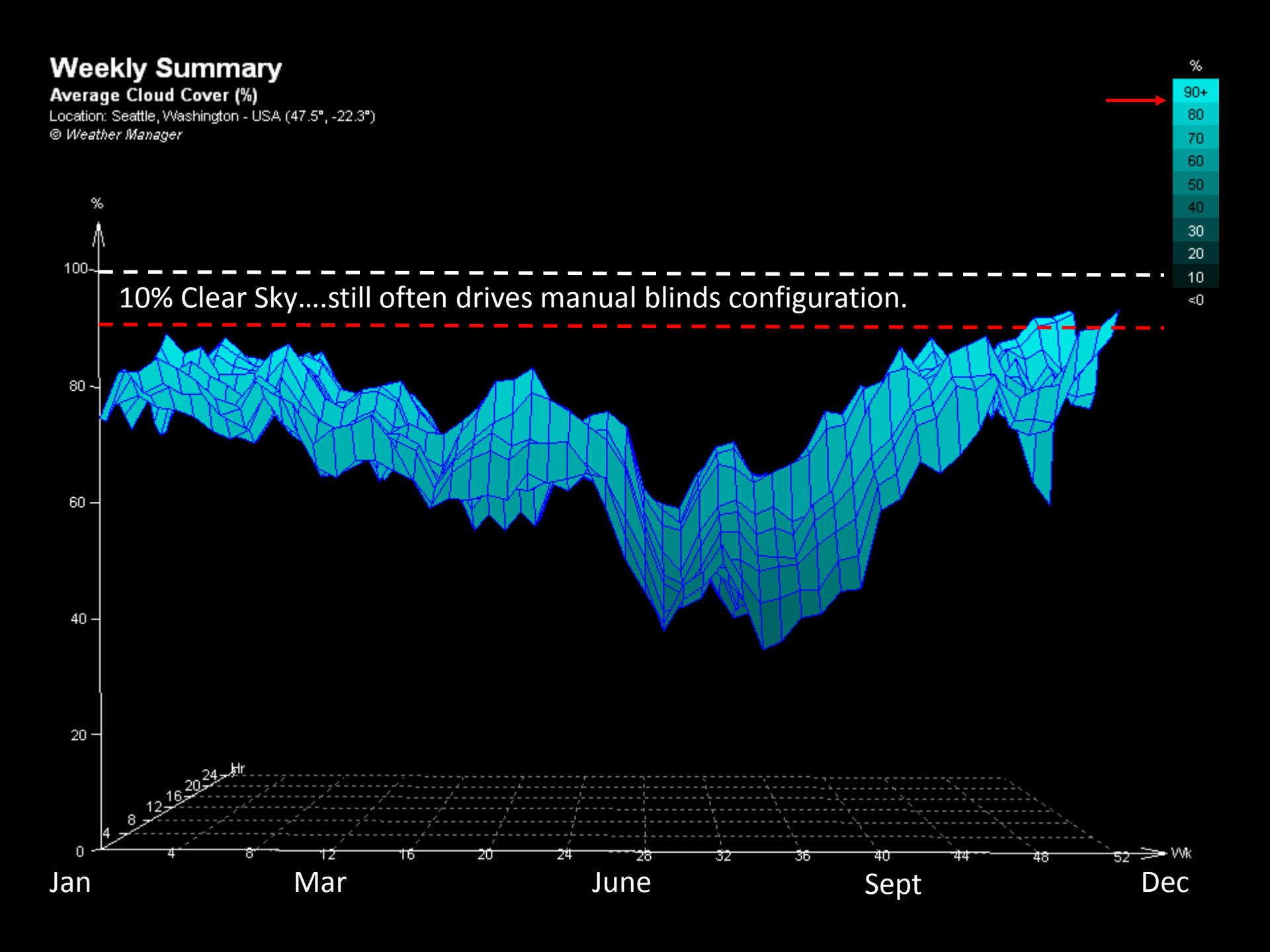
www.idlseattle.com

Photo Credit: Craig F. Johnson PE, UCSD FD&C

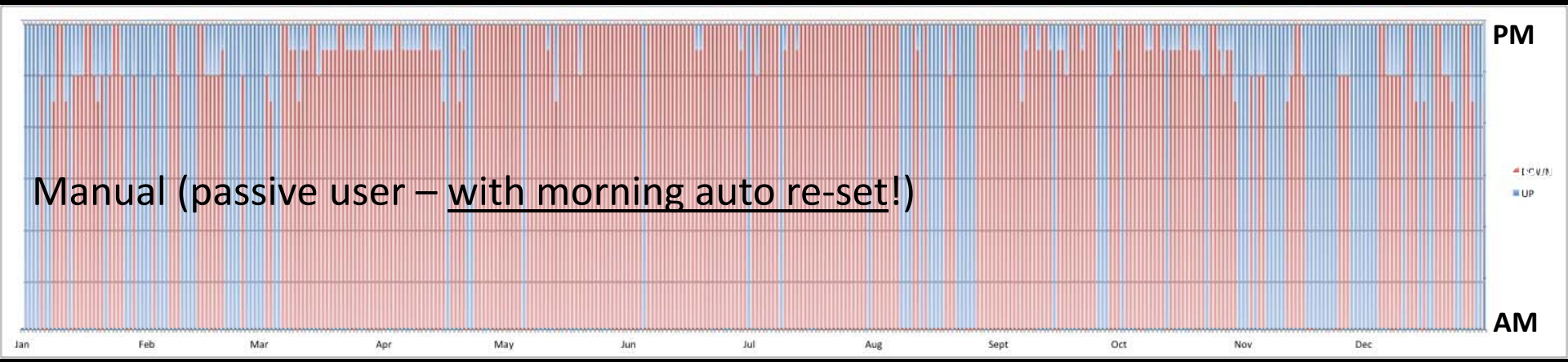
Photo Credit: Craig F. Johnson PE, UCSD FD&C

Photo Credit: Craig F. Johnson PE, UCSD FD&C

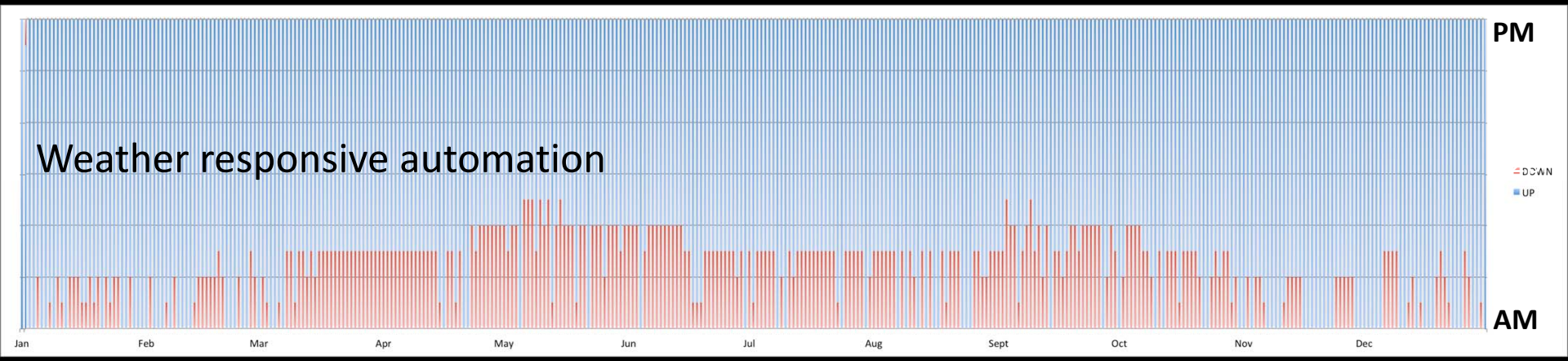
North!


Weekly Summary
Average Cloud Cover (%)
Location: Seattle, Washington - USA (47.5°, -22.3°)
© Weather Manager
%
90+
80
70
60
50
40
30
20
10
<0
10% Clear Sky….still often drives manual blinds configuration.
100
80
60
40
20
0
Hr
Wk
Jan
Mar
June
Sept
Dec

Frequency of Deployment (East Façade)



January June Dec

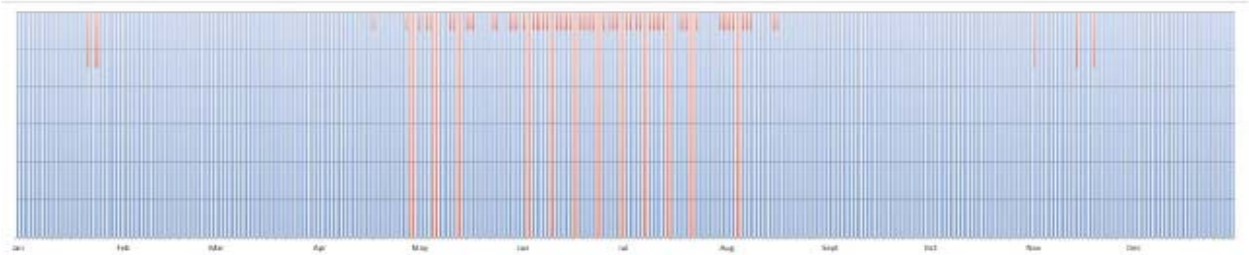


Expected Cycling for Glare Control

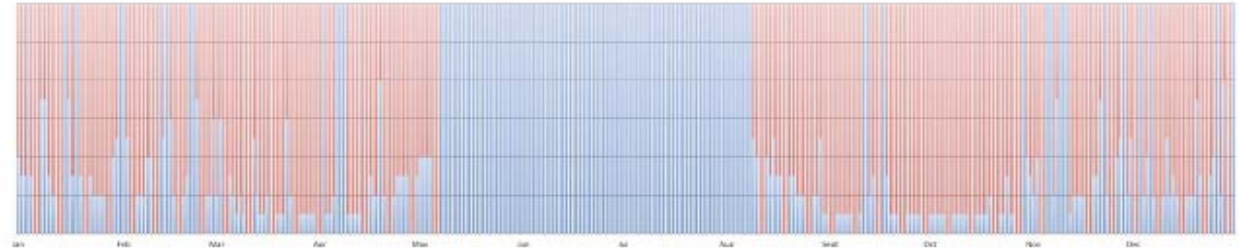
Passive User System vs. Weather Responsive Automation
(DAYSIM per Phoenix TMY)

Frequency of Deployment: All Facades

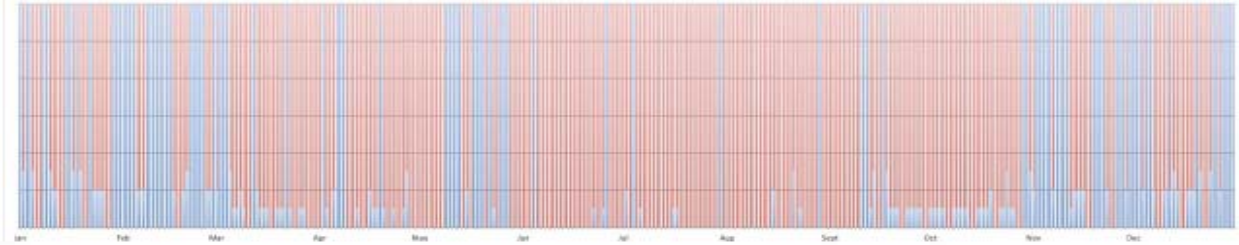
North



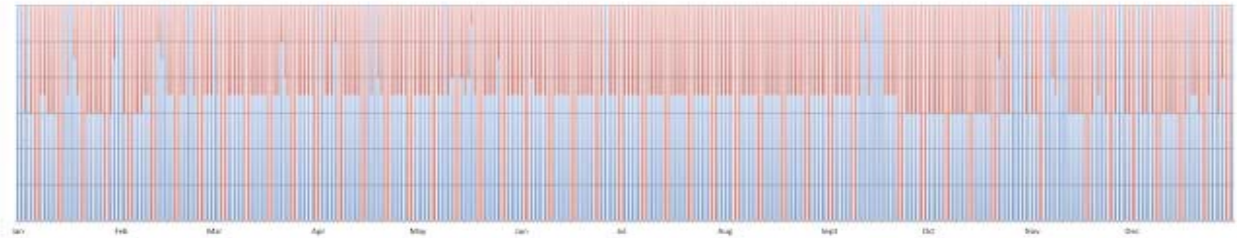
South



East



West

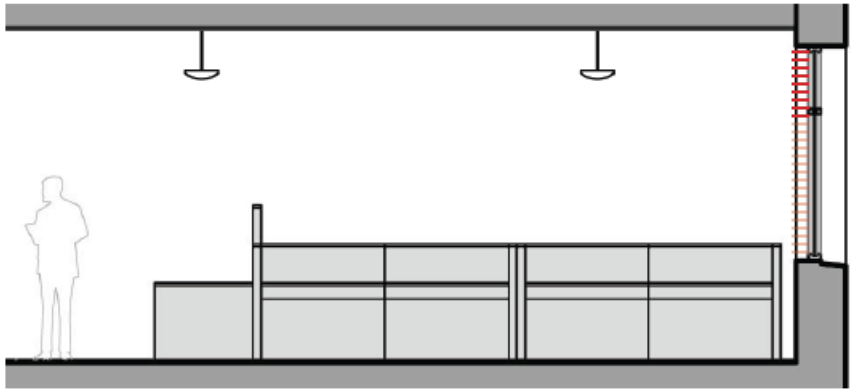


Open

Closed

Via DAYSIM Simulation/Passive User
(SEATTLE per TMY Data)

East Façade: Hourly Illuminance with Blinds Retraction



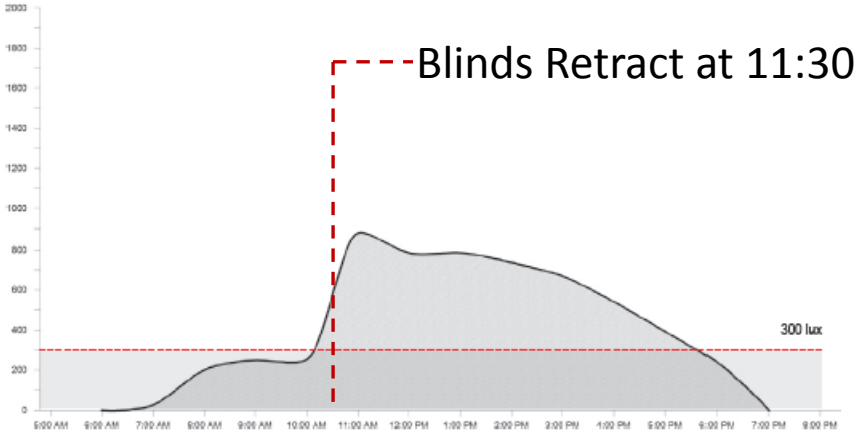
Automated

** Closed once transmitted direct sunlight above 50 W/m² hits work plane*

** Opens once 50 W/m² criteria is no longer met*

Sep 21 @ 9:00am

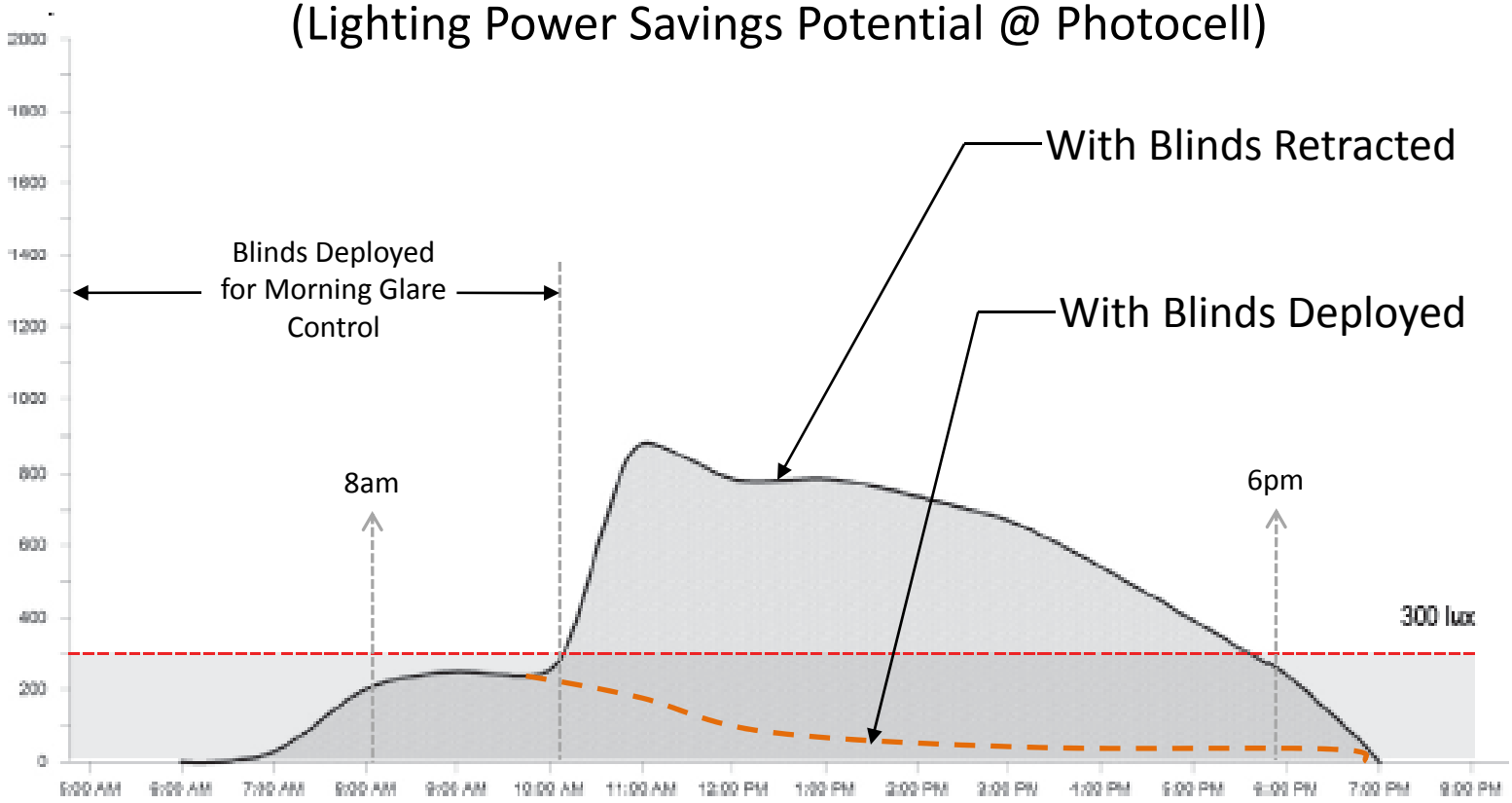
Impact on Illuminance



Sep 21 @ 3:00pm

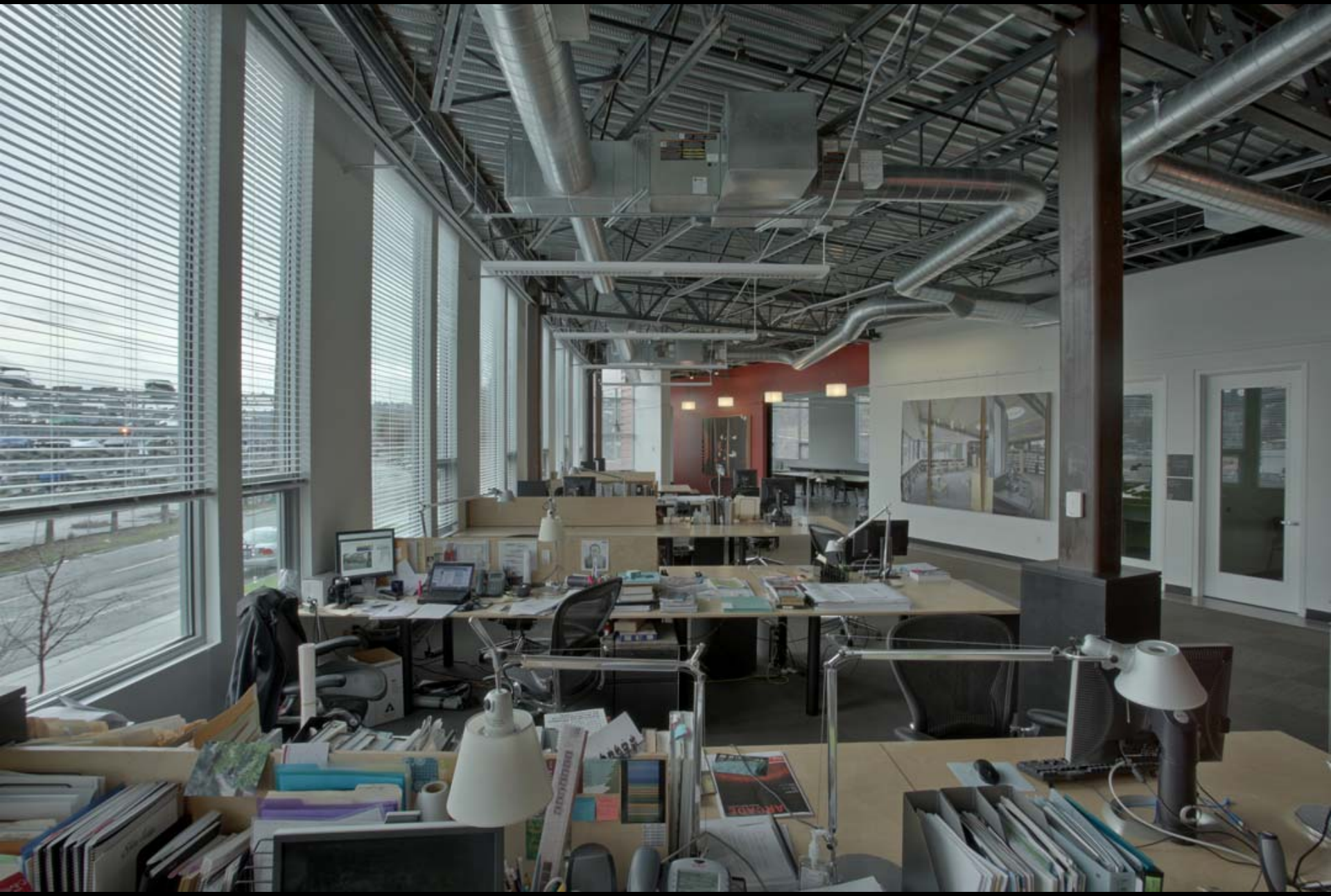
Deployment Impact on Lighting Power Savings

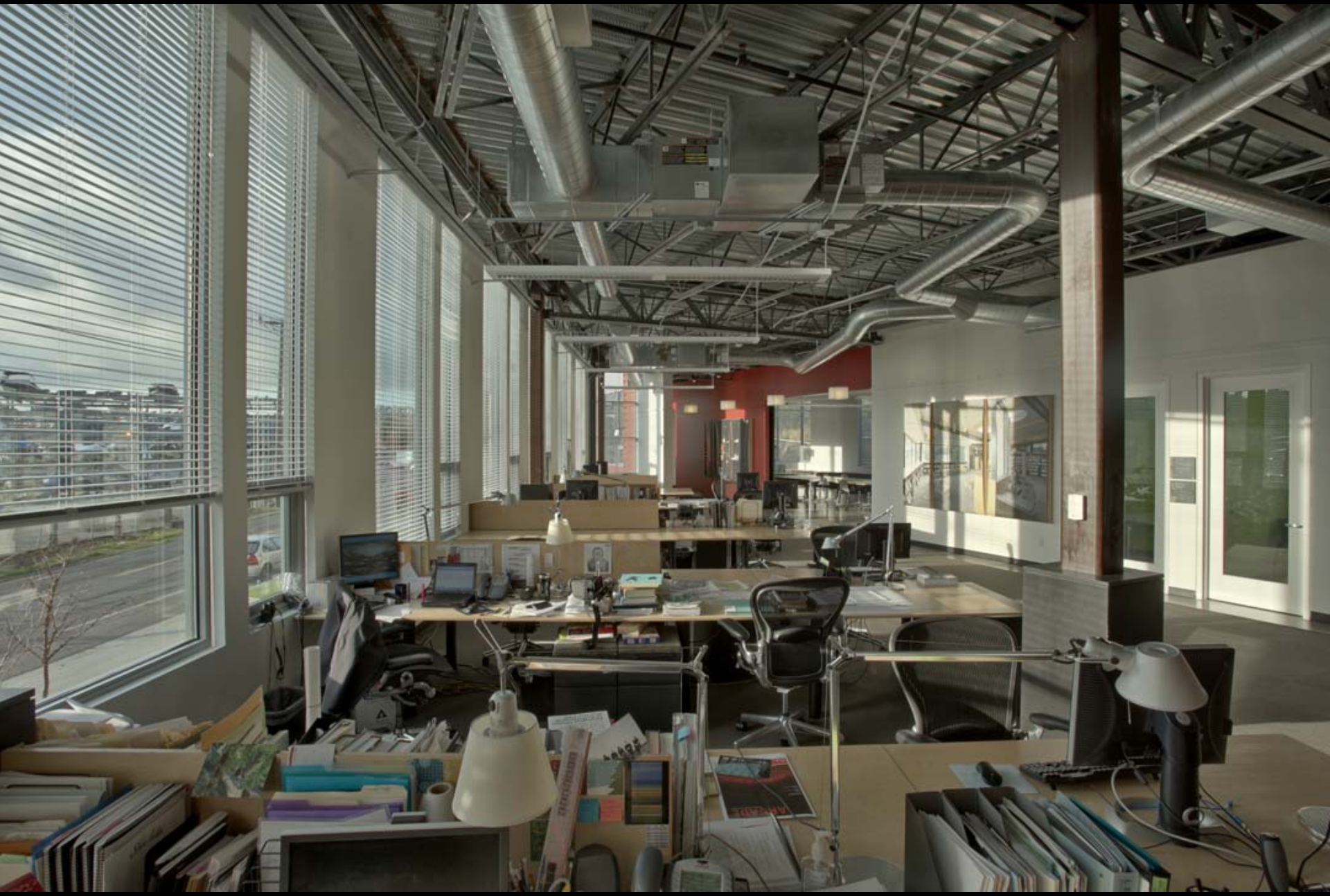
Interior Illuminance with Blinds Retracted and Deployed
(Lighting Power Savings Potential @ Photocell)



September 21st Clear Sky

70% Increase In Lighting Savings





Architectural Record

Modeled End-Use Energy Distribution

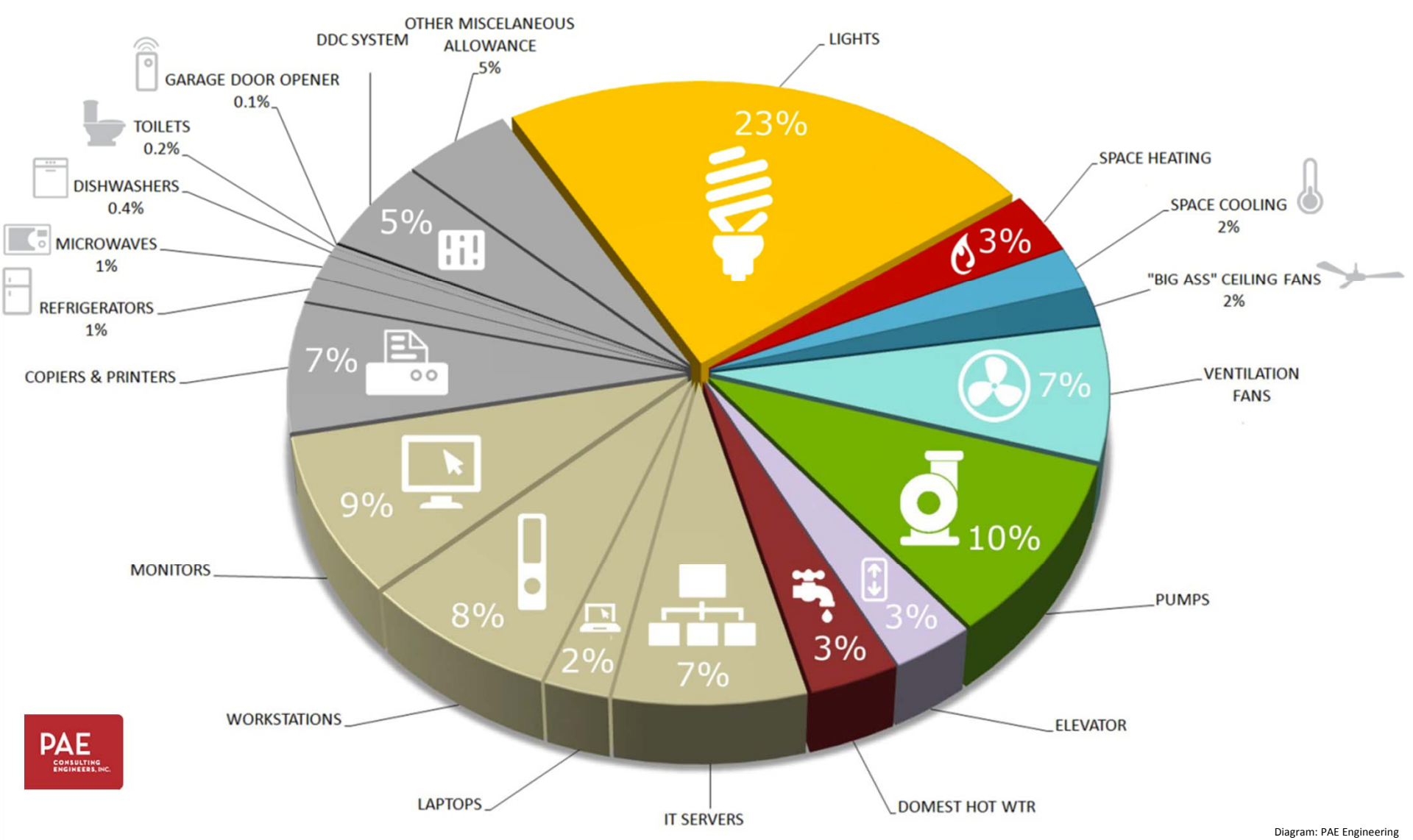


Diagram: PAE Engineering

Integrated Lighting Design

Lighting EUI < 4 (Code < 12)

- Daylight is the Primary Source of Ambient Illumination
- Automated Glare Control
- 0.4 W/sf Connected Lighting Load
- Photo-responsive Dimming
- Comprehensive Vacancy Sensing
- Localized Task Lighting

Image: UW IDL


Architectural Record

Automated Venetian Blind and Fabric Shades Deployment Schedules

	Schedule 1					Schedule 2		
	Upper Louver blind					Lower Louver blind		
	PDT	PDT	PST			PDT	PDT	PST
	21-Jun	**21-Sep**	**21-Dec**			**21-Jun**	**21-Sep**	**21-Dec**
Sunrise	5:41	6:16	6:47		Sunrise	5:41	6:16	6:47
Sunset	20:00	19:26	16:47		Sunset	20:00	19:26	16:47
6:00	N	N			6:00	N	N	
7:00	N	N	N		7:00	N	N	N
8:00	N	N	N		8:00	N	N	N
9:00	N	N	N		9:00	N	N	N
10:00	N	N	N		10:00	N	N	N
11:00	N	N	N		11:00	N	N	N
12:00	N	N	0		12:00	N	N	**N**
13:00	0	0	0		13:00	**N**	**N**	**N**
14:00	0	0	0		14:00	**N**	**N**	0
15:00	0	0	22.5		15:00	**N**	**N**	22.5
16:00	0	22.5	45		16:00	**N**	22.5	45
17:00	22.5	22.5			17:00	22.5	22.5	
18:00	22.5	45			18:00	22.5	45	
19:00	45	45			19:00	45	45	
20:00	45				20:00	45		

This matrix establishes separate schedules for blinds. The matrix is broken into four blinds modes that maximize views and indirect daylight while minimizing unwanted direct sunlight.

Four modes:

N no louver blinds/ unobstructed view

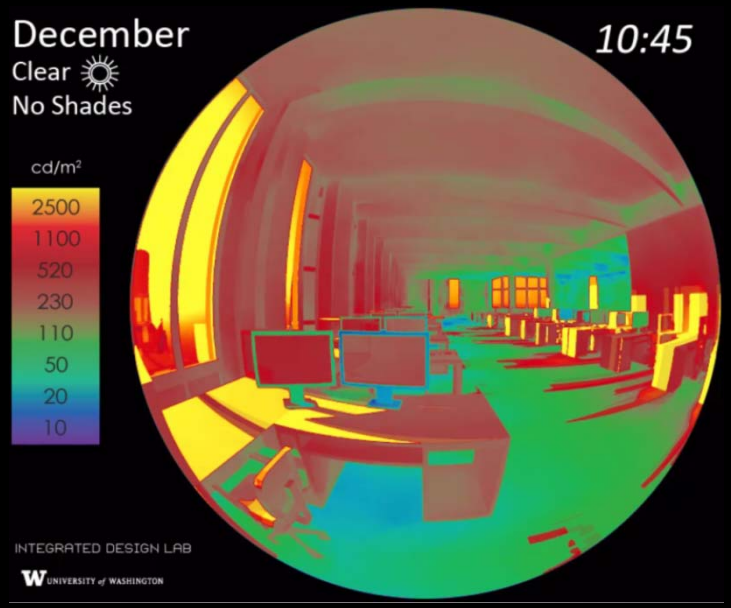
0 blinds at 0 degrees from horizontal

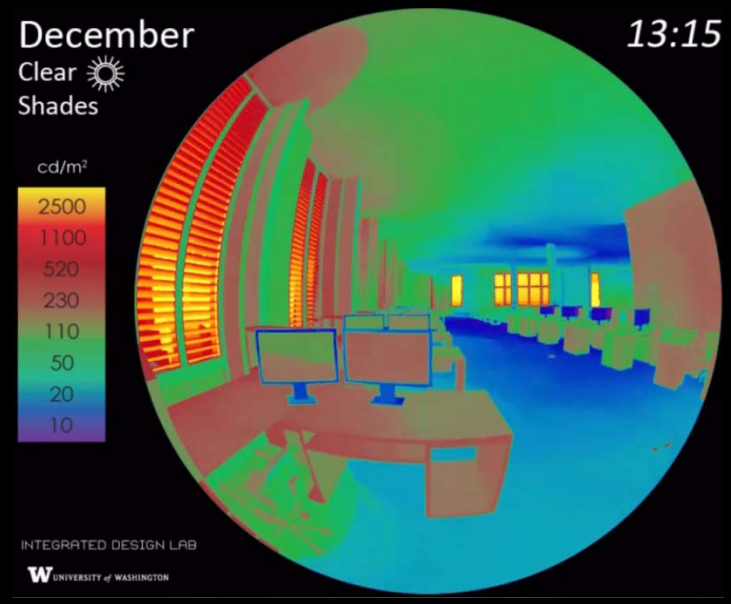
22.5 blinds at 22.5 degrees from horizontal

45 blinds at 45 degrees from horizontal

Shaded areas represents times when there is no lower blinds(due to overshadowing) while other blinds are deployed.

High-Performance Building Envelope





- Dynamic Exterior Shading System
- Simulation

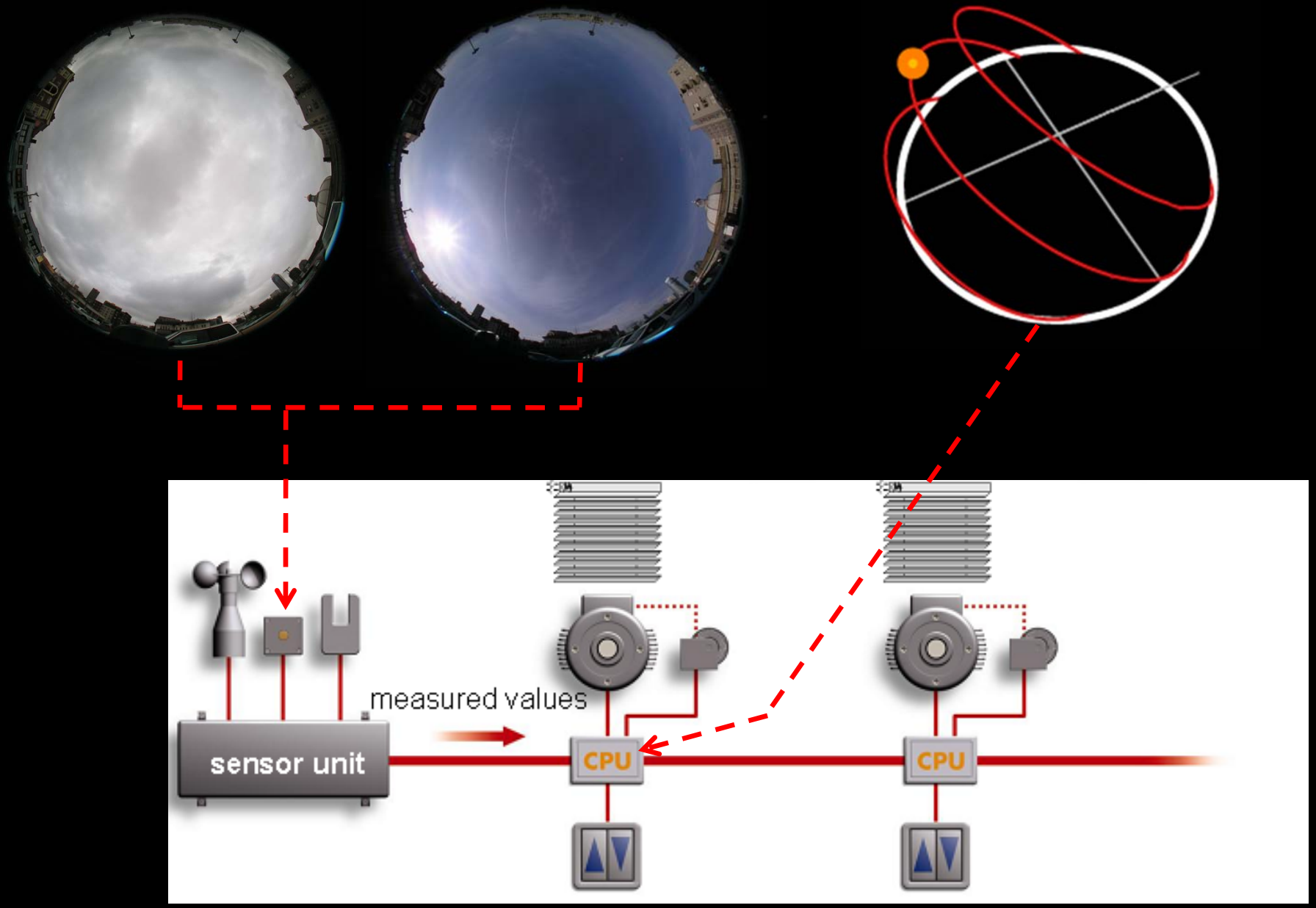


Image: Warema

Optimized per Sky Condition and Weather

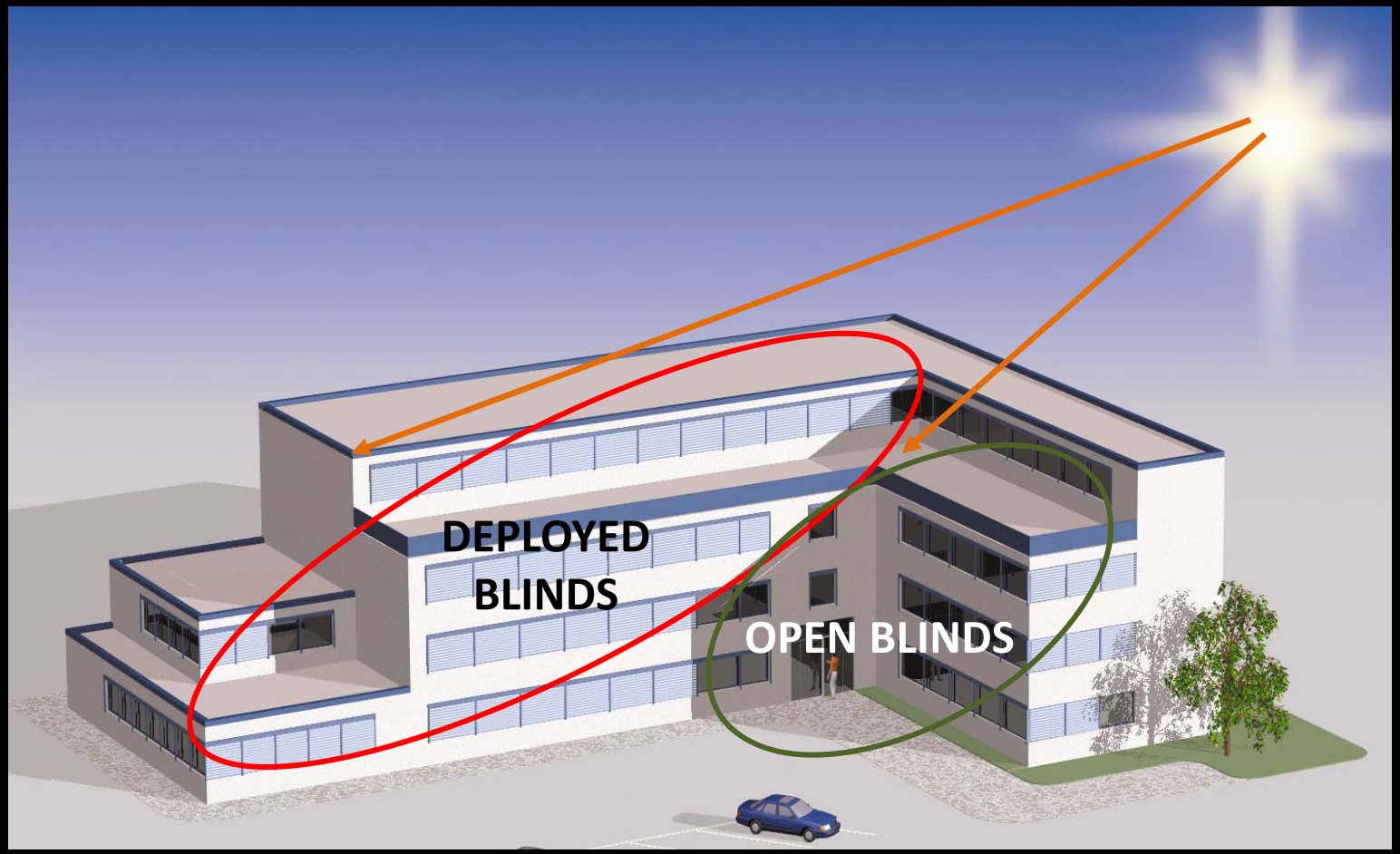
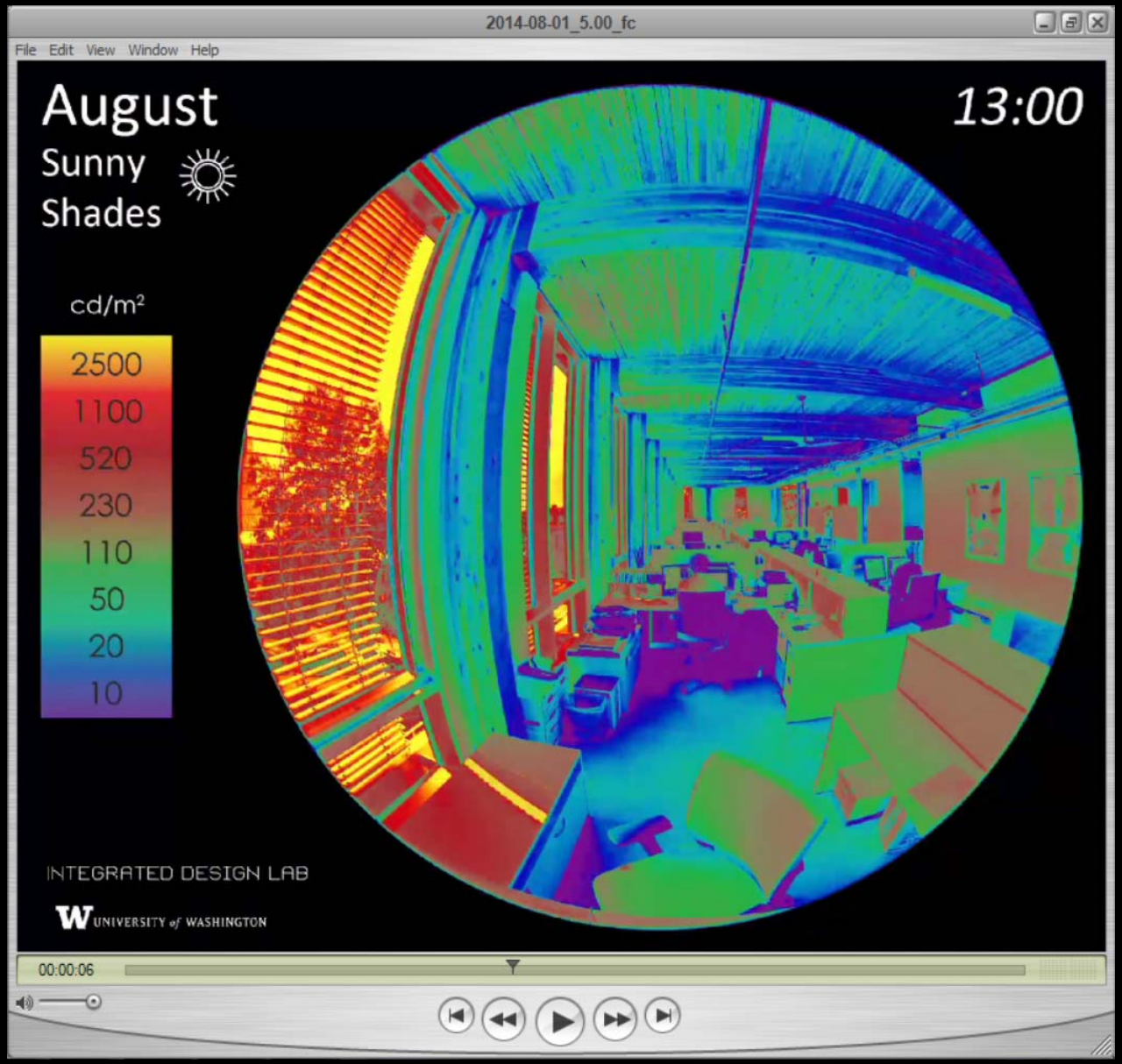


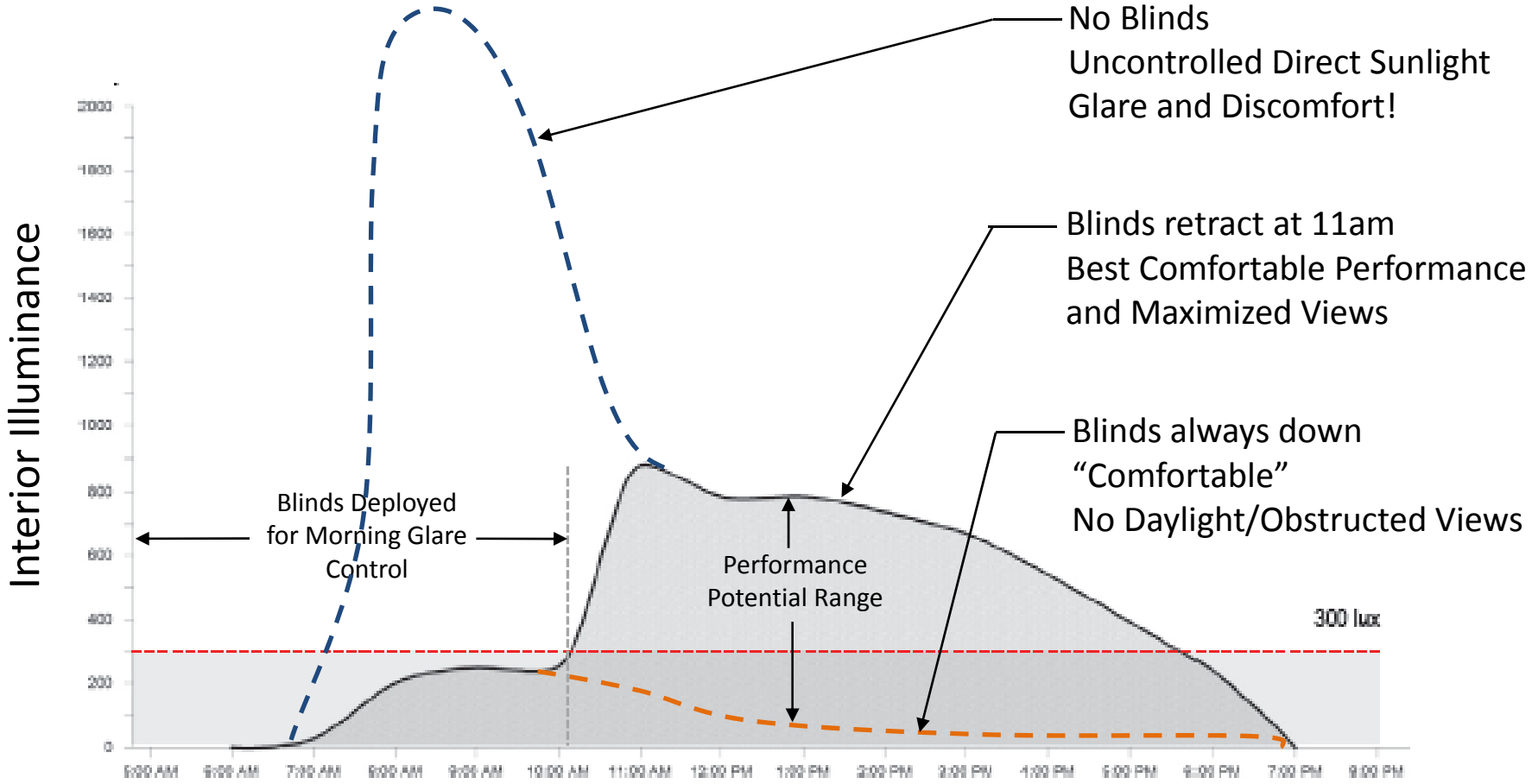
Image: Warema

Pre-programmed for Solar Orientation and Overshadowing



Dynamic Luminance Map: *Dynamic Blinds Deployment*

Operational Performance Range



September 21st Clear Sky

70% Delta In Lighting Savings + Visual Comfort

Thank you!

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Integrated Design Lab

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