The Weidt Group®

The Company for Energy Decision Makers℠

twgi.com

Collaboration Analysis Research

The Weidt Group

Tools and Consulting for Energy Decision Makers

- Energy Design Assistance for over 1,200 commercial buildings for 5 utility DSM programs.
- First EDA program in 1992 named Energy Assets
- Net zero building consulting
- Benchmarking for over 7,600 public buildings
- WeidtSim[SM] software tools
  - ECOnirman—code compliance modeling in India
  - NEO—Commercial New Construction
  - B3 Benchmarking—existing buildings
  - SB 2030—Operational benchmark targets
  - Energy Analyzer II—HVAC modeling for Daikin/McQuay

NEO net energy optimizer

I was brought up to believe that the only thing worth doing was to add to the sum of accurate information in the world.

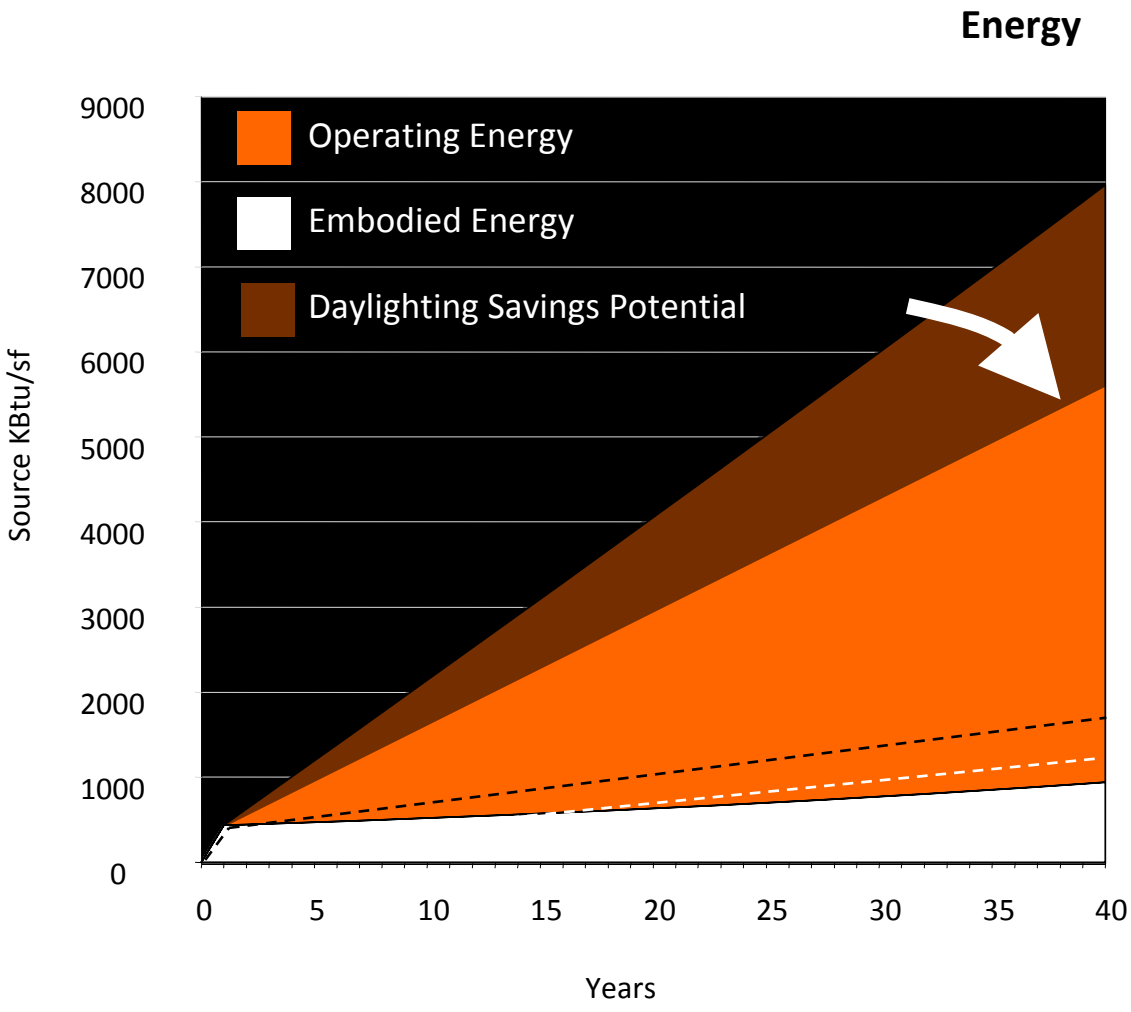
- *Margaret Mead*

Impact of Daylighting

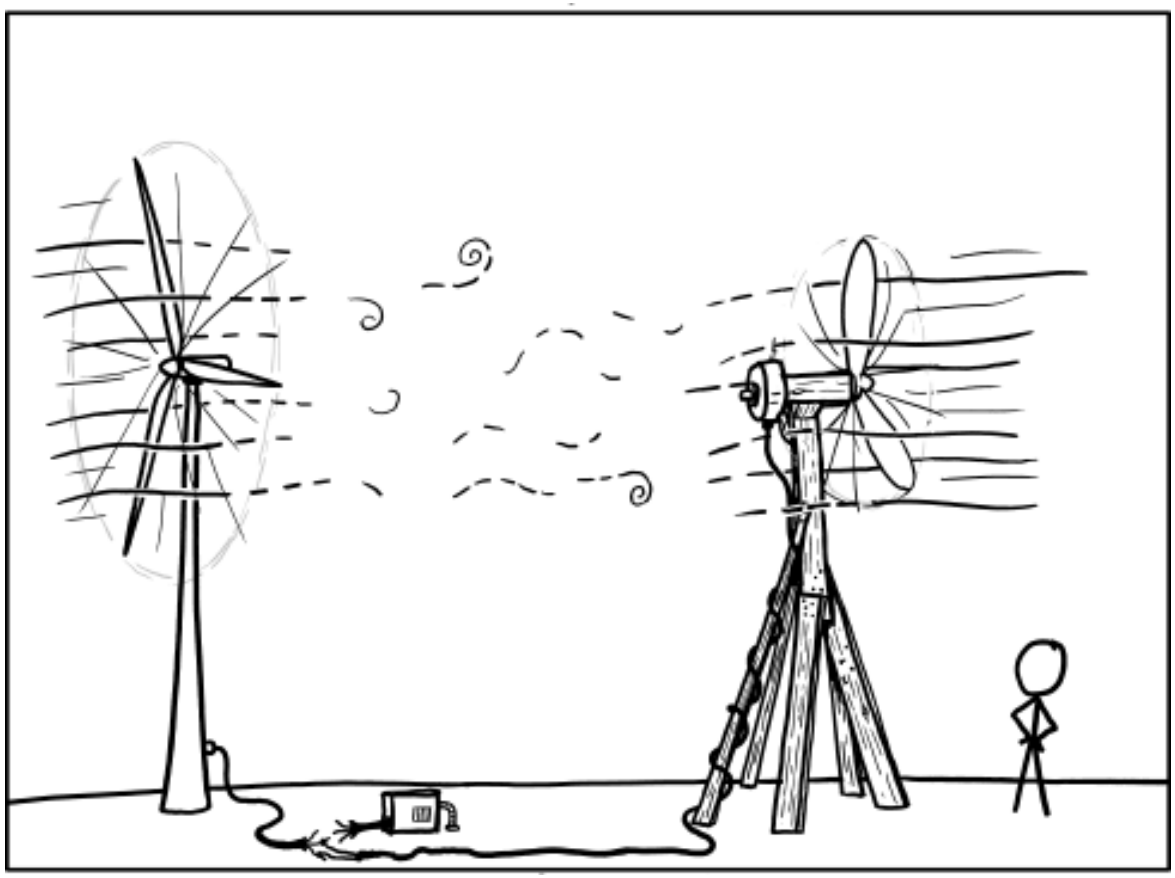
"Over time, environmental impacts from high energy use may far outweigh all other (environmental) factors."

Environmental Resource Guide

Electric Energy to illuminate buildings represents 35% to 55% of US buildings energy use.



Daylighting Makes Sense



Source: XKCD.com

- The sun shines every day
- We need light to work
- Why not use free light?

Agenda

- Bare Bones Need to Know
- Codes in Context
- Daylighting Old School to New School
- Examples

Daylighting in NetZero Buildings

What you need to know in the Code:

Automatic daylighting controls are required for primary sidelighted areas when sidelighted area is equal to or exceeds 250 sf, the lamps must be controlled with a photosensor and contain at least one control step that is between 50% and 70% and another to no greater than 35%.

Daylighting in NetZero Buildings

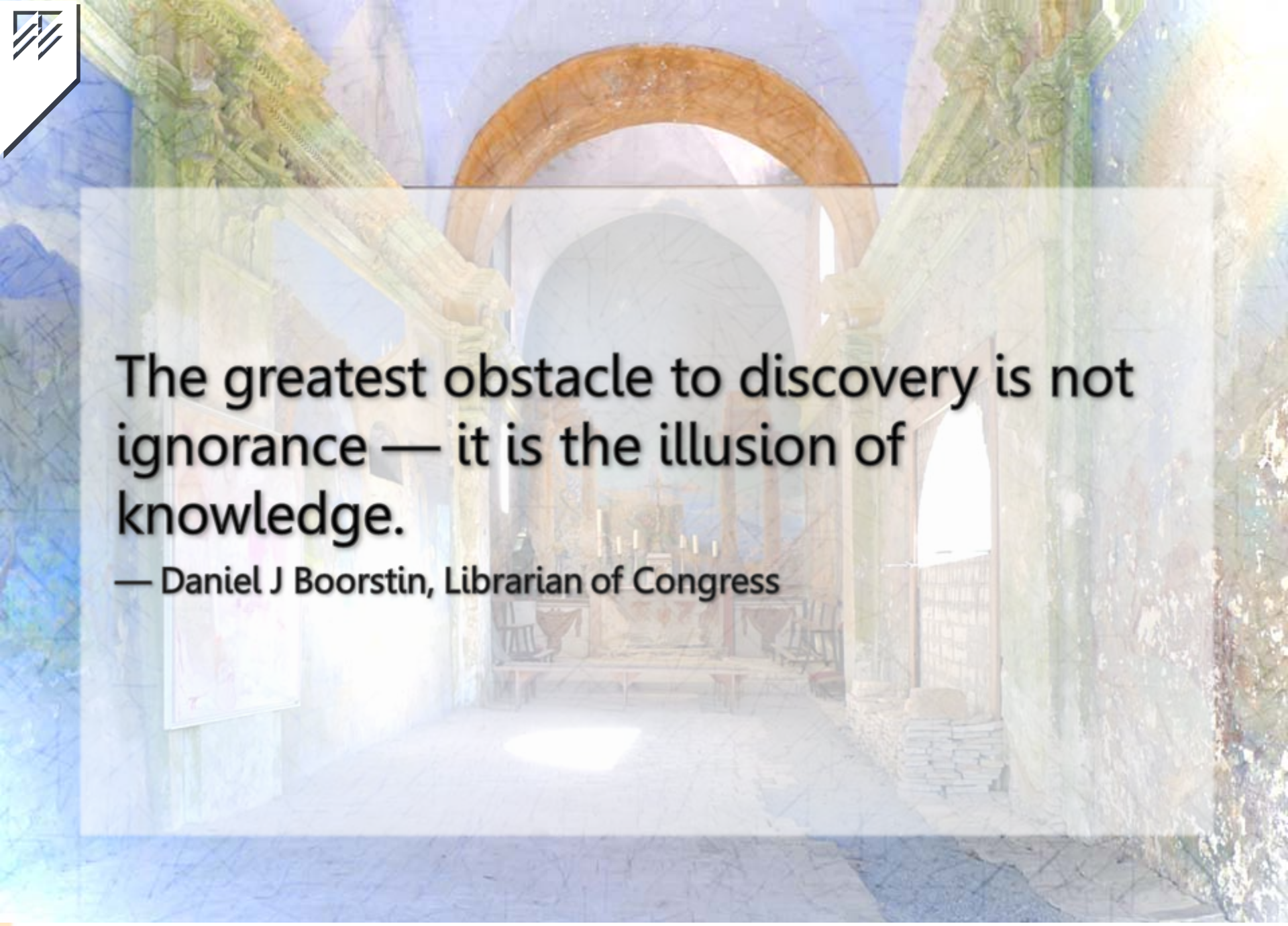
What you need to know in the Code:

Automatic daylighting controls are required for toplighting when the daylight area under the skylights or roof monitors exceeds 900 s.f., the lamps must be controlled with a photosensor and contain at least one control step that is between 50% and 70% and another to no greater than 35%.

Daylighting in NetZero Buildings

What you need to *about* the Code:

-It won't get you to NetZero any time soon.
-It won't guarantee good daylighting



Codes and Guidelines

Conceptual Exercise

- Write a description of The Wizard of Oz using the following guidelines
  - One sentence, under 30 words
  - Standard English
  - No abbreviations or slang.
  - Be comprehensive, with a beginning, middle and end.
  - Be accurate.

Codes and Guidelines

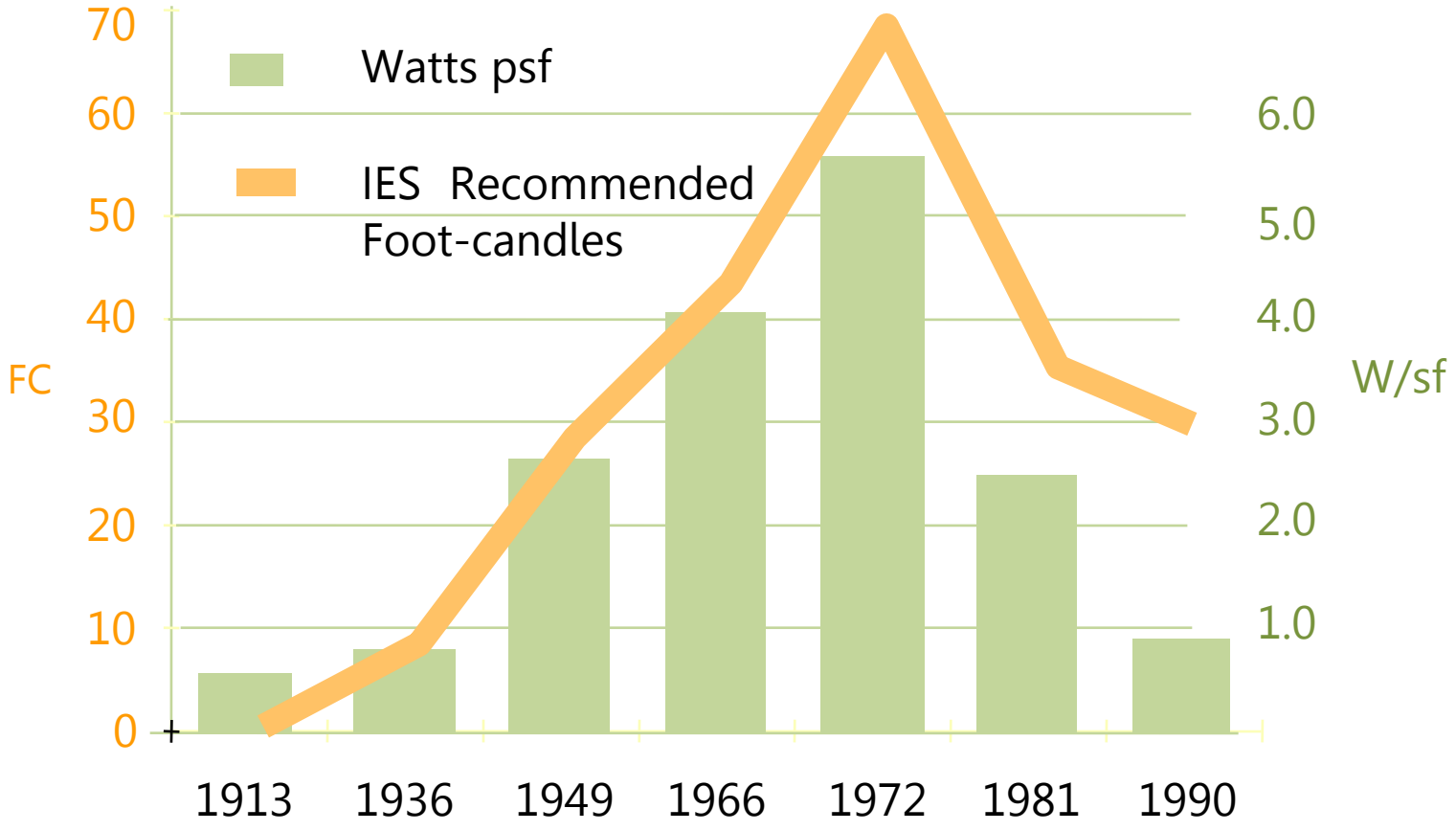
Sample Results

- A Kansas girl, rendered unconscious by a tornado, dreams of a land called OZ, where various adventures lead her to a wizard who reveals the secret to return home.
- Transported to a surreal landscape, a girl and her dog kill the first woman they meet and then team up with three apparent strangers to kill again before returning home.

Enough Light To See By

IESNA

Tells us How Much Light We Need in an Office



Code

- Architects and engineers tell us their intention is always to design to a level better than code
  - Establishes minimum baselines
  - Raises design standards
  - Difficult to enforce
  - Codes do not address value

> What you cannot enforce, do not command.
>
> - Sophocles

Seminars and Workshops

- The absence of a real application and real consequences limits retention
- Failure modes are many
  - Cascading incremental failures
  - Right techniques applied to the wrong projects
- Workshops
  - Indoctrination to principles
  - Training in a technique as an augmentation of code
  - Not an education in critical problem solving

> We Believe as much as we can. We would believe everything if we could.
>
> — William James

Components

- Energy conservation is the product of efficient components, their quantity and how they interact
  - Using efficient components is not the same as conserving energy
- Market transformation using a component approach
  - A good job of identifying higher efficient components
  - Fails to addresses fundamental design issues that create consumption demands
  - Too often only care that a product is used, not that it is used appropriately or well

> We have to sell what we have to sell.
>
> Attributed to a former CEO of a major component manufacturer

Components

- Segregates architectural, mechanical and electrical system decisions
  - Misapplied and non-optimized technology purchases
- Component rebate amounts derived as a blended savings value over a broad market spectrum
  - Skewed project economics

Cost-effective demand reductions are better achieved through applied design practice where technologies are interactively evaluated across professional boundaries.

Power and Influence

- Every participant in the process
  - Has a risk relative to everyone else
  - Has values in conflict with the values of others
  - Manages risks based on
    - Position, personal goals, specialized knowledge, and personality
  - Has preconceptions and misconceptions about "the right thing to do"

> The only thing harder to change than law is custom.
>
> — Will Durant The History of Western Civilization

Definitions

Do this and we'll call it compliance without ever knowing its true impact, merits or performance indicators.

- Prescriptive
  - A strategy or guideline based on or stipulating a norm or standard as the means for meeting a goal

Meet this goal and show us how the performance indicators were calculated and can be verified.

- Performance
  - A strategy or guideline stipulating a calculable and measurable outcome for meeting a goal

> Consistency is the last refuge of the unimaginative.
>
> — Oscar Wilde

The Problem…

Prescriptive instructions are hedged

Performance is not comparatively analyzed

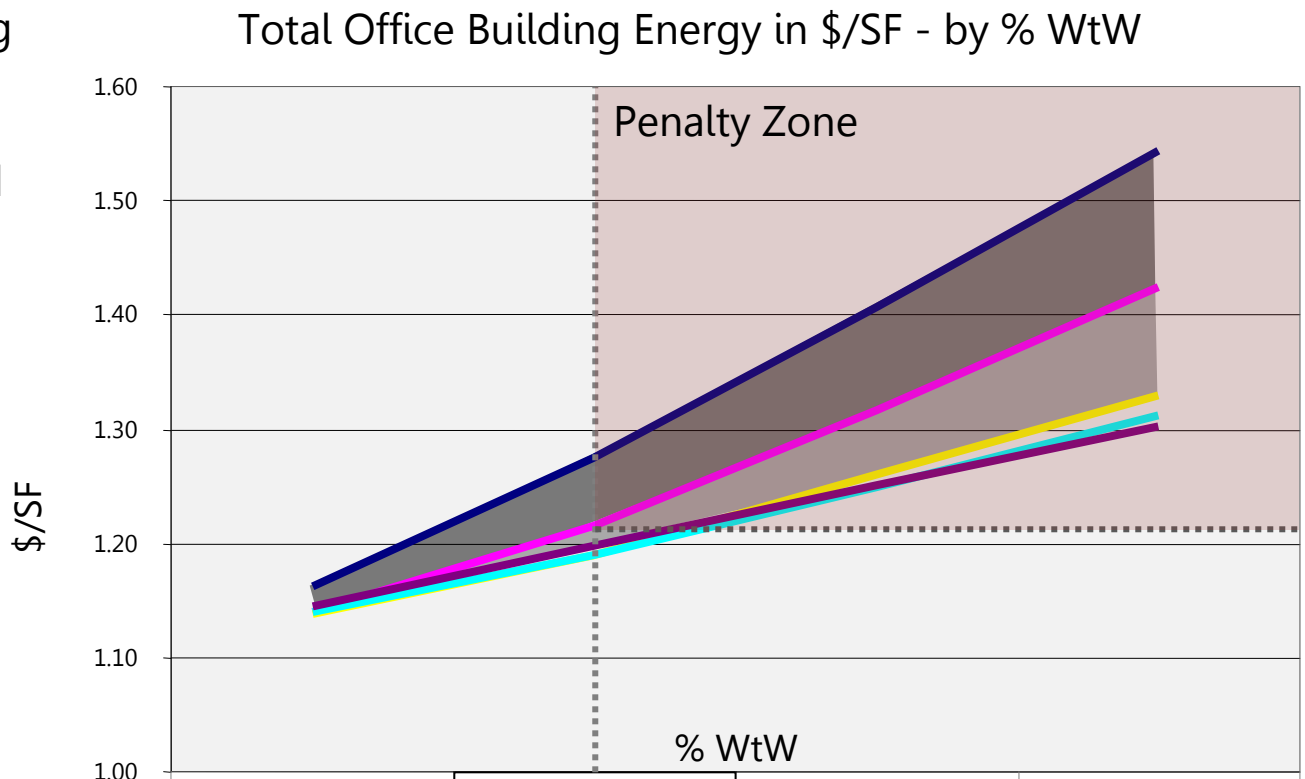
Old School

From the Energy Optimized Perspective

- We love glass…
  - Clean modern look
  - Natural light and views
  - Connection to environment
  - Philosophical transparency
- But…
  - Even the best glass insulates less than a code level wall
  - To much glass causes glare
  - To much glass causes thermal discomfort

Energy Consumption

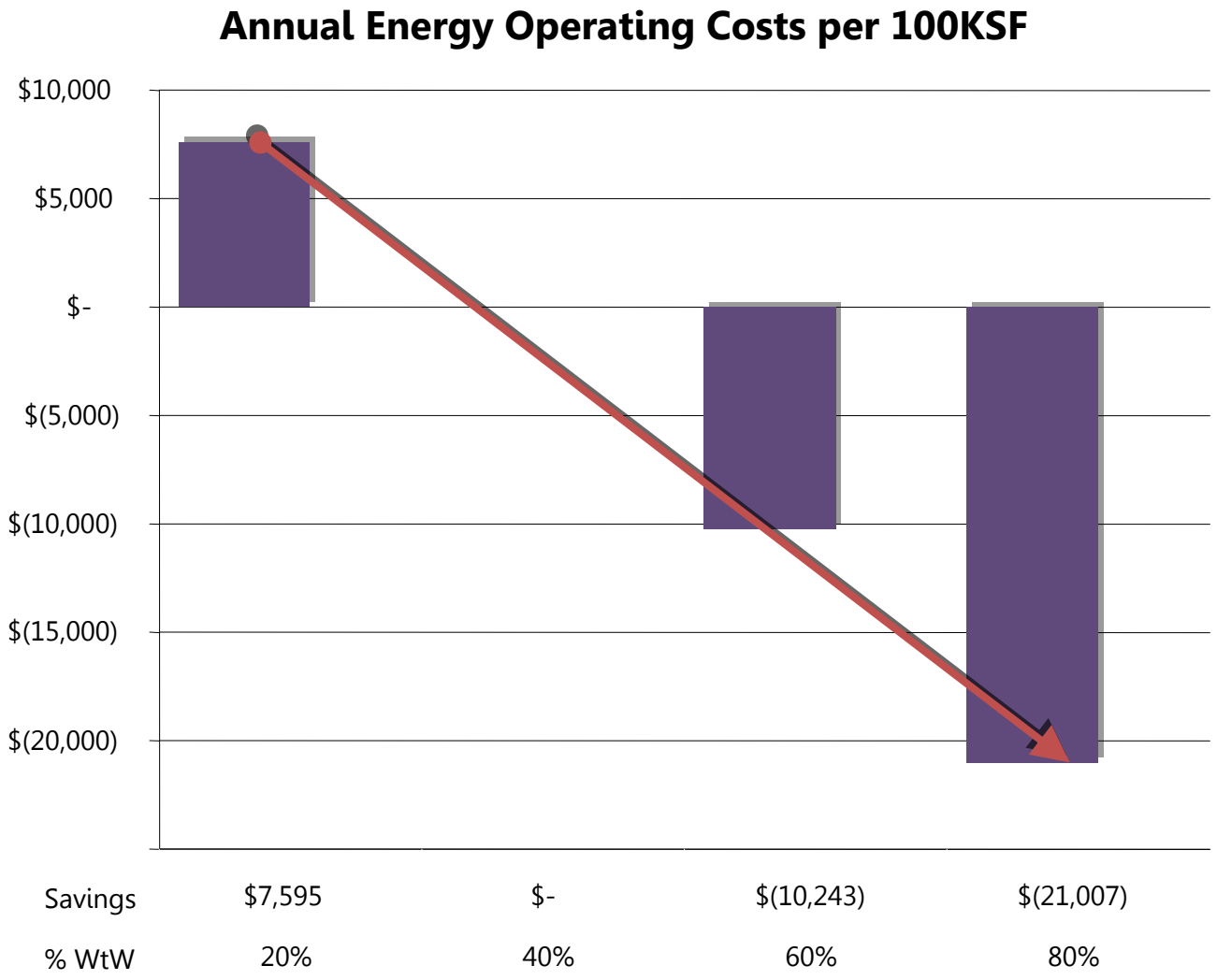
- All other things being equal energy consumption per square foot is related to window area
- 40% is the LEED and code threshold on ASHRAE 90.1



	20%	40%	60%	80%
Standard clear/ 2 pane	1.16	1.27	1.41	1.54
Low E clear/ 2 pane	1.14	1.22	1.32	1.43
Low E clear high performance	1.14	1.19	1.26	1.33
Low E tint high performance	1.14	1.19	1.25	1.31
Low E reflective	1.14	1.20	1.25	1.30

Office – Operating Costs

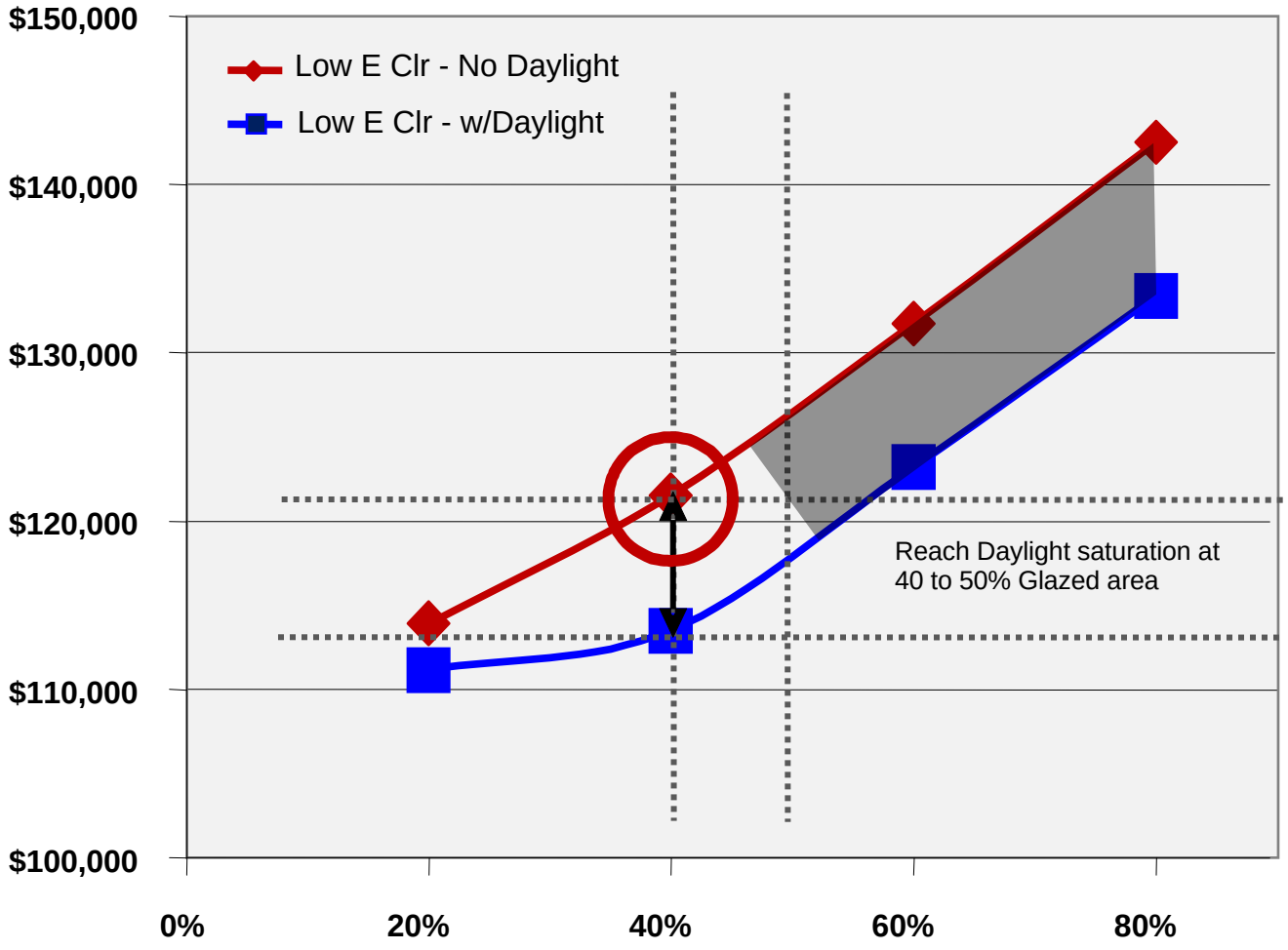
Low-E Clear 100,000 SF Potential Operating Savings $21,800 per Year



Office – Add Daylighting Controls

Low-E Clear 100,000 SF

- Daylighting Controls increase glazing area potential
- Increments of High Performance Glass only add very marginal opportunity



Emerging Daylighting Metrics

- Some Questions
- Some History
- An Example
- The New Metric
- More Questions

Some Questions

How many of these are a factor in resolving a good daylighting design?

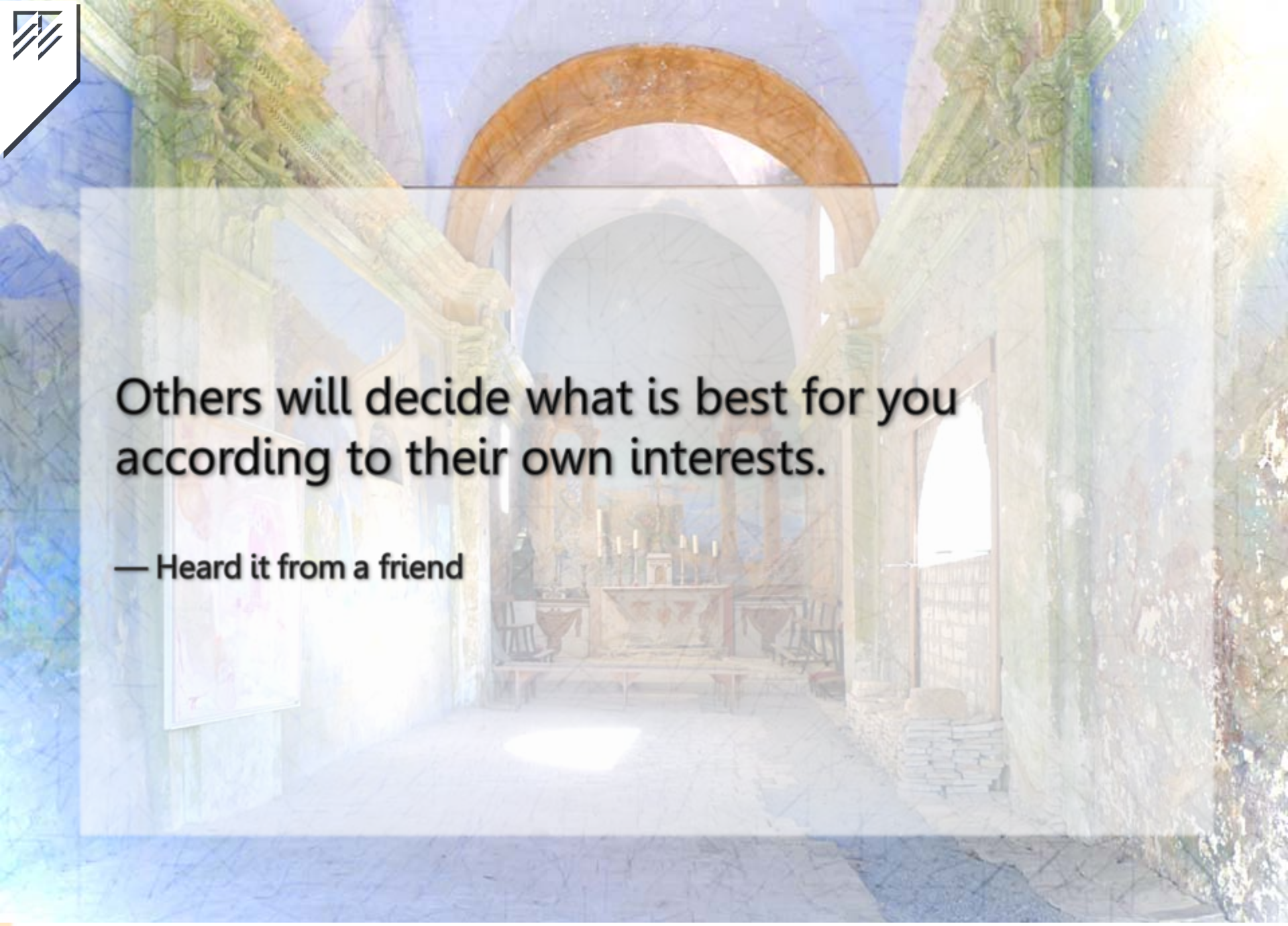
- Building Orientation
- Climate Variables
- Building Section
- Culture Variables
- Window Size
- Window Location
- Glass Characteristics
- Sun Shading
- Space Programming
- Space Layout
- Interior Surfaces
- Lighting Design & Control
- Continued Maintenance

System Efficacy

Component	Perfection	Excellent	Good	Fair	Poor
Window size	100%	98%	95%	100%	85%
Sun shading	100%	98%	95%	91%	85%
Lighting design	100%	99%	95%	85%	85%
Calibration	100%	95%	95%	90%	85%
Total	**100%**	**90%**	**81%**	**70%**	**52%**

Emerging Daylighting Metrics
ACEEE 2006

Experts gather and ask
"What is good daylighting?"



Emerging Daylighting Metrics

Looking for Agreement beginning at ACEEE 2006

David Eijadi
The Weidt Group

Lisa Heschong
Heschong Mahone Group

Eleanor Lee
Lawrence Berkeley National Laboratory

George Loisos and M. Susan Ubbelohde
Loisos + Ubbelohde Associates

Joel Loveland
University of Washington

Christine Magar
Greenform

Kevin Van Wymelenberg
University of Idaho

Daylighting

Courtesy Stephen Selkowitz LBL

- **Architectural definition**: the interplay of natural light and building form to provide a visually stimulating, healthful, and productive interior environment.
- **Lighting Energy Savings definition**: the replacement of indoor electric illumination needs by daylight, resulting in reduced annual energy consumption for lighting.
- **Building Energy Consumption definition**: the use of fenestration systems and responsive electric lighting controls to reduce overall building energy requirements (heating, cooling, lighting).
- **Load Management definition**: dynamic control of fenestration and lighting to manage and control building peak electric demand and load shape, and provide demand response function.
- **Cost definition**: the use of daylighting strategies to minimize operating costs and maximize output, sales, or productivity.
- **LEED definition**: achieve 2% daylight factor and view, reduce energy use as part of energy savings beyond ASHRAE standard

Daylighting

My Definition

- Comfortable people, working productive, with the electric lights off
  - If the lights aren't off, you aren't saving energy
  - If people aren't comfortable and productive the energy doesn't matter

Some More Questions

The Experts Answered at ACEEE 2006

How many of these conditions makes for a good daylighting design?

- Views of the outside
- Effective illumination for half the floor area
- Being able to turn off the electric lights
- Comfortable contrast between the brightest and darkest areas

Emerging Daylighting Metrics

ACEEE 2006

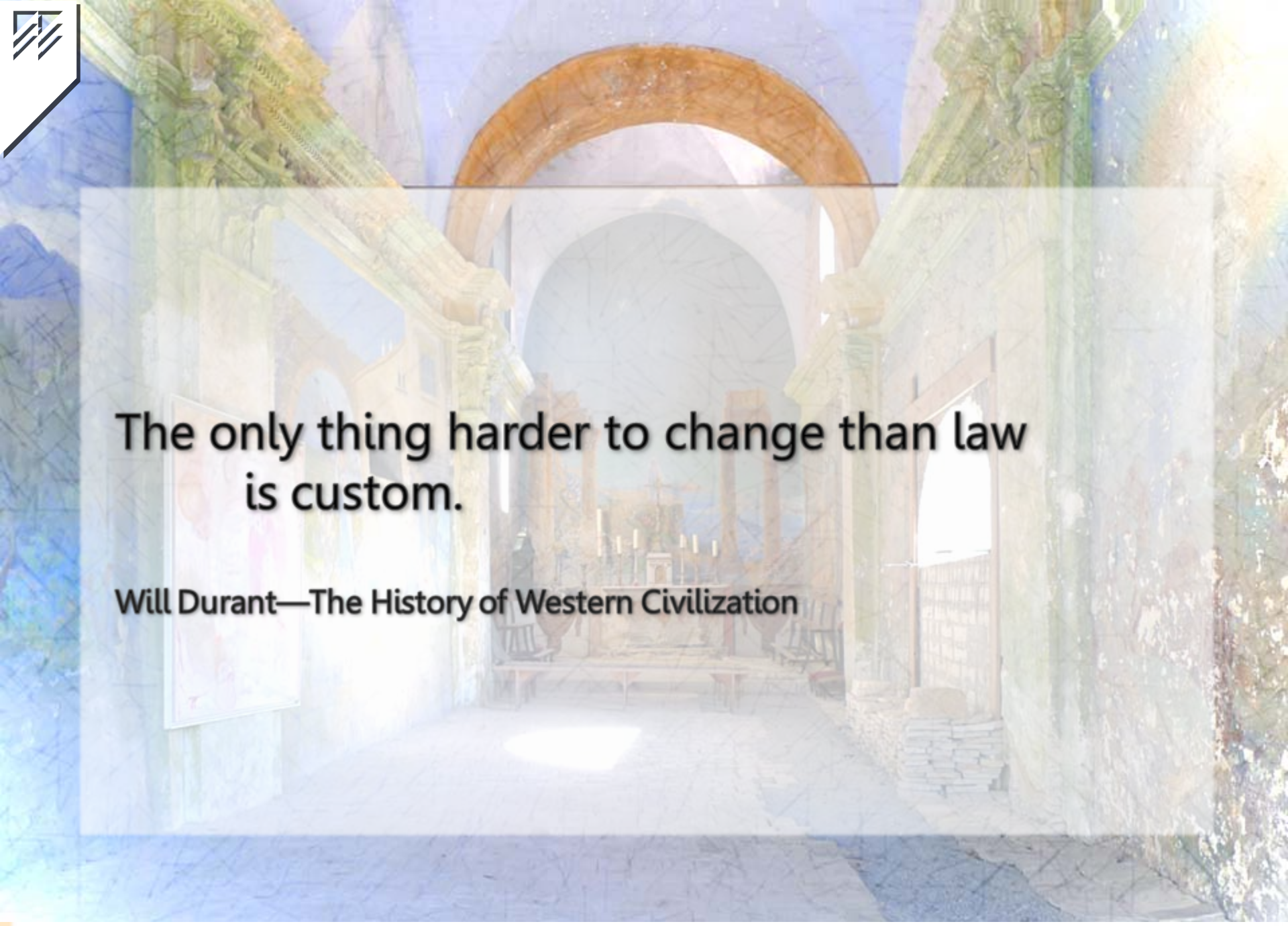
The Issues

Sufficiency vs. excess for human tasks and comfort

More than one kind of "good" daylighting solution

Needed better daylighting metrics

The effort was eventually led by Lisa Heschong



Current Daylighting Metrics

- Daylight Factor
  – Historical Method
  - Minimum and Average
- Illuminance
  – Historical Method
  - At specific times, minimum, average, max
- Uniform Daylight Index
  – New Method
- Daylight Autonomy
  – New Method
  - Minimum, Average

The last two in particular have not been tested fully for human performance, satisfaction. Thresholds based on these metrics are theories by academics or experience of daylighting practitioners.

Use of Metrics

In Standards, Codes and Rating Systems

- USGC and LEED
- IgCC and ASHRAE 189
- Other sustainability rating systems, B3 and CalGreen
- CA Title 24
- CHPS
- ASHRAE 90.1
- IeCC
- NFRC
- CIE

The main questions they are all trying to answer:

How much of this space is daylight? And how well is this space daylit?

Use of Metrics

For Aspects of Building Design and Performance Rating

- Any new tool or and metric would have to address
  - Performance goals
  - Design prediction and optimization
  - Building specifications
  - Code compliance
  - Field verification
  - Building stock descriptions
  - Seasonal and cultural location variables

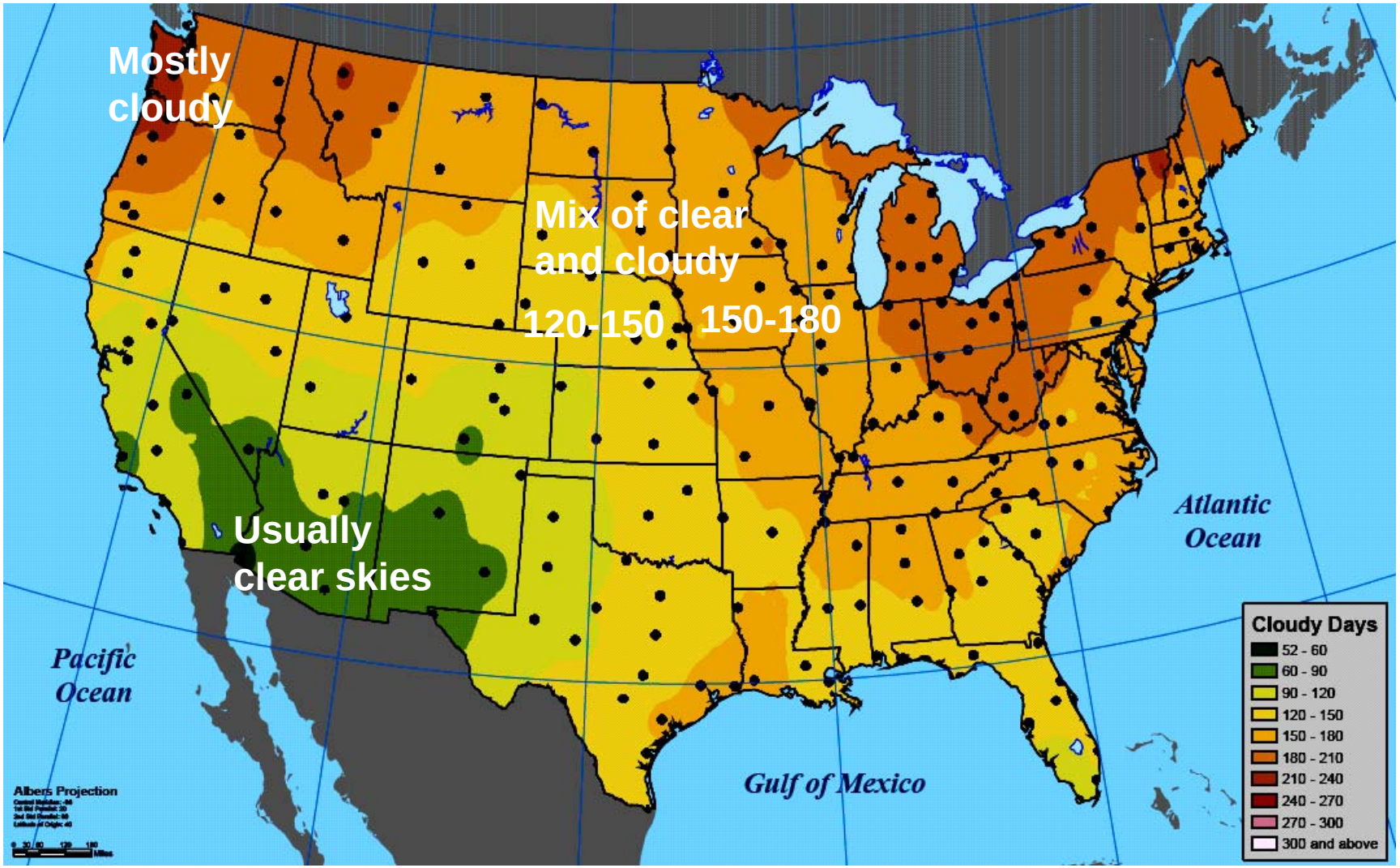
Metrics are different from criteria.

A metric is a scale of measurement or calculation.

A criteria is a threshold value on that scale.

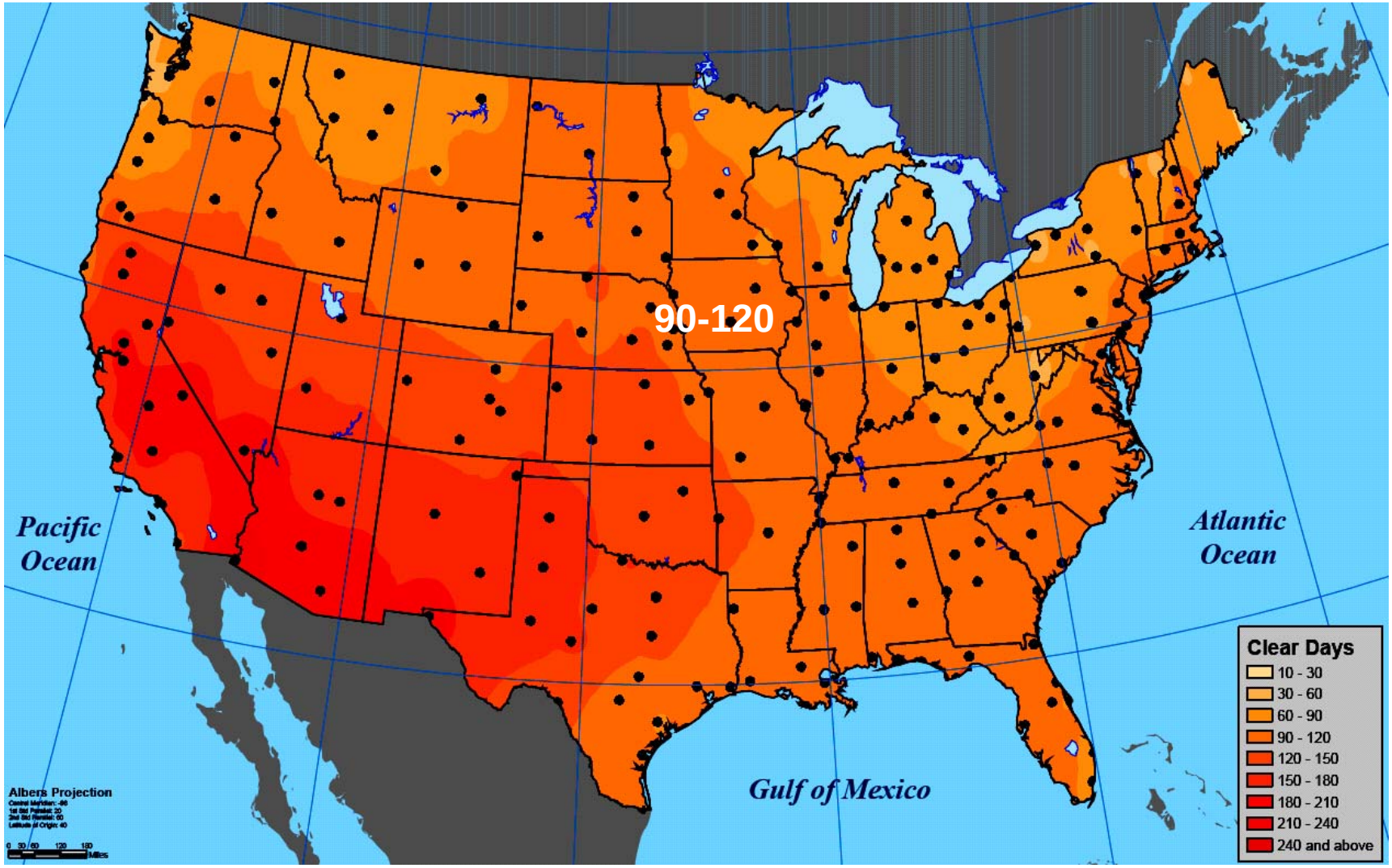
Climate

Annual Cloudy Days



Climate

Annual Clear Days

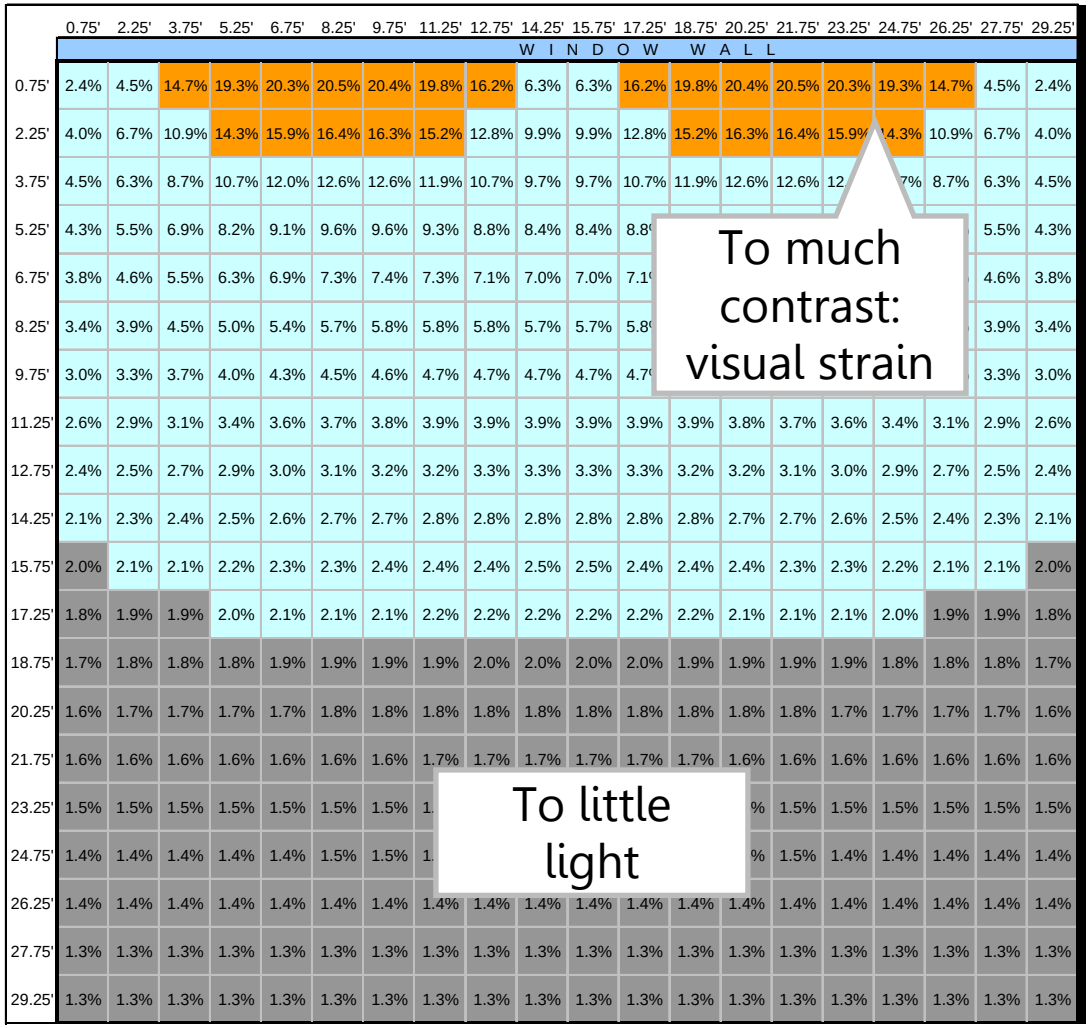


How We Have Measured

- Old School
- New School

Old School

Traditional Overcast Sky Daylighting



	0.75'	2.25'	3.75'	5.25'	6.75'	8.25'	9.75'	11.25'	12.75'	14.25'	15.75'	17.25'	18.75'	20.25'	21.75'	23.25'	24.75'	26.25'	27.75'	29.25'
0.75'	2.4%	4.5%	14.7%	19.3%	20.3%	20.5%	20.4%	19.8%	16.2%	6.3%	6.3%	16.2%	19.8%	20.4%	20.5%	20.3%	19.3%	14.7%	4.5%	2.4%
2.25'	4.0%	6.7%	10.9%	14.3%	15.9%	16.4%	16.3%	15.2%	12.8%	9.9%	9.9%	12.8%	15.2%	16.3%	16.4%	15.9%	14.3%	10.9%	6.7%	4.0%
3.75'	4.5%	6.3%	8.7%	10.7%	12.0%	12.6%	12.6%	11.9%	10.7%	9.7%	9.7%	10.7%	11.9%	12.6%	12.6%	12	7%	8.7%	6.3%	4.5%
5.25'	4.3%	5.5%	6.9%	8.2%	9.1%	9.6%	9.6%	9.3%	8.8%	8.4%	8.4%	8.8							5.5%	4.3%
6.75'	3.8%	4.6%	5.5%	6.3%	6.9%	7.3%	7.4%	7.3%	7.1%	7.0%	7.0%	7.1							4.6%	3.8%
8.25'	3.4%	3.9%	4.5%	5.0%	5.4%	5.7%	5.8%	5.8%	5.8%	5.7%	5.7%	5.8							3.9%	3.4%
9.75'	3.0%	3.3%	3.7%	4.0%	4.3%	4.5%	4.6%	4.7%	4.7%	4.7%	4.7%	4.7							3.3%	3.0%
11.25'	2.6%	2.9%	3.1%	3.4%	3.6%	3.7%	3.8%	3.9%	3.9%	3.9%	3.9%	3.9%	3.9%	3.8%	3.7%	3.6%	3.4%	3.1%	2.9%	2.6%
12.75'	2.4%	2.5%	2.7%	2.9%	3.0%	3.1%	3.2%	3.2%	3.3%	3.3%	3.3%	3.3%	3.2%	3.2%	3.1%	3.0%	2.9%	2.7%	2.5%	2.4%
14.25'	2.1%	2.3%	2.4%	2.5%	2.6%	2.7%	2.7%	2.8%	2.8%	2.8%	2.8%	2.8%	2.8%	2.7%	2.7%	2.6%	2.5%	2.4%	2.3%	2.1%
15.75'	2.0%	2.1%	2.1%	2.2%	2.3%	2.3%	2.4%	2.4%	2.4%	2.5%	2.5%	2.4%	2.4%	2.4%	2.3%	2.3%	2.2%	2.1%	2.1%	2.0%
17.25'	1.8%	1.9%	1.9%	2.0%	2.1%	2.1%	2.1%	2.2%	2.2%	2.2%	2.2%	2.2%	2.2%	2.1%	2.1%	2.1%	2.0%	1.9%	1.9%	1.8%
18.75'	1.7%	1.8%	1.8%	1.8%	1.9%	1.9%	1.9%	1.9%	2.0%	2.0%	2.0%	2.0%	1.9%	1.9%	1.9%	1.9%	1.8%	1.8%	1.8%	1.7%
20.25'	1.6%	1.7%	1.7%	1.7%	1.7%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.8%	1.7%	1.7%	1.7%	1.7%	1.6%
21.75'	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%	1.7%	1.7%	1.7%	1.7%	1.7%	1.7%	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%	1.6%
23.25'	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.					%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%	1.5%
24.75'	1.4%	1.4%	1.4%	1.4%	1.4%	1.5%	1.5%	1.					%	1.5%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%
26.25'	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%	1.4%
27.75'	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%
29.25'	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%	1.3%

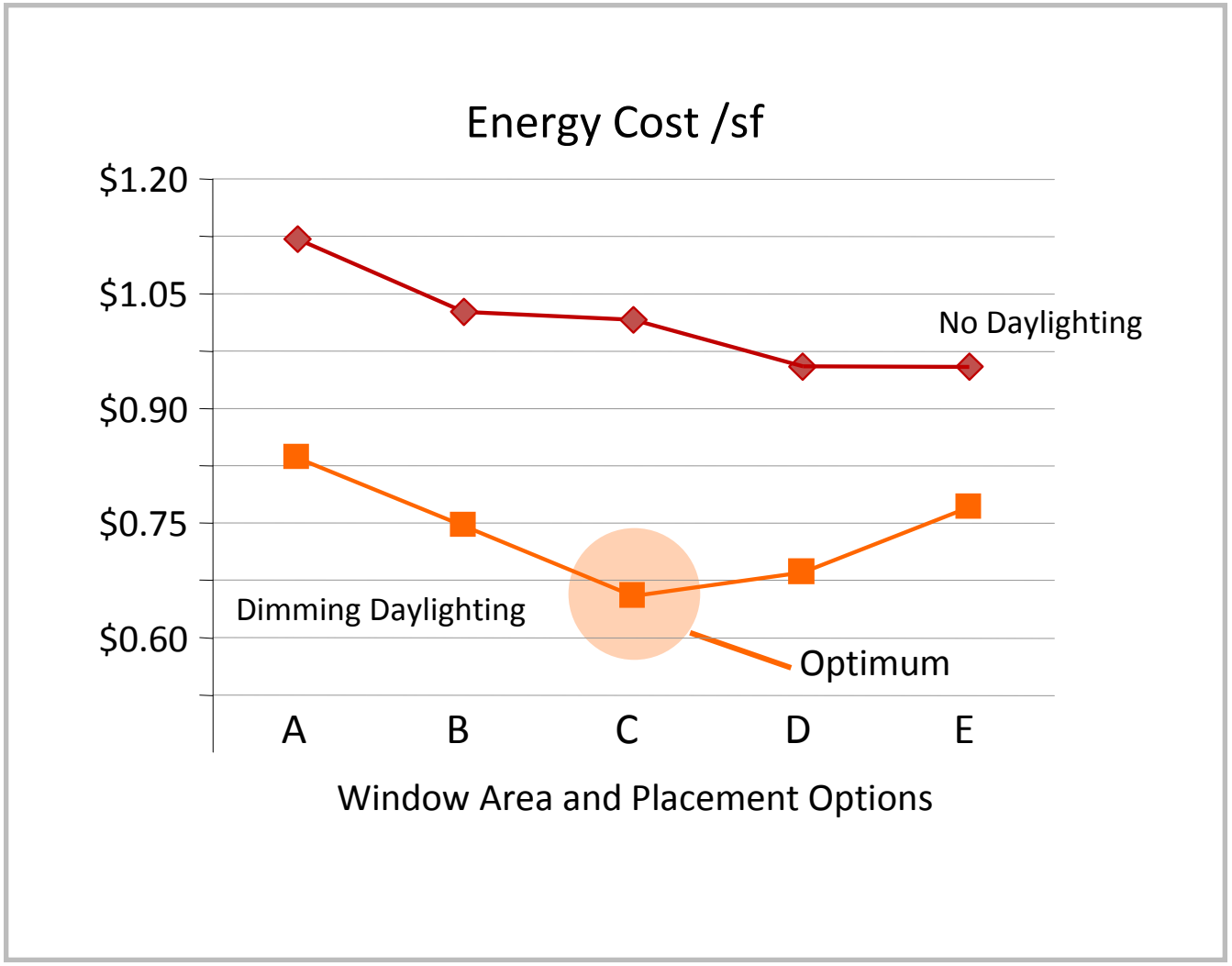
Uniformity ratio > 10

Daylight factor < 2%

Daylight factor and uniformity ok

Old School

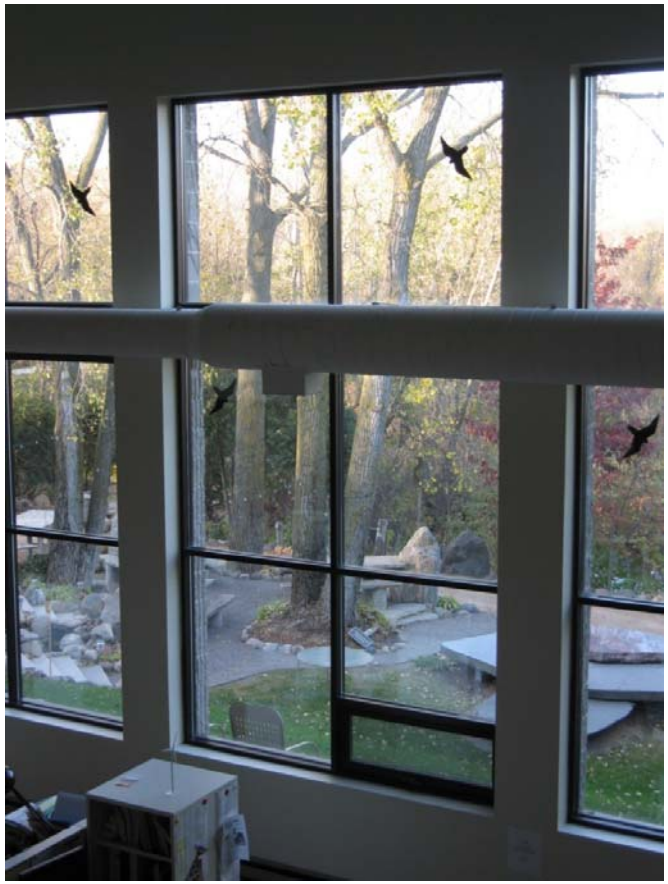
Energy Optimized Daylighting



Old School Daylight Elements

Aperture Rules of Thumb

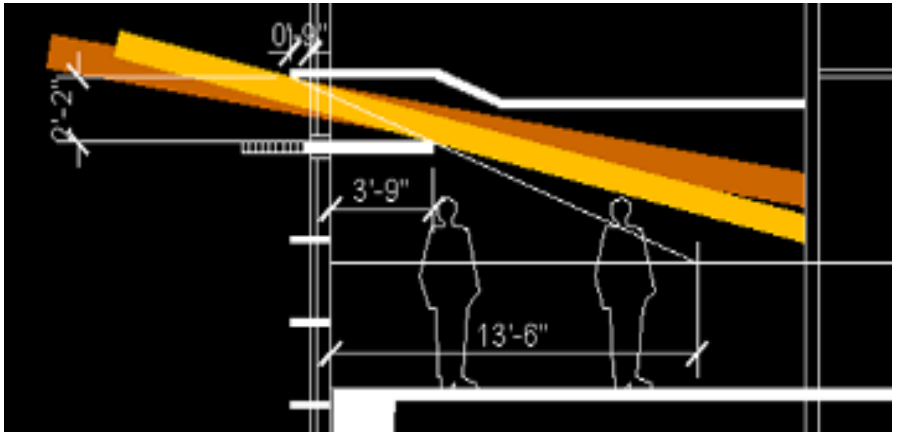
- Windows rules of thumb
  - Reflected daylight is better than direct sunlight
  - Size and location of openings determines potential
  - Head height determines depth of penetration
  - Daylighting depth is 1.5 to 2.5x the head height
  - 20% to 40% window to wall area is optimal
- Skylights rules of thumb
  - Height determines width of coverage
  - Generally 2 x height above floor
  - Opening area determines amount of light
  - 4% skylight area to floor area
- Balance lighting needs with heating and cooling loads



Old School Daylight Elements

Visual Comfort Rules of Thumb

- Direct sun causes glare and thermal impacts
  - LEED 2009 requires a maximum of 500 fc
  - If shades/ blinds are drawn to protect from direct sun, available daylighting levels and potential energy savings are reduced
- High contrast inhibits vision and is uncomfortable
  - Contrast ratio of 20 or less is preferred
- Design anticipates horizontal blinds in slit windows and roller shades in the curtain wall windows



Old School Daylight Elements

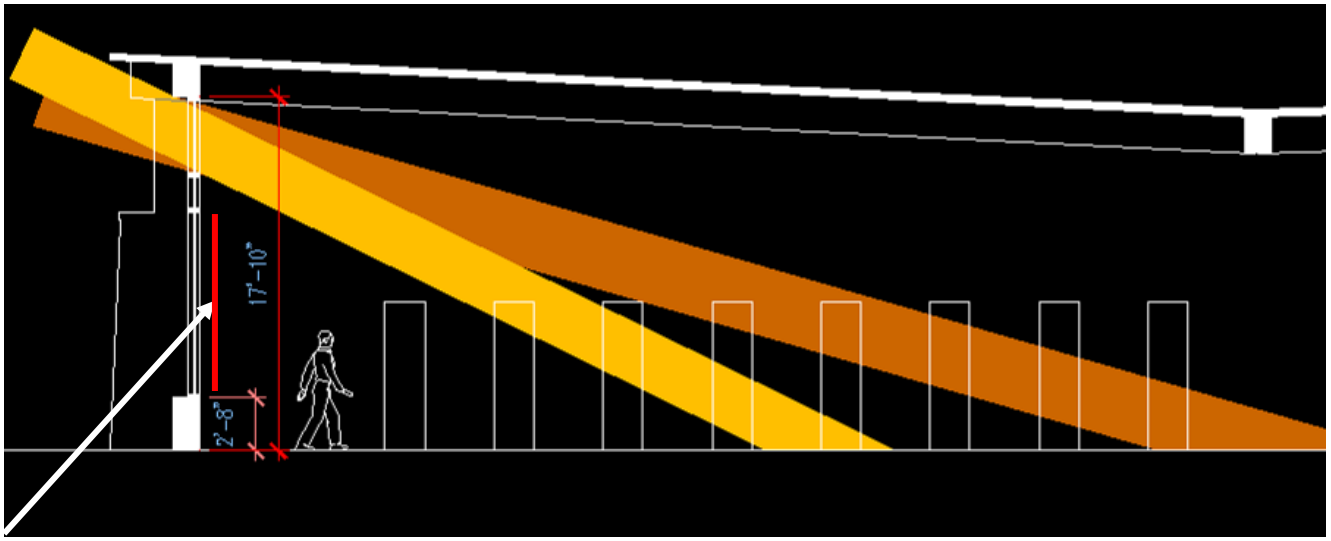
Reflectance Rules of Thumb

- Surface Reflectance
  - Lower reflectance yields lower light levels

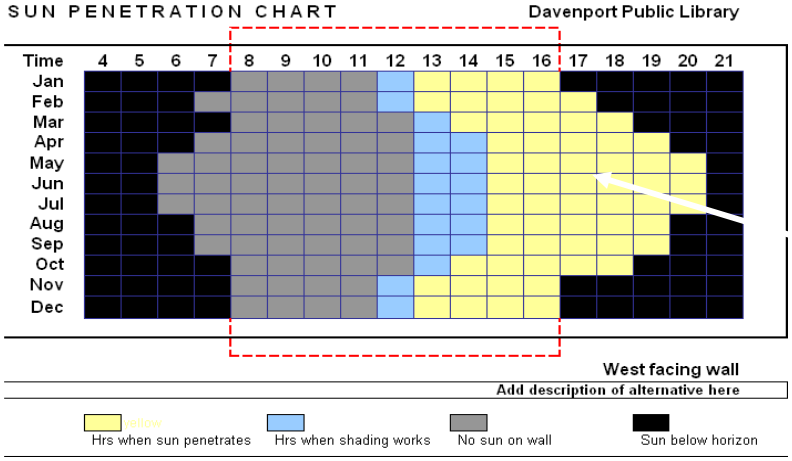
	Typical	Design	Goal
Ceiling	80%	82 - 90%	90%
Wall	50%	50 - 80%	50%
Floor	20%	-	20%
Glass Trans	50%	31%	70%

Old School Reading Room

West Facing Clerestory Example Base Case- No Blinds/Shades/Frit



Blinds assumed for vision windows

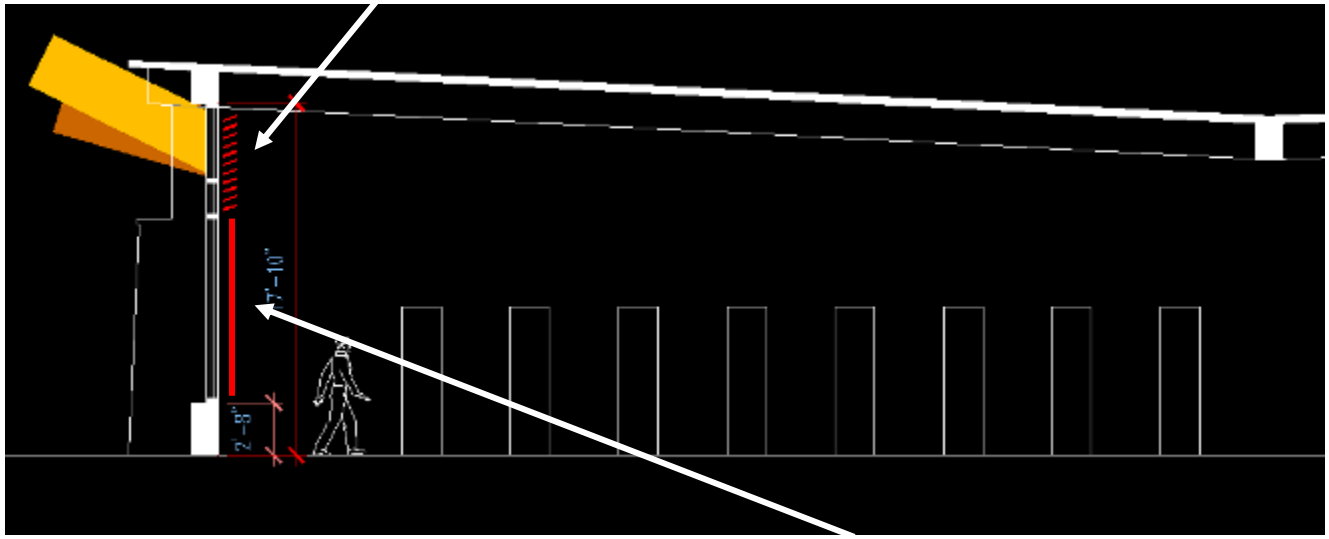


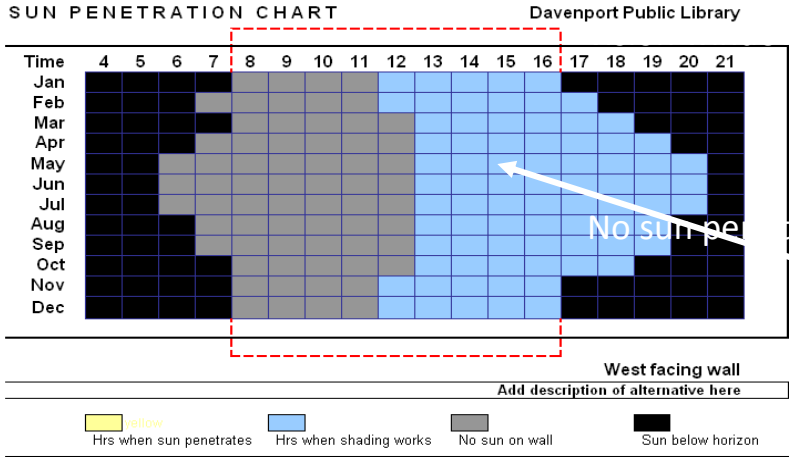
Sun penetration during afternoon hours throughout year

Old School Reading Room

West Facing Clerestory Example With Blinds/Shades

Fixed blinds/Solera/Okasolar

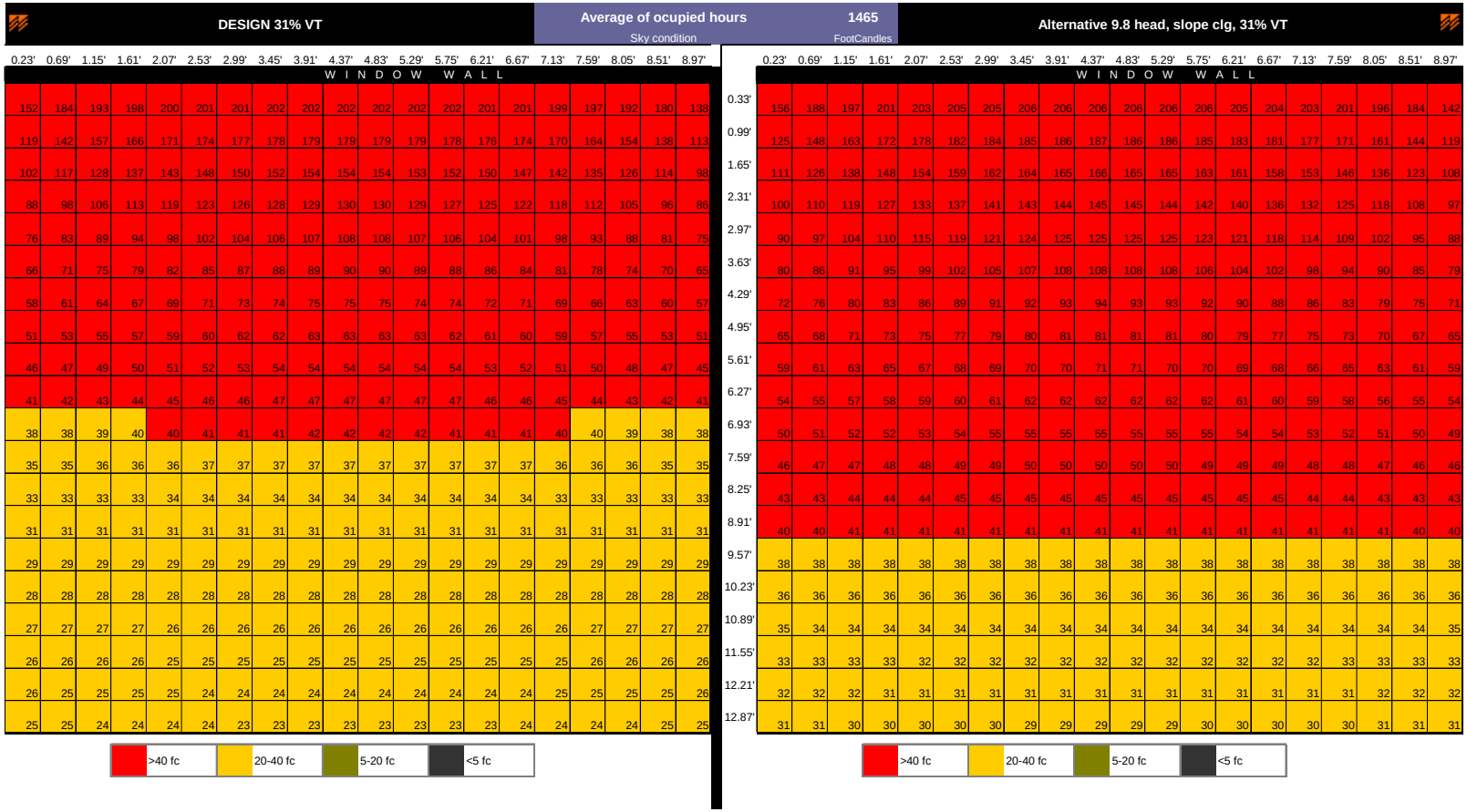




Old School Key Spaces

Example Office – Curtain Wall

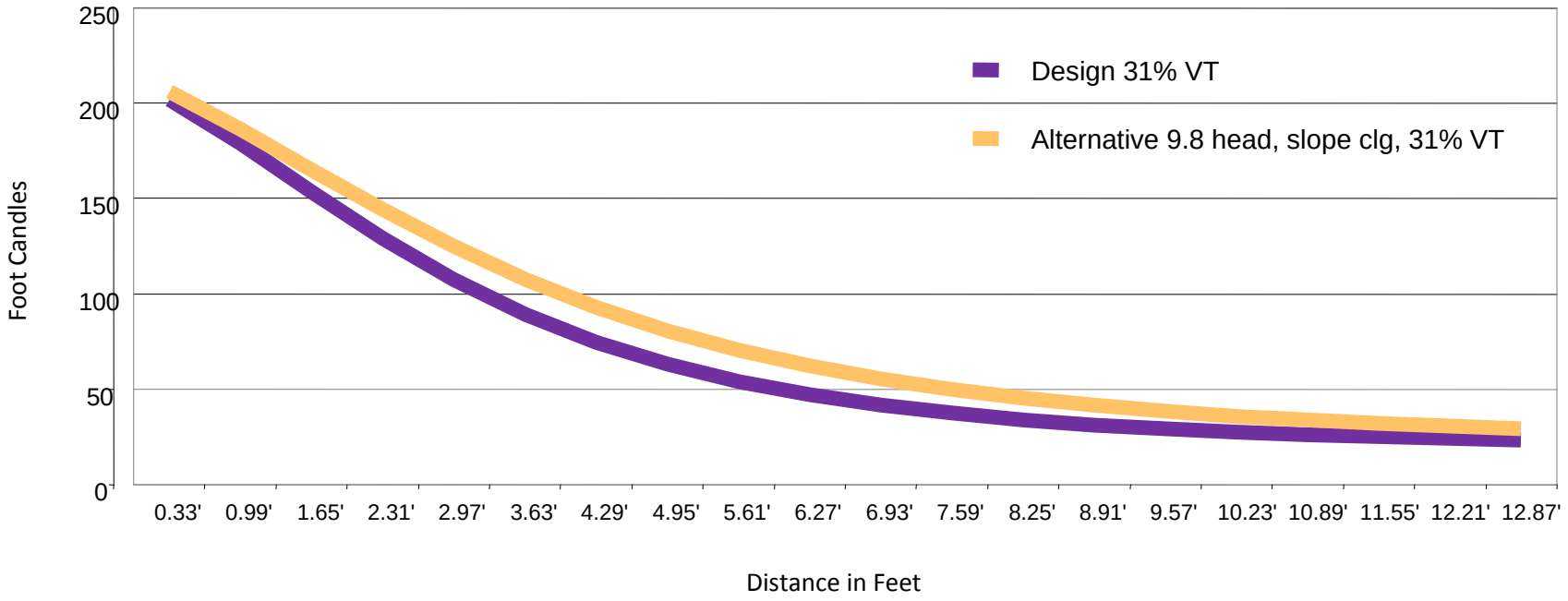
- Distribution in plan

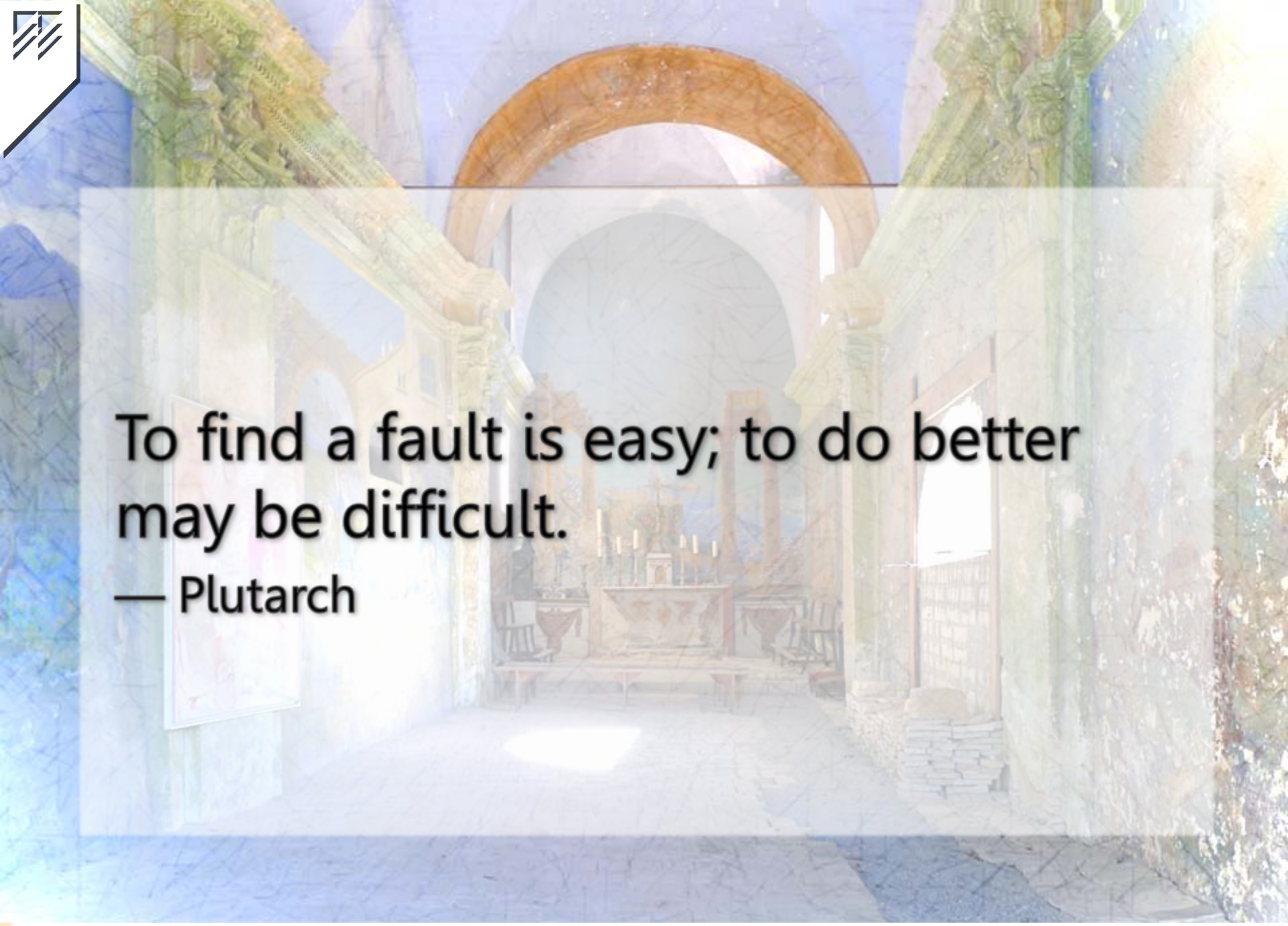


Key Spaces

Example Office -Curtainwall

- Distribution in Section
  Light profile perpendicular to window wall (fc)





New School

Daylighting Metrics From IESNA Daylighting Metrics Subcommittee

Primary Source:

Daylighting Metrics Report
March 31, 2011
by Heschong Mahone Group
for California Energy Commission

IES Daylighitng Subcomittee Focus

Initial Metric Objective

- Analysis by space rather than by building
- Representation of annual performance
- Focus on visual comfort
- Focus on daylight illumination quality and not energy performance
- Standardize metrics and not criteria

Methodology of Research

Spaces Studied

- Spacetypes
  - Classroom/conference room, open office, library/lobby
- Climates
  - Coastal, inland, moderate to temperate, sunny to very overcast, 35-50 def latitude. CA, WA, NY.
- Spaces
  - 77 spaces proposed by panel of experts, 62 selected
  - Spaces ranged from "well daylit" to "poorly daylit"
    - Spaces included lightshelves, skylights, clerestories, translucent glazing, advanced blinds, simple windows, variety of tints and shading conditions

Methodology for Research

Surveys

- Occupant Survey
  - Surveyed 9.5 occupants per space
  - Based on recollection of previous year in space
- Expert Survey
  - assessments had average of 5.2 experts per spaces
  - Observation at time and prediction of performance over a year
- Radiance daylight simulation
  - Using typical weather year

Methodology for Research

Continued

- Concepts tested
  - Sufficiency of daylight
  - Sun Penetration
  - Uniformity
  - Glare
- Simulation results and analysis
  - Results from the metrics with various criteria or threshold values were tested for correlation against the qualitative opinions of the experts and occupants

Summary of Findings

Simulations with blinds operation is absolutely necessary to predict daylight performance of a space

- Sufficiency
  - 300 lux DA was the best predictor, slightly better than 200 or 500 lux
  - No discomfort for high level of illuminance
    Discomfort, like contrast or glare was related to low levels of illuminance
- Uniformity
  - Did not correlate with occupant or expert surveys
- Glare/contrast
  - Weak correlation with survey results
- Sun Penetration
  - Less than 600 hours of direct sunlight penetration at any one point was not a clear indicator of comfort
  - Less than 350 hours of direct sunlight penetration at any one point was a predictor of comfort
  - A metric for this is currently under development

Primary source: Daylighting Metrics Report, March 31, 2011 by Heschong Mahone Group for California Energy Commission

Metric Proposed

Metric Proposed

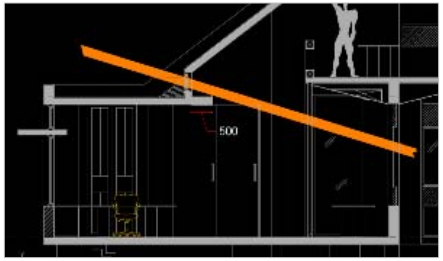
- Spatial Daylight Autonomy (sDA)
  - sDA_{500}
    - Reports on at least 500 lux of daylight available over the year
    - Thus sDA_{500} of 40% indicates that at least 500 lux is available for 40% of daylight hours (approximately 8.00 to 18.00 over 365 days)
  - $sDA_{500,75\%}$
    - Reports on at least 500 lux of daylight available for 75% of daylight hours for each sensor location
    - Thus $sDA_{500,75\%}$ of 40% indicates that at least 40% of the sensor locations have 500 lux available for 75% of daylight hours
  - >50% $sDA_{500,75\%}$
    - Indicates that more than 50% of the sensor locations are required to have at least 500 lux of daylight available for 75% of daylight hours
  - **Based on the occupant and expert survey >55% $sDA_{300,50\%}$ was a nominally acceptable, >75% $sDA_{300,50\%}$ is preferred**

Primary source: Daylighting Metrics Report, March 31, 2011 by Heschong Mahone Group for California Energy Commission

Small Lab-Office Building

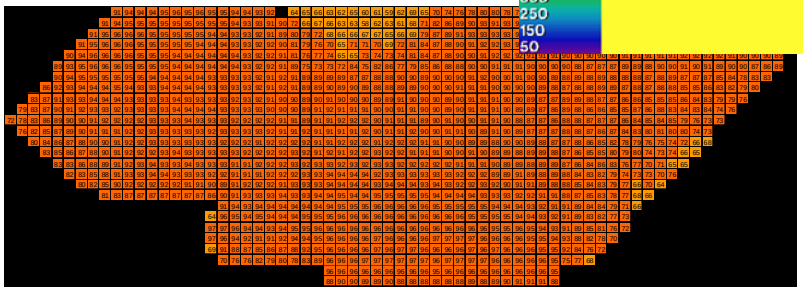
Ahmedabad, India

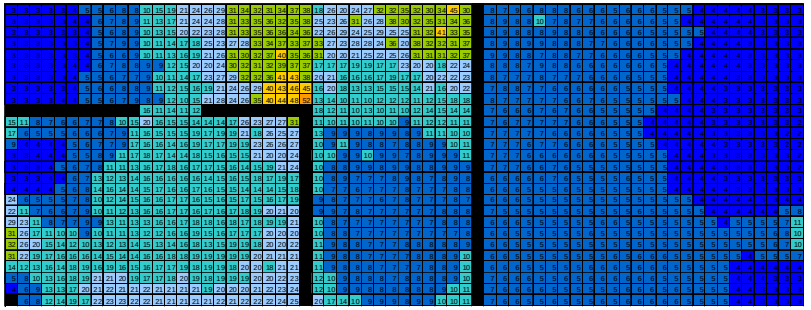
- Daylighting Analysis Results Meeting Energy Design Assistance – several daylight analysis methods applied



Sun Penetration Analysis

Time	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Jan				12.2	30.7	39.6	44.1	46.2	46.9	46.2	44.1	39.6	30.7	12.2				
Feb				29.5	45.3	51.3	54.1	55.4	55.8	55.4	54.1	51.3	45.3	29.5				
Mar				65.4	66.2	66.4	66.5	66.6	66.6	66.6	66.5	66.4	66.2	65.4				
Apr			-23.0	-74.6	89.3	83.2	80.3	79.0	78.6	79.0	80.3	83.2	89.3	-74.6	-23.0			
May			-23.0	-58.2	-76.7	-85.6	89.9	87.8	87.1	87.8	89.9	-85.6	-76.7	-58.2	-23.0			
Jun			-23.0	-53.8	-72.1	-81.5	-86.4	88.8	89.6	88.8	-86.4	-81.5	-72.1	-53.8	-23.0			
Jul			-23.0	-57.8	-76.3	-85.2	89.7	88.1	87.4	88.1	89.7	-85.2	-76.3	-57.8	-23.0			
Aug			-23.0	-74.2	89.6	83.4	80.5	79.2	78.8	79.2	80.5	83.4	89.6	-74.2	-23.0			
Sep				66.2	66.6	66.7	66.8	66.8	66.8	66.8	66.8	66.7	66.6	66.2				
Oct				28.2	44.4	50.6	53.5	54.8	55.2	54.8	53.5	50.6	44.4	28.2				
Nov				11.8	30.3	39.2	43.7	45.9	46.6	45.9	43.7	39.2	30.3	11.8				
Dec				7.8	26.1	35.5	40.4	42.8	43.6	42.8	40.4	35.5	26.1	7.8				





Daylighting & Sun Control Analysis

Net-Zero Energy Building at CEPT, Ahmedabad, India

- Daylighting Goals
  - Usable daylight in 100% of the building
  - Illuminance levels in task areas
    - Minimum light level: 300 – 500 lux
    - Maximum light level: 2300 – 5000 lux
  - Daylight Autonomy (150 & 300 lux)
    - 70% of daylight hours

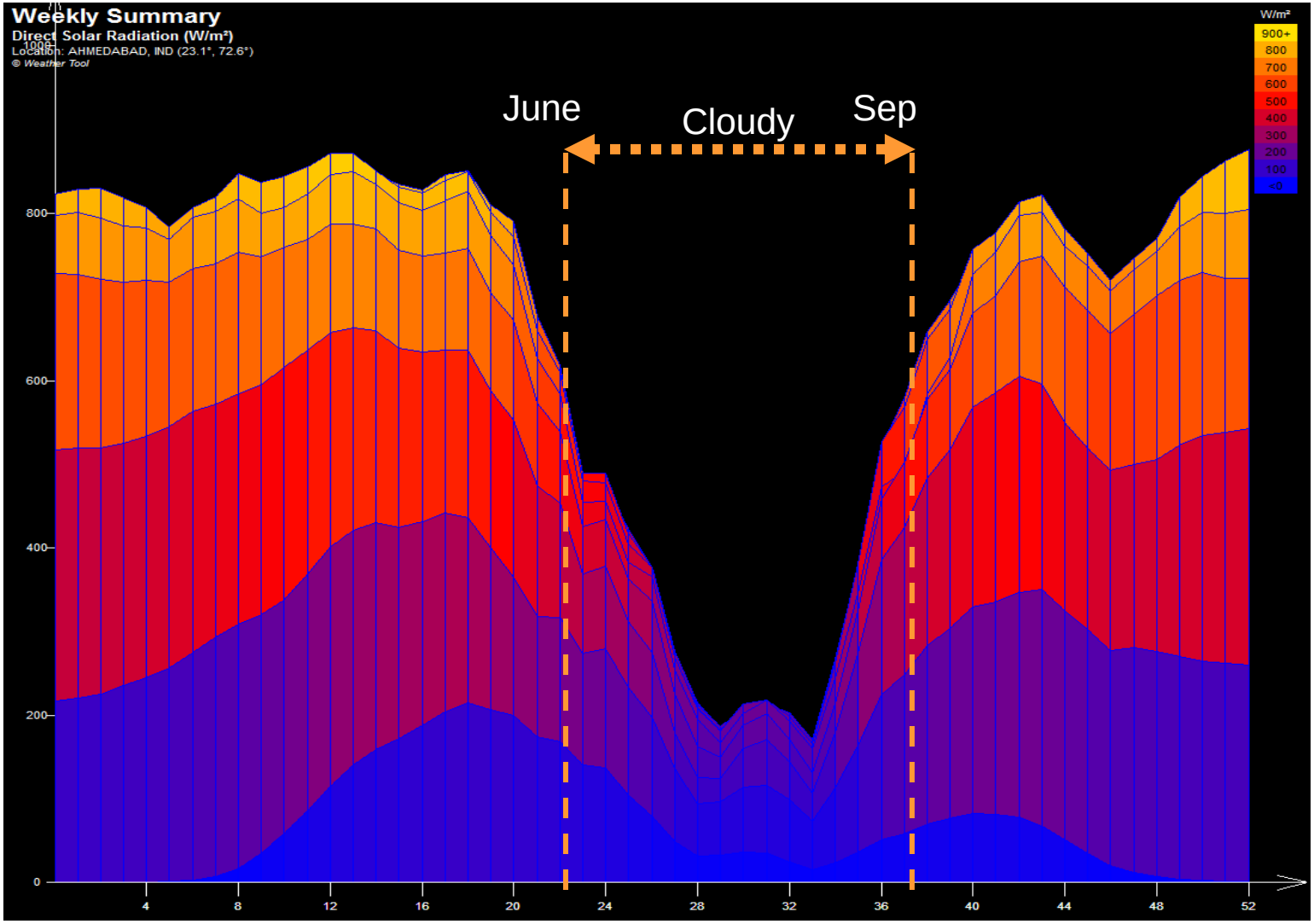
Daylighting Parameters

	Typical	Preferred	Project Goal
Ceiling	80%	90%	80%
Wall	50%	75%	75%
Floor	20%	40%	20%
Vision T_{vis}	50%	20-30%	40%
Daylight T_{vis}	50%	50-65%	65%

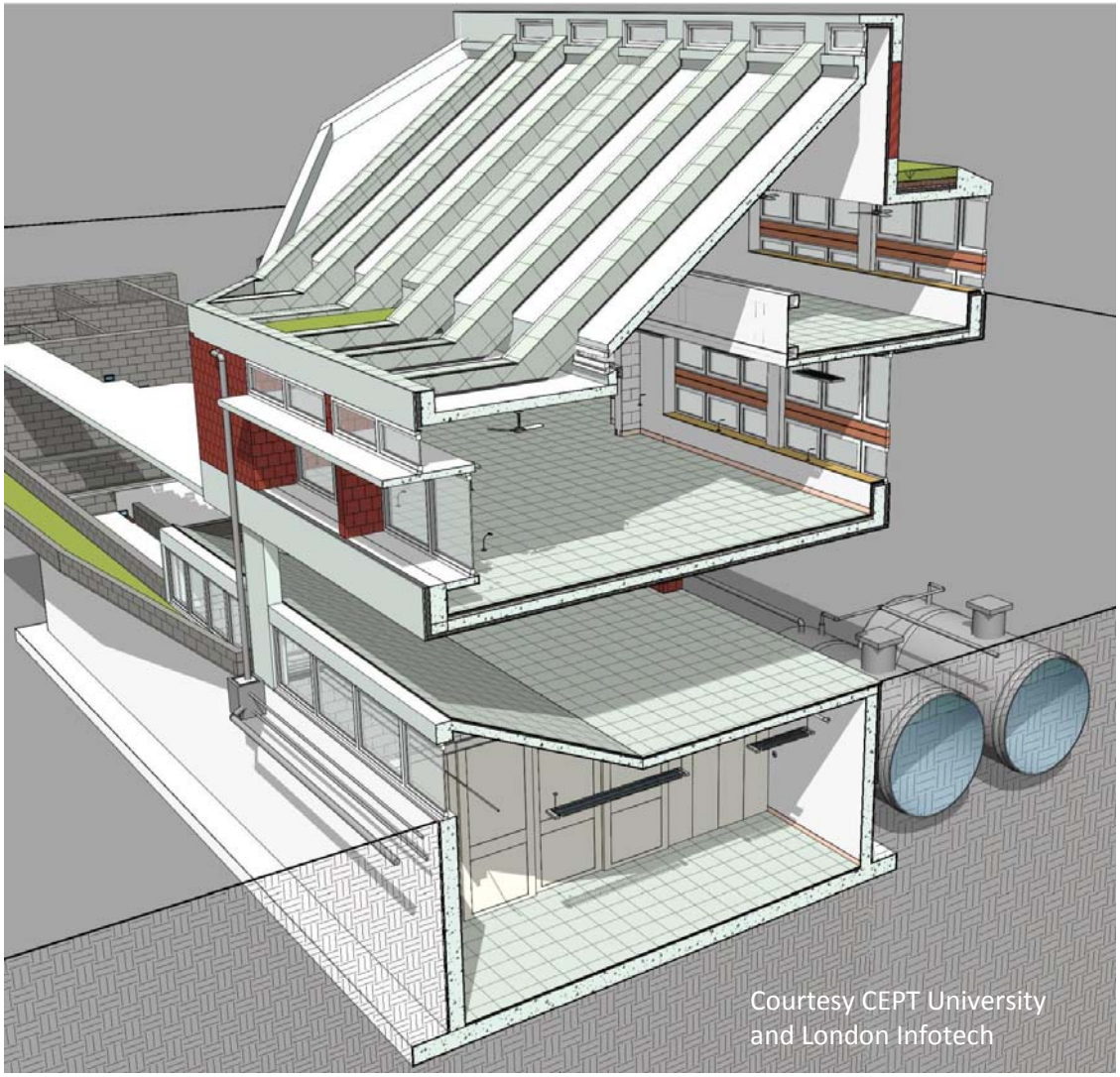
- Predesign goal 100% of space daylit
- Lighting level of 300 - 500 lux

Daylighting Parameters

Direct Solar Radiation

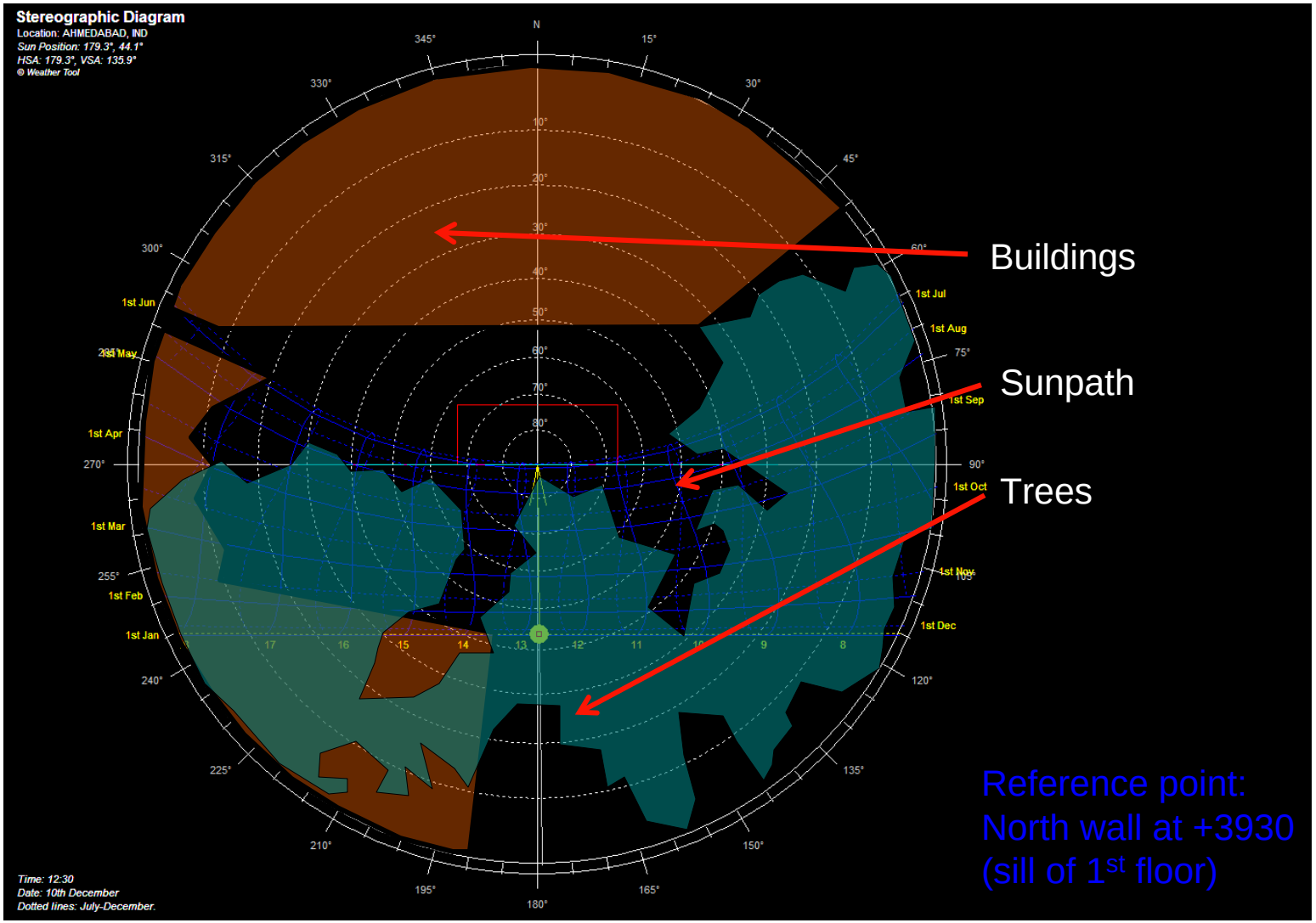


Building Exterior Views



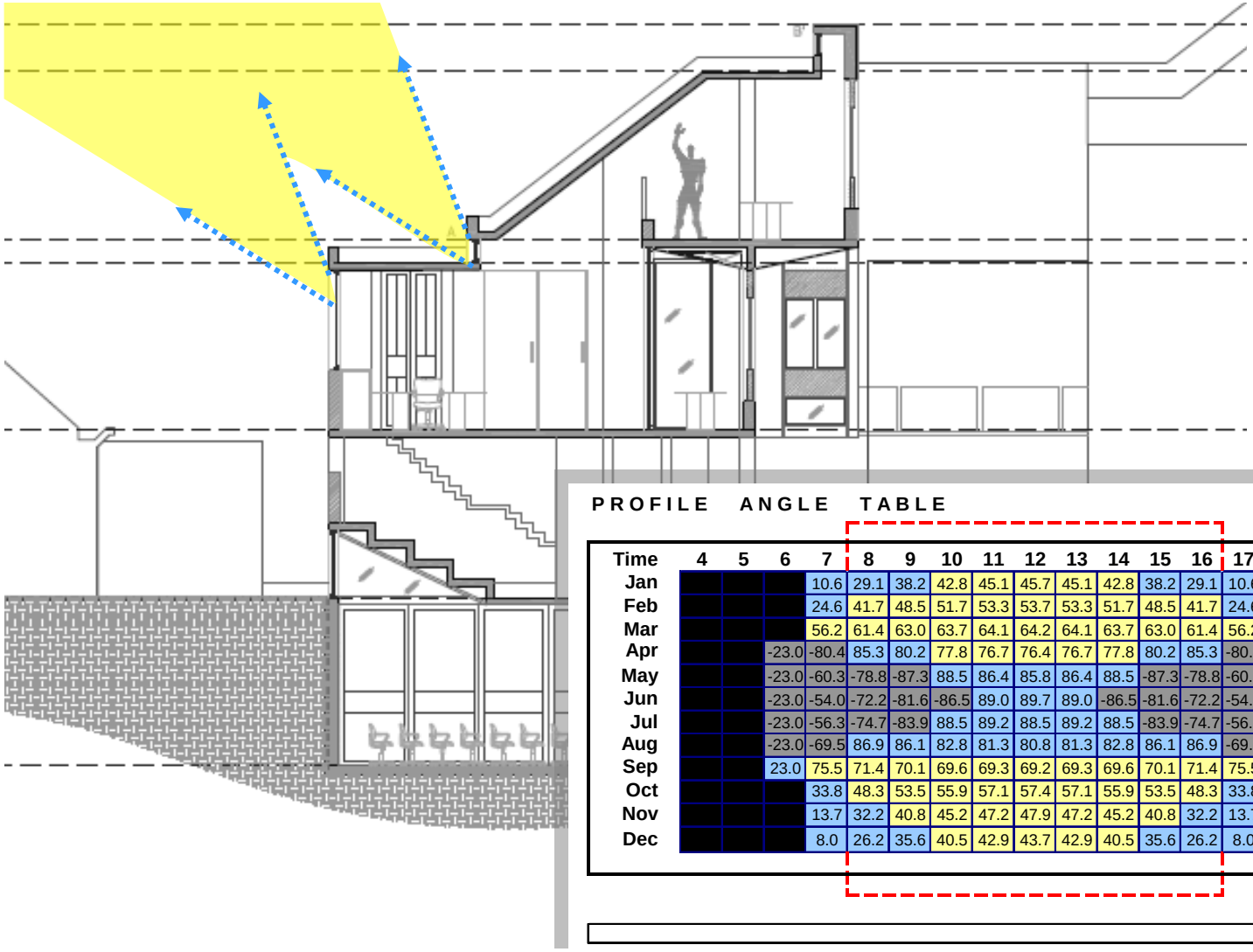
Daylighting Parameters

Sunpath Diagram



Direct Sun Access Needed

Daylighting 40° Minimum, 80° Maximum



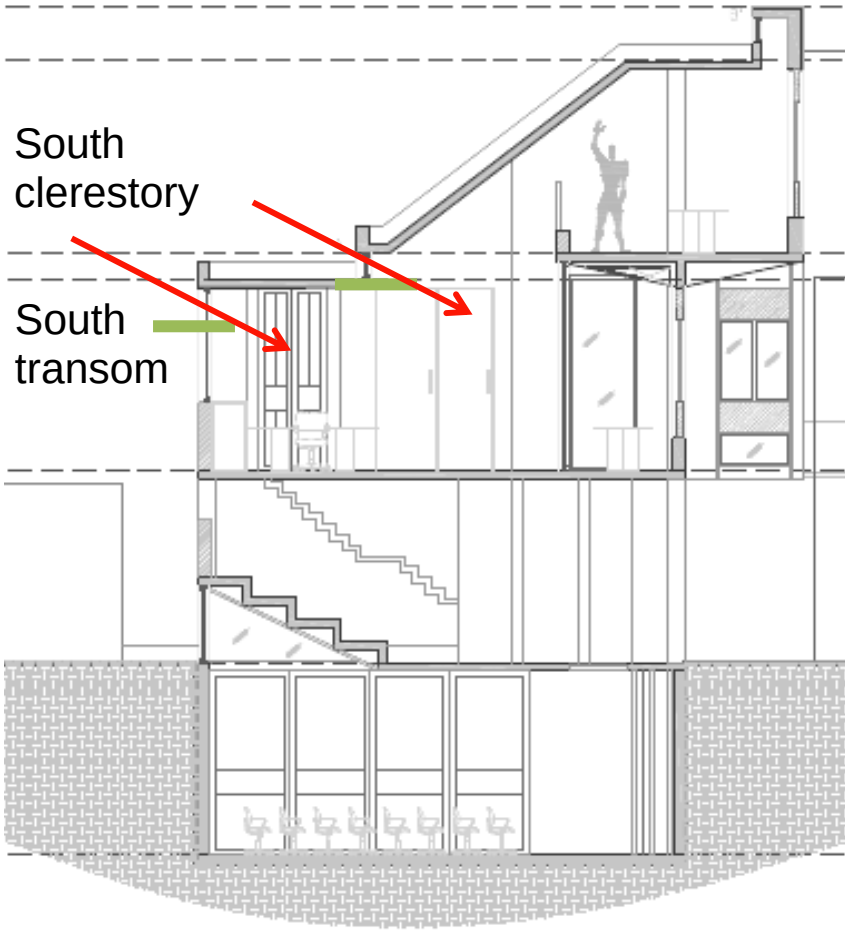
PROFILE ANGLE TABLE

Time	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Jan				10.6	29.1	38.2	42.8	45.1	45.7	45.1	42.8	38.2	29.1	10.6				
Feb				24.6	41.7	48.5	51.7	53.3	53.7	53.3	51.7	48.5	41.7	24.6				
Mar				56.2	61.4	63.0	63.7	64.1	64.2	64.1	63.7	63.0	61.4	56.2				
Apr			-23.0	-80.4	85.3	80.2	77.8	76.7	76.4	76.7	77.8	80.2	85.3	-80.4	-23.0			
May			-23.0	-60.3	-78.8	-87.3	88.5	86.4	85.8	86.4	88.5	-87.3	-78.8	-60.3	-23.0			
Jun			-23.0	-54.0	-72.2	-81.6	-86.5	89.0	89.7	89.0	-86.5	-81.6	-72.2	-54.0	-23.0			
Jul			-23.0	-56.3	-74.7	-83.9	88.5	89.2	88.5	89.2	88.5	-83.9	-74.7	-56.3	-23.0			
Aug			-23.0	-69.5	86.9	86.1	82.8	81.3	80.8	81.3	82.8	86.1	86.9	-69.5	-23.0			
Sep			23.0	75.5	71.4	70.1	69.6	69.3	69.2	69.3	69.6	70.1	71.4	75.5	23.0			
Oct				33.8	48.3	53.5	55.9	57.1	57.4	57.1	55.9	53.5	48.3	33.8				
Nov				13.7	32.2	40.8	45.2	47.2	47.9	47.2	45.2	40.8	32.2	13.7				
Dec				8.0	26.2	35.6	40.5	42.9	43.7	42.9	40.5	35.6	26.2	8.0				

South facing wall

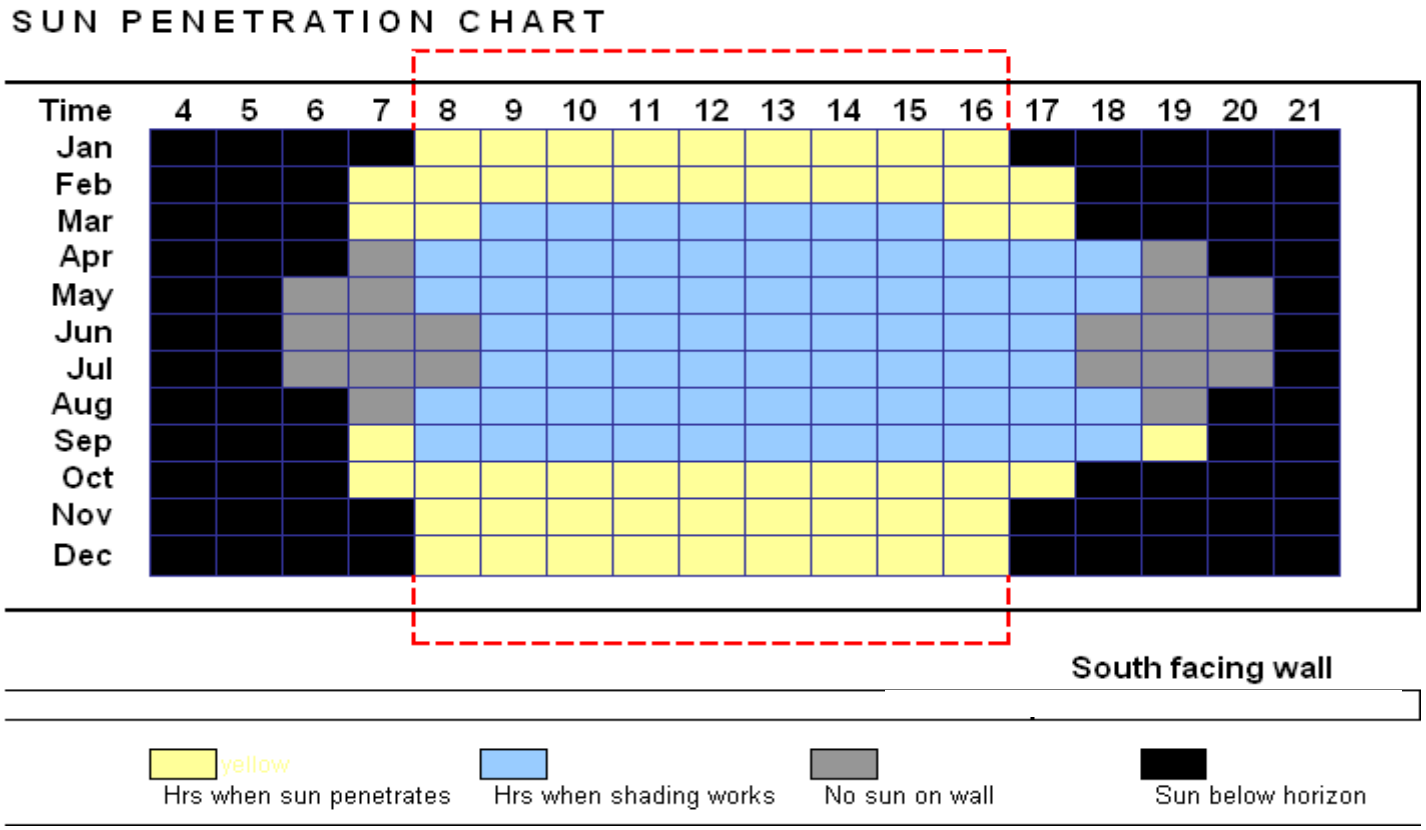
Sun Penetration Analysis Objectives

- Optimize shading elements
  - Basement south monitor
  - 1st floor south window light-shelf (translucent material)
  - 1st floor clerestory light-shelf (w/ triangular fins every 1800 mm)
  - Minimize summer heat gain
  - Minimize direct sun glare
- Use optimized shading elements for luminance analysis
  - Clear sky condition
  - Cloudy sky condition
  - Daylight autonomy
  - Useful Daylight Index



Sun Control Analysis

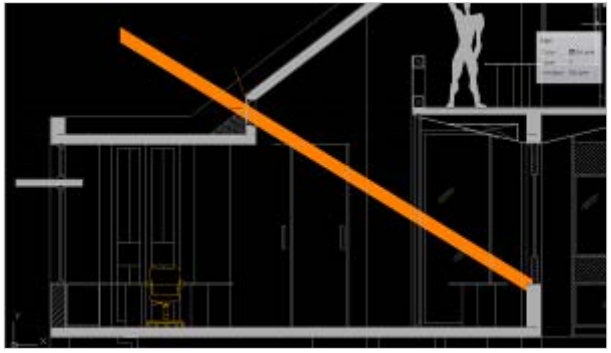
Sample Chart



Sun Control Analysis

South Facing Clerestory

Base Case



Time	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Jan				12.2	30.7	39.6	44.1	46.2	46.9	46.2	44.1	39.6	30.7	12.2				
Feb				29.5	45.3	51.3	54.1	55.4	55.8	55.4	54.1	51.3	45.3	29.5				
Mar				65.4	66.2	66.4	66.5	66.6	66.6	66.6	66.5	66.4	66.2	65.4				
Apr			-23.0	-74.6	89.3	83.2	80.3	79.0	78.6	79.0	80.3	83.2	89.3	-74.6	-23.0			
May			-23.0	-58.2	-76.7	-85.6	89.9	87.8	87.1	87.8	89.9	-85.6	-76.7	-58.2	-23.0			
Jun			-23.0	-53.8	-72.1	-81.5	-86.4	88.8	89.6	88.8	-86.4	-81.5	-72.1	-53.8	-23.0			
Jul			-23.0	-57.8	-76.3	-85.2	89.7	88.1	87.4	88.1	89.7	-85.2	-76.3	-57.8	-23.0			
Aug			-23.0	-74.2	89.6	83.4	80.5	79.2	78.8	79.2	80.5	83.4	89.6	-74.2	-23.0			
Sep				66.2	66.6	66.7	66.8	66.8	66.8	66.8	66.8	66.7	66.6	66.2				
Oct				28.2	44.4	50.6	53.5	54.8	55.2	54.8	53.5	50.6	44.4	28.2				
Nov				11.8	30.3	39.2	43.7	45.9	46.6	45.9	43.7	39.2	30.3	11.8				
Dec				7.8	26.1	35.5	40.4	42.8	43.6	42.8	40.4	35.5	26.1	7.8				

Option 1

Time	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Jan				12.2	30.7	39.6	44.1	46.2	46.9	46.2	44.1	39.6	30.7	12.2				
Feb				29.5	45.3	51.3	54.1	55.4	55.8	55.4	54.1	51.3	45.3	29.5				
Mar				65.4	66.2	66.4	66.5	66.6	66.6	66.6	66.5	66.4	66.2	65.4				
Apr			-23.0	-74.6	89.3	83.2	80.3	79.0	78.6	79.0	80.3	83.2	89.3	-74.6	-23.0			
May			-23.0	-58.2	-76.7	-85.6	89.9	87.8	87.1	87.8	89.9	-85.6	-76.7	-58.2	-23.0			
Jun			-23.0	-53.8	-72.1	-81.5	-86.4	88.8	89.6	88.8	-86.4	-81.5	-72.1	-53.8	-23.0			
Jul			-23.0	-57.8	-76.3	-85.2	89.7	88.1	87.4	88.1	89.7	-85.2	-76.3	-57.8	-23.0			
Aug			-23.0	-74.2	89.6	83.4	80.5	79.2	78.8	79.2	80.5	83.4	89.6	-74.2	-23.0			
Sep				66.2	66.6	66.7	66.8	66.8	66.8	66.8	66.8	66.7	66.6	66.2				
Oct				28.2	44.4	50.6	53.5	54.8	55.2	54.8	53.5	50.6	44.4	28.2				
Nov				11.8	30.3	39.2	43.7	45.9	46.6	45.9	43.7	39.2	30.3	11.8				
Dec				7.8	26.1	35.5	40.4	42.8	43.6	42.8	40.4	35.5	26.1	7.8				

May be shaded by fins / trees

Option 2

Time	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Jan				12.2	30.7	39.6	44.1	46.2	46.9	46.2	44.1	39.6	30.7	12.2				
Feb				29.5	45.3	51.3	54.1	55.4	55.8	55.4	54.1	51.3	45.3	29.5				
Mar				65.4	66.2	66.4	66.5	66.6	66.6	66.6	66.5	66.4	66.2	65.4				
Apr			-23.0	-74.6	89.3	83.2	80.3	79.0	78.6	79.0	80.3	83.2	89.3	-74.6	-23.0			
May			-23.0	-58.2	-76.7	-85.6	89.9	87.8	87.1	87.8	89.9	-85.6	-76.7	-58.2	-23.0			
Jun			-23.0	-53.8	-72.1	-81.5	-86.4	88.8	89.6	88.8	-86.4	-81.5	-72.1	-53.8	-23.0			
Jul			-23.0	-57.8	-76.3	-85.2	89.7	88.1	87.4	88.1	89.7	-85.2	-76.3	-57.8	-23.0			
Aug			-23.0	-74.2	89.6	83.4	80.5	79.2	78.8	79.2	80.5	83.4	89.6	-74.2	-23.0			
Sep				66.2	66.6	66.7	66.8	66.8	66.8	66.8	66.8	66.7	66.6	66.2				
Oct				28.2	44.4	50.6	53.5	54.8	55.2	54.8	53.5	50.6	44.4	28.2				
Nov				11.8	30.3	39.2	43.7	45.9	46.6	45.9	43.7	39.2	30.3	11.8				
Dec				7.8	26.1	35.5	40.4	42.8	43.6	42.8	40.4	35.5	26.1	7.8				

Sun Penetration Analysis

Design Guidelines & Implications

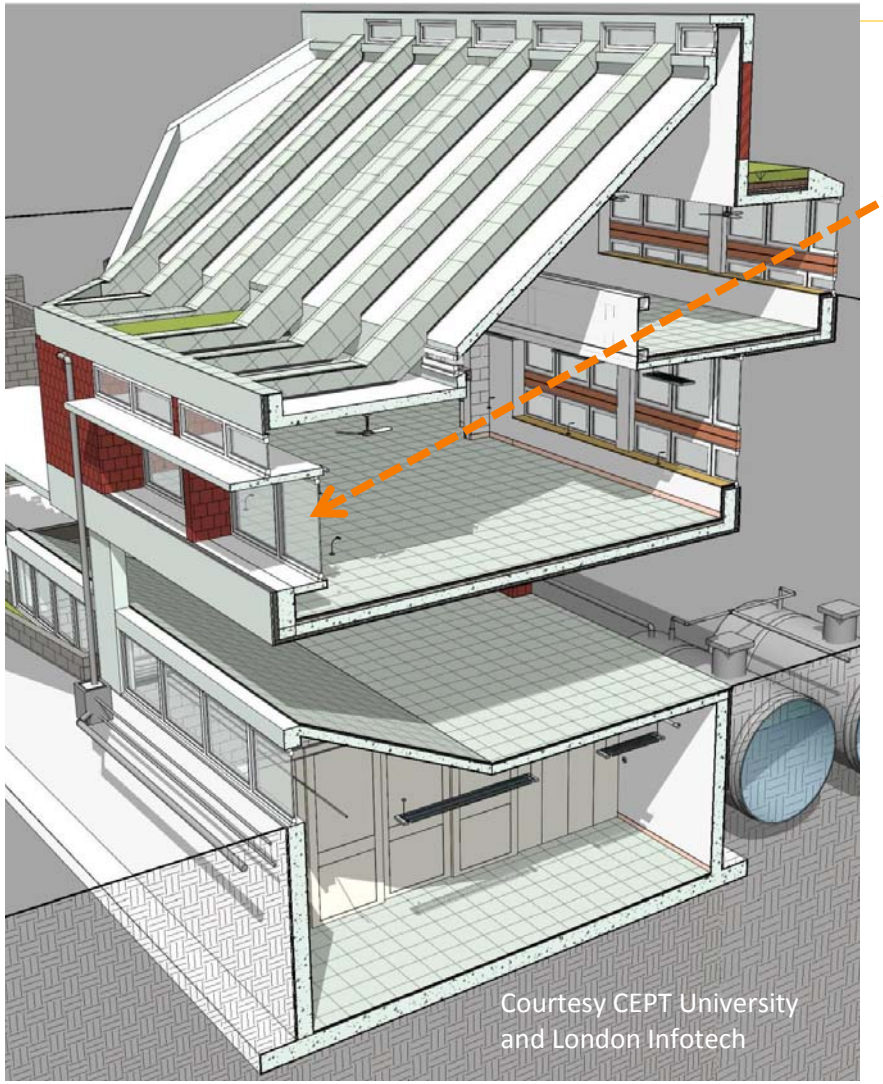
- South Clerestory
  - Provide 500 mm wide translucent light shelf
  - Low sun angles during winter morning and evening may get shaded by structural fins and adjacent trees
  - Trim exterior trees (min 40 deg angle and max 80 deg angle) to get direct sun for daylighting
- South Transom
  - Provide 500 mm wide translucent light shelf
  - An hour of sun penetration occurs during winter morning and evening at equipment lab
  - Two hours of sun penetration occur during winter morning and evening at circulation
  - No sun penetration at office desk
- South Vision
  - Provide 800 mm exterior sun-shade
  - Shading works from March thru' September
  - Provide blinds/shades for shading during other months and also to control glare
- Basement
  - Provide 500 mm exterior sun-shade or interior light-shelf
  - Shading works from March thru' September
  - Provide bottom-up translucent shades for shading during other months and also to control glare
  - Adjacent trees may provide shading during other months

Daylighting Analysis

Daylight Model Parameters

- Model Parameters
  - Sky conditions: Clear / Cloudy
  - Simulation Day / Time: Annual + September 21, 1:00 PM
  - Simulation tools:
    - Radiance™
    - DAYSIM™
  - Location: Ahmedabad, India
  - Latitude: 23 N

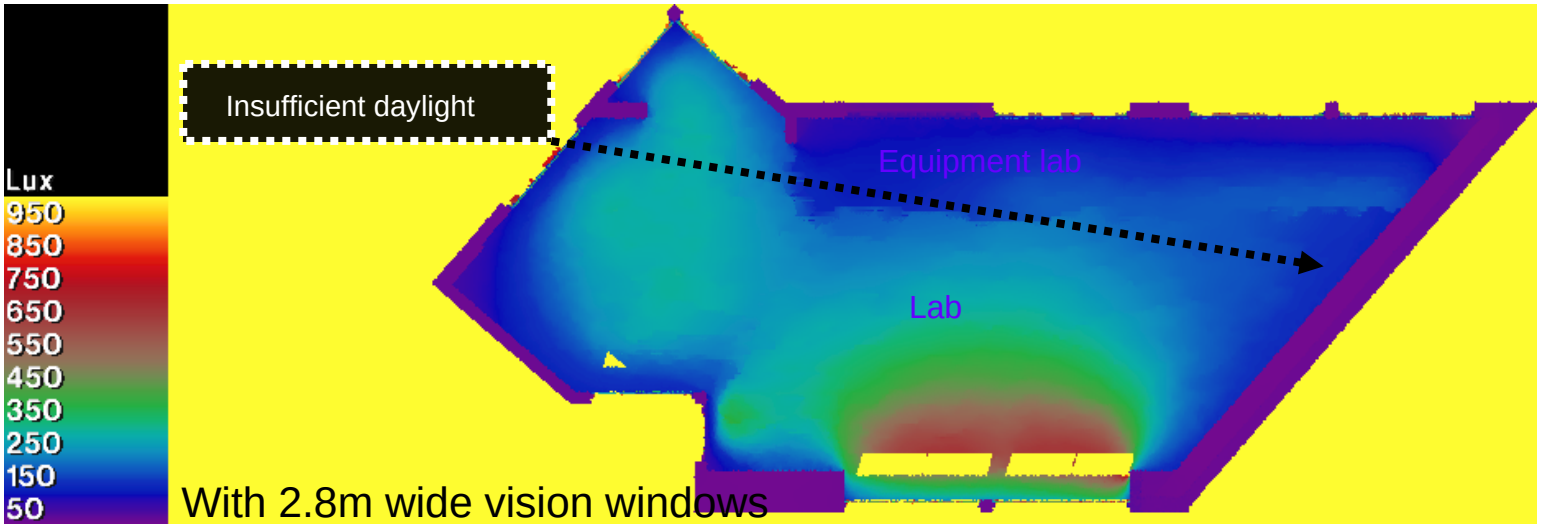
Daylighting Options

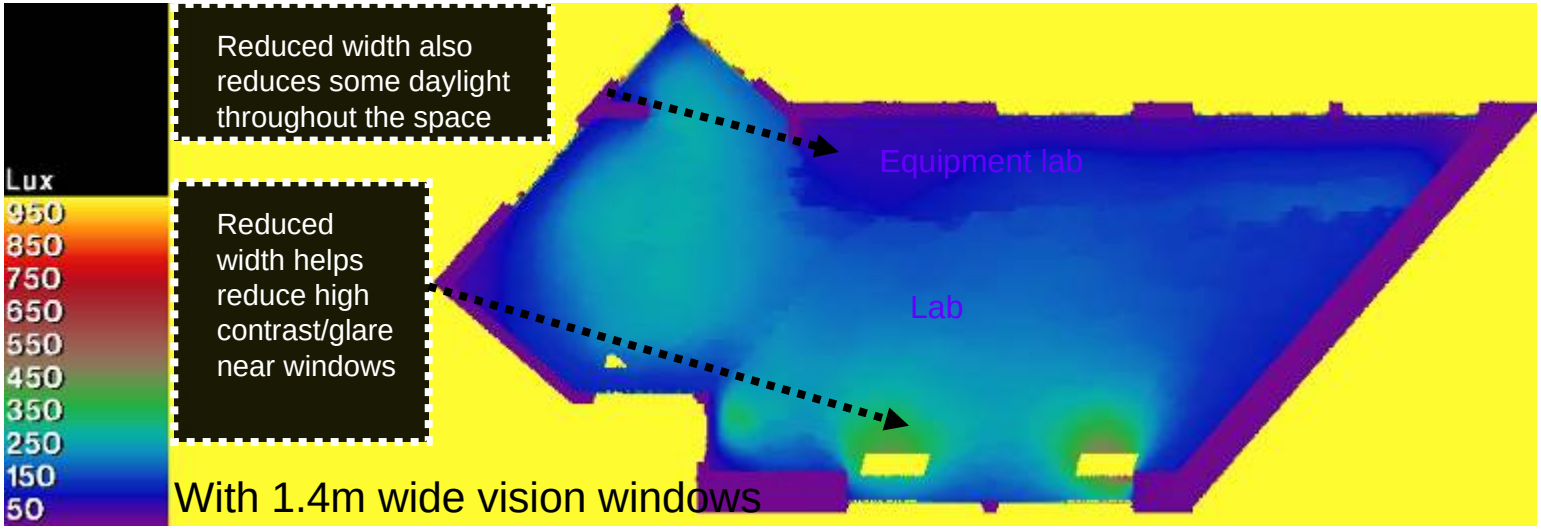


- I Floor
  - Reduce vision windows on South
    - Base case: 2 nos 2.8m wide
    - Alternate: 2 nos 1.4m wide
  - Reduced Clerestory
    - Base case: 450mm ht
    - Alternate: 300mm ht
  - Change glass partition to opaque wall
    - Base case: Glass partition wall
    - Alternate: Opaque partition wall

Illuminance of I Floor

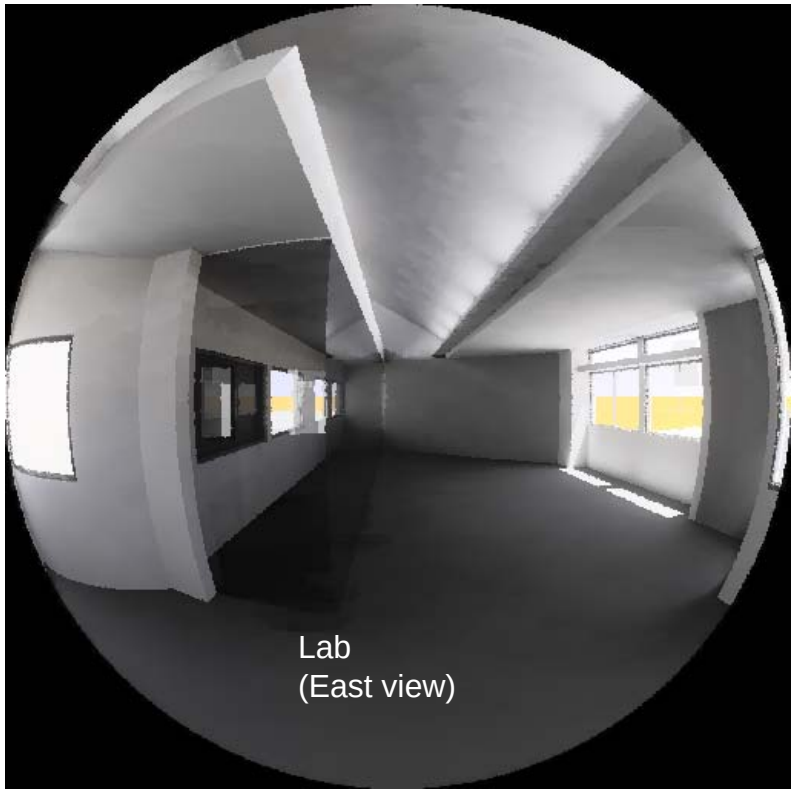
Clear Sky, September 21 at 1.00 pm





Luminance Views

Clear Sky I Floor

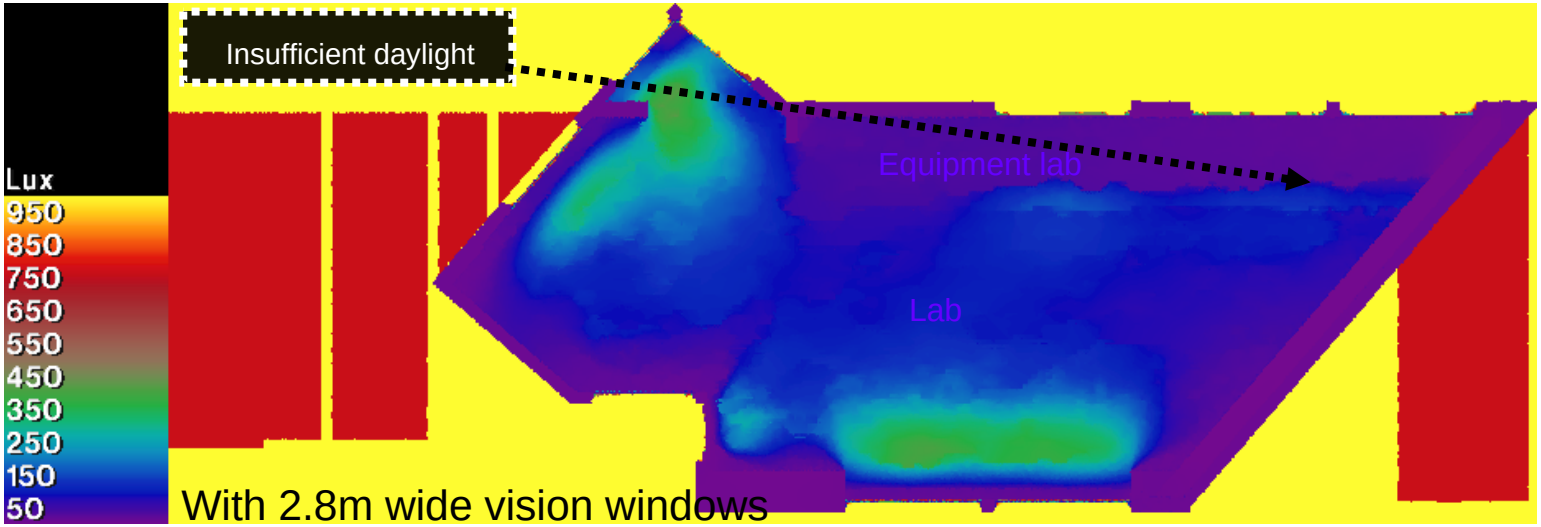


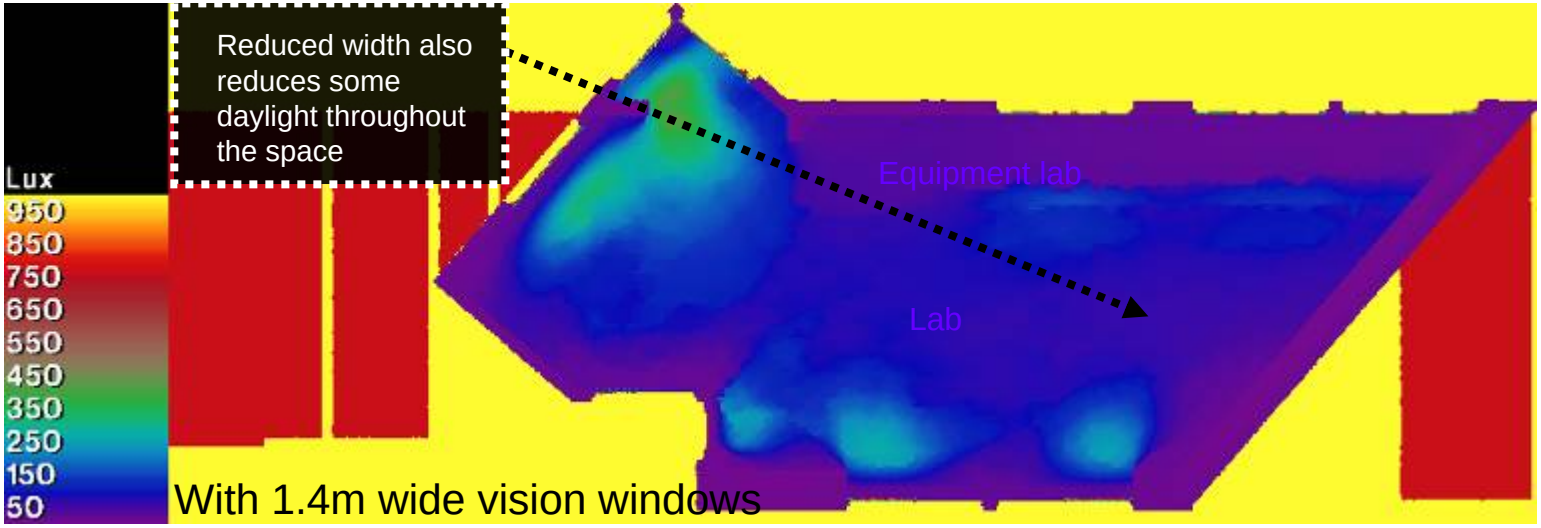
With 2.8m wide
vision windows

With 1.4m wide
vision windows

Illuminance of I Floor

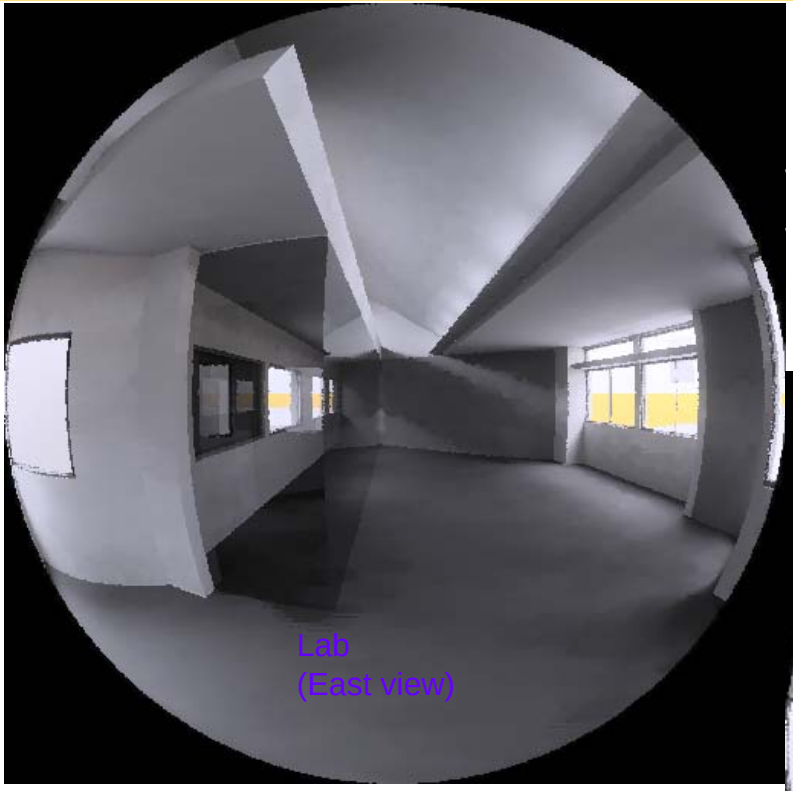
Cloudy Sky, September 21 at 1.00 pm





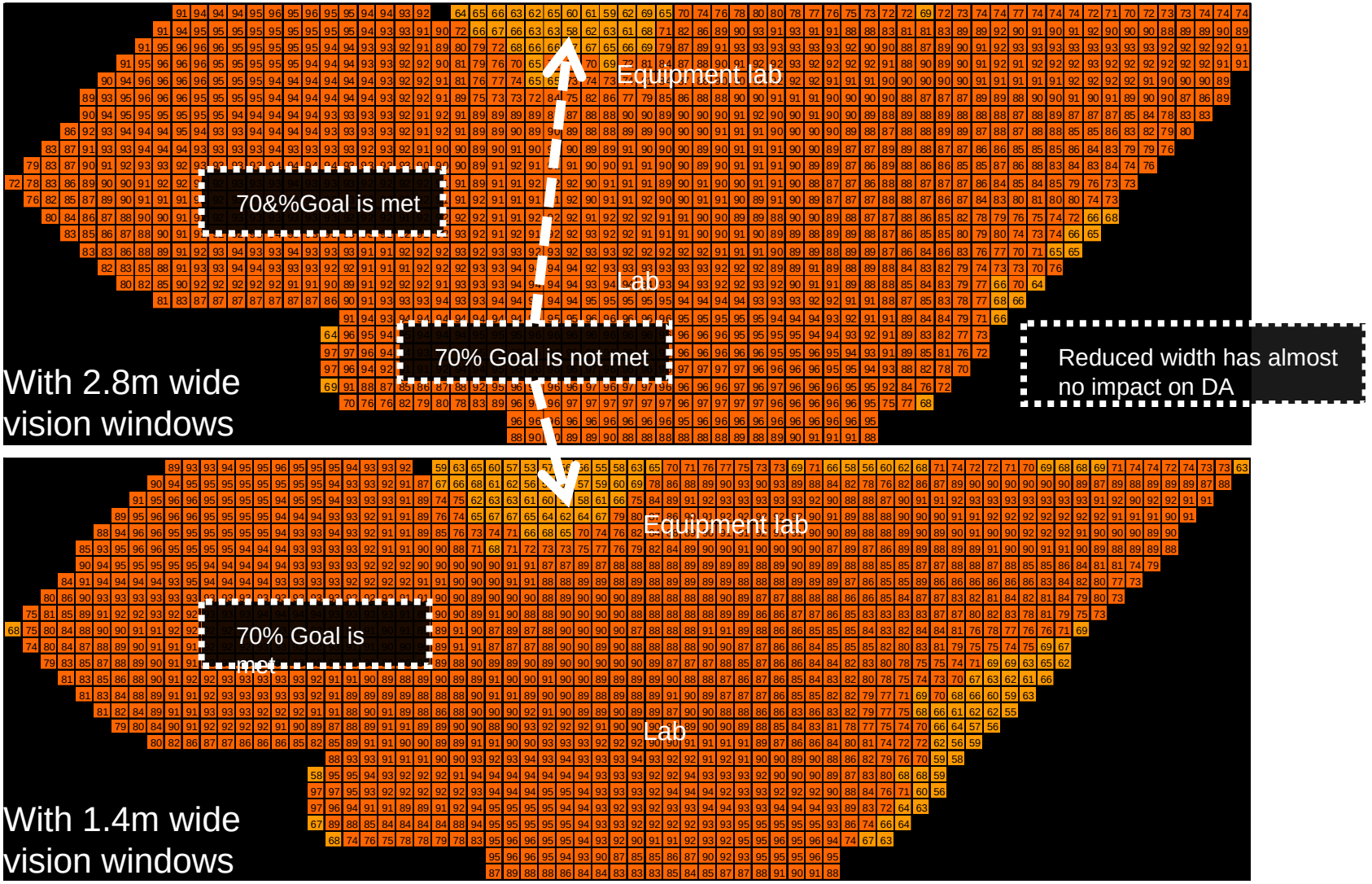
Luminance Views

Cloudy Sky I Floor



Continuous Daylight Autonomy

Goal of 300 lux more than 70% of the Time - Work Plane I Floor



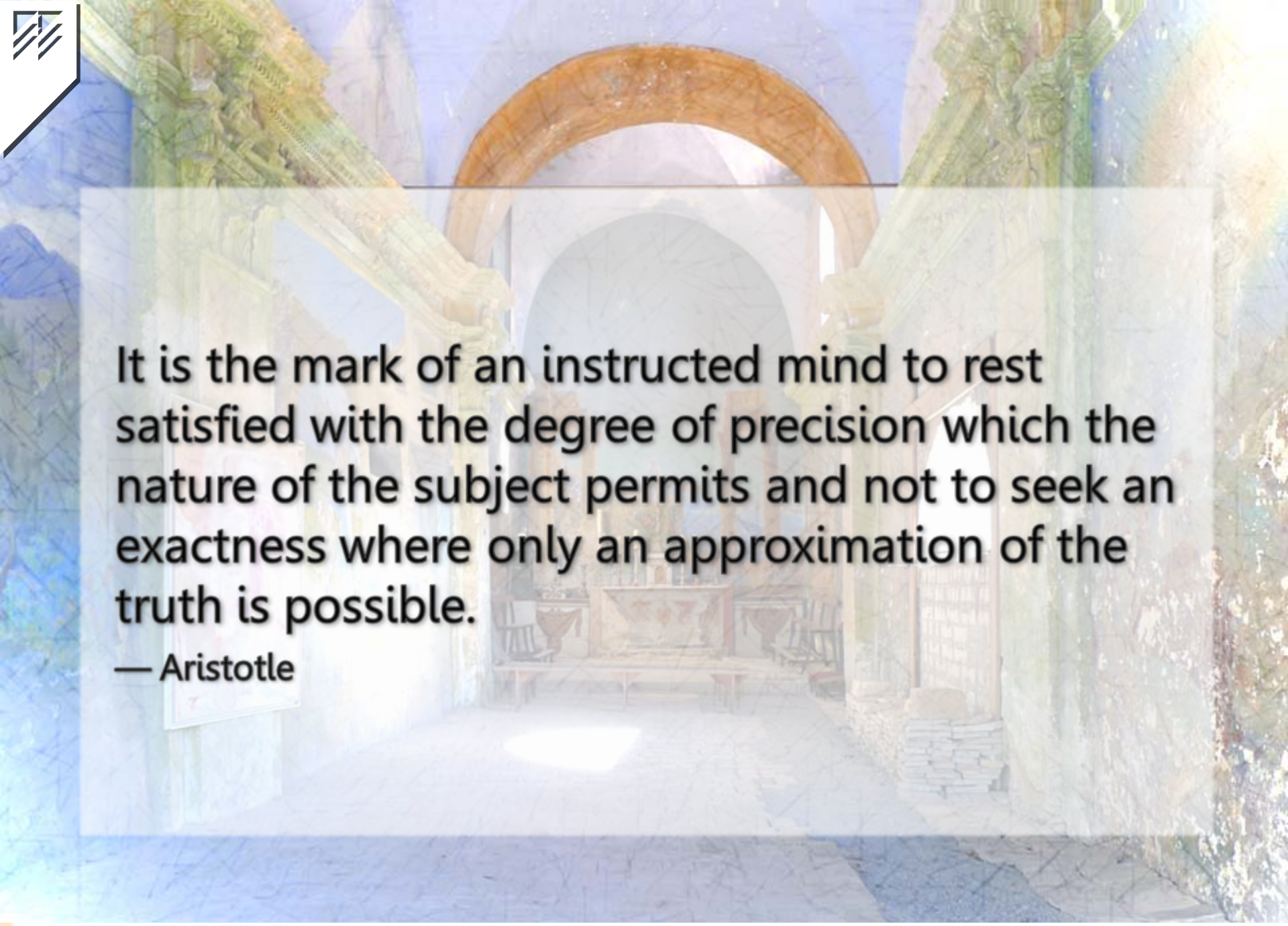
Example Conclusions

First Floor

- Reduced vision windows on South
  - Has no significant impact on DA
  - Helps reduce excess daylight near windows
- Reduced Clerestory
  - Has no significant impact on daylight levels
  - Clerestory can be reduced to 300 mm ht
- Changing glass partition to opaque wall
  - Split Glass partition wall as clear and opaque bands:
    - Top: Opaque
    - Middle: Transparent
    - Bottom: Opaque
  - Increase North windows VT to 67%

Recap

- Daylighting offers good potential for energy savings
  - Need well coordinated designs to achieve it
- Daylighting metrics are evolving
  - From Daylight Factor
  - To Daylight Autonomy Factor
- Lighting needs need to be balanced against heating and cooling loads



Thank You

The Weidt Group®

The Company for Energy Decision Makers℠

twgi.com

Collaboration Analysis Research