ERIC COREY FREED

Founding Principal, organic**architect**

nearly 20 years of experience in green building
LEED Accredited Professional, US Green Building Council
Author: "Green Building & Remodeling for Dummies"
Author: "Green$ense: How to Pay For and Profit From 50 Green Home Projects"
Author: "Sustainable School Architecture"
Founding Chair of Architecture, The San Francisco Design Museum
Board of Directors, Architects/ Designers/ Planners for Social Responsibility
Advisory Boards: Green Home Guide, Ecosa Capital, West Coast Green
Co-Founder, ecoTECTURE: The Online Journal of Ecological Design
Columnist: Natural Home Magazine, GreenerBuildings.com, Luxe Magazine
Developer: Sustainable Design Curriculum Academy of Art University
University of California Berkeley

CONNECT:
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CONTACT:
415.474.7777
info@organicarchitect.com

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ericcoreyfreed eric@organicarchitect.com

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organicarchitect.com/downloads/daylighting.pdf

L11D09 DAYLIGHTING IN SCHOOLS

9:00am – 10:25am
ERIC COREY FREED
Founding Principal
organicARCHITECT, San Francisco

Daylighting strategies for schools, from initial planning, through design and operation.

10:25am – 10:35am
BREAK

10:35am – 12:00pm
BARBARA GHERRI
PhD Student
Architect Universita' Degli Studi di Parma, Parma, Italy

Consideration of psychological, physiological effects and energy performance from Daylighting.


ericcoreyfreed
FOUNDING PRINCIPAL
organicarchitect
Honorary Fellow, Institute of Green Professionals
LEED Accredited Professional

SAN FRANCISCO MAGAZINE
BEST OF THE BAY AREA
WINNER

Best Green Architect
2005

LOWE'S

UNICO

McKESSON
Empowering Healthcare

WILLIAMS-SONOMA

FULLBLOOM BAKING CO.

PETCHITECTURE
goes green

MAYACAMAS
·R·A·N·C·H·

LIEBHERR

NanaWall®
The Leader in Opening Glass Walls

arterra

PIXAR
ANIMATION STUDIOS

Autodesk®

NEW WORLD™
HOME

LOS VALLES

SIMPATICO

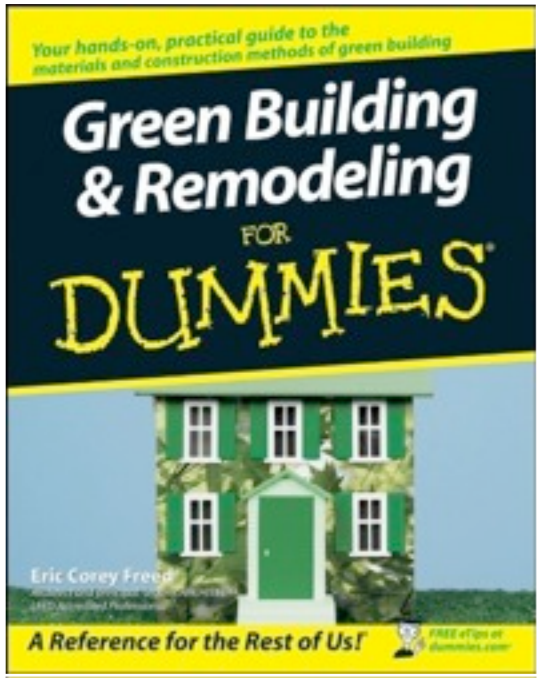
LUTRON®

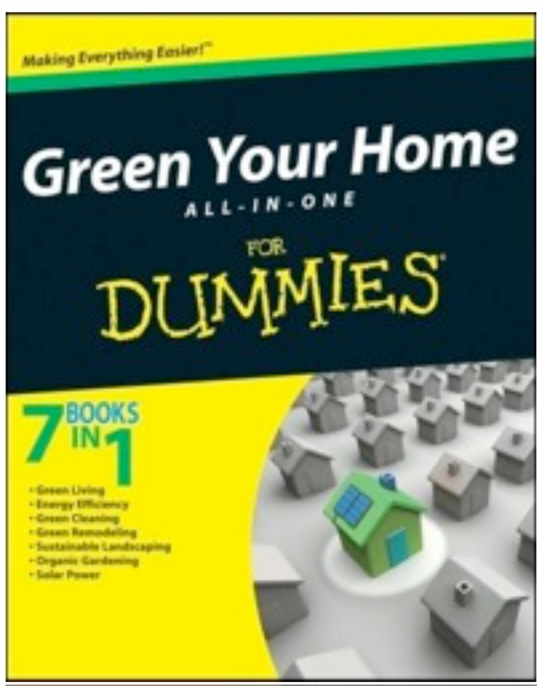
ACADEMY *of* ART
UNIVERSITY

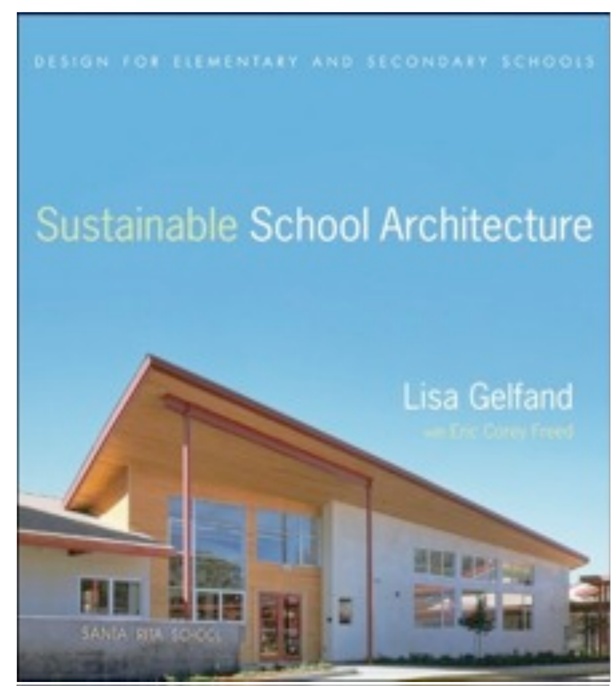
UC Berkeley Extension

CityUniversity
of Seattle

UNIVERSITY OF CALIFORNIA
UCRIVERSIDE







Books written by Eric Corey Freed

SEEING GREEN

THE ROOF HOLDS SECRETS AND UNTAPPED POTENTIAL WHEN IT COMES TO GREEN HOME DESIGN. TRADITIONALLY A PLACE FOR CHRISTMAS LIGHTS AND LOST FRISBEES, THE ROOF OF MOST HOMES COULD POSSIBLY PRODUCE ALL OF A HOME'S ENERGY NEEDS. THIS FEAT OF MAGIC COMES FROM SOLAR PANELS, AN OLD TECHNOLOGY.

SOLAR PANELS (AKA: PHOTOVOLTAIC PANELS, OR PV PANELS) ARE THE LATEST STATUS SYMBOL, ALONGSIDE HYBRID CARS, FOR THOSE WHO LIKE TO SHOW OFF THEIR GREEN APTITUDE. AND WITH GREEN CONSCIOUSNESS ON THE RISE, BARE ROOFS MIGHT GO THE WAY OF THE DINOSAUR. RECENTLY OVERHEARD AT A CONFERENCE: "EVERYONE WHO IS ANYONE PUTS SOLAR ON THEIR ROOFS."

LIGHT YEARS
The Earth receives more energy from the sun in just one hour than the world uses in an entire year.

SOLAR INSPIRATION

WRITTEN BY **ERIC COREY FREED**

CURRENT THINKING

The principle behind a solar panel is simpler than you might expect. French scientist Edmond Becquerel in 1839 first discovered the photovoltaic effect—which makes solar power possible. When sunlight strikes the panel's thin wafer of silicon, the electrons get "excited" and start moving, and this produces electrical current.

Companies are seeking ways to produce more efficient solar panels, yet all panels essentially use the same type of solar cells used since Bell Labs produced the first silicon solar panels in 1954. Consider this: It is a 53-year-old product based on a 168-year-old scientific discovery. With that kind of history, solar power is hardly a trend or a risky new alternative.


CONFERENCE
SAN FRANCISCO

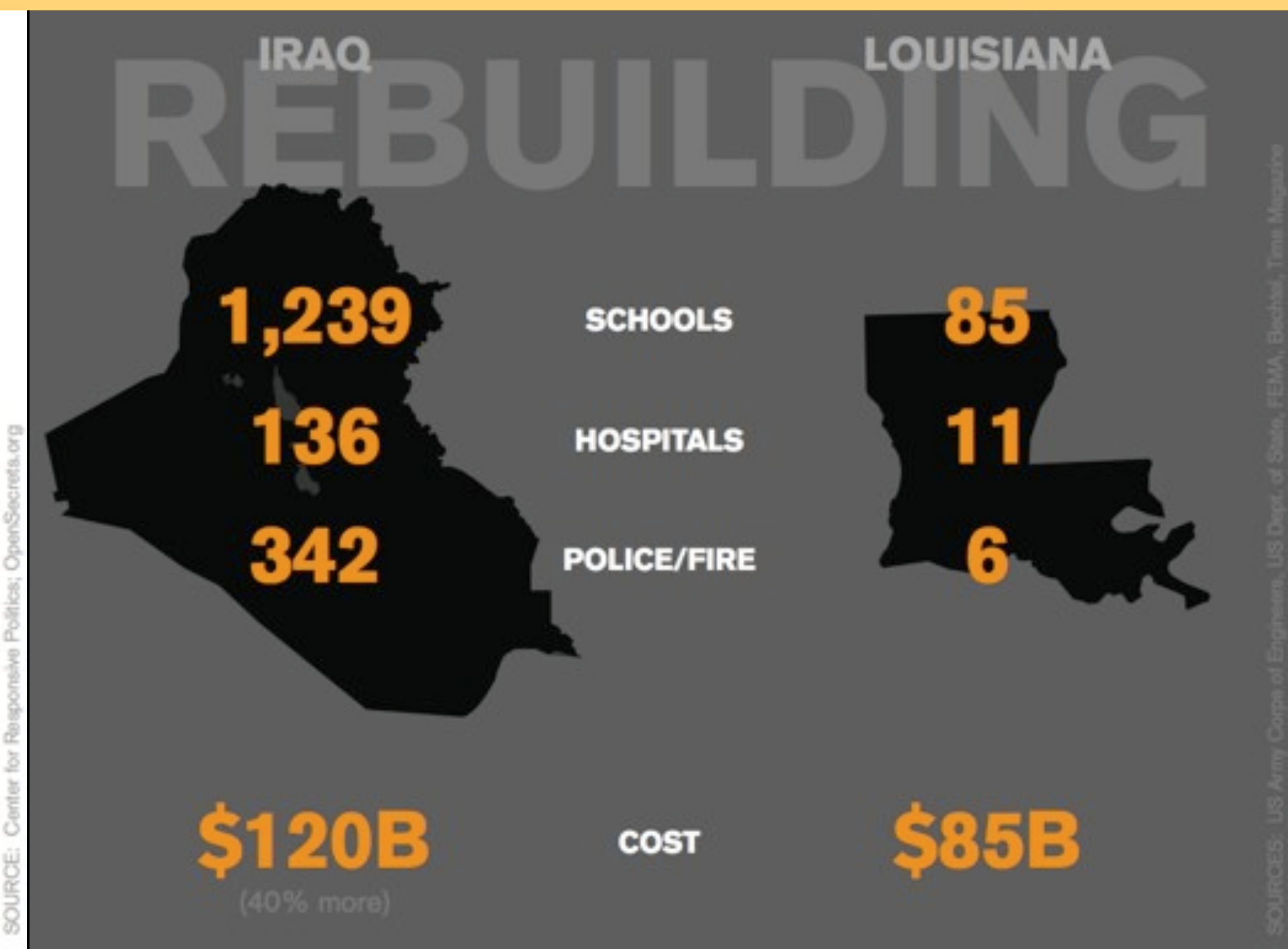

NATIONAL


Utopia


Detroit
San Francisco
Boston
Manhattan
Area of Detroit: 139 square miles
SFO+BOS+NYC: 118 square miles
SOURCE: University of Detroit Mercy


Patch Roof
Install Shading
Heat Loss
Mold Detection


1st six months of 2009
Clean Tech Lobbying
$ 12,100,000
5x increase 2005
ExxonMobil Lobbying
$ 14,900,000
23% more
7 times more
Oil & Coal Lobbying
$ 82,200,000
SOURCE: Center for Responsive Politics; OpenSecrets.org


REBUILDING
IRAQ
LOUISIANA
1,239
SCHOOLS
85
136
HOSPITALS
11
342
POLICE/FIRE
6
$120B
(40% more)
COST
$85B
SOURCES: US Army Corps of Engineers, US Dept. of State, FEMA, Bechtel, Time Magazine


LIVE
SAN FRANCISCO
MARKET ALERT
9572.16
140.12
Eric Corey Freed
ORGANIC ARCHITECT FOUNDER
INTERNET
TECHNOLOGY
TOP STORIES
AKAMAI (AKAM) 18.78 0.90
11:46a ET
S&P 1038.30 18.80 NASDAQ 2073.20 49.22
Eric Corey Freed
Author/Architect
LIVE
7:54a PT
Eric Corey Freed
URBAN RE:VISION EXECUTIVE DIRECTOR
FOX FIFTY
TOP STORIES
WEATHER
UPS (UPS) 57.19 0.03
DOW 10293.90 38.54 S&P 1088.75 6.15 NASDAQ 2139.61 17.21
CONSERVATION
MAKE YOUR LIFE EASIER.
WORLD A BETTER
American Standard
Eric-Corey Freed
Author
Green Building for Dummies
green building pro
Eric Corey Freed
FOUNDER, ORGANIC ARCHITECT
smartplanet
Eric Corey Freed
Executive Director
organicARCHITECTURE
LIVE
7:54a PT
GREENER TAXES
FOX FIFTY
TOP STORIES
WEATHER
CHARLES SCHWAB (SCHW) 18.10 0.21
DOW 10293.30 39.14 S&P 1088.70 6.20 NASDAQ 2139.47 17.35
ERIC COREY FREED
LIVE
DOW
9570.50
141.78
GREEN BUILDINGS HAVE HIGHER
WORKER PRODUCTIV. IN FACTORIES
INTERNET
TECHNOLOGY
TOP STORIES
YAHOO! INC (YHOO) 17.34 0.47
11:46a ET
S&P 1038.25 18.85 NASDAQ 2072.96 49.46

big ideas
FOR A SMALL PLANET

sundance
CHANNEL.

design | e²

smartplanet

AIR
AMERICA
RADIO

lime.com
healthy living with a twist

HGTV®

BuildingGreen

featured on
roadtrip nation
2008

FOX
NEWS
Channel

abc

CNN

NEXT AMERICAN CITY
americancity.org

Metropolitan Home

Sustainable Industries

LIVING WISELY > LIVING WELL
natural HOME

dwell

K+BB THE OFFICIAL SPONSOR OF KBIS

common ground

california HOME+DESIGN

ed+c
environmental design + construction

luxe.
interiors + design

The New York Times

San Francisco Chronicle
NORTHERN CALIFORNIA'S LARGEST NEWSPAPER

Marin Independent Journal
www.marinij.com

The Desert Sun
SERVING THE COACHELLA VALLEY SINCE 1927

FT
FINANCIAL TIMES

7x7 SAN FRANCISCO

Forbes

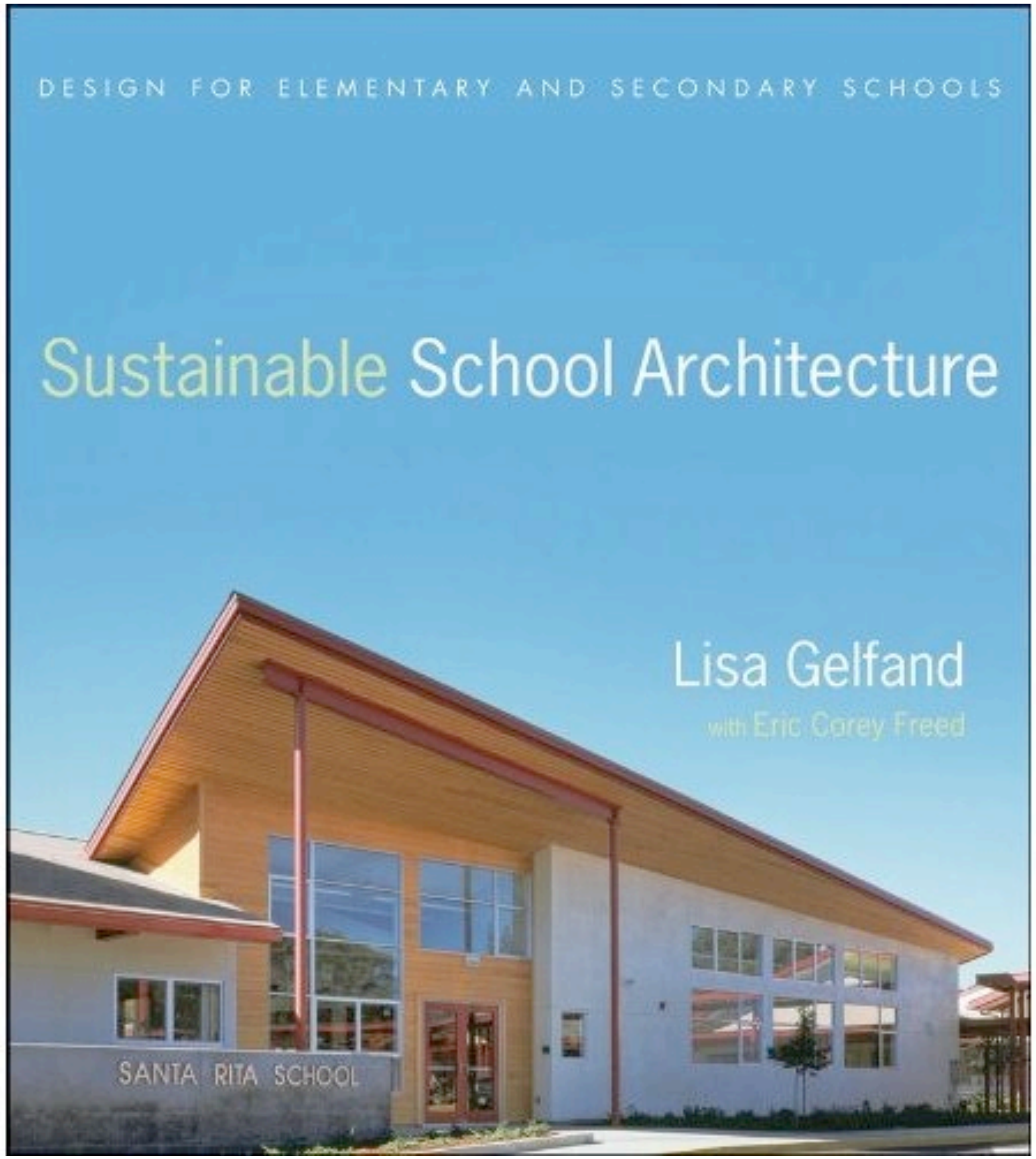
Entrepreneur
MAGAZINE

FAST COMPANY

THE SAN FRANCISCO BAY
GUARDIAN

Money
FOR YOU, YOUR FAMILY, YOUR FUTURE


Green is
MORE


DESIGN FOR ELEMENTARY AND SECONDARY SCHOOLS
Sustainable School Architecture
Lisa Gelfand
with Eric Corey Freed
SANTA RITA SCHOOL

TIME TO DO SOMETHING

“SENTIMENT without **action** is the ruin of the **SOUL...”**

-Edward Abbey


THE NEW SCHOOL
66
LEED Certified
Hippies Welcome.


55,394,000
students
SOURCE: Capital E


1 in
5
people


student growth
60,443,000
by 2017


schools spend
$35,000,000,000
in annual tax dollars


number of schools
125,766
K-12


Schools typically
designed just to
meet codes

Studies show many schools are **unhealthy**

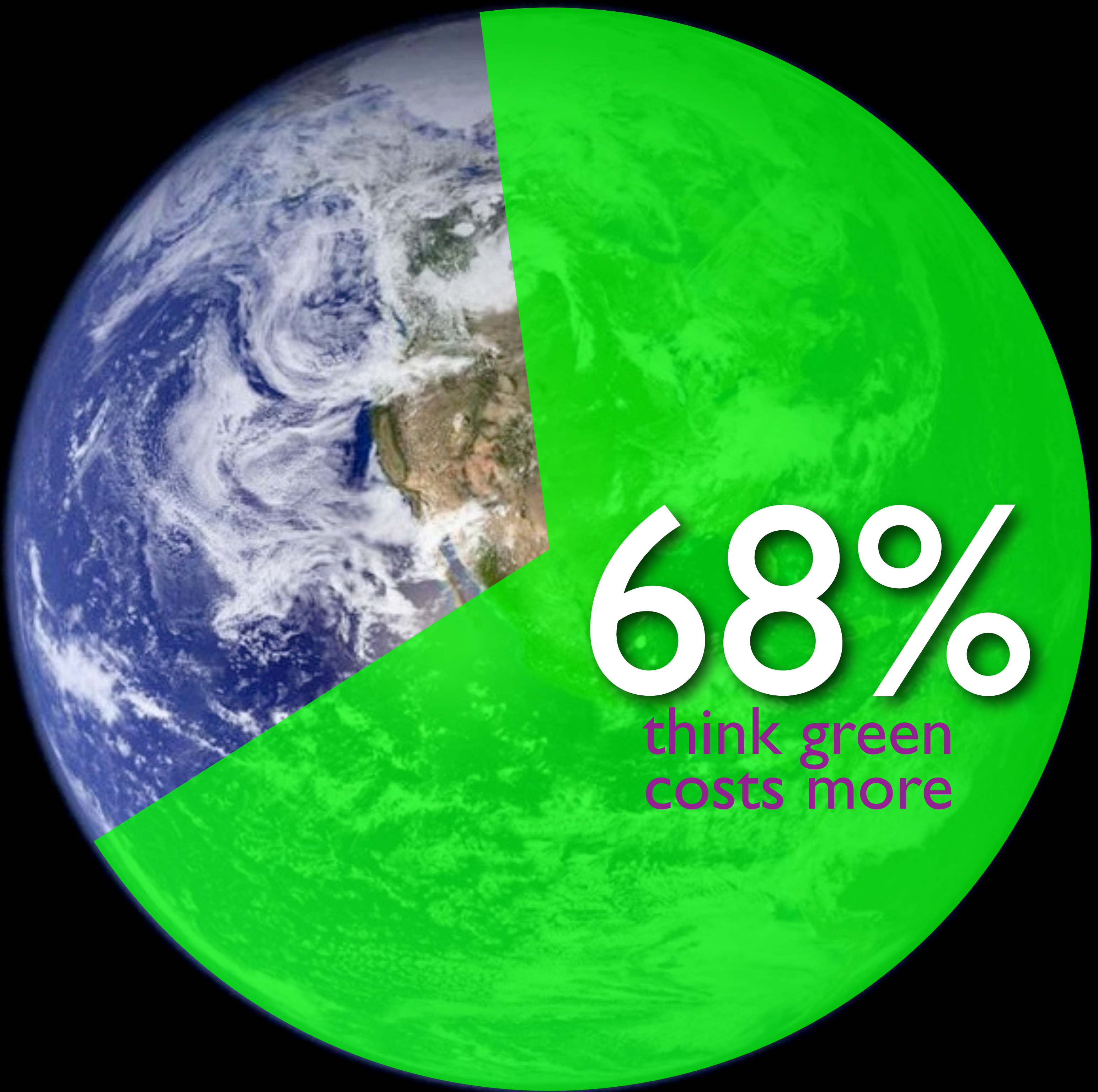

poor indoor air quality
15,000
schools
8,000,000
children
SOURCE: US General Accounting Office
Alexandra
Elias


national dropout rates
2007
8.7%


50 largest cities
50%
graduate


in Detroit
50%
illiteracy rate
marchandmeffre.com


need for
green
schools



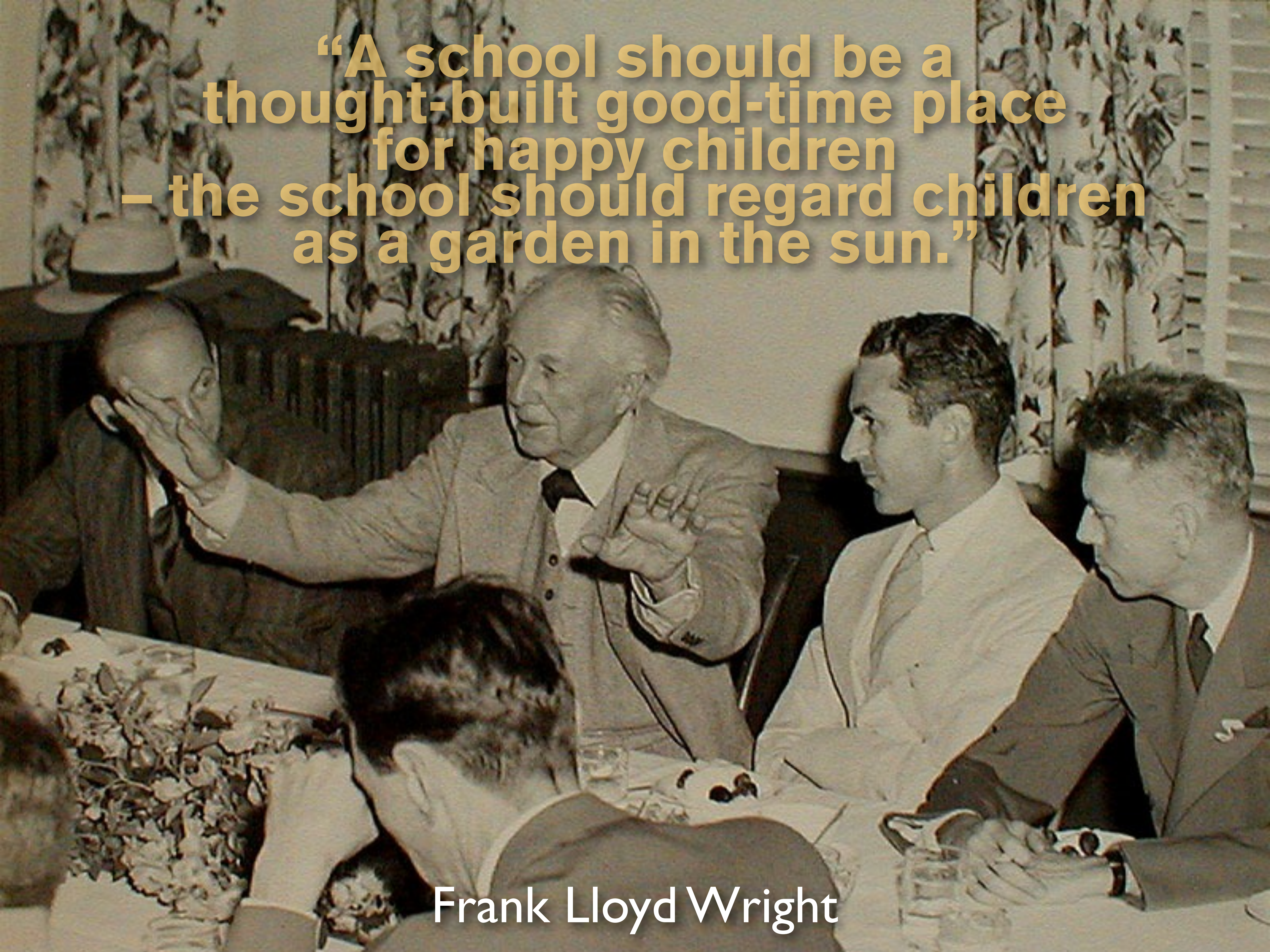
perception of the green schools

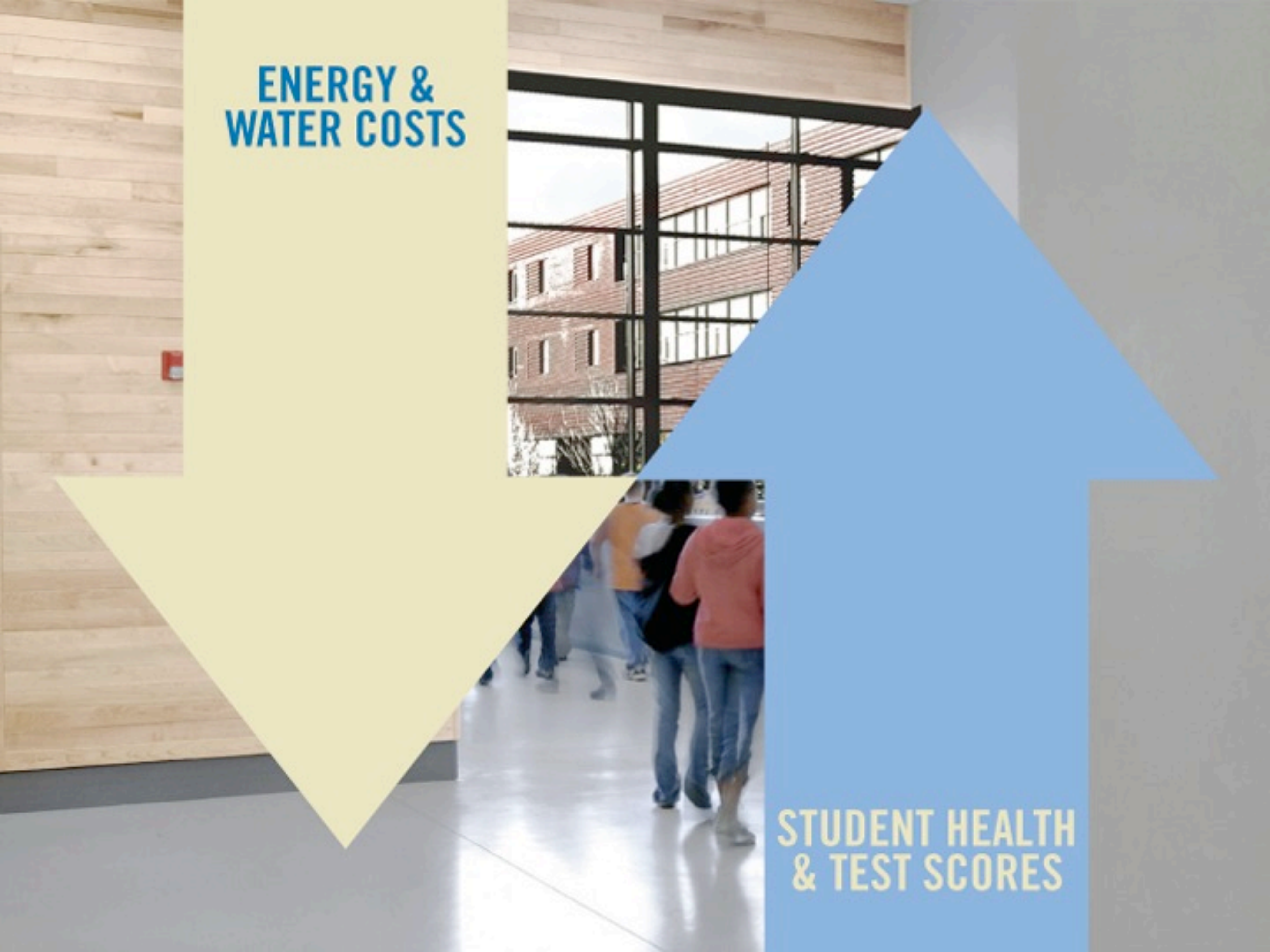
among executives

SOURCE: Capital E

Benefits of Green Schools

3%	Increased Learning, Productivity & Performance
1.4%	Increased Future Earnings of Students
25%	Reduced Asthma
15%	Reduced Colds and Flu
3%	Reduced Teacher Turnover


"A school should be a
thought-built good-time place
for happy children
– the school should regard children
as a garden in the sun."
Frank Lloyd Wright


ENERGY &
WATER COSTS
STUDENT HEALTH
& TEST SCORES

Green Schools are Springing Up Everywhere

LEED Certified: 379

Registered: 1,741

Photo by James Steinkamp

As of October 2010

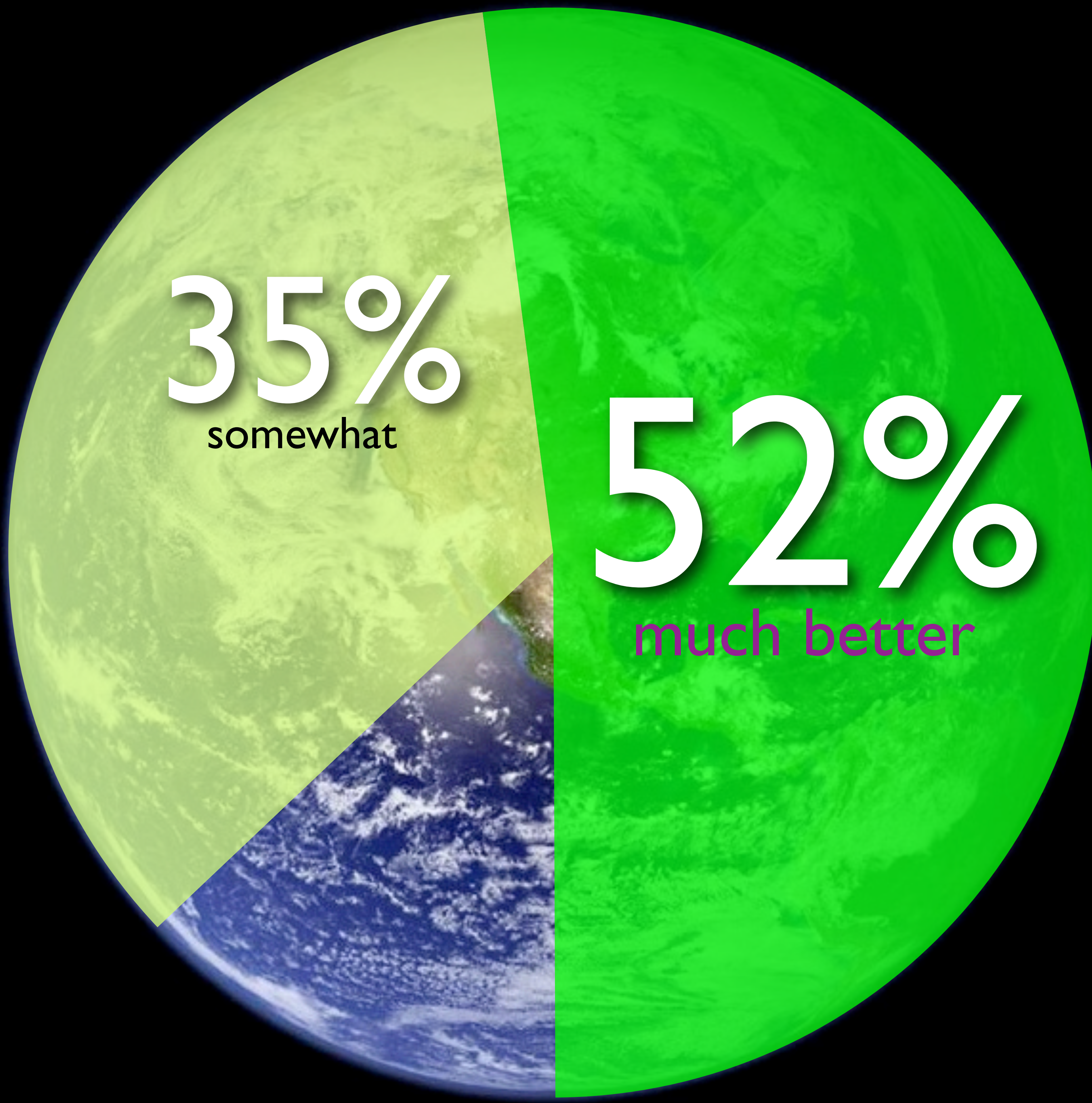
$71 savings

$4 increase per square foot

SOURCE: Capital E; US Green Building Council

payback
20
times
over cost
of greening
Ciphering
Add:
Multiply by 5:
Reading
Memorization
Spelling

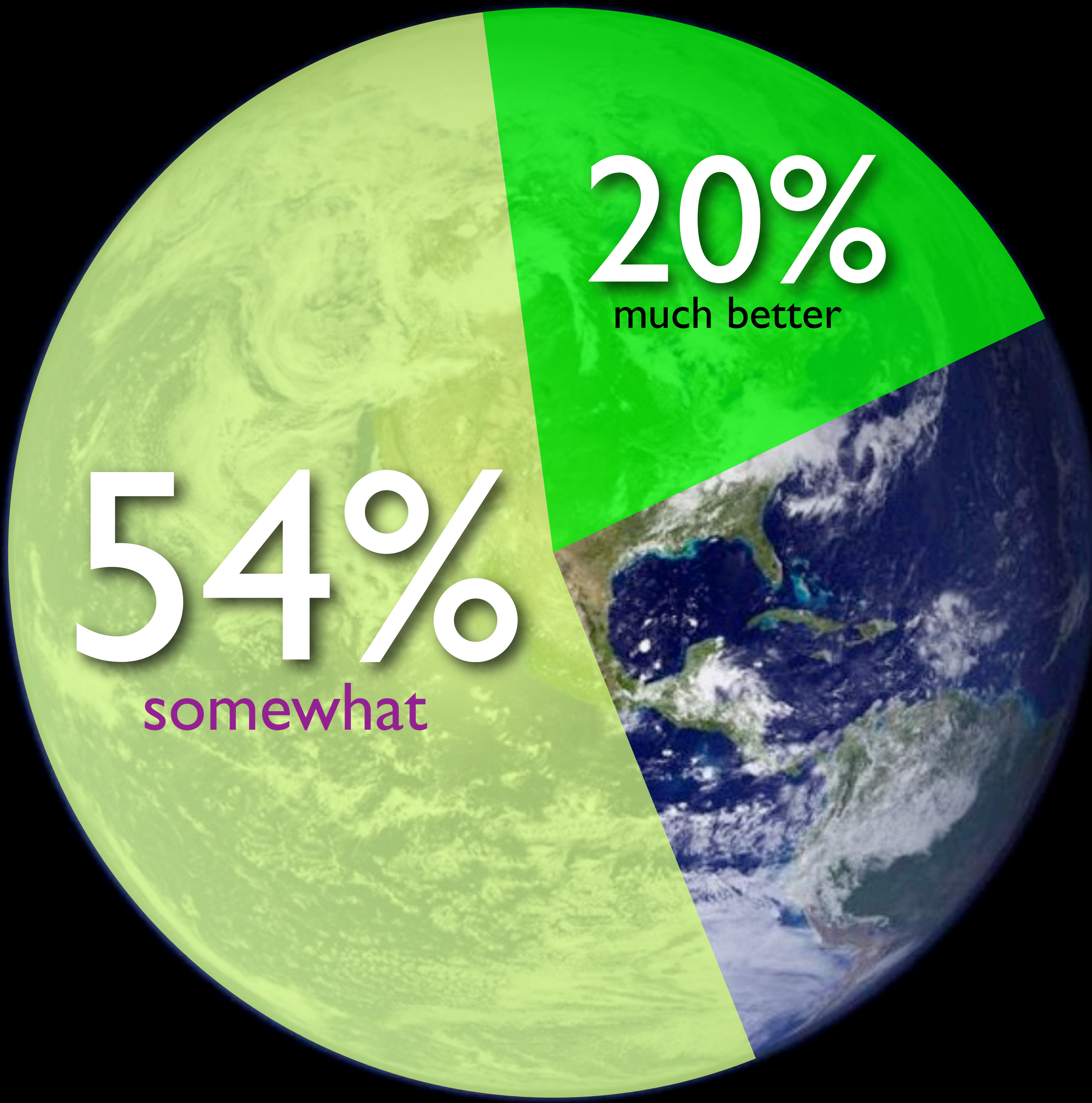

up-front cost of green
1.65%
SOLON SCHOOL
EST. 1898



perception of community image

green school benefits

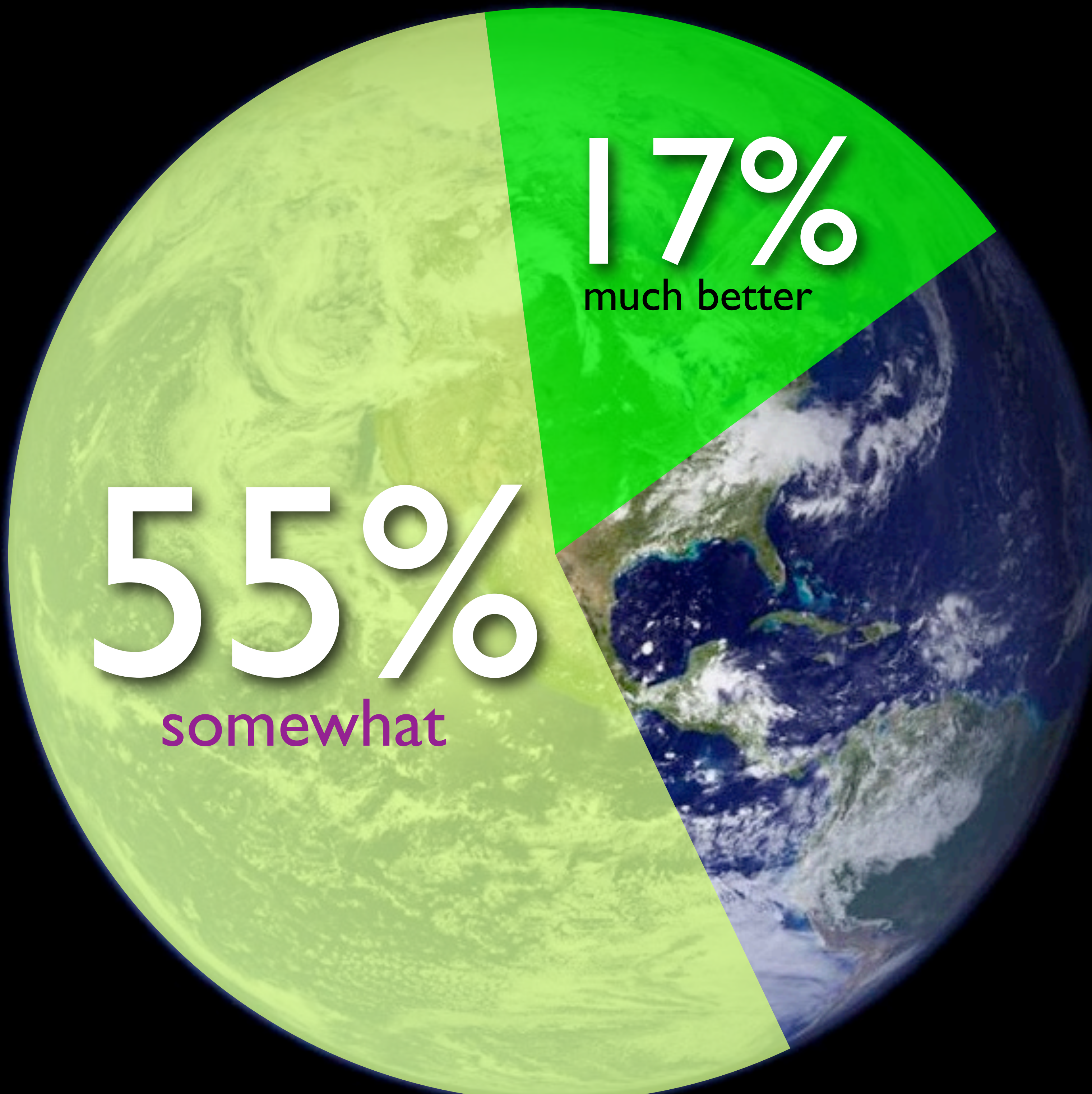
SOURCE: Turner Construction Company, 2005 Survey of Green Schools



ability to retain/attract teachers

green school benefits

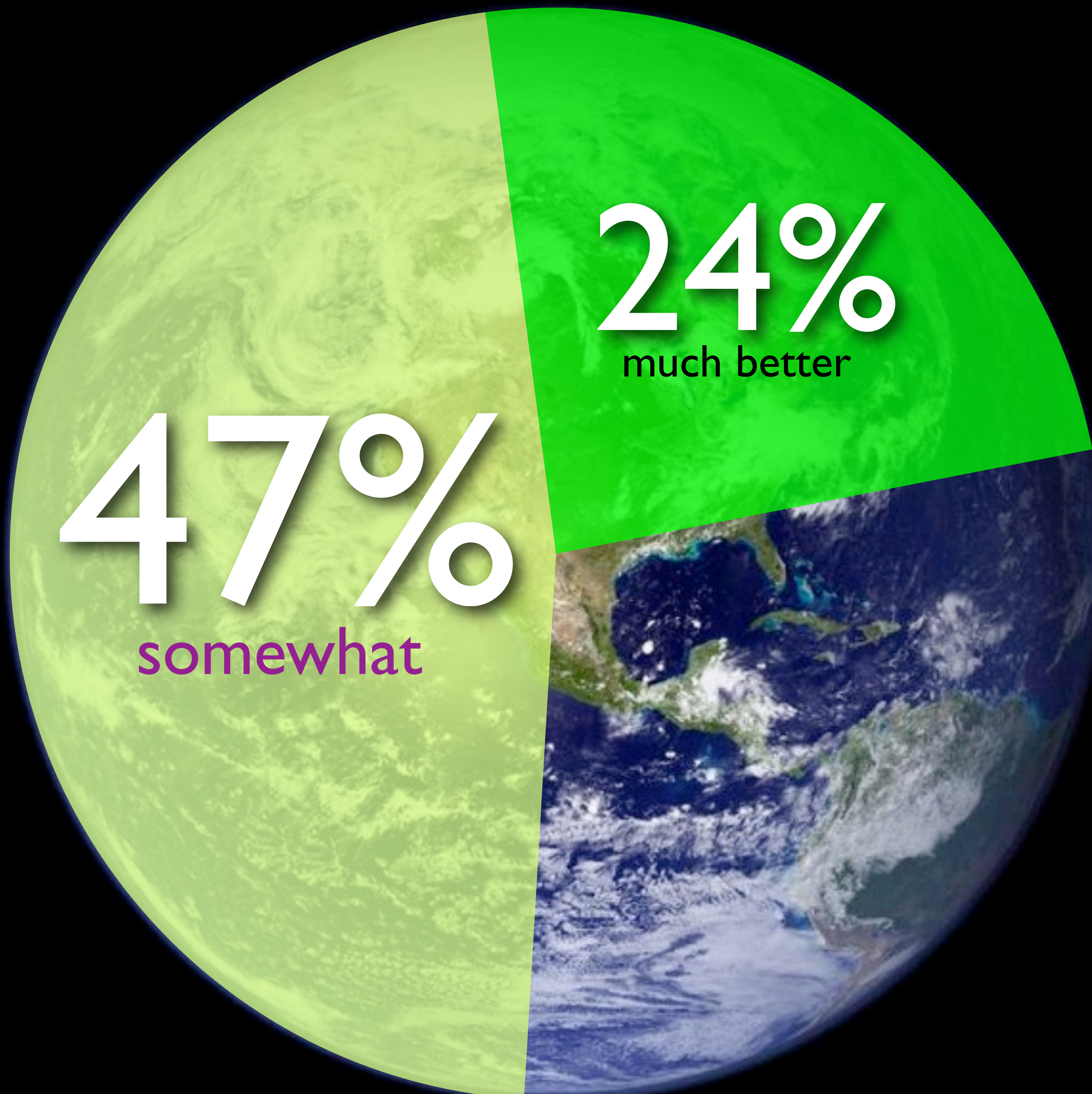
SOURCE: Turner Construction Company, 2005 Survey of Green Schools



reduced student absenteeism

green school benefits

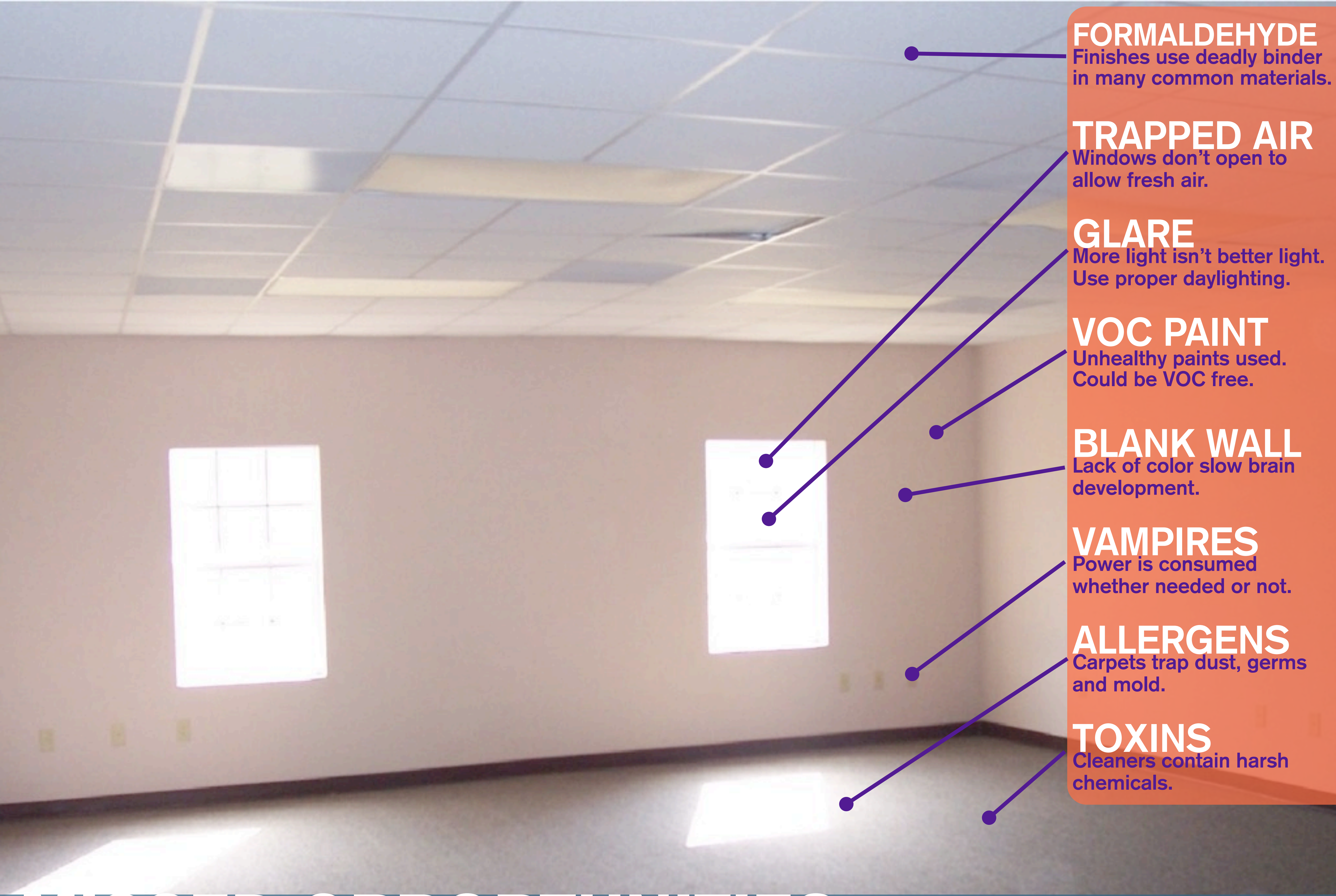
SOURCE: Turner Construction Company, 2005 Survey of Green Schools



student performance

green school benefits

SOURCE: Turner Construction Company, 2005 Survey of Green Schools



MISSED OPPORTUNITIES

DIRECT SAVINGS FOR AN AVERAGE GREEN SCHOOL
$47,880
Annual Direct Energy Savings Per School
$95,760
Annual Total Direct Savings Per School


annual green building savings
2
teachers
5,000
textbooks
200
computers

MAINTENANCE


schools spend more on
trash disposal
than
new textbooks

MAINTENANCE

is the primary decision

DESIGN

a 40 year building.


PREVAILING WAGE
determines the walls.


A.D.
1920
CORNER
STONE

HEALTH


3 percent
IN 1980
9 percent
IN 2003

22 percent

higher on

S.A.T.'s


natural light
3
.2-.8
more days
SOURCE: Energy Performance of Daylit Schools in North Carolina (Mike Nicklas and Gary Bailey, 1996)

WATER

green schools water savings

using ultra low flow fixtures

SOURCE: Capital E

WATER CATCHMENT

1000sf = 632 gal/in

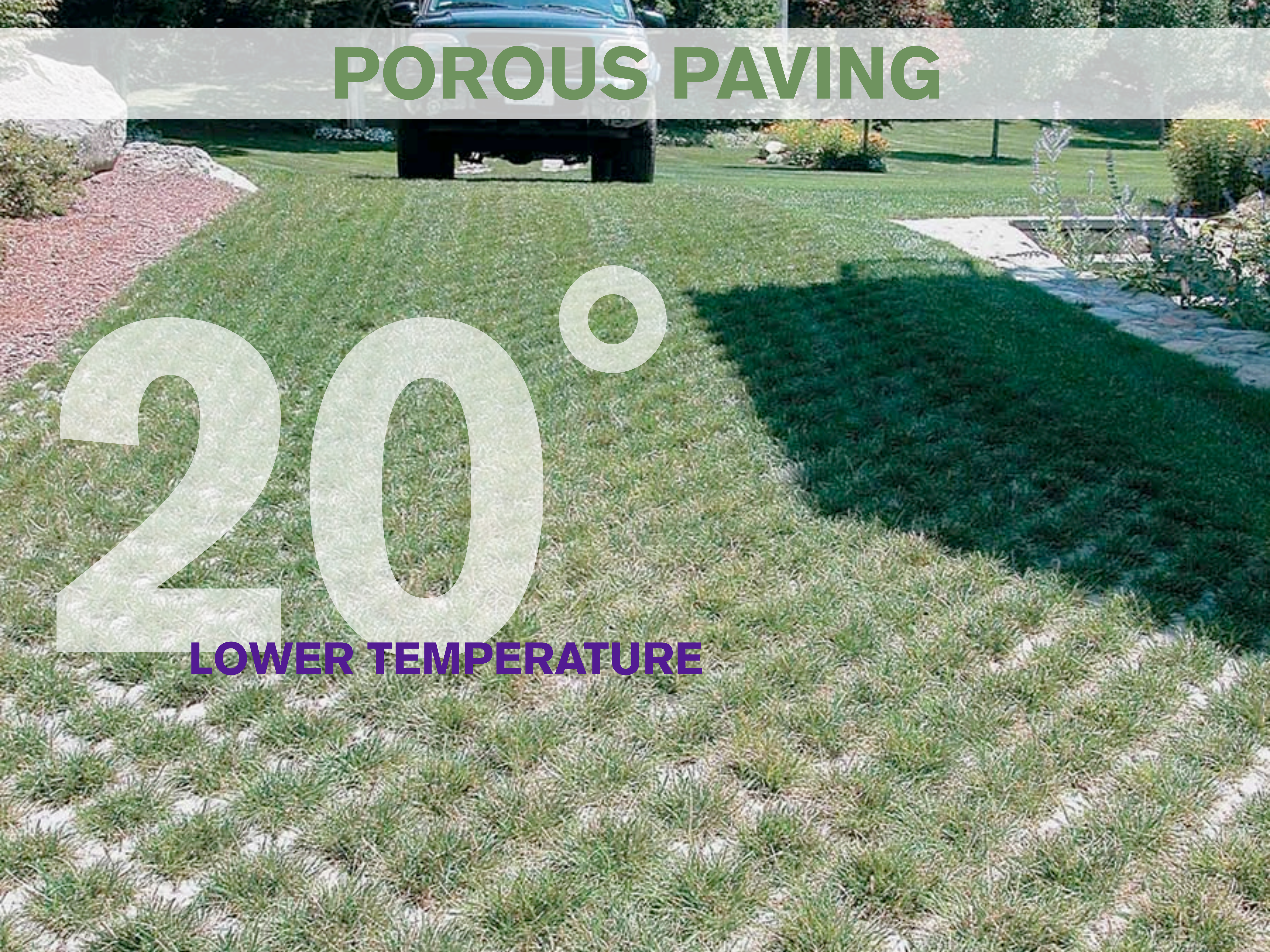
10,000 = 6320 gal/in

30,000sf building / 3 floors
= 10,000sf roof area

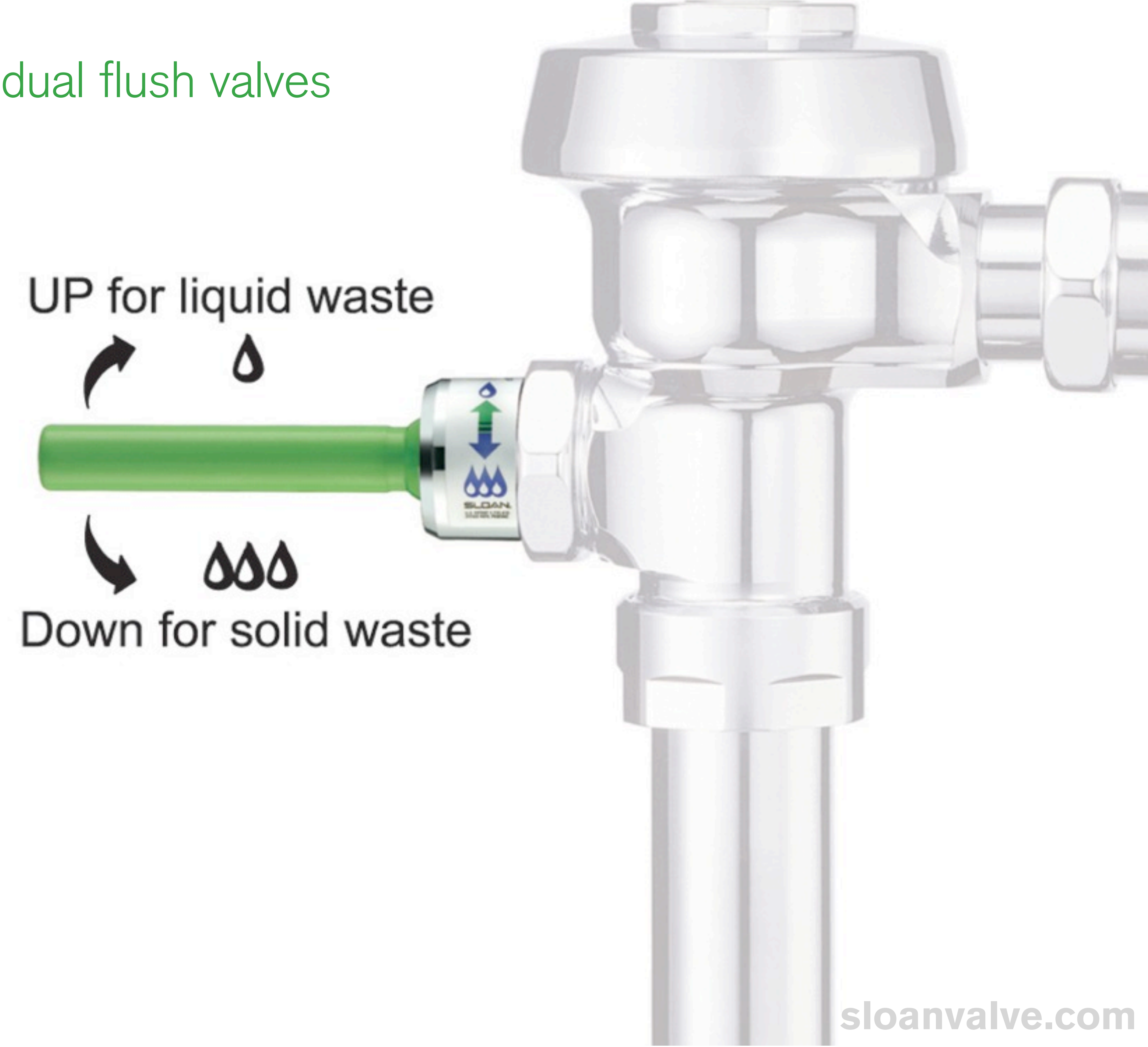
= __21__ inches per year

x _6,320_ gallons = _132,720_ gallons/year


DRIP IRRIGATION
WATER SAVINGS
60%


POROUS PAVING
20°
LOWER TEMPERATURE

retrofit with dual flush valves

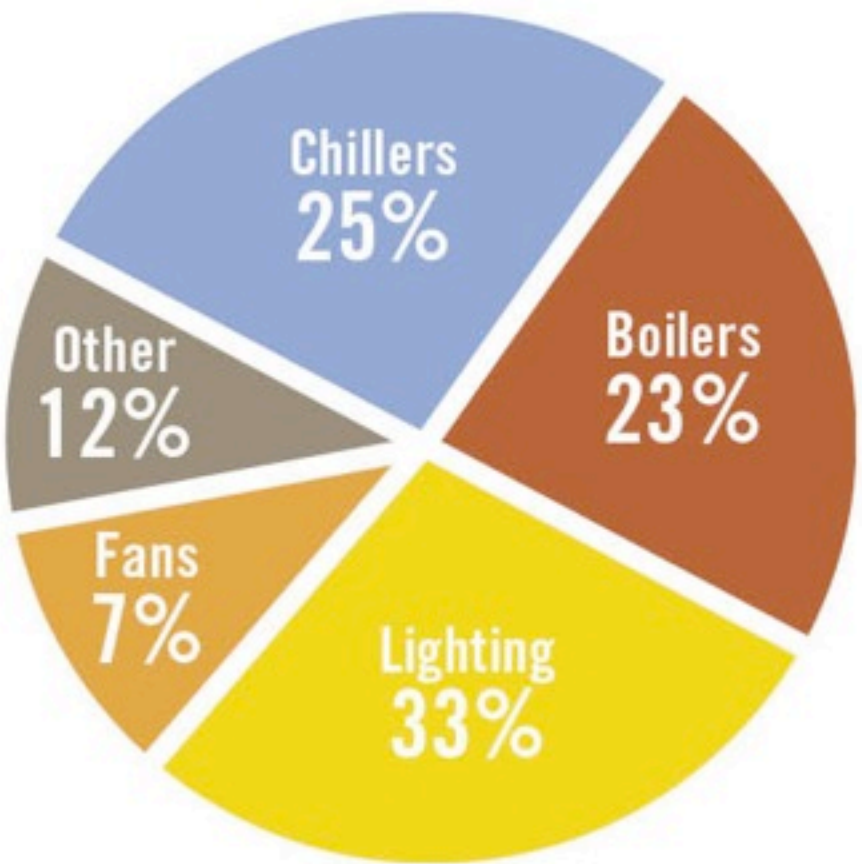



CPT-
collect condensate from A/C

ENERGY


school energy costs
$110
per student/yr
What's the answer?

Understanding Energy Use in Schools



This will vary depending on your climate region.

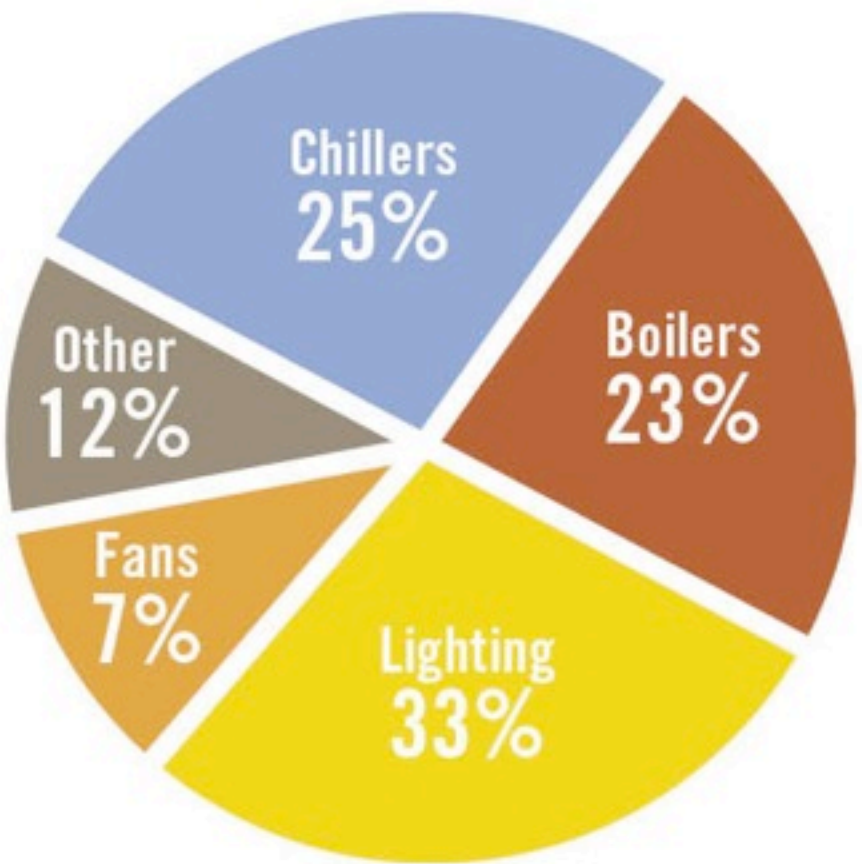
How much does your school spend each year on energy?

Elementary School:
$70,000 to $150,000

Middle School:
$100,000 to 200,000

High School:
$200,000 to $650,000

Understanding Energy Use in Schools



This will vary depending on your climate region.

How much does your school spend each year on energy?

Potential No-Cost Savings ➔ 10%

Elementary School:

$70,000 to $150,000 ~ $10,000

Middle School:

$100,000 to 200,000 ~ $15,000

High School:

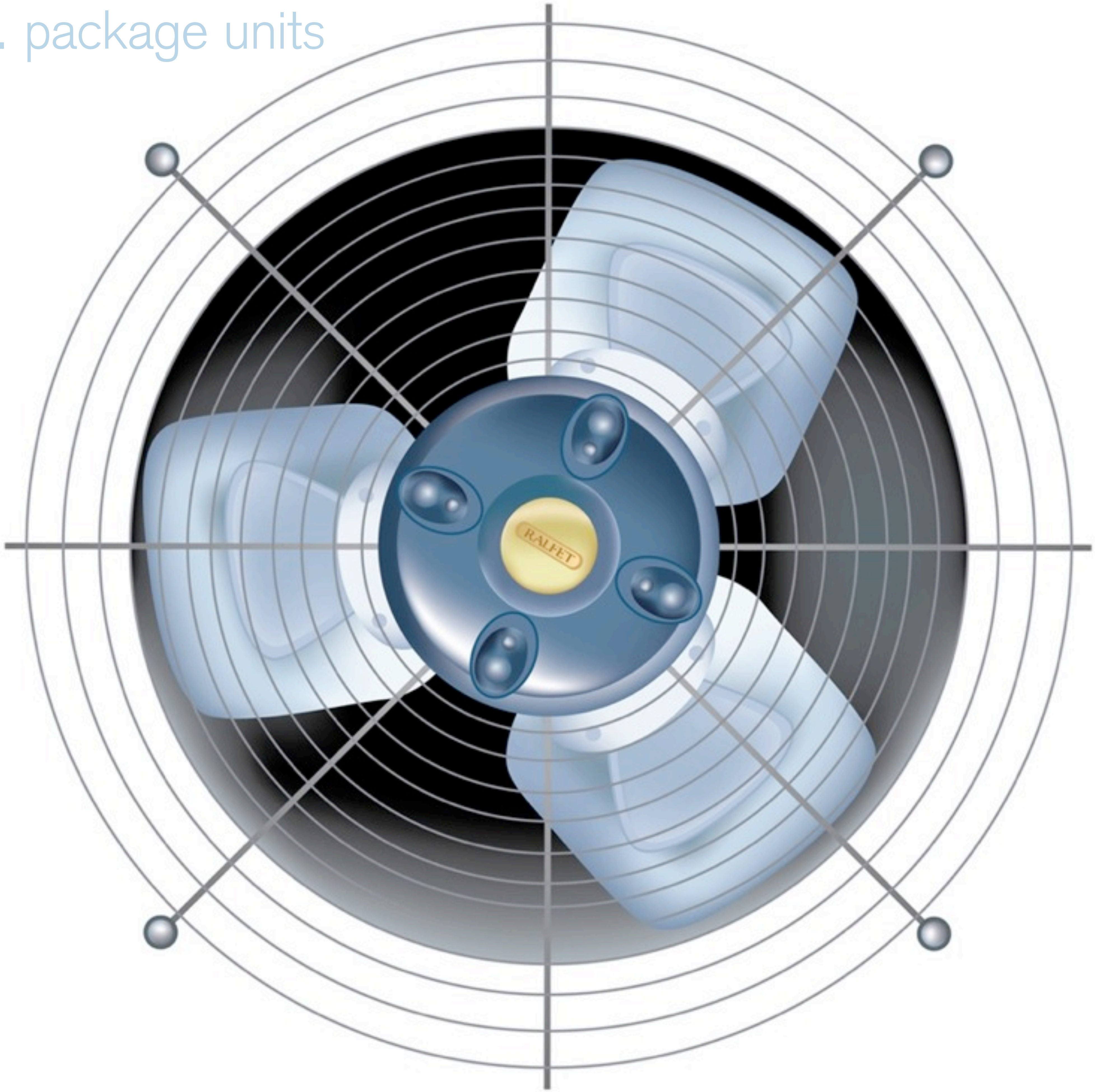
$200,000 to $650,000 ~ $30,000


if every school went green
$ 20,000,000,000
over next 10 years


GREEN ROOF SAVINGS
40%
energy savings

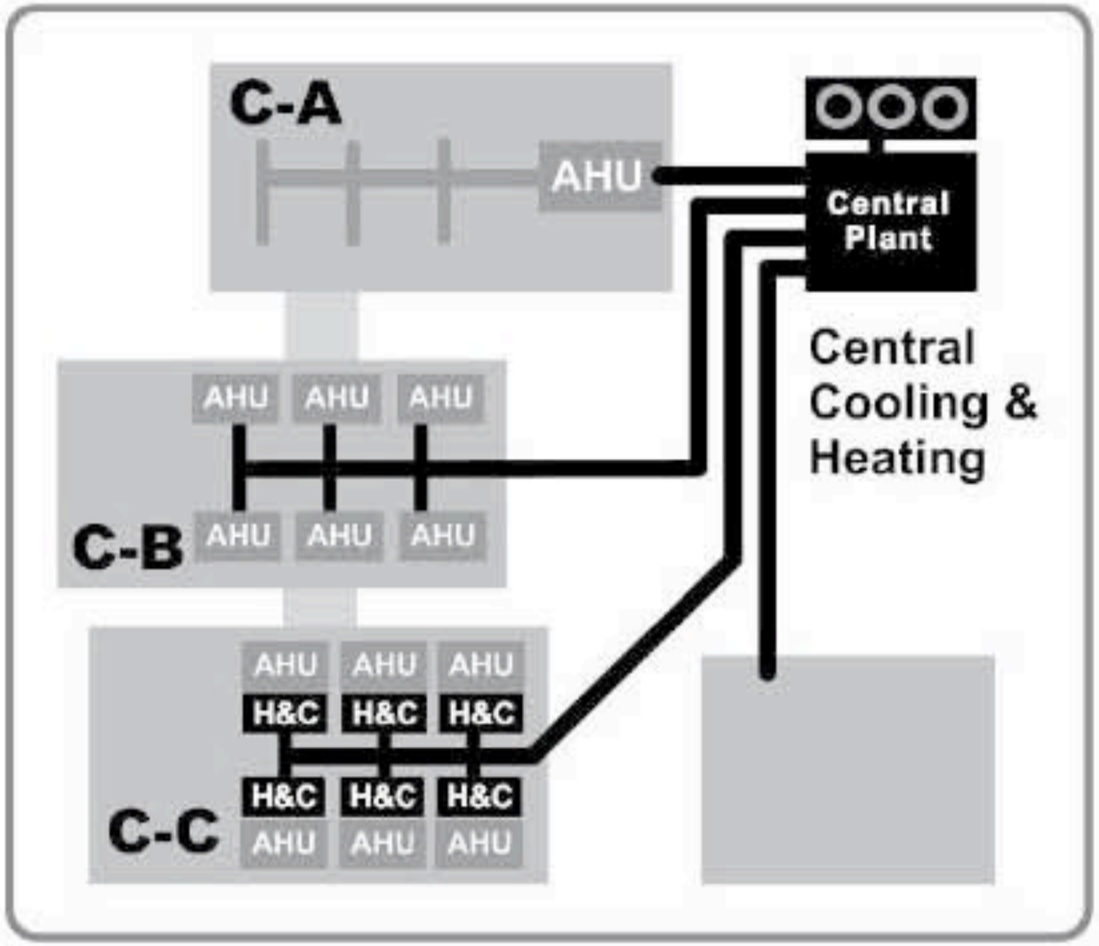

$12-24 sq ft
green roof
$8 sq ft
green grid
hydrotechusa.com

central vs. package units



no heat = no school

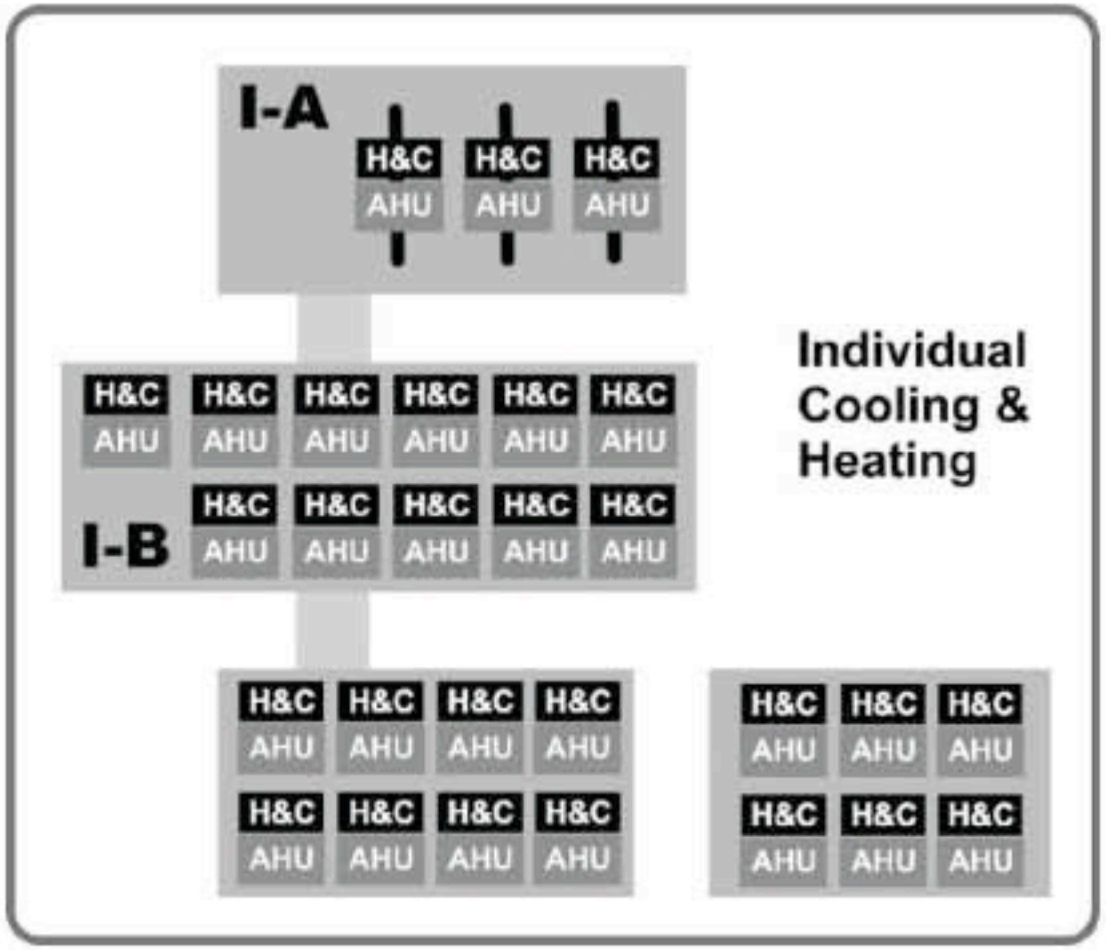
Central Plant



- Chiller system
- Hot water/steam
- Water-source HP

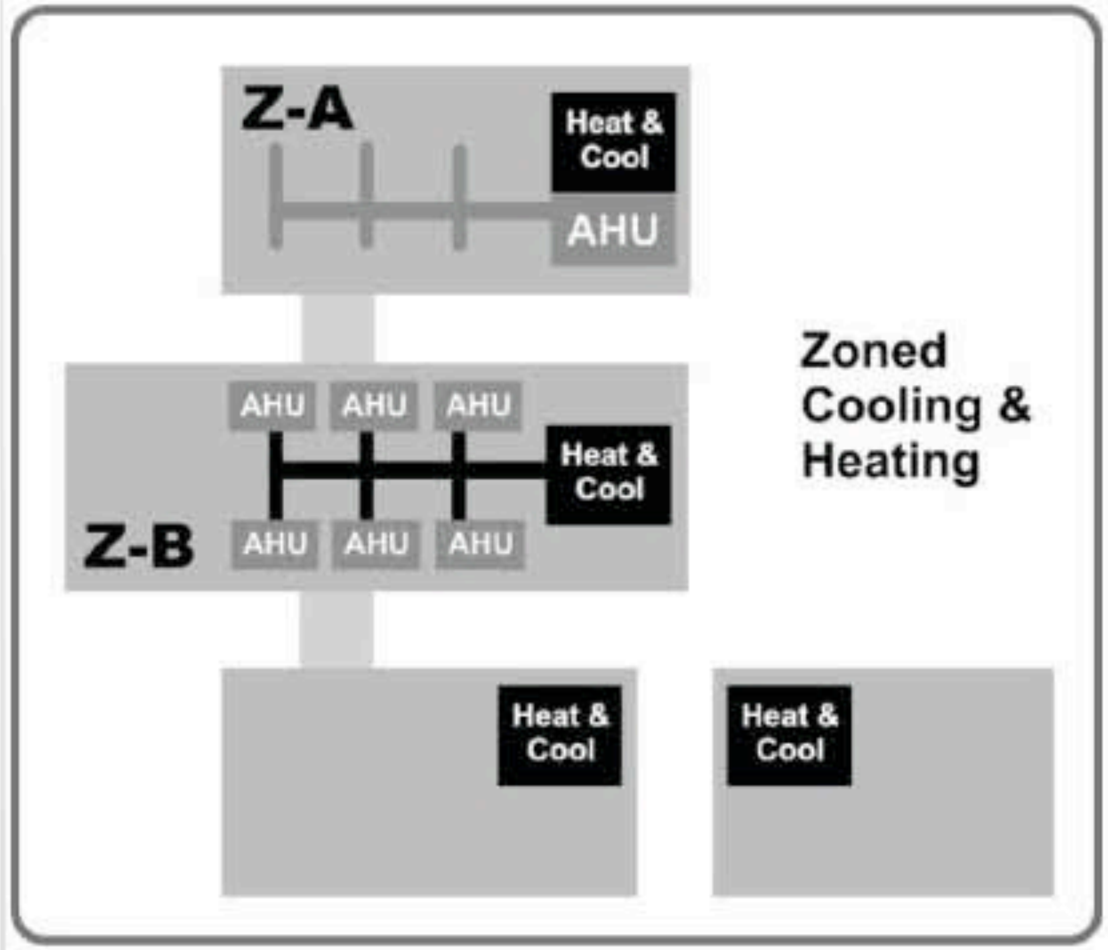
redundant, but reliable

Individual Units



- Wall units
- Roof top units
- Split systems

Zoned Systems

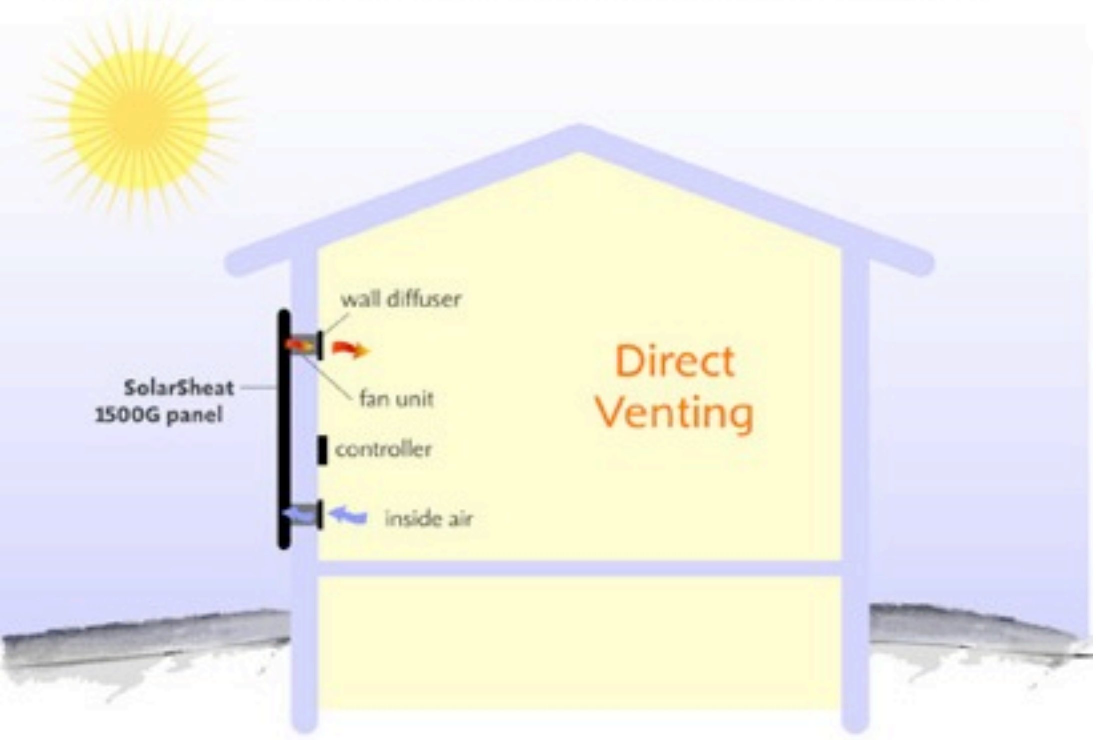


- Small chiller systems
- DX systems
- Split systems


NOISY AIR CONDITIONER
gets shut off and the door opens.

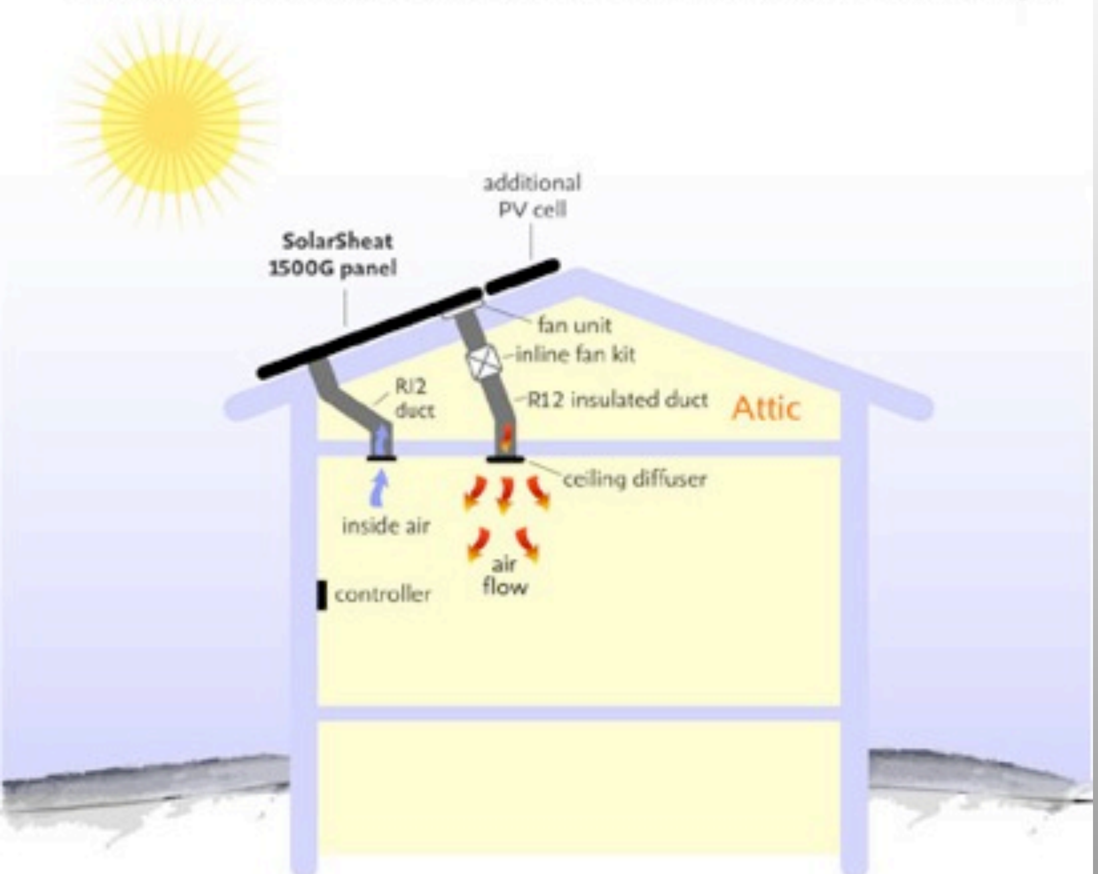
Direct Venting into a Room - SolarSheat 1500G

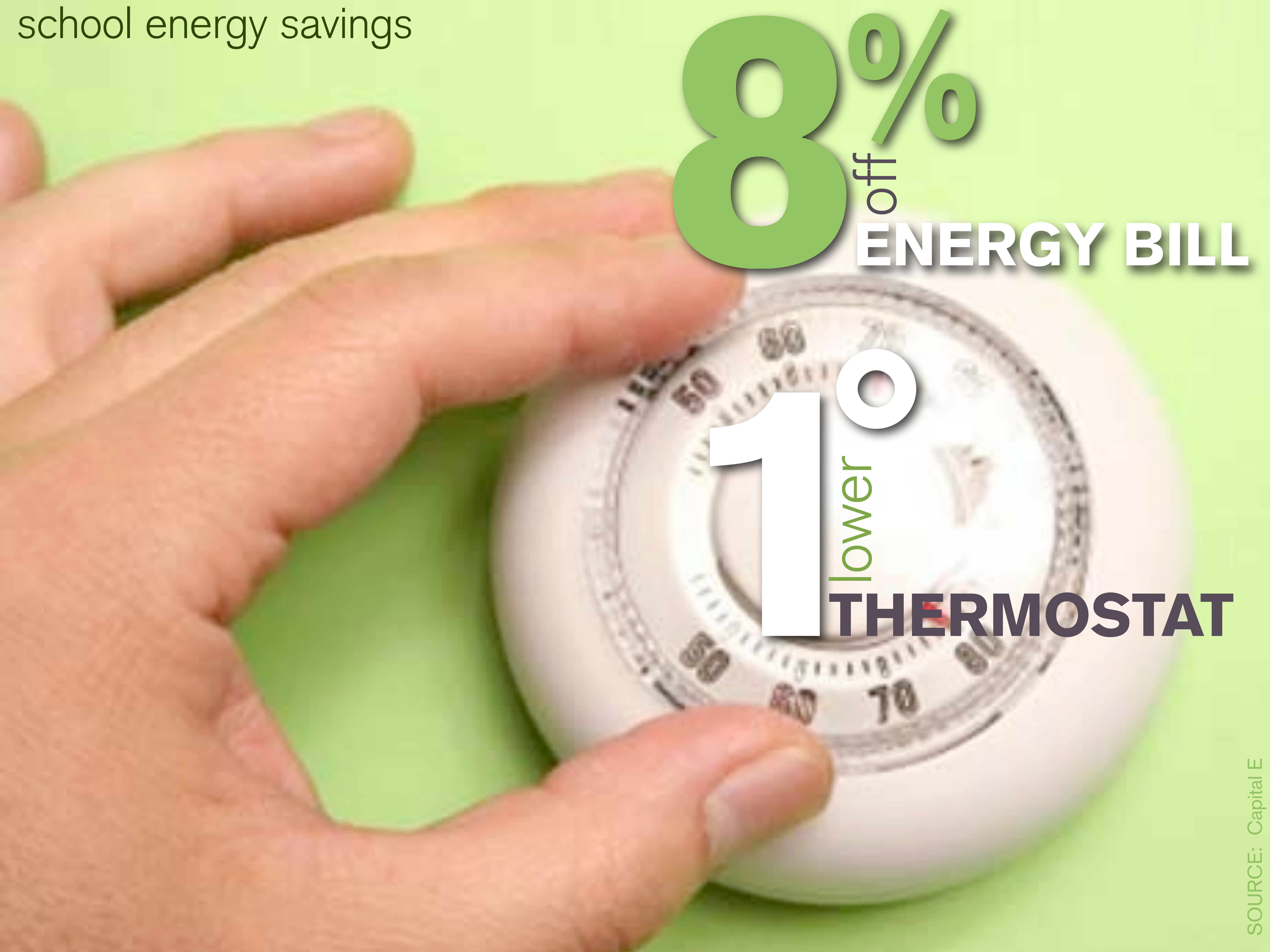
How it works: The SolarSheat 1500G panel heats inside air. The amount of heat produced is based on the volume of air passing through the solar panels and the degree of sunshine. The SolarSheat is a supplemental heating system. It does not work at night. No AC electricity is required.



Roof Mounting - SolarSheat 1500G

How it works: The SolarSheat 1500G panel heats inside air. The amount of heat produced is based on the volume of air passing through the solar panels and the degree of sunshine. The inline fan kit can be powered by an AC/DC wall adaptor or with an additional PV cell, to keep it off the grid.




school energy savings
8% off
ENERGY BILL
1° lower
THERMOSTAT
SOURCE: Capital E

agilewaves.com

SHADE SOUTH & WEST WINDOWS

LIGHT

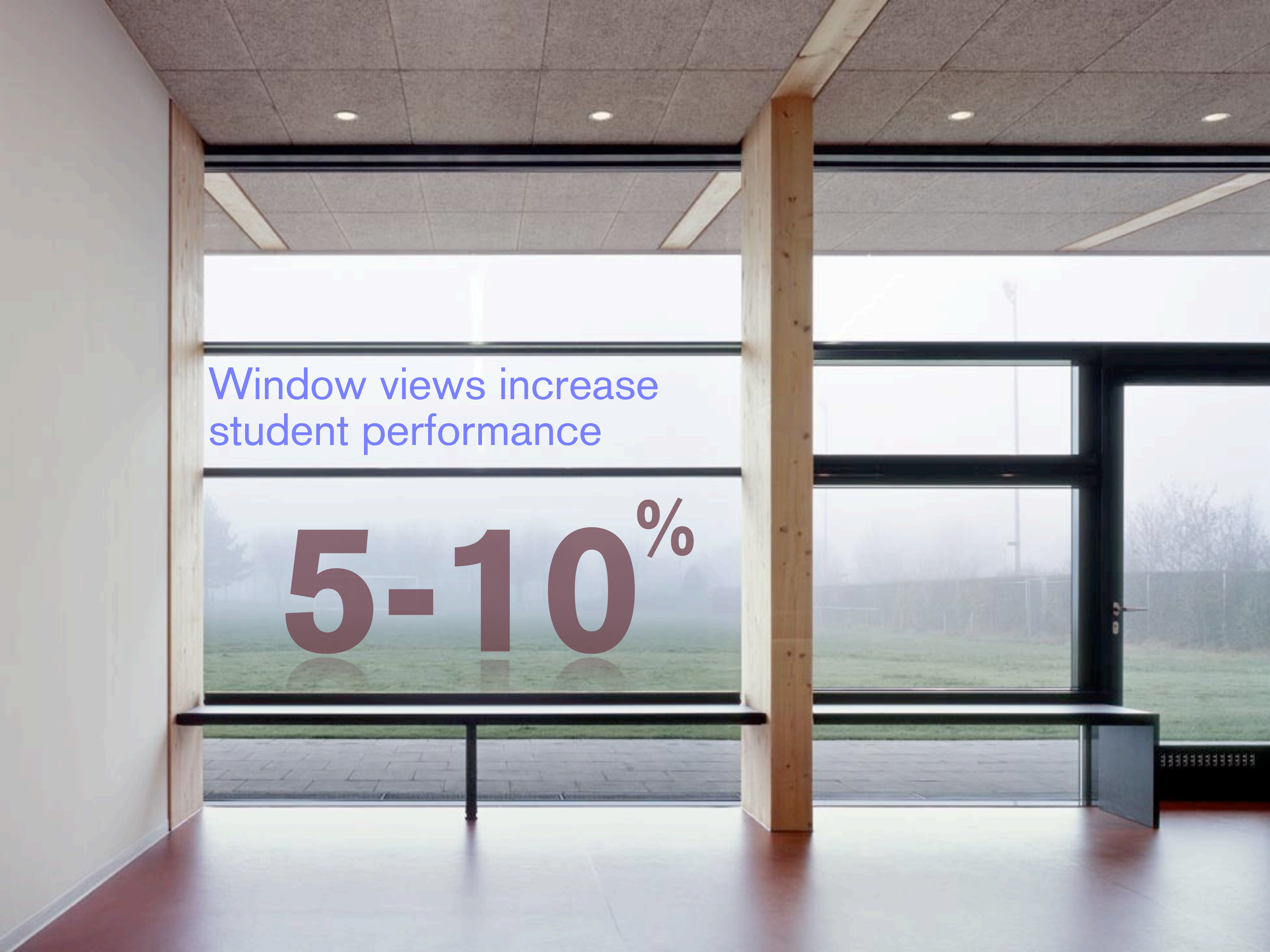

EXIT
Excellence is the gradual result of always striving to do better.
-Pat Riley

more than
student/teacher ratio

more than
classroom size


daylit schools
20%
math progression
Energy Performance of Daylit Schools in North Carolina (Mike Nicklas and Gary Bailey, 1996)


26%
in reading
daylit schools
Energy Performance of Daylit Schools in North Carolina (Mike Nicklas and Gary Bailey, 1996)


Window views increase student performance
5-10%

GLOSSARY OF TERMS

LUMINANCE

The luminous intensity
(photometric brightness)
of a light source or reflecting surface
including factors of reflection, transmission
and emission.

Units are candelas per sq.ft. or per sq.m.

ILLUMINANCE

The measure of light intensity striking a surface.

Measured in foot-candles or lux.

LUMINOUS FLUX

The flow of light from a source to a receiving surface.

Measured in lumens.

LUMEN

Unit measuring the rate of light flow (luminous flux).

One lumen produces a 1 foot-candle (lux) illuminance..

CANDELA

an SI unit of luminous intensity.

A candle has a luminous intensive of one candlepower.

FOOT-CANDLE (fc)

An imperial measure of illuminance.

The amount of direct light from one candle falling on a square **foot** of surface one **foot** away.

Measured in lumens per square foot.

LUX

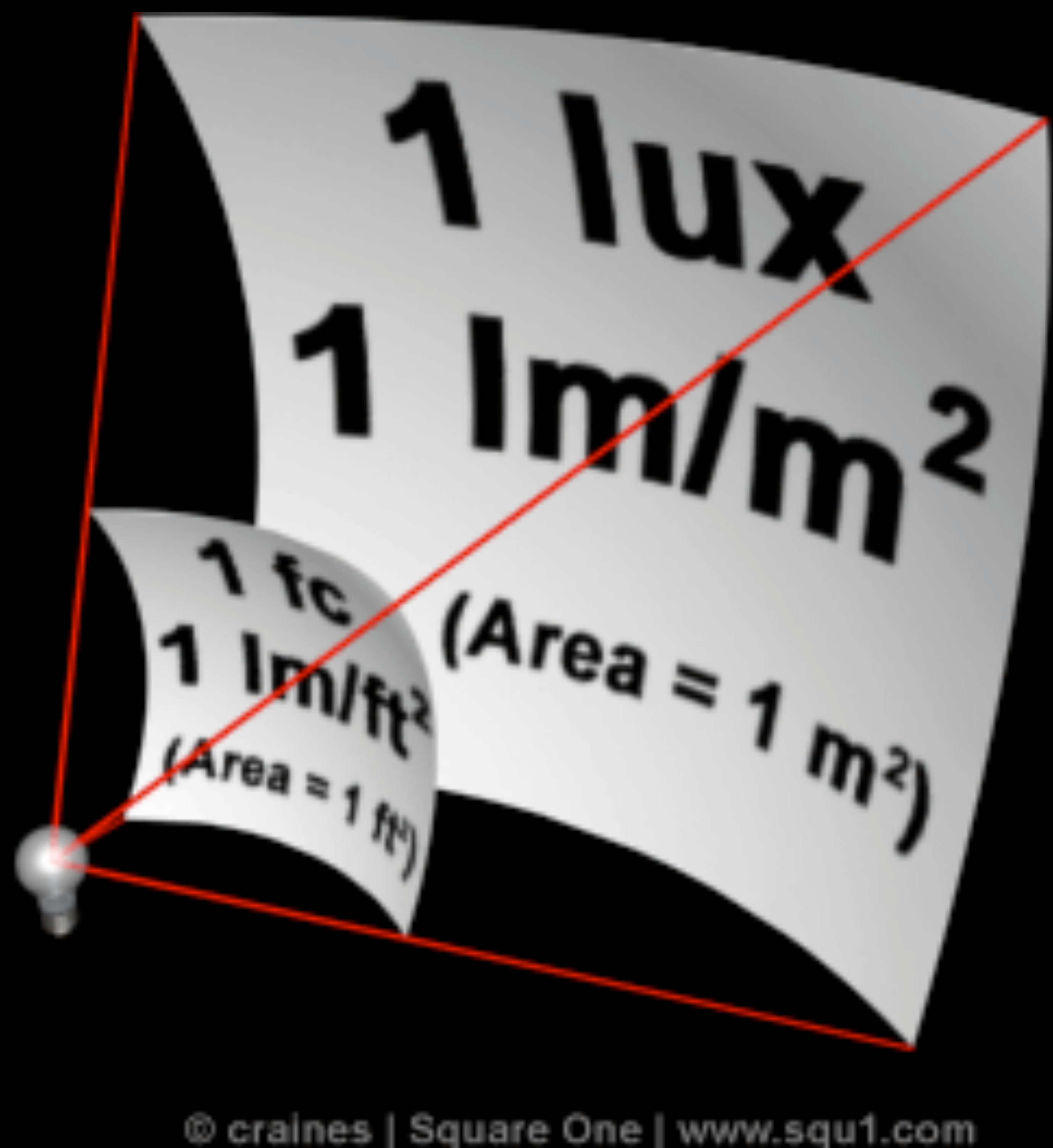
An SI measure of illuminance.

The amount of light from one candle falling on a square **meter** of surface one **meter** away (lumens/m2).

Measured in lumens per square meter.

1 lux x 0.0929 = 1 foot-candle
1 fc x 10.764 = 1 lux

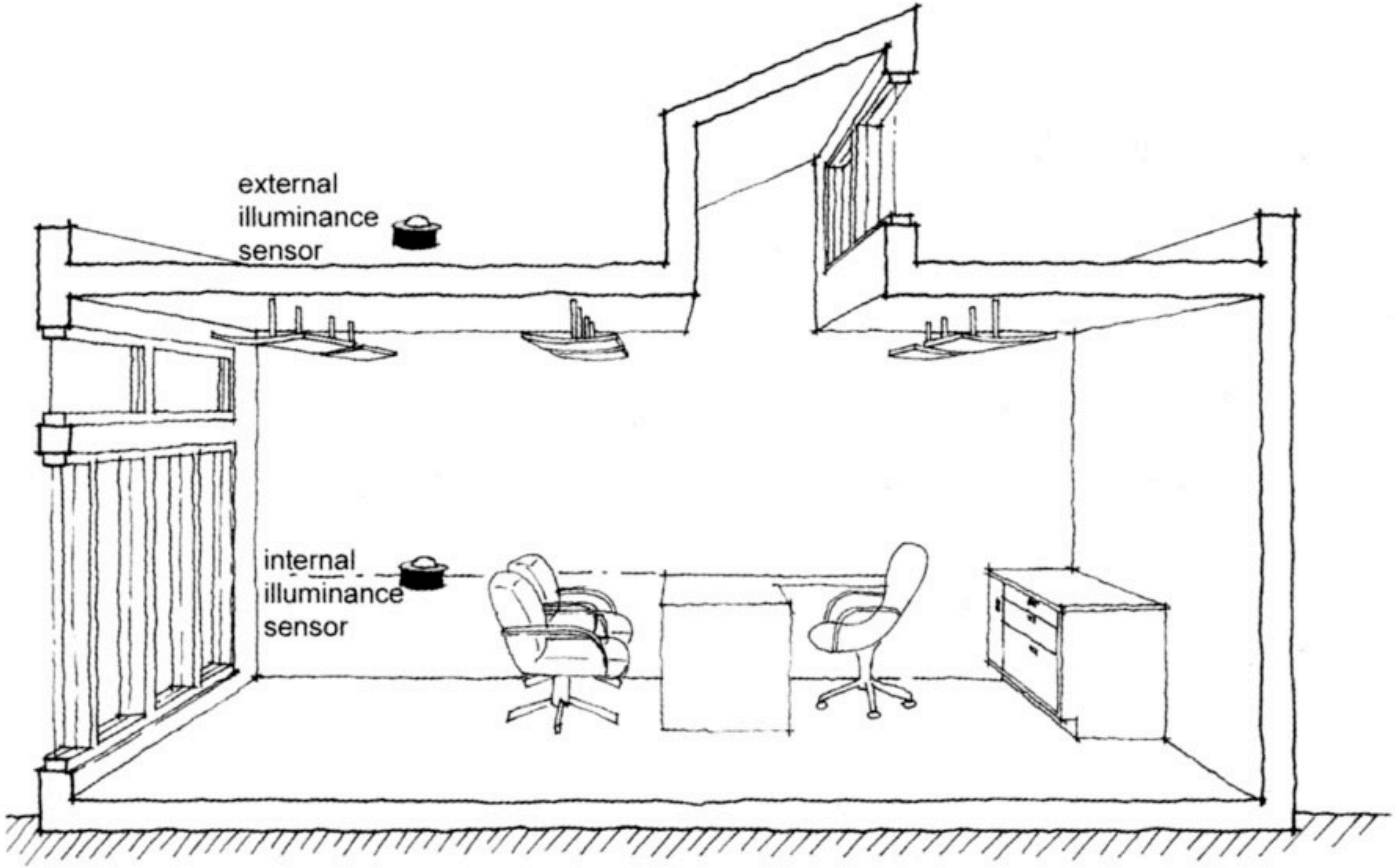
1 lux x **0.0929** = 1 foot-candle
1 fc x **10.764** = 1 lux



DAYLIGHT FACTOR

a numerical ratio used to describe the relationship between indoor and outdoor daylight luminance.
(typically under overcast sky conditions)

Ratio of internal daylight illuminance to exterior
& specific to a particular point inside the building

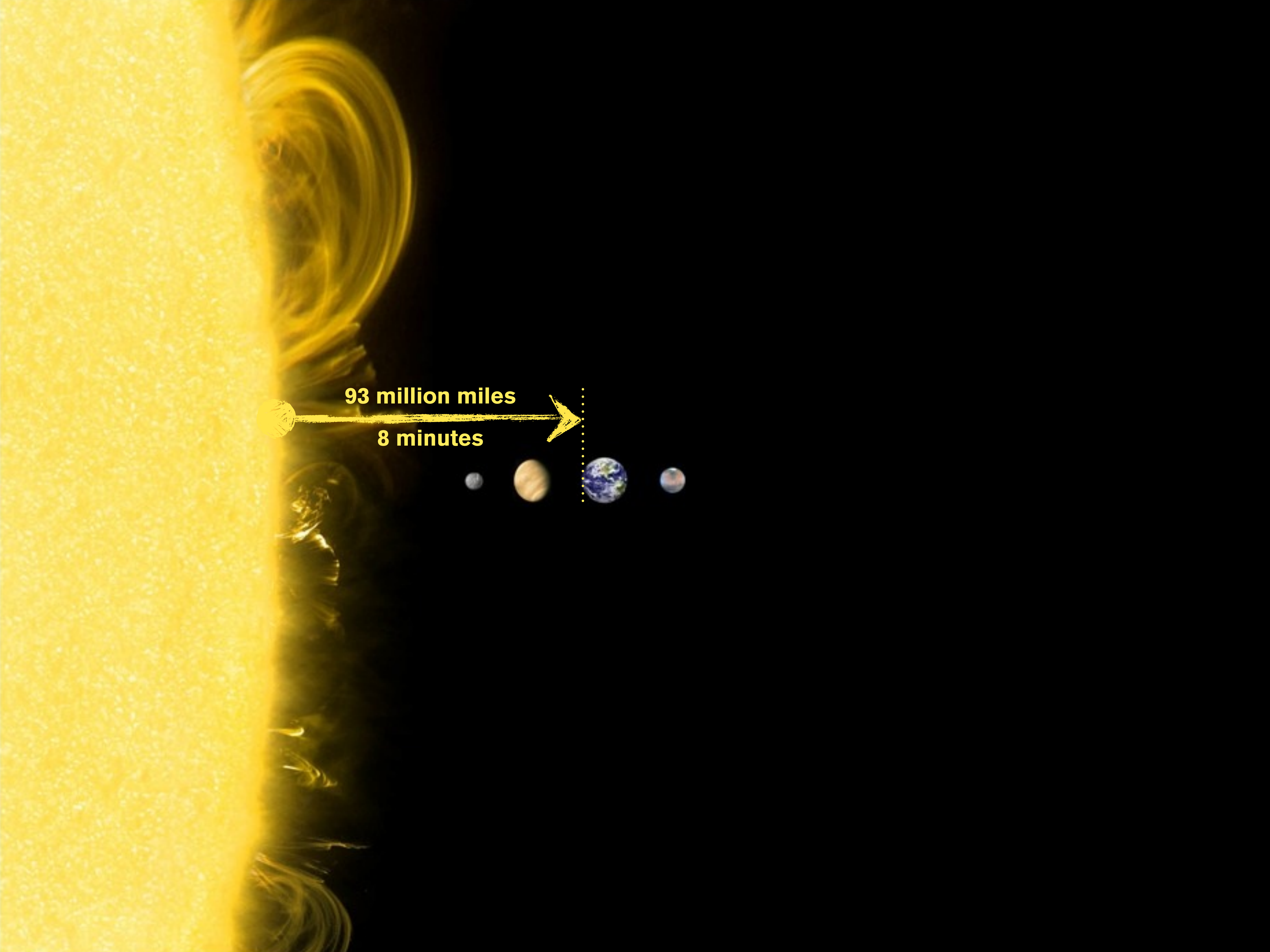


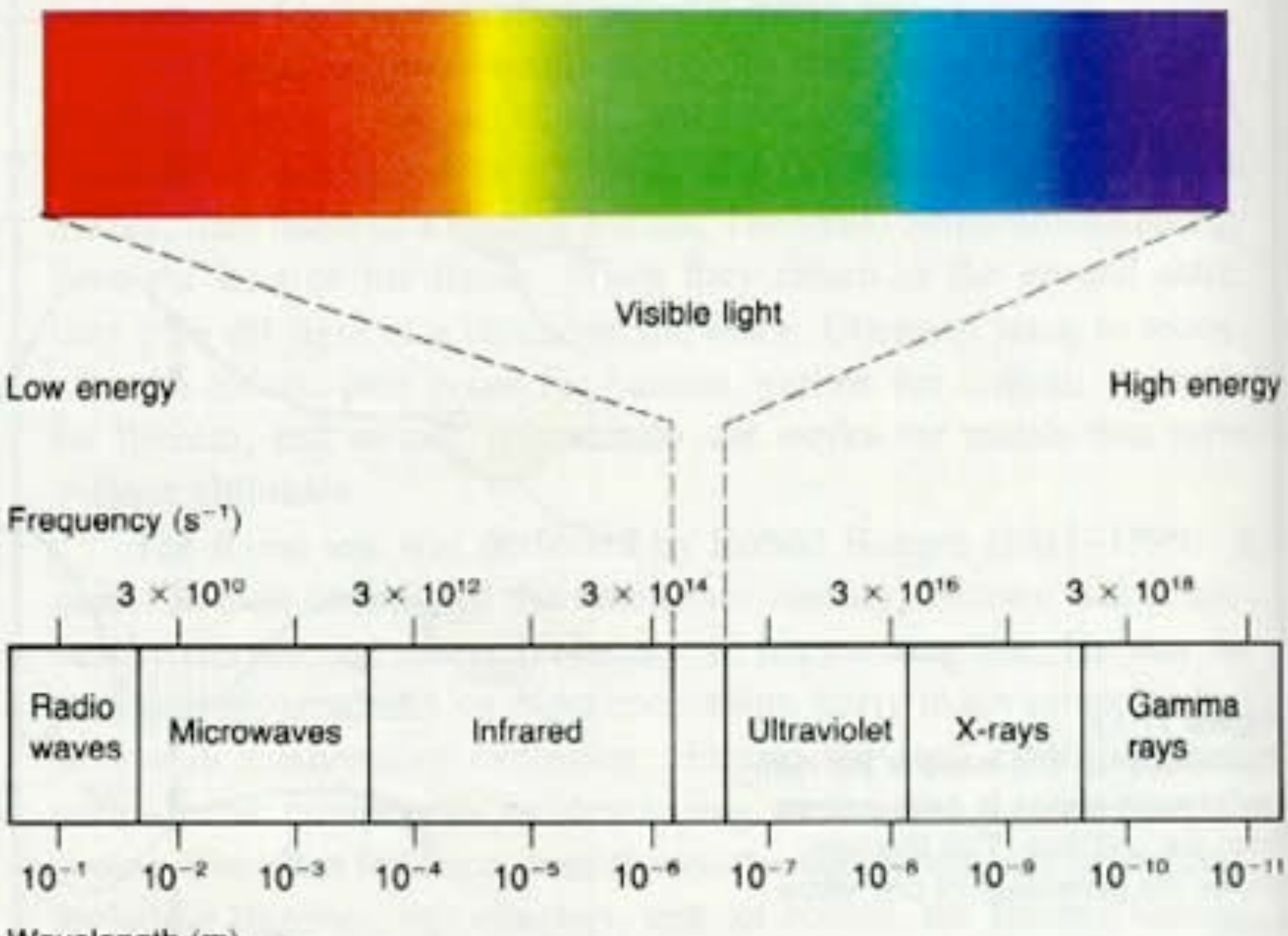
The fundamental concept of daylight factor—the relationship between indoor and outdoor daylight illuminances. JONATHAN MEENDERING

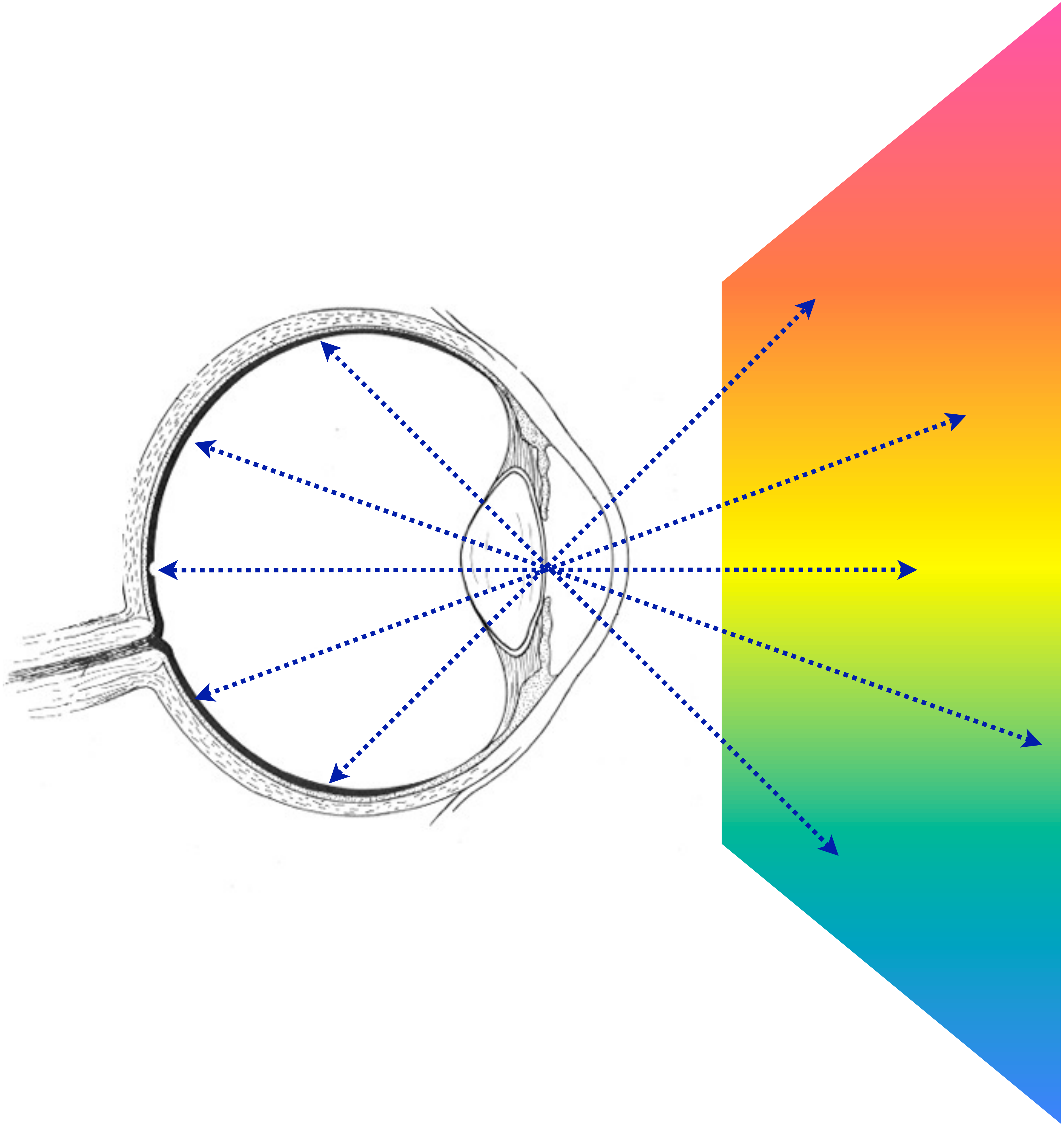
Daylight Factor: Key Architectural Issues

- Size of daylight apertures
  (windows, skylights etc.)
- Location of daylight apertures
  (sidelighting, toplighting etc.)
- Access to daylight
  (considering the site, building, and room contexts)
- Room geometry
  (height, width and depth)
- Location of the point of interest relative to apertures
- Visible transmittance of glazing
- Reflectances of room surfaces and contents
- Reflectances of exterior surfaces
  affecting daylight entering the aperture
- The effects of daylighting enhancements
  (such as light shelves)

LIGHT

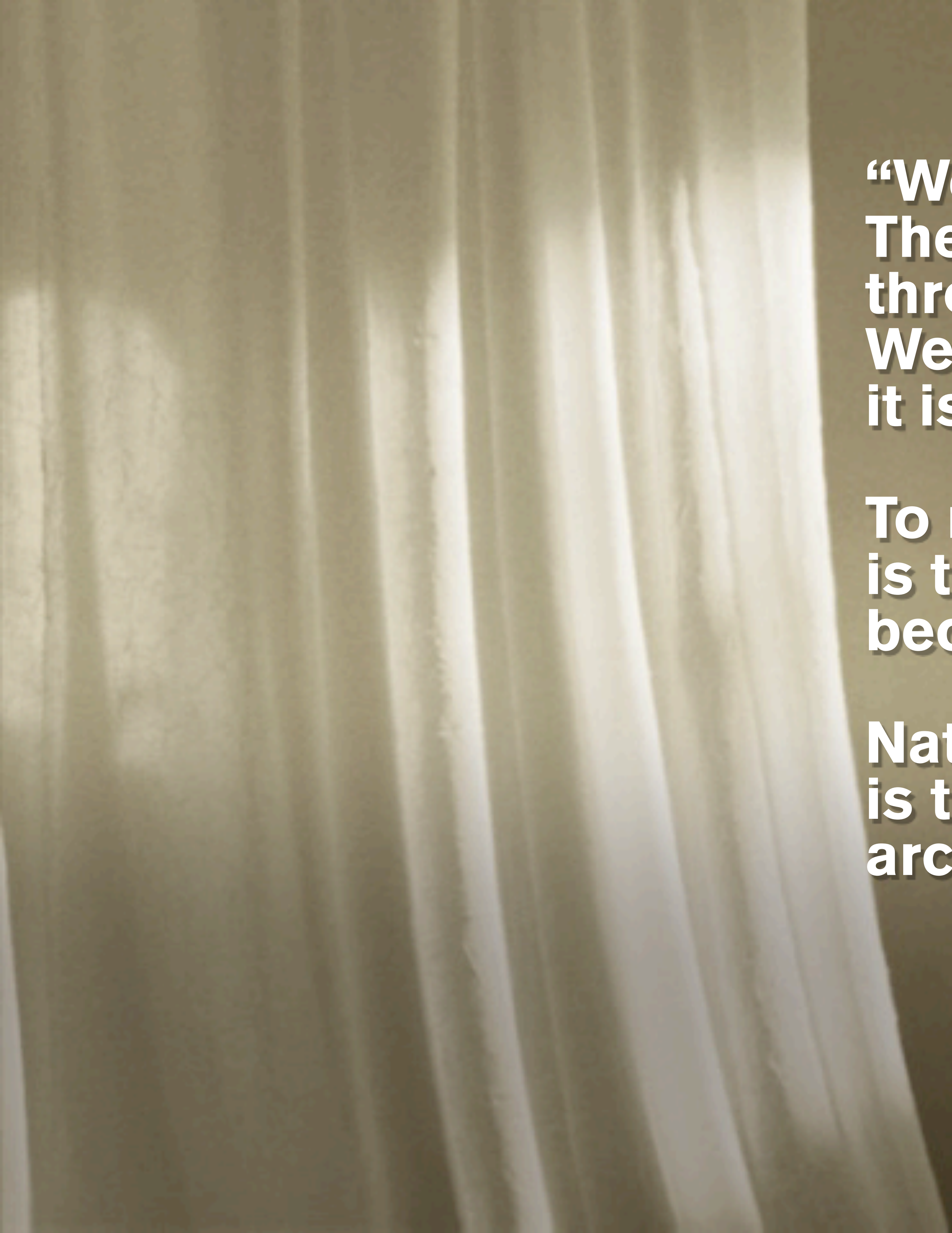

93 million miles
8 minutes


Visible light
Low energy
High energy
Frequency (s^{-1})
3×10^{10}
3×10^{12}
3×10^{14}
3×10^{16}
3×10^{18}
Radio waves
Microwaves
Infrared
Ultraviolet
X-rays
Gamma rays
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
10^{-6}
10^{-7}
10^{-8}
10^{-9}
10^{-10}
10^{-11}




LIGHT IS
absorbed
transmitted
reflected


DAYLIGHTING
controlled light
not as much light as possible



**"We were born of light.
The seasons are felt
through light.
We only know the world as
it is evoked by light…**

**To me natural light
is the only light,
because it has mood.**

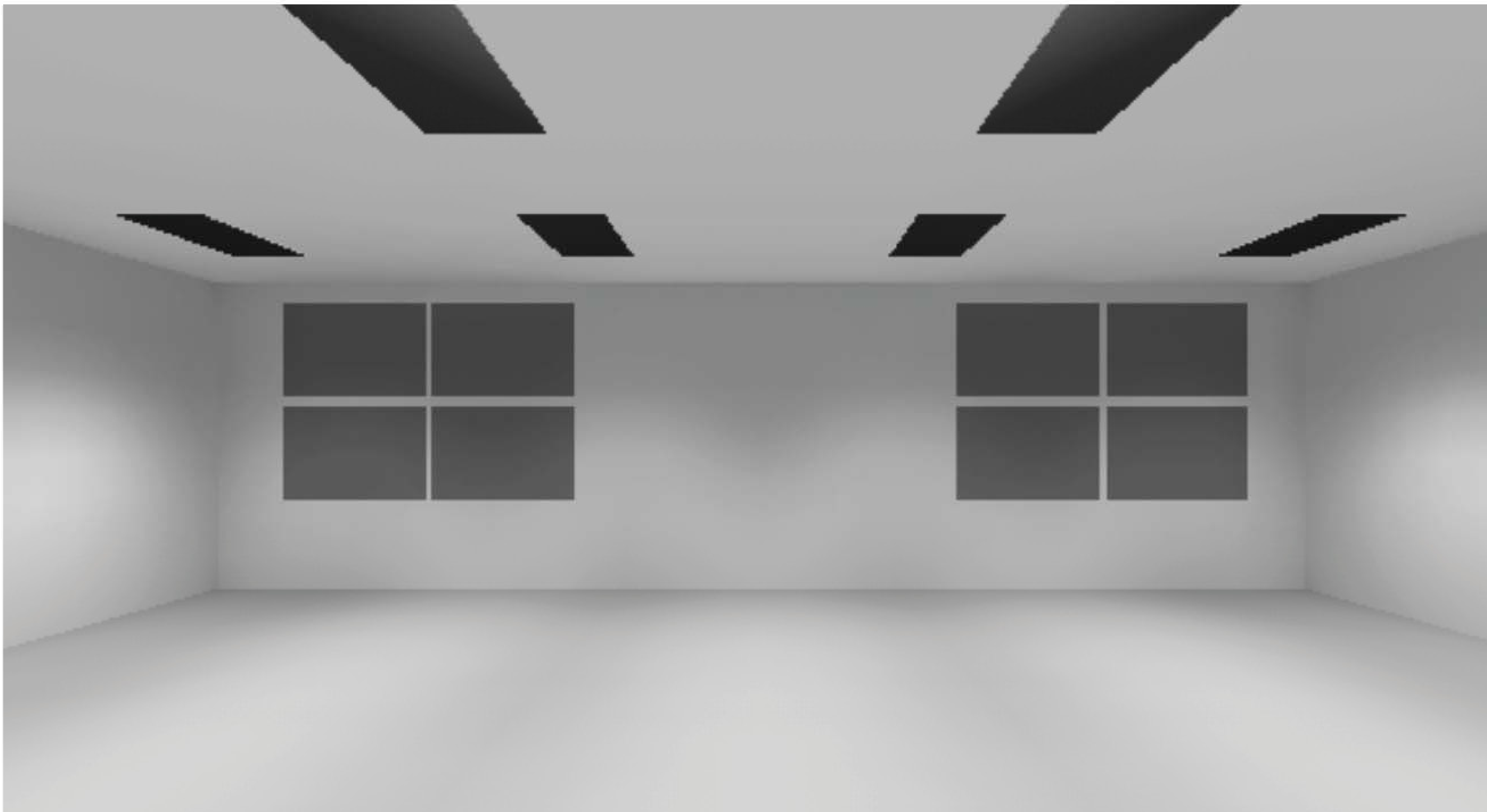
**Natural light
is the only light that makes
architecture architecture."**

-Louis I. Kahn

<Artificial Daylighting>

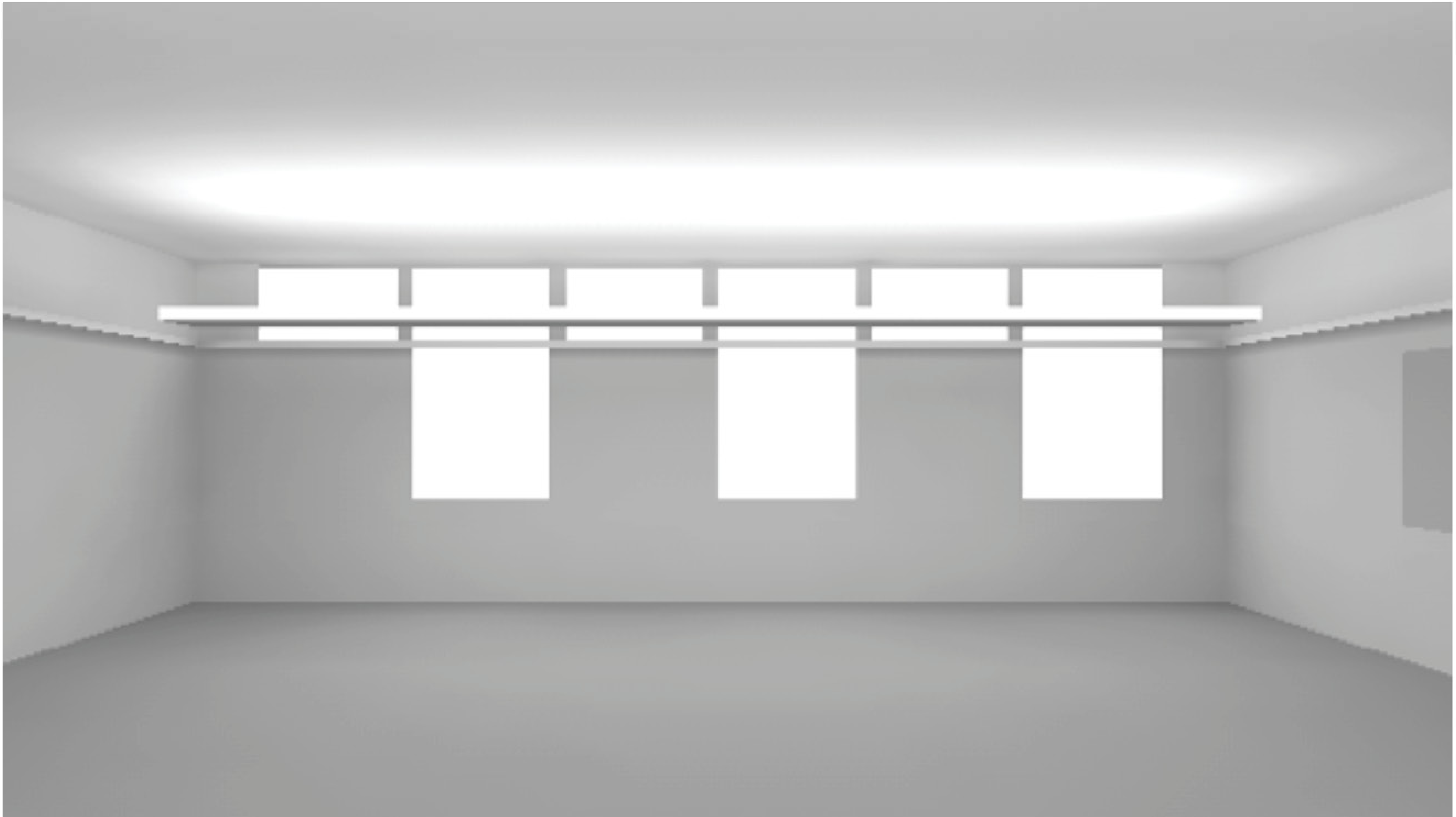
Glazing Placement – no thinking

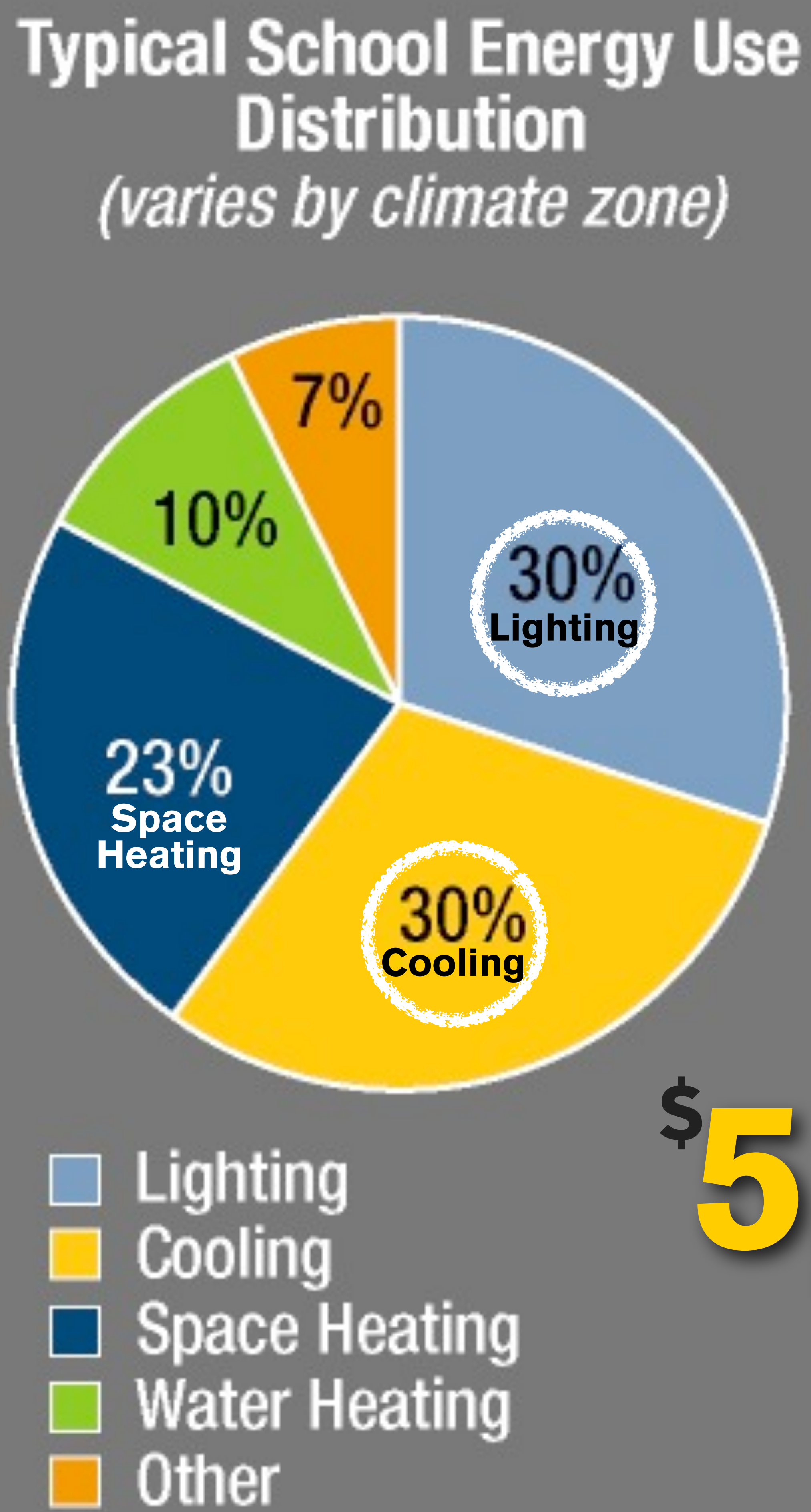
Exterior Window-to-Wall Ratio: 22%



Glazing Placement – thinking daylighting

Exterior Window-to-Wall Ratio: 28%





daylighting could affect:

electricity use
heating load
cooling load

k-12 schools spend

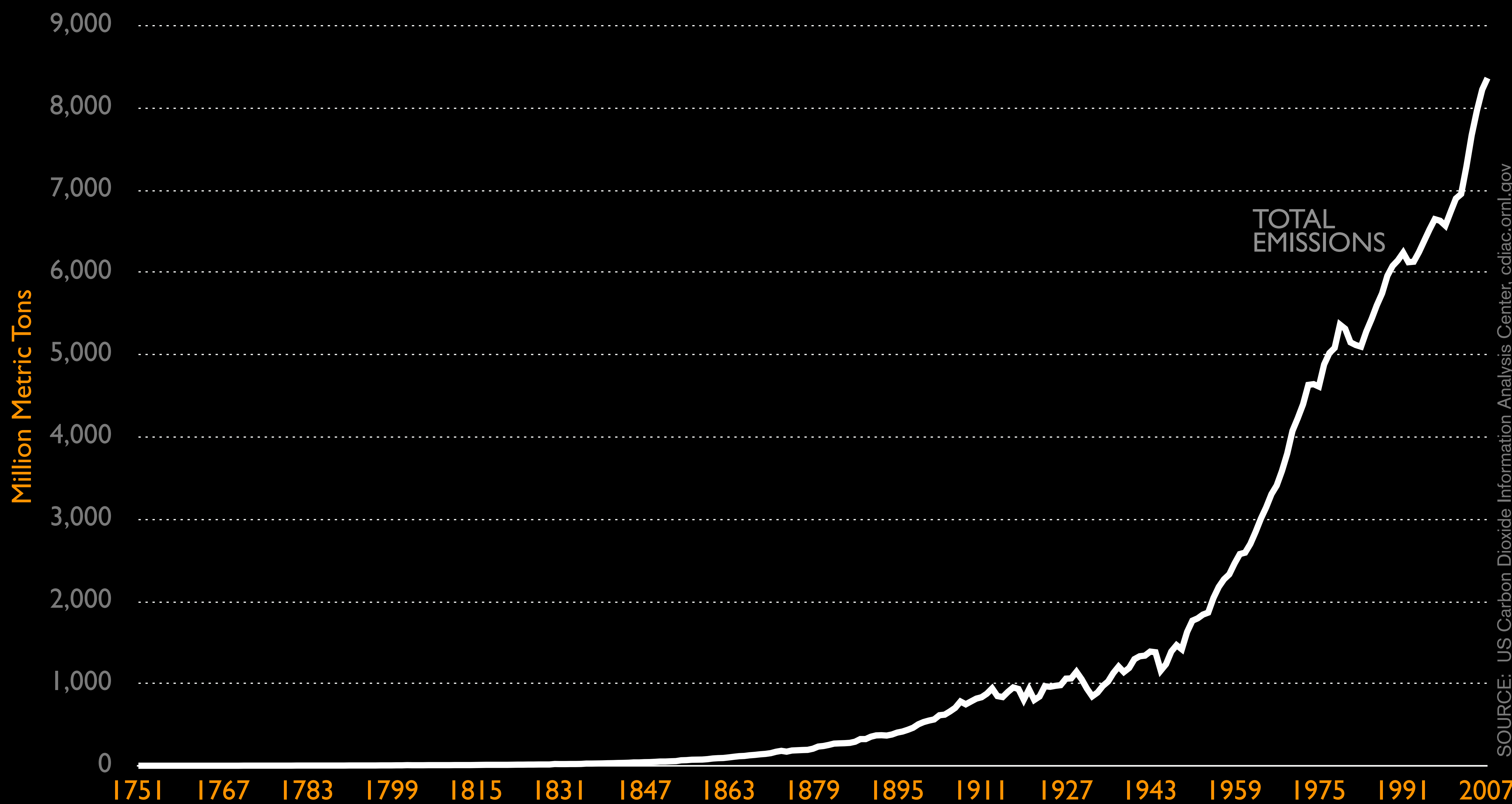
$5,000,000,000

annually on electricity

Global Carbon Emissions

1751-2007

Fossil fuels from Colonial days through the Industrial Revolution




GLOBAL
WARMING

DESIGN ELEMENTS	AESTHETIC	HUMAN	ENERGY
Integrated Design	Low	Medium	High
Orientation/Form/Footprint/Massing	X	X	X
Sidelighting (including WWR and view)	One or other	One or other	X (both)
Toplighting (including SFR)	One or other	One or other	X (both)
Glazing Performance	X	X	X
Building Occupancy		X	X
Electric Lighting - Fixture Selection		X	X
Floor to Ceiling Height		X	X
Interior Colors/Surface Reflectances		X	X
External Shading		X	X
Interior Shading/Lightshelves			X
Electric Lighting - Task/Ambient Lighting Strategy			X
Lighting Power Density (kW and kWh reduction)			X
Lighting Controls (kW and kWh reduction)			X
HVAC sizing (kW and kWh reduction)			X
Climate Appropriate Design			X

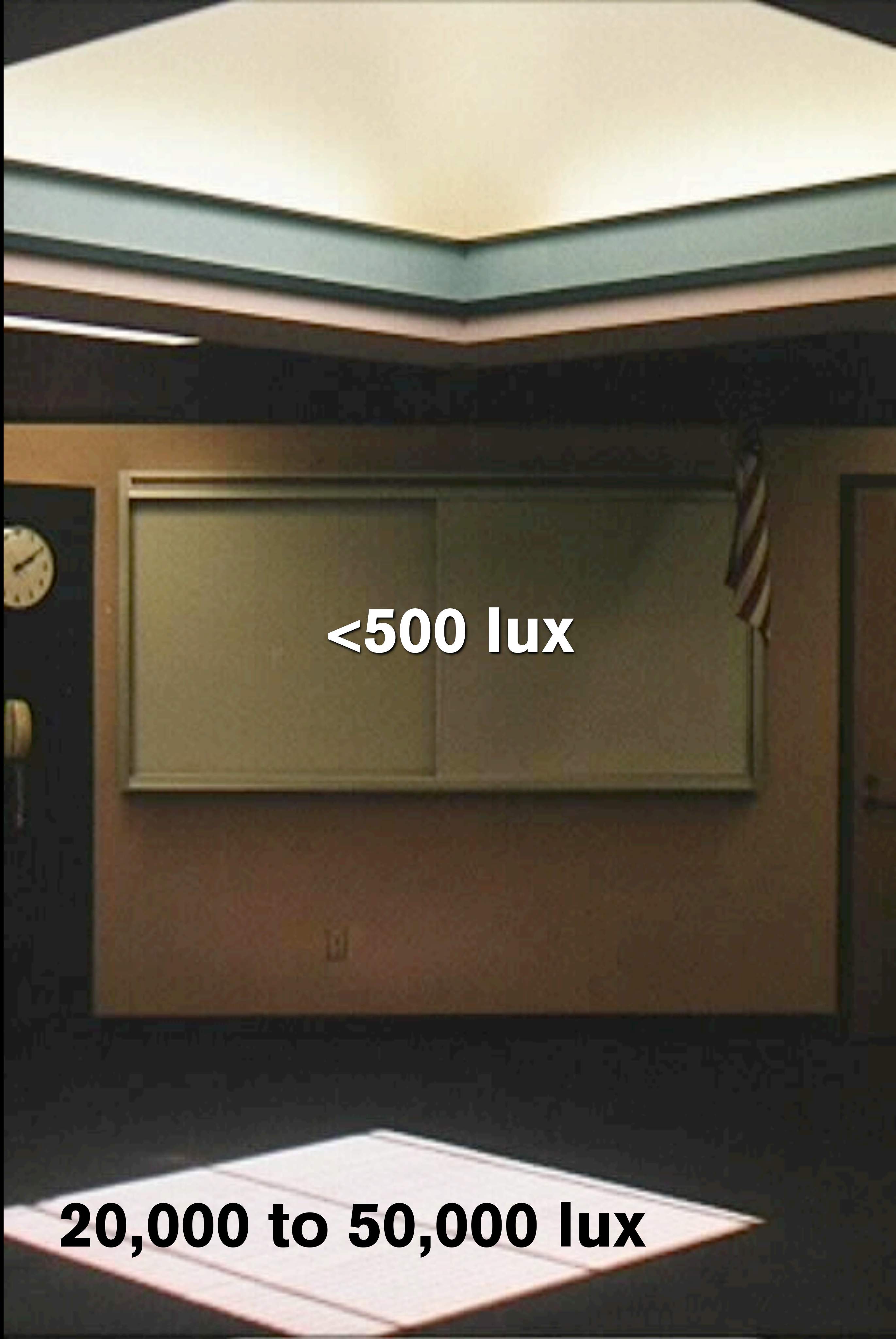
CONTROL, NOT QUANTITY


Too much daylight =
a solar oven
NOTE

Controlled sunlight, not direct sunlight

too bright = contrast

visual comfort problems
thermal discomfort
still requires electric lighting to balance
increased cooling load



DAYLIGHT ILLUMINANCE

depends on specific building:

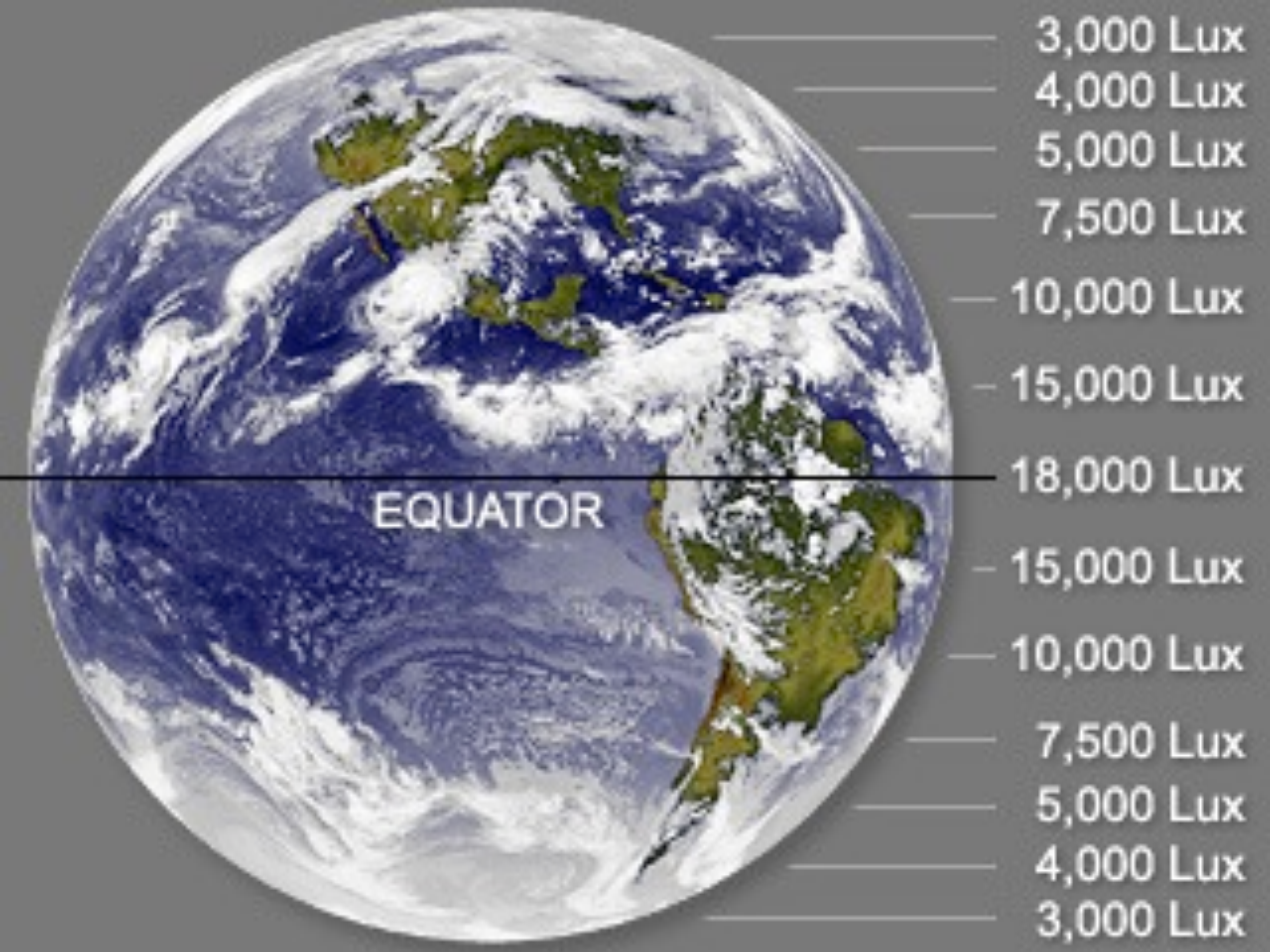
- global location
- prevailing climate
- time of day/month/year
- current sky conditions

Measured in foot-candles or lux.

TABLE 12.5 COMMONLY EXPERIENCED BRIGHTNESS LEVELS

	Brightness (cd/sq. ft.)*	
Sidewalk on a dark night	0.0003	Poor vision
Sidewalk in moonlight	0.003	
Sidewalk under a dim streetlight	0.03	
Book illuminated by a candle	0.3	
Wall in an office	3	Normal indoor brightness
Well-illuminated drafting table	30	
Sidewalk on a cloudy day	300	Normal outdoor brightness
Fresh snow on a sunny day	3,000	
500-watt incandescent lamp	30,000	Blinding glare

*For S.I., (cd/sq. m.) ≈ (cd/sq. ft.) × 11


3,000 Lux
4,000 Lux
5,000 Lux
7,500 Lux
10,000 Lux
15,000 Lux
18,000 Lux
EQUATOR
15,000 Lux
10,000 Lux
7,500 Lux
5,000 Lux
4,000 Lux
3,000 Lux

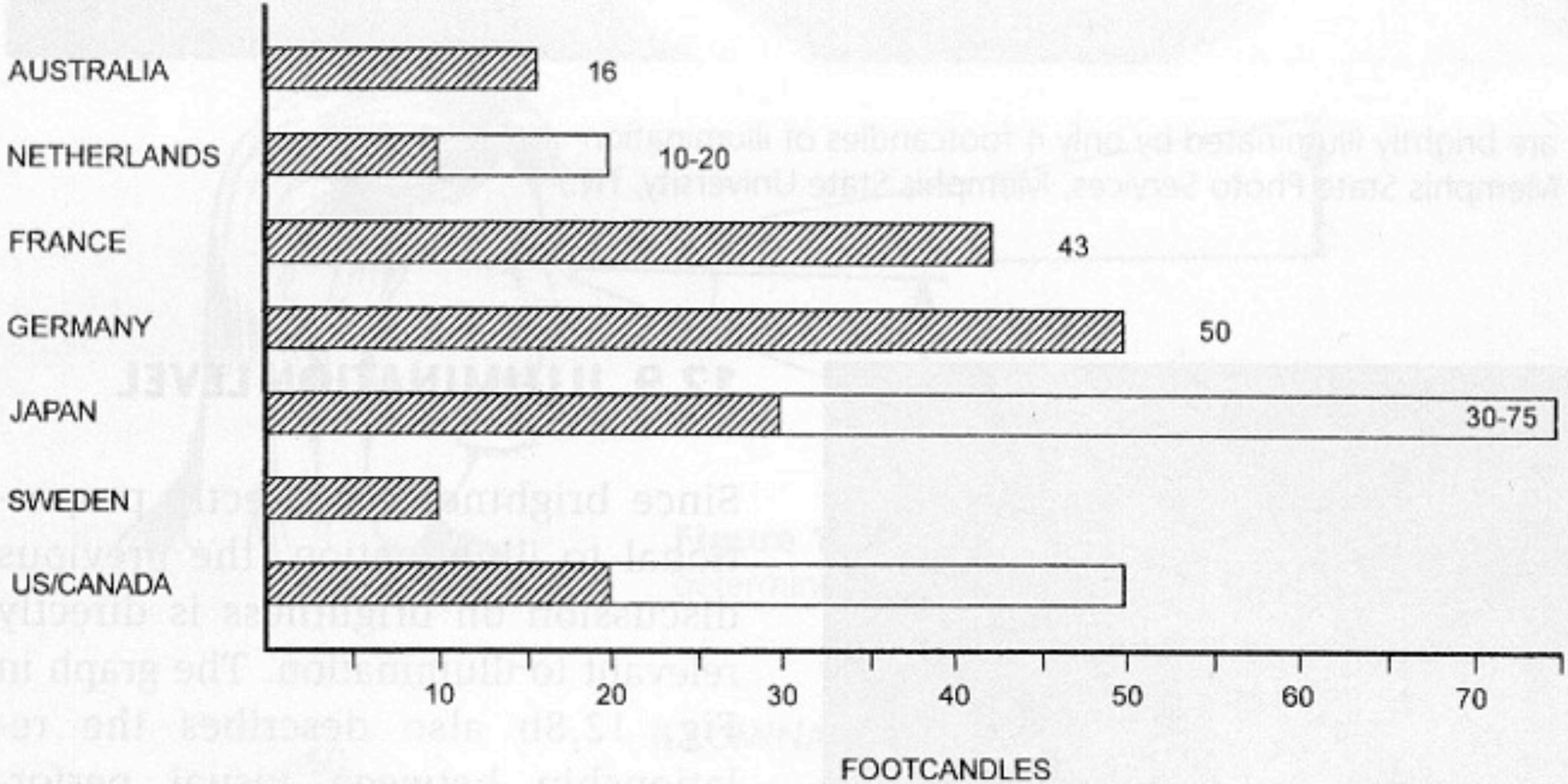
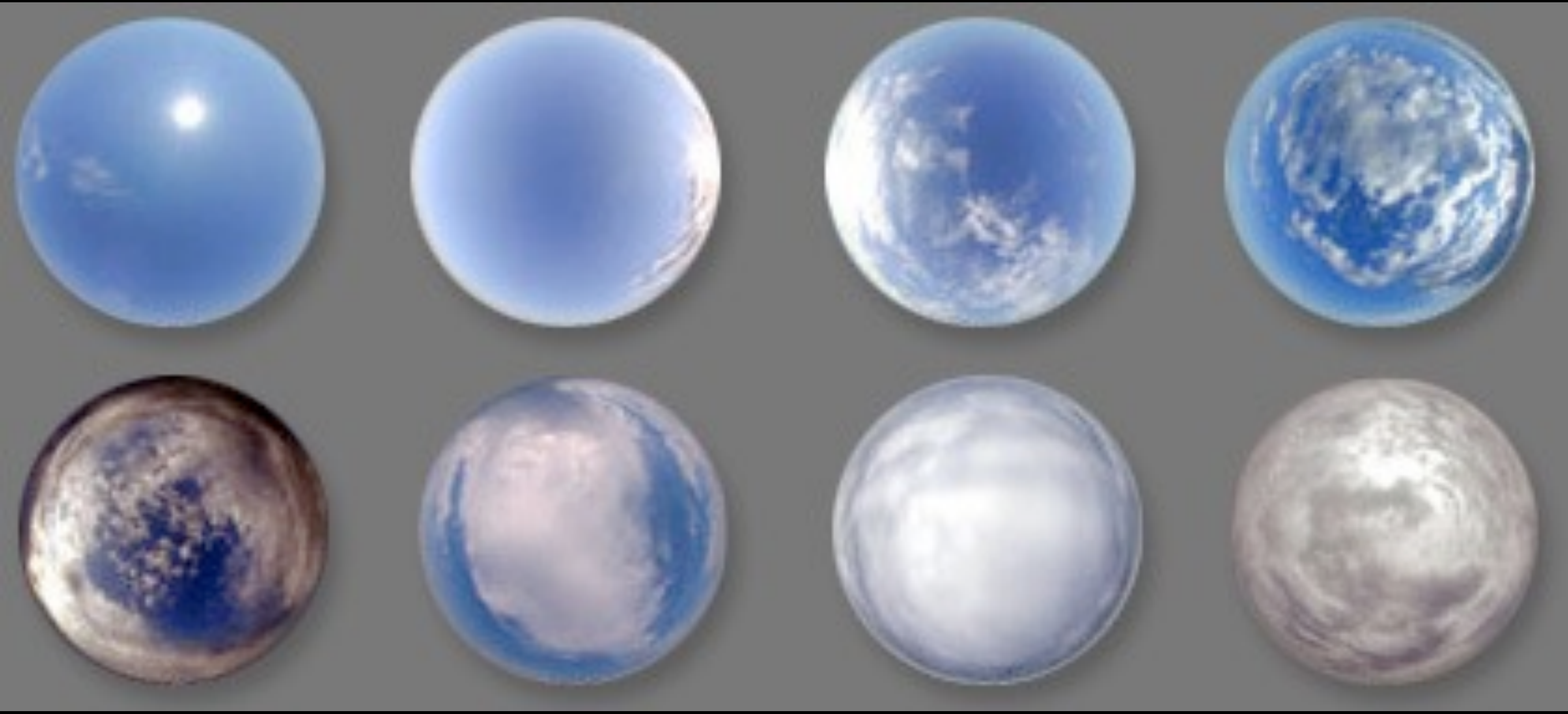


Figure 12.9 A comparison of recommended lighting levels for general office work in horizontal footcandles. Note that some countries recommend ranges instead of a specific value. (After Mills and Borg. "Rethinking Light Levels." IAEEL Newsletter, 7 (20), 4-7 (1998).)

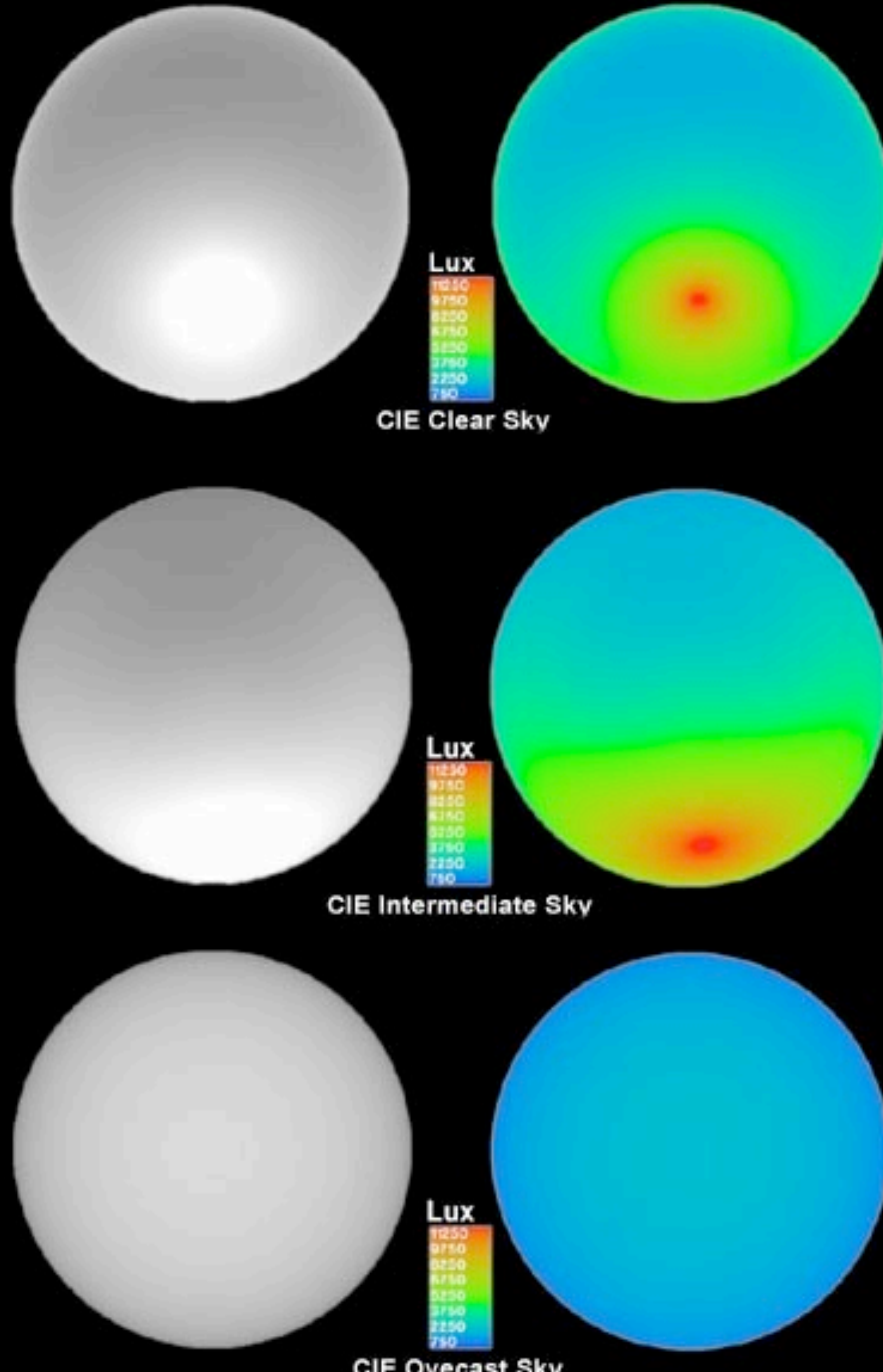
SKY TYPES



Examples of different sky distributions.

These images are the result of taking photographs using a fish-eye lens.
Such images capture the full hemisphere of the sky, with the horizon around the perimeter and the zenith in the centre.

Local climate must be considered when designing for daylight.



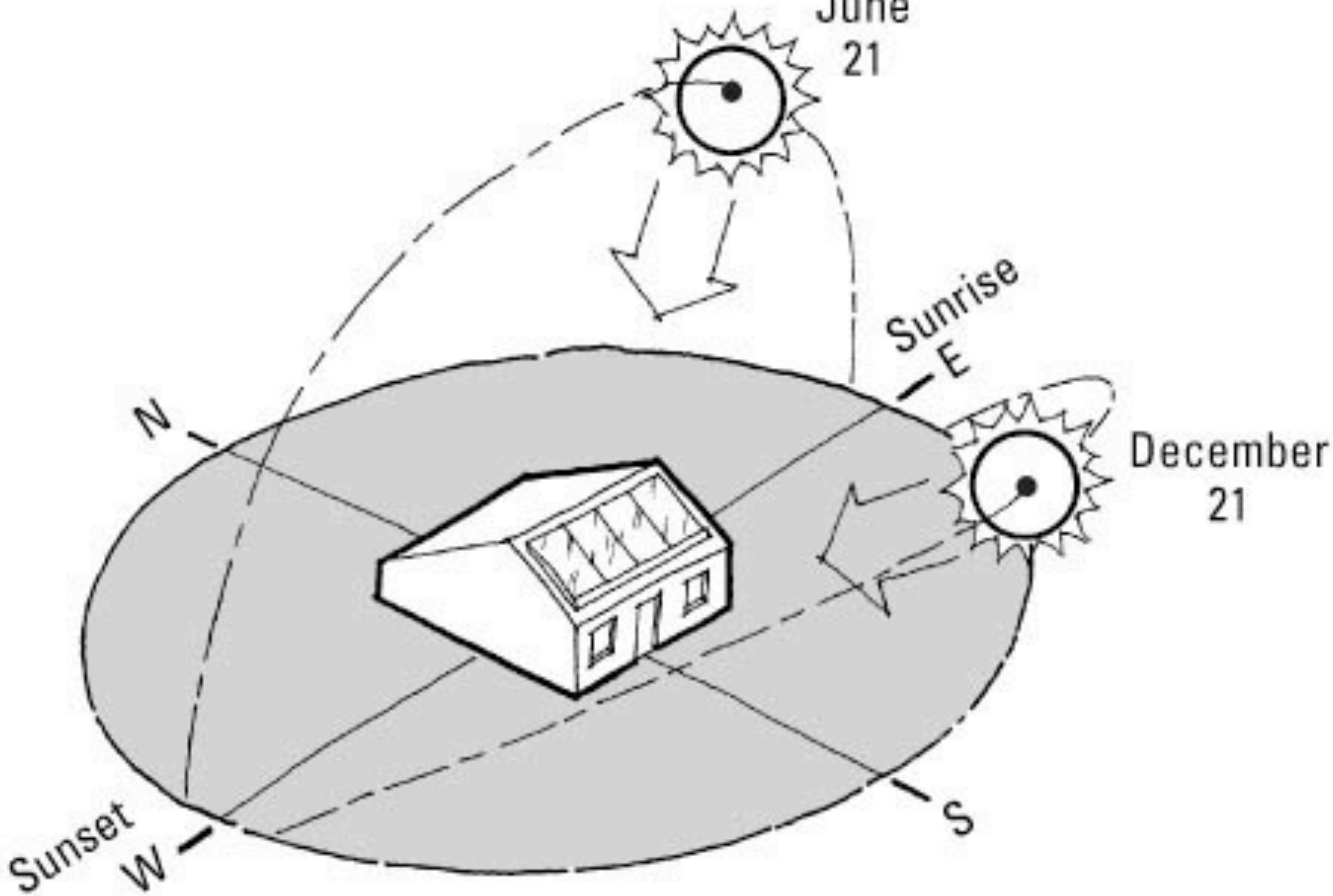
CLEAR

INTERMEDIATE

OVERCAST

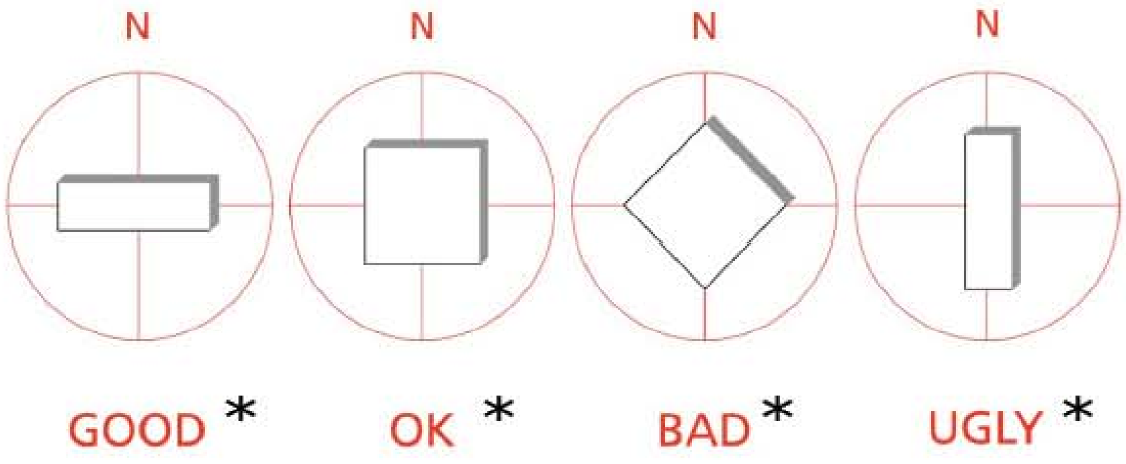
Defined by the CIE (Commission International de l'Eclairage)

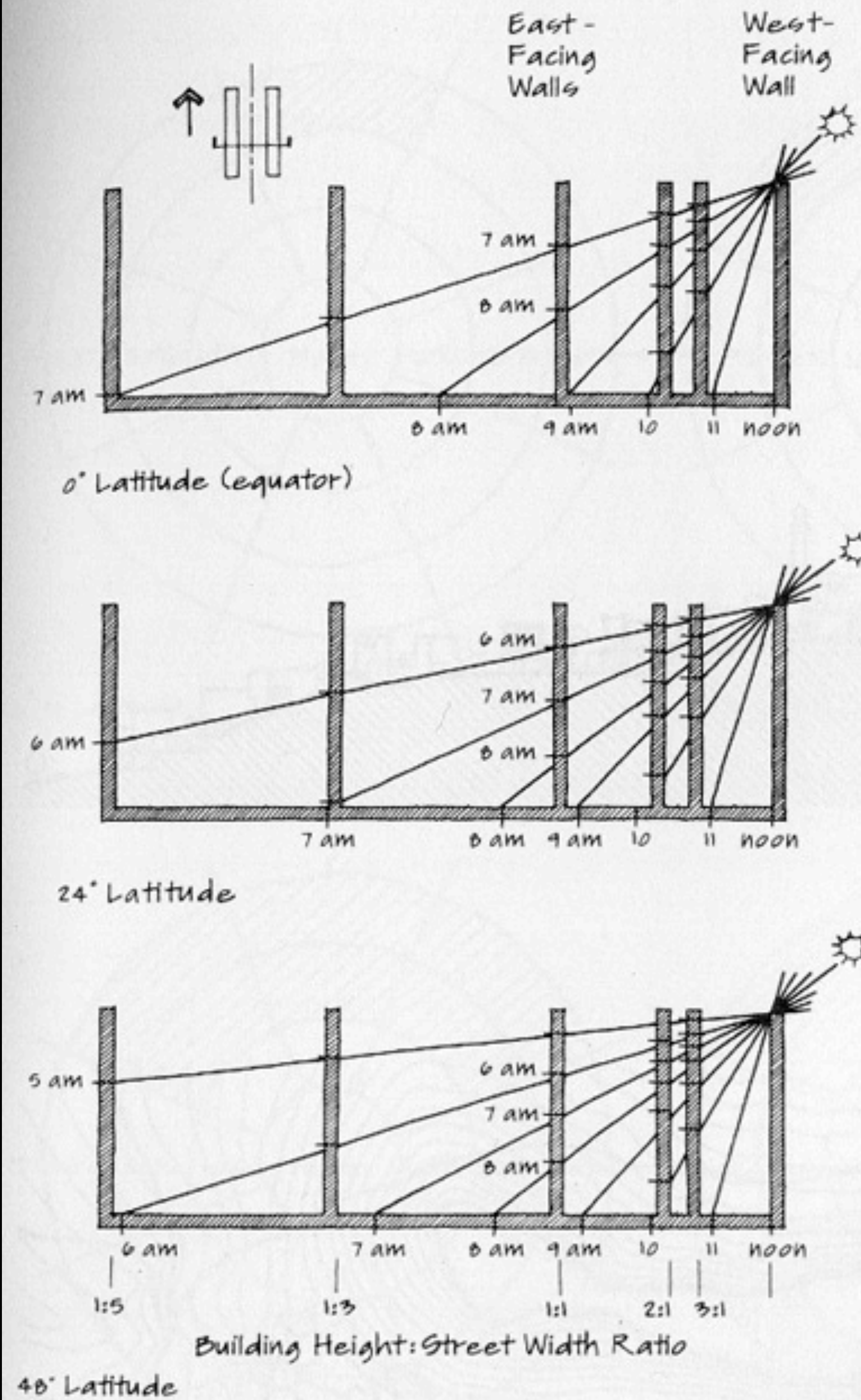
SITING STRATEGIES


June
21
Sunrise
E
N
December
21
Sunset
W
S

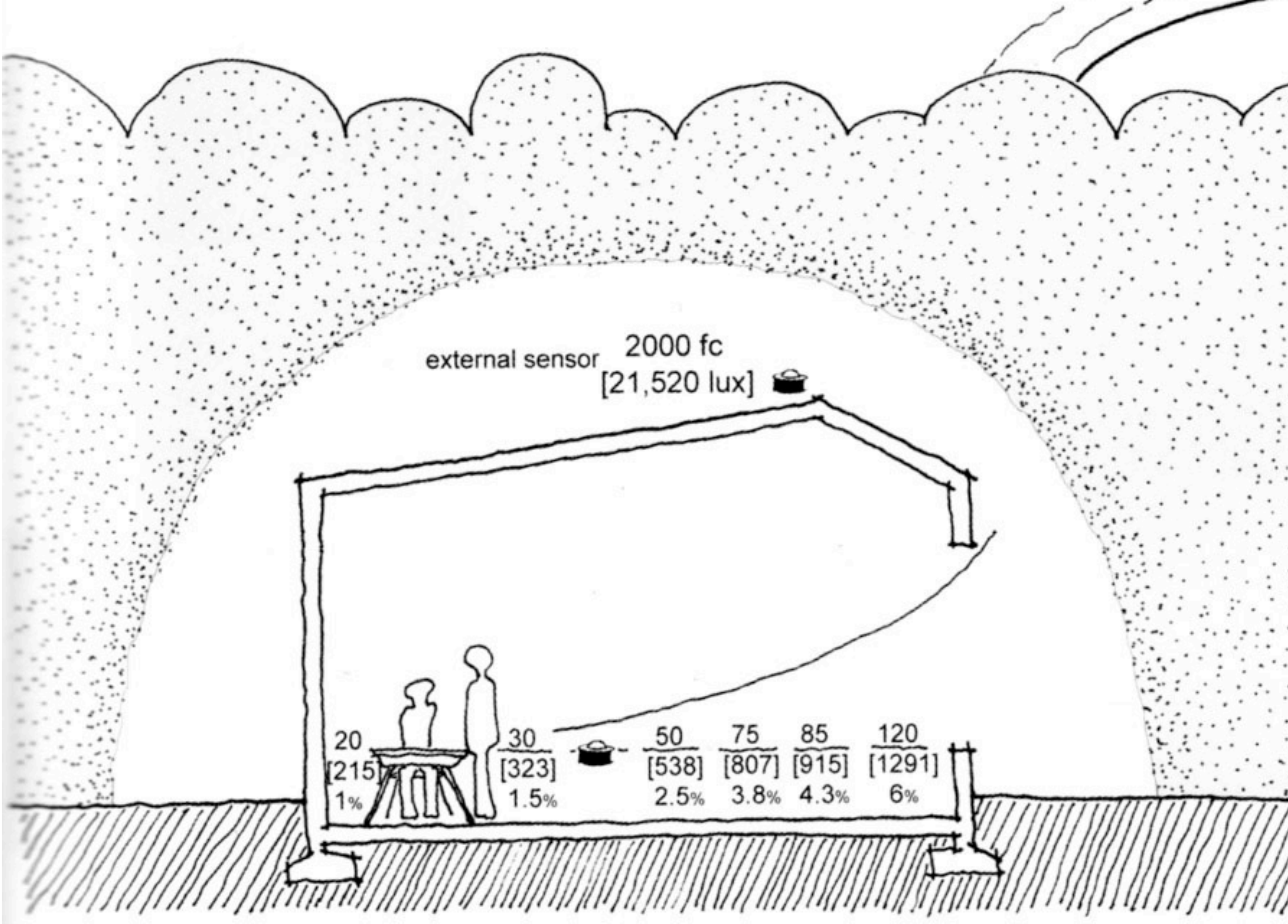
Climate Appropriate Design

- Sky conditions
- Internal/external load dominated
- Building orientation

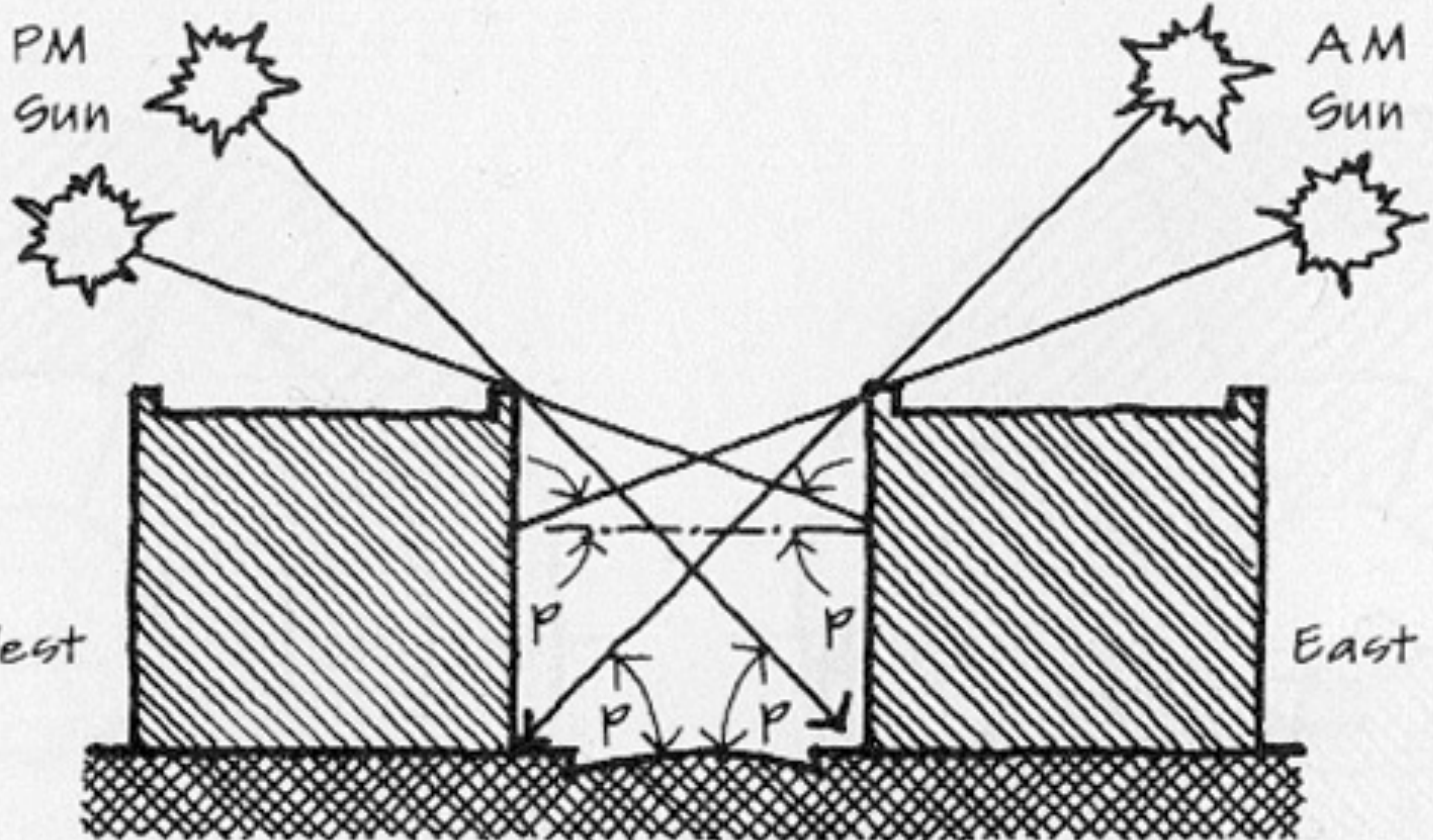




Impact of Cross-Section on Shading Patterns, North-South Canyons on Jun 21



Daylight factor versus illuminance as a measure of daylighting. The illuminance values will change throughout the day, while the daylight factors will be reasonably constant throughout the day (under similar sky conditions). KATE BECKLEY



Profile Angle for North-South Canyons

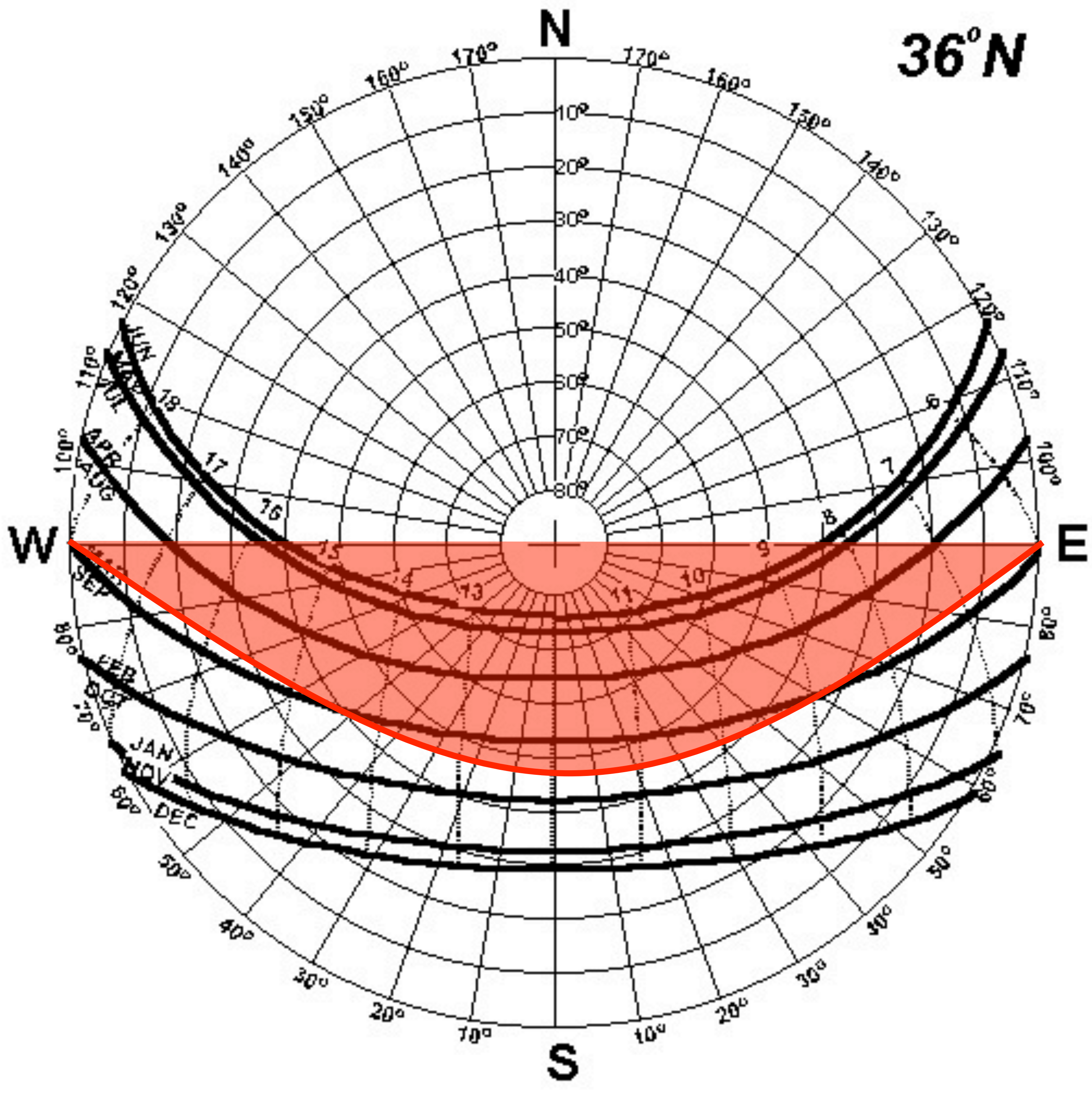
TABLE 21a

Suggested room orientations

	N	NE	E	SE	S	SW	W	NW
Bedroom*	•	•	•	•	•			
Bath*	•	•	•	•	•	•	•	•
Kitchen			•	•	•			
Dining			•	•	•	•		
Living				•	•			
Family				•	•	•		
Utility / Laundry*	•	•						•
Workshop*	•	•						•
Storage*	•						•	•
Garage*	•					•	•	•
Sun porch				•	•	•		
Outdoor space*			•	•	•	•		

*The most suitable location of those indicated will depend on local climate — whether largely too hot or too cold, direction of winter winds and summer breezes, etc.

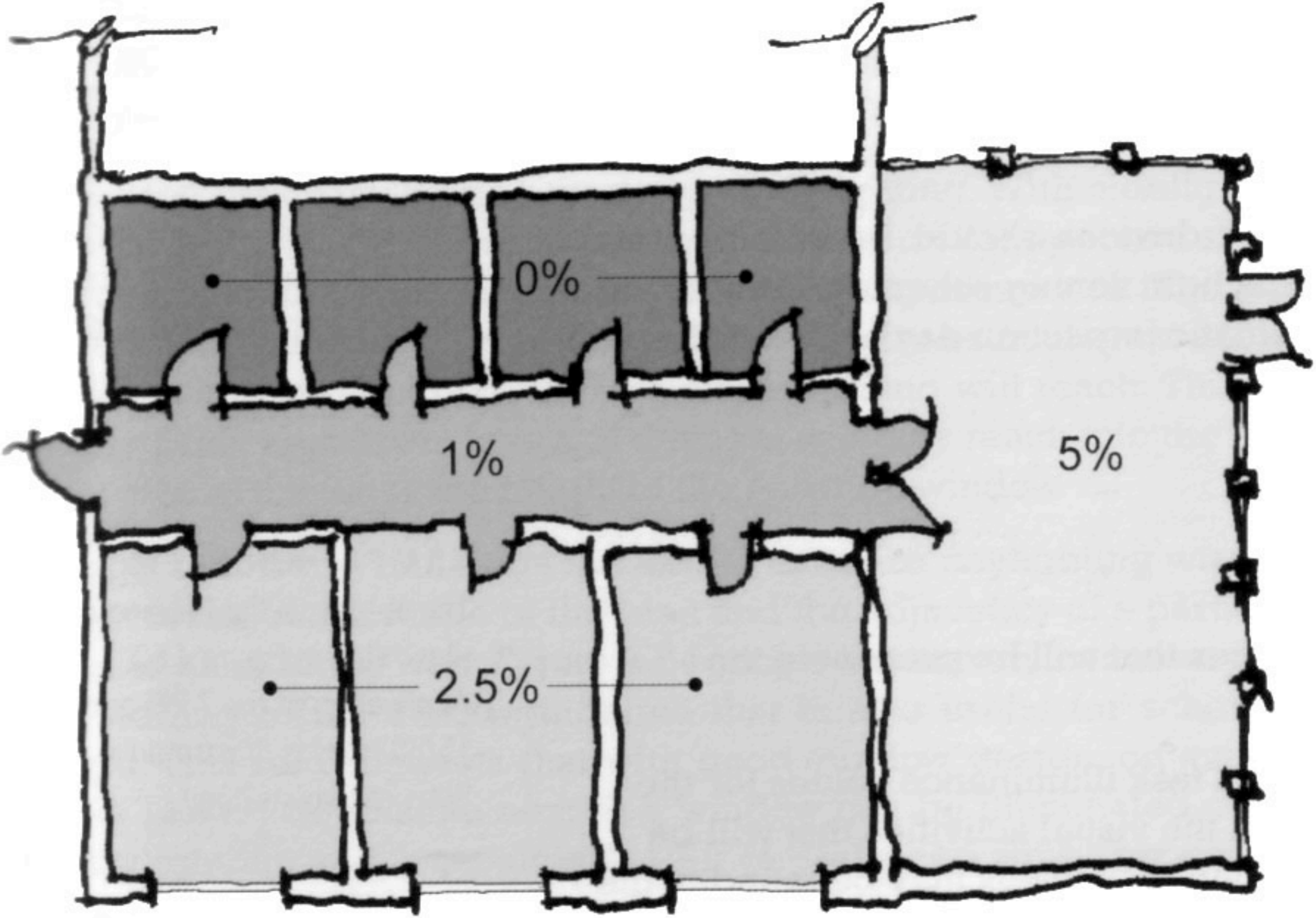
Sun Path Diagram



DESIGN CRITERIA

Suggested daylight factor criteria (under overcast skies)

SPACE	AVERAGE DF	MINIMUM DF
Commercial/Institutional		
Corridor	2	0.6
General Office	5	2
Classroom	5	2
Library	5	1.5
Gymnasium	5	3.5
Residential		
Dining Room/Studio	5	2.5
Kitchen	2	0.6
Living Room	1.5	0.5
Bedroom	1.0	0.3



Example of a daylight zoning diagram. KATE BECKLEY

Design Requirements

50 Lux

Car Parks
Main Entrances and exits
Store rooms
Outdoor platforms
Stables
Hotel bedrooms
Garages

100 Lux

Corridors and passageways
Stairs and escalators
Entrance gates
Changing rooms
Rest rooms
Raw material stores
Machine rooms
Loading bays
Foyers
Domestic living rooms

Design Requirements

200 Lux

Lifts and lift lobbies
Waiting rooms
Medical stores
Machine assembly rooms
Finished goods stores
Vaults and strong-rooms
Print rooms
Shopping centre circulation
Airport lounges
Museum areas (general)
School assembly halls
Lecture theatres
Gymnasiums
Sports spectator areas

400 Lux

Enquiry desks and counters
Food preparation areas
Consulting and treatment rooms
General clerical offices
Library reading tables
Assembly hall platforms
Classroom white-boards
Laboratories
Hospital dispensing rooms
Workshop benches

Design Requirements

600 Lux

Engine testing rooms
Cutting and assembly rooms
Inspection testing benches
Computer rooms
Drawing board task lighting
Food sales counters
Cashier counters
Supermarkets
School art rooms
Vision testing rooms
Sewing rooms

900 Lux

Electronics assembly areas
Instrumentation workbenches
Supermarket displays

1200+ Lux

Sorting and grading areas
Clothing inspection areas
Hand engraving workbenches
Jewellery workbenches
Boxing rings

TASK/USE	fc (Lux)	Latitude 10°–20°	30°	40°	50°	60–70°
Assembly Tasks, simple	20-50 (215-538)	1.5-3	1.5-4	2-6	3.5-9	4-10
moderatly difficult	50-100 (538-1076)	3-6.5	4-8	5.5-14.5	9-17.5	10-20
Air Terminals	10-20 (108-215)	0.5-1	1-1.5	1-2.5	2-3.5	2-4
Bank, lobby	10-20 (108-215)	0.5-1	1-1.5	1-2.5	2-3.5	2-4
teller	50-100 (538-1076)	3-6.5	4-8	5.5-14.5	9-17.5	10-20
Calssroom, general	20-50 (215-538)	1.5-3	1.5-4	2-6	3.5-9	4-10
reading	50-100 (538-1076)	3-6.5	4-8	5.5-14.5	9-17.5	10-20
Conference Room	20-50 (215-538)	1.5-3	1.5-4	2-6	3.5-9	4-10
Corridor, stairs	5-10 (54-108)	0.5-1	0.5-1	0.5-1	1-2	1-2
Dining Hall	5-10 (54-108)	0.5-1	0.5-1	0.5-1	1-2	1-2
Drafting	50-100 (538-1076)	3-6.5	4-8	5.5-14.5	9-17.5	10-20
Exhibition, general	10-20 (108-215)	0.5-1	1-1.5	1-2.5	2-3.5	2-4
display	20-50 (215-538)	1.5-3	1.5-4	2-6	3.5-9	4-10
Hotel Rooms	20-50 (215-538)	1.5-3	1.5-4	2-6	3.5-9	4-10
Lobby, lounge, reception	10-20 (108-215)	0.5-1	1-1.5	1-2.5	2-3.5	2-4
Library stacks, active	20-50 (215-538)	1.5-3	1.5-4	2-6	3.5-9	4-10
inactive	5-10 (54-108)	0.5-1	0.5-1	0.5-1	1-2	1-2
Locker Rooms	10-20 (108-215)	0.5-1	1-1.5	1-2.5	2-3.5	2-4
Museum Display	20-50 (215-538)	1.5-3	1.5-4	2-6	3.5-9	4-10
Offices, general	10-20 (108-215)	0.5-1	1-1.5	1-2.5	2-3.5	2-4
Reading, normal	20-50 (215-538)	1.5-3	1.5-4	2-6	3.5-9	4-10
Restaurant Kitchen	50-100 (538-1076)	3-6.5	4-8	5.5-14.5	9-17.5	10-20
Residences, kitchens	20-50 (215-538)	1.5-3	1.5-4	2-6	3.5-9	4-10
living	10-20 (108-215)	0.5-1	1-1.5	1-2.5	2-3.5	2-4
bedrooms	5-10 (54-108)	0.5-1	0.5-1	0.5-1	1-2	1-2
Sewing	50-100 (538-1076)	3-6.5	4-8	5.5-14.5	9-17.5	10-20
Science Lab	50-100 (538-1076)	3-6.5	4-8	5.5-14.5	9-17.5	10-20
Sports, indoor	50-100 (538-1076)	3-6.5	4-8	5.5-14.5	9-17.5	10-20
Toilet Rooms	10-20 (108-215)	0.5-1	1-1.5	1-2.5	2-3.5	2-4

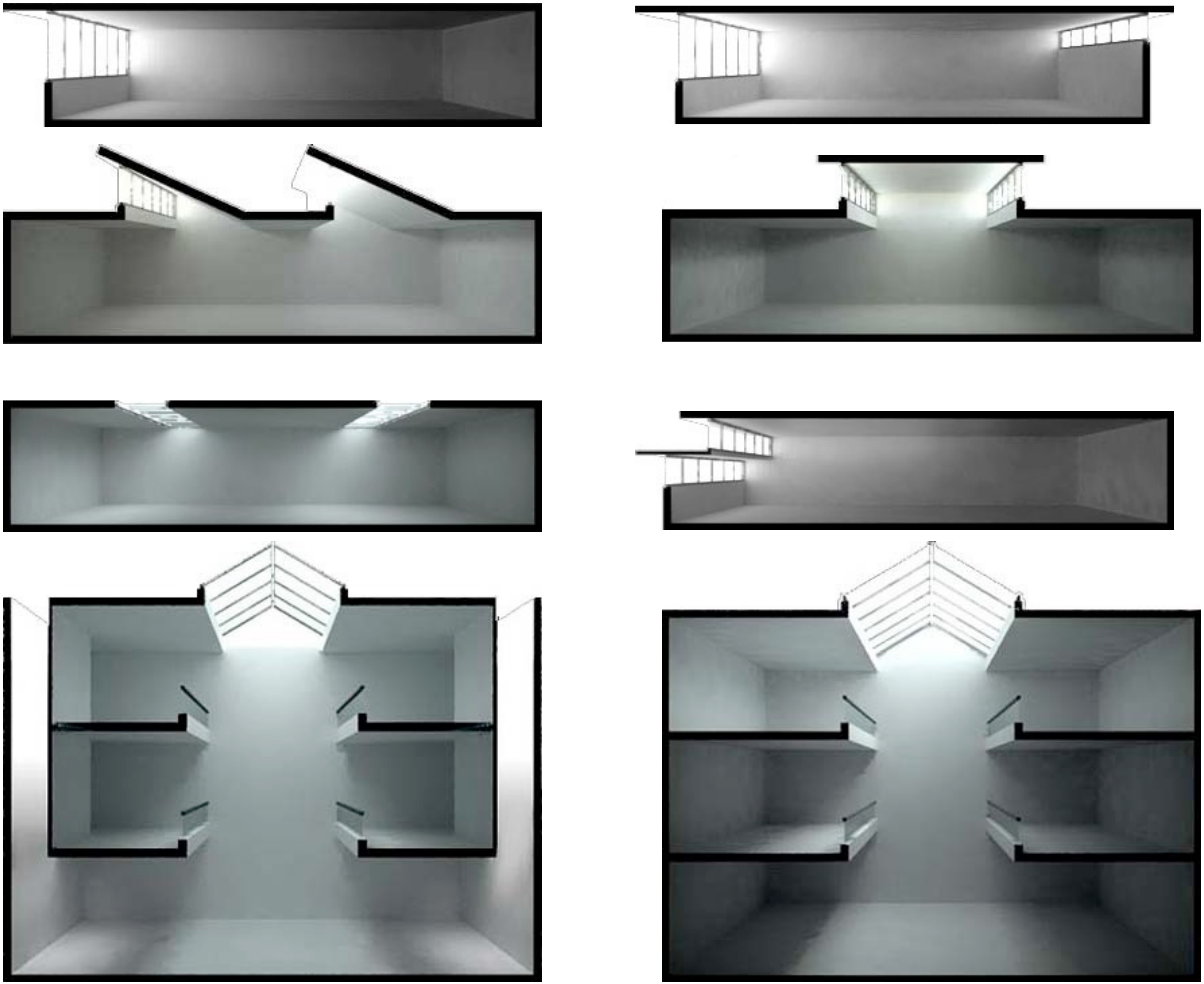
Recommended Daylight Factors by Room Use and Site Latitude

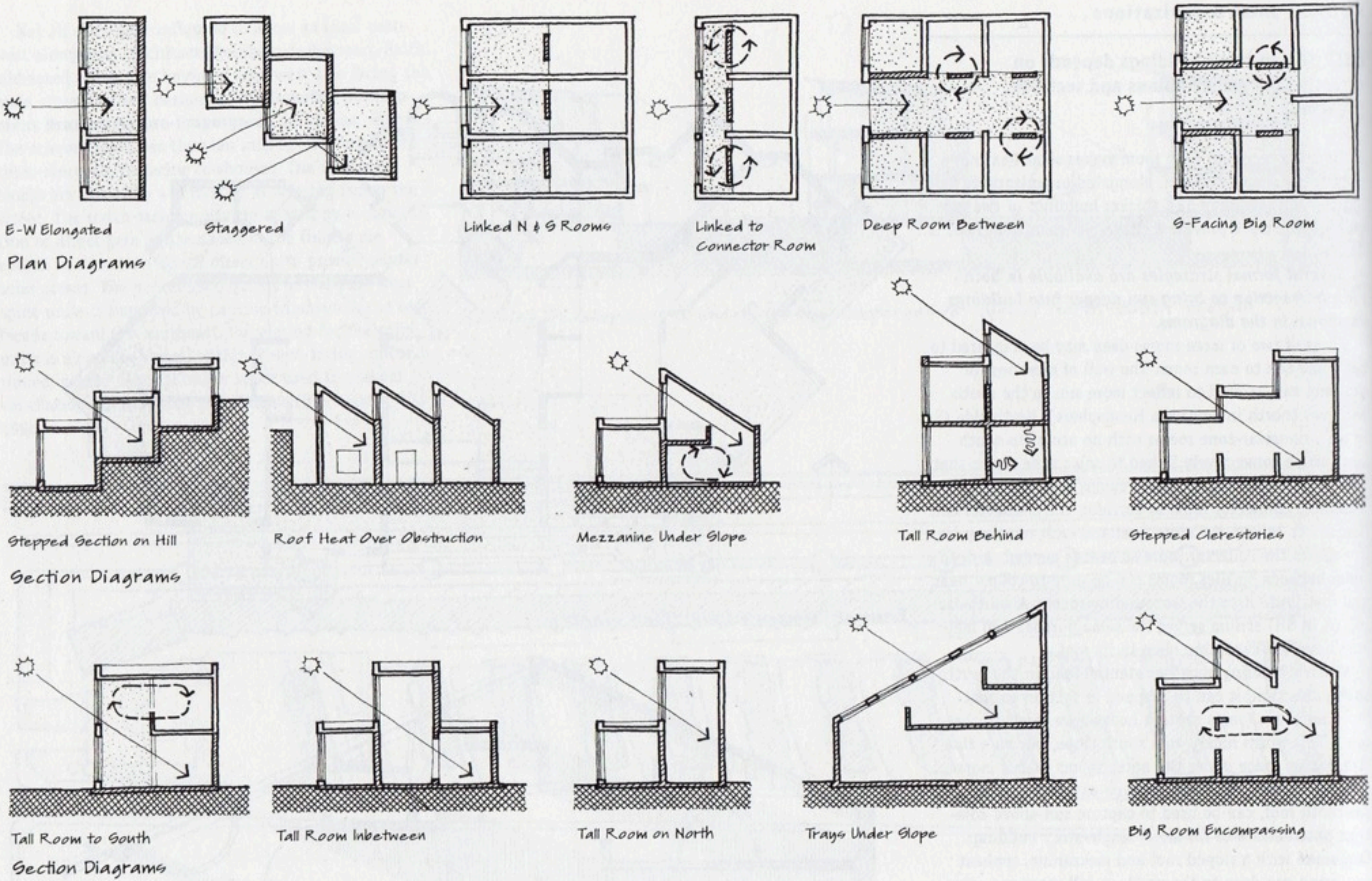
TABLE 12.9 GUIDELINES FOR ILLUMINATION LEVELS

Approximate Type of Activity	Footcandles*
1. General lighting throughout space	
a. Public spaces with dark surroundings	3
b. Simple orientation for short, temporary visits	8
c. Working spaces where visual tasks are only occasionally performed	15
2. Illumination on task	
a. Performance of visual tasks of high contrast or large size	30
b. Performance of visual tasks of medium contrast or small size	75
c. Performance of visual tasks of low contrast and very small size over a prolonged period	150

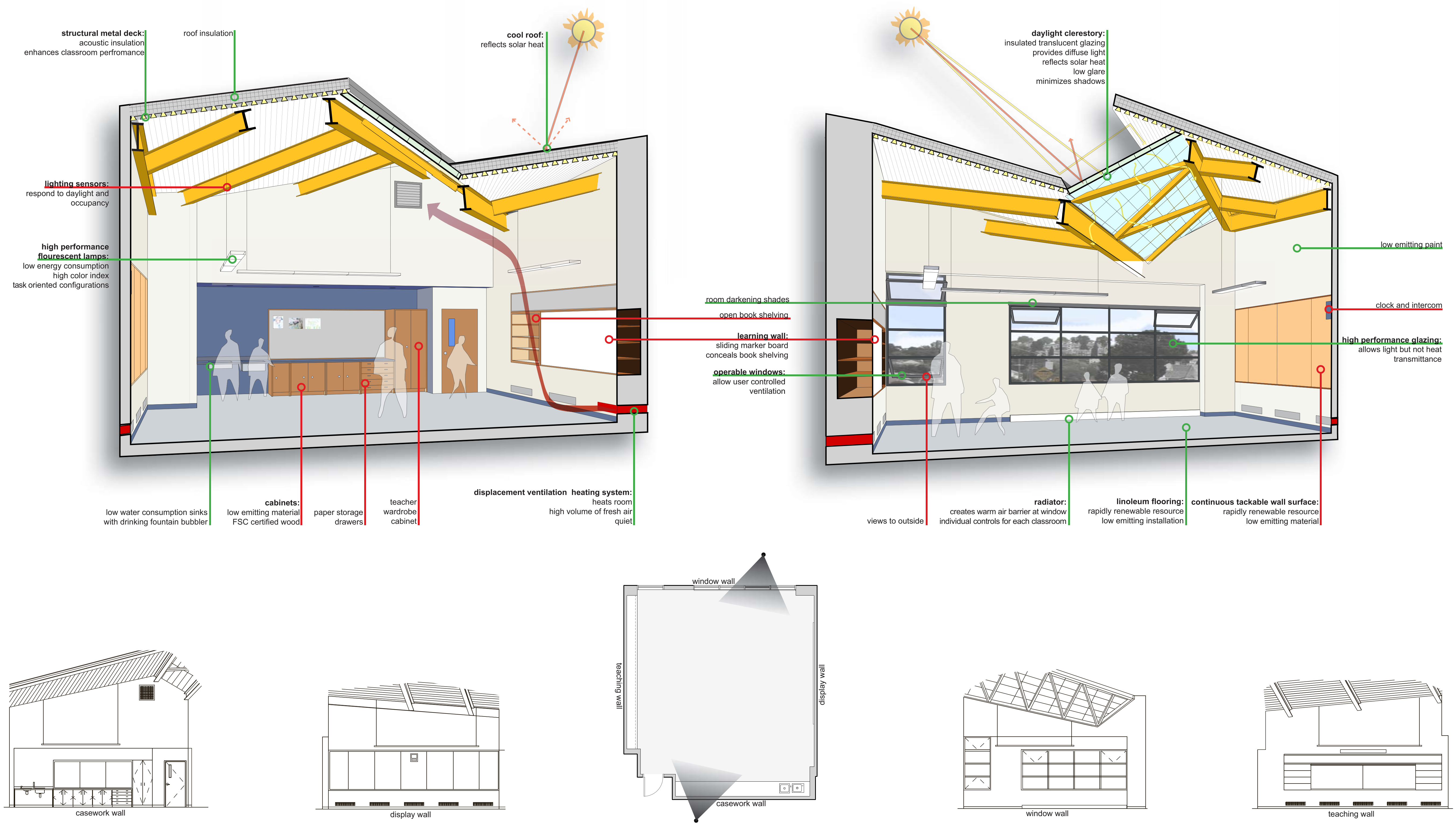
*Because of the variability of actual conditions, the final design illumination values will often be 50 percent larger or smaller than these guideline values. Precise values are not appropriate because of the large tolerance of human vision, and because the quality of the light determines whether more or less light is required. These values can be reduced by 25 percent if the quality of the lighting is very high and they should be increased 35 percent if the average age is over forty. This table is adapted from IESNA tables for recommended illumination levels.

TYPES OF DAYLIGHTING





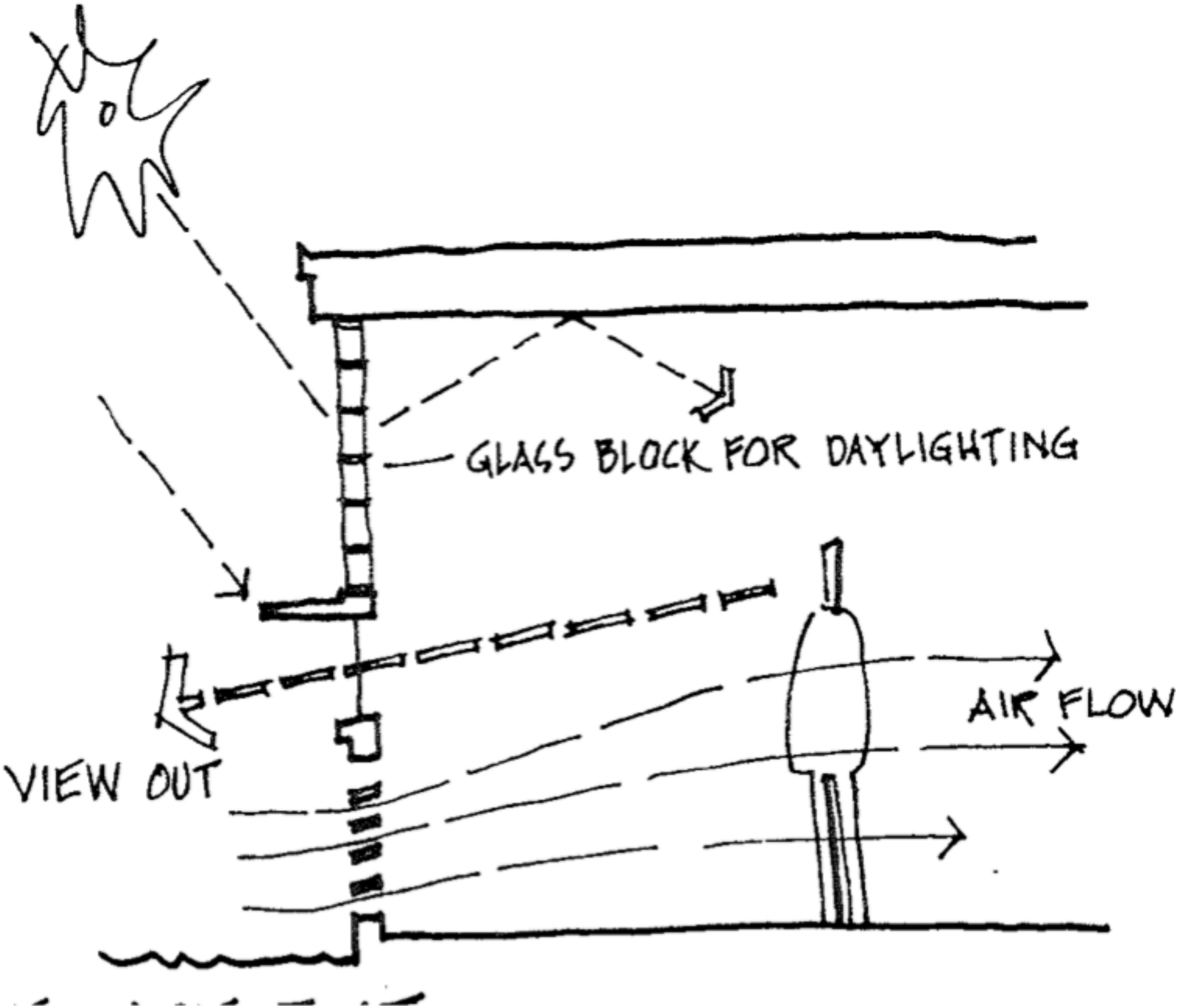
Plan and Section Organizations for Solar Heating of Thick Buildings



Gelfand Partners
ARCHITECTS

COX NEW CONSTRUCTION: TYPICAL CLASSROOM

May 14, 2008

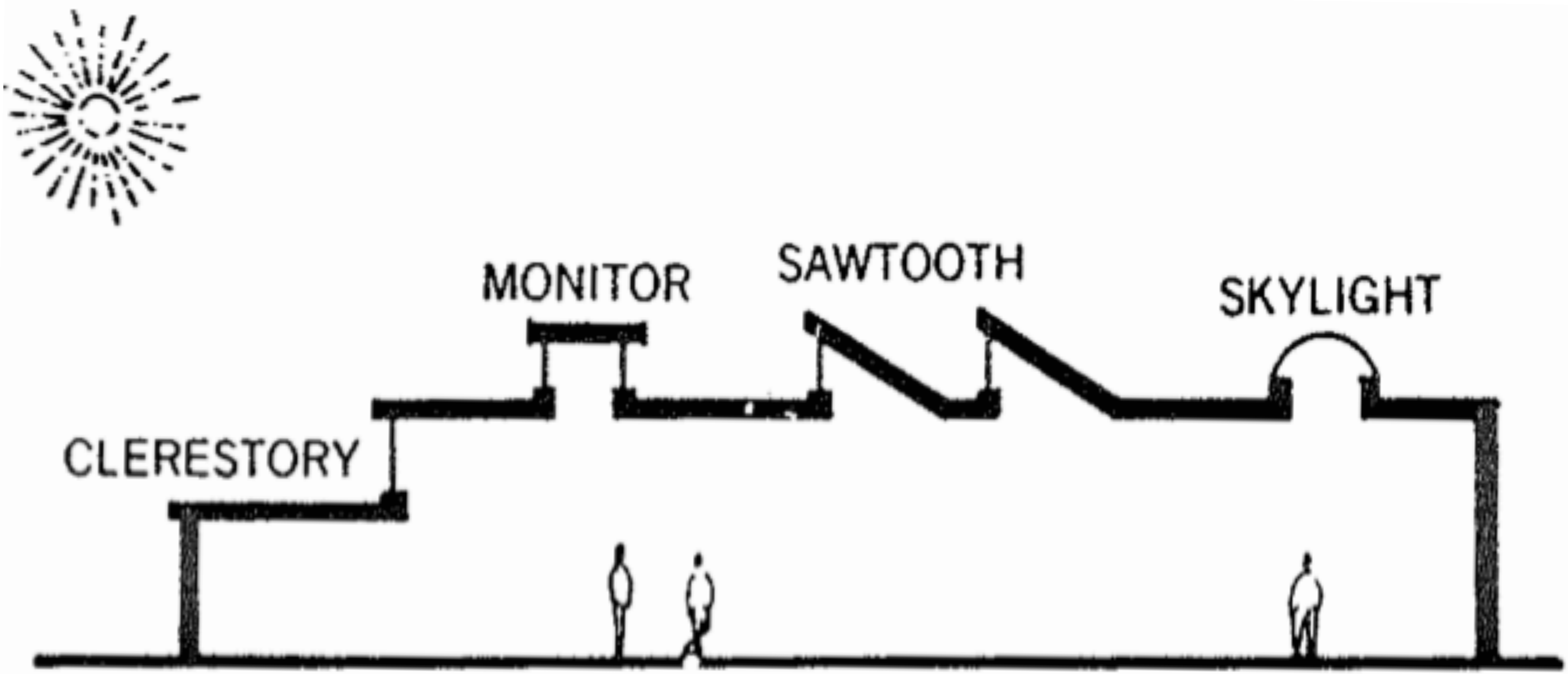

GLASS BLOCK FOR DAYLIGHTING
AIR FLOW
VIEW OUT

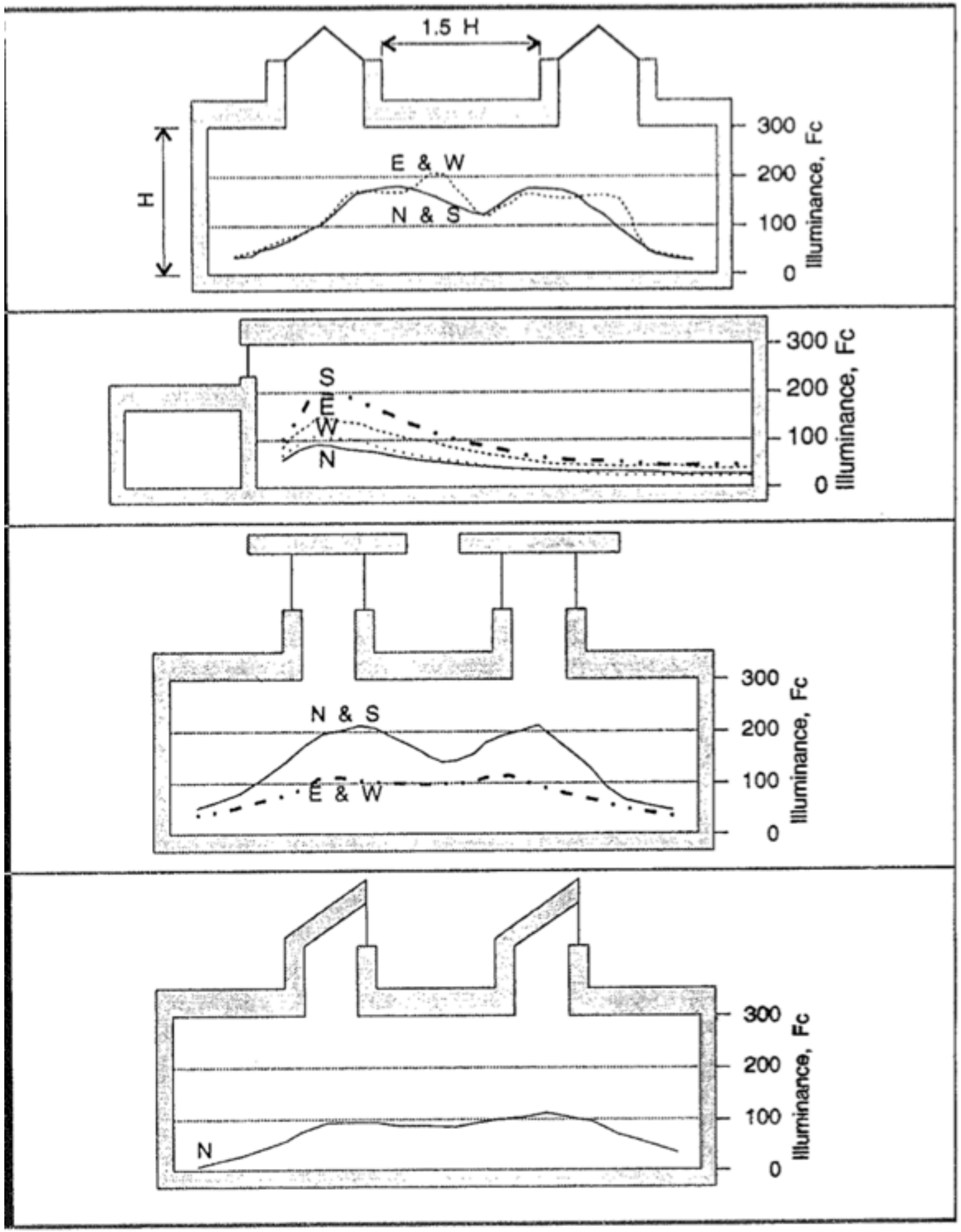
TOPLIGHTING

Skylight

Roof monitor

Sawtooth


MONITOR
SAWTOOTH
SKYLIGHT
CLERESTORY



Skylight

Clerestory

Monitor

Sawtooth

Splayed opening

Wall Wash Toplighting

Central Toplighting

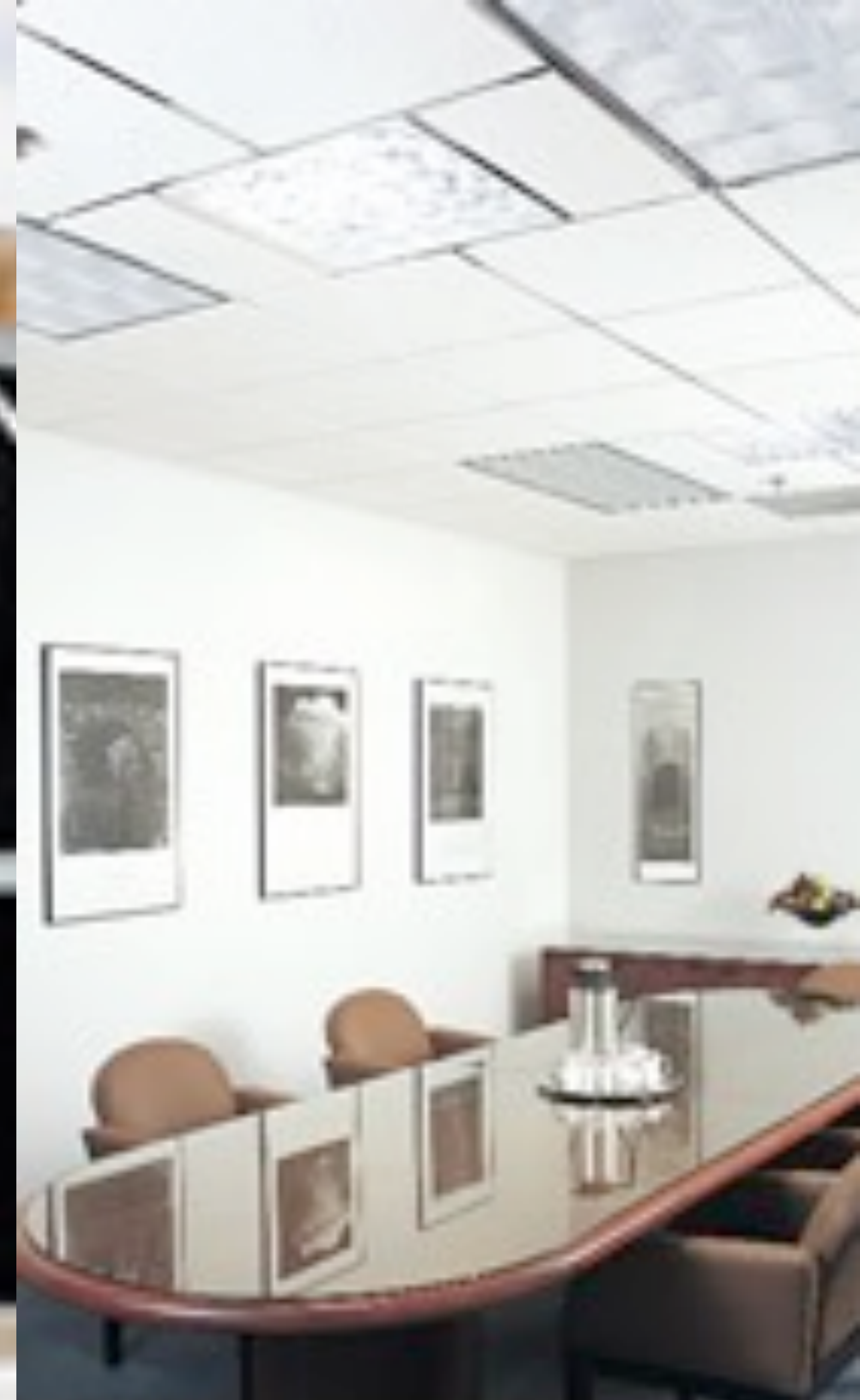
Linear Toplighting

Toplighting (with Clerestory)

North Clackamas High School
BOORA, Architects

Skylights

Tubular Skylights



Toplighting washes brick walls with light in an interior courtyard in Montepulciano, Italy.

Skylight and clerestory monitors on the roof (left) of the administration building at Guandong Pei Zheng Commercial College in Huadu, China; resulting toplighting distributed by light wells (right) provides illumination for four floors along a circulation corridor.

Toplighting: Key Architectural Issues

•Toplighting liberates the walls of a space. Daylighting from above, rather than sides, allows for a greater latitude in how the walls of a space are used.

•Light scoops, clerestories, roof monitors, and skylights all provide opportunities for architectural expression in the building form.

•An inherent limitation is that toplighting suits only one story high buildings or can the top level of multistory buildings.

•Toplighting can however reach a great depth as lighting access is not limited to the walls.

•Toplighting encourages the activation of the ceiling plane, an area often forgotten in the design process

CLERESTORIES

Clerestories (High Windows)

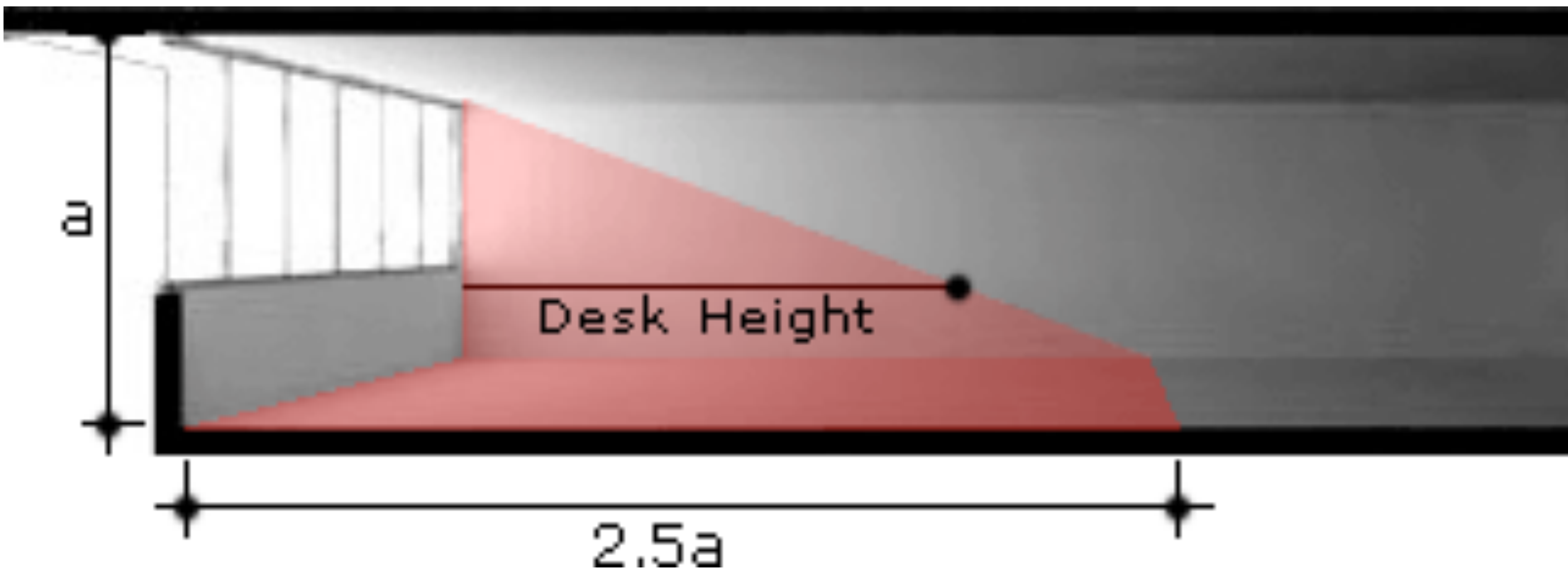
SIDE LIGHTING

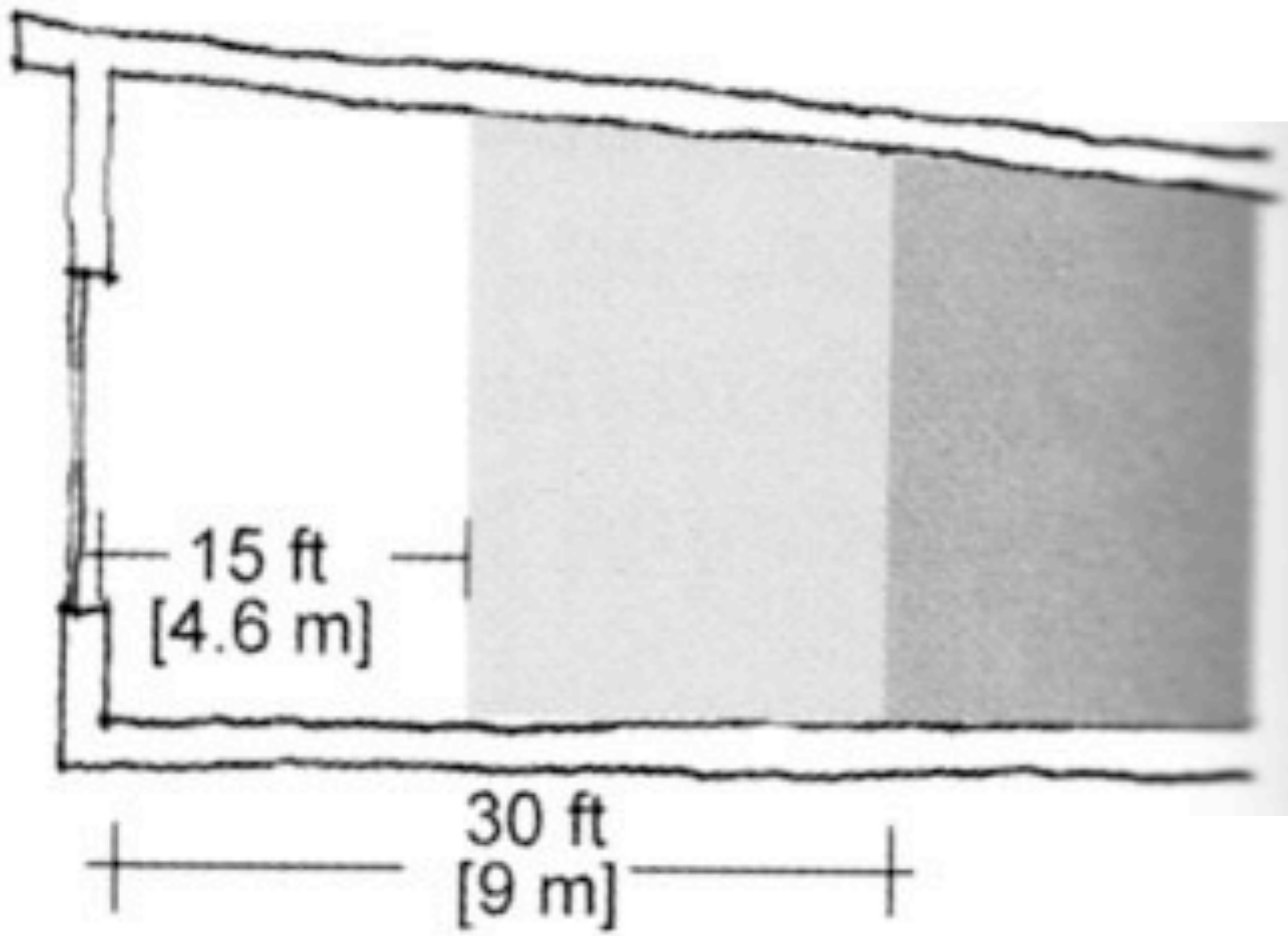
Window Distribution

Window

Windows both sides

Lightshelf


a
Desk Height
2.5a


15 ft
[4.6 m]
30 ft
[9 m]

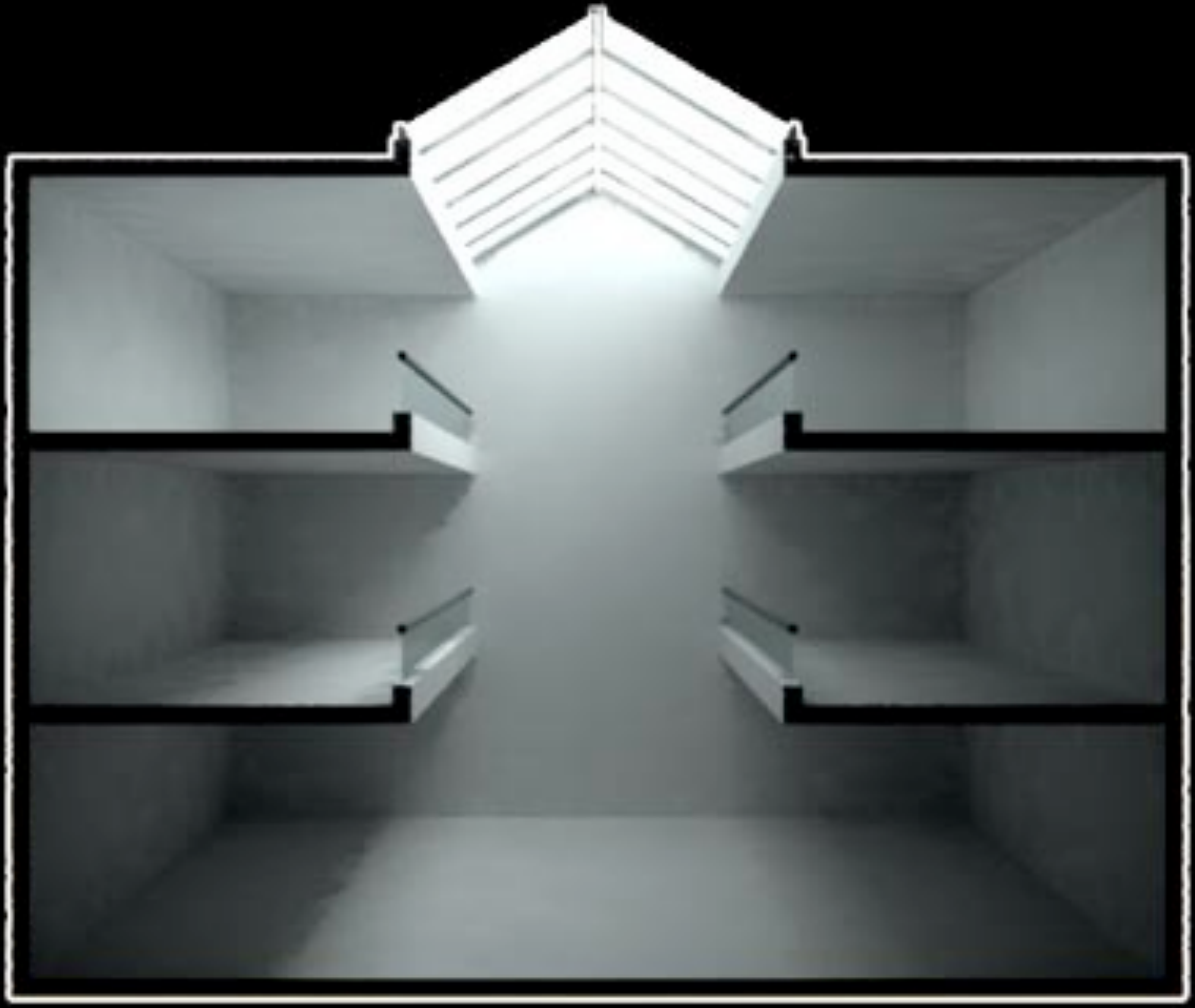
Multiuse room with toplighting and sidelighting to provide even daylight distribution at the Christopher Center at Valparaiso University, Indiana. © PETER AARON/ESTO

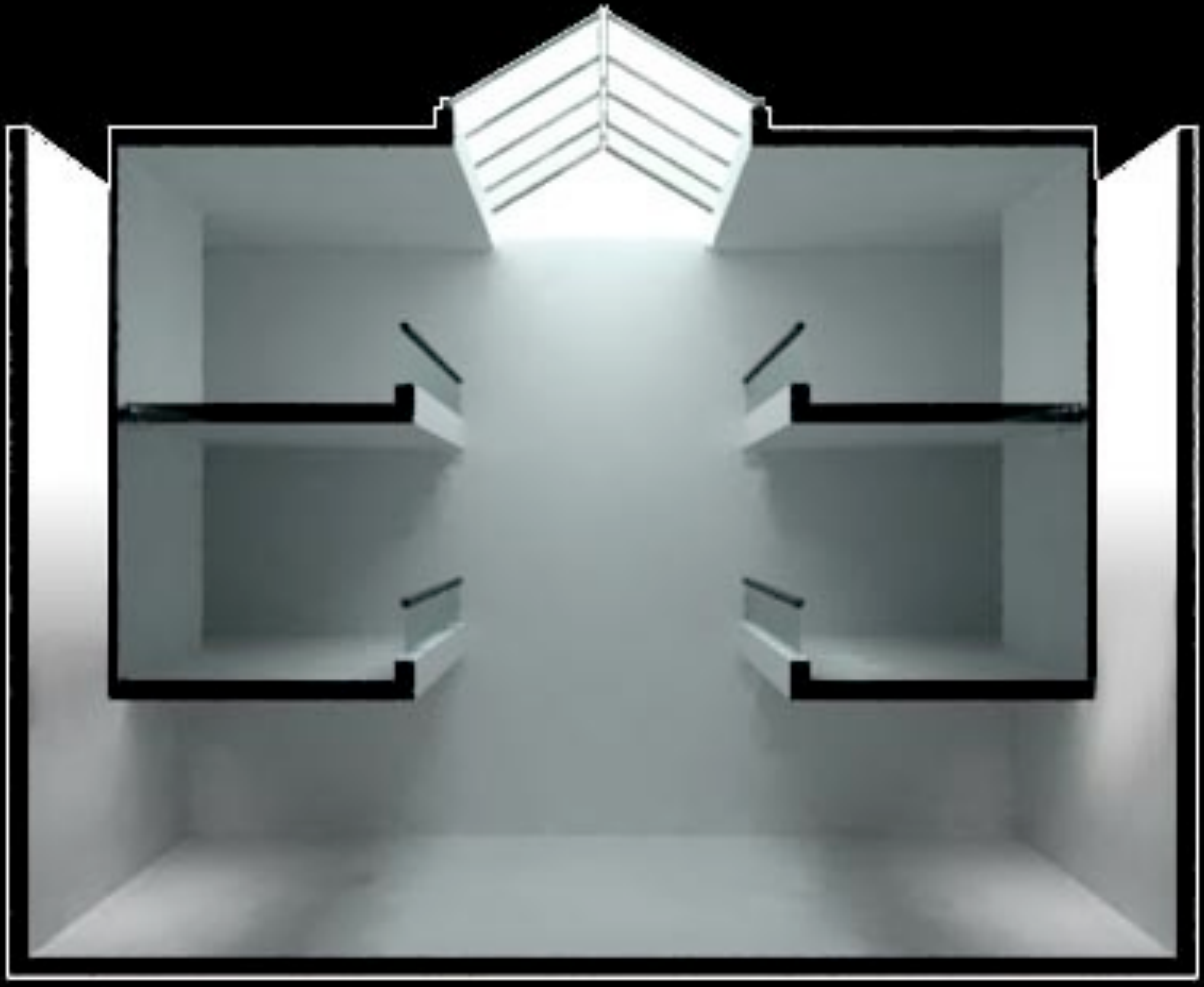
View Windows

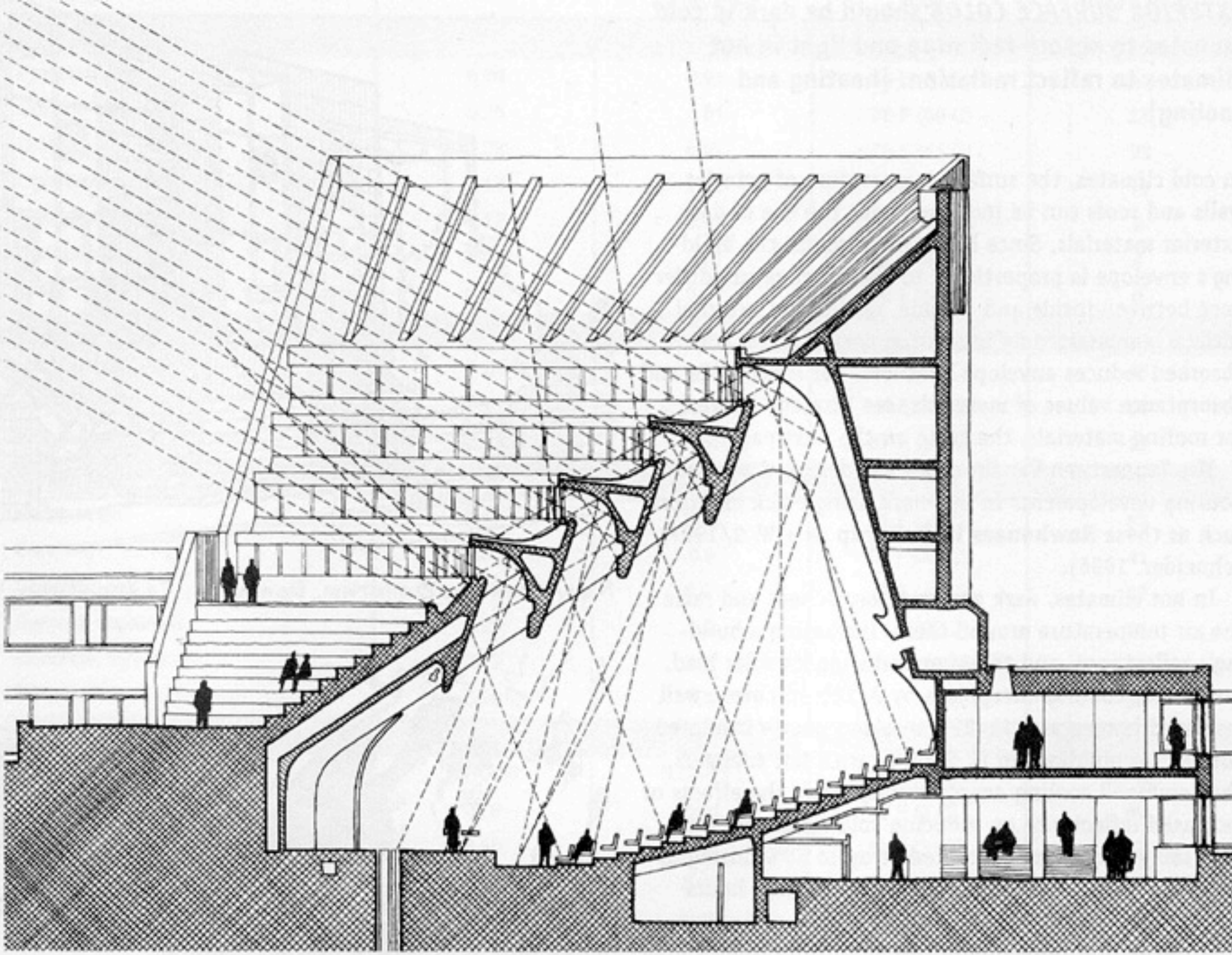
Two Sources of Light

Bilateral sidelighting from view windows and clerestories in a computer lab at the Global Ecology Research Center at Stanford University, Palo Alto, California. © PETER AARON/ESTO

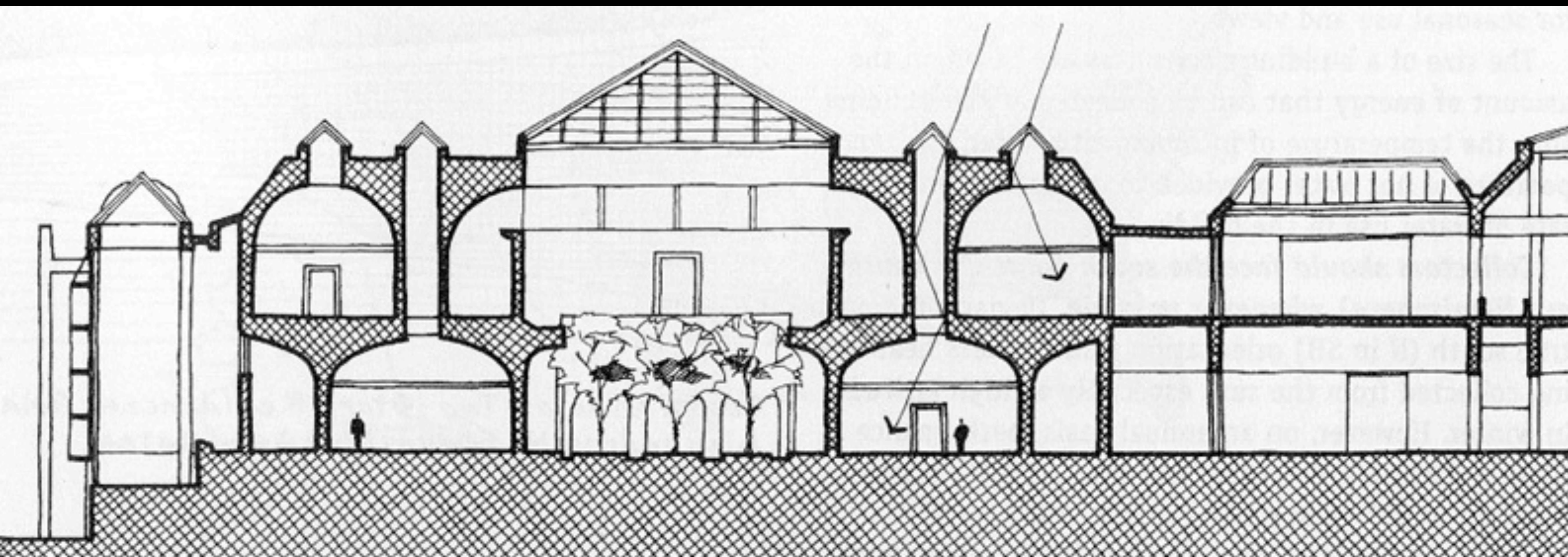
LIGHTWELLS



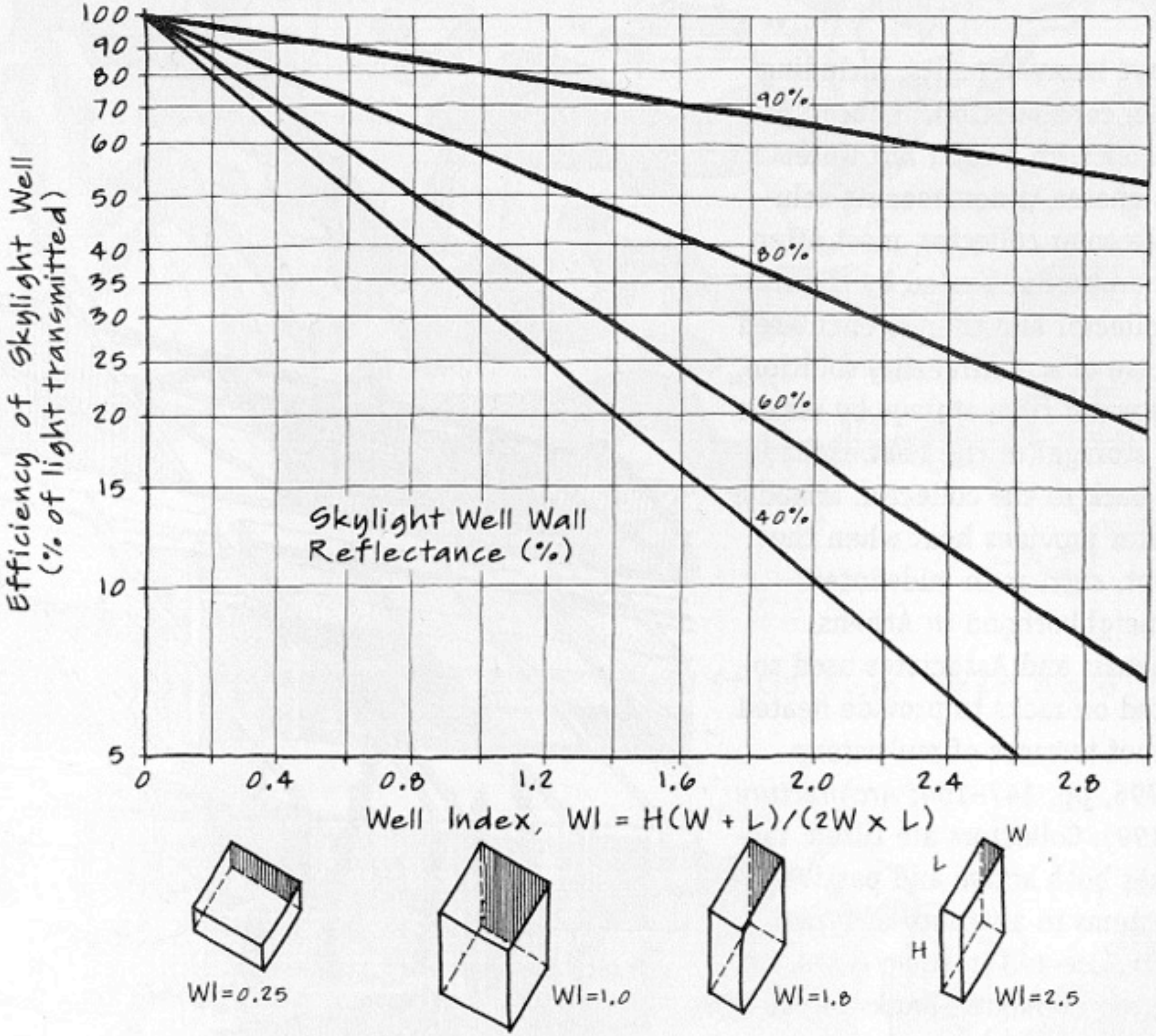




Main Auditorium, Institute of Technology, Otaniemi, Finland, Alvar Aalto

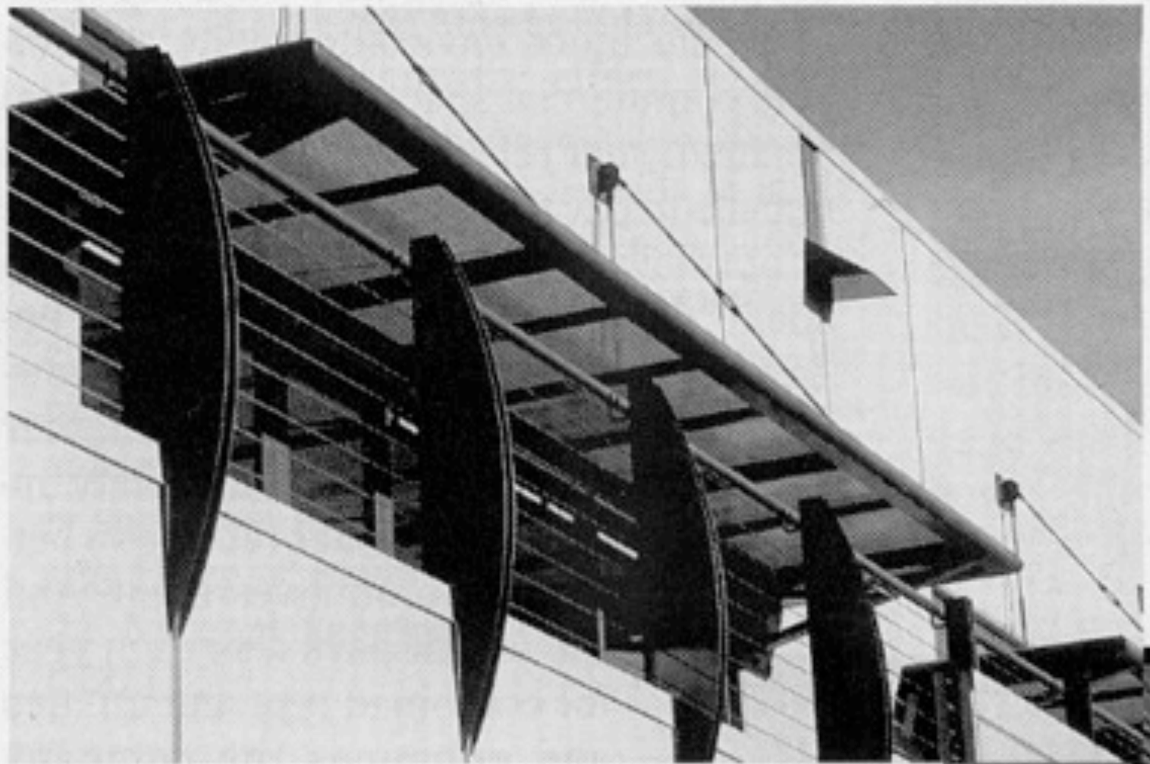


Lightwells in the National Gallery of Canada, Moshe Safdie



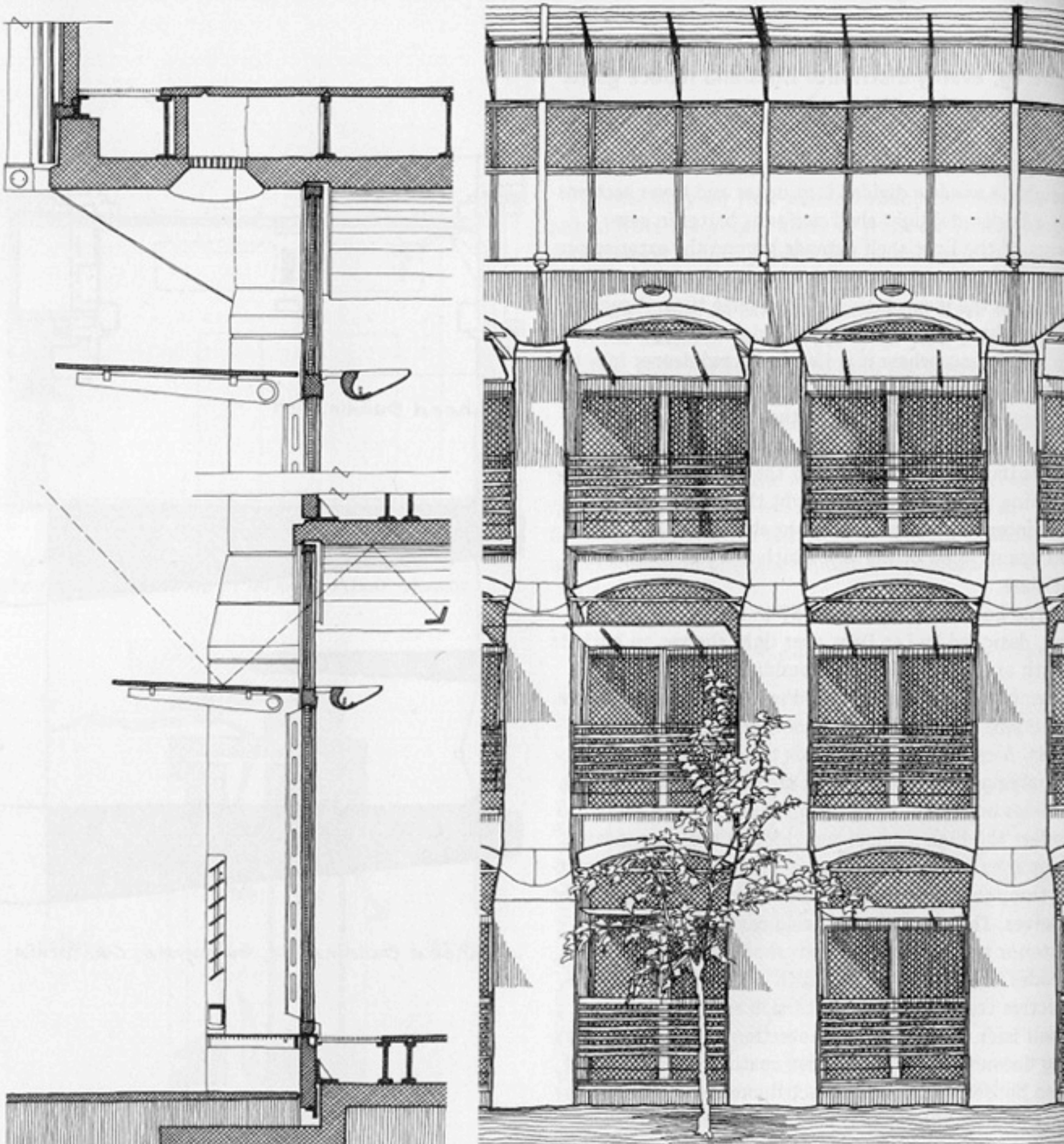
Sizing and Shaping Light Wells to Transmit Light Efficiently

LIGHT SHELVES



External light shelves shade windows below, minimizing glare and heat gain while reflecting diffused light into the building through glazing above.

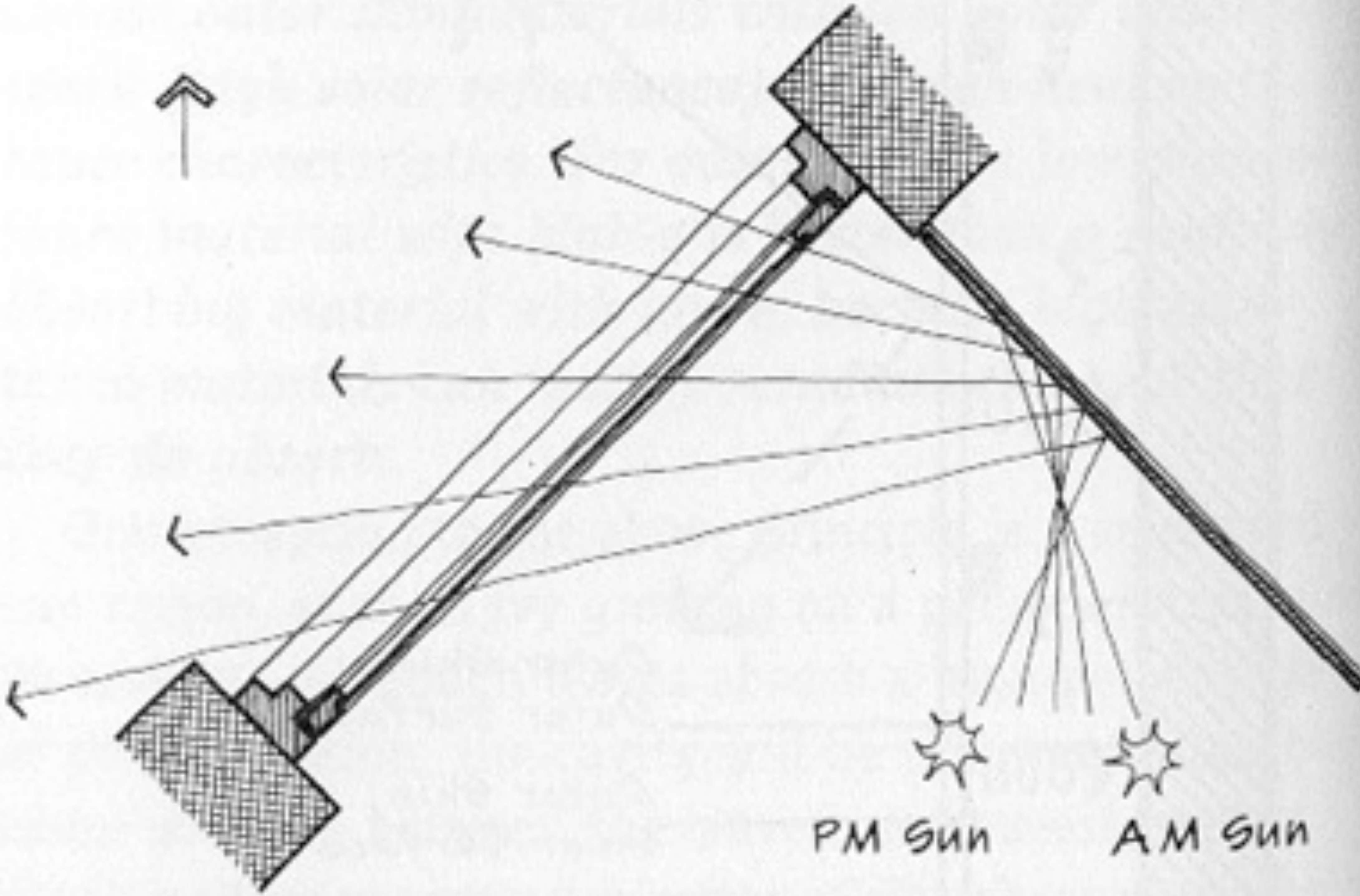
Daylighting provides most of the ambient lighting in the building. Tall windows on the long south side, combined with interior light shelves, allow daylight to penetrate deep into the open office space.



Inland Revenue Offices, Nottingham, England, Michael Hopkins & Partners

d for BC Gas Operations Centre in Surrey BC.

MATERIAL REFLECTANCE



Plan View, Vertical Reflector for a Southeast-Facing Window
(northeast-facing in the Southern Hemisphere)

Surface	Recommended Reflectance (%)
Ceilings	70-80
Walls	40-80
Floors	20-40

Recommended Finish Reflectances

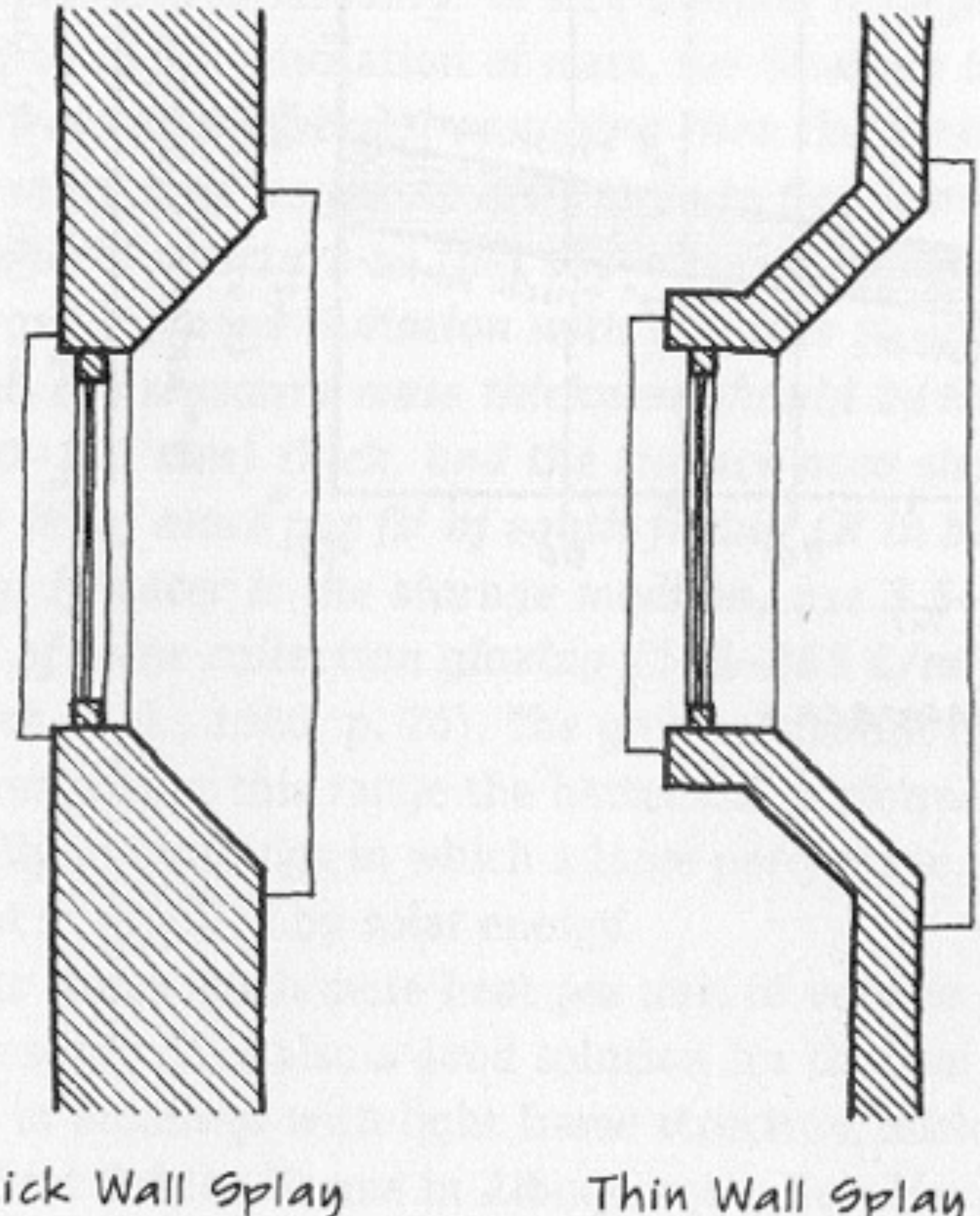
Color	Reflectance (%)
white	80-90
pale yellow & rose	80
pale beige & lilac	70
pale blue & green	70-75
mustard yellow	35
medium brown	25
medium blue & green	20-30
black	10

Daylight Reflectance of Colors

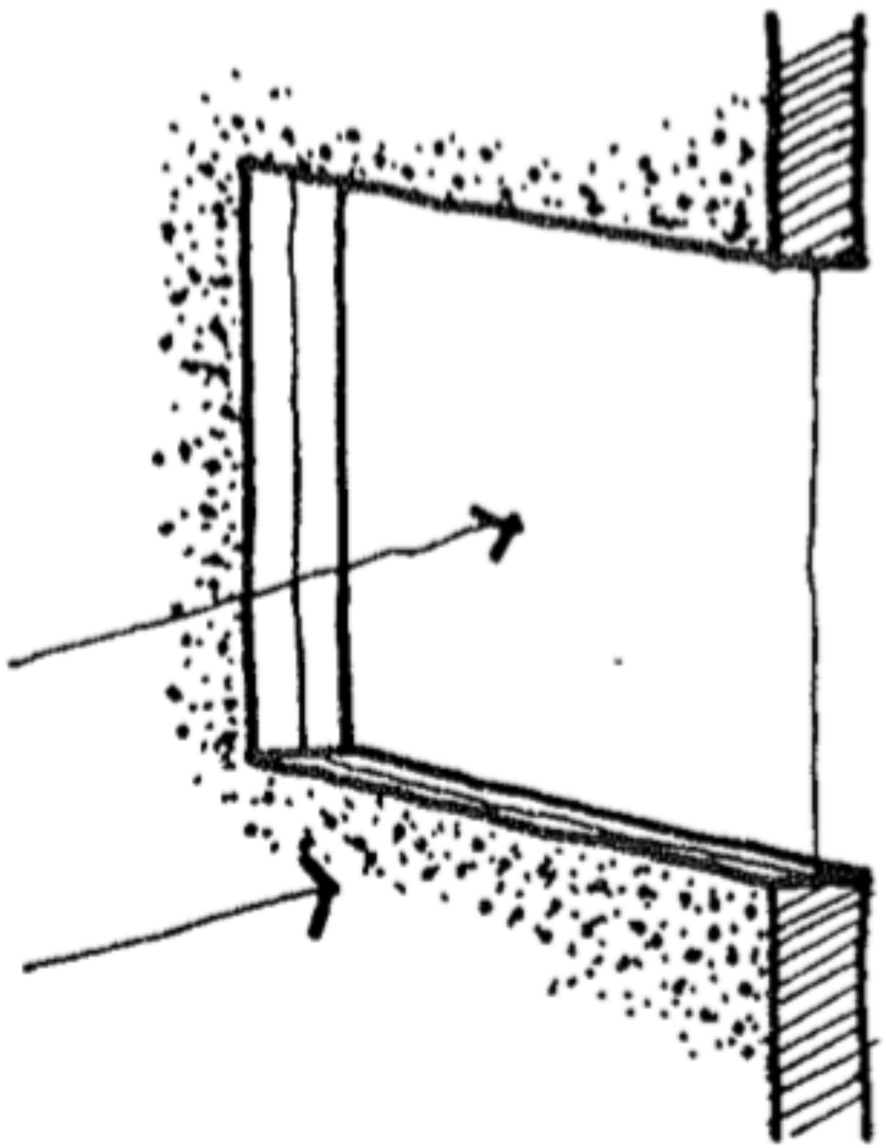
Reflector Finish	Reflectance (%)
Concrete	30-50
Old snow	40-70
New snow	80-90
Polished aluminum	75-95
Aliminized mylar	60-80
Polished stainless steel	60-80
White porcelain enamel	70-77
Acrylic with aluminized backing	85
Aluminum foil	86
Electroplated Silver, new	96

Solar Reflectance of Finishes

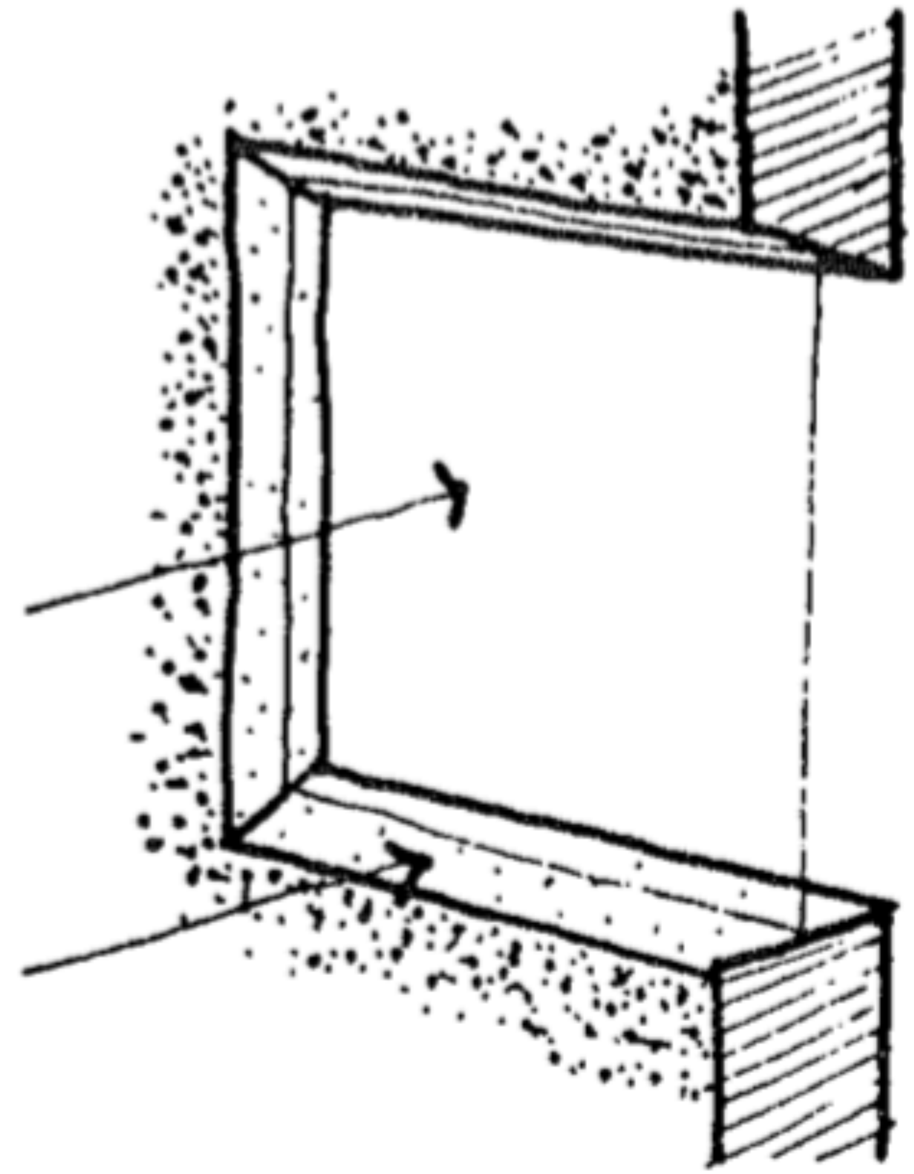
WINDOW OPENINGS



Splayed Window Jamb Options



FLUSH OPENINGS PRODUCE SHARP **CONTRASTS**



SPLAYED WINDOW JAMBS **SOFTEN** CONTRASTS

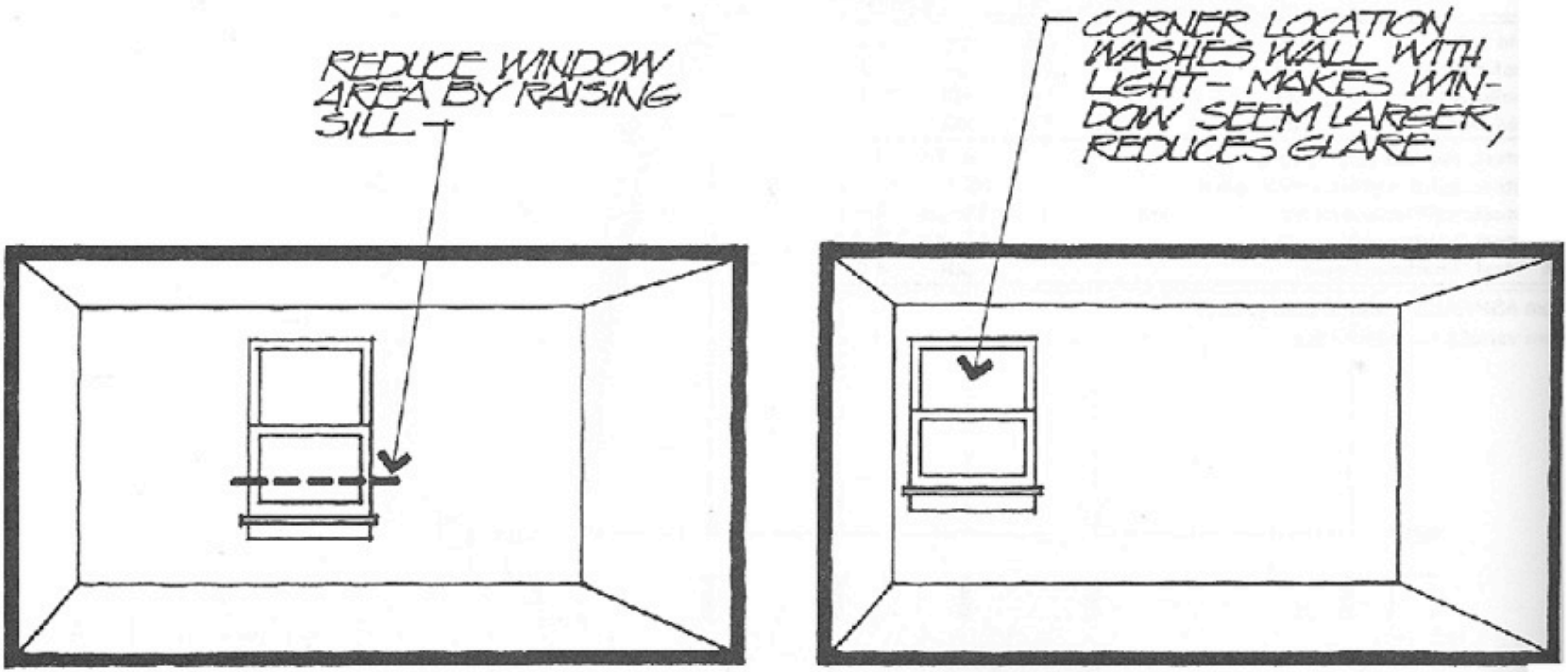
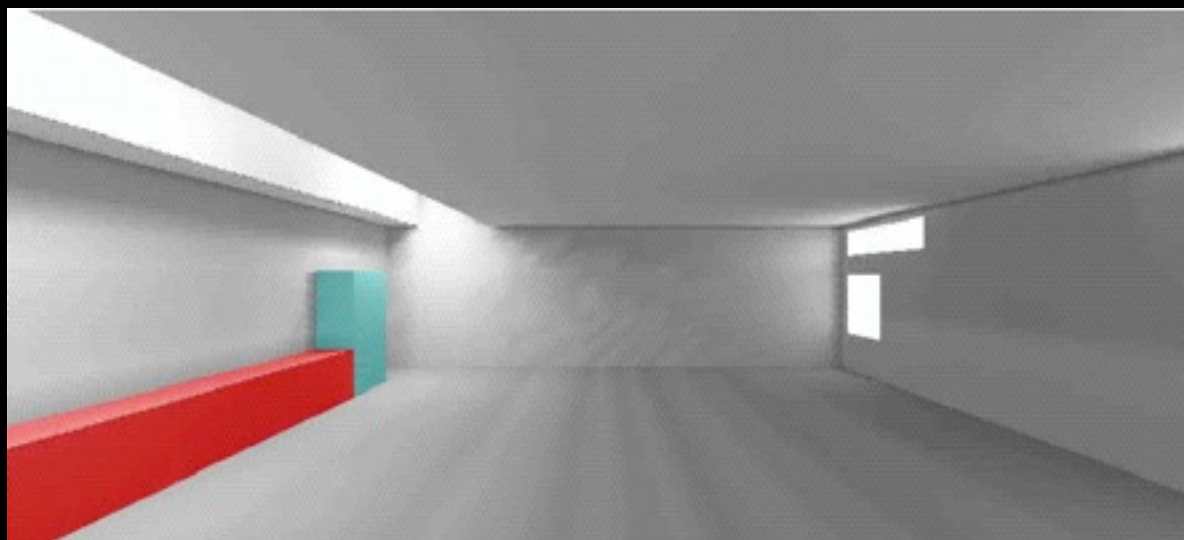


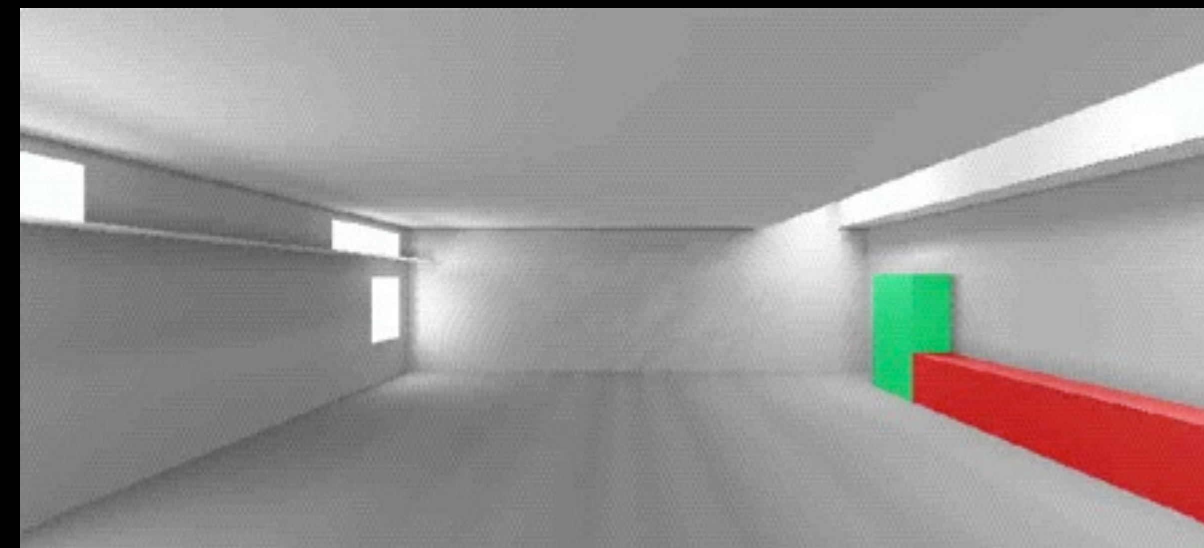
FIG. 40b. When windows must be placed in north, west and east walls, keep the opening small, and use internal placement to best advantage.

Design Daylighting

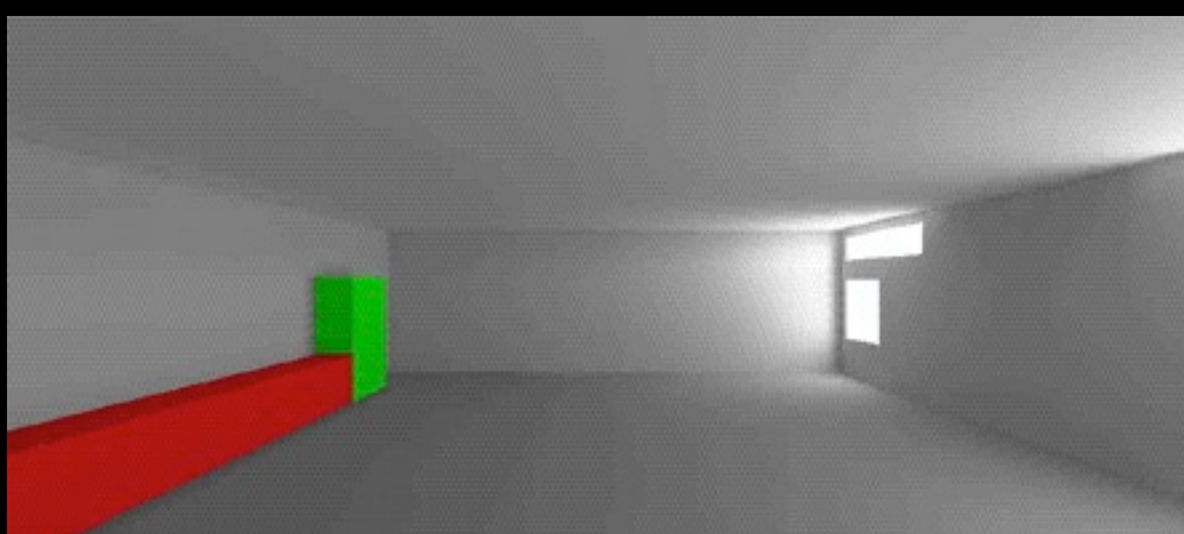
North wall view

South wall view





Two Sided Daylighting (preferred)

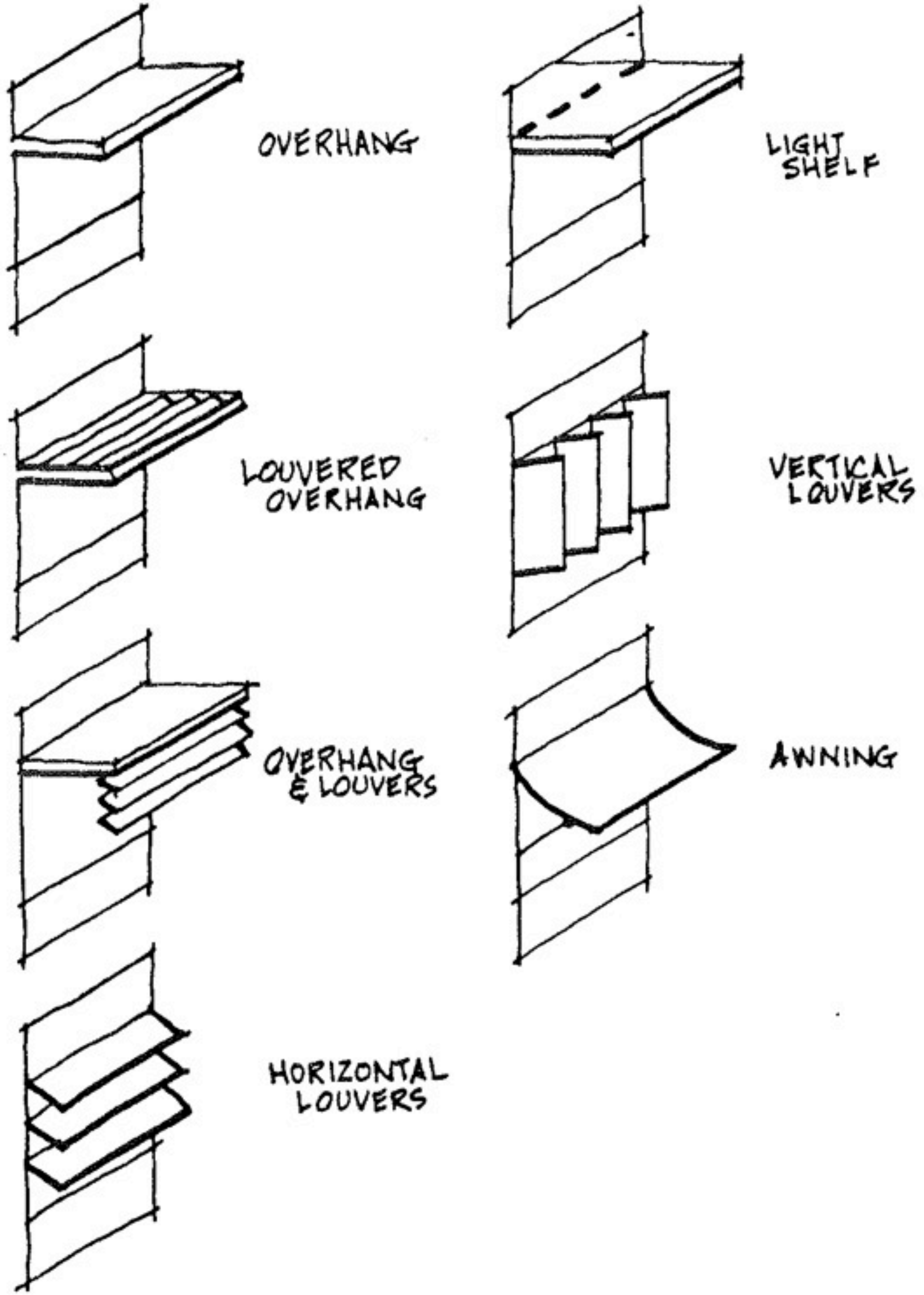


Side lighting only

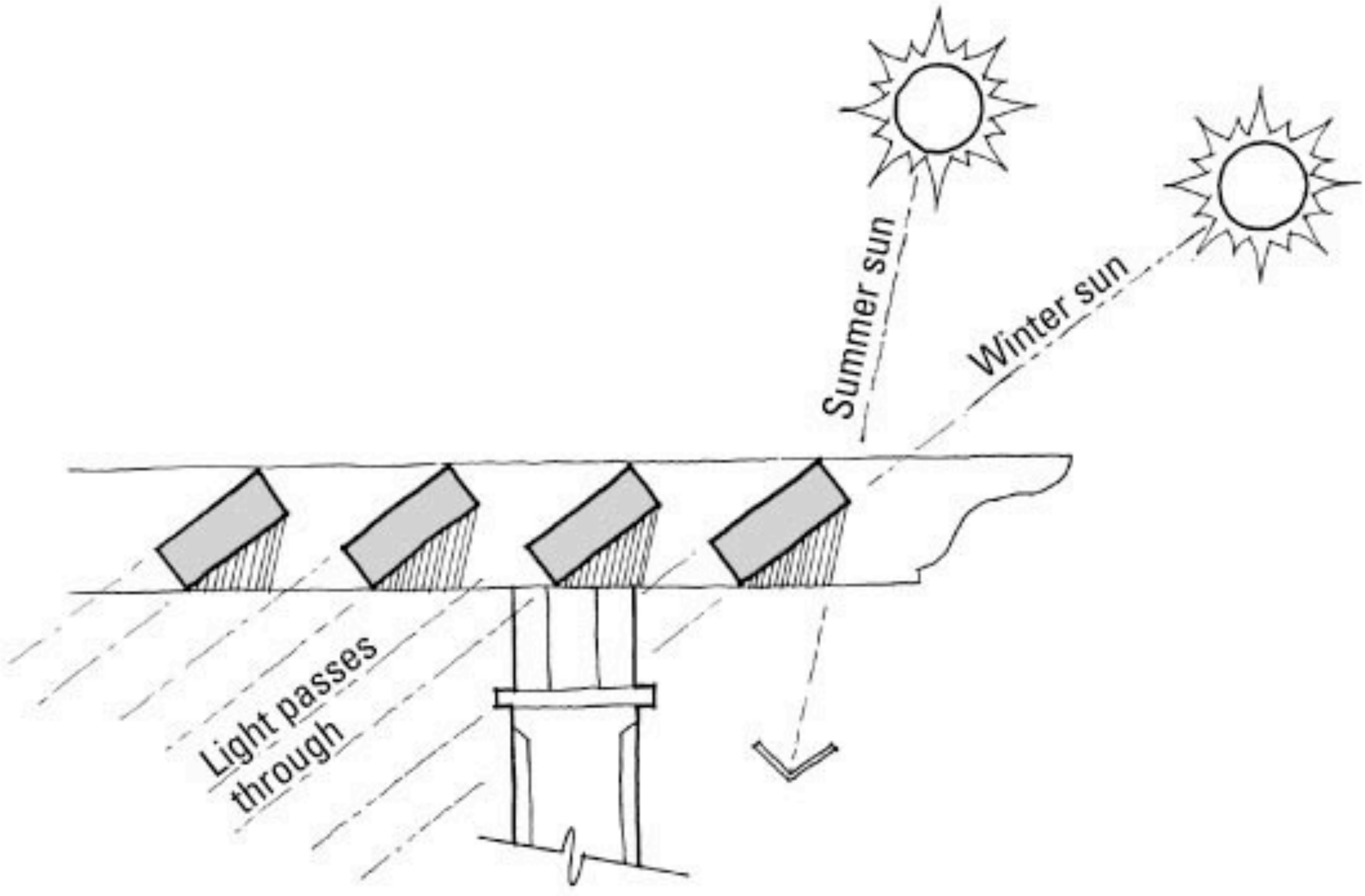
Small windows with shear wall

EXTERIOR SHADING DEVICES

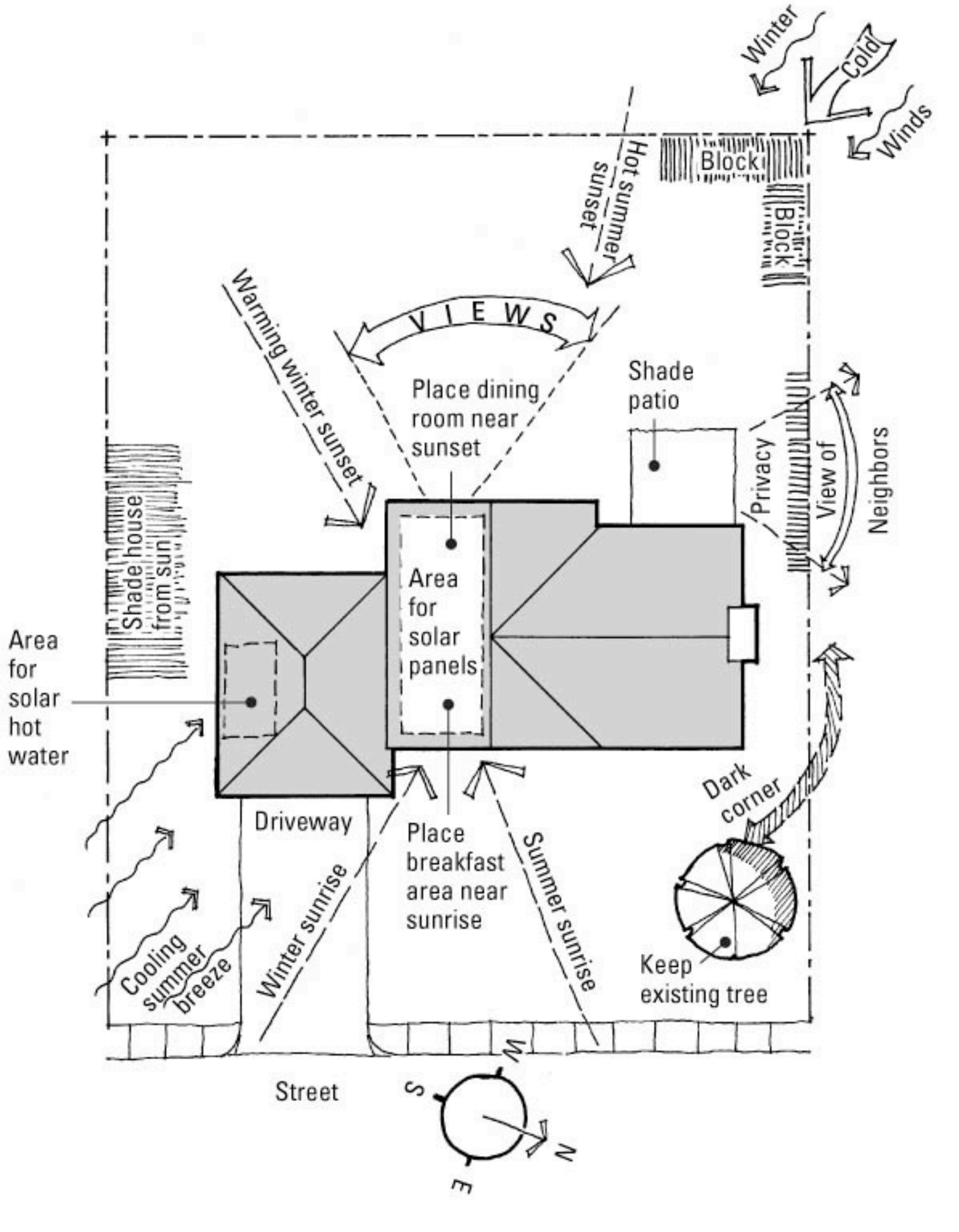
OVERHANGS


OVERHANG
LIGHT SHELF
LOUVERED OVERHANG
VERTICAL LOUVERS
OVERHANG & LOUVERS
AWNING
HORIZONTAL LOUVERS

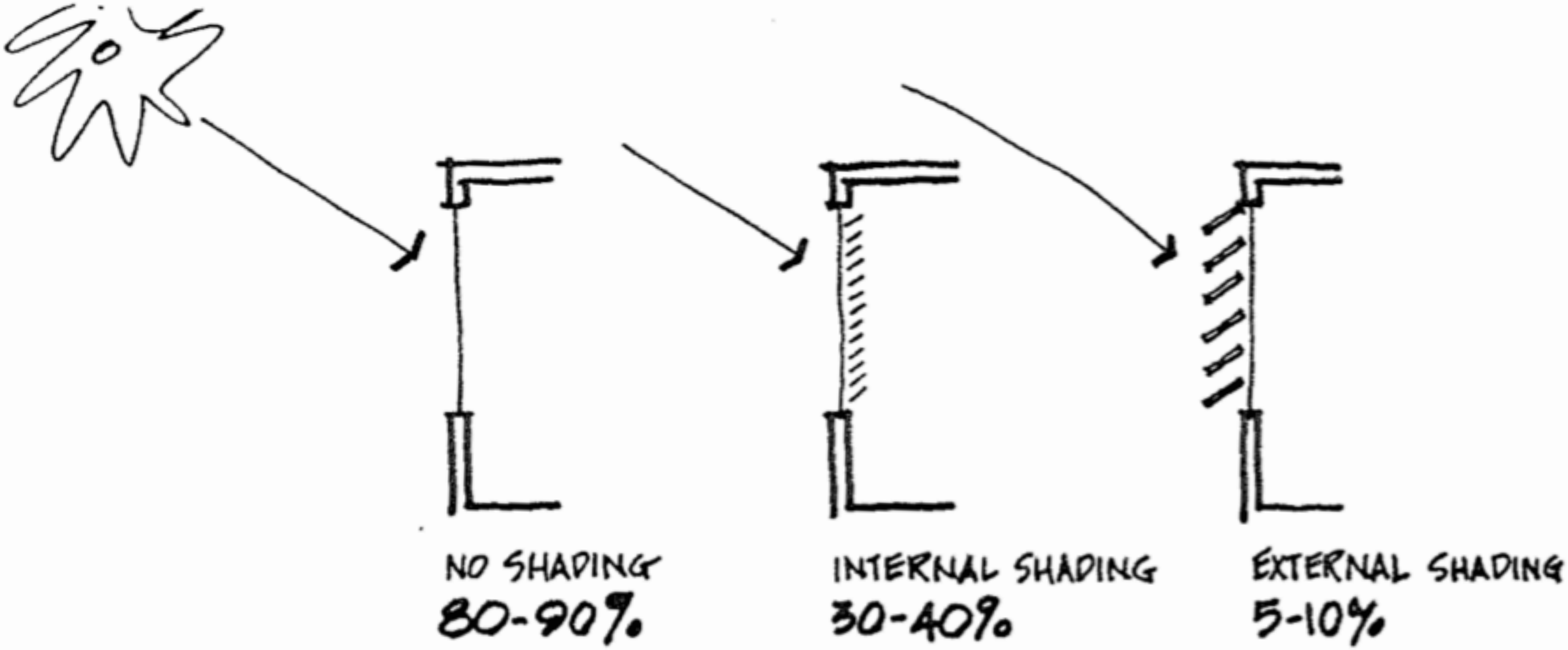
TRELLIS


Summer sun
Winter sun
Light passes
through

TREES


Winter
Cold
Winds
Block
Block
Hot summer sunset
Warming winter sunset
VIEWS
Place dining room near sunset
Shade patio
Privacy
View of
Neighbors
Shade house from sun
Area for solar panels
Area for solar hot water
Driveway
Place breakfast area near sunrise
Winter sunrise
Summer sunrise
Dark corner
Keep existing tree
Cooling summer breeze
Street
W
S
N
E

INTERIOR SHADING CONTROLS



SOLAR TRANSMISSION

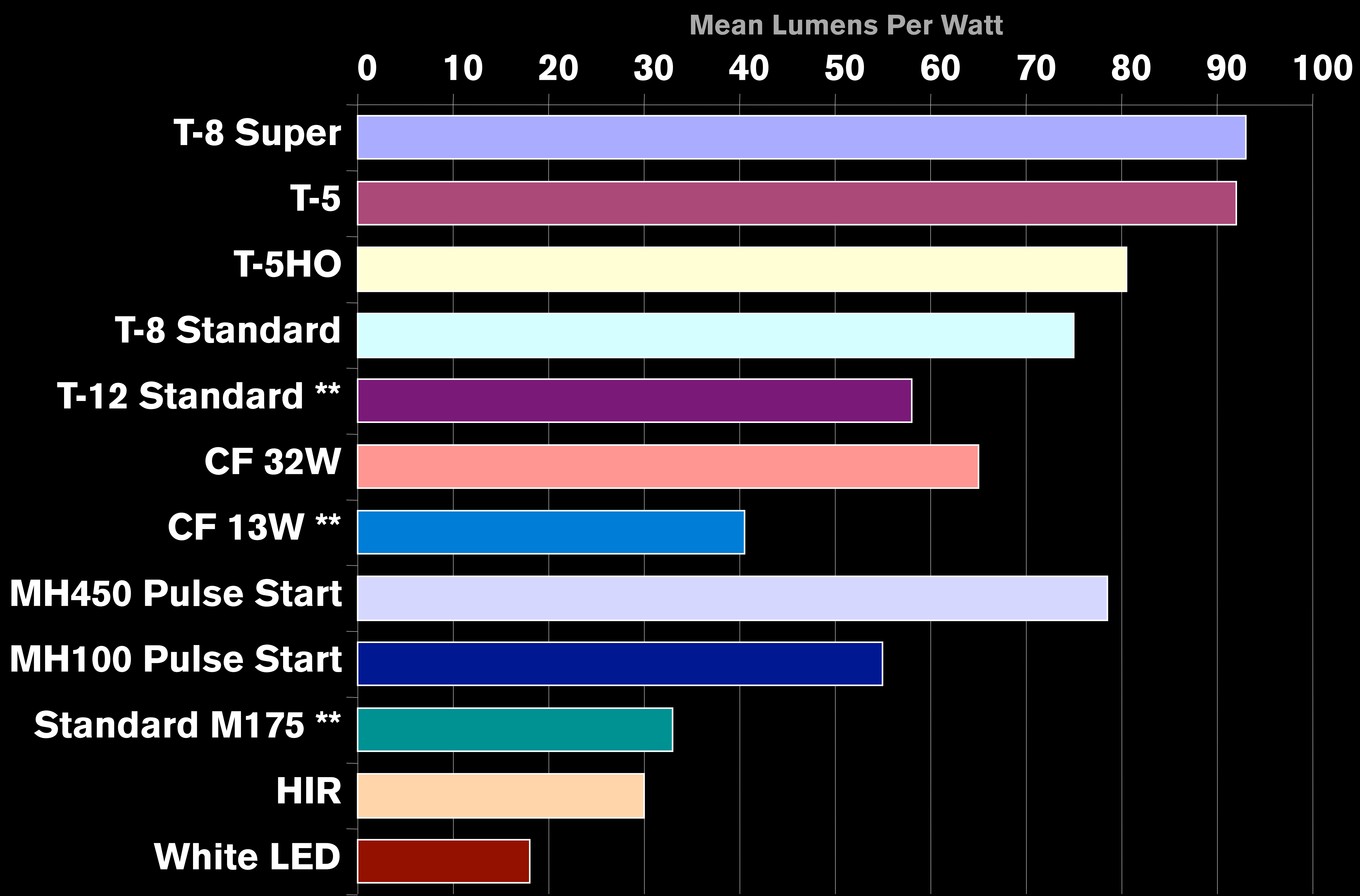

VIA

INTEGRATING LIGHTING FIXTURES

Integrating Daylight

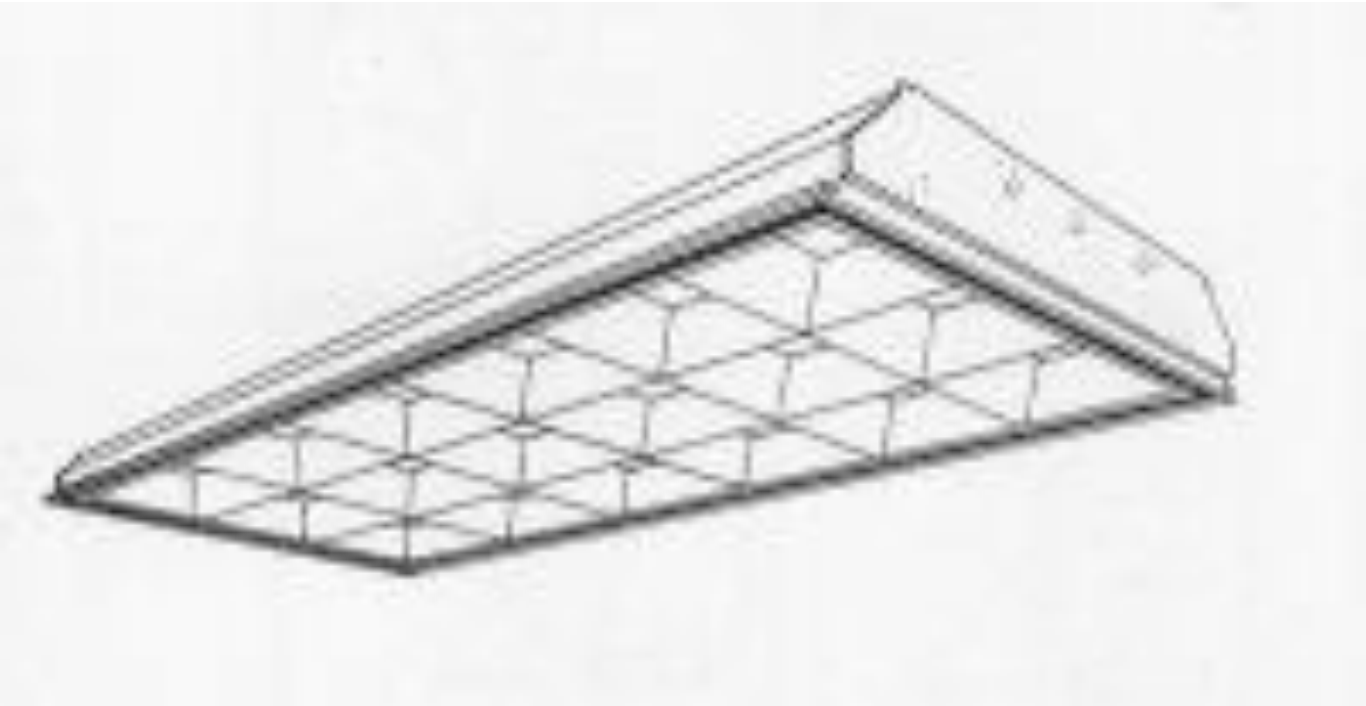
1. Design electric lighting rows PARALLEL to the daylight source.
   - Provide separate switches so that rows of lights nearest the window can be extinguished.
2. Provide separate switches for daylighted and non-daylighted zones.
   - Required by some energy codes
3. If desired, provide automatic daylight switching or dimming
   - Be certain to provide override controls when video shading systems are being used

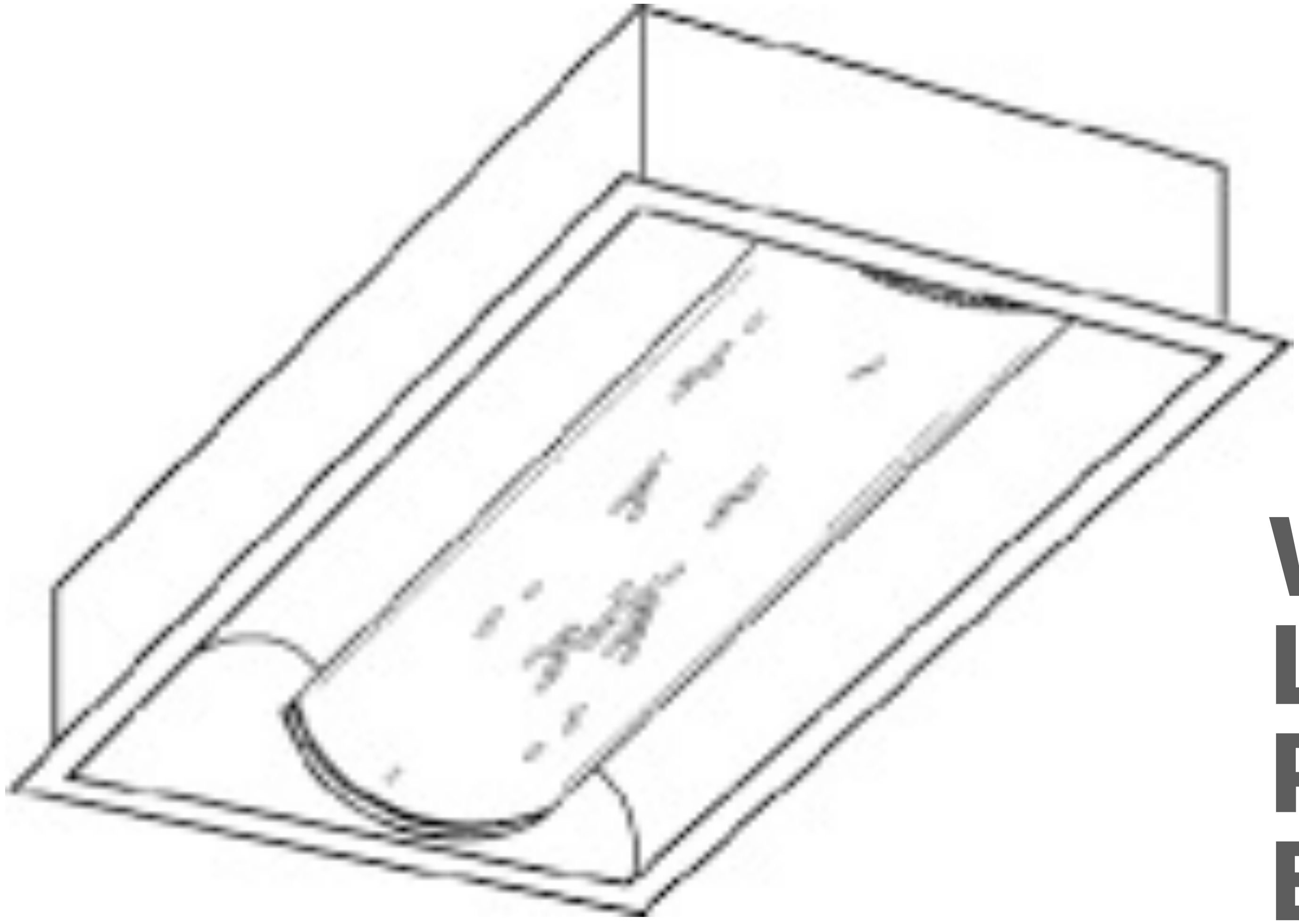
Comparison of Lamp Efficacy

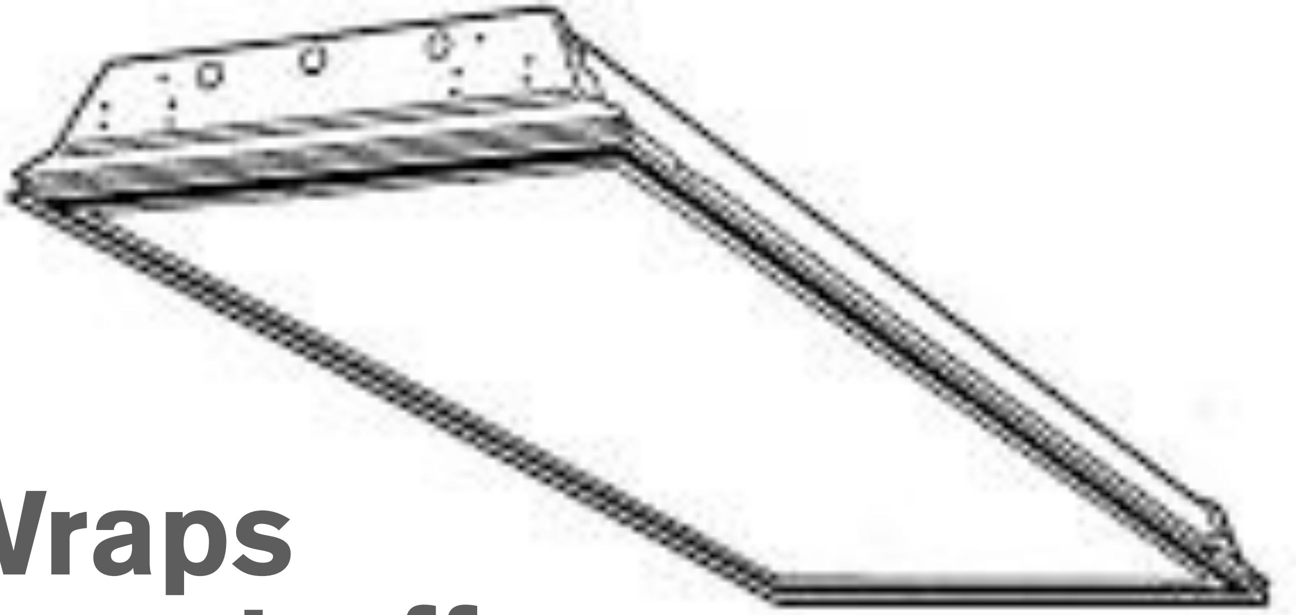


Electronic ballasts except where noted by **

Classroom Lighting Choices





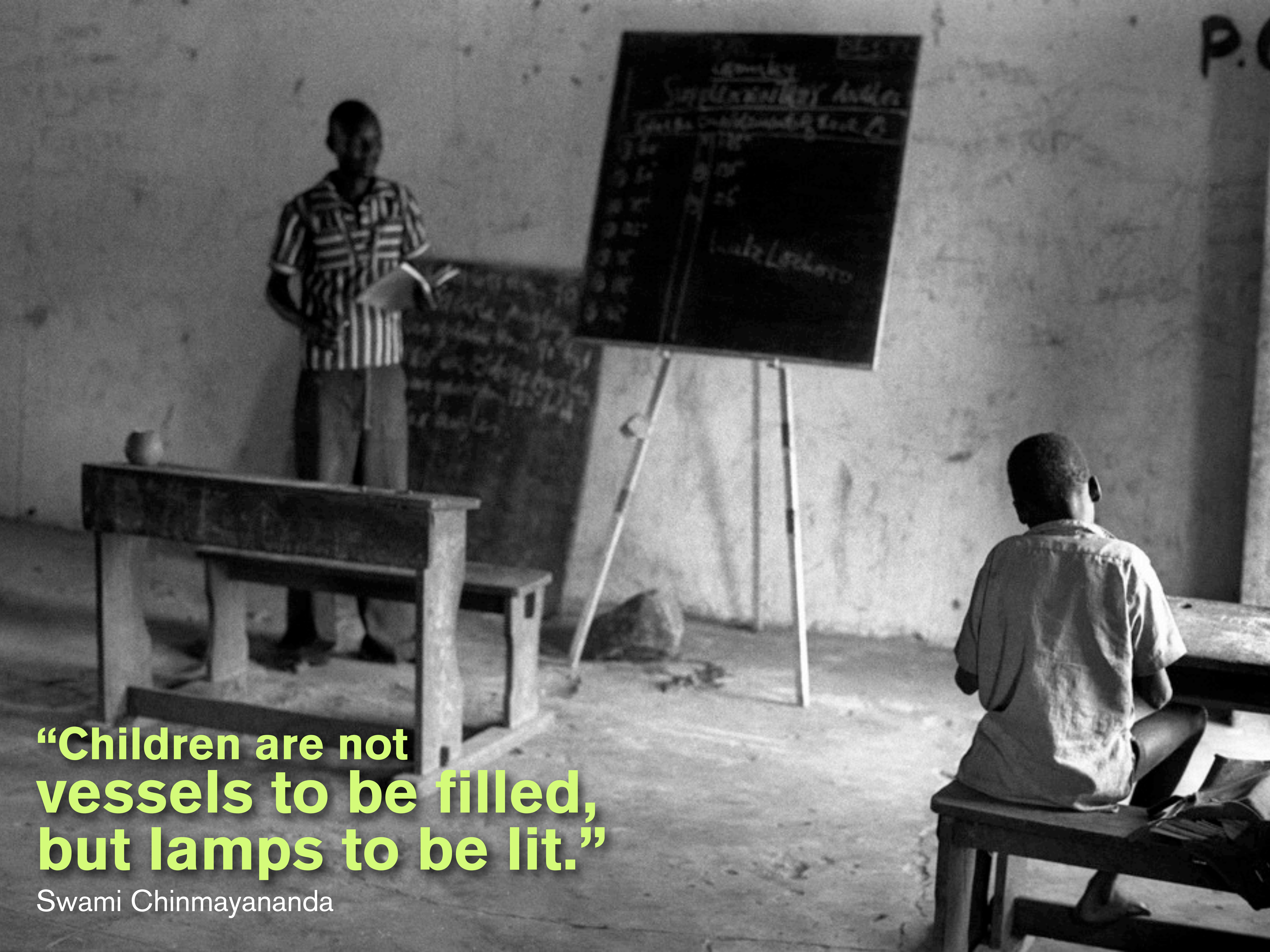


Wraps
Lens troffers
Parabolic troffers
Basket troffers

CASE STUDY: CLASSROOM


SOLIDS

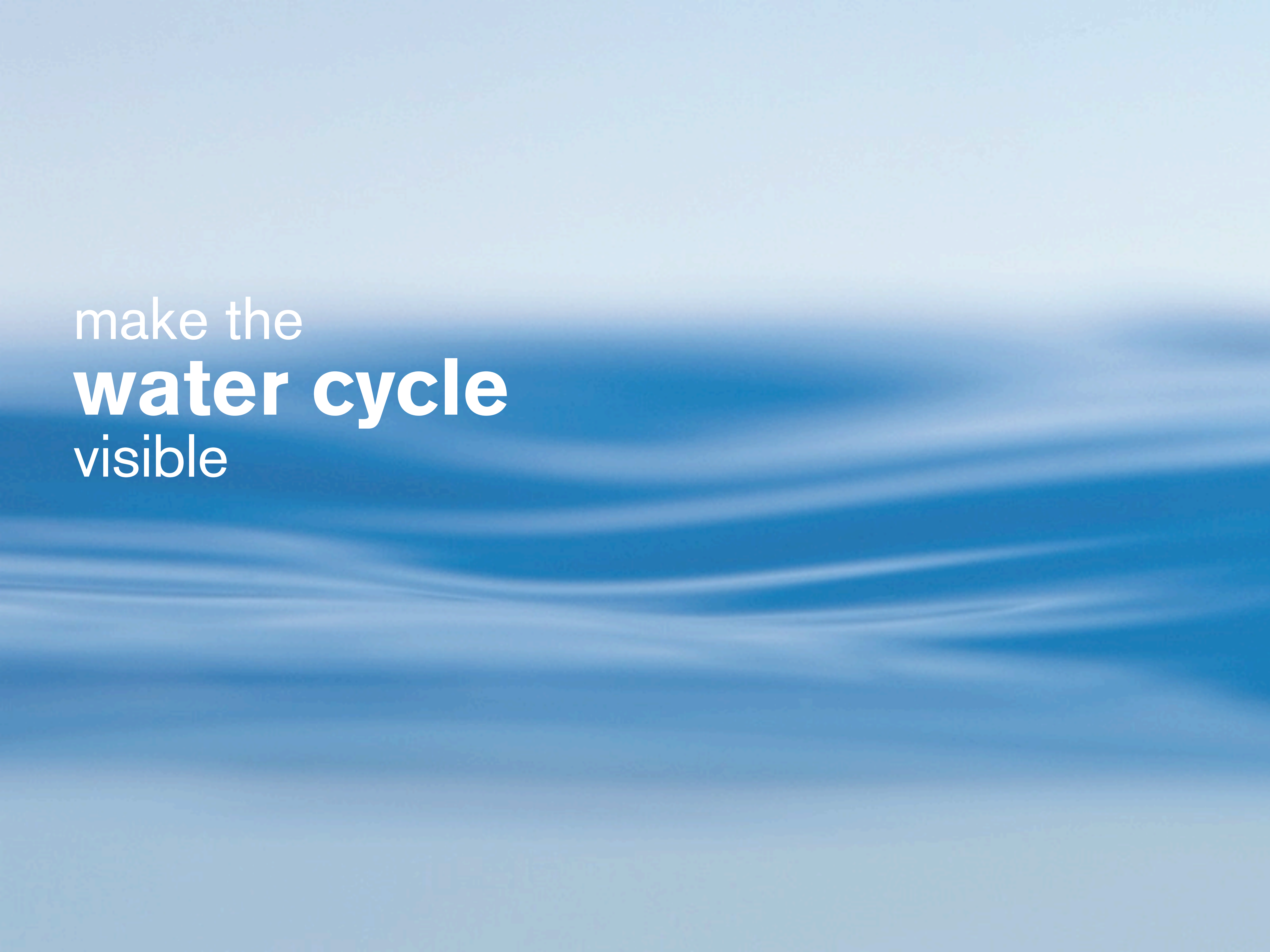

EDUCATION


"Children are not
vessels to be filled,
but lamps to be lit."
Swami Chinmayananda


Recycle
Compost
Landfill
SMART


24 HOUR
FITNESS
DUMB


• High school students calculating energy from
solar panels on the roof.
• Middle school students studying ecosystems in their
constructed wetland.
• Kindergarteners growing lunch in an
organic garden.


make the
water cycle
visible


make the
energy use
visible


EDIBLE
SCHOOLYARD
THE EDIBLE SCHOOLYARD
NEW ORLEANS
esynola.org


OWING &


Seaton primary School
Wind System
Solar System
Wind Power [W]
70
Solar Power [W]
1687
Total Wind Energy [kWh]
377
Total Solar Energy [kWh]
8126
Wind
Power


Seaton Primary, Devon

Eastchurch Primary, Kent


CARBON DETECTIVES
CARBON DETECTIVES
CARBON DETECTIVES
CARBON DETECTIVES
CARBON DETECTIVES
CARBON DETECTIVES


PIT CREW


U.S. GREEN BUILDING COUNCIL
LEED CERTIFIED
2007

Daylighting Evolution in LEED

NCv2.1, EQc6.1 – Controllability of Systems

Provide a high level of thermal, ventilation, and lighting system control

- Perimeter Spaces
- Requirements: one operable window and one lighting control zone per 200 sq.ft. for regularly occupied areas within 15 feet of the perimeter wall.

NCv2.2, EQc6.1 – Controllability of Systems

Provide a high level of lighting system control

- Lighting
- Requirements: individual lighting controls for min. 90% building occupants, lighting system controllability for shared spaces.

LEED 2009 Green Building Design and Construction, EQc6.1 – Controllability of Systems: Lighting

- Requirements: same as NCv2.2

Daylighting Evolution in LEED (continued)

EBv2.0, EQc6.1 – Controllability of Systems

Provide a high level of temperature, ventilation, and lighting control

- Lighting
- Requirements: lighting controls for at least 50% of building occupants

EB O&M, EQc2.2 – Occupant Comfort: Occupant-Controlled Lighting

Provide a high level of lighting control

- Requirements: lighting controls for 50% of individual workstations AND for 50% of multioccupant spaces

LEED 2009 Green Building Operations and Maintenance, IEQc2.2 – Controllability of Systems: Lighting

- Requirements: same as EB O&M

Daylighting Evolution in LEED (continued)

NCv2.1, EQc8.1 – Daylight and Views

Providing a connection between indoor and outdoor spaces with daylight and views

- Daylight 75% of Spaces
- Requirements: Minimum 2% Daylight Factor for 75% of all space occupied for critical visual tasks.

NCv2.2, EQc8.1 – Daylight and Views

- Daylight 75% of Spaces
  Requirements: Glazing Factor Calculation OR Daylight Simulation Model OR Daylight Measurement. For all options, only sq. footage associated with the portions for the rooms meeting the min. illumination requirements apply towards 75% AND provide daylight redirection and/or glare control devices.

LEED 2009 Green Building Design and Construction, EQc8.1 – Daylight and Views: Daylight

- Requirements: Simulation OR Prescriptive OR Measurement OR Combination. For all options, only sq. footage associated with the portions for the rooms meeting the min. illumination requirements apply towards 75% AND provide daylight redirection and/or glare control devices. In Schools, there is an option for up to 3 points, with 90% achievement of all classrooms and/or 75% of all other regularly occupied spaces.

Daylighting Evolution in LEED (continued)

EBv2.0, EQc8.1 – Daylight and Views

Providing a connection between indoor and outdoor spaces with daylight and views

- Daylight
- Requirements: achieve a minimum Daylight Factor of 2% in space occupied for critical visual tasks

EB O&M, EQc2.4-2.5 – Occupant Comfort: Daylight and Views

- Requirements: 2% daylight factor in 50% or 75% of all spaces. Measurement OR Calculation OR Simulation

LEED 2009 Green Building Operations and Maintenance, IEQc2.4 – Daylight and Views

- Requirements: Simulation OR Prescriptive OR Measurement OR Combination. For all options, only sq. footage associated with the portions for the rooms meeting the min. *illumination requirements apply towards 75% AND provide daylight redirection and/or glare control devices.*
- Same requirements as LEED 2009 Green Building Design and Construction, EQc8.1 – Daylight and Views: Daylight.

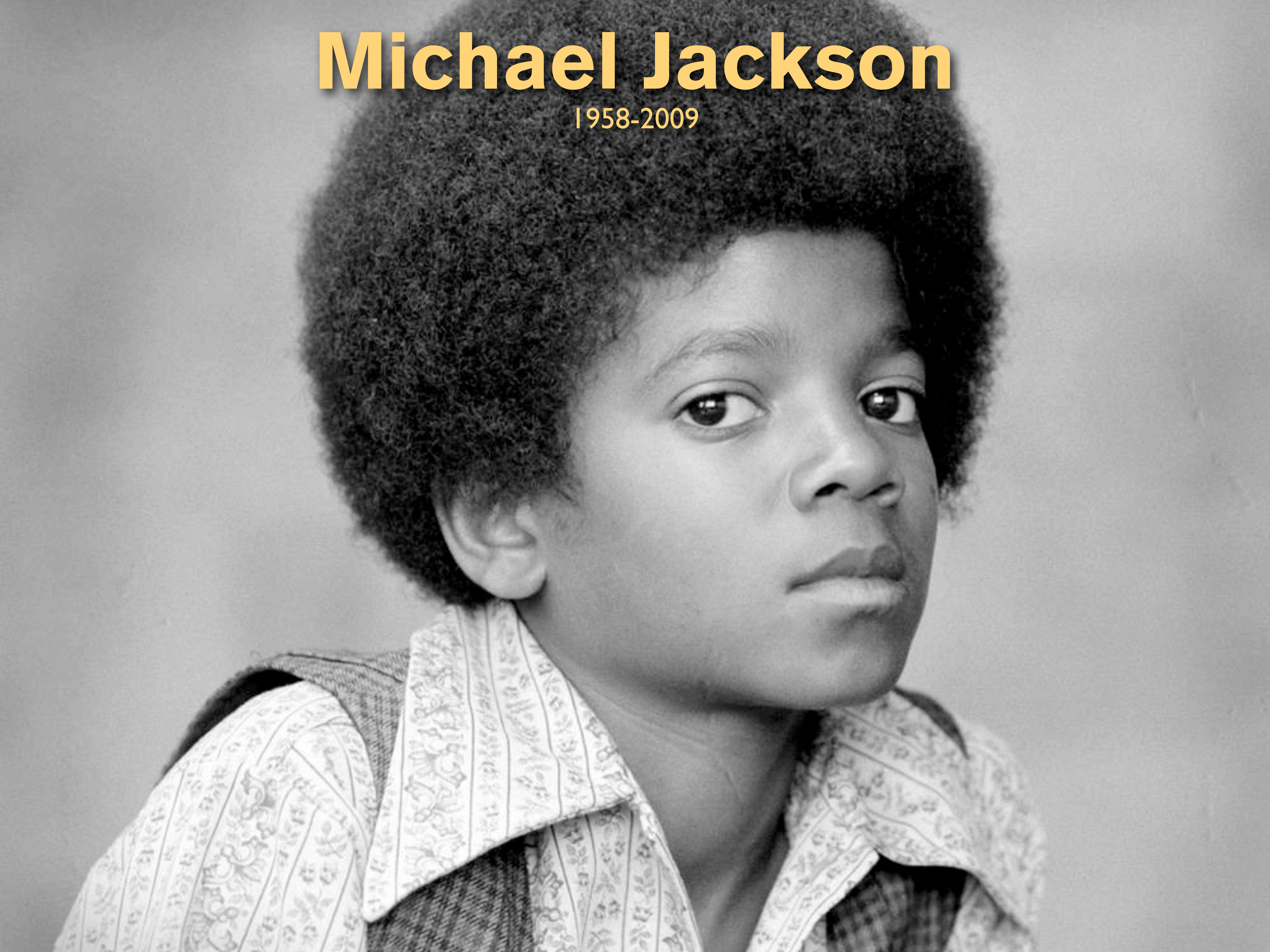
COLLABORATIVE FOR HIGH PERFORMANCE SCHOOLS

CHPS

Better buildings. Better students.

CHPS
Daylighting Guidelines

- View Windows
- High Sidelighting (clerestory)
- Clerestory with lightshelf
- Wall Wash Toplighting
- Central Toplighting
- Patterned Toplighting
- Linear Toplighting
- Tubular skylights


Michael Jackson
1958-2009


michael jackson
IS
AMERICA

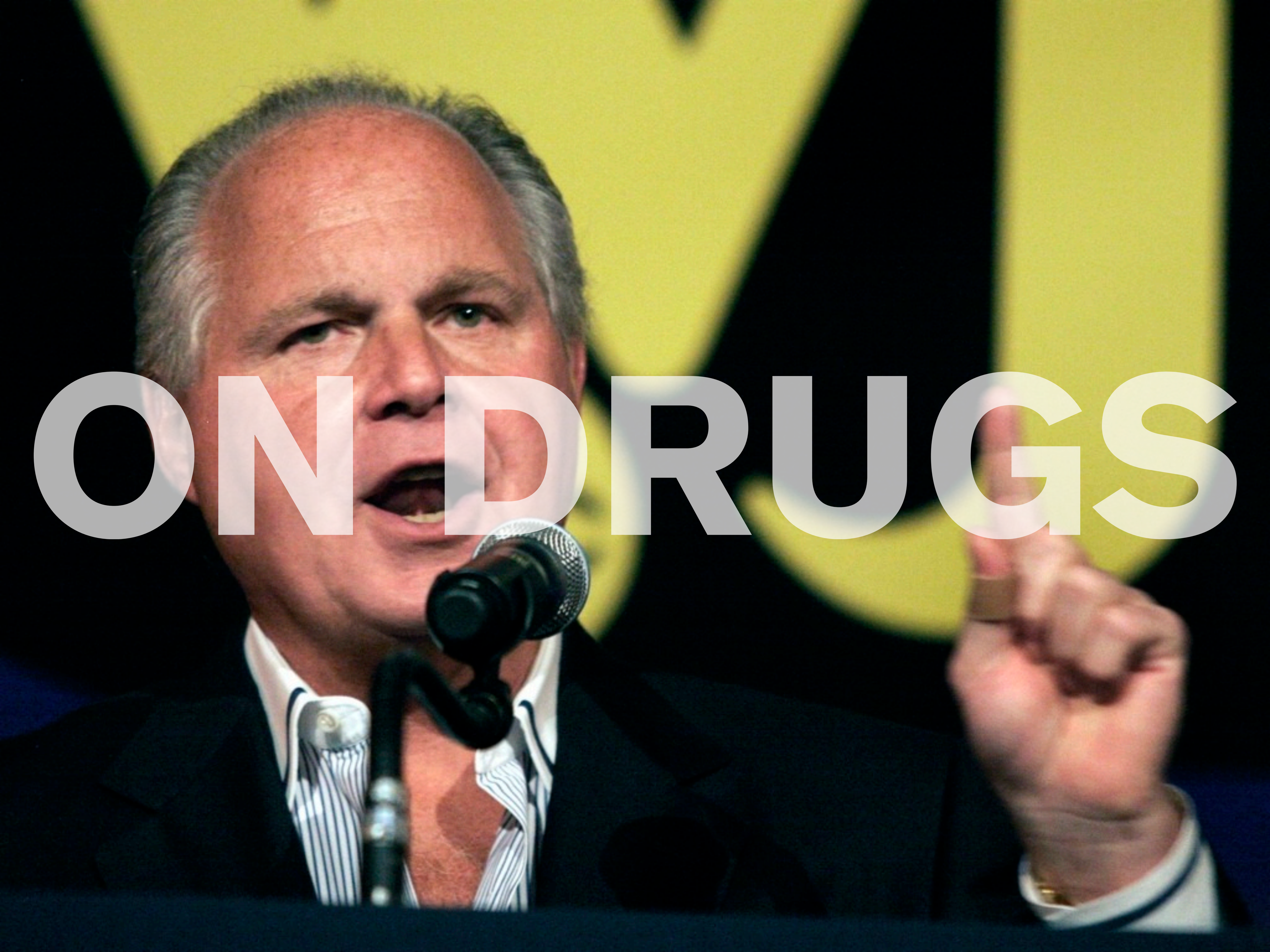
delusional
fragile
childish
in debt
on drugs
indulgent
bad diet
obsessed
over the hill


DELUSIONAL


FRAGILE


CHILDISH


IN DEBT


ON DRUGS


OVER
INDULGENT

BAD DIET


NEW!
Jimmy Dean
Pancakes & Sausage
ON A STICK
Pancake Batter Covering a Sausage Link
14
Chocolate Chip

OBSESSED


OVER
THE HILL

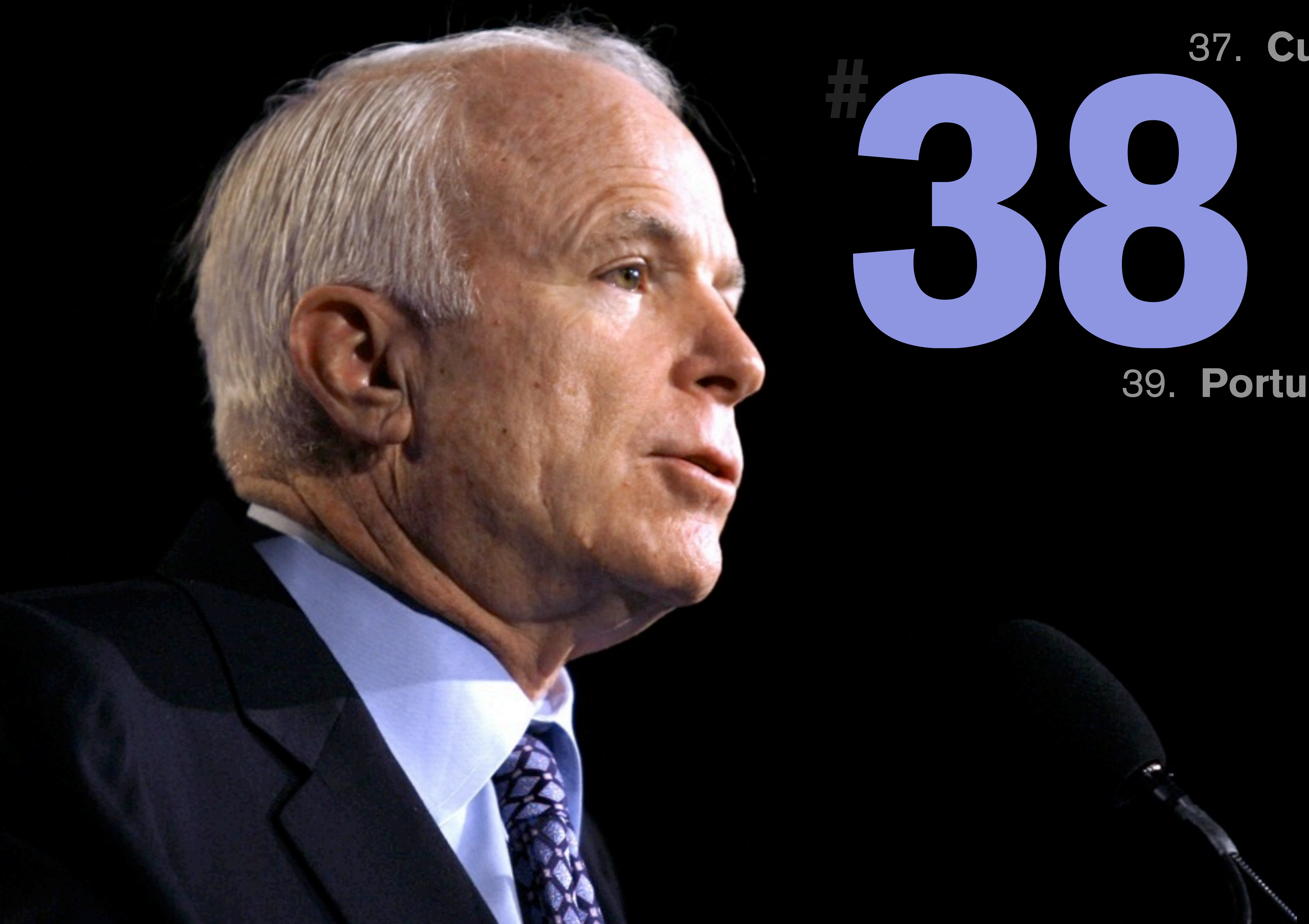
No Apology:
The Case For American Greatness

Gov. Mitt Romney


#1
U.S.A.


DWIGHT SCHRUTE
DETERMINED
WORKER
INTENSE
GOOD WORKER
HARD WORKER
TERRIFIC

LIFE EXPECTANCY



37. **Cuba**

#38

39. **Portugal**

SOURCE: Wikipedia

INFANT MORTALITY

HEALTH CARE

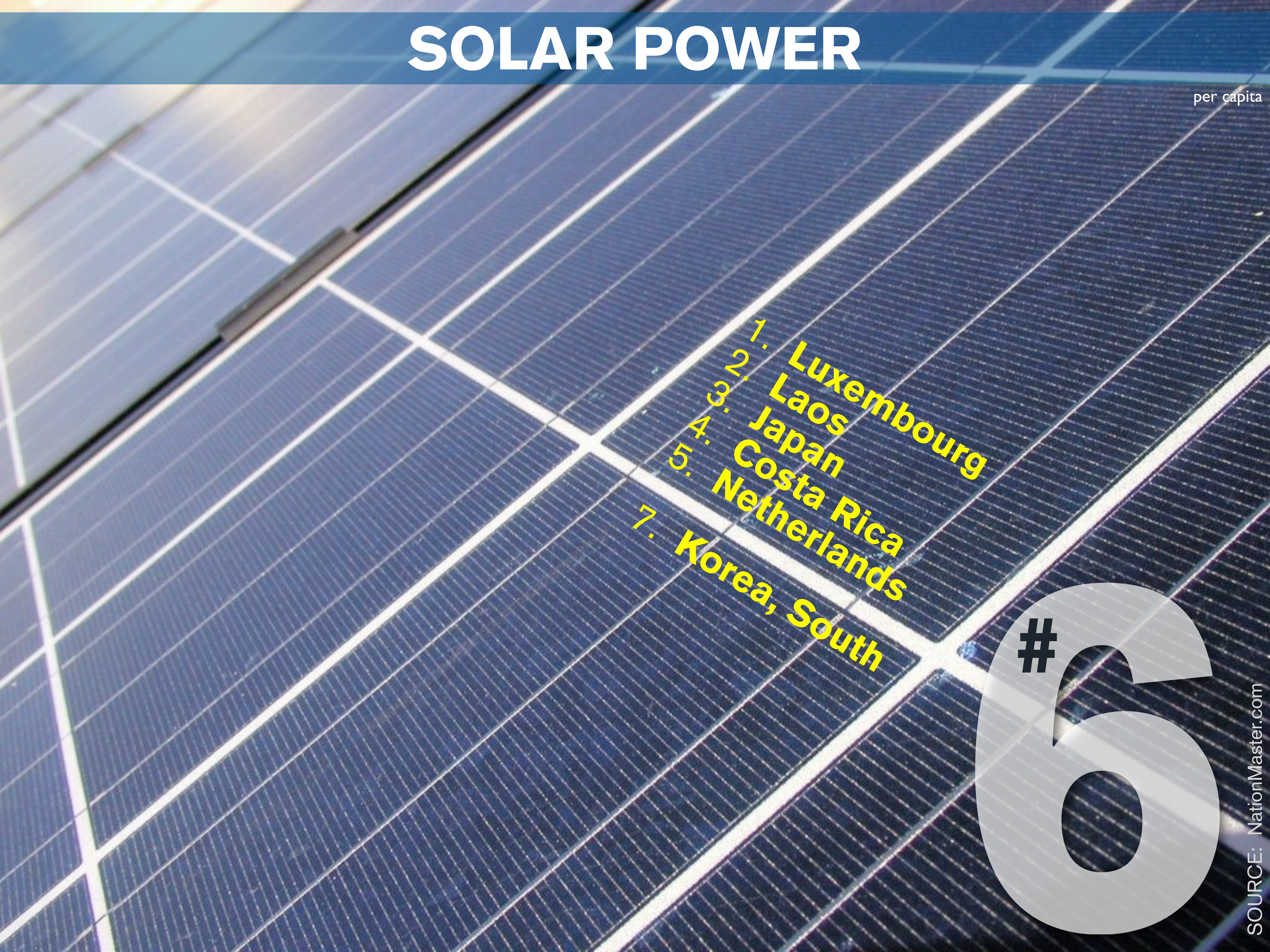
31. **Finland**
32. **Australia**
33. **Chile**
34. **Denmark**
35. **Dominica**
36. **Costa Rica**

#37

38. **Slovenia**

SOURCE: World Health Organization


NUMBER OF DOCTORS
per capita
#52
51. Cyprus
53. Slovenia
SOURCE: NationMaster.com


SOLAR POWER
per capita
1. Luxembourg
2. Laos
3. Japan
4. Costa Rica
5. Netherlands
7. Korea, South
#6
SOURCE: NationMaster.com

GROSS DOMESTIC PRODUCT

#8

7. Ireland

9. Iceland

SOURCE: InfoPlease.com

EMPLOYMENT

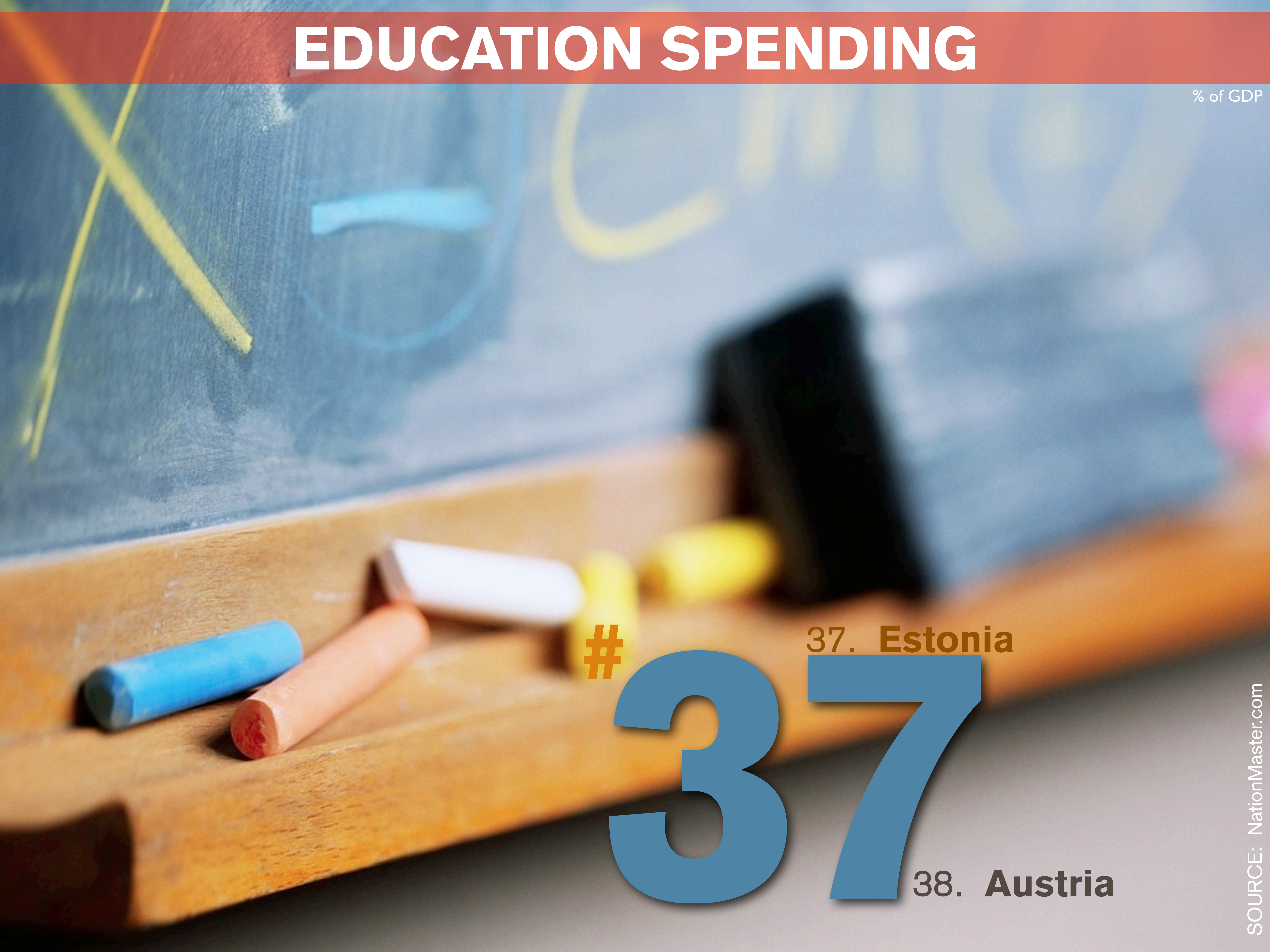
#10

9. **Canada**

11. **Australia**

SOURCE: Wikipedia


MINIMUM WAGE
McDonald's
i'm lovin' it
#13
12. Switzerland
14. Austria
SOURCE: Wikipedia


EDUCATION SPENDING
% of GDP
#37
37. Estonia
38. Austria
SOURCE: NationMaster.com


MATHEMATICAL LITERACY
#18
17. Czech Republic
19. Germany
SOURCE: NationMaster.com


BEER CONSUMPTION
#13
12. Spain
14. Croatia
SOURCE: Wikipedia

#1
handgun deaths
SOURCE: NationMaster.com


CRIME SCENE-DO NOT ENTER
#1
total crime
SOURCE: NationMaster.com


#1
prisoners
SOURCE: NationMaster.com


#1
executions
SOURCE: NationMaster.com


#1
rape
SOURCE: NationMaster.com


DANCING ELK
CONDORS
#1
teen pregnancy
SOURCE: NationMaster.com


#1
healthcare expense
SOURCE: NationMaster.com

#1
personal spending
SOURCE: NationMaster.com


#1
population below 50%
SOURCE: NationMaster.com


#1
plastic surgery

#1
motor vehicle death
SOURCE: NationMaster.com


#1
external debt
SOURCE: Wikipedia

#1
military spending
SOURCE: NationMaster.com


#1
garbage production
SOURCE: InfoPlease.com


#1
total energy use
SOURCE: CIA World Factbook; DOE

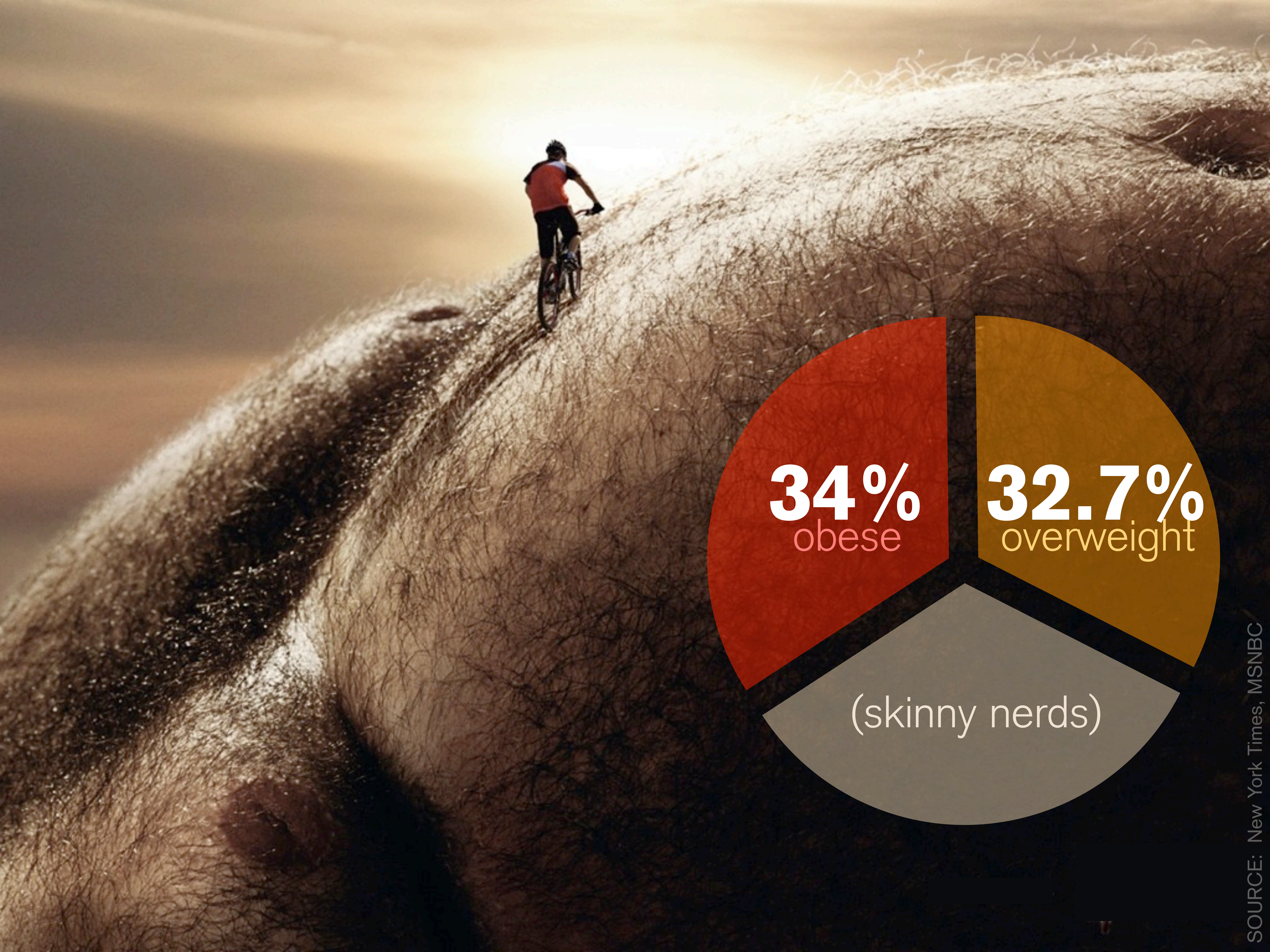

#1
energy consumption
SOURCE: CIA World Factbook; DOE


#1
oil consumption
SOURCE: CIA World Factbook; DOE


#1
oil imports
SOURCE: CIA World Factbook; DOE


#1
carbon emissions


#1
obesity
SOURCE: New York Times, National Geographic


34%
obese
32.7%
overweight
(skinny nerds)
SOURCE: New York Times, MSNBC


obese americans
72,000,000
SOURCE: New York Times


obesity is associated with over
300,000
deaths/yr
$
117,000,000
healthcare costs
SOURCE: US Department of Health & Human Services

by **2030**

86%

of americans obese

SOURCE: Johns Hopkins Bloomberg School of Public Health

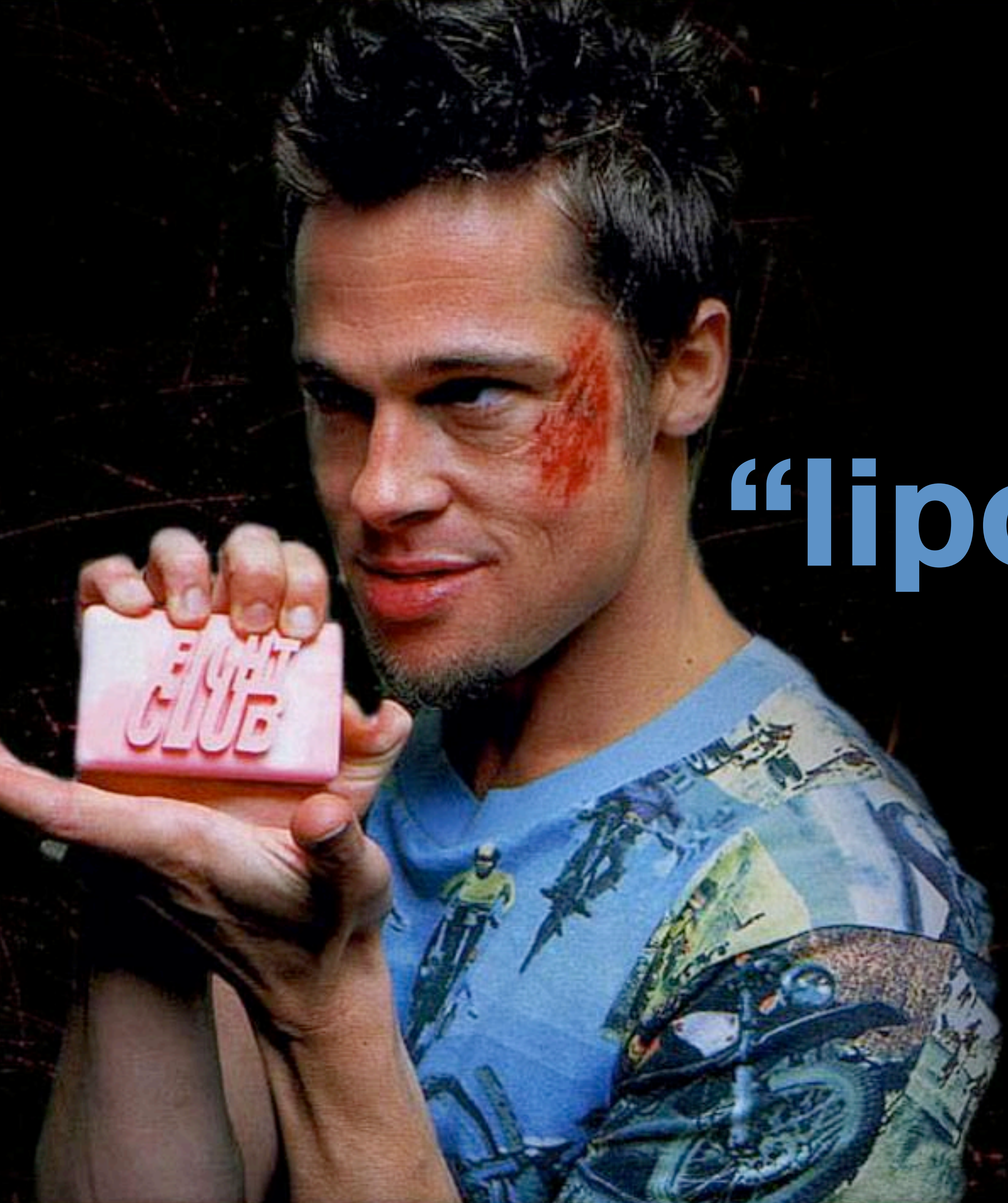

every hour
in a car
each day
6%
increase in
likelihood
of obesity
SOURCE: Georgia Tech Study, 2009
TU 4154


COLD

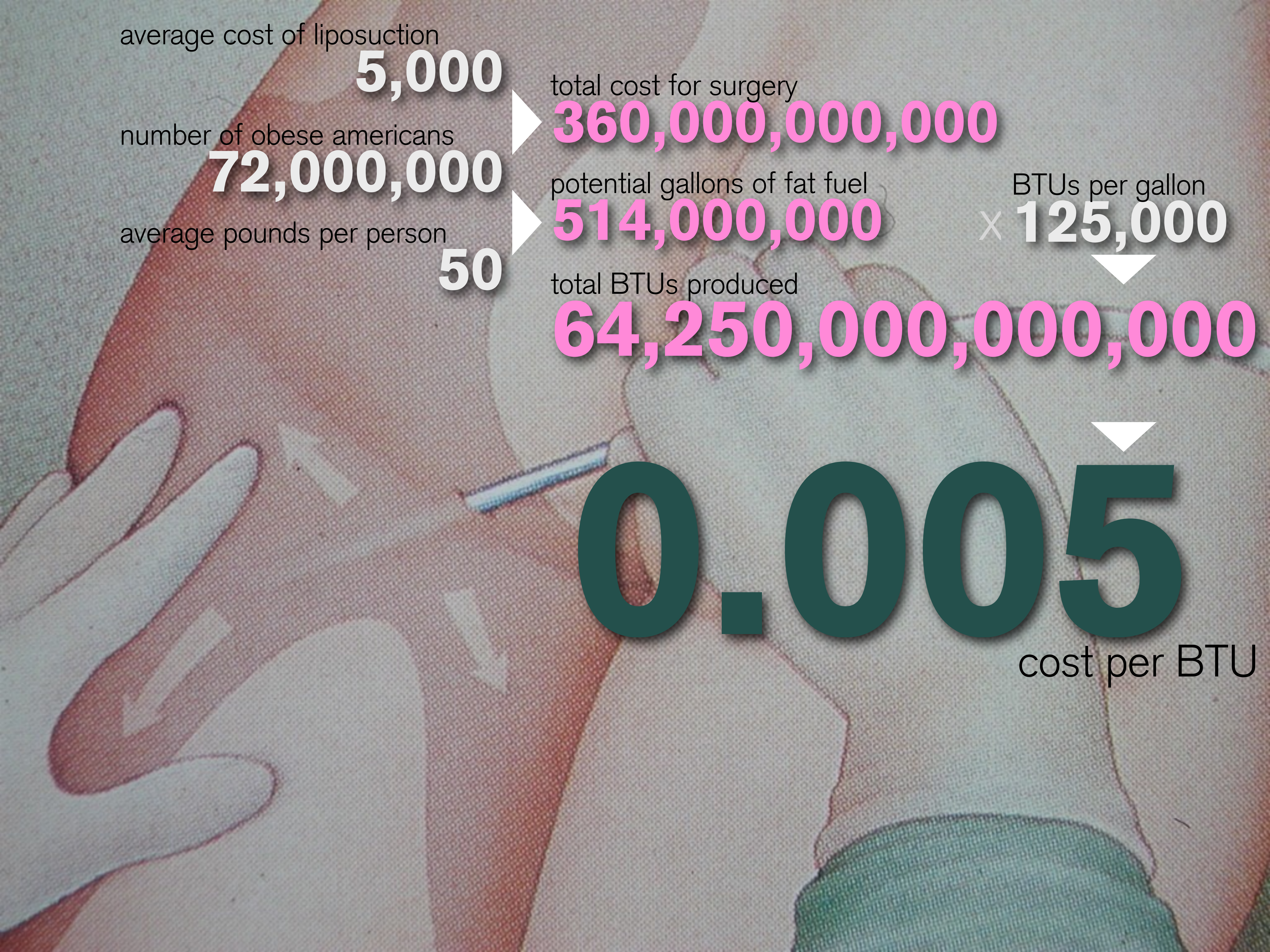

SONIC



35%
walkable neighborhoods
decrease in risk of obesity
Divine Food
EST
FLABBYS
1952
Schnitzelburg
STOP
walkscore.com



“lipodiesel”


average cost of liposuction
5,000
number of obese americans
72,000,000
average pounds per person
50
total cost for surgery
360,000,000,000
potential gallons of fat fuel
514,000,000
BTUs per gallon
x 125,000
total BTUs produced
64,250,000,000,000
0.005
cost per BTU

metric tons of co2 saved

3,210,350

791,256

homes/year

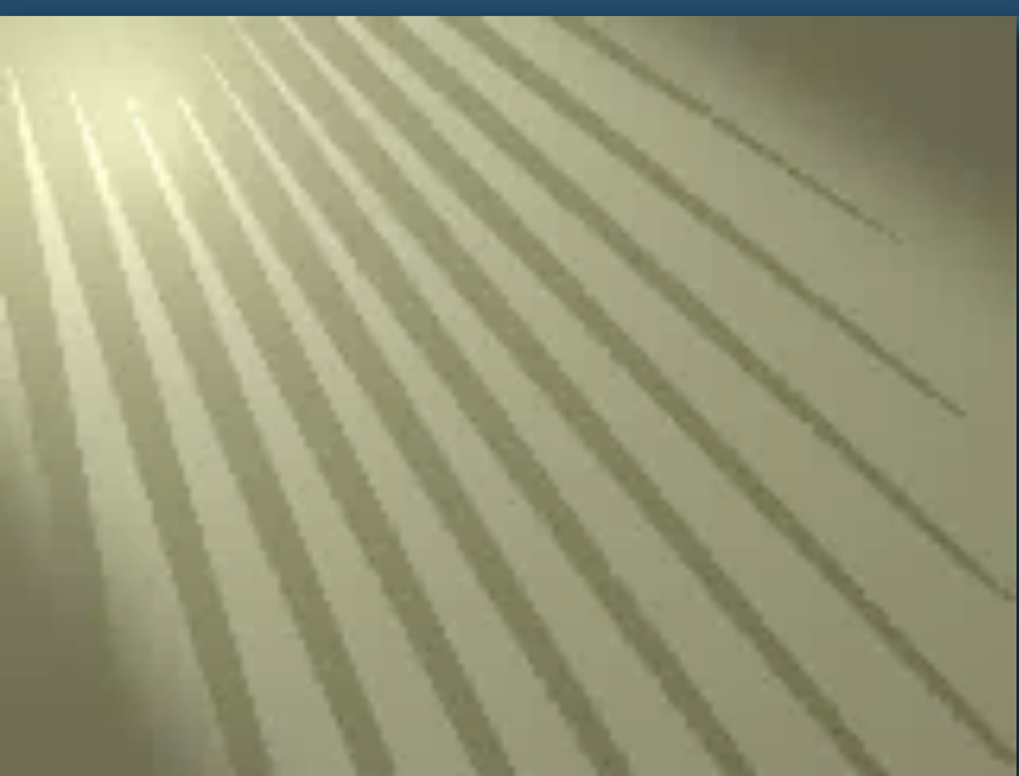

1.21
gigawatts per person
DANGER
FLUX
CAPACITOR
1.21 JIGAWATTS


Gene Wilder

what's next: 5 action steps

1

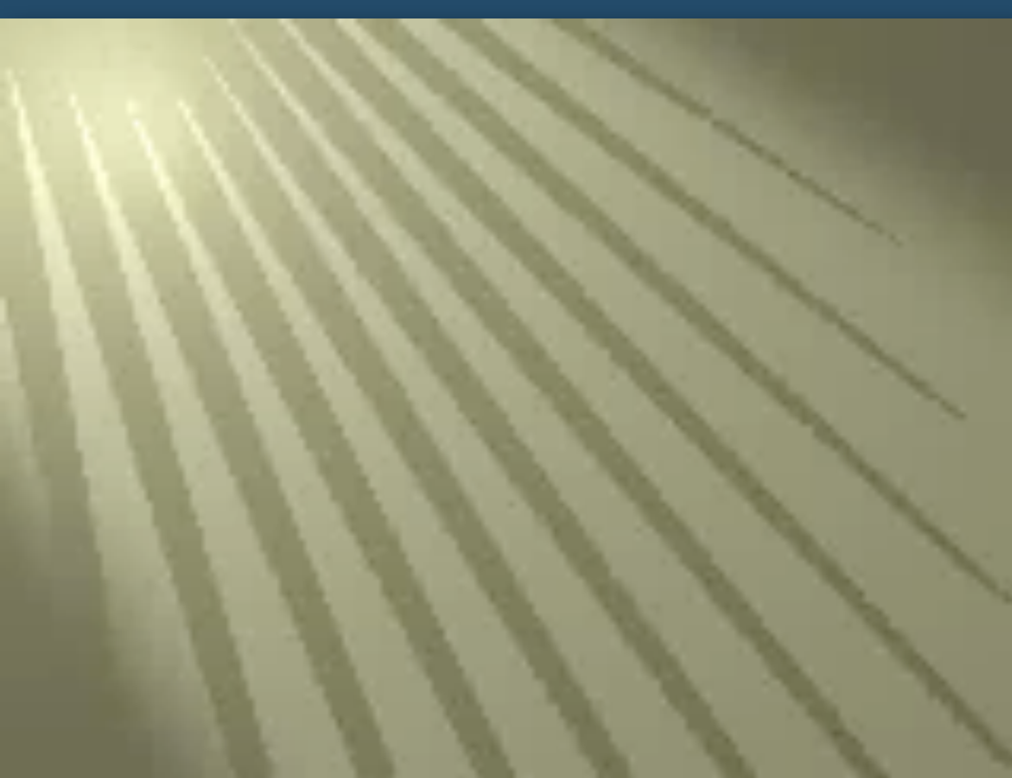
take action.
do something.
think big.



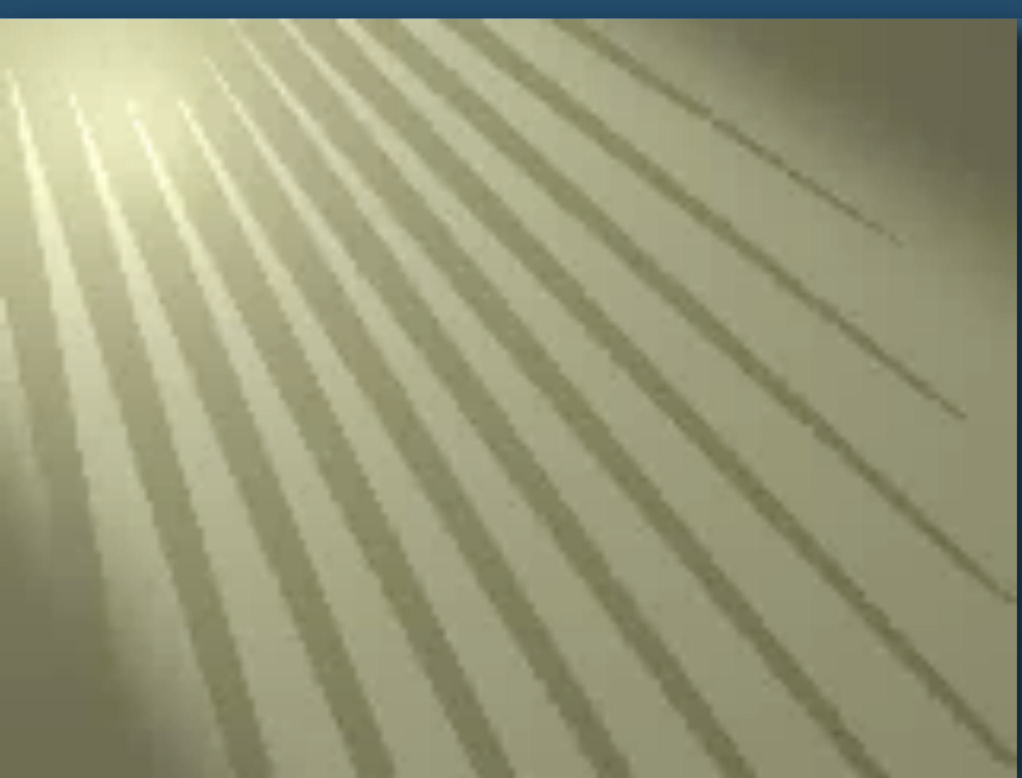
2 tell others. share your enthusiasm.

3 fill the materials library with green materials.

4 make a list of things you will not compromise.



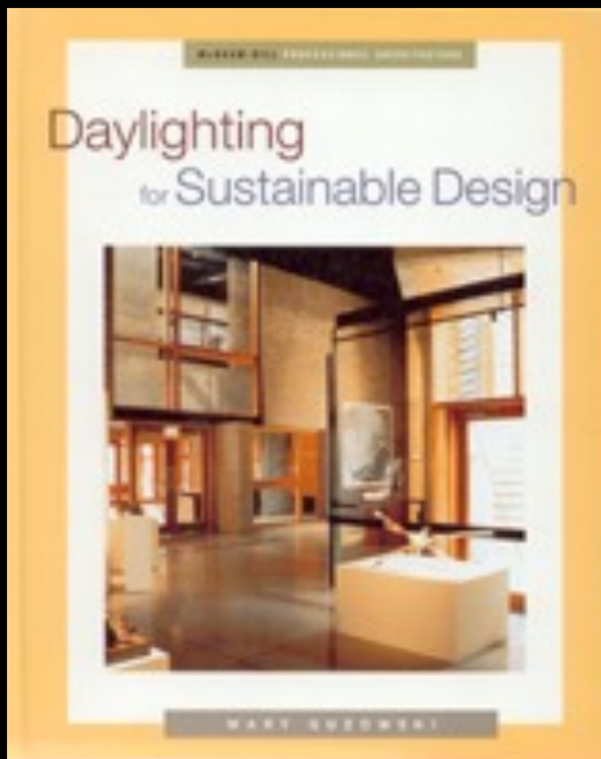
5 become champion of one issue. innovate.

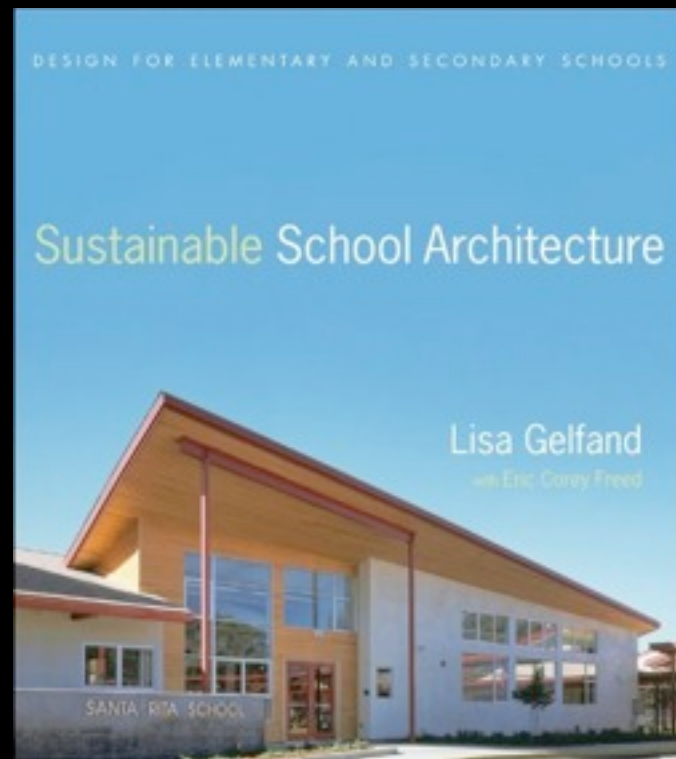


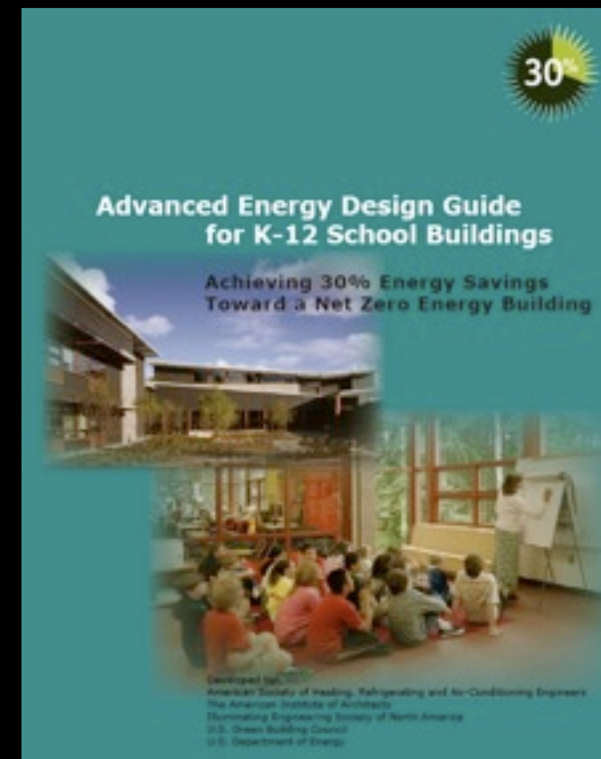

"you must be the
CHANGE
you wish to see in the
WORLD..."
-Mahatma Gandhi

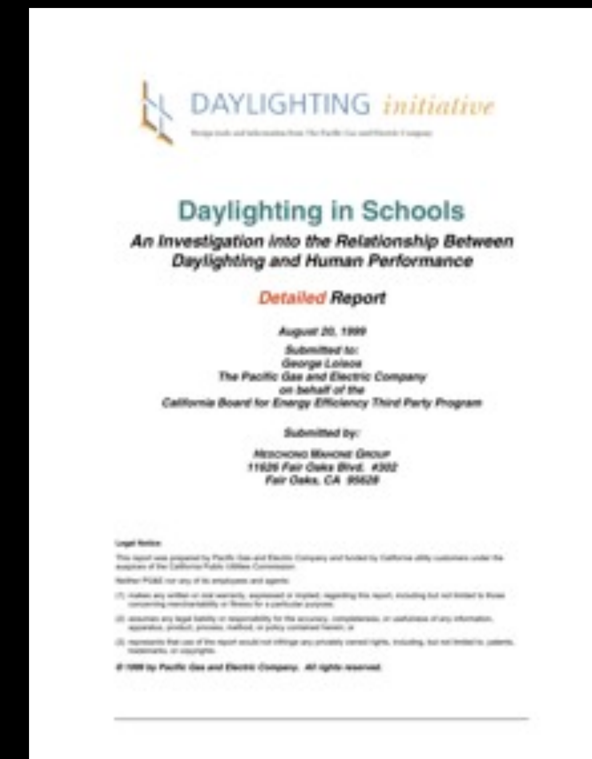
RESOURCES

Reference Books









Online Resources

U.S. Dept. of Energy - Energy Smart Schools
www.eere.energy.gov/buildings/energysmartschools

Energy Efficiency and Renewable Energy Education
www.eere.energy.gov/education

EnergyStar
www.energystar.gov (Buildings & Plants)

Collaboration for High Performance Schools (CHPS)
www.chps.net

National Clearinghouse for Educational Facilities (NCEF)
www.edfacilities.org

ASHRAE Advanced Energy Design Guides
www.ashrae.org/publications/page/1604

Organizations

International Commission on Illumination
www.cie.co.at

Illuminating Engineering Society of North America (IESNA)
www.iesna.org

Lawrence Berkeley National Laboratory
www.lbl.gov

Lightsearch.com
www.light-link.com

Lighting Research Center, Rensselaer Polytechnic Institute
www.lrc.rpi.edu

Online Tools

Sensor Placement and Optimization Tool (SPOT)
www.archenergy.com/SPOT/index.html

Daylighting: Healthy Schools Network, Albany, NY
www.healthyschools.org/downloads/Daylighting.pdf

Study: Effect of IEQ on Occupant's Perception
www.cce.ufl.edu

Heschong Study: Daylighting in Schools
www.coe.uga.edu/sdpl/research/daylightingstudy.pdf

Student Performance in Daylit Schools
www.innovativedesign.net

Daylighting Collaborative
www.daylighting.org

Windows and Daylighting (LBNL)
windows.lbl.gov

organicarchitect

QUESTIONS?

ericcoreyfreed eric@organicarchitect.com

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organicarchitect.com/downloads/daylighting.pdf

DROP OFF YOUR BUSINESS CARD

L11D09 DAYLIGHTING IN SCHOOLS

9:00am – 10:25am
ERIC COREY FREED
Founding Principal
organicARCHITECT, San Francisco

Daylighting strategies for schools, from initial planning, through design and operation.

10:25am – 10:35am
BREAK

10:35am – 12:00pm
BARBARA GHERRI
PhD Student
Architect Universita' Degli Studi di Parma, Parma, Italy

Consideration of psychological, physiological effects and energy performance from Daylighting.


10 MINUTE BREAK