The Weidt Group®
The Company for Energy Decision Makers℠
twgi.com
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℠ 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
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
“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

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

Source: XKCD.com
Agenda

• Bare Bones Need to Know
• Codes in Context
• Daylighting Old School to New School
• Examples
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
The greatest obstacle to discovery is not ignorance — it is the illusion of knowledge.
— Daniel J Boorstin, Librarian of Congress
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

IES Recommended Foot-candles

Watts psf

FC
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

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

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

The Problem...
Prescriptive instructions are hedged
Performance is not comparatively analyzed

Consistency is the last refuge of the unimaginative.
— Oscar Wilde
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
- Too much glass causes glare
- Too much glass causes thermal discomfort
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.
Office – Operating Costs
Low-E Clear 100,000 SF Potential Operating Savings $21,800 per Year

Annual Energy Operating Costs per 100KSF

<table>
<thead>
<tr>
<th>Savings</th>
<th>$7,595</th>
<th>$-</th>
<th>$(10,243)</th>
<th>$(21,007)</th>
</tr>
</thead>
<tbody>
<tr>
<td>% WtW</td>
<td>20%</td>
<td>40%</td>
<td>60%</td>
<td>80%</td>
</tr>
</tbody>
</table>

© 2012 The Weidt Group
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

Reach Daylight saturation at 40 to 50% Glazed area
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

<table>
<thead>
<tr>
<th>Component</th>
<th>Perfection</th>
<th>Excellent</th>
<th>Good</th>
<th>Fair</th>
<th>Poor</th>
</tr>
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<tbody>
<tr>
<td>Window size</td>
<td>100%</td>
<td>98%</td>
<td>95%</td>
<td>100%</td>
<td>85%</td>
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<tr>
<td>Sun shading</td>
<td>100%</td>
<td>98%</td>
<td>95%</td>
<td>91%</td>
<td>85%</td>
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<tr>
<td>Lighting design</td>
<td>100%</td>
<td>99%</td>
<td>95%</td>
<td>85%</td>
<td>85%</td>
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<tr>
<td>Calibration</td>
<td>100%</td>
<td>95%</td>
<td>95%</td>
<td>90%</td>
<td>85%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100%</strong></td>
<td><strong>90%</strong></td>
<td><strong>81%</strong></td>
<td><strong>70%</strong></td>
<td><strong>52%</strong></td>
</tr>
</tbody>
</table>
Experts gather and ask “What is good daylighting?”
Others will decide what is best for you according to their own interests.

— Heard it from a friend
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
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
The only thing harder to change than law is custom.

Will Durant—The History of Western Civilization
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

- Mostly cloudy
- Mix of clear and cloudy
- Usually clear skies

Cloudy Days
- 52 - 60
- 60 - 90
- 90 - 120
- 120 - 150
- 150 - 180
- 180 - 210
- 210 - 240
- 240 - 270
- 270 - 300
- 300 and above
How We Have Measured

- Old School
- New School
# Old School

## Traditional Overcast Sky Daylighting

<table>
<thead>
<tr>
<th>WINDOW</th>
<th>WALL</th>
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<tbody>
<tr>
<td>0.75'</td>
<td>2.4%</td>
</tr>
<tr>
<td>2.25'</td>
<td>4.0%</td>
</tr>
<tr>
<td>3.75'</td>
<td>4.5%</td>
</tr>
<tr>
<td>5.25'</td>
<td>4.3%</td>
</tr>
<tr>
<td>6.75'</td>
<td>3.8%</td>
</tr>
<tr>
<td>8.25'</td>
<td>3.4%</td>
</tr>
<tr>
<td>9.75'</td>
<td>3.0%</td>
</tr>
<tr>
<td>11.25'</td>
<td>2.6%</td>
</tr>
<tr>
<td>12.75'</td>
<td>2.4%</td>
</tr>
<tr>
<td>14.25'</td>
<td>2.1%</td>
</tr>
<tr>
<td>15.75'</td>
<td>2.0%</td>
</tr>
<tr>
<td>17.25'</td>
<td>1.8%</td>
</tr>
<tr>
<td>18.75'</td>
<td>1.7%</td>
</tr>
<tr>
<td>20.25'</td>
<td>1.6%</td>
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<tr>
<td>21.75'</td>
<td>1.6%</td>
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<tr>
<td>23.25'</td>
<td>1.5%</td>
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<tr>
<td>24.75'</td>
<td>1.4%</td>
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<tr>
<td>26.25'</td>
<td>1.4%</td>
</tr>
<tr>
<td>27.75'</td>
<td>1.3%</td>
</tr>
<tr>
<td>29.25'</td>
<td>1.3%</td>
</tr>
</tbody>
</table>

**To much contrast:** visual strain

**To little light**

**Uniformity ratio > 10**

**Daylight factor < 2%**

**Daylight factor and uniformity ok**
Old School
Energy Optimized Daylighting

<table>
<thead>
<tr>
<th>Window Area and Placement Options</th>
<th>Energy Cost /sf</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>$0.60</td>
</tr>
<tr>
<td>B</td>
<td>$0.75</td>
</tr>
<tr>
<td>C</td>
<td>$0.80</td>
</tr>
<tr>
<td>D</td>
<td>$0.85</td>
</tr>
<tr>
<td>E</td>
<td>$0.90</td>
</tr>
<tr>
<td>No Daylighting</td>
<td>$1.05</td>
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<tr>
<td>Dimming Daylighting</td>
<td>$1.10</td>
</tr>
<tr>
<td>Optimum</td>
<td>$1.20</td>
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</table>
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
Surface Reflectance

Lower reflectance yields lower light levels

<table>
<thead>
<tr>
<th></th>
<th>Typical</th>
<th>Design</th>
<th>Goal</th>
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</thead>
<tbody>
<tr>
<td>Ceiling</td>
<td>80%</td>
<td>82 - 90%</td>
<td>90%</td>
</tr>
<tr>
<td>Wall</td>
<td>50%</td>
<td>50 - 80%</td>
<td>50%</td>
</tr>
<tr>
<td>Floor</td>
<td>20%</td>
<td>-</td>
<td>20%</td>
</tr>
<tr>
<td>Glass Trans</td>
<td>50%</td>
<td>31%</td>
<td>70%</td>
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</tbody>
</table>
Blinds assumed for vision windows

Sun penetration during afternoon hours throughout year

<table>
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<tr>
<th>Time</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
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</tr>
</tbody>
</table>

Add description of alternatives here.

- Yellow when sun penetrates
- Light blue when shading works
- Dark grey when no sun on wall
- Dark grey when sun below horizon
Old School Reading Room
West Facing Clerestory Example With Blinds/Shades

Fixed blinds/Solera/Okasolar

Sun Penetration Chart

Davenport Public Library

West facing wall

No sun penetration

Time
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec

Hrs when sun penetrates
Hrs when shading works
No sun on wall
Sun below horizon

4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21

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### Old School Key Spaces

**Example Office – Curtain Wall**

#### Distribution in plan

<table>
<thead>
<tr>
<th>DESIGN 31% VT</th>
<th>Average of occupied hours</th>
<th>1465</th>
<th>Alternative 9.8 head, slope clg, 31% VT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2%</td>
<td>0.6%</td>
<td>1.1%</td>
<td>1.6%</td>
</tr>
<tr>
<td>2.0%</td>
<td>2.5%</td>
<td>3.0%</td>
<td>3.5%</td>
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<tr>
<td>4.0%</td>
<td>4.5%</td>
<td>5.0%</td>
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<tr>
<td>8.0%</td>
<td>8.5%</td>
<td>9.0%</td>
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</table>

#### Table

<table>
<thead>
<tr>
<th>FootCandles</th>
<th>Sky condition</th>
<th>Average of occupied hours</th>
<th>1465</th>
<th>Alternative 9.8 head, slope clg, 31% VT</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;40 fc</td>
<td>20-40 fc</td>
<td>5-20 fc</td>
<td>&lt;5 fc</td>
<td></td>
</tr>
</tbody>
</table>

#### Example

- **FootCandles**: 9.8
- **Sky condition**: head, slope clg
- **Average of occupied hours**: 31% VT

---

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Key Spaces
Example Office - Curtainwall

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

![Graph showing light profile perpendicular to window wall with two lines representing Design 31% VT and Alternative 9.8 head, slope clg, 31% VT. The graph shows foot candles on the y-axis and distance in feet on the x-axis.](chart)
To find a fault is easy; to do better may be difficult.
— Plutarch
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 Daylighting Subcommittee 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
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

> 55% sDA 300, 50%

Area  Lux  Hours
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

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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

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- Predesign goal 100% of space daylit
- Lighting level of 300 - 500 lux
Daylighting Parameters
Direct Solar Radiation

Weekly Summary
Direct Solar Radiation (W/in²)
Location: Ahmedabad, India (22.51°, 72.8°N)
© Weidt Group
Building Exterior Views
Daylighting Parameters

Sunpath Diagram

Reference point: North wall at +3930 (sill of 1st floor)
Direct Sun Access Needed
Daylighting 40° Minimum, 80° Maximum

South facing wall

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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 Penetration Chart

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- **Yellow**: Hrs when sun penetrates
- **Blue**: Hrs when shading works
- **Gray**: No sun on wall
- **Black**: Sun below horizon

**South facing wall**
## Sun Control Analysis

### South Facing Clerestory

### Base Case

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### Option 1

- **500 light shelf (39 deg cut-off)**

### Option 2

- **800 light shelf (30 deg cut-off)**

May be shaded by fins / trees

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### Sun Penetration Analysis

#### Design Guidelines & Implications

<table>
<thead>
<tr>
<th>South Clerestory</th>
<th>South Vision</th>
<th>Basement</th>
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<tbody>
<tr>
<td>Provide 500 mm wide translucent light shelf</td>
<td>Provide 800 mm exterior sun-shade</td>
<td>Provide 500 mm exterior sun-shade or interior light-shelf</td>
</tr>
<tr>
<td>Low sun angles during winter morning and evening may get shaded by structural fins and adjacent trees</td>
<td>Shading works from March thru’ September</td>
<td>Shading works from March thru’ September</td>
</tr>
<tr>
<td>Trim exterior trees (min 40 deg angle and max 80 deg angle) to get direct sun for daylighting</td>
<td>Provide blinds/shades for shading during other months and also to control glare</td>
<td>Provide bottom-up translucent shades for shading during other months and also to control glare</td>
</tr>
<tr>
<td>An hour of sun penetration occurs during winter morning and evening at equipment lab</td>
<td>No sun penetration at office desk</td>
<td>Adjacent trees may provide shading during other months</td>
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<td>Two hours of sun penetration occur during winter morning and evening at circulation</td>
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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 1 Floor
Clear Sky, September 21 at 1.00 pm

With 2.8m wide vision windows
- Insufficient daylight
- Reduced width helps reduce high contrast/glare near windows
- Reduced width also reduces some daylight throughout the space

With 1.4m wide vision windows
Luminance Views
Clear Sky I Floor

With 2.8m wide vision windows

Lab (East view)

With 1.4m wide vision windows

Lab (East view)
Illuminance of I Floor
Cloudy Sky, September 21 at 1.00 pm

With 2.8m wide vision windows
Insufficient daylight

With 1.4m wide vision windows
Reduced width also reduces some daylight throughout the space
Luminance Views
Cloudy Sky I Floor

Lab (East view)

Lab (East view)
Continuous Daylight Autonomy
Goal of 300 lux more than 70% of the Time - Work Plane I Floor

With 2.8m wide vision windows

With 1.4m wide vision windows

Reduced width has almost no impact on DA

70% Goal is not met

70% Goal is met

70&%Goal is met
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
It is the mark of an instructed mind to rest satisfied with the degree of precision which the nature of the subject permits and not to seek an exactness where only an approximation of the truth is possible.

— Aristotle
Thank You

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Collaboration  Analysis  Research

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