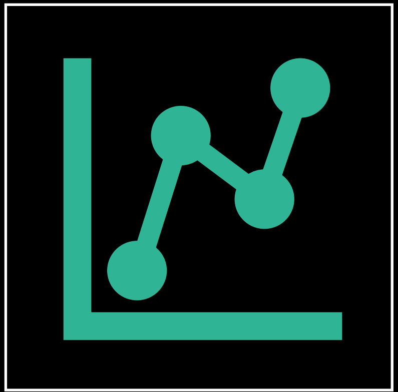
Performance

Someone or something's performance is how successful they are or how well they do something.



A metric used to evaluate an outcome, such as efficiency.

Energy Efficiency

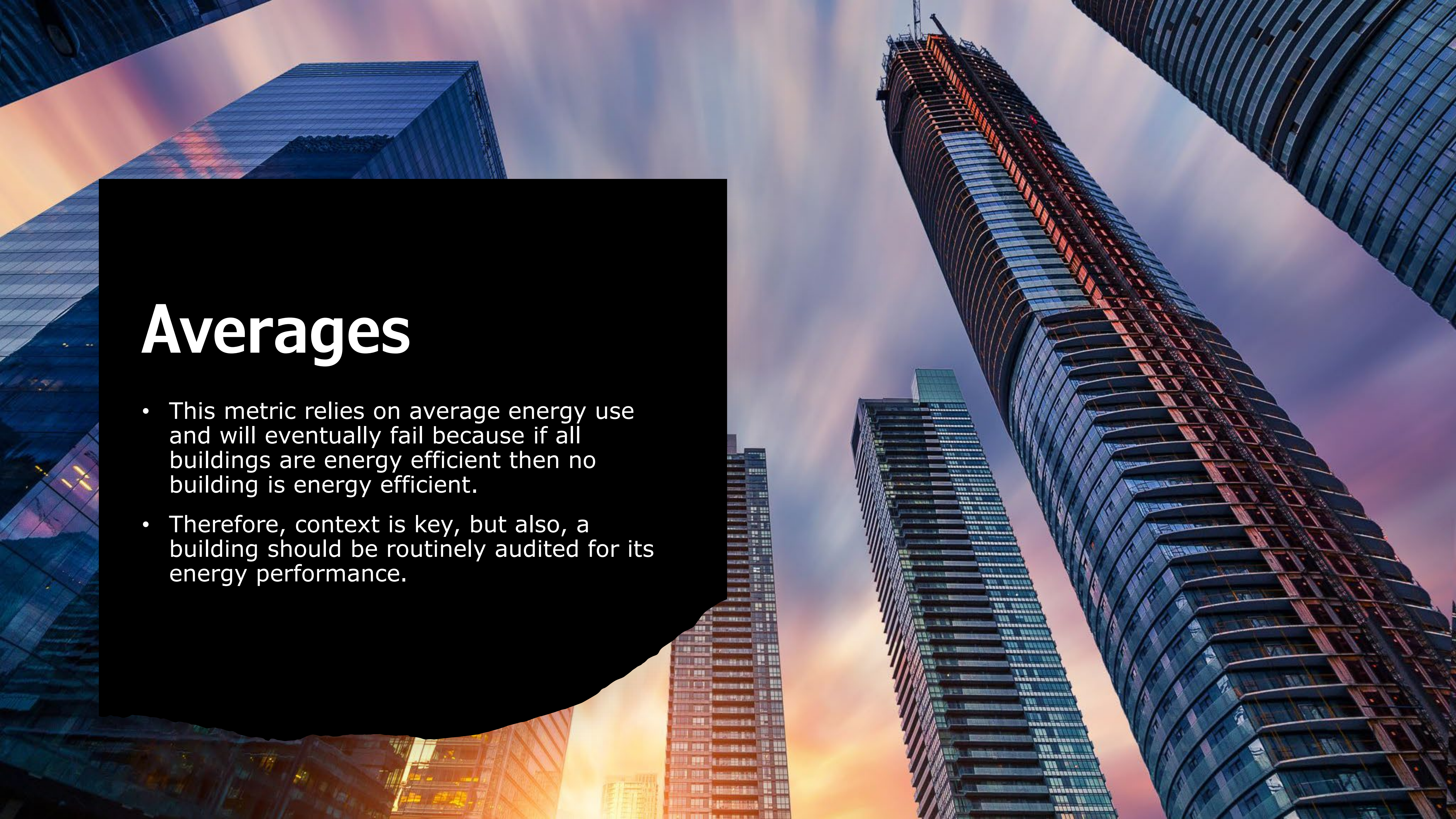
- We as a country decided to care about energy performance in the 70’s as a response to the Arab Oil Embargo.
- Metrics and programs developed during this time are still used today, such as, EnergyStar or CBECS.

Commercial Building Energy Consumption Survey or CBECS

- A national sample survey that collects information on the stock of U.S. commercial buildings, including their energy related building characteristics and energy usage data.

Energy Use Intensity or EUI

- Is a snapshot or a single point in time that describes a building's energy use in two forms.
  - Total Energy Consumed
  - Categories of Energy Consumption
    - Lighting, Heating, Cooling, Ventilation, Computers, etc.



Averages

- This metric relies on average energy use and will eventually fail because if all buildings are energy efficient then no building is energy efficient.
- Therefore, context is key, but also, a building should be routinely audited for its energy performance.

Simulation

A calculation engine.

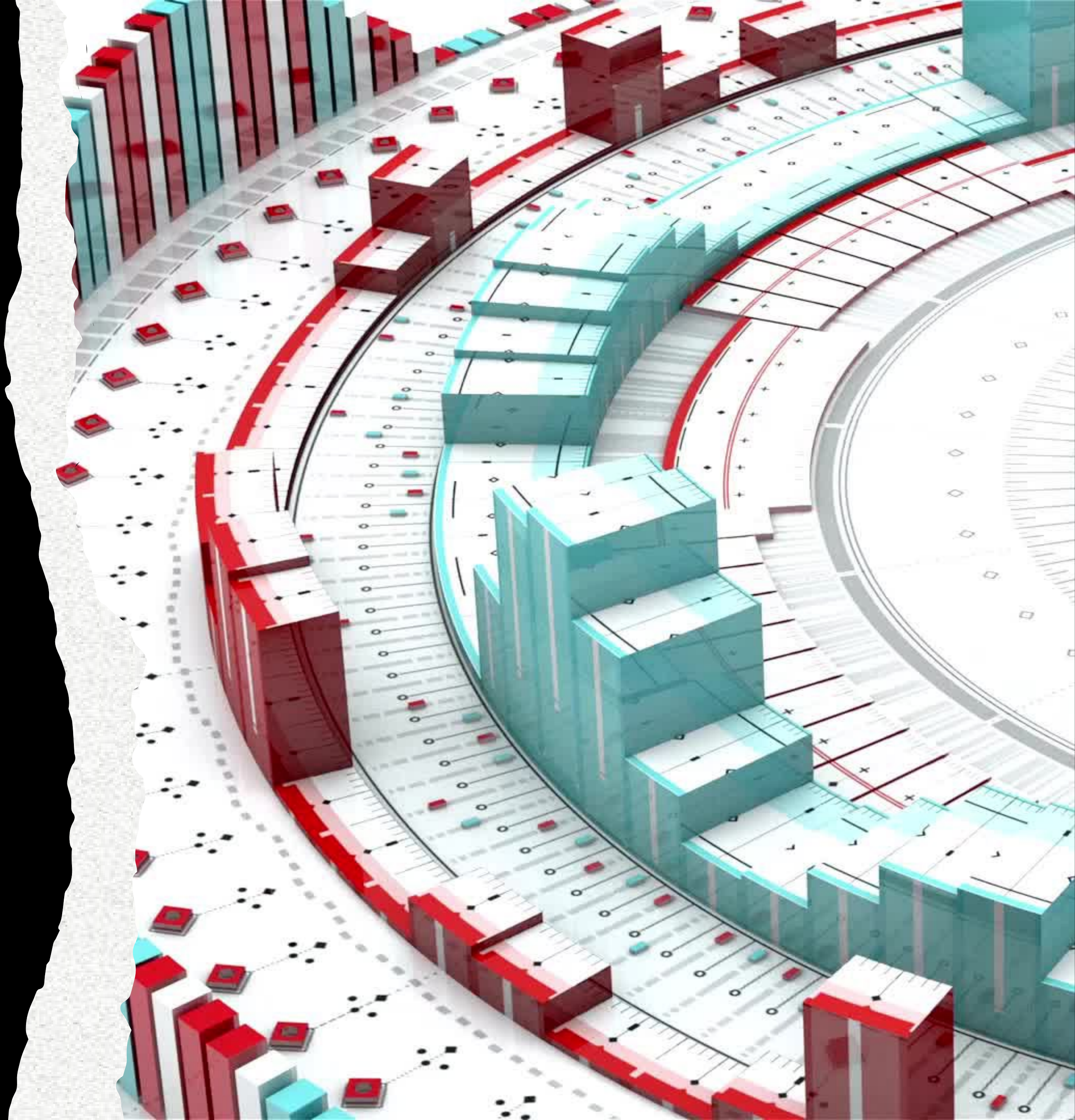
GIGO

Garbage In =
Garbage Out

Intended to be used throughout the design process but in reality, its used in construction documentation to validate compliance.

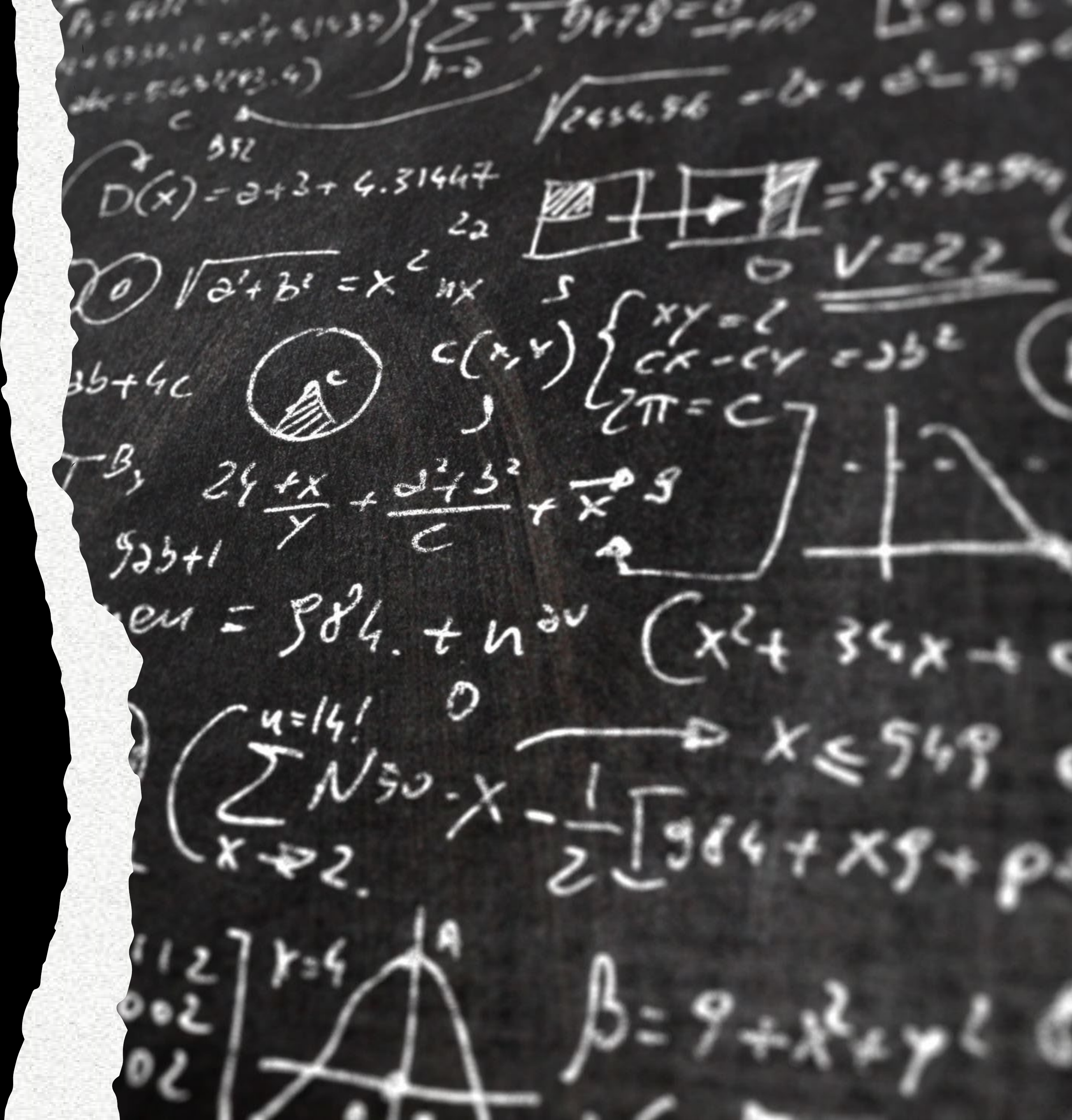
Simulation

- BEM is physics-based software simulation of building energy use.
- A BEM program takes an input such as description of a building including geometry, construction materials, and lighting, HVAC, refrigeration, water heating, and renewable generation system configurations, component efficiencies, and control strategies.



Simulation

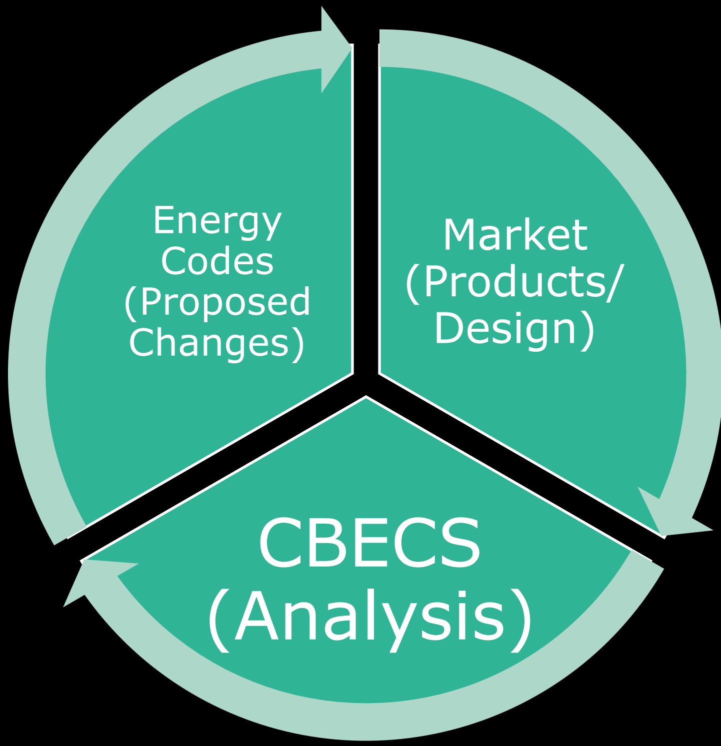
- It also takes descriptions of the building’s use and operation including schedules for occupancy, lighting, plug-loads, and thermostat settings.
- A BEM program combines these inputs with information about local weather and uses physics equations to calculate thermal loads, system response to those loads, and resulting energy use, along with related metrics like occupant comfort and energy costs.

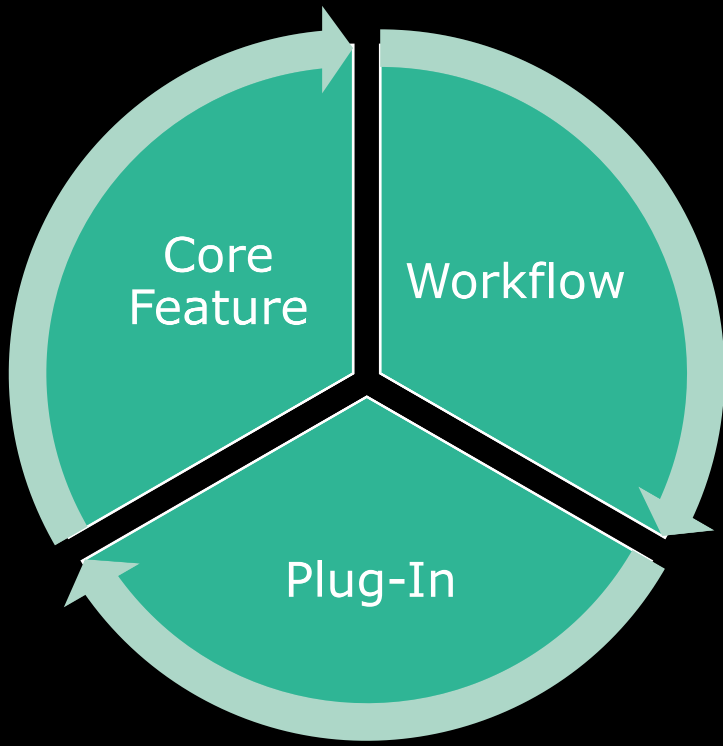


Why Simulations

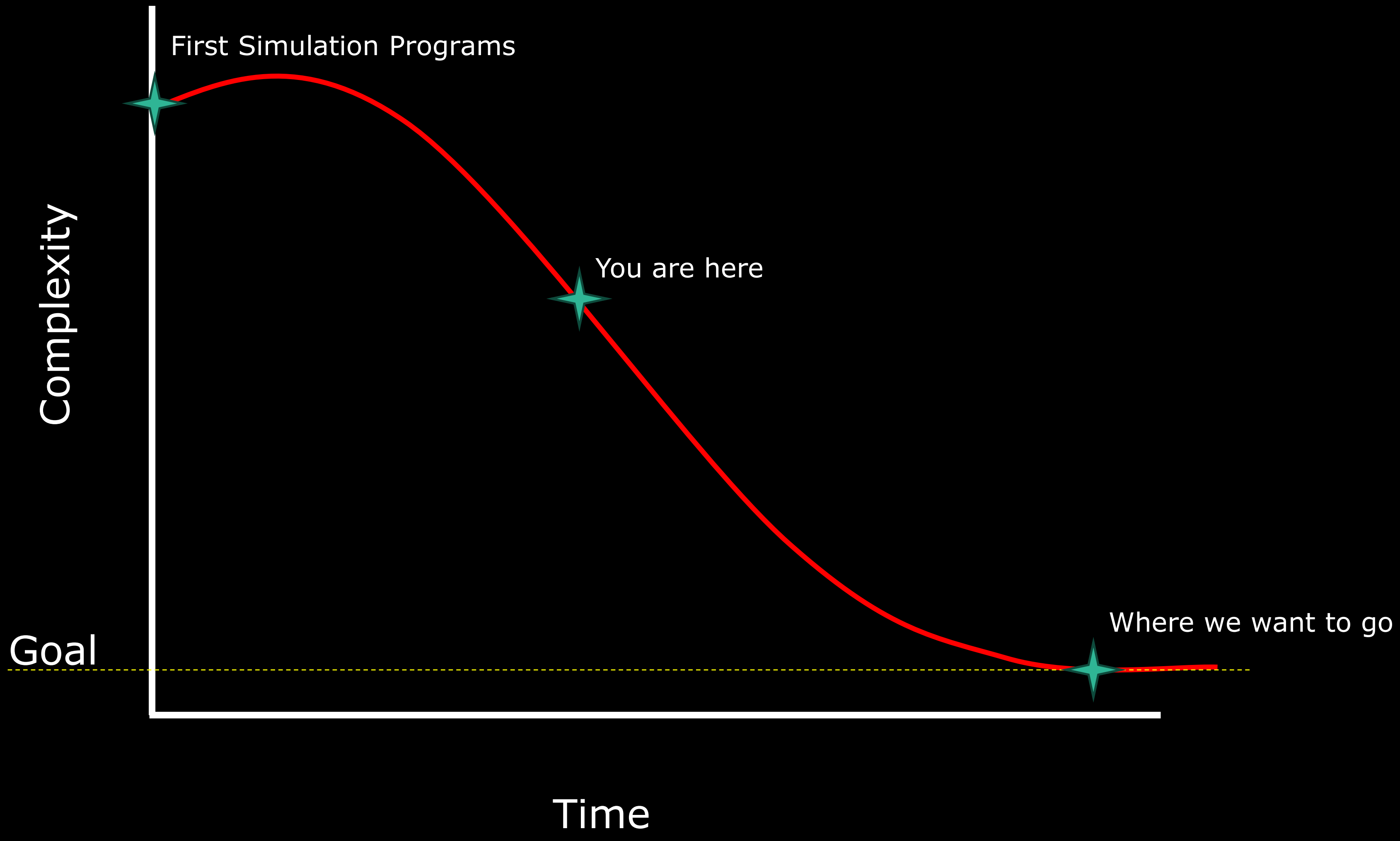
- As-Designed – Current Performance = Difference
- Identify Energy Efficiency Measures (EEMs)
    - How effective are those measures?
    - Energy Efficiency can be translated to ROI or $$$.
- Optimize building performance.

Simulation Cycles





Computer Science Knowledge

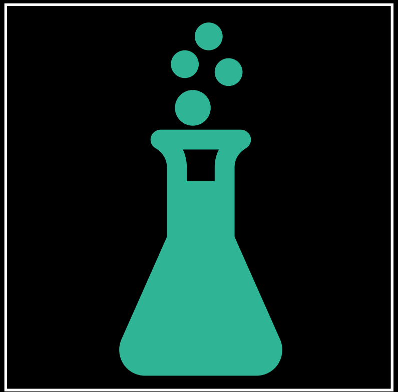


2030 Challenge

- Architecture is behind while Engineering has been leading.
- A lack of adoption for firms to use simulation or energy modeling for the 2030 challenge.
- 2014 & 2017 – Publication – “Architect’s Business Case for Energy Performance Modeling”.

2030 Challenge

Energy modeling should assist not replace design experience.



Use it to SCIENTIFICALLY validate design decisions.

Types of Simulations

Whole Building Simulation

Single Instance

Single Instance

OR SUB-
DOMAIN

THERMAL
SIMULATION

LIGHTING
SIMULATION

ACOUSTICAL
SIMULATION

AIR FLOW
SIMULATION

What can you model?

DAYLIGHT SIMULATION

ENERGY SIMULATION

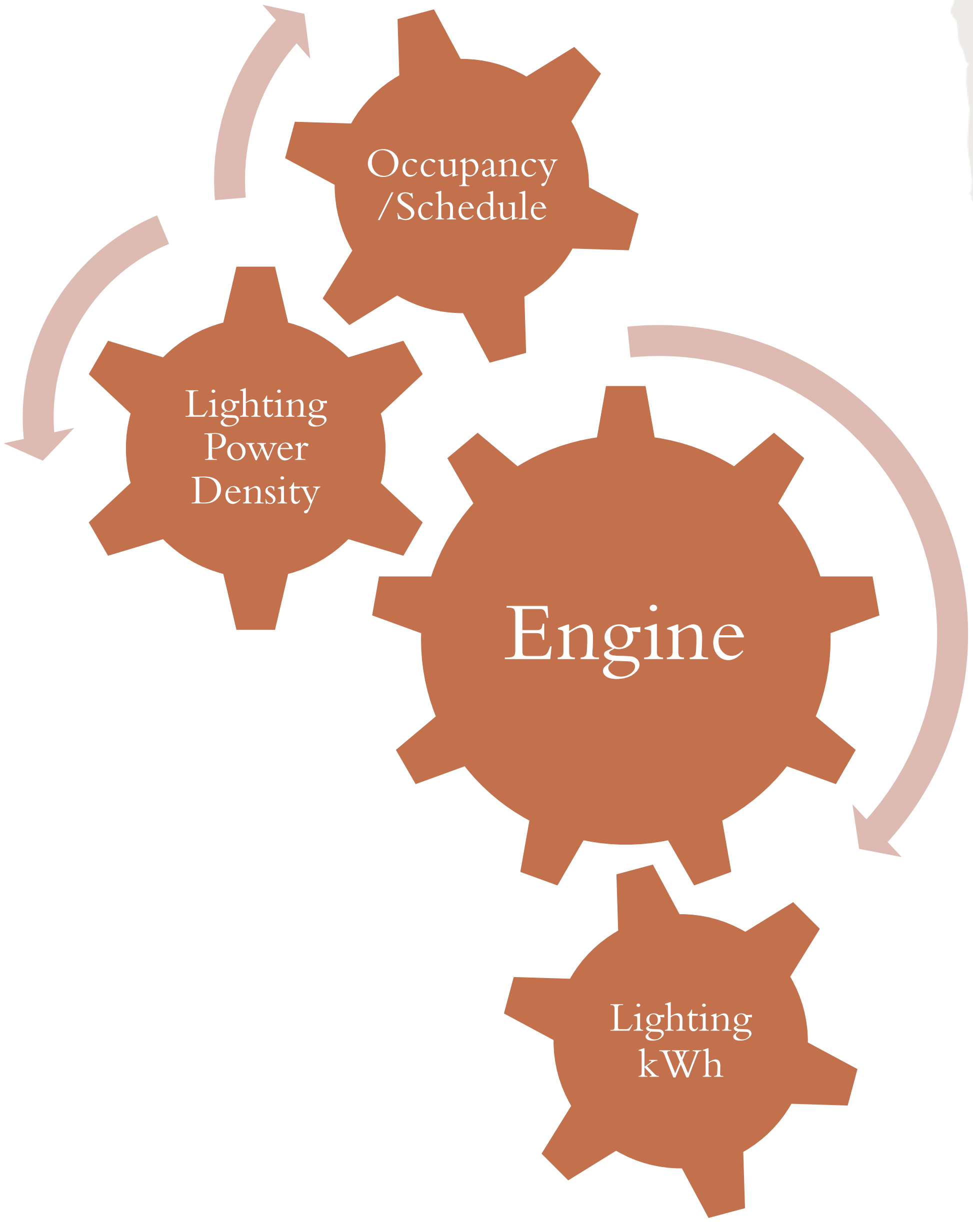
COMPUTATIONAL FLUID DYNAMICS

What can you model?

- Daylight Simulation
  - Qualitative (Subjective)
    - Luminance or Glare
  - Quantitative (Measurement)
    - Illuminance – Lux/Foot-candles

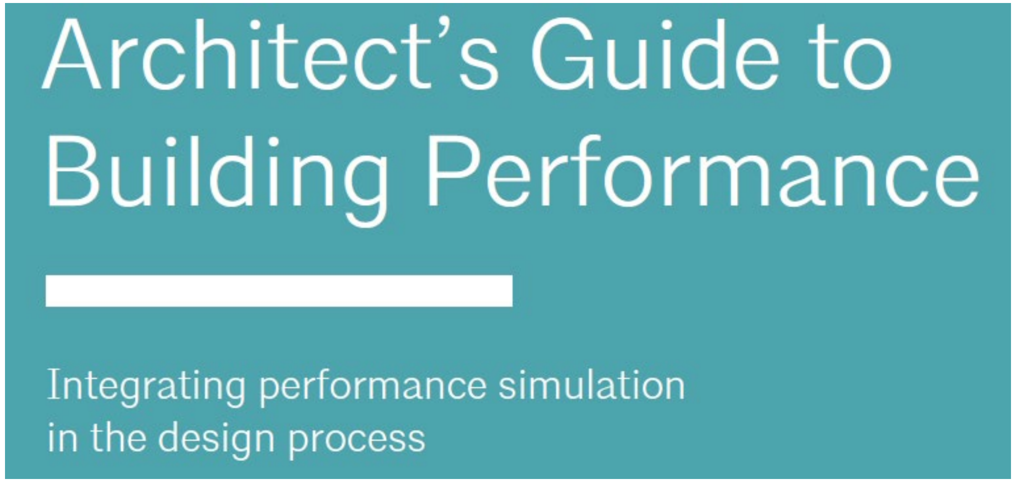
ENERGY MODELING

- In its simplest form, an energy model is a calculation engine that accepts inputs, such as, building geometry or characteristics, and operation schedules.
- These inputs are processed by the 'engine' to derive outputs, such as, performance comparisons and compliance reports.

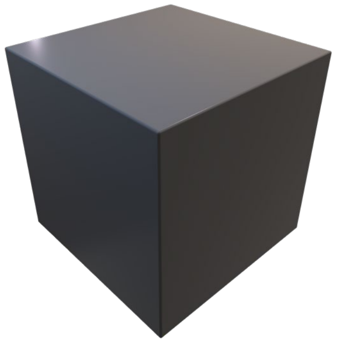


ENERGY MODELING

- The energy model as well as focusing on energy efficiency is not meant to supplant the importance of design.
- Instead, a building energy model can be thought of as a tool that can be utilized throughout the design process.
- It can test various design options or optimize the performance of a building technology.



LANGUAGES



Design

Energy

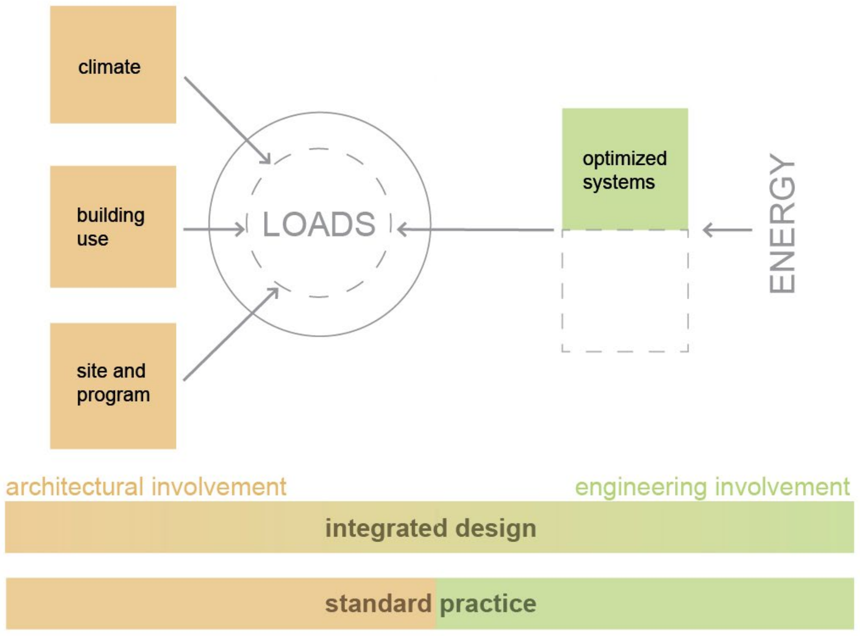
kWh

$$$

Economic Incentive

INTEGRATE THE DESIGN PROCESS

Figure 1.2 - The Concept of Integrated Design



graphic based upon G.Z. Brown with the University of Oregon and Jeff Cole with Konstrukt

Design Decision	Energy Performance Design Decision
Form and Orientation	Solar geometry
Roof form and slope	Solar geometry, natural ventilation, solar ready
Structural systems	Thermal mass
Floor-to-floor height	Daylight
Wall design	Thermal mass, insulation, heat transfer
Skin-to-core-depth	Daylight and natural ventilation
Façade development	Window-to-wall ratio
Window Size	Window-to-wall ratio
Window design, orientation, and size	Passive heating and cooling, daylight, shading, glare control
Mullion spacing	Thermal bridging
Window operation	Natural ventilation

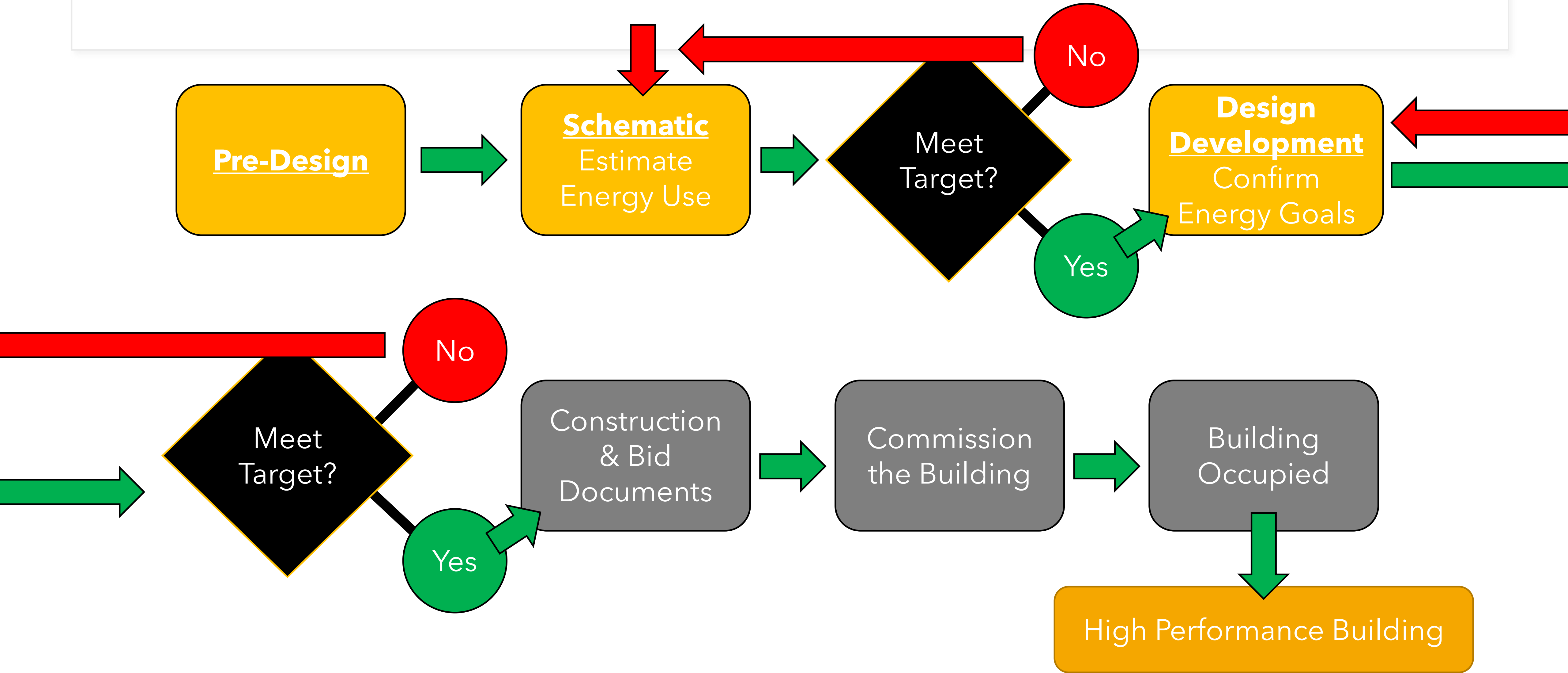
INTEGRATE THE DESIGN PROCESS

When to Daylight

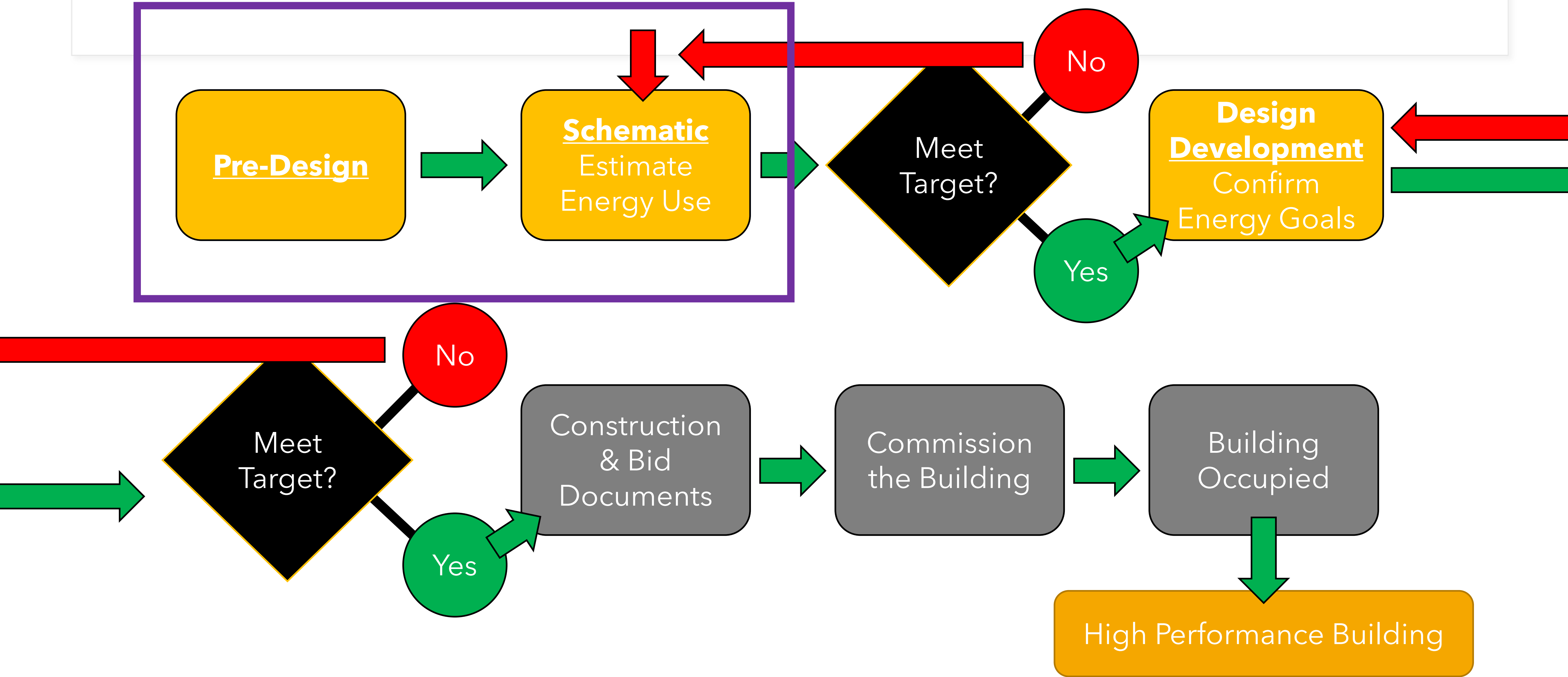
Daylighting is the **"controlled"** admission of natural light, sunlight, into a building for the *purpose of illuminating a space.*

Daylight Harvesting is the **"controlled"** admission of natural light, sunlight, into a building for the *purpose of reducing electric lighting and energy (kWh).*

When to Daylight



When to Daylight



When to Daylight

Pre-Design

- Building Characteristics
  - Form & Shape
  - Orientation
  - Glazing
  - Window to Wall Ratio
- Site
  - Context
  - Climate & Weather Data

Schematic

- Daylighting Strategies
  - Skylights
  - Clerestory Windows
  - Side-Lighting
- Control Strategies
  - Glazing
  - Shading
  - Light-Shelves
  - Site Context
  - Sensors

How to Daylight

- Site
  - Context
  - Climate & Weather Data

Pre-Design

- Building Characteristics
  - Orientation
  - Form & Shape
  - Glazing
  - Window to Wall Ratio

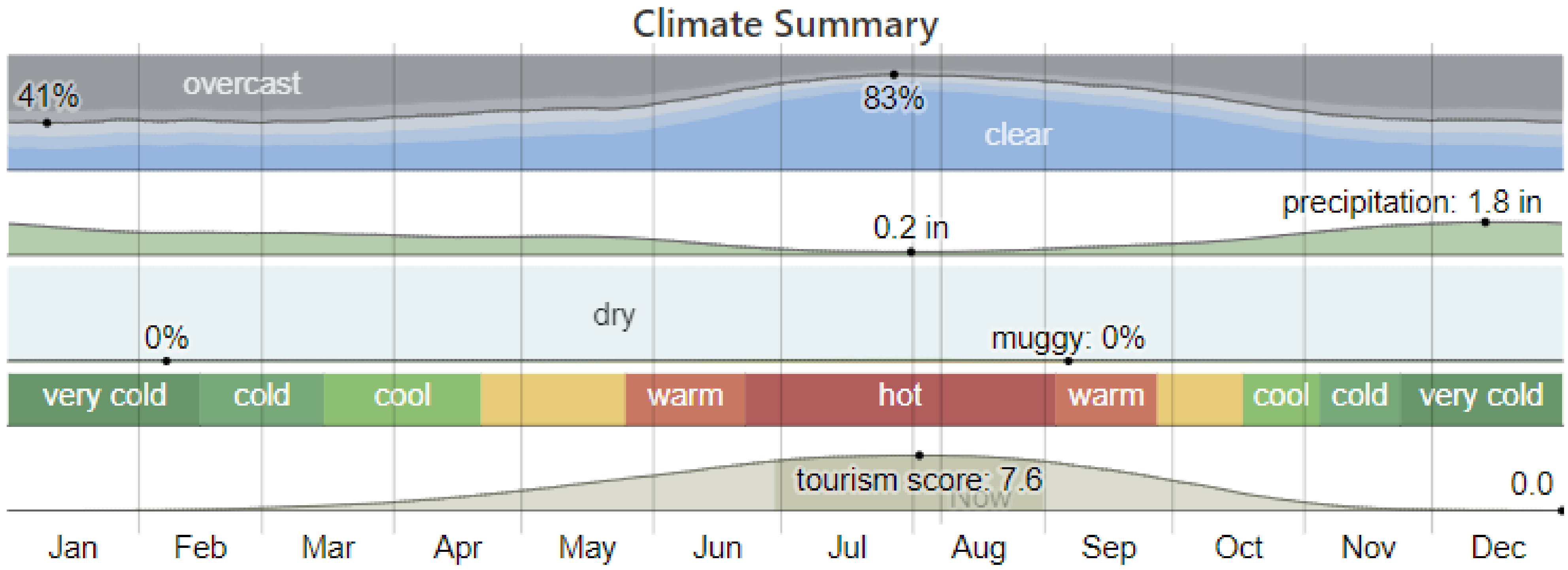
How to Daylight

Site with context

- It is important to understand your site as it will provide you with *data to help you get started.*
- For example, *what strategies, if any, are the surrounding buildings using*, but also, note the orientation and width. If possible, conduct a survey/study of the surrounding buildings.
- Your buildings should *take advantage of the sun path* as relative to the Latitude & Longitude, *however, other site conditions such as Circulation, Wind, and Obstructions should not be disregarded.*

How to Daylight

- Site with context
  - Weather Spark
  - https://weatherspark.com/y/2142/Average-Weather-in-Boise-Idaho-United-States-Year-Round



How to Daylight

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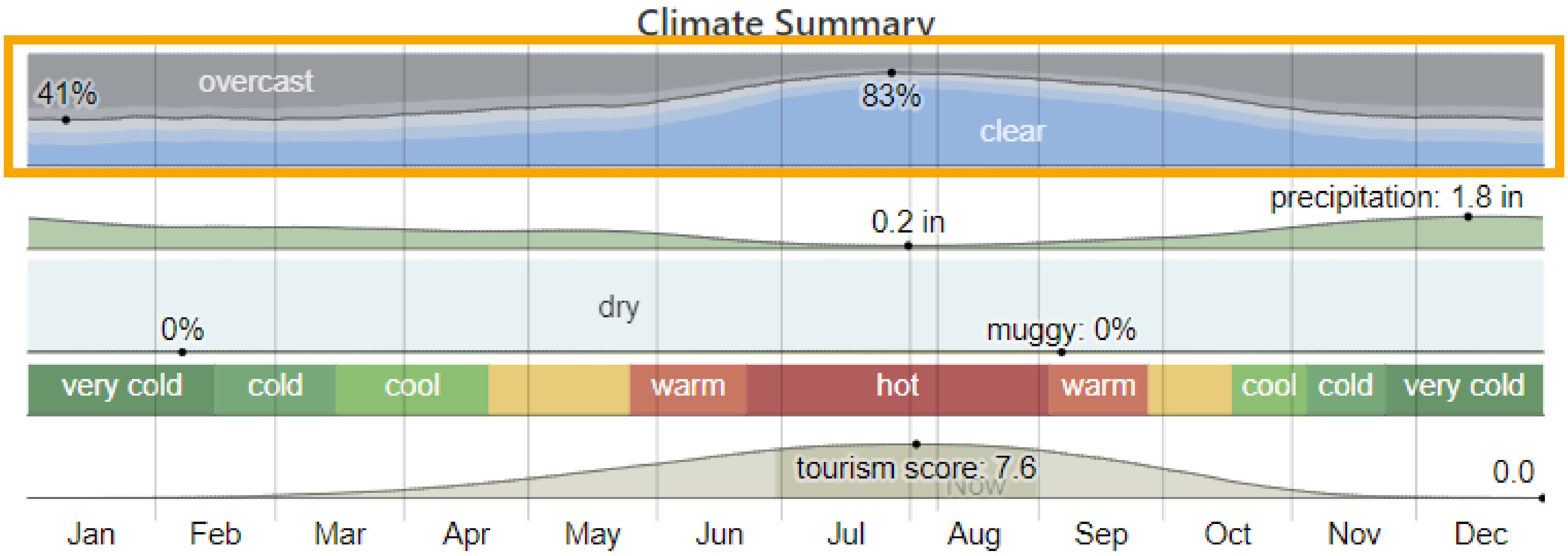
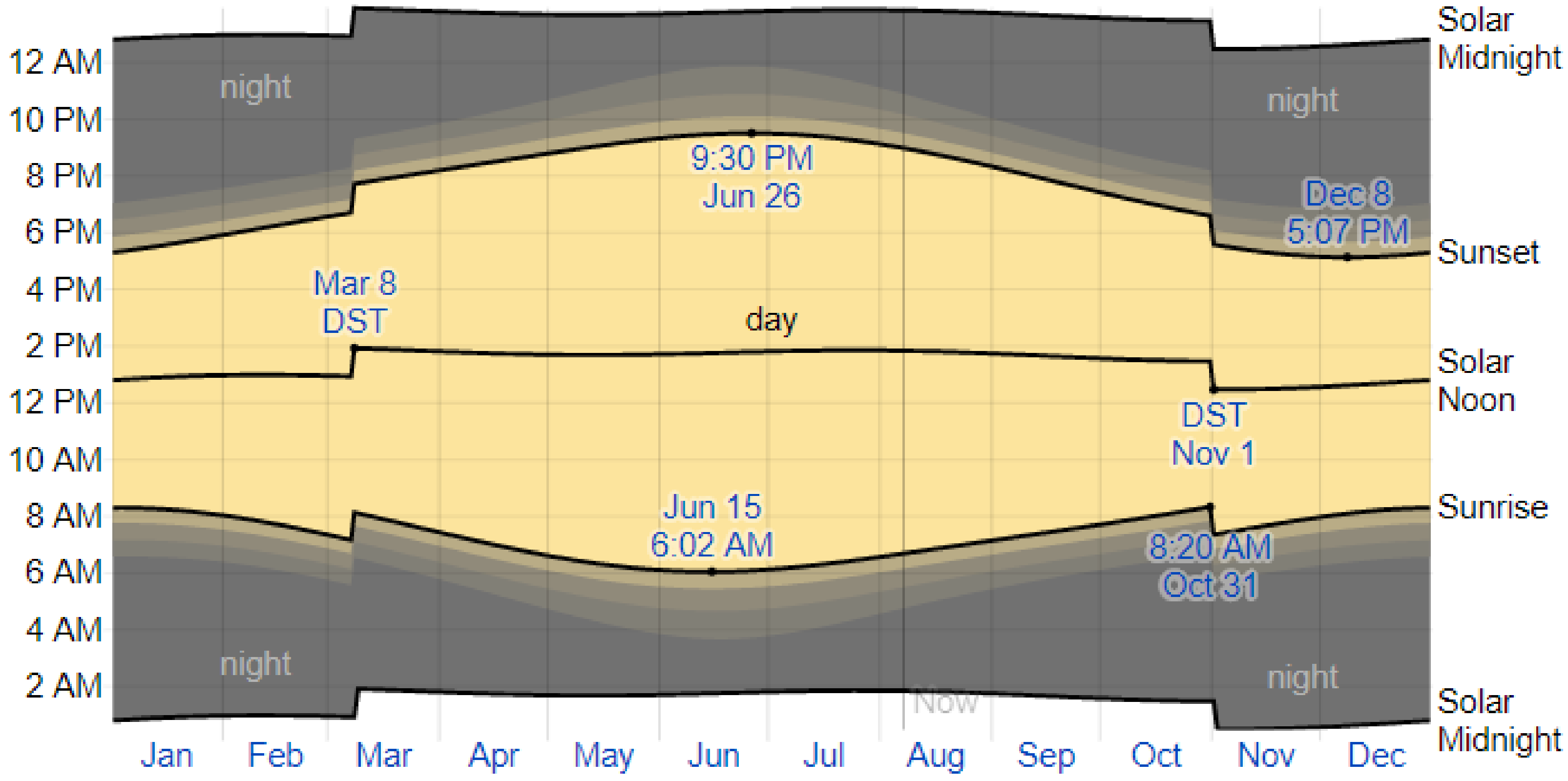
  - Weather Spark
  - https://weatherspark.com/y/2142/Average-Weather-in-Boise-Idaho-United-States-Year-Round



How to Daylight

- Site with context
  - Weather Spark
  - https://weatherspark.com/y/2142/Average-Weather-in-Boise-Idaho-United-States-Year-Round

Sunrise & Sunset with Twilight and Daylight Saving Time



How to Daylight

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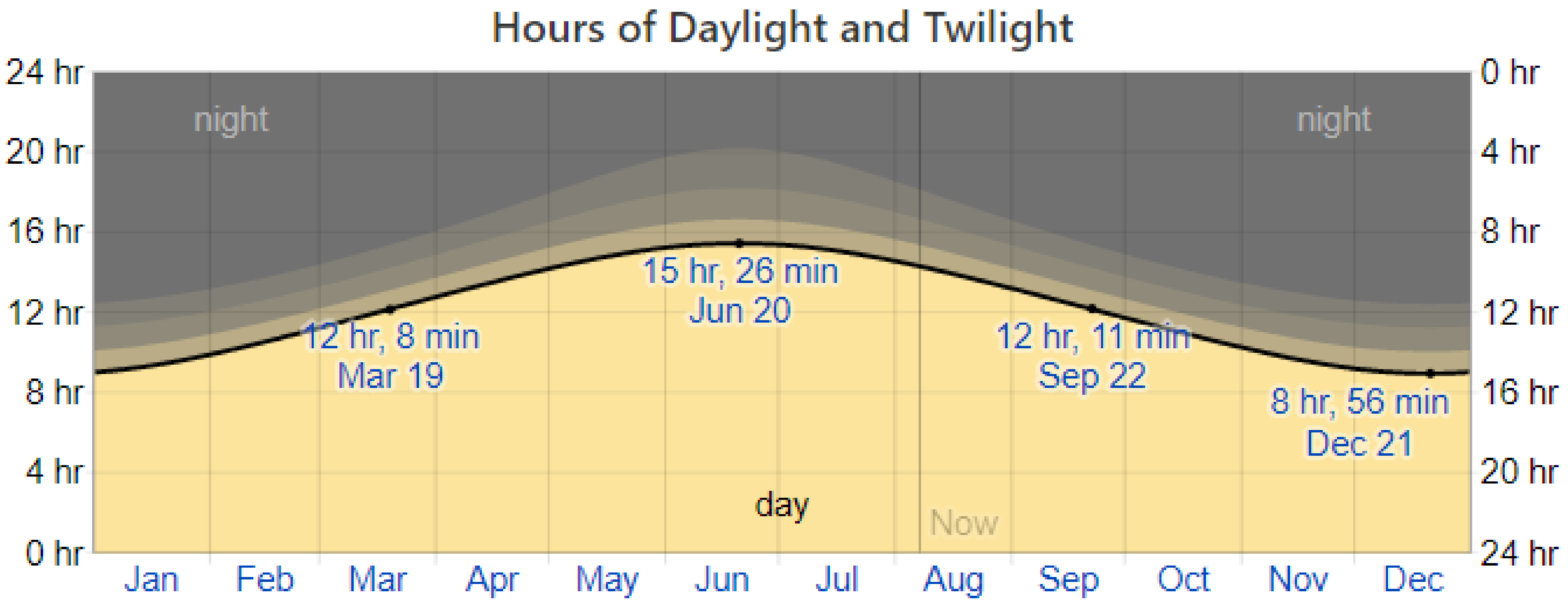
  - https://weatherspark.com/y/2142/Average-Weather-in-Boise-Idaho-United-States-Year-Round



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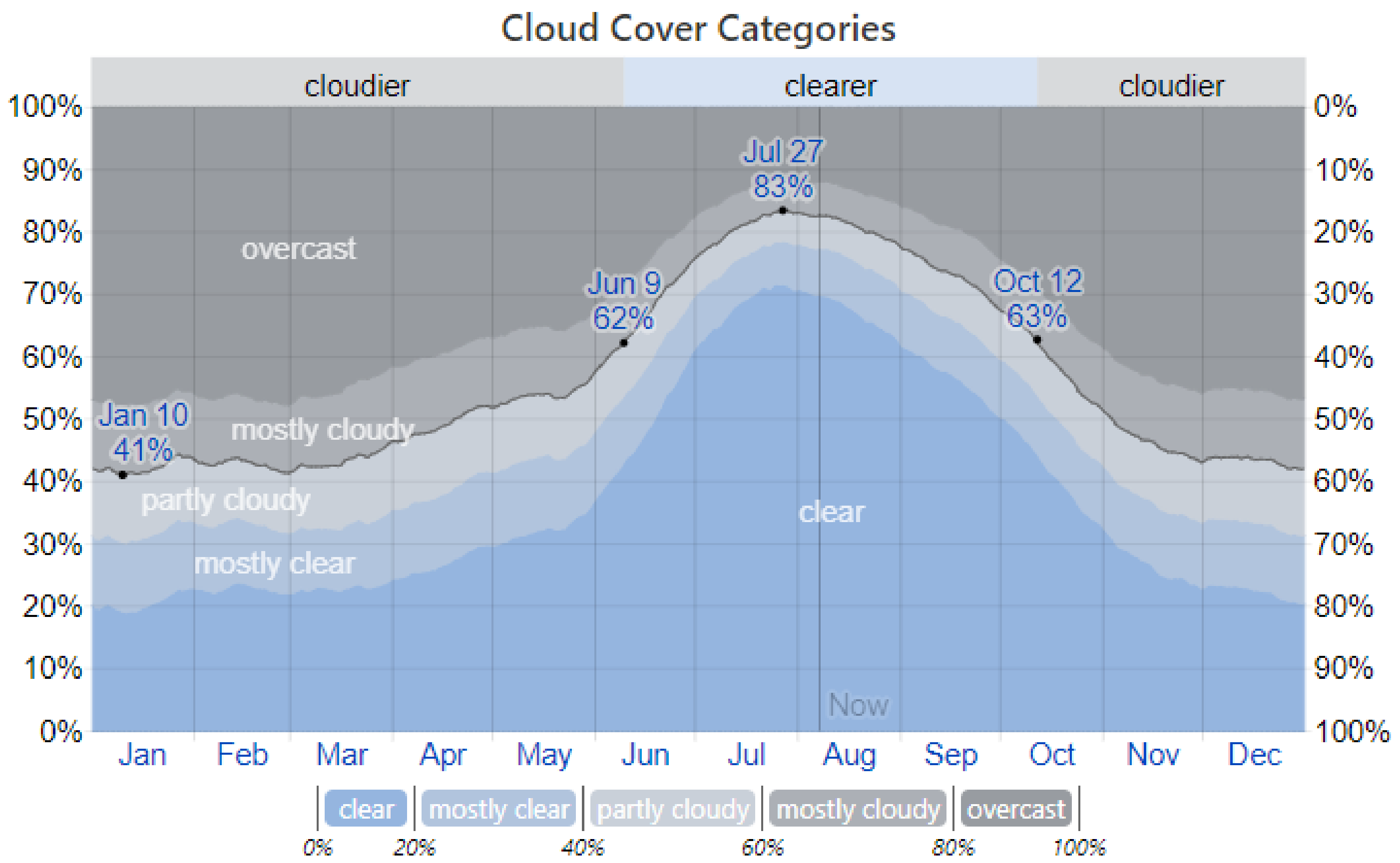


How to Daylight

- Site with context
  - Weather Spark
  - https://weatherspark.com/y/2142/Average-Weather-in-Boise-Idaho-United-States-Year-Round

Frequency of occurrence of standard sky for calendar month (%)														
	Sky Type	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**September**	**October**	**November**	**December**	**Overall**
A	**Clear**	14%	8%	21%	12%	5%	9%	11%	7%	12%	11%	18%	17%	12%
	Clear Turbid	30%	52%	44%	28%	23%	17%	12%	12%	14%	20%	27%	44%	27%
	Intermediate	42%	35%	25%	40%	37%	32%	31%	32%	34%	36%	33%	30%	34%
	Overcast	14%	6%	10%	20%	36%	43%	45%	49%	41%	33%	22%	9%	27%

Fun Fact

- The first weather report was "forecasted" on August 1st 1861
- Robert Fitzroy – Vice Admiral in the Royal Navy
- Created "weather stations"
- Collected data via Morse code in real time

Perez Sky Diffuse Model

While the sky diffuse model presented up to this point separated the isotropic, circumsolar, and horizon components explicitly, Perez developed a more complex model that relies on a set of empirical coefficients for each term.

The basic form of the model is:

$$E_d = DHI \times \left[(1 - F_1)\left(\frac{1+\cos(\theta_T)}{2}\right) + F_1\left(\frac{a}{b}\right) + F_2 \sin(\theta_T)\right],$$

where F_1 and F_2 are complex empirically fitted functions that describe circumsolar and horizon brightness, respectively.

$a = \max(0 \cos(AOI))$, and $b = \max(\cos(85^\circ), \cos(\theta_Z))$.

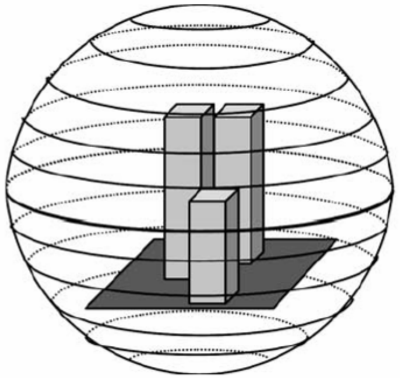
- DHI is diffuse horizontal irradiance,
- AOI is the angle of incidence between the sun and the plane of the array.
- θ_Z is the solar zenith angle.
- θ_T is the array tilt angle from horizontal.

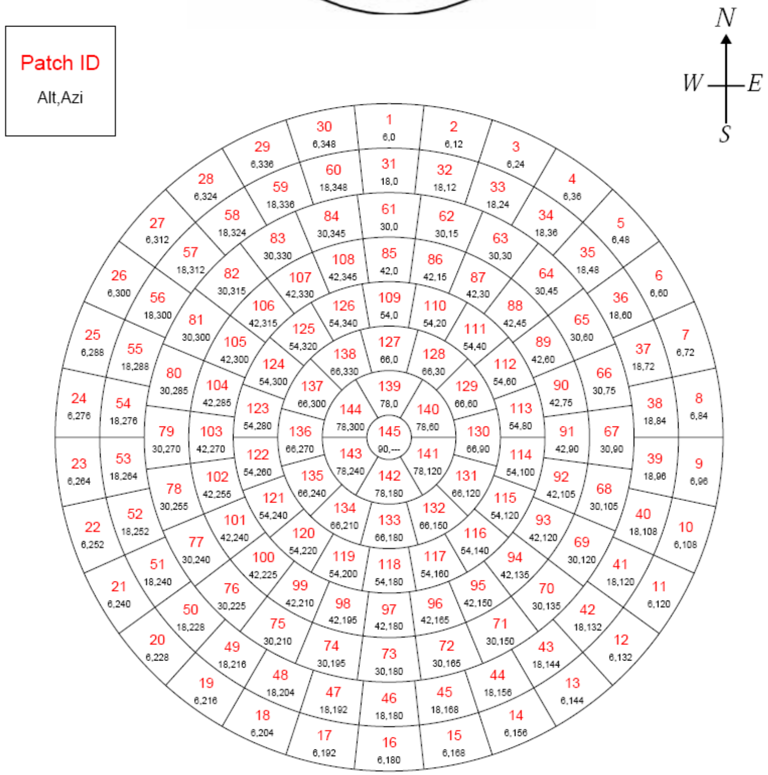
$$F_1 = \max\left[0, \left(f_{11} + f_{12}\Delta + \frac{\pi\theta_Z}{180^\circ} f_{13}\right)\right],$$

$$F_2 = f_{21} + f_{22}\Delta + \frac{\pi\theta_Z}{180^\circ} f_{23}$$

The f coefficients are defined for specific bins of clearness (ε), which is defined as:

$$\varepsilon = \frac{DHI+DNI)/DHI +\kappa \theta_Z^{3}}{1+\kappa \theta_Z^{3}}$$,



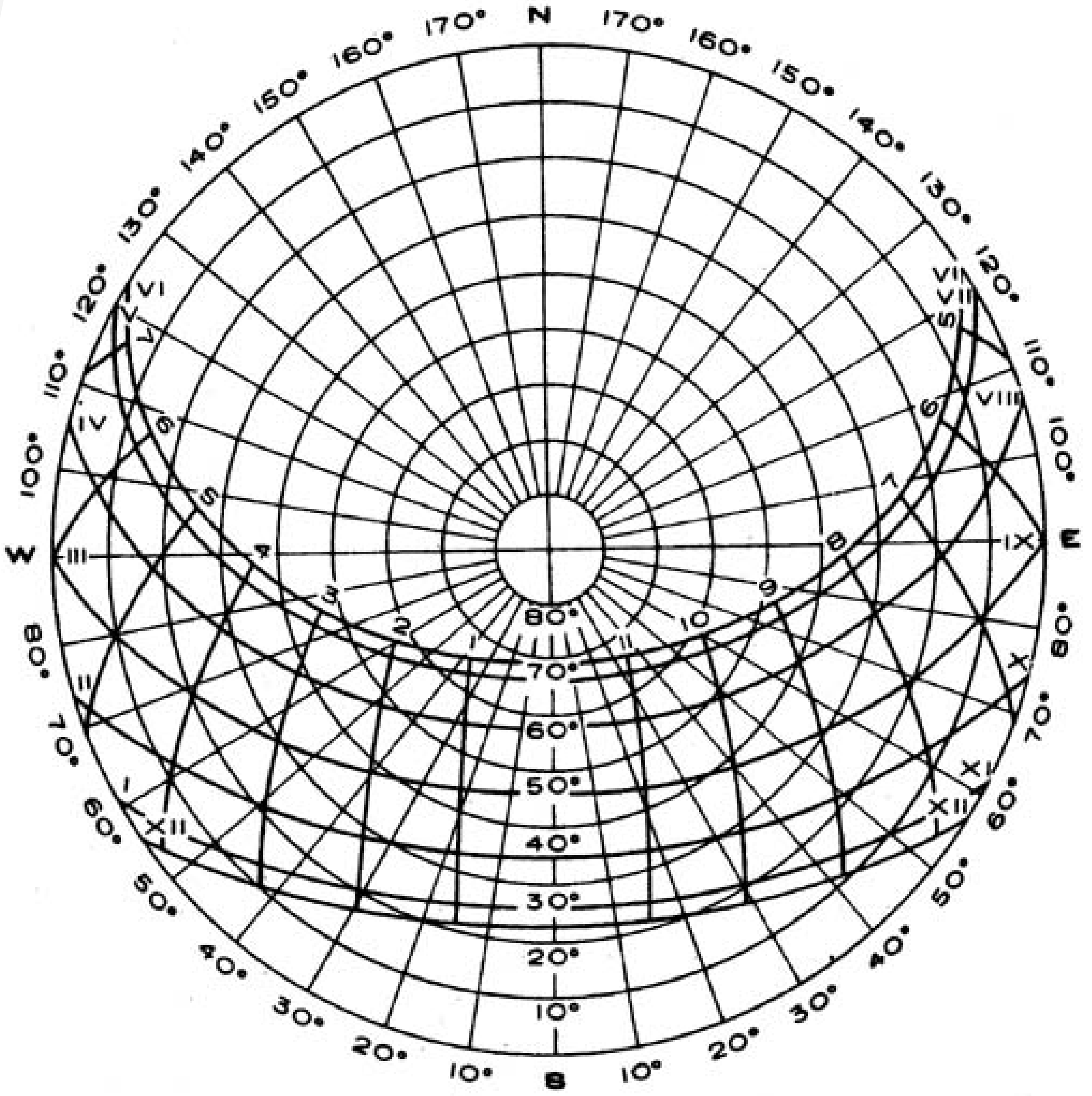


How to Daylight

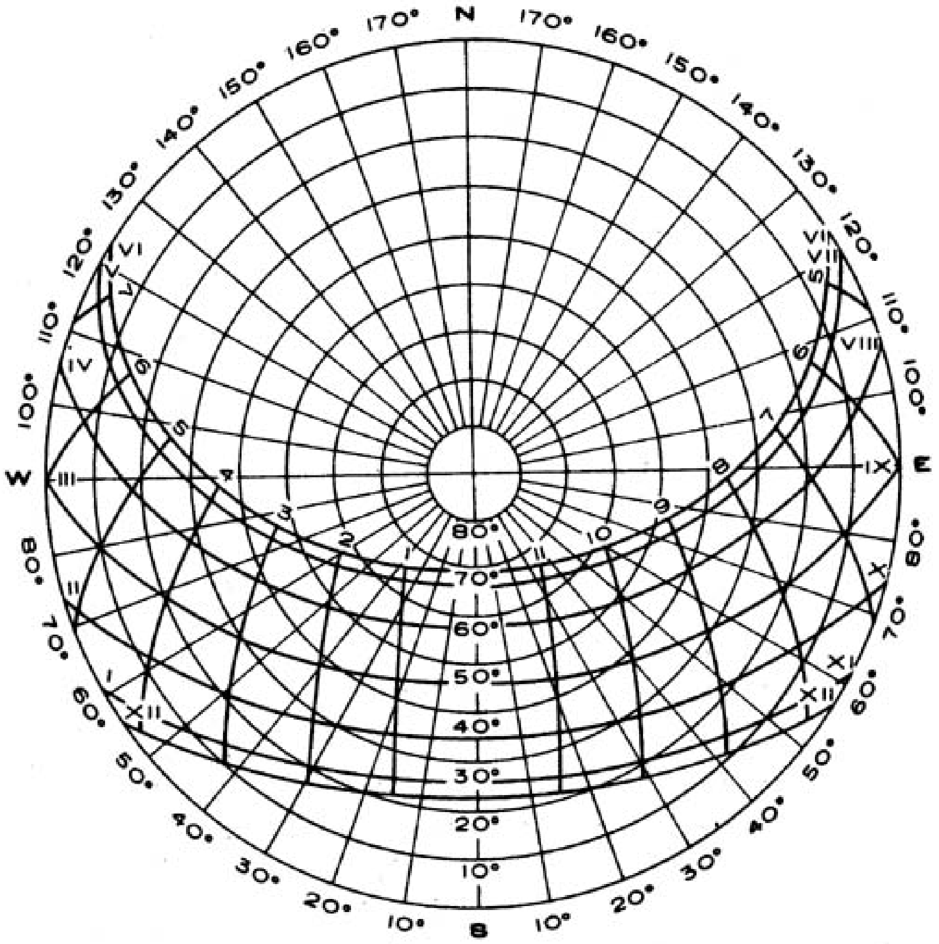
- Pre-Design
- Building Characteristics
  - Orientation
  - Form & Shape
  - Window to Wall Ratio
  - Glazing

How to Daylight

- Pre-Design
- Building Characteristics
  - Orientation – Sun Path Diagram



44°N LATITUDE



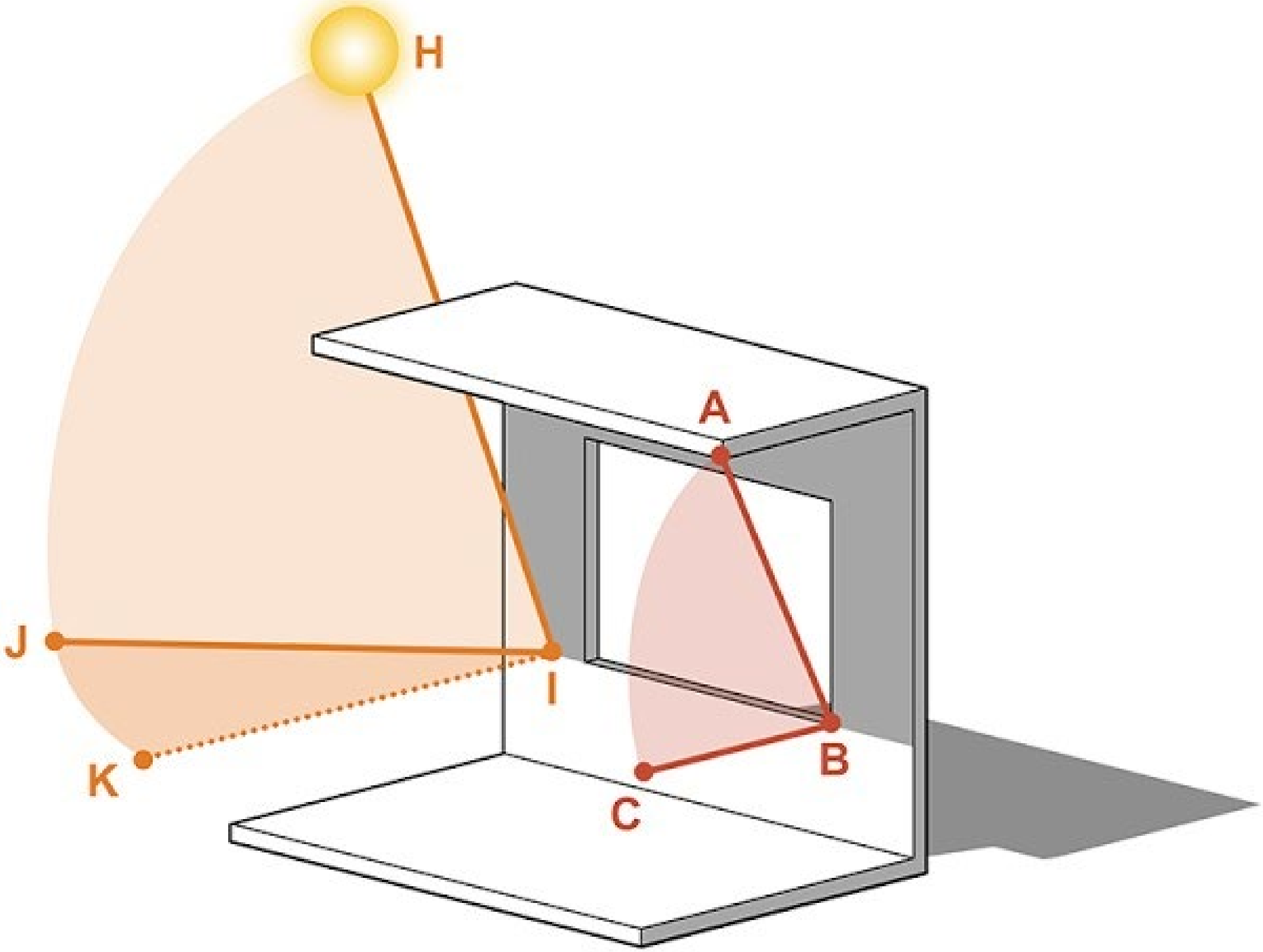
How to Daylight

Sun Path Diagram

- "Sun Path Diagrams show the path of the sun in the sky dome as a projected onto a horizontal surface."
- "The sun path diagram for a given latitude can be used to determine the sun's position in terms of altitude and azimuth for any hour of the year. "
- "The same diagram of altitudes and azimuths may also be used to describe the position and size of objects from a particular viewpoint on a site. Trees, buildings, and hills can be described in terms of their altitude and azimuth from that viewpoint."
    - Sun, Wind, and Light – Architectural Design Strategies by G.Z. Brown and Mark Dekay

Data Goals

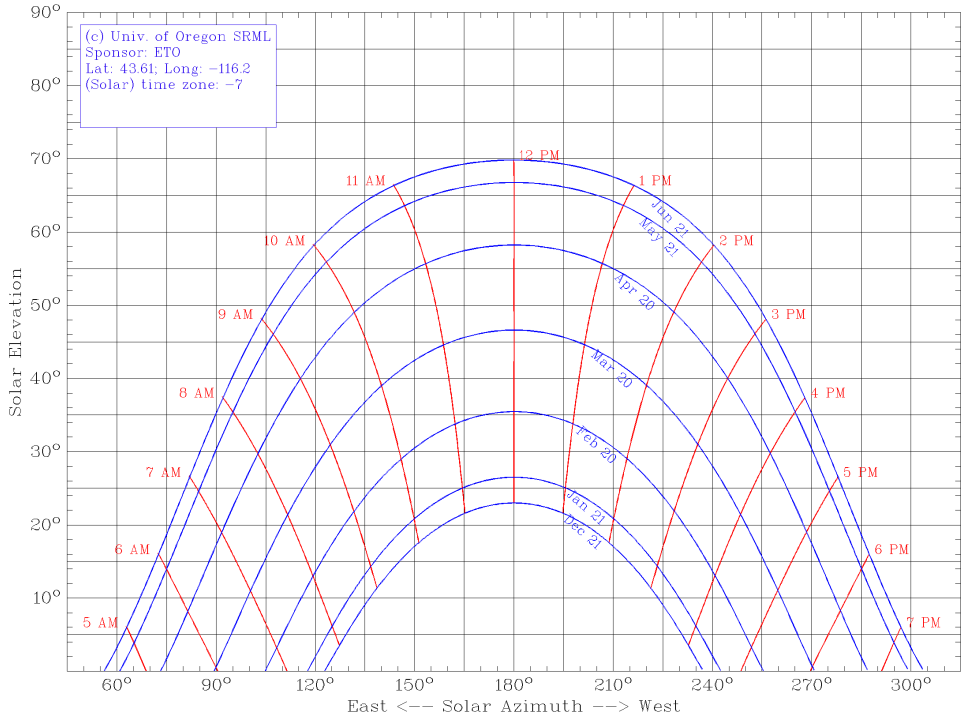
- Angle H-I-J is the Altitude angle
- Angle J-I-K is the Azimuth angle
- I-B represent the horizontal axis
- Angle A-B-C is the profile angle



How to Daylight

Sun Path Diagram

- However, if you don't want to go old school there are now a few options for creating a Sun path diagram or conducting a solar study digitally.

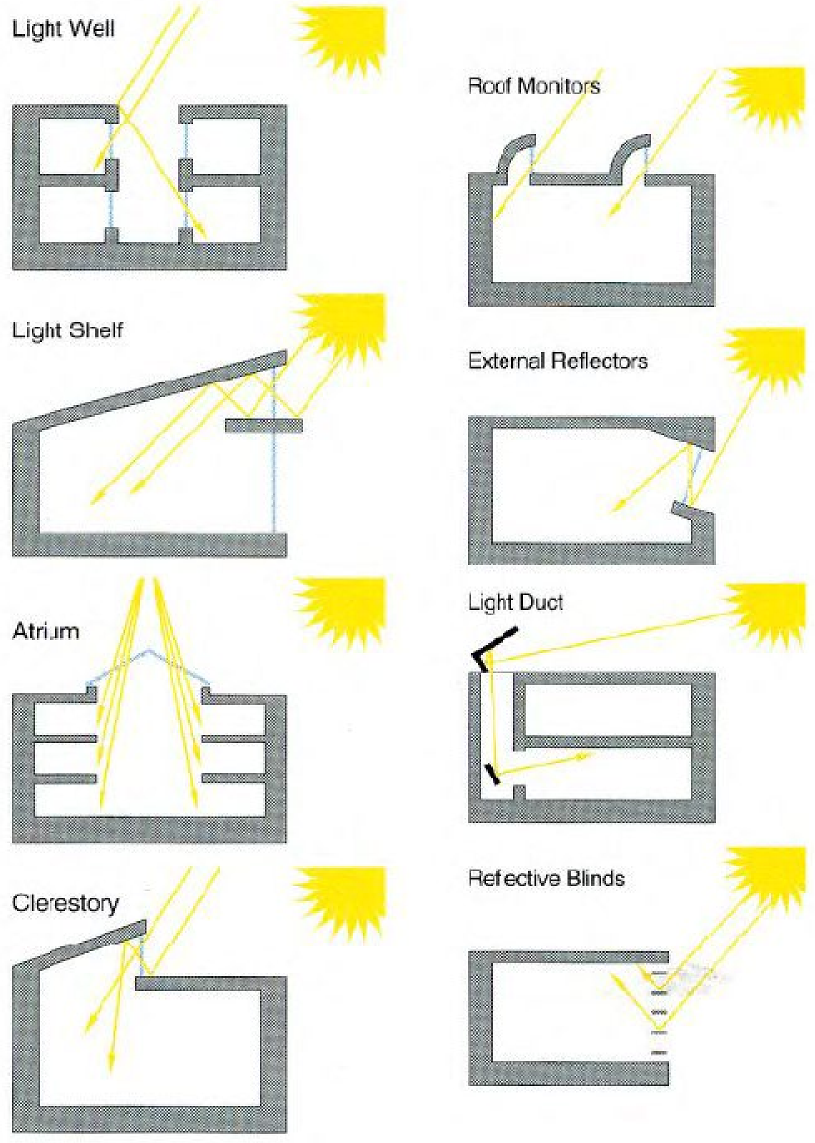


How to Daylight

Pre-Design

- Building Characteristics
  - Form & Shape

Form will affect the type of strategy you choose while shape will determine the effectiveness of that strategy.



How to Daylight

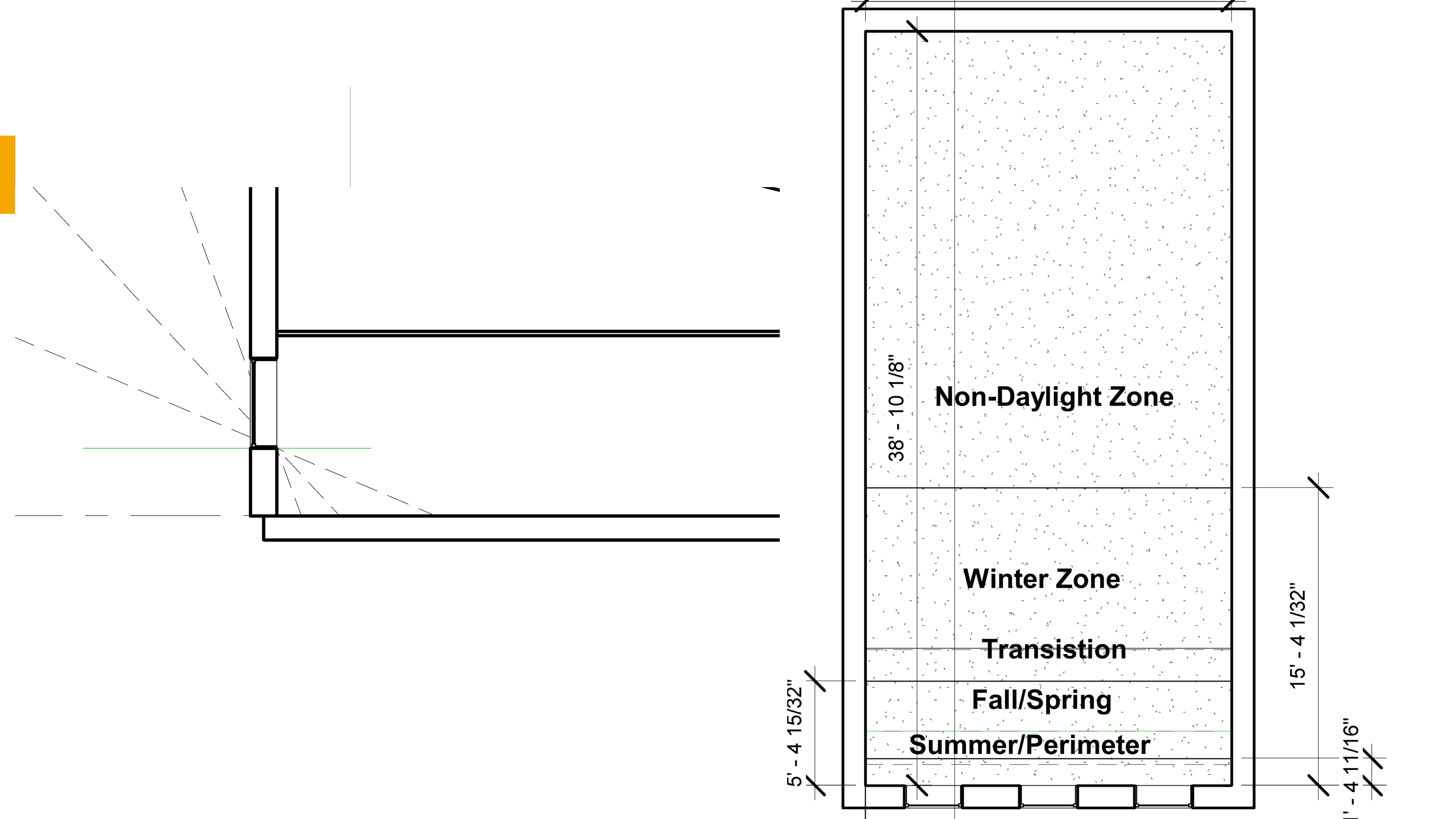
Optimizing the building's footprint for daylighting

- Maximize exposure on the south and north façade while limiting exposure on the east and west façade. (Assumes cardinal orientation)
- Determine the correct ceiling
  - Open
  - Drop-down
  - Inclined

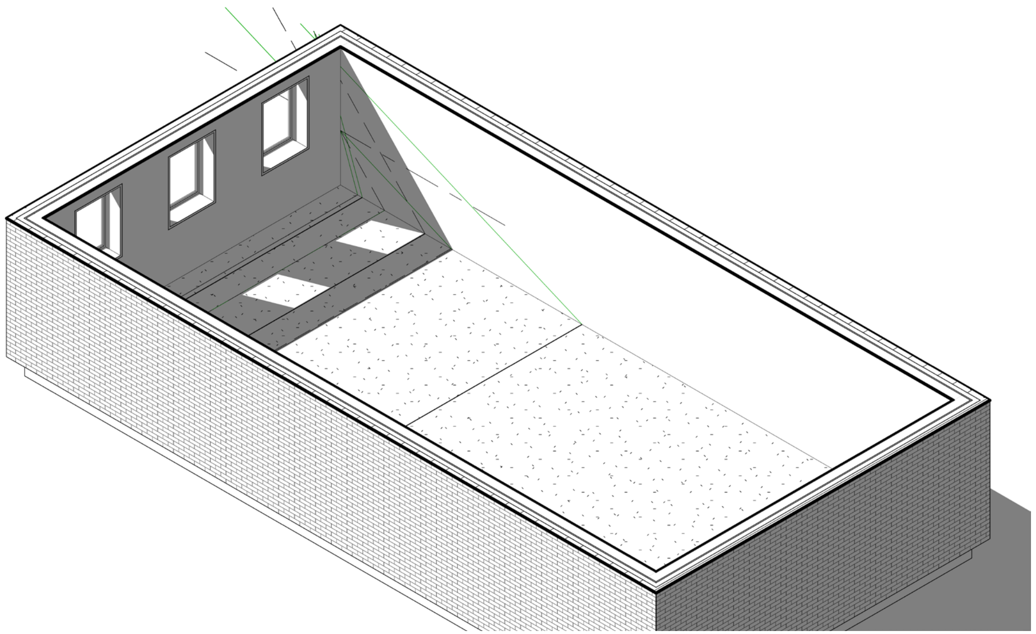
How to Daylight

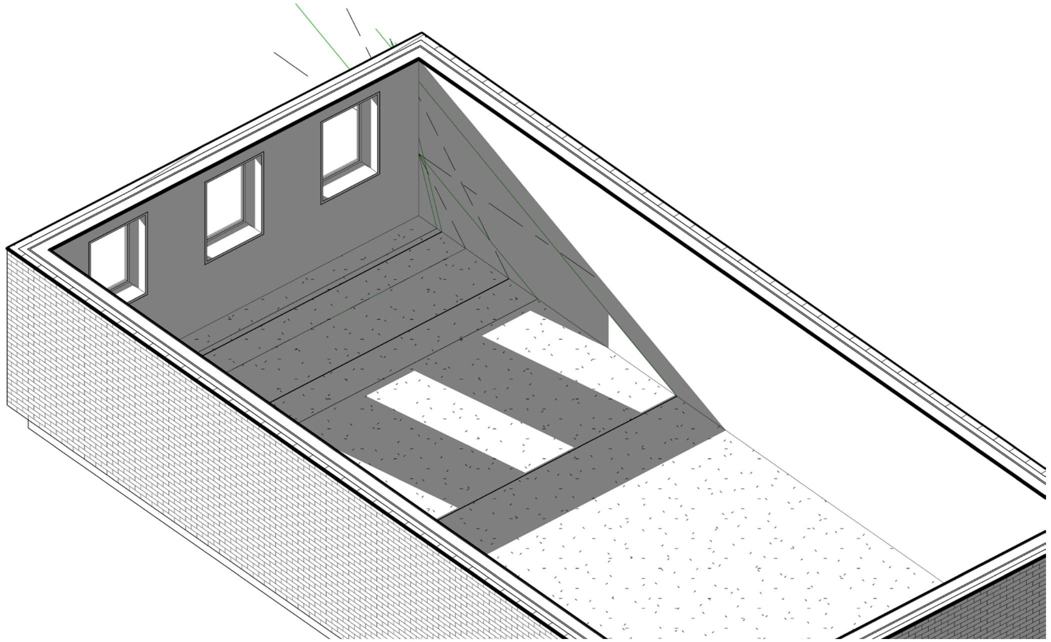
Optimizing the building's footprint for daylighting

- Limit floor plate depth (north to south) as there are limitations to how far light can be distributed. (the building's width)
- http://idlboise.com/content/daylight-pattern-guide


Non-Daylight Zone
Winter Zone
Transistion
Fall/Spring
Summer/Perimeter
38' - 10 1/8"
15' - 4 1/32"
5' - 4 15/32"
' - 4 11/16"

- Left – Fall/Spring
- Right – Winter





How to Daylight

Optimizing the building's footprint for daylighting

- Limit interior furniture or partitions near the perimeter of the building to less than 30"
- http://idlboise.com/content/daylight-pattern-guide

How to Daylight

Window to Wall area ratio impacts:

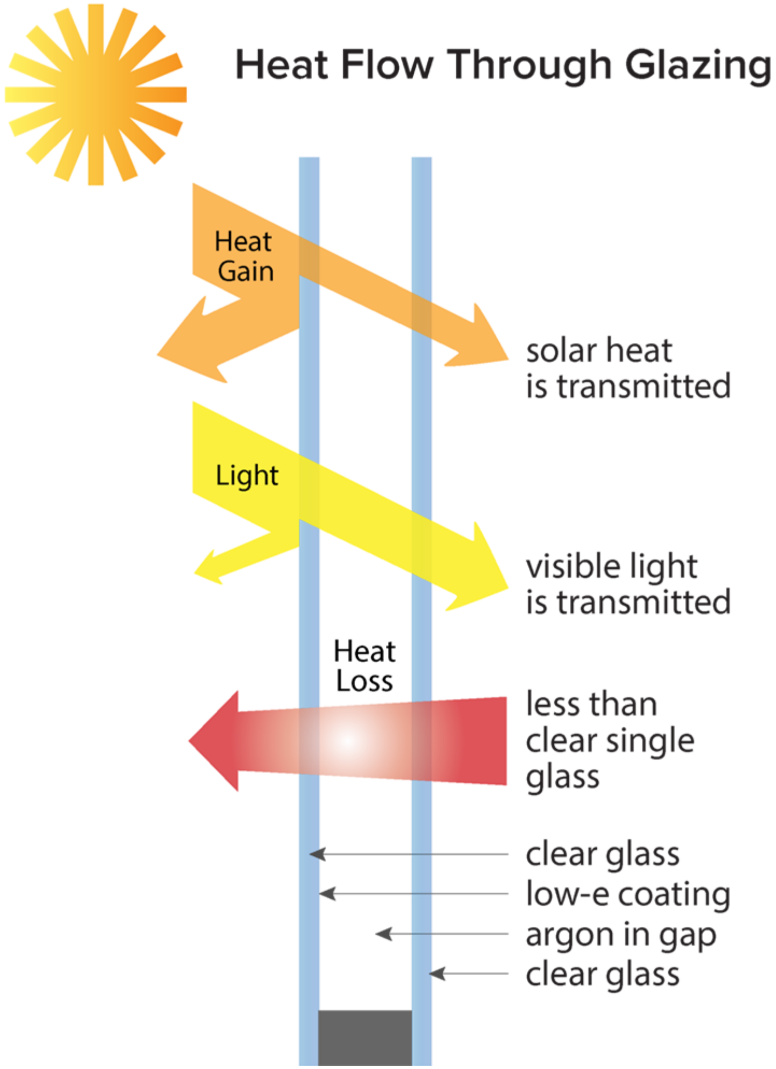
- Heating/Cooling loads
- Daylighting
- Ventilation
- Views
- Cost

http://patternguide.advancedbuildings.net/patterns/pattern-2-window-area

How to Daylight

Glazing

- Visible Light Transmittance (VLT)
  - The amount of light in the visible portion of the spectrum that passes through a glazing material.
- Solar Heat Gain Coefficient (SHGC)
  - The fraction of solar radiation admitted through a glazing material that is either transmitted directly or absorbed to then be radiated over time.

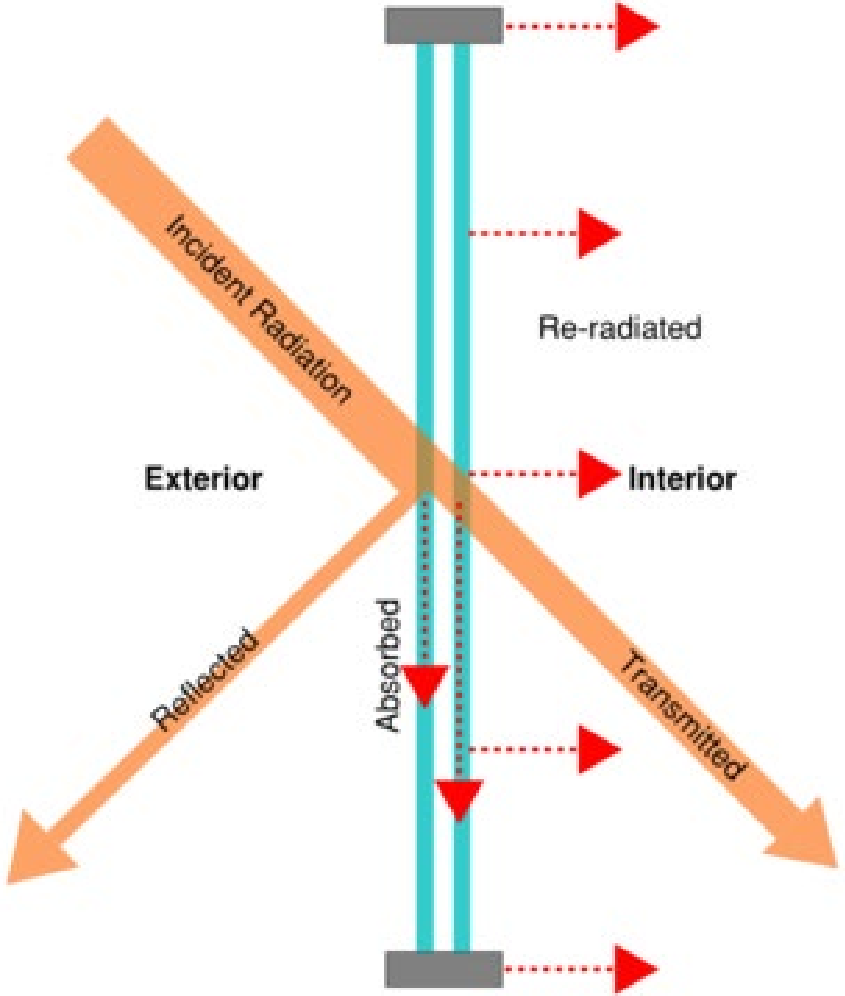


How to Daylight

Glazing

- Visible Light Transmittance (VLT)
  - Is expressed as a percentage
- Visible Light (VT)
  - Is expressed as a number from 0 to 1

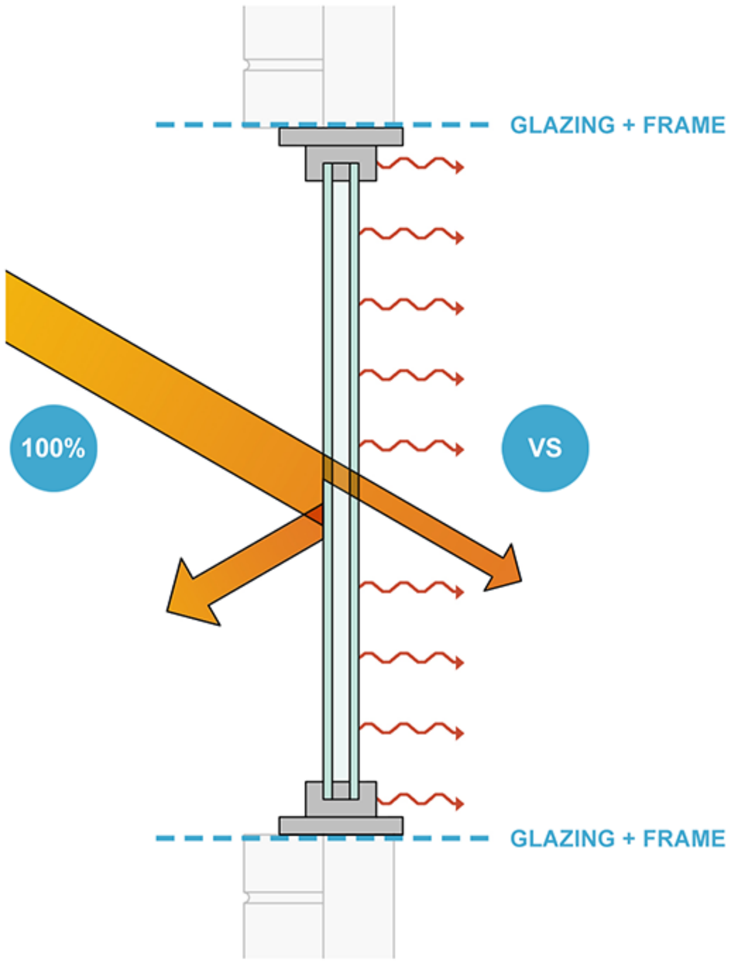
Example: VT of .67 would allow 67% transmittance of light



How to Daylight

Glazing

- Solar Heat Gain Coefficient (SHGC)
  - U-Factor
  - Thermal bridging
  - Heating/Cooling loads impact
- Light-to-solar gain (LSG)
  - Ratio between the SHGC and VT.
  - Provides a gauge of the relative efficiency of different glass or glazing types in transmitting daylight while blocking heat gains. The higher the number, the more light transmitted without adding excessive amounts of heat.
  - *"This energy performance rating isn't always provided."*

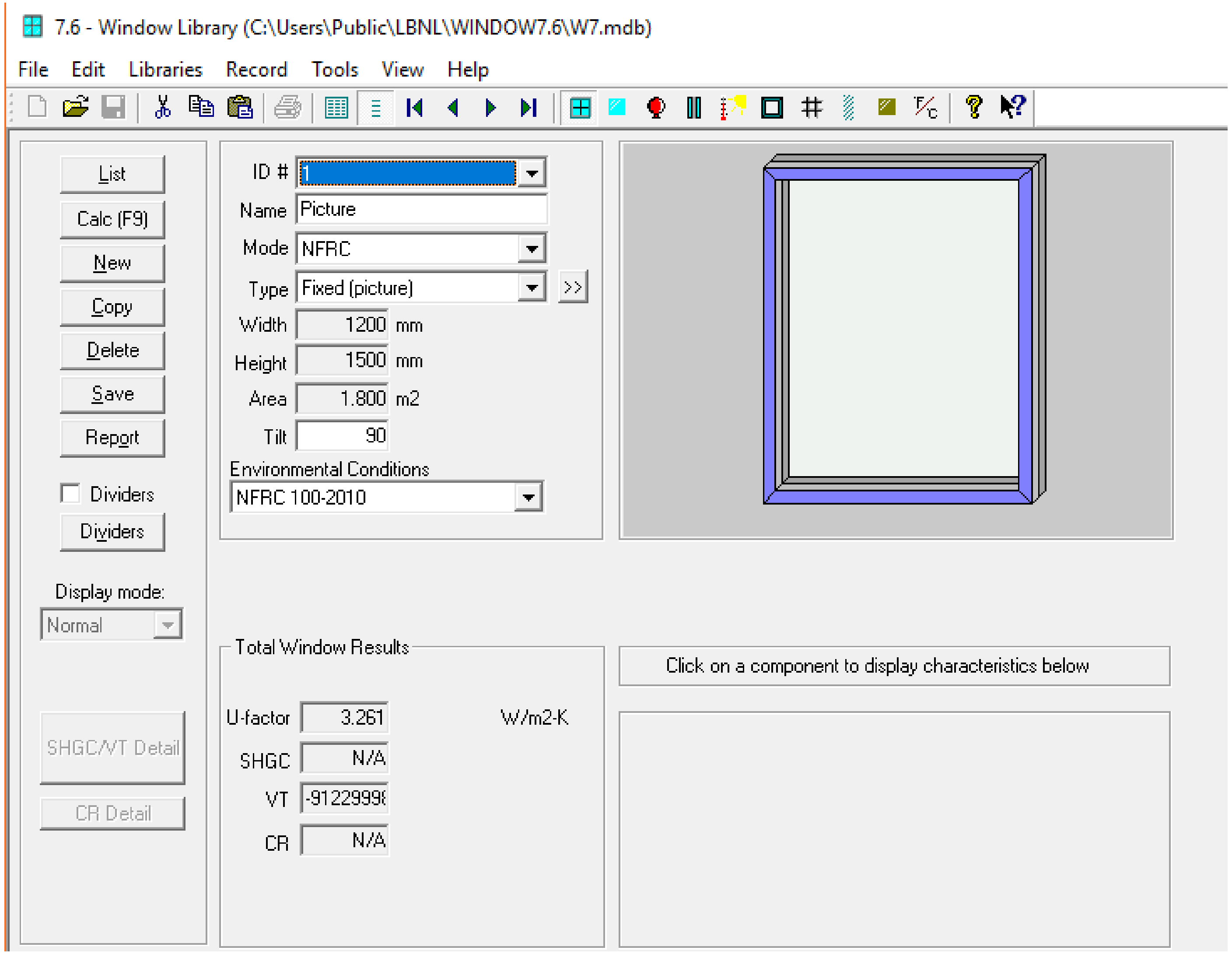


SOLAR HEAT GAIN COEFFICIENT (SHGC)

How to Daylight

Glazing

- Window 7.7 (No not Microsoft)
- https://windows.lbl.gov/software-release-window-7707



How to Daylight

Glazing

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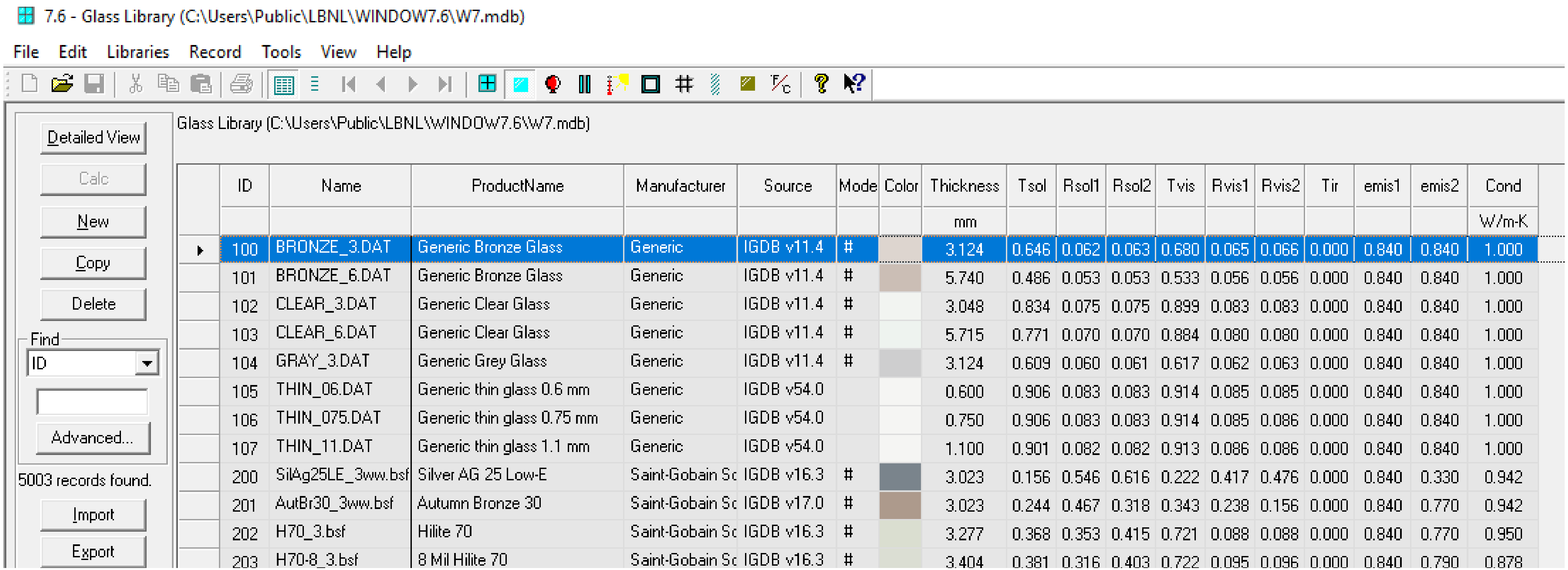
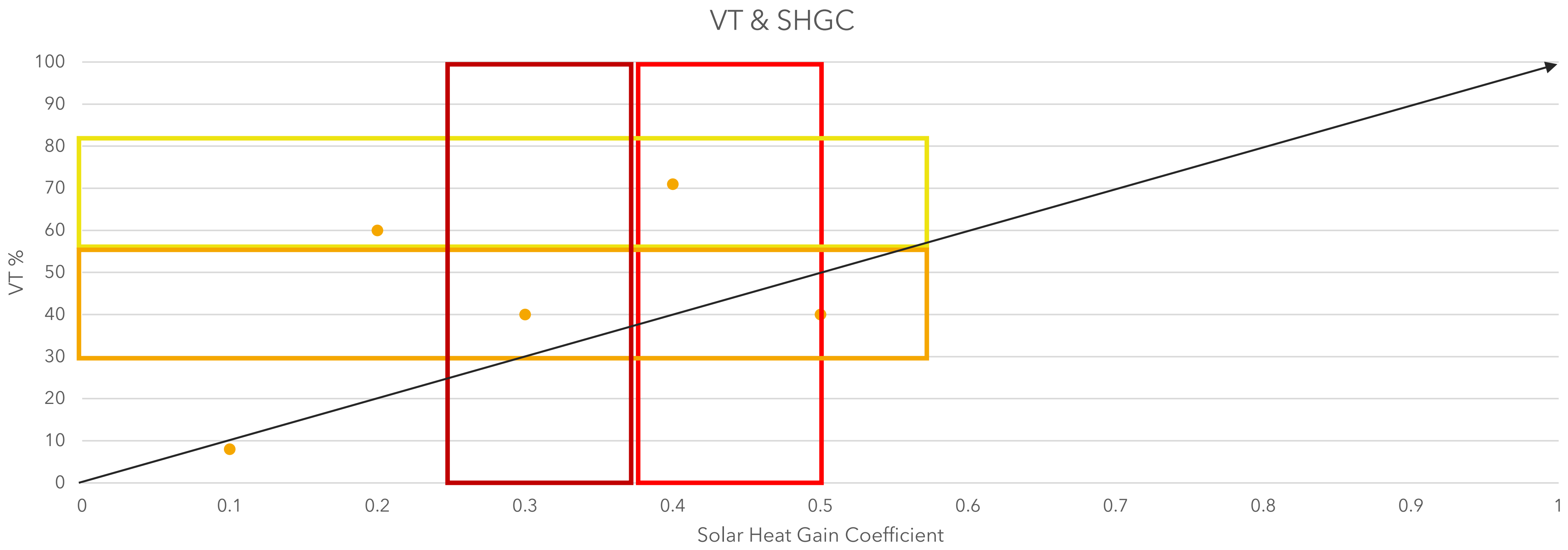
- https://windows.lbl.gov/software-release-window-7707



ID	Name	ProductName	Manufacturer	Source	Mode	Color	Thickness	Tsol	Rsol1	Rsol2	Tvis	Rvis1	Rvis2	Tir	emis1	emis2	Cond
							mm										W/m-K
100	BRONZE_3.DAT	Generic Bronze Glass	Generic	IGDB v11.4	#		3.124	0.646	0.062	0.063	0.680	0.065	0.066	0.000	0.840	0.840	1.000
101	BRONZE_6.DAT	Generic Bronze Glass	Generic	IGDB v11.4	#		5.740	0.486	0.053	0.053	0.533	0.056	0.056	0.000	0.840	0.840	1.000
102	CLEAR_3.DAT	Generic Clear Glass	Generic	IGDB v11.4	#		3.048	0.834	0.075	0.075	0.899	0.083	0.083	0.000	0.840	0.840	1.000
103	CLEAR_6.DAT	Generic Clear Glass	Generic	IGDB v11.4	#		5.715	0.771	0.070	0.070	0.884	0.080	0.080	0.000	0.840	0.840	1.000
104	GRAY_3.DAT	Generic Grey Glass	Generic	IGDB v11.4	#		3.124	0.609	0.060	0.061	0.617	0.062	0.063	0.000	0.840	0.840	1.000
105	THIN_06.DAT	Generic thin glass 0.6 mm	Generic	IGDB v54.0			0.600	0.906	0.083	0.083	0.914	0.085	0.085	0.000	0.840	0.840	1.000
106	THIN_075.DAT	Generic thin glass 0.75 mm	Generic	IGDB v54.0			0.750	0.906	0.083	0.083	0.914	0.085	0.086	0.000	0.840	0.840	1.000
107	THIN_11.DAT	Generic thin glass 1.1 mm	Generic	IGDB v54.0			1.100	0.901	0.082	0.082	0.913	0.086	0.086	0.000	0.840	0.840	1.000
200	SilAg25LE_3ww.bsf	Silver AG 25 Low-E	Saint-Gobain Sc	IGDB v16.3	#		3.023	0.156	0.546	0.616	0.222	0.417	0.476	0.000	0.840	0.330	0.942
201	AutBr30_3ww.bsf	Autumn Bronze 30	Saint-Gobain Sc	IGDB v17.0	#		3.023	0.244	0.467	0.318	0.343	0.238	0.156	0.000	0.840	0.770	0.942
202	H70_3.bsf	Hilite 70	Saint-Gobain Sc	IGDB v16.3	#		3.277	0.368	0.353	0.415	0.721	0.088	0.088	0.000	0.840	0.770	0.950
203	H70-8_3.bsf	8 Mil Hilite 70	Saint-Gobain Sc	IGDB v16.3	#		3.404	0.381	0.316	0.403	0.722	0.095	0.096	0.000	0.840	0.790	0.878

LSG


VT & SHGC
VT %
100
90
80
70
60
50
40
30
20
10
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Solar Heat Gain Coefficient

How to Daylight – Questions?

- Site
  - Context
  - Climate & Weather Data

Pre-Design

- Building Characteristics
  - Orientation
  - Form & Shape
  - Window to Wall Ratio
  - Glazing

Measuring Light

Lux

- Unit of measurement for scientific analysis
- 1 lux is the amount of light from the same source at 1 meter
- LEED v4

Foot-Candle

- Unit of measurement for code compliance
- 1 foot away:1 foot-candle = 1 lumen/ft^2
- IECC 2018

Measuring Light

Spatial Daylight Autonomy

- sDA is the percentage of a space that can be daylight most of the time.
- sDA 300/50 at 55% is saying that at least 55% of the area is illuminated to 300 lux at least 50% of the time.

Annual Sunlight Exposure

- ASE is the percentage of a space that receives too much illumination resulting in glare.
- ASE 1000/250 at 13% is saying that no more than 13% of the space receives more than 1000 lux for more than 250 hours per year.

Measuring Light

Useful Daylight Factor/Illuminance

- UDI is the percentage of time when useful daylight is available.

Daylight Glare Probability

- DGP is an index that is used to measure glare from daylight.
- Index that considers vertical illuminance at the eye level.

Measuring Light

Daylight Factor

- DF is the ratio of indoor to outdoor illuminance.
- Typically used for analyzing light uniformity.

Illuminating Engineering Society

- IES has a Footcandle Guide (abbreviated) as well as a complete listing in the IES Footcandle Handbook.
- Google "IES Footcandle recommendations" and you should be able to find a pdf from a lighting manufacturer.

Evaluating Light

Lighting Controls/Strategies	All Lit buildings	Large Buildings (<50,000 ft2)
Occupancy Sensors	16%	55%
Scheduling	18%	43%
Multi-Level Lighting or Dimming	7%	23%
Building Automation System	4%	19%
Daylight Harvesting	2%	9%
Demand Responsive Lighting	4%	6%
Plug-Load Control	1%	3%
High-End Trimming or Light Level Tuning	1%	1%

Evaluating Light

Energy Benefits

- A measurable difference that can be calculated and used to project savings for a cost-benefit analysis.
  - kWh reduction
  - Reduction of maintenance
  - Data analysis for trends

Non-Energy Benefits

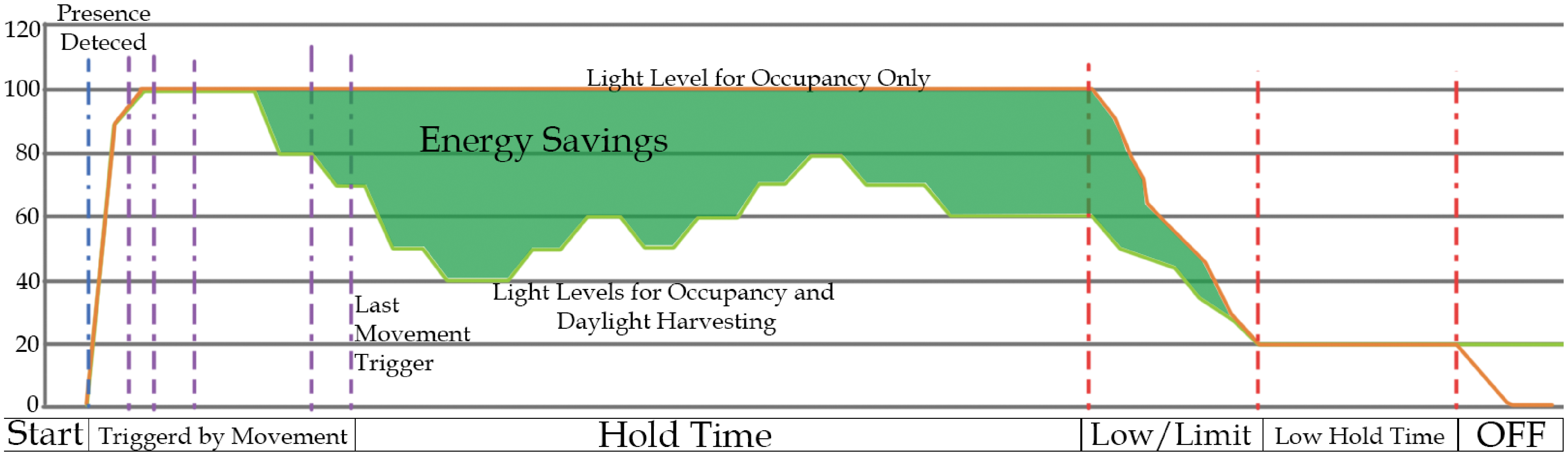
- Either non-measurable or its unit of measurement is still being debated.
  - Productivity
  - Sleep Cycle – Melatonin
  - Wellness
    - Reduction in sick days

Evaluating Light

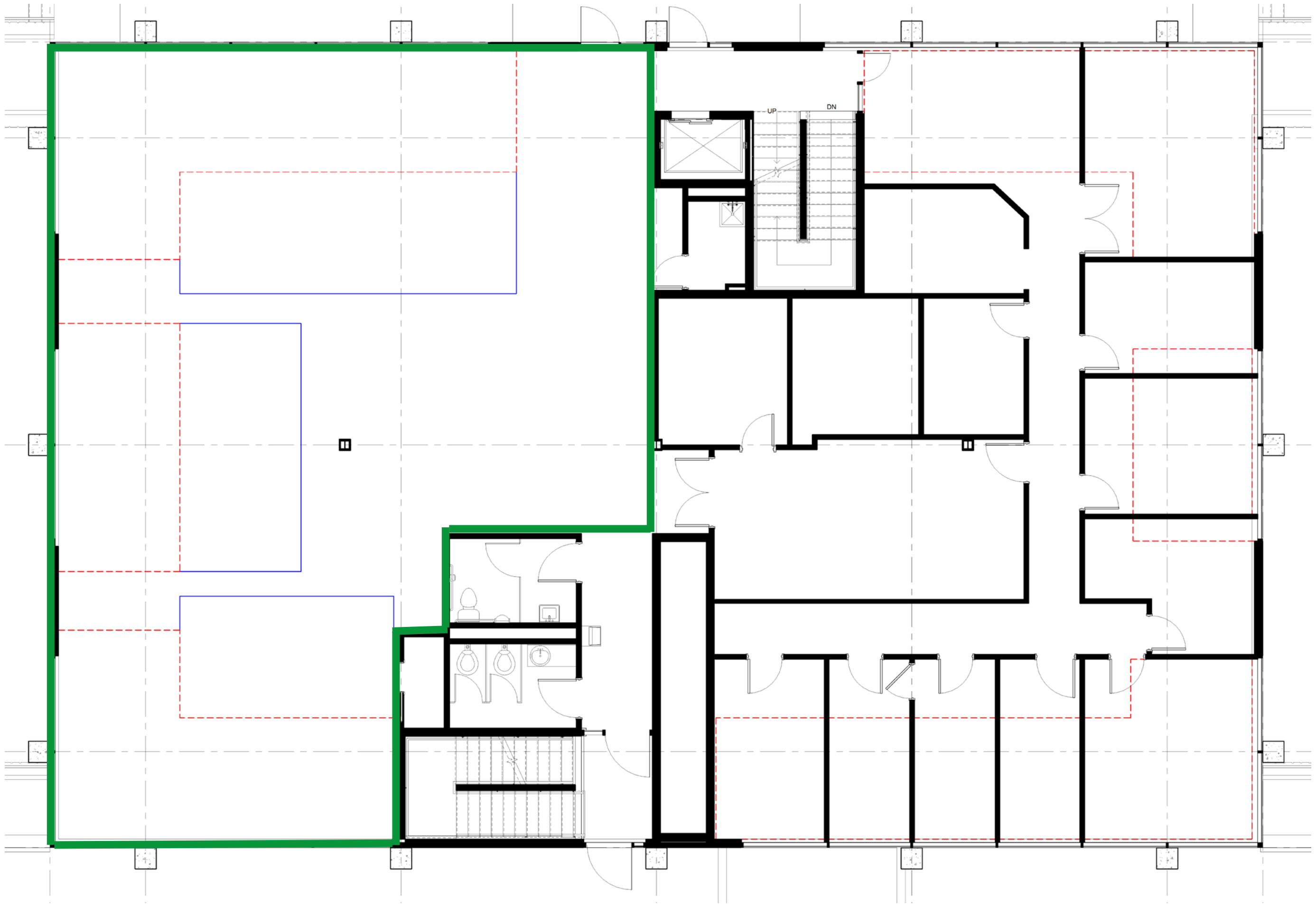
Max: 100% / Max: 80%	**High-end trim/tuning** sets the maximum light level based on customer requirements in each space.*	10–30% Lighting
Auto On / Auto Off	**Occupancy/vacancy sensing** turns lights on when occupants are in a space and off when they vacate the space.*	20–60% Lighting
Full On / Dim	**Daylight harvesting** dims electric lights when daylight is available to light the space.*	25–60% Lighting
Full On / Dim	**Personal dimming control** gives occupants the ability to set the light level.*	10–20% Lighting
Shade Open / Shade Closed	**Controllable window shading** moves shades to reduce glare and solar heat gain.*	10–20% Cooling
7am: Dim / 7pm: Off	**Scheduling** provides scheduled changes in light levels based on the time of day.*	10–20% Lighting
Full On / Dim	**Demand response** automatically reduces lighting loads during peak electricity usage times.*	30–50% During peak period
Appliance On / Appliance Off	**Plug load control** automatically turns off loads after occupants leave a space.*	15–50% of Controlled loads
Heating / Cooling	**HVAC integration** controls heating, ventilation, and air conditioning systems through a contact closure.*	5–15% HVAC

*Go to lutron.com/references for more information

Evaluating Light

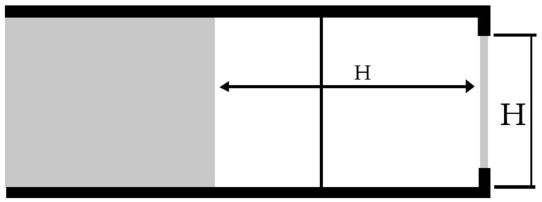


Evaluating Light

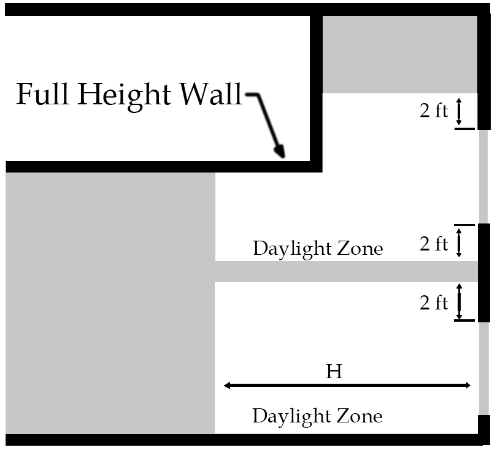


Evaluating Light

(a)

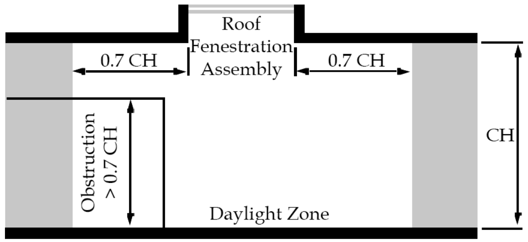


(b)



(a) Section View
(b) Plan view of daylight zone under rooftop monitor

(a)



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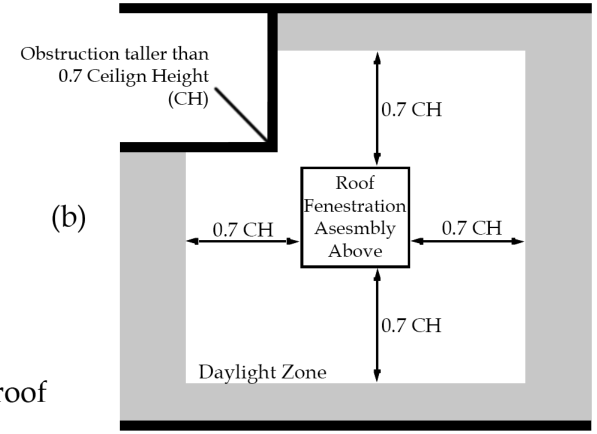
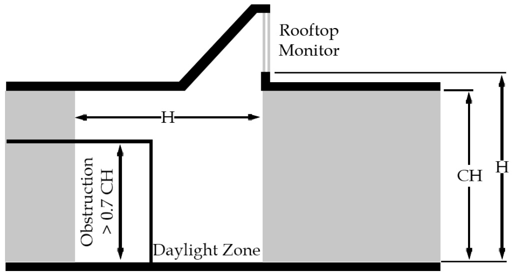
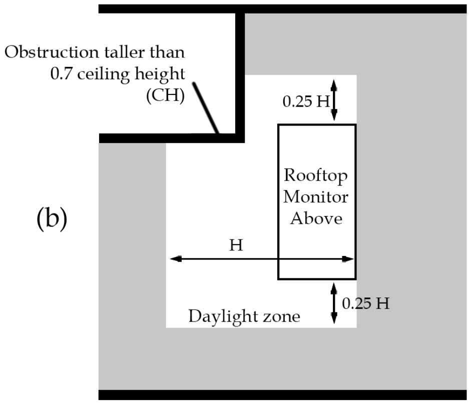


(a) Section View
(b) Plan view of daylight zone under a roof fenestration assembly

(a)

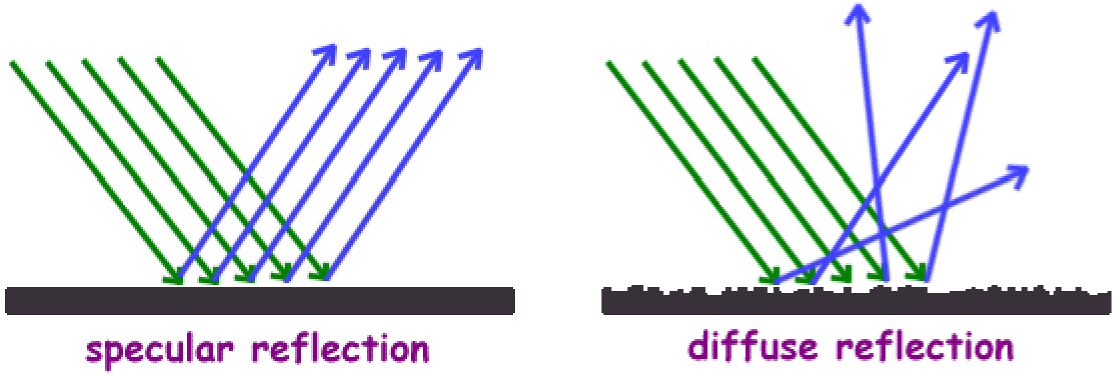


(b)



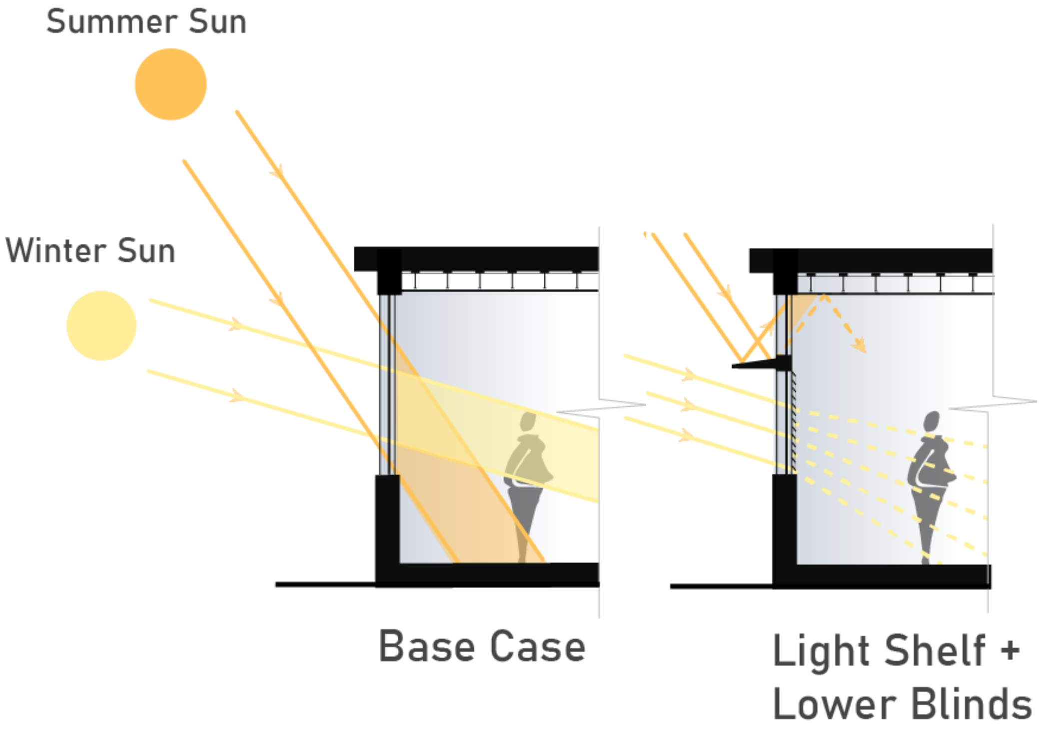
(a) Section view
(b) Plan view of daylight zone under a rooftop monitor

Evaluating Light

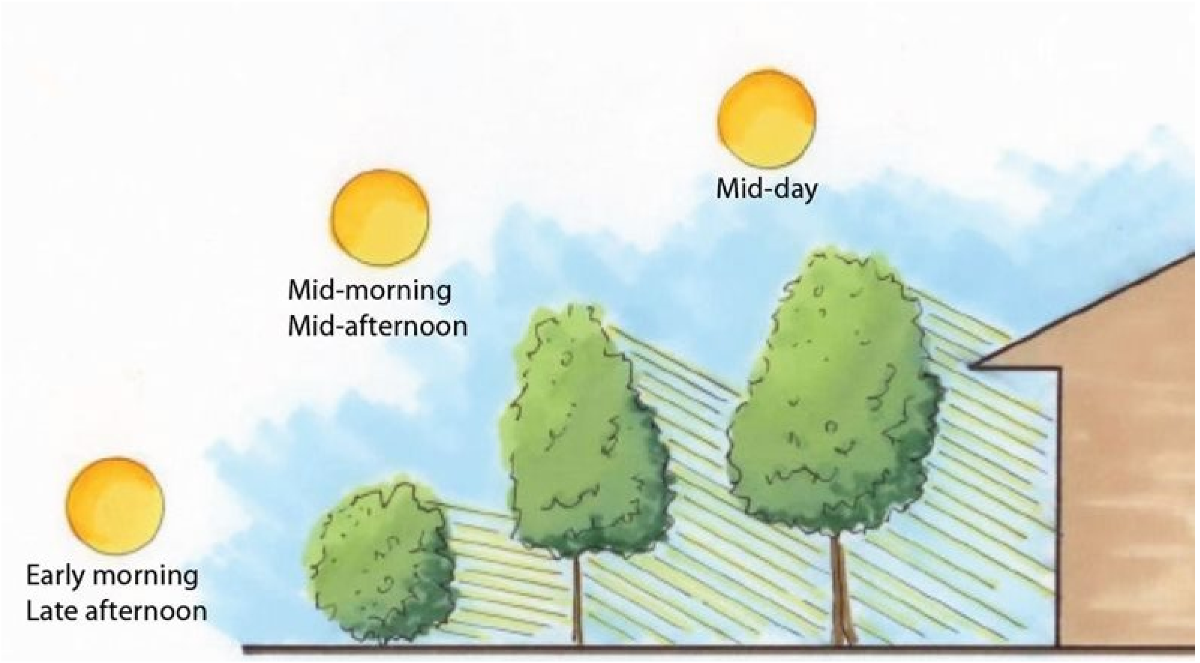


Shading

- Exterior
  - Vertical vs Horizontal
  - Solid vs Perforated
  - Angle of Incident
    - Mitigate summer sun exposure
    - Increase winter sun exposure
    - Heating/Cooling Loads



Evaluating Light



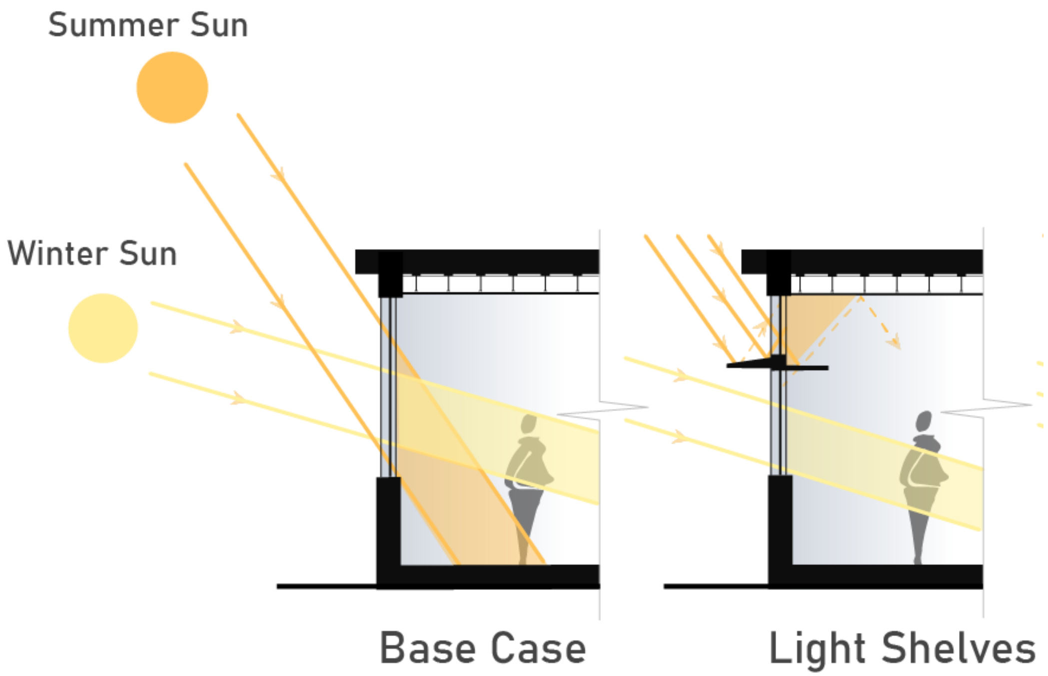
Site Context

- Trees
  - Passive shading system for mitigating summer sun while allowing exposure for the winter sun.
- Buildings
  - Shading
  - Angle of Incident
- Car Parking

Evaluating Light

Light Shelves

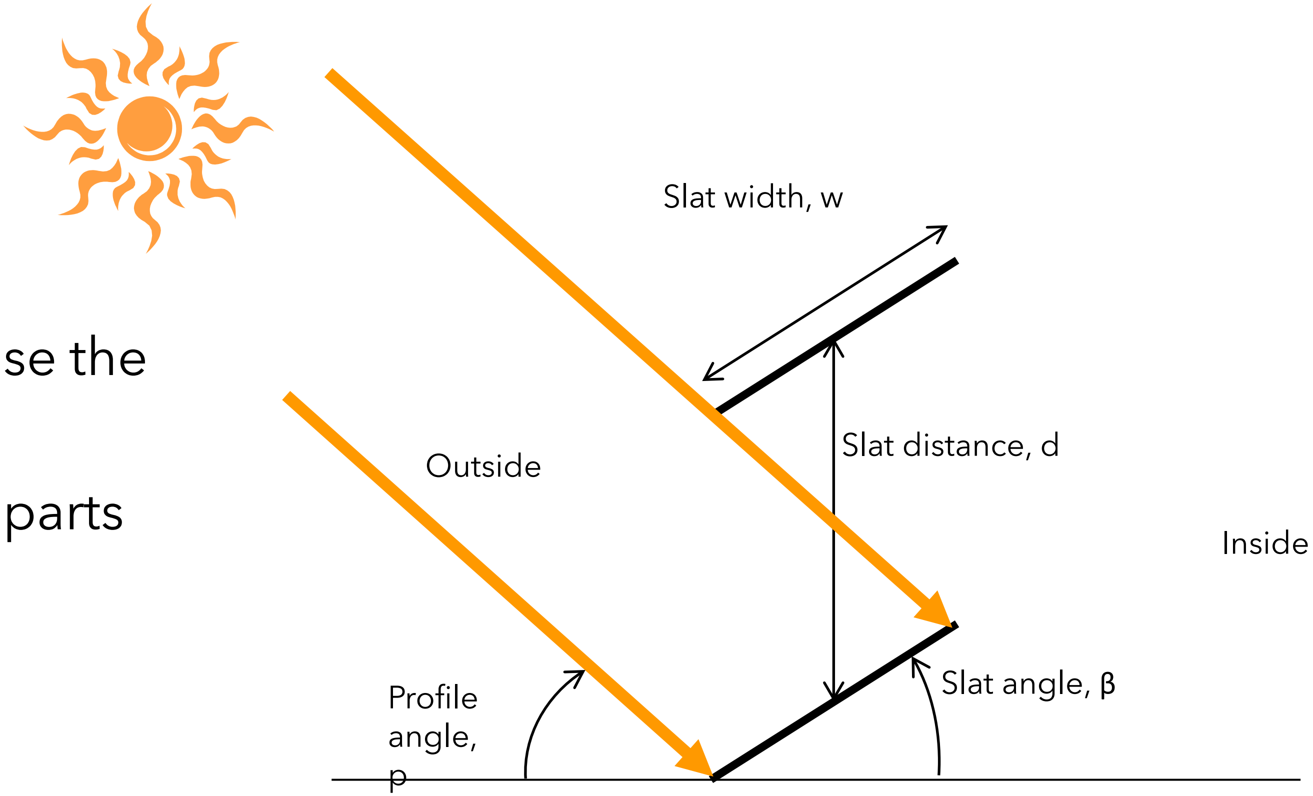
- Interior
  - Shading
  - Redirect light to shift/increase the daylight zone
  - Separates window into two parts
    - Daylight
    - View

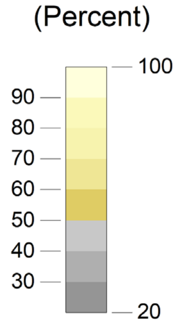


Evaluating Light

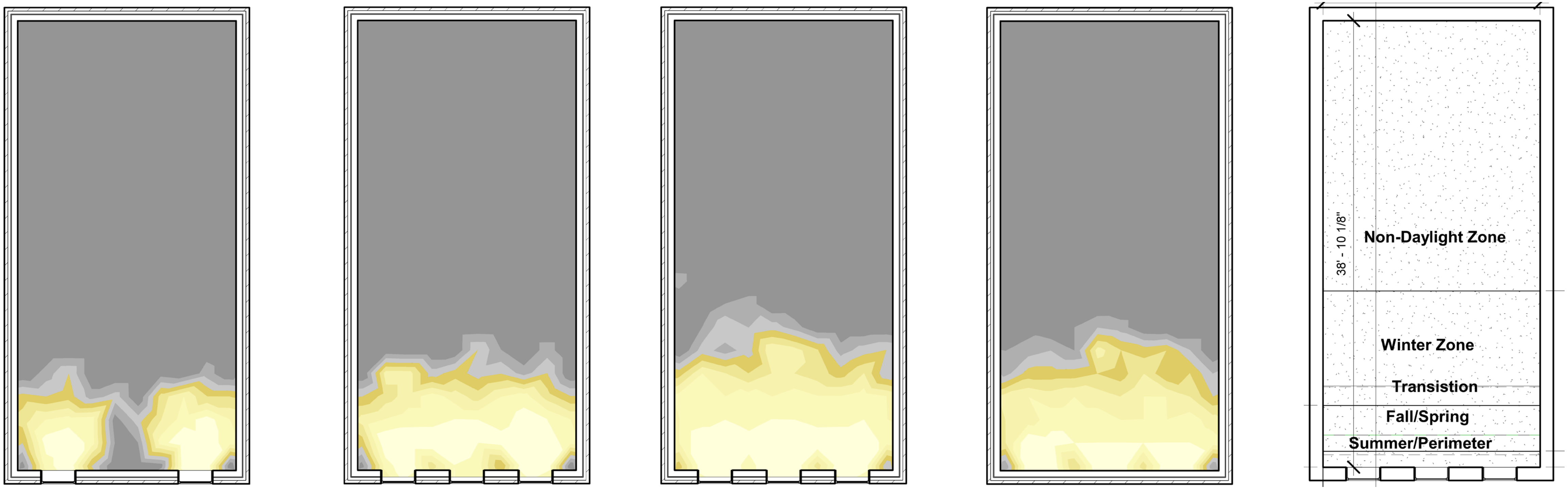
Blinds

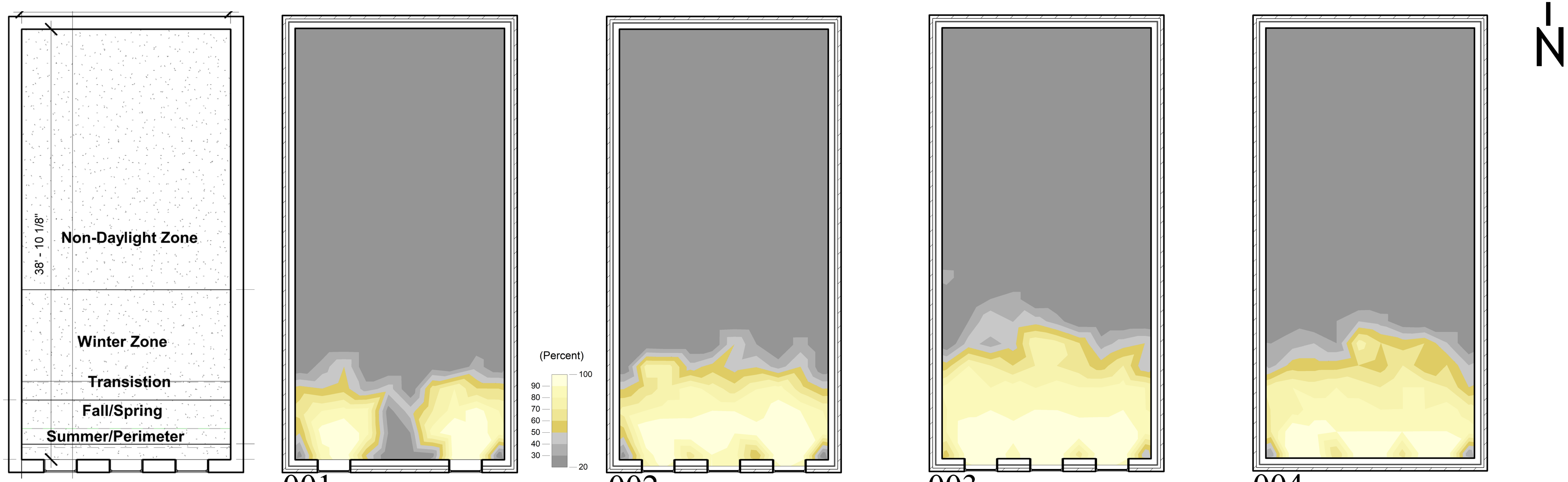
- Interior
  - Shading
  - Redirect light to shift/increase the daylight zone
  - Separates window into two parts
    - Daylight
    - View





Lighting sDA Annual Hours





001
2 windows - VT 75%
Sill Height 3'
4'X3' Windows

sDA300/50 = 14%
ASE1000/250 = 4%

Area = 732 SF
Baseline

002
3 Windows - VT 75%
Sill Height 3'
4'X3' Windows

sDA300/50 = 22%
ASE1000/250 = 4%

8% change for sDA

003
3 Windows - VT 75%
Sill Height 0'
7'X3' Windows

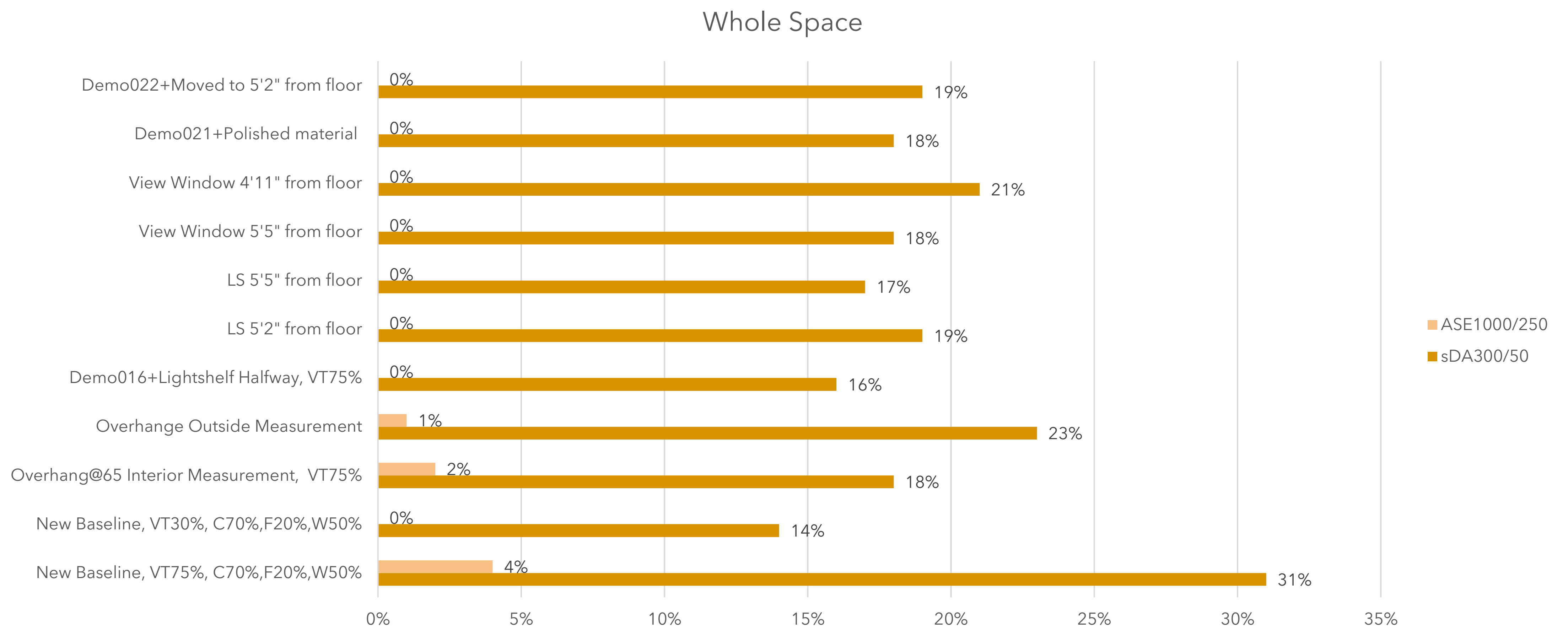
sDA300/50 = 26%
ASE1000/250 = 4%

4% change for sDA

004
3 Windows - VT 75%
Sill Height 0'
Overhang 3'
7'X3' Windows
sDA300/50 = 25%
ASE1000/250 = 1%

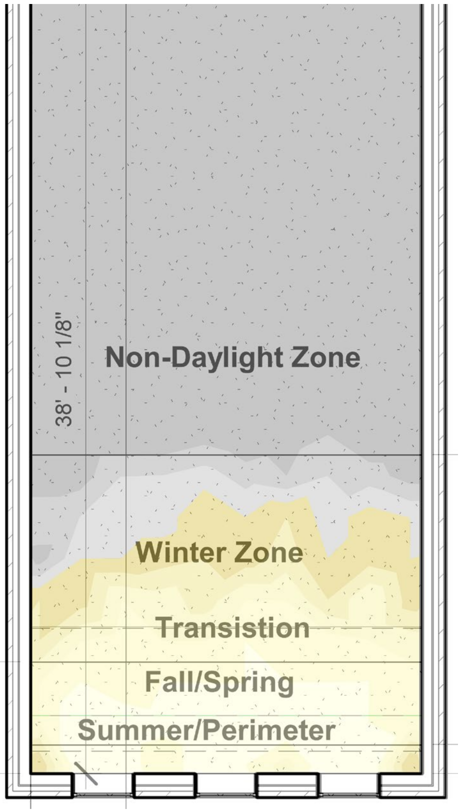
1% change for sDA
3% change for ASE

Demo sDA & ASE

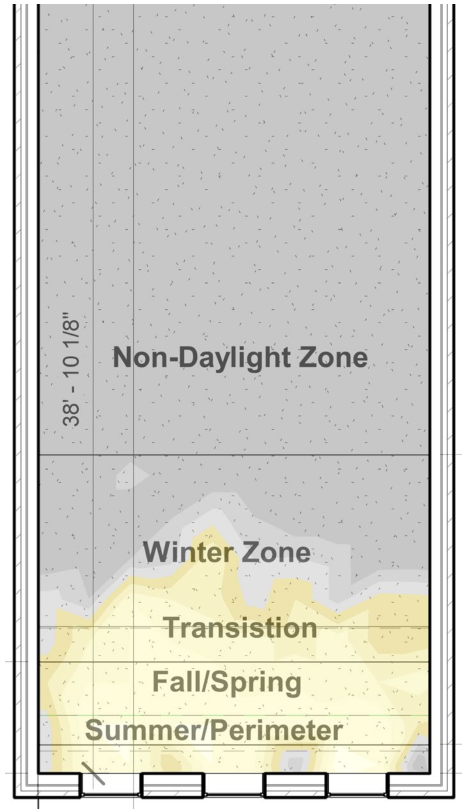


Whole Space
Demo022+Moved to 5'2" from floor
Demo021+Polished material
View Window 4'11" from floor
View Window 5'5" from floor
LS 5'5" from floor
LS 5'2" from floor
Demo016+Lightshelf Halfway, VT75%
Overhange Outside Measurement
Overhang@65 Interior Measurement, VT75%
New Baseline, VT30%, C70%,F20%,W50%
New Baseline, VT75%, C70%,F20%,W50%
0%
19%
0%
18%
0%
21%
0%
18%
0%
17%
0%
19%
0%
16%
1%
23%
2%
18%
0%
14%
4%
31%
0%
5%
10%
15%
20%
25%
30%
35%
ASE1000/250
sDA300/50

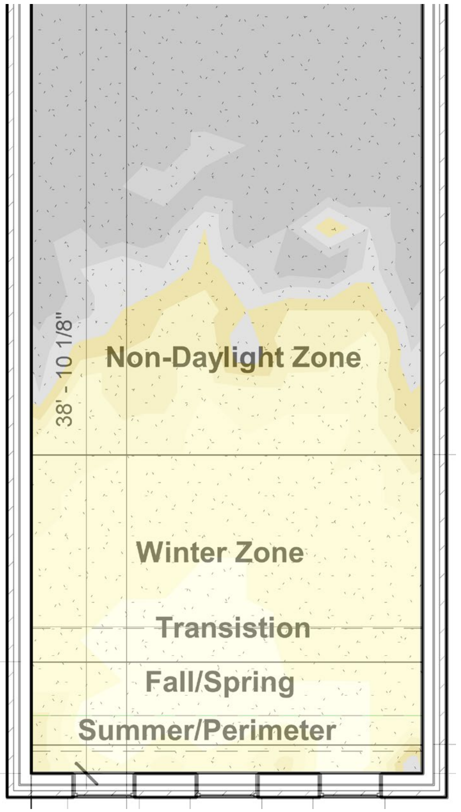
Traveling Light



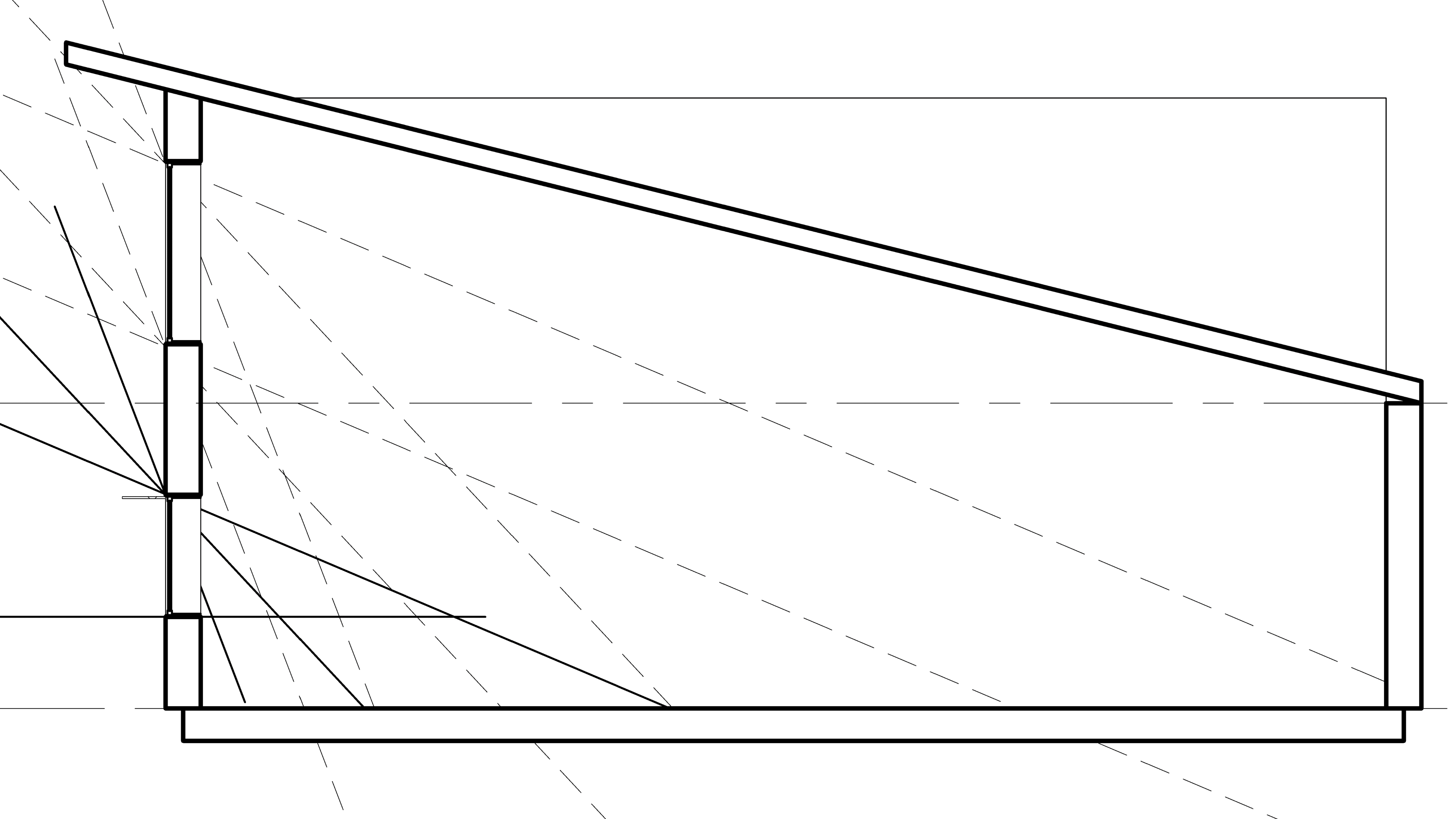
011 - New Baseline,
VT75%, C70%,F20%,W50%



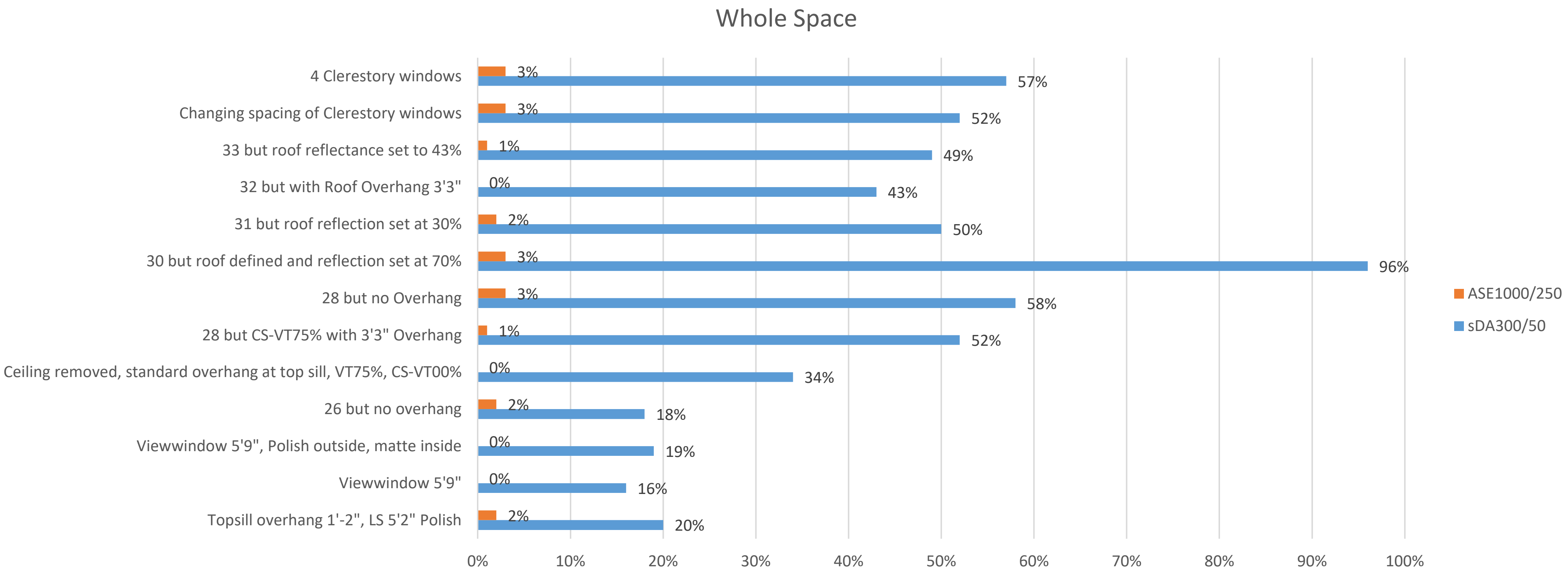
024 - Top sill overhang
1'-2", LS 5'2" Polish



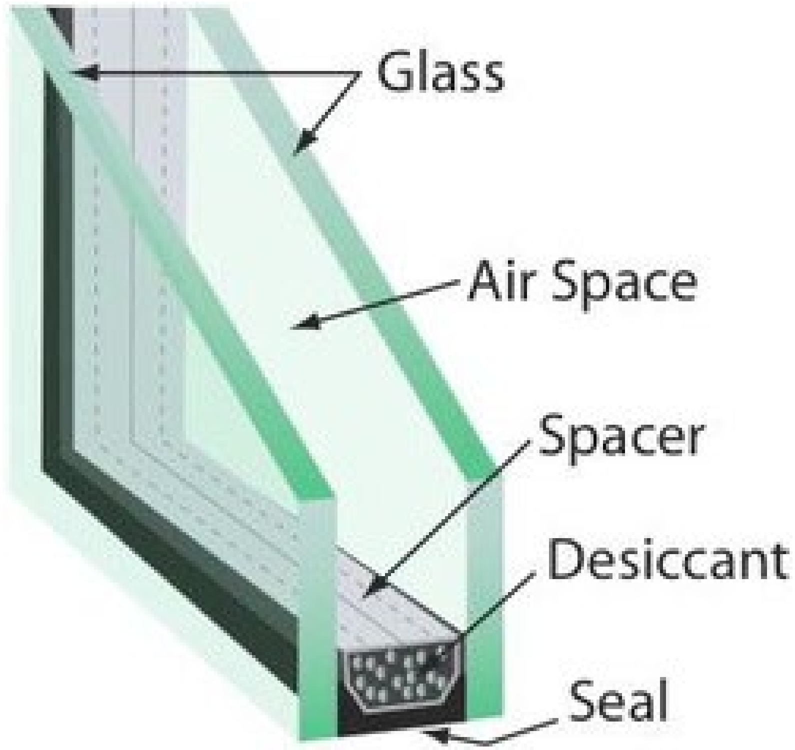
030 - Ceiling removed,
VT75%, CS-VT75%



Demo sDA & ASE, adding clerestory windows



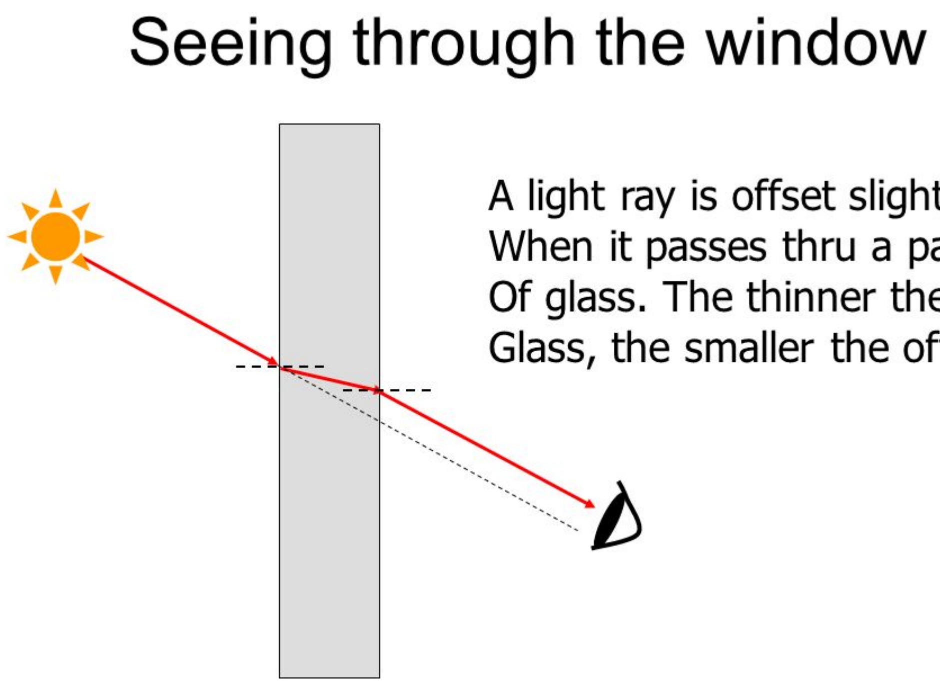
Evaluating Light



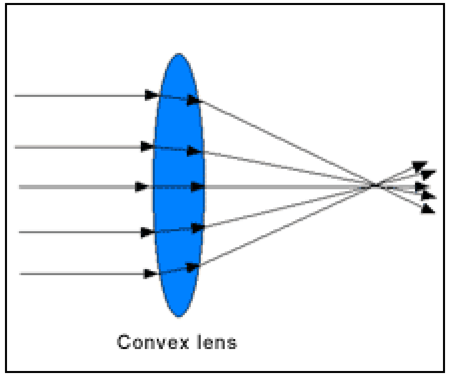
Glazing

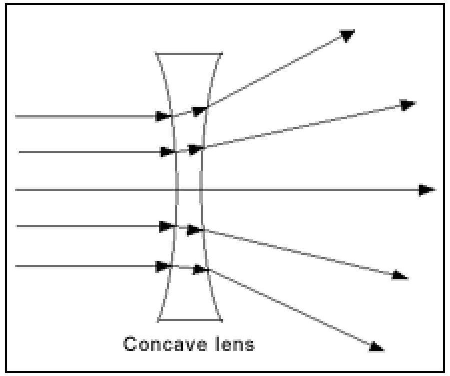
- Low-e coating
  - Offers an increase in VLT while maintaining a low SHGC.
- Panes
  - Typical double paned w/ insulation

Evaluating Light



A light ray is offset slightly
When it passes thru a pane
Of glass. The thinner the
Glass, the smaller the offset.





Touching the Sun

- Radiance
  - LightStanza
- Honeybee
- Insight

Touching the Sun

- My Checklist
  - Climate data estimation
  - Site context
  - Design restrictions/constraints
  - LEED v4
    - Standards
    - Perimeter and/or daylight strategies
    - Spaces
  - What if's
  - Recommendations

Use visual aids to present data to clients, even Architects.

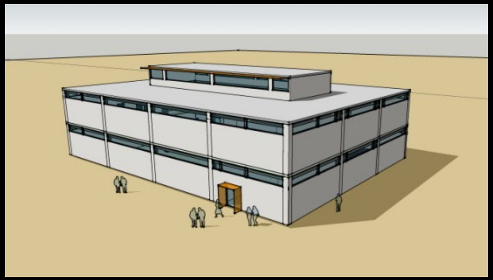
- https://patternguide.advancedbuildings.net/patterns.html
- There is such a thing as too much data, ☹
- You MUST use your goals to filter data, i.e. Max, Min, or Avg.

The Process

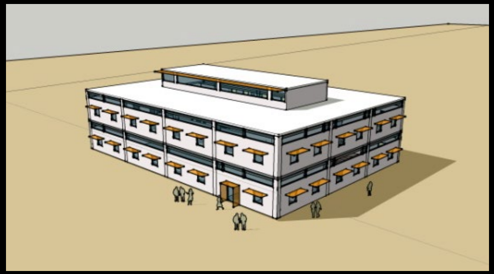
- Actionable Information
  - “All models are wrong, but some are useful” – George EP Box

Summary

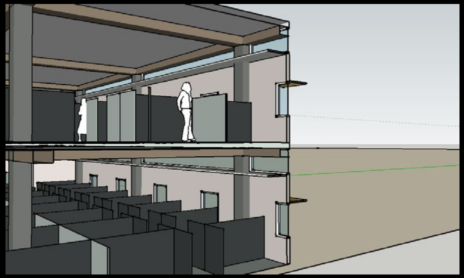
CASE 1 3 FT DAYLIGHT WINDOW



CASE 2 + 4x4 VIEW WINDOW

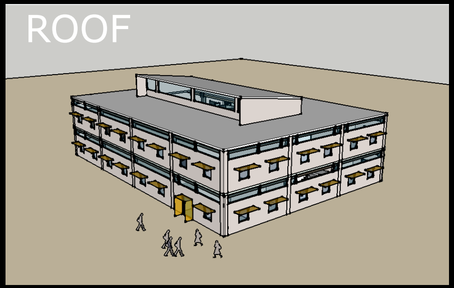


CASE 3 + LIGHT SHELVES



CASE 4 +ROLLERSHADES

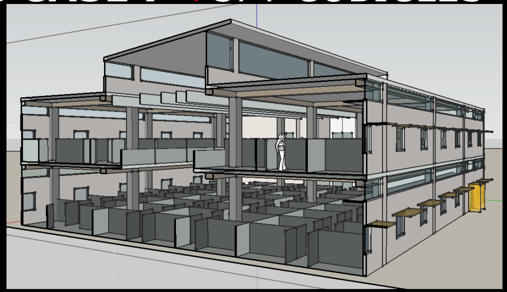
CASE 5 + SHED ROOF



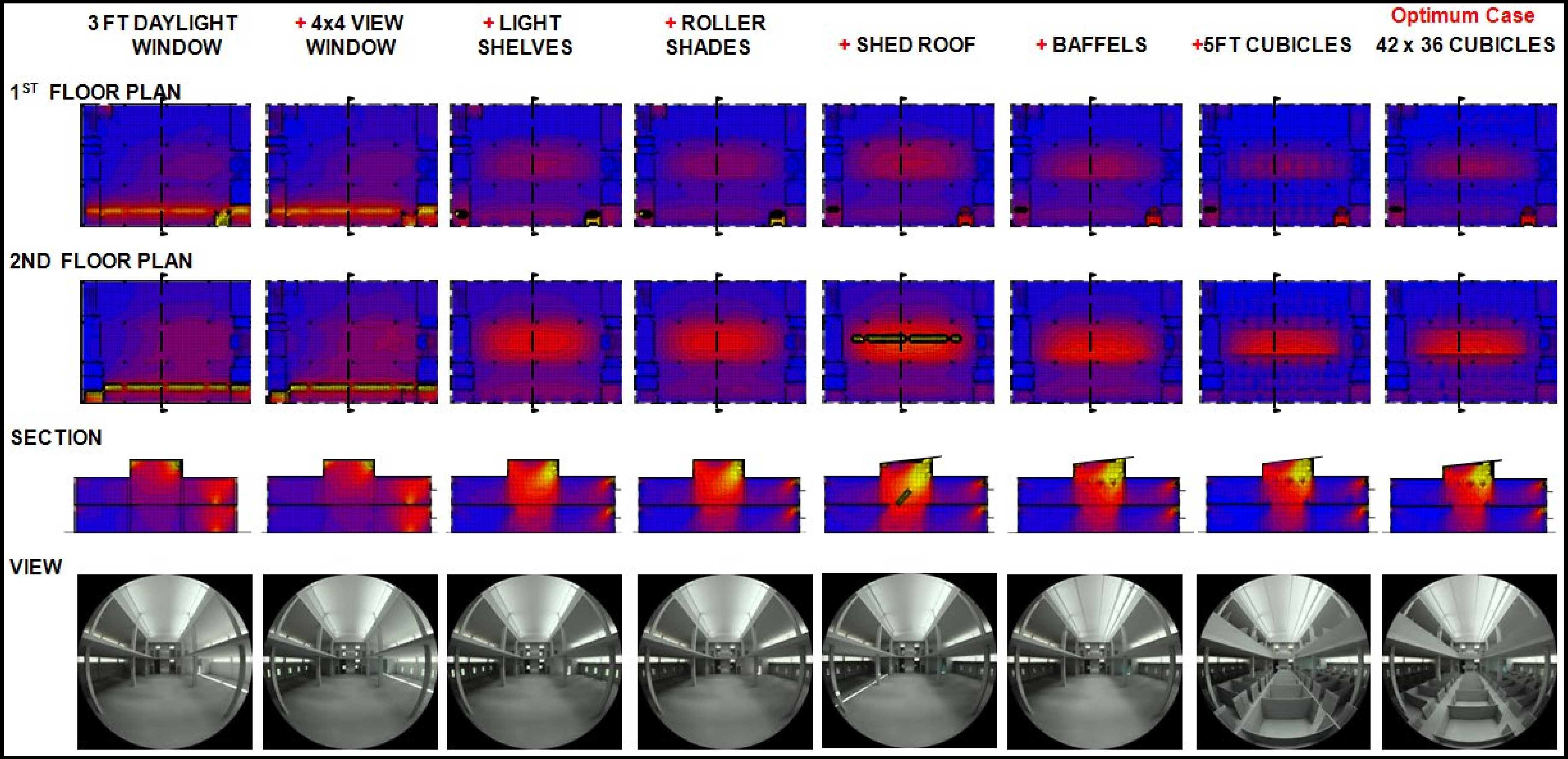
CASE 6 + BAFFELS

CASE 8 +42 x 36 CUBICLES

CASE 7 +5FT CUBICLES

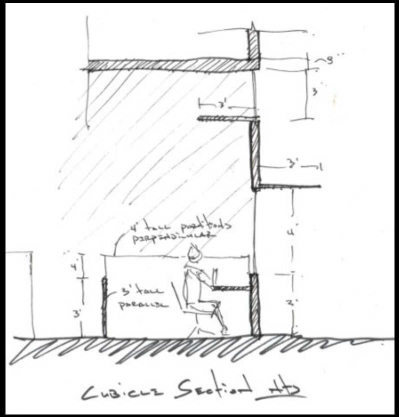


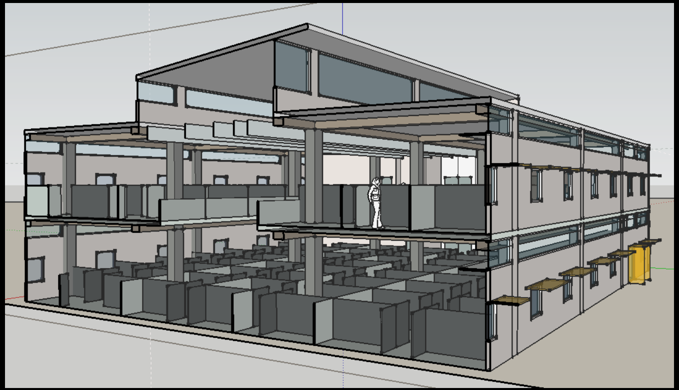
Summary

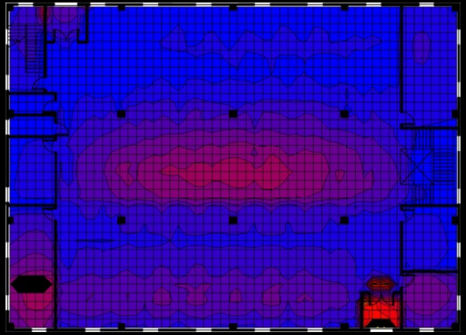


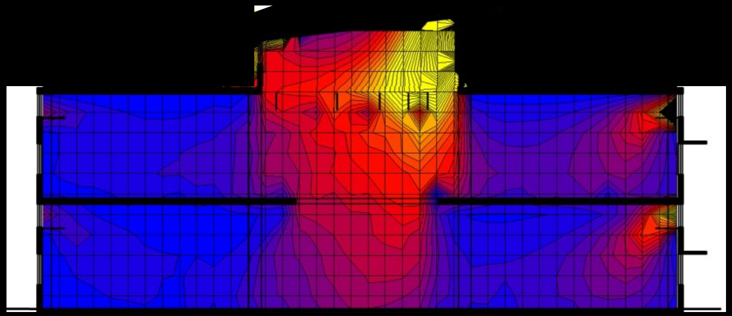
3 FT DAYLIGHT WINDOW
+ 4x4 VIEW WINDOW
+ LIGHT SHELVES
+ ROLLER SHADES
+ SHED ROOF
+ BAFFELS
+5FT CUBICLES
Optimum Case
42 x 36 CUBICLES
1ST FLOOR PLAN
2ND FLOOR PLAN
SECTION
VIEW

Summary


4' tall partitions perpendicular
3' tall parallel
Cubicle Section

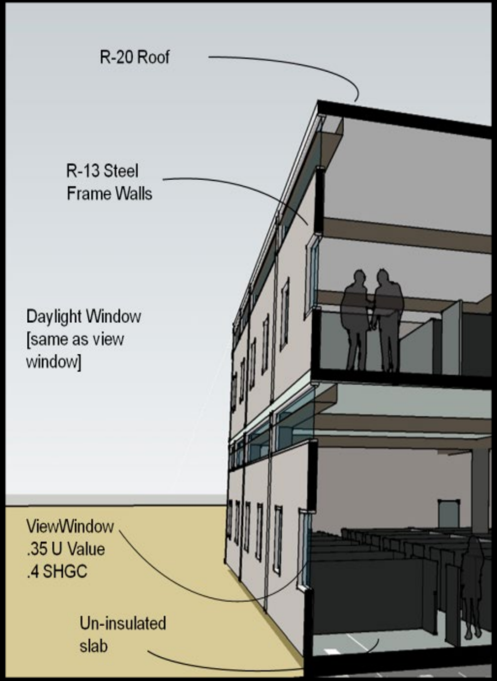




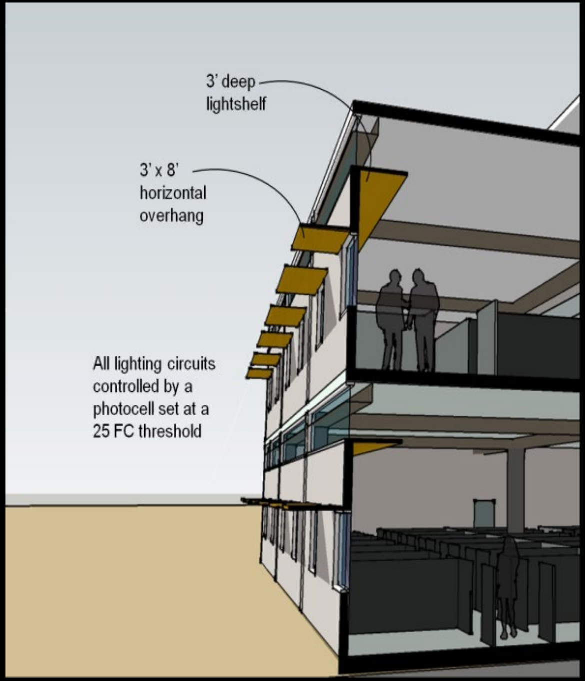


Summary

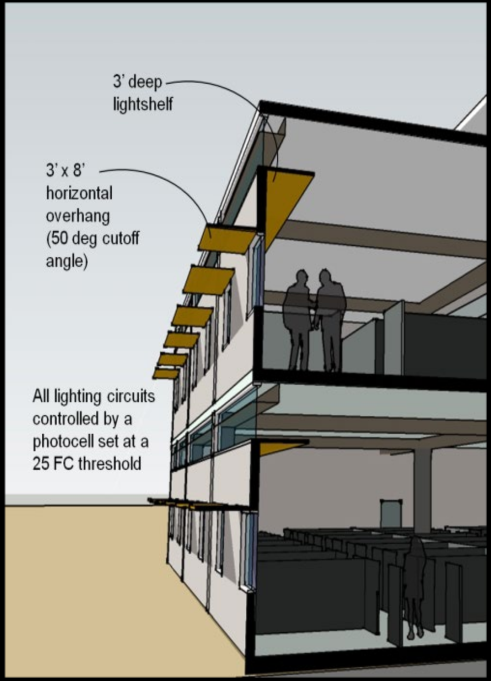
Baseline



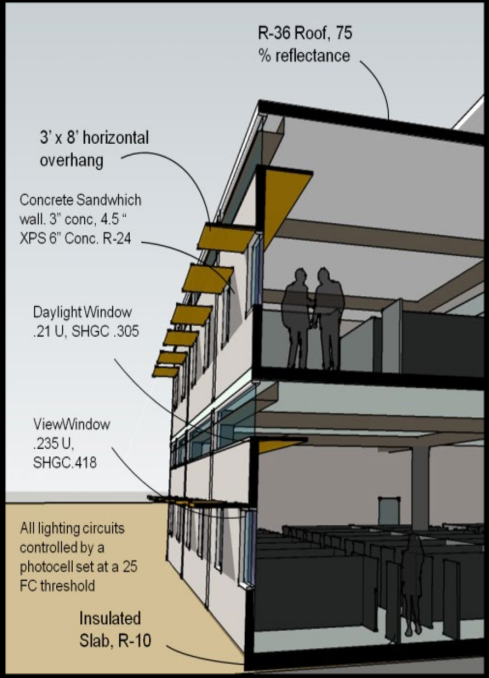
+ Shading



DC + Shading

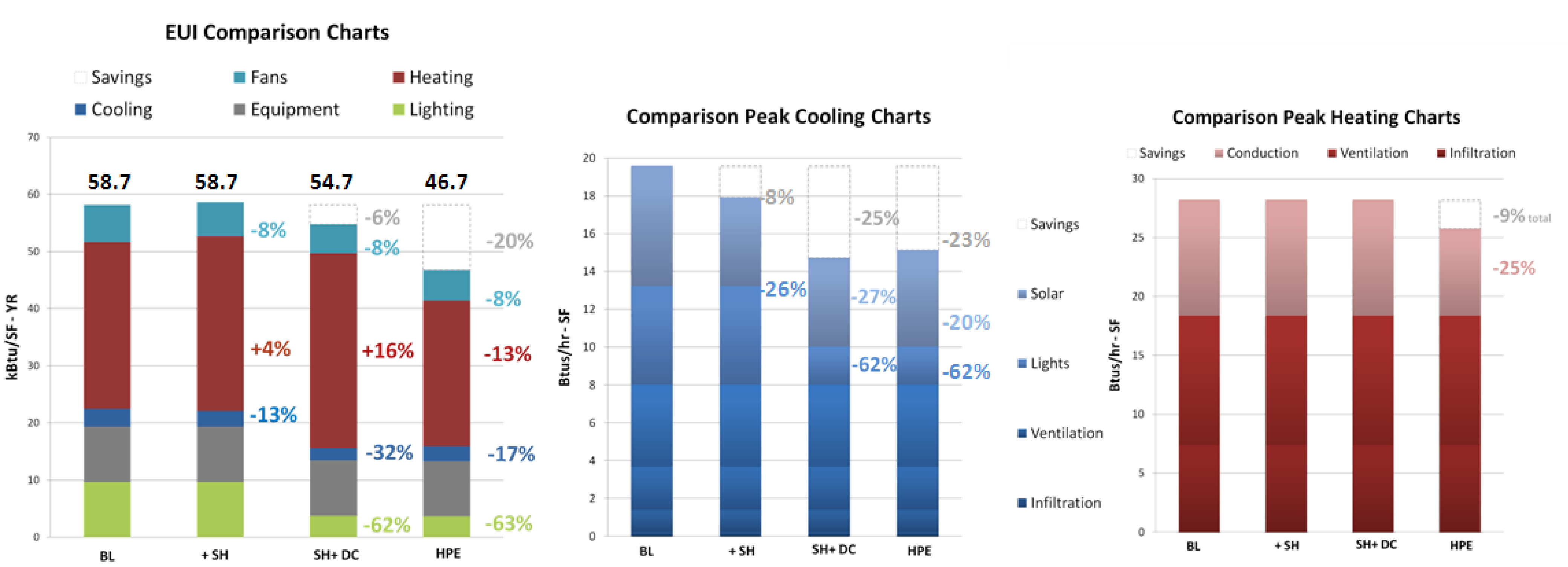


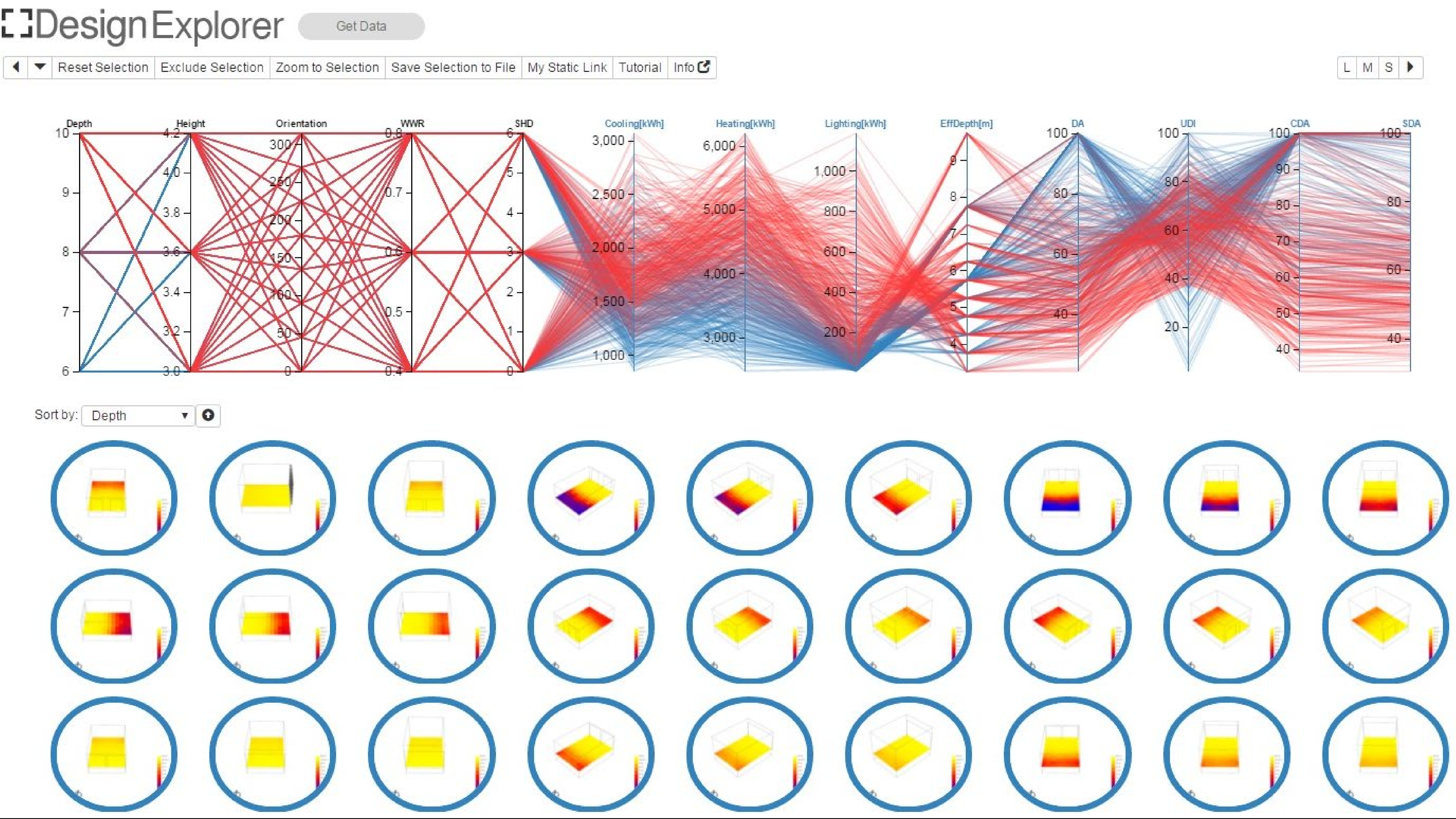
HP Envelope



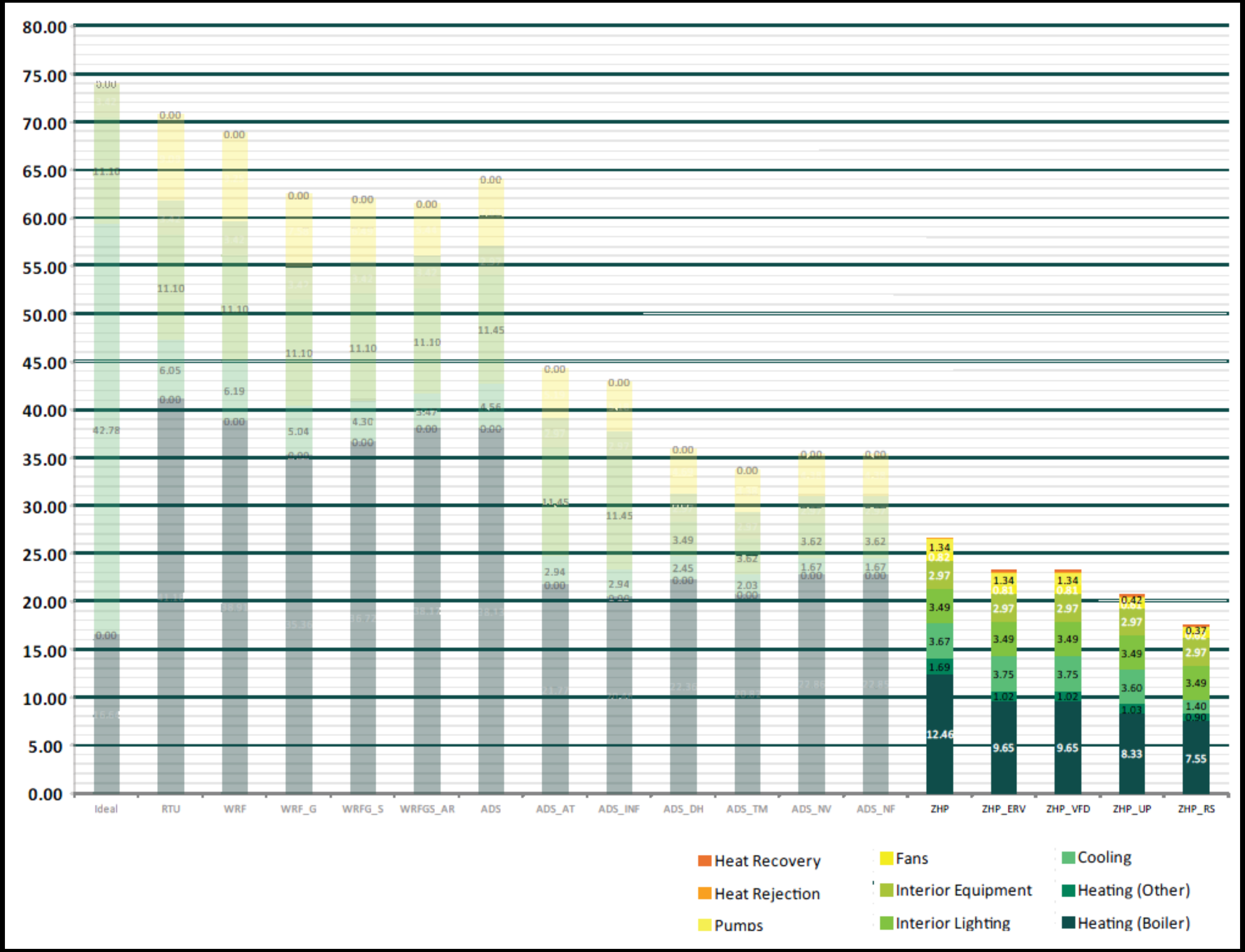
How does each design decision impact the EUI of the building?

Summary




DesignExplorer
Get Data
Reset Selection
Exclude Selection
Zoom to Selection
Save Selection to File
My Static Link
Tutorial
Info
L
M
S
Depth
Height
Orientation
WWR
SHD
Cooling[kWh]
Heating[kWh]
Lighting[kWh]
EffDepth[m]
DA
UDI
CDA
SDA
Sort by:
Depth

Summary


80.00
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30.00
25.00
20.00
15.00
10.00
5.00
0.00
Ideal
RTU
WRF
WRF_G
WRFG_S
WRFGS_AR
ADS
ADS_AT
ADS_INF
ADS_DH
ADS_TM
ADS_NV
ADS_NF
ZHP
ZHP_ERV
ZHP_VFD
ZHP_UP
ZHP_RS
Heat Recovery
Heat Rejection
Pumps
Fans
Interior Equipment
Interior Lighting
Cooling
Heating (Other)
Heating (Boiler)

Summary

Up to ##% of performance reduction

01% Efficient Lighting	14% Outdoor Programming	02% Thermal Envelope
17% Daylighting	07% Exterior Shading	09% Fan Management
08% VAV System	03% Solar Hot Water	10% Adaptive Comfort Measure

Energy Programming - Daylighting Zones