PARAMETRIC COMPUTATION AND DIGITAL PROTOTYPING
FOR ENVIRONMENTAL RESPONSIVE ENVELOPES
Workshop Program 2016

computing the environment and designing envelopes in architectural crafting.

UNIVERSITÀ DEGLI STUDI FIRENZE
Scuola di Architettura

Lab.biz
MULTIMEDIA ARCHITECTURE INTERACTION

why «computing the environment» ?

Informing Matter.

"For me, it is calculus that wzs the subject of the issuu and it is the discovery and implementation of calculus by architects that continue to drive the field in terms of formal and constructed complexity"
(G. Lynn)

because, we are now able to interplay with physics
through *agent-data computable hypo-thesis*.

We are having now an impressive capacity to quantify nature, to trap her
inside the digital computable world (dico.world), inside the digital matema, the mathematical formulas shaped through bits.
Today, sensors, and **data entry sources** in general are multiples of people that leave in the world.
But almost zero in comparison with the infinite aspects of the phenomenological world and for this reason we can affirm that «the Environmental Computing» is just started.

Through digital data we can conceive, model, design, and fabricate artifacts at different scales;
No doubt, with more accuracy, reliability, …and ignorance.

why «designing responsive envelopes»?

Performative Informed Un-materiality (PIU)

Because, envelops are the building system more related to the environment or – in many words – to the site, the place, the climate, the weather, the socio-political and economical aspects,..
In short words: building envelopes are the inside / outside mediator.

In a correlated explosion with sensoring, computable actuators are growing faster, as well.
Robotic arms are the most popular example today,
Many other sectors, like softrobotica, are increasing in importance for broader application fields.
In other scales (micro or nano) we found the most quantities of digital actuators still a kind of elettromechanical devices able to react under the basic *what-if* condition. At different scale we also have a rapid growing of "informed" devices, able to operate through multidimensional patches and large amount of data.
Devices that – more and more– let us to interplay dynamically with the environment.

We are at the point that is possible to inform matter for predictable behaviors.
Informing matter is not anymore and only the production of materials with predictable or definitive forms; materials do not come to live through designing forms, assigning meaningful, visible and understandable forms to matter, assigning univocity, and worshipping the aura.
Today, mastering the matter, is an activity that takes place at the structural level, dealing with relationships, parameters, forces, and energy fields expressed and formulated through the numerical *matema*.
With new technological abilities we are now able to produce *materia operata* (materials), and even *materia prima* (matters), that can be invisible, with multiple possible shapes, able to incorporate performative (more than connotative) information.
As a result we deal with «performative informed un-materiality»: materials «farcé» of that special untouchable matter that is the knowledge; for this reason we can define objects mainly made of un-materiality, able to incorporate information, memories; able to mutate dynamically presences and attitudes, to respond under complex and interrelated conditions, variables, parameters.

We can use all this new potentiality to build responsive architectures.

why «crafting»?

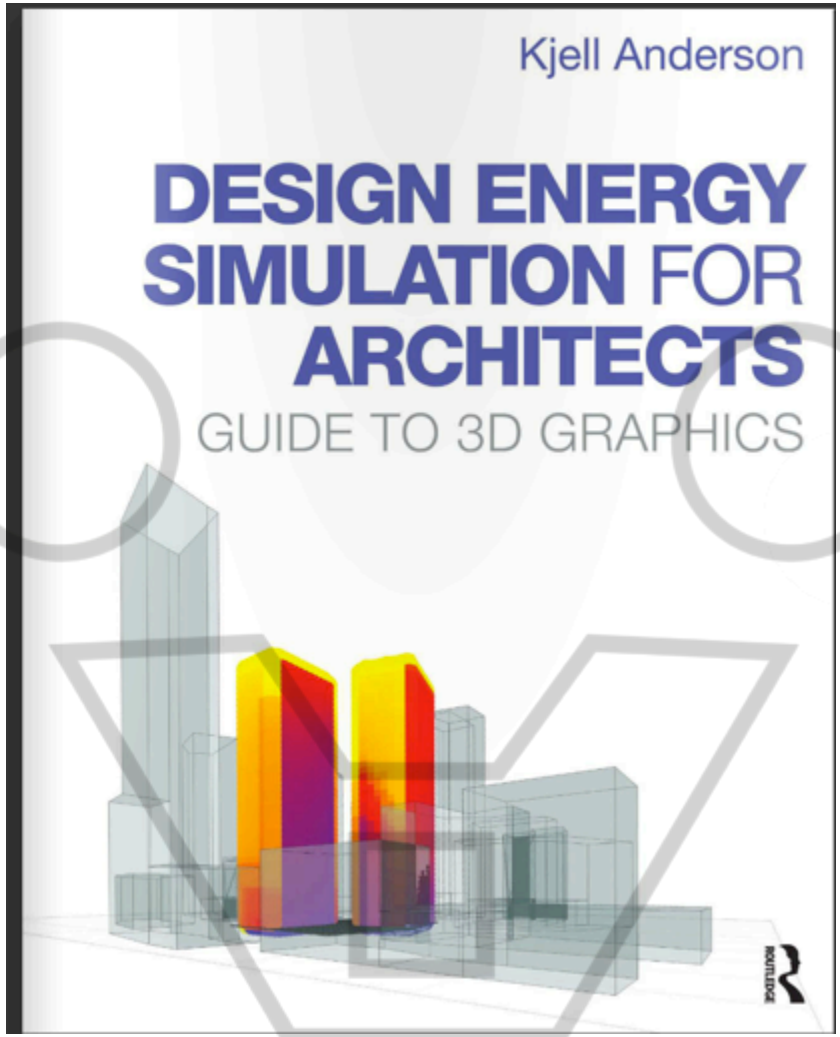
Digital Crafting

Because, the industrial system of production is over. The moral imperative of the modern world to re-produce and to assemble identical pieces optimized for functions, and manufacturing reasons lost centrality.
The sample, the analogical repetition of elements inside the diagrammatic rules of the Modulor is now replaced by parametrical formulas, by calculus, by the mathematic of curvilinearity.

Through intangible mathematical formulas we are now able to put in relationship small grains of the reality and to differentiate them at micro scale as well.
Algorithms are now the standard, a new sample totally different from the previous past ones. Object produced by algorithms are not anymore a repetition. From algorithms comes singular entities, member of families that share a communal code. In this new dimension we are now producing and living with new artifacts that are mutants, generated by topological differentiations and genetic adaptations of the same matter: artifacts that are more closed to the organic world, that declare – in Mumford's words – the end of the «paleotechnics».

For this reason production is not anymore a static diagram but a flexible context using different and multiple tools, variable and simultaneous strategies: a new way of conceive, design and fabricate in a continuous flow. All aspects that are related to the art of crafting where artisans were able to control all the processes, using skills and know-how, learning and perfecting their object by trials and errors at heir own risk; preparing, like Galileo with the telescope (the starry messenger), instruments and tools for that specific work and in relationship with the final product.

In any case, the digital craftsmanship of the post industrial era have some differences from the tradition of crafting.
The new craftsman is now able to formalize is know-how transforming the tacit knowledge in explicit and transmissible knowledge. He can objectify the intimate properties of matter through quantitative specifications. Quantitative specifications made of data that can be acquired, transmitted, and computed.
The skill of the new craftsman is adapting software; coding specific patches for singular and specific goal. The new craftsman has that ability to weave matter, to create macramé for Damien Hirst or in our words to weave intricacy between the macro and the micro, the visible and the invisible.
He can now runs trials and test through digital simulations inside the no risky «white room» of the computer. He can now formulates and evaluates multiple alternatives through no-destructive practices. The digital craftsman can now practice architectural design as an experimental research more than observing prescriptions, and rules of thumb. He is now able to objectify input and output, to produce consistent feedback, to activate evolutionary process of morphogenesis. He can adapts tools for his specific need almost as in the Past, the traditional instruments fitted his hand; he can explore new opportunities for functions and forms, he can finally recover that specific community of practice that lived in the medieval «bottega»; he can have back that desire and proud – in the Richard Sennet's word – to do a job well for its own sake.



This the text-book
https://issuu.com/jesic/docs/design_energy_simulation_for_archit

See in assignment#01
In mailab workshop section of “in progress menu”

"we live in a era where data is abundant, yet very little of this data is used to effectively inform the early design of buildings"

Kjell Anderson, practices at LMN Architects in Seattle Washington, USA

Data are the intangible aspect of materiality that allows us to model the phenomena and through numerical modeling to understand and predict their behaviors:

to design the built environment.

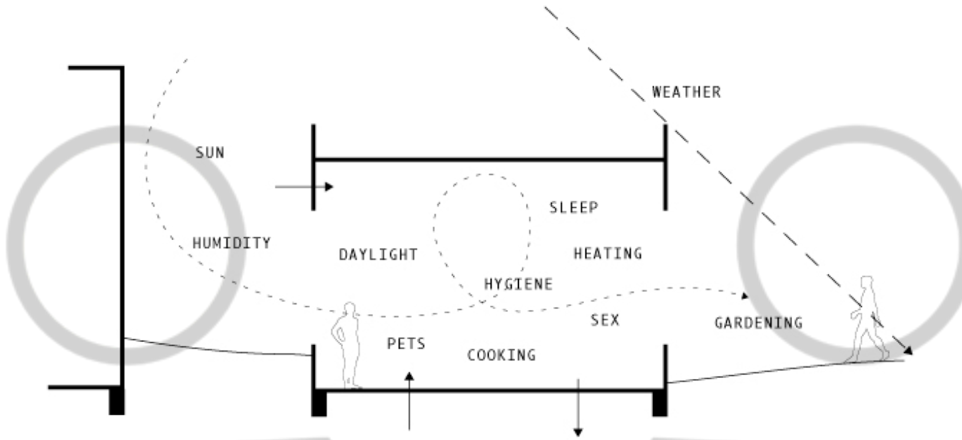
Today there are a lot of software to approach and modeling architectural designing
That are very intuitive and give the opportunity also to architects to run some
technical analysis that in the past were served to enginnering and specialist

As a result architect today can use this tool to inform their project, deciding
on evidence of test, controlling the machinery for the fabrication (files to factory)

Assuming responsible decisions based on facts and optaining an higher performance building
in terms of energy consumption Co2 footprint, comfort for occupancy

MODELING HUMAN BEHAVIOURS
AND COMPUTING COMFORT CONDITIONS

Environmental elements that affect people's comfort



Building is the deliberate organization of the processes of life.

Hannes Meyer

Thermal
Light
Ventilation
Humidity
Acustic

METEREOLOGICAL FACTORS

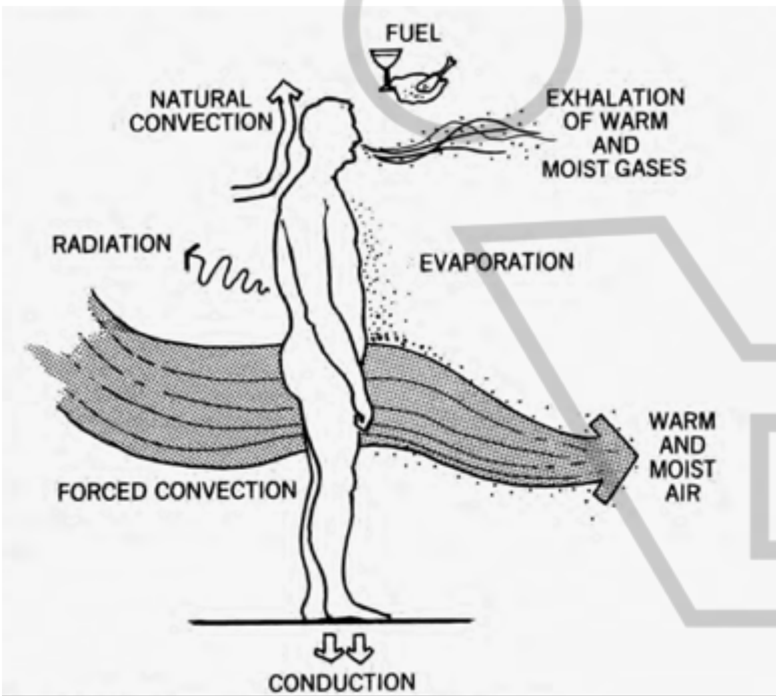
SOLAR ENERGY
NATURAL LIGHT
WINDS
HUMIDITY
RAIN
SKY CONDITION

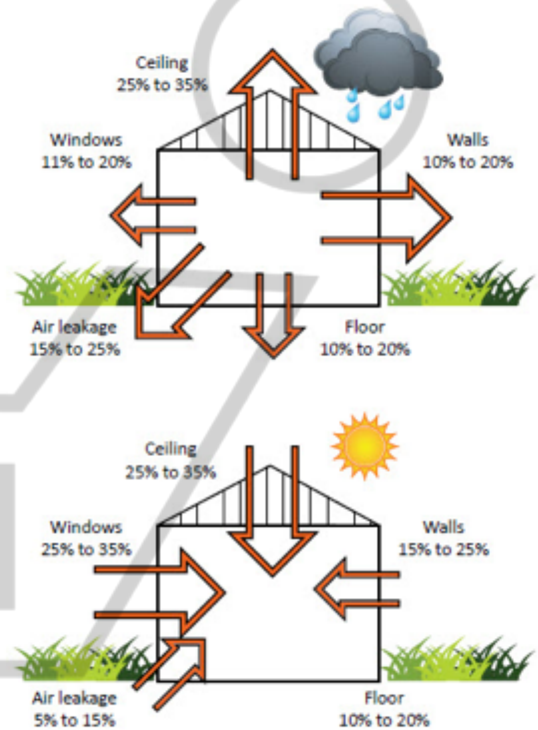
View
Security
…….

NOT METEREOLOGICAL FACTORS

Environmental elements that affect people's comfort

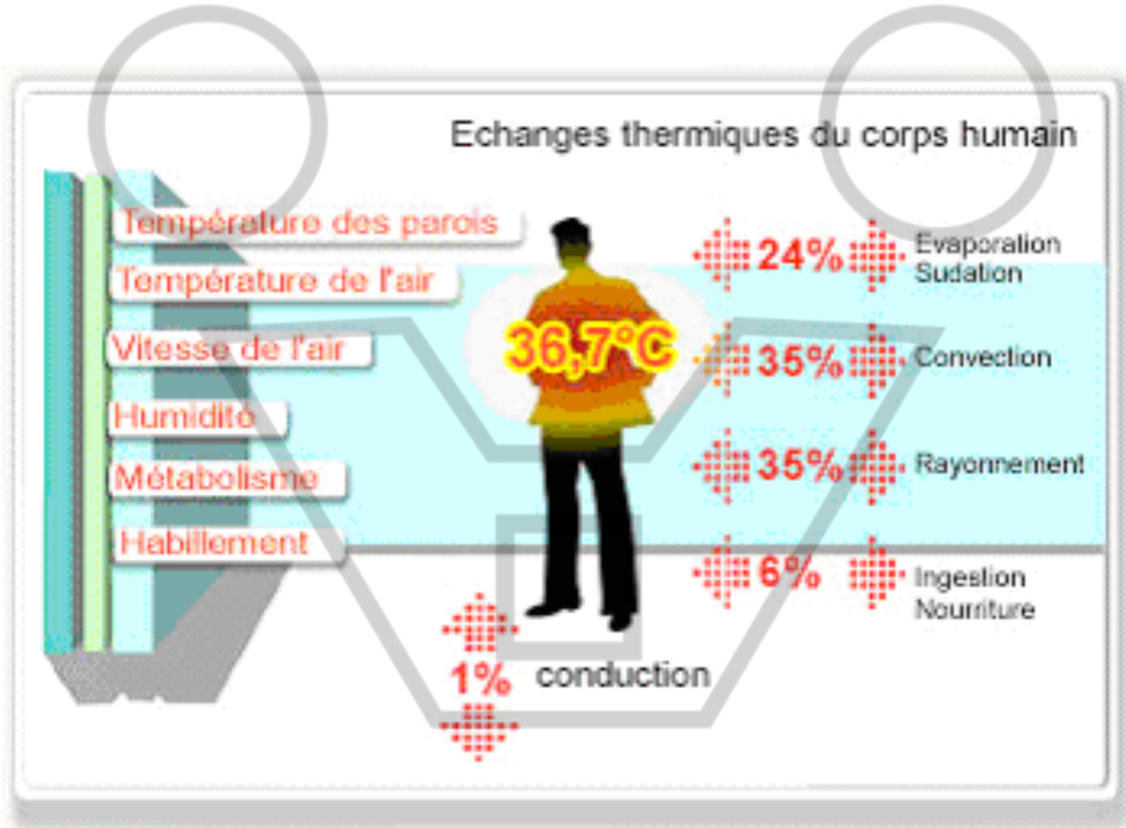
THERMAL COMFORT: AN INTERACTIVE PHENOMENA



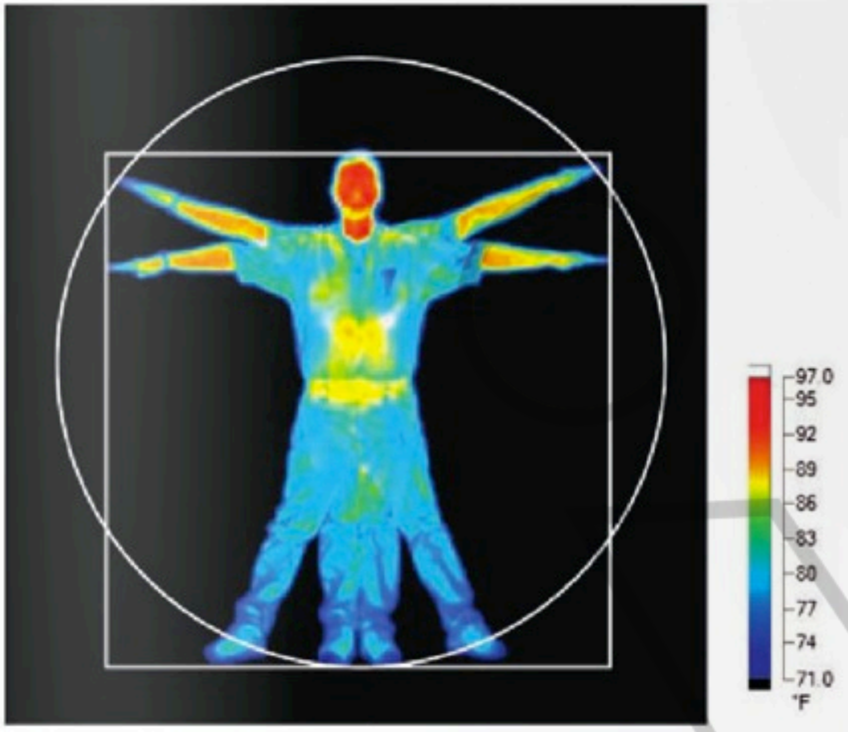


Environmental elements that affect people's comfort

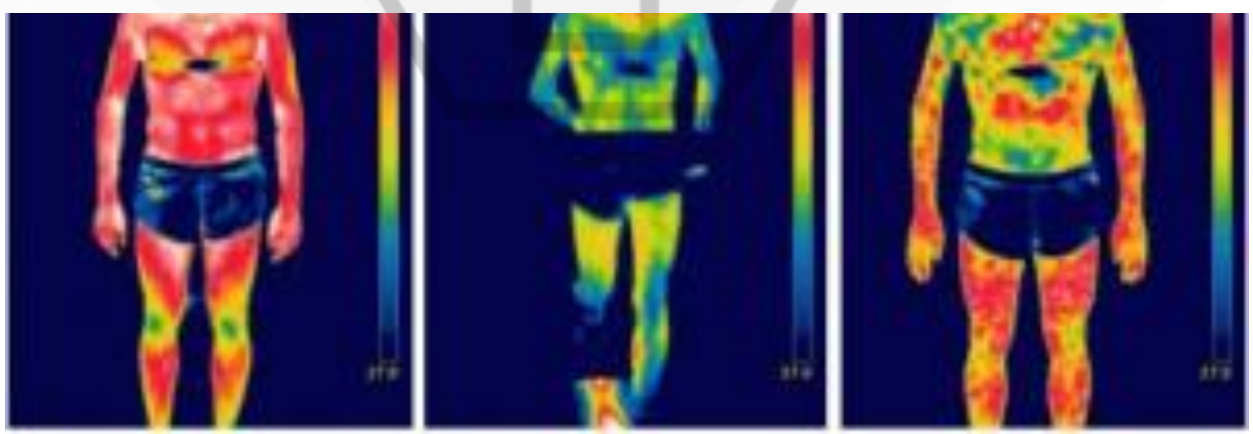
HOW THE BODY EXCHANGE THERMAL ENERGY



Environmental elements that affect people’s comfort



MODELING HUMAN THERMAL COMFORT



Environmental elements that affect people's comfort

METABOLIC PROFILES

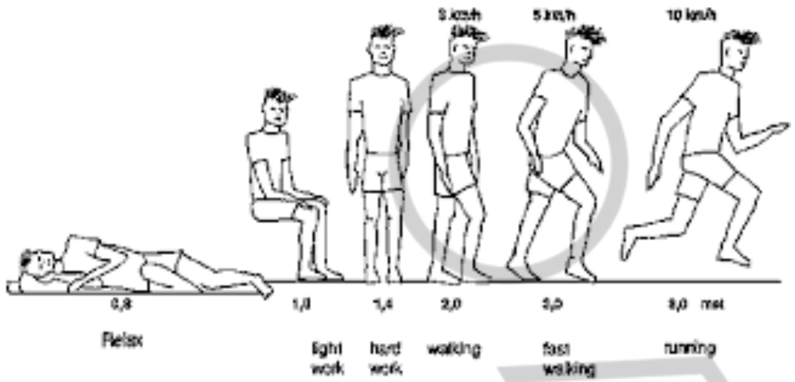


Table 4 Typical Metabolic Heat Generation for Various Activities

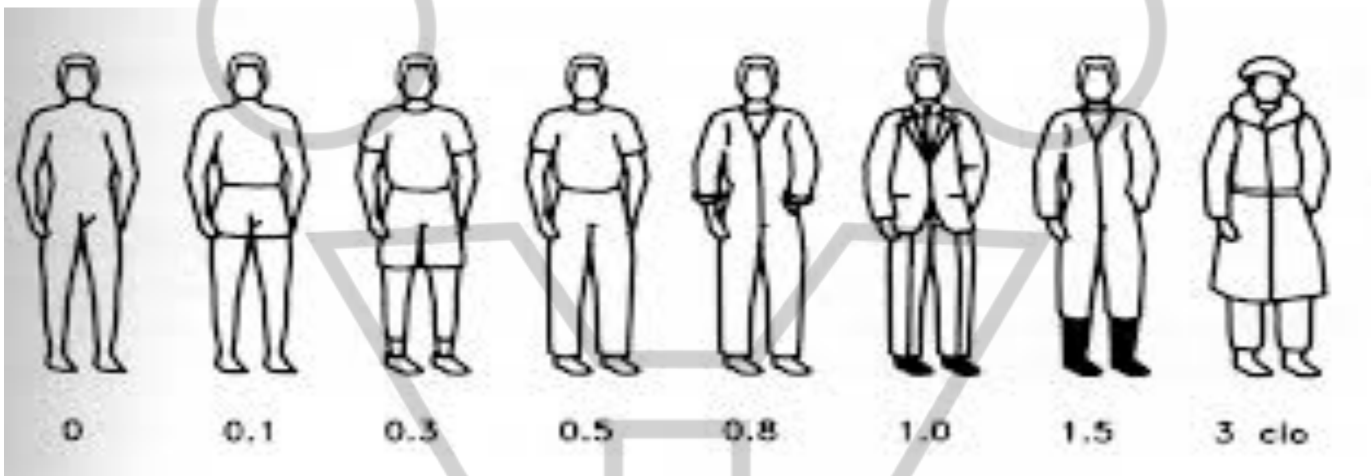
	Btu/h·ft²	met*
Resting		
Sleeping	13	0.7
Reclining	15	0.8
Seated, quiet	18	1.0
Standing, relaxed	22	1.2
Walking (on level surface)		
2.9 fps (2 mph)	37	2.0
4.4 fps (3 mph)	48	2.6
5.9 fps (4 mph)	70	3.8
Office Activities		
Reading, seated	18	1.0
Writing	18	1.0
Typing	20	1.1
Filing, seated	22	1.2
Filing, standing	26	1.4
Walking about	31	1.7
Lifting/packing	39	2.1
Driving/Flying		
Car	18 to 37	1.0 to 2.0
Aircraft, routine	22	1.2
Aircraft, instrument landing	33	1.8
Aircraft, combat	44	2.4
Heavy vehicle	59	3.2
Miscellaneous Occupational Activities		
Cooking	29 to 37	1.6 to 2.0
Housecleaning	37 to 63	2.0 to 3.4
Seated, heavy limb movement	41	2.2
Machine work		
sawing (table saw)	33	1.8
light (electrical industry)	37 to 44	2.0 to 2.4
heavy	74	4.0
Handling 110 lb bags	74	4.0
Pick and shovel work	74 to 88	4.0 to 4.8
Miscellaneous Leisure Activities		
Dancing, social	44 to 81	2.4 to 4.4
Calisthenics/exercise	55 to 74	3.0 to 4.0
Tennis, singles	66 to 74	3.6 to 4.0
Basketball	90 to 140	5.0 to 7.6
Wrestling, competitive	130 to 160	7.0 to 8.7

Sources: Compiled from various sources. For additional information, see Buskirk (1960), Passmore and Durnin (1967), and Webb (1964).

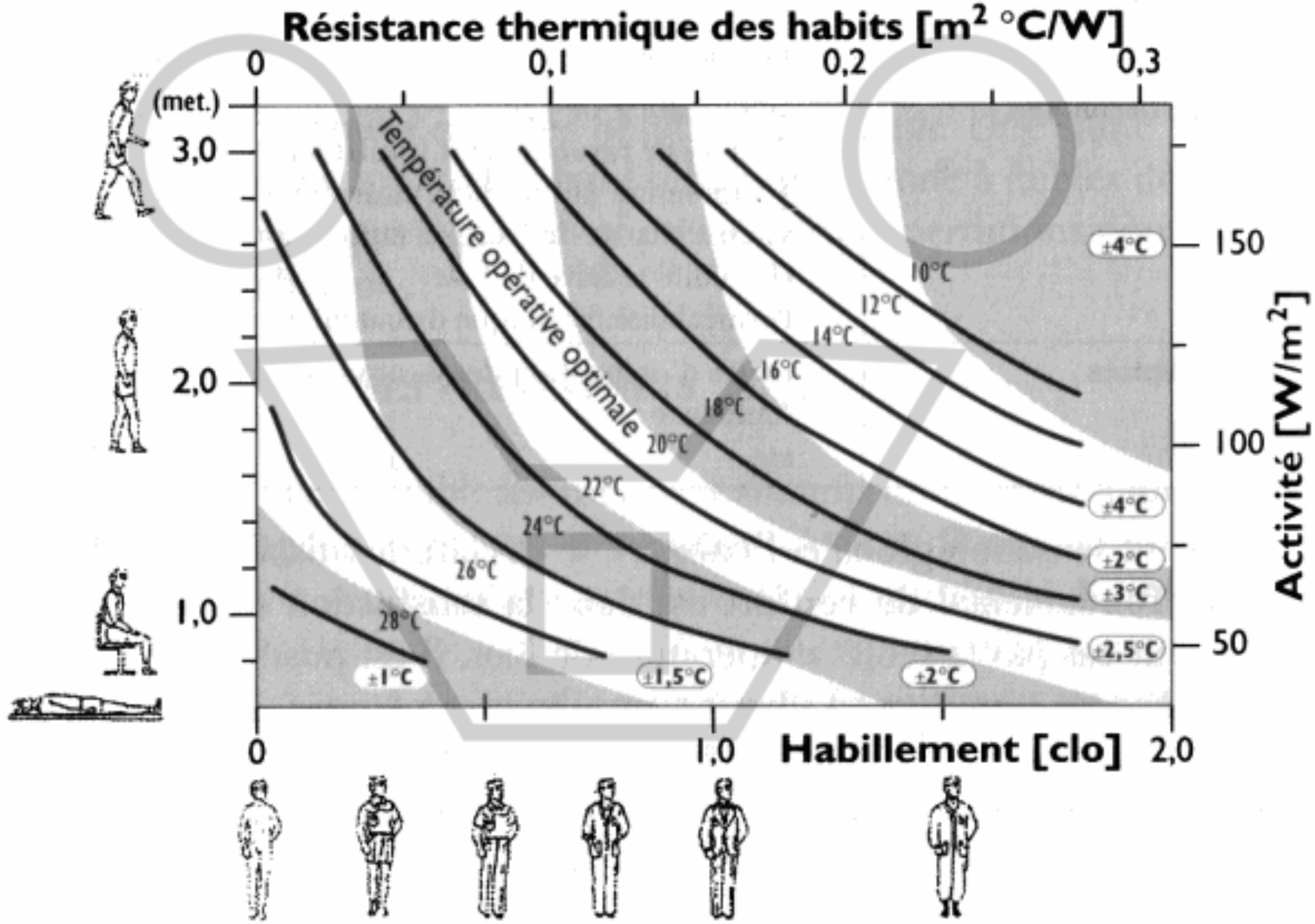
*1 met = 18.4 Btu/h·ft²

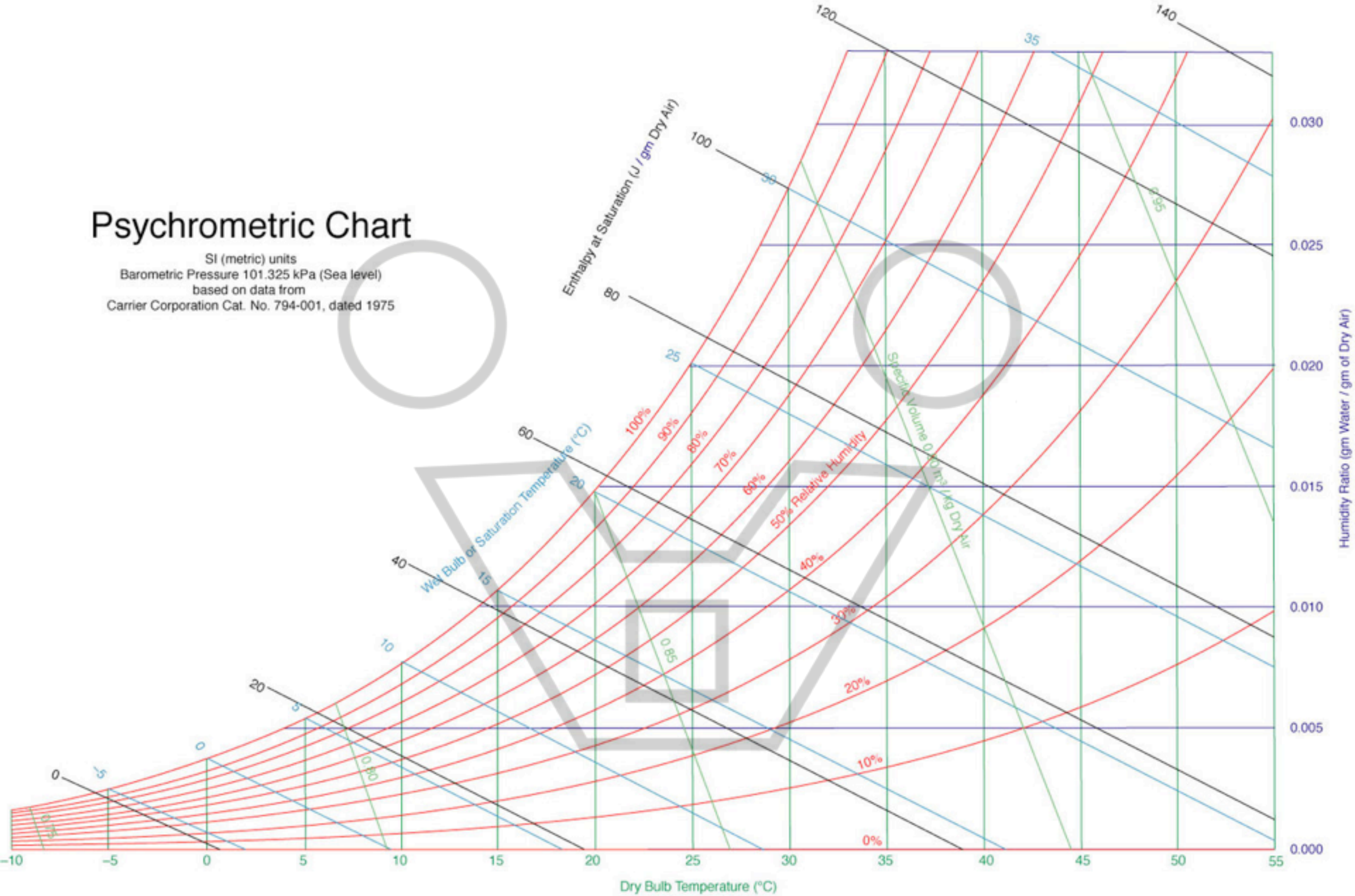
Environmental elements that affect people's comfort

DRESSING PROFILES



THERMAL COMFORT ZONE




Psychrometric Chart
SI (metric) units
Barometric Pressure 101.325 kPa (Sea level)
based on data from
Carrier Corporation Cat. No. 794-001, dated 1975
Enthalpy at Saturation (J / gm Dry Air)
Wet Bulb or Saturation Temperature (°C)
50% Relative Humidity
Specific Volume 0.90 m3 / kg Dry Air
Humidity Ratio (gm Water / gm of Dry Air)
Dry Bulb Temperature (°C)

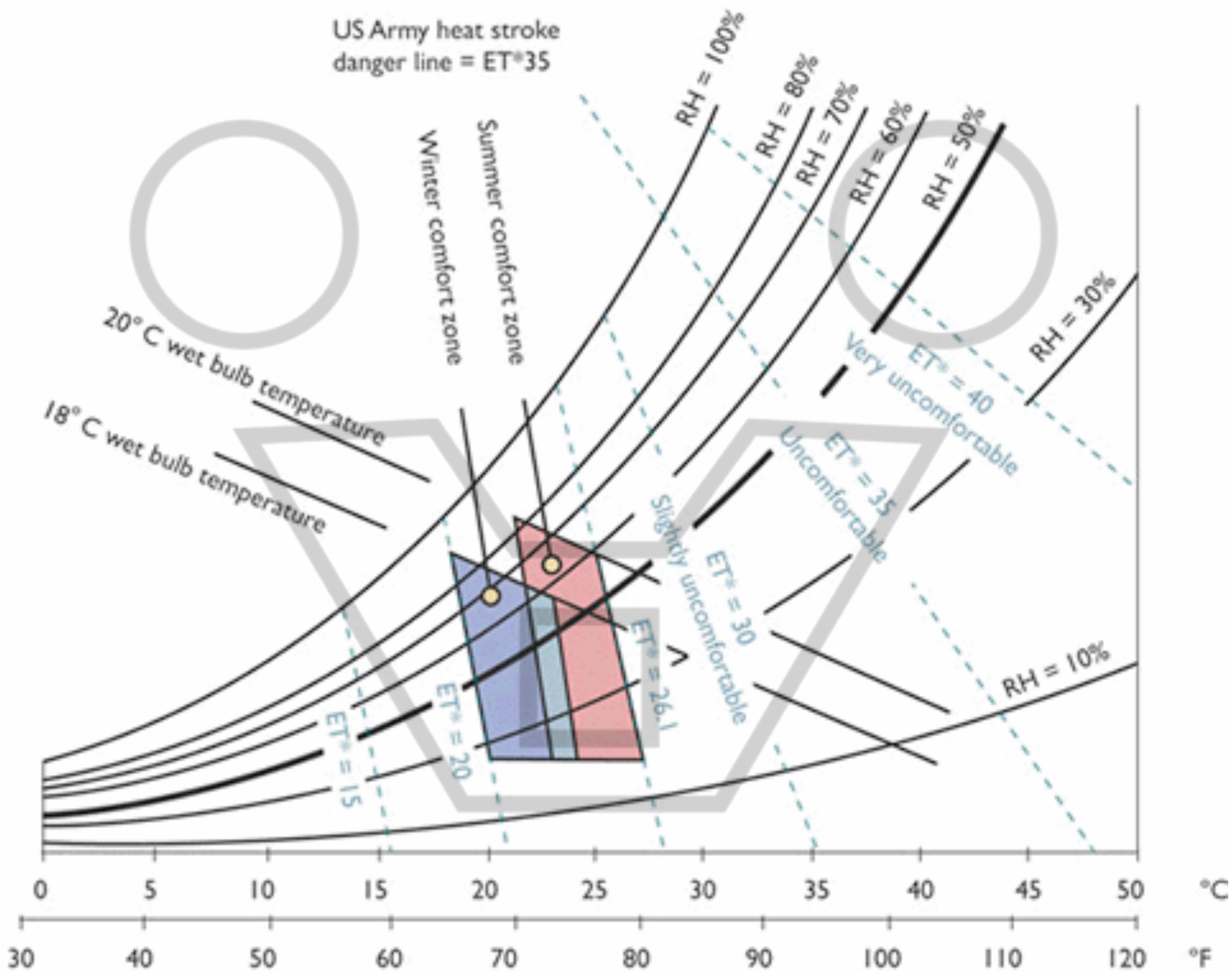
Environmental elements that affect people's comfort

PERCEIVED TEMPERATURE AND DISCOMFORT INDEX

	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
42°	48	50	52	55	57	59	62	64	66	68	71	73	75	77	80	82
41°	46	48	51	53	55	57	59	61	64	66	68	70	72	74	76	79
40°	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75
39°	43	45	47	49	51	53	55	57	59	61	63	65	66	68	70	72
38°	42	44	45	47	49	51	53	55	56	58	60	62	64	66	67	69
37°	40	42	44	45	47	49	51	52	54	56	58	59	61	63	65	66
36°	39	40	42	44	45	47	49	50	52	54	55	57	59	60	62	63
35°	37	39	40	42	44	45	47	48	50	51	53	54	56	58	59	61
34°	36	37	39	40	42	43	45	46	48	49	51	52	54	55	57	58
33°	34	36	37	39	40	41	43	44	46	47	48	50	51	53	54	55
32°	33	34	36	37	38	40	41	42	44	45	46	48	49	50	52	53
31°	32	33	34	35	37	38	39	40	42	43	44	45	47	48	49	50
30°	30	32	33	34	35	36	37	39	40	41	42	43	45	46	47	48
29°	29	30	31	32	33	35	36	37	38	39	40	41	42	43	45	46
28°	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
27°	27	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
26°	26	26	27	28	29	30	31	32	33	34	34	35	36	37	38	39
25°	25	25	26	27	27	28	29	30	31	32	33	34	34	35	36	37
24°	24	24	24	25	26	27	28	28	29	30	31	32	33	33	34	35
23°	23	23	23	24	25	25	26	27	28	28	29	30	31	32	32	33
22°	22	22	22	22	23	24	25	25	26	27	27	28	29	30	30	31

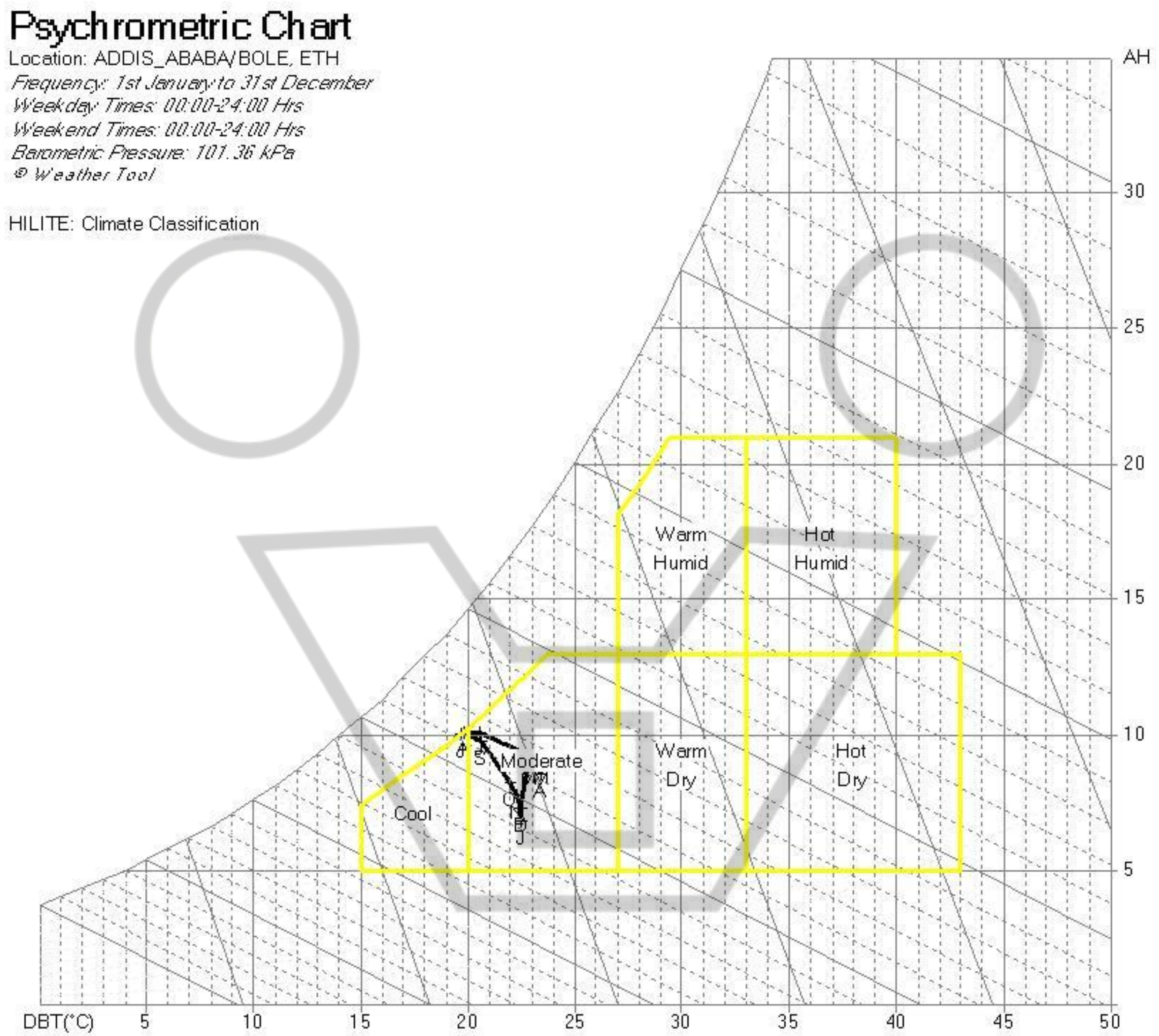
Fino a 29 C°	Nessun disagio
Da 30 a 34 C°	Sensazione di disagio
Da 35 a 39 C°	Intenso disagio. Prudenza: limitare le attività fisiche più pesanti
Da 40 a 45 C°	Forte sensazione di malessere. Pericolo: evitare gli sforzi
Da 46 a 53 C°	Pericolo grave: interrompere tutte le attività fisiche
Oltre 54 C°	Pericolo di morte: colpo di calore imminente

Environmental elements that affect people's comfort

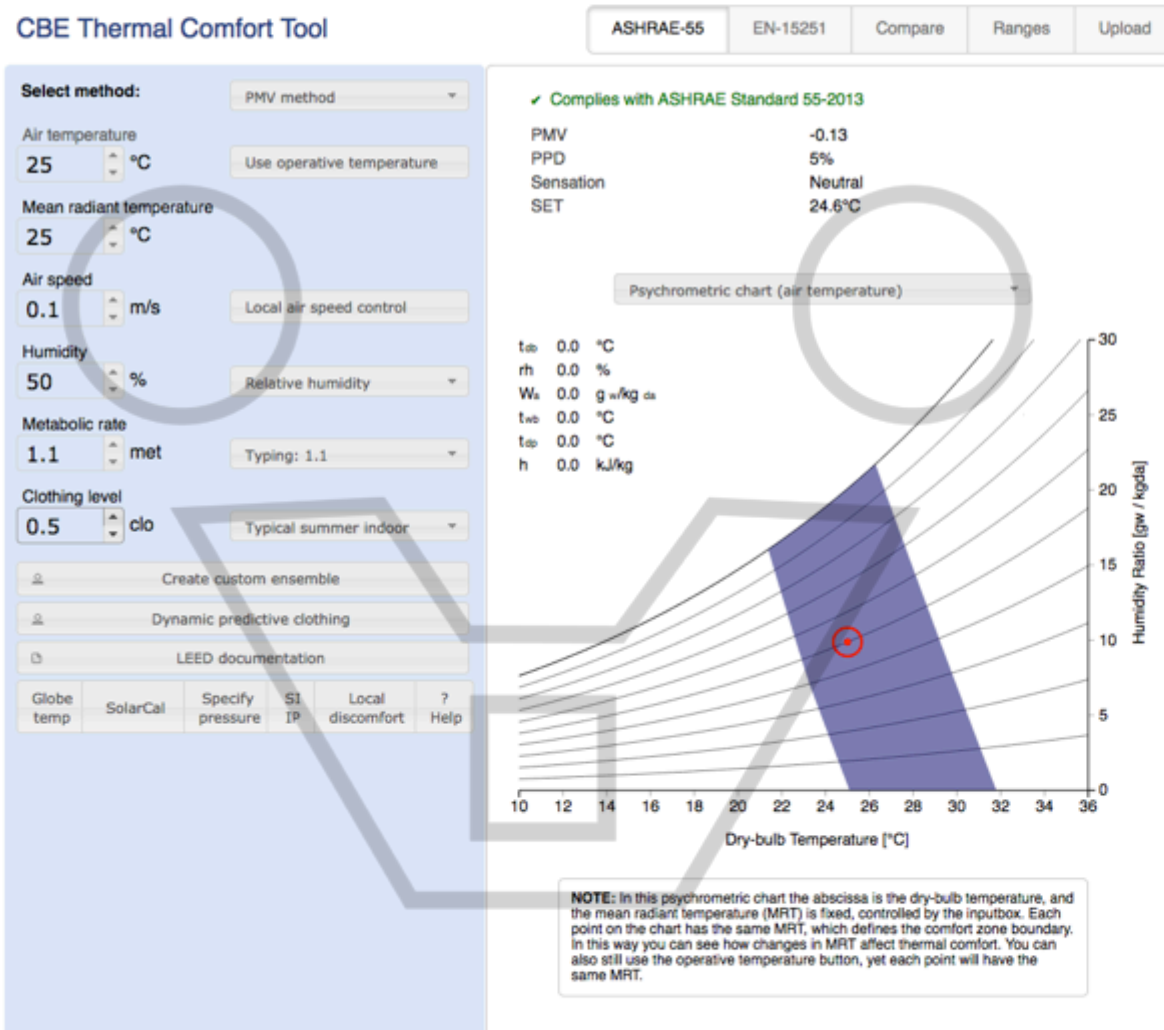


Effective Temperature & THERMAL COMFORT ZONE

Environmental elements that affect people's comfort

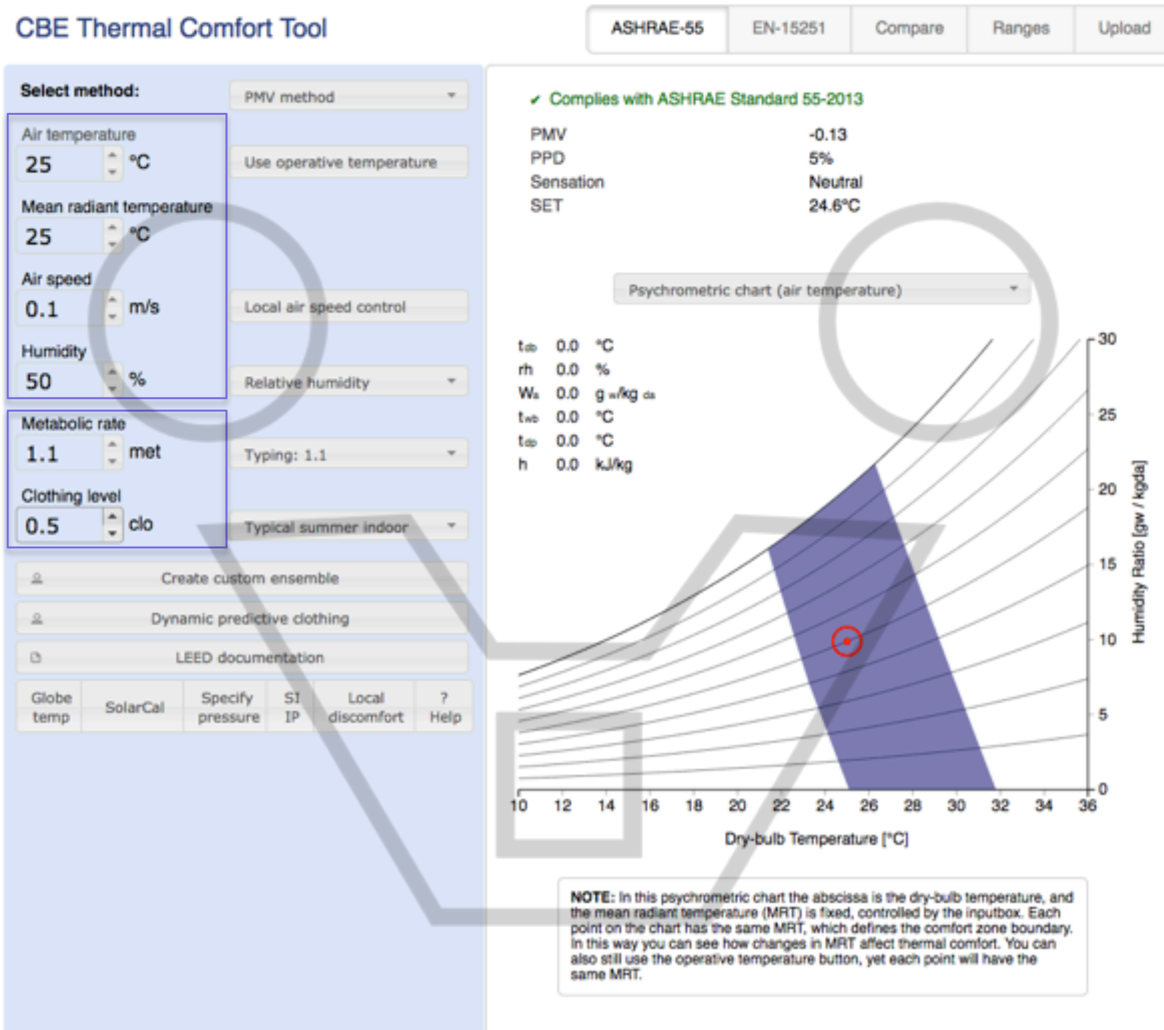


Environmental elements that affect people's comfort



>to access the tool:
http://comfort.cbe.berkeley.edu/EN

Environmental elements that affect people's comfort



>to access the tool:
http://comfort.cbe.berkeley.edu/EN

WEATHER AND CLIMATE COMPUTATIONAL MODELING DATA ANALYSIS IN RELATIONSHIP WITH HUMAN COMFORT

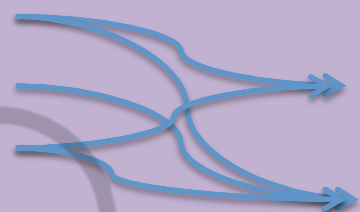
- THERMAL FACTOR
- DAYLIGHT FACTOR

WEATHER AND CLIMATE COMPUTATIONAL MODELING
DATA ANALYSIS IN RELATIONSHIP WITH HUMAN COMFORT

- THERMAL FACTOR

Environmental parameters affecting thermal comfort:

- **SOLAR ENERGY**
- **VENTILATION**
- **HUMIDITY**



- radiant temperature
- air temperature

HOW TO MEASURE SOLAR ENERGY ?

RADIATION=W/m2

Environmental parameters affecting thermal comfort:

- **SOLAR ENERGY**
- **VENTILATION**
- **HUMIDITY**

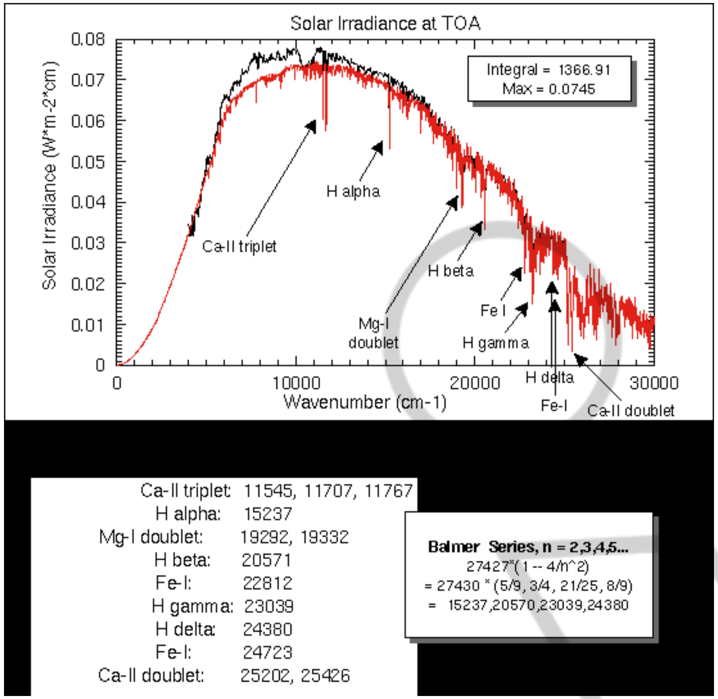
- radiant temperature
- air temperature

HOW TO MEASURE SOLAR ENERGY ?

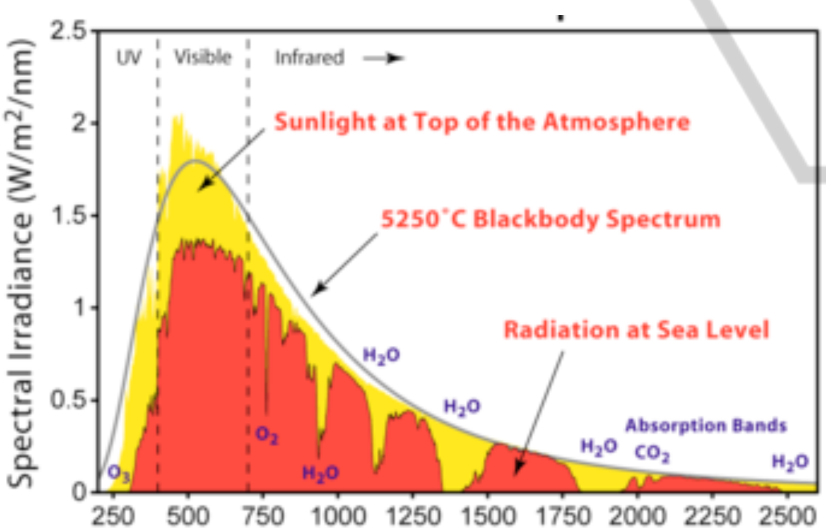
RADIATION=W/m2

Environmental parameters affecting thermal comfort: : SOLAR ENERGY

Solar radiation at top of the atmosphere.



Solar radiation spectrum



1366 W/m² (solar costant)

1 W = 3,416 Btu.

Considering the earth surface,
the total solar energy is= 174 PW
Peta= million of billions

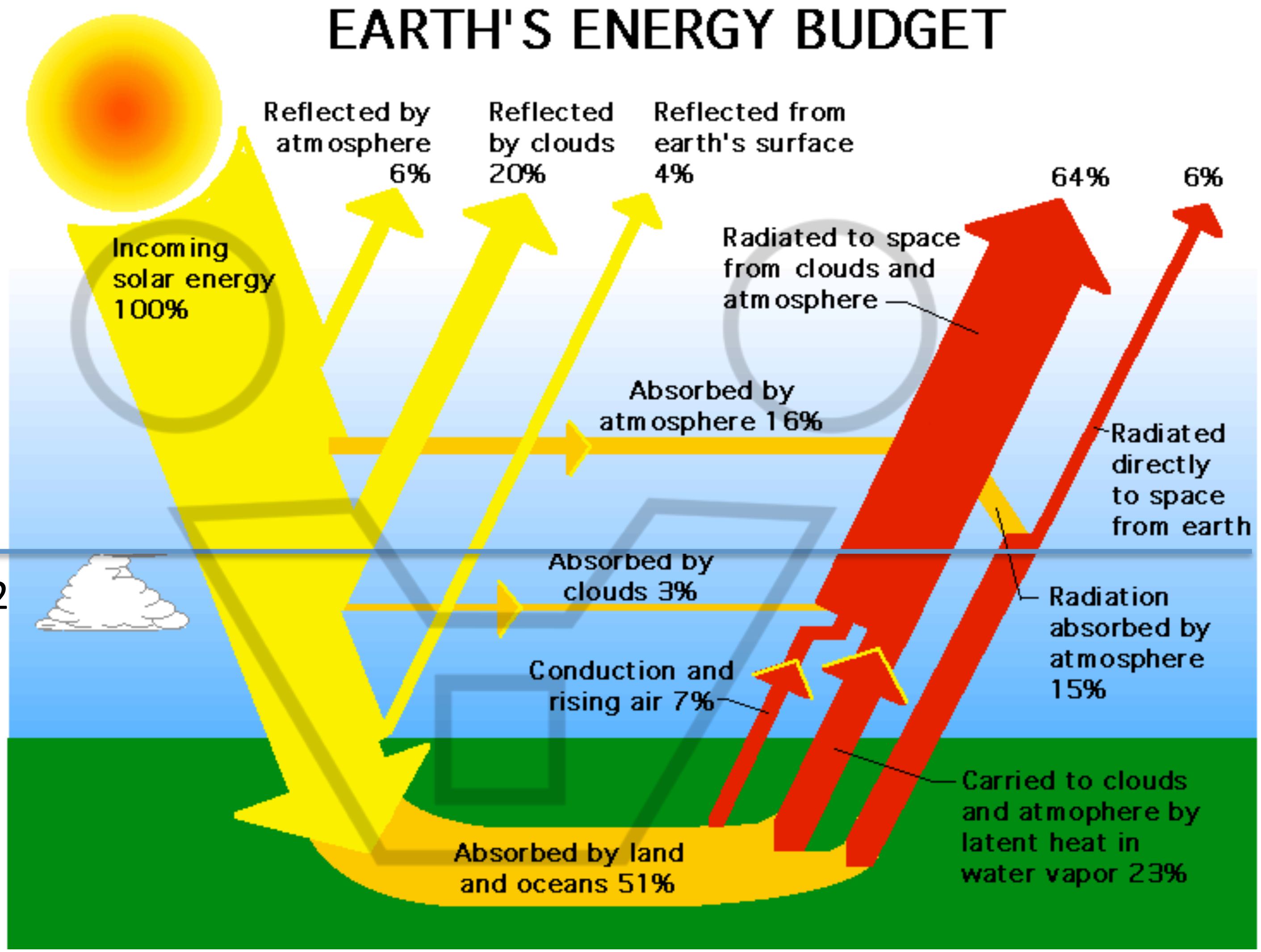
Environmental parameters affecting thermal comfort: : SOLAR ENERGY

100%=1366 W/m2

26%= 356 W/m2

74% =1010 W/m2

1.000 W/m2

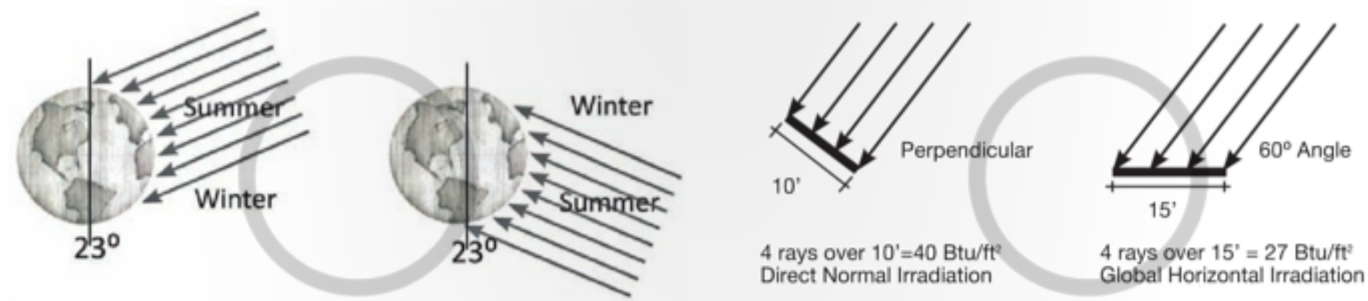


Other source says 45% absorbed by land and oceans

Environmental parameters affecting thermal comfort: : SOLAR ENERGY

Environmental parameters affecting thermal comfort: : SOLAR ENERGY

SOLAR ENERGY f(power, angle of incidence, sky conditions)

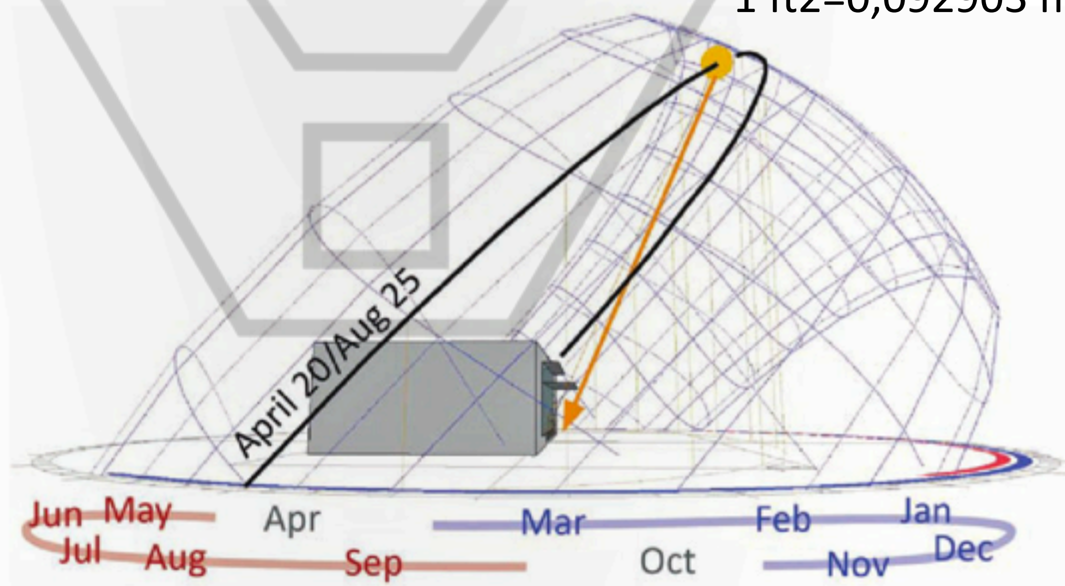


1 Btu=0,293071 W/h
1 ft2=0,092903 m2

7.2

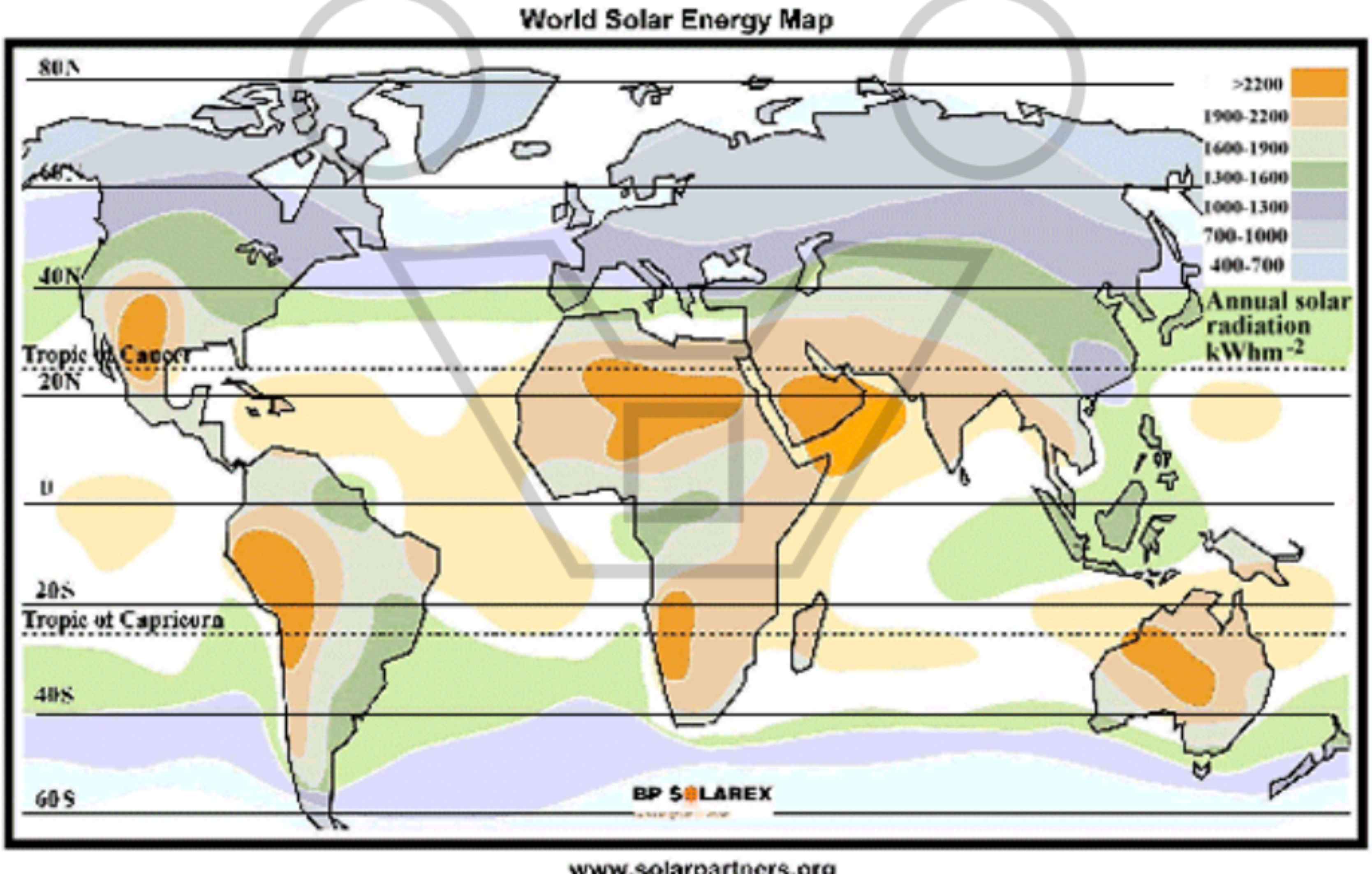
Solar path analysis, looking east. Unfortunately, fixed shading that reduces heat gain in the cooling month of September also reduces heat gain in the heating month of March. Solar path analysis from Ecotect using Toronto Airport weather data.

Source: Courtesy of Callison.



http://andrewmarsh.com/software/sunpath-on-map-web/

Environmental parameters affecting thermal comfort: : SOLAR ENERGY



Environmental parameters affecting thermal comfort: : SOLAR ENERGY

Site Inventory: Physical Attributes 121

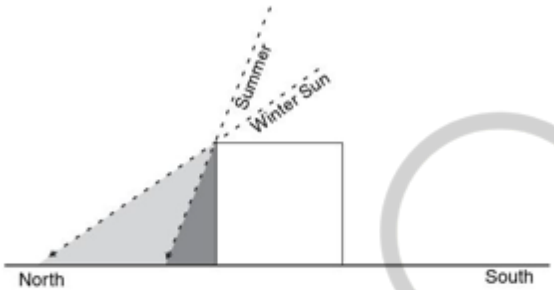
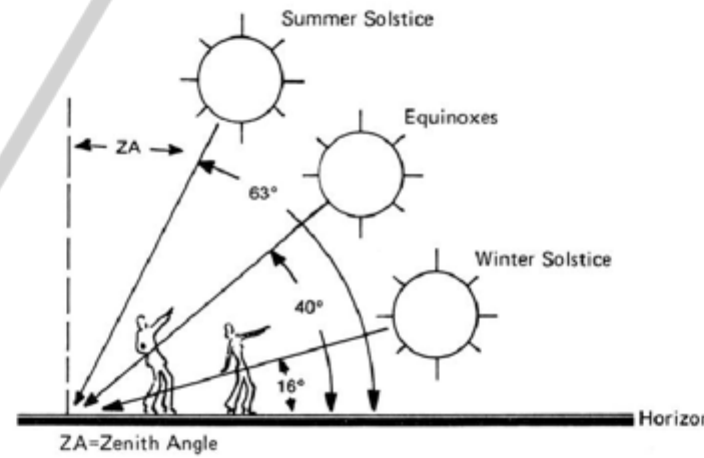


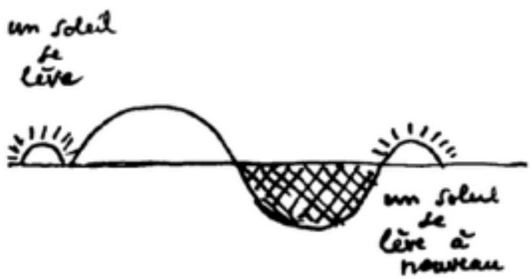
Figure 5-15 Schematic diagram of the seasonal variation in shade cast by a building in the northern hemisphere. Solar exposure in outdoor spaces near a building varies not only with weather conditions but also with time of day, day of year, and location of the space in relation to both the building and the sun.

120 Site Analysis

Figure 5-14 Diagram of seasonal changes in the maximum daily sun angle for a mid-latitude location in the Northern Hemisphere. Source: Marsh, *Landscape Planning*, Third Ed., copyright © 1998, p. 290, Figure 15.3. Reprinted by permission of John



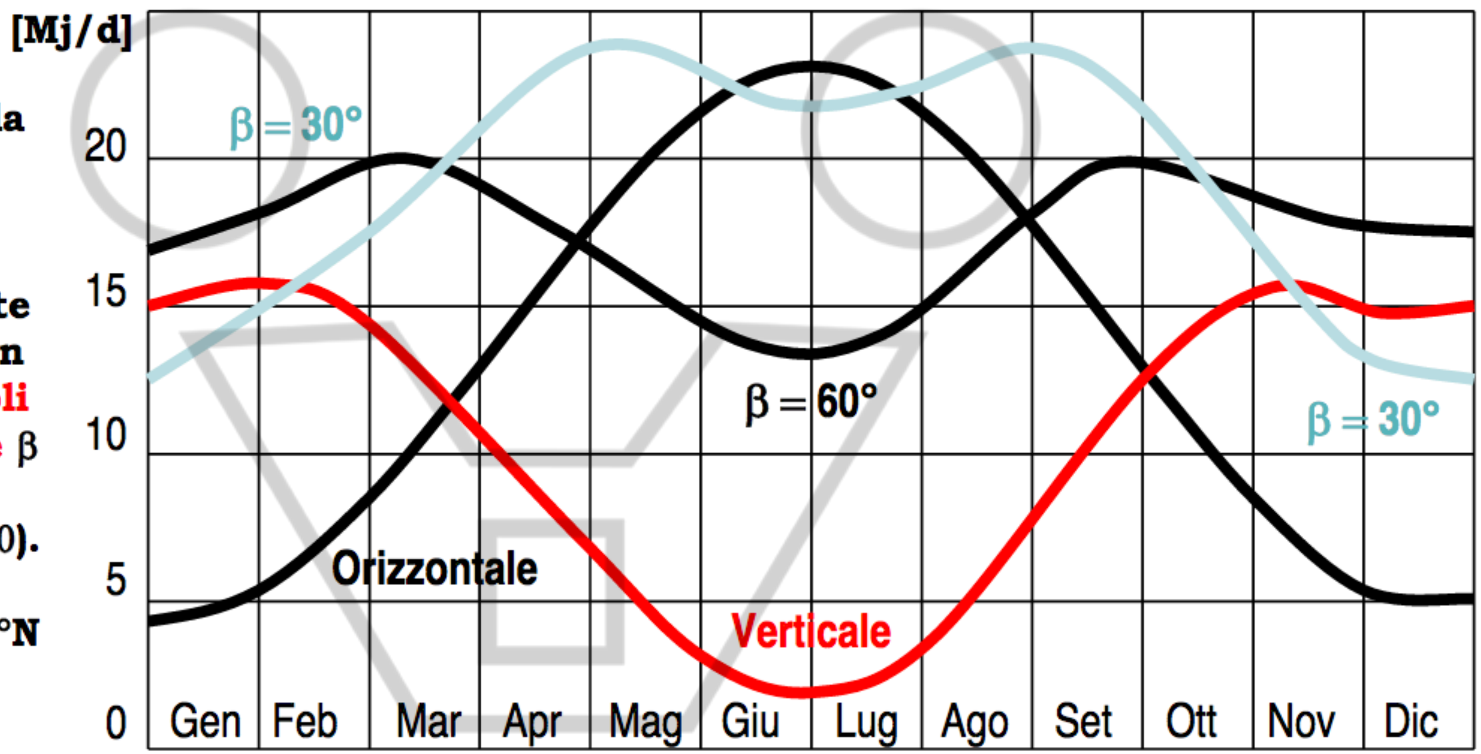
les 24 heures Solaires



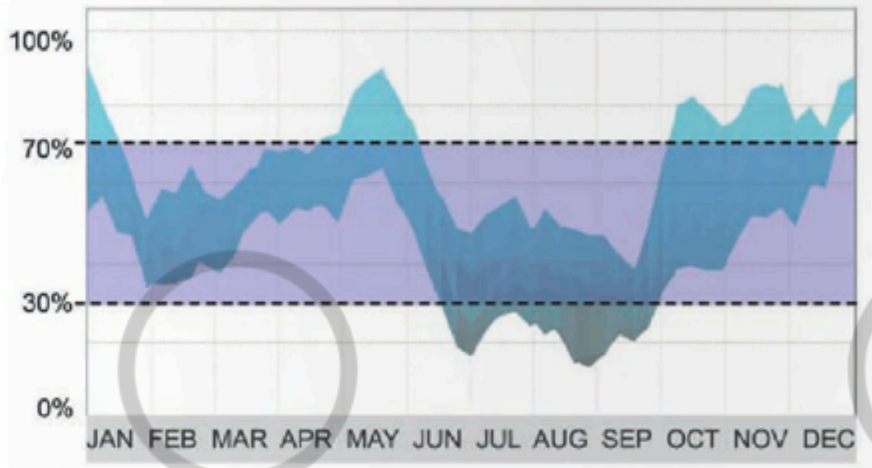
Si la totalité des conditions necessaires et suffisantes n'est pas acquise, il y a déséquilibre, insuffisance — malheur chaque jour et ... toute la vie !

Environmental parameters affecting thermal comfort: : SOLAR ENERGY

Confronto fra la radiazione solare giornaliera media incidente su superfici con differenti angoli di inclinazione β ed orientate a Sud (azimut γ=0). Località con latitudine φ=40°N (Nuoro) e cielo sereno



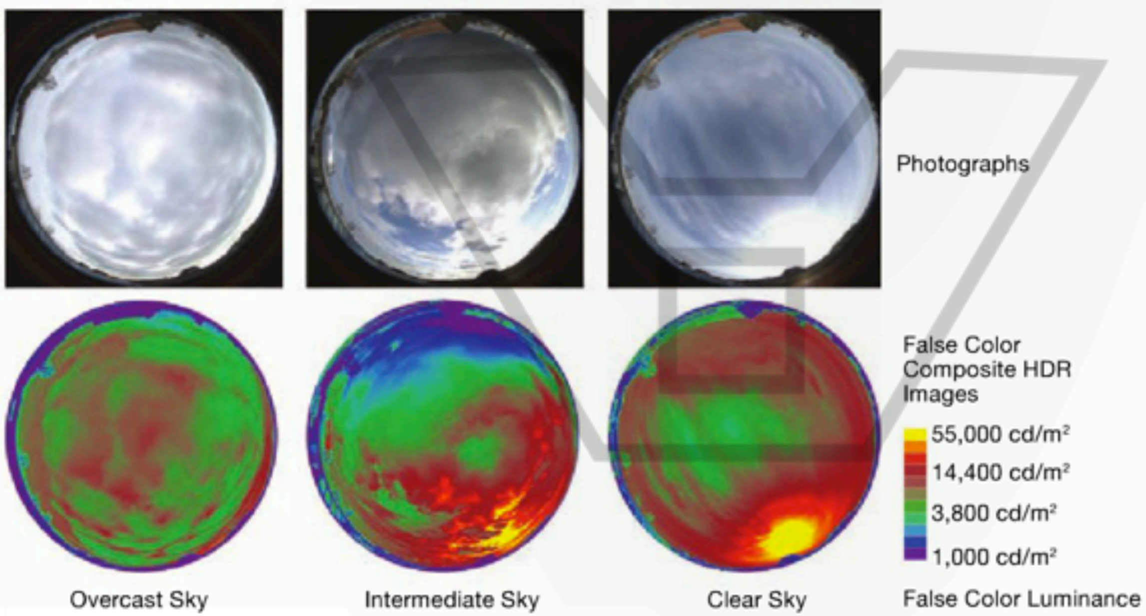
Environmental parameters affecting thermal comfort: : SOLAR ENERGY



8.2

Cloud cover in Allen, Texas, varies from intermediate and overcast in winter, to intermediate and clear in summer. The CIE defines clear skies as >70% cloud cover, overcast skies as <30% cloud cover, and other skies as intermediate.

Source: Modified output from Autodesk Ecotect Suite. Courtesy of Callison.



8.3

Actual sky conditions that correspond to overcast, intermediate, and clear skies are shown using high dynamic range (HDR) fish-eye photographs and false color images. While most daylight simulation uses synthetic, averaged sky conditions, actual sky conditions vary by the minute. HDR skies can be used in daylighting simulations, see Case Study 8.6.

Source: Inanici (2010). Images © Illuminating Engineering Society, www.ies.org.

The influence of the site: sky conditions

Environmental parameters affecting thermal comfort: : SOLAR ENERGY

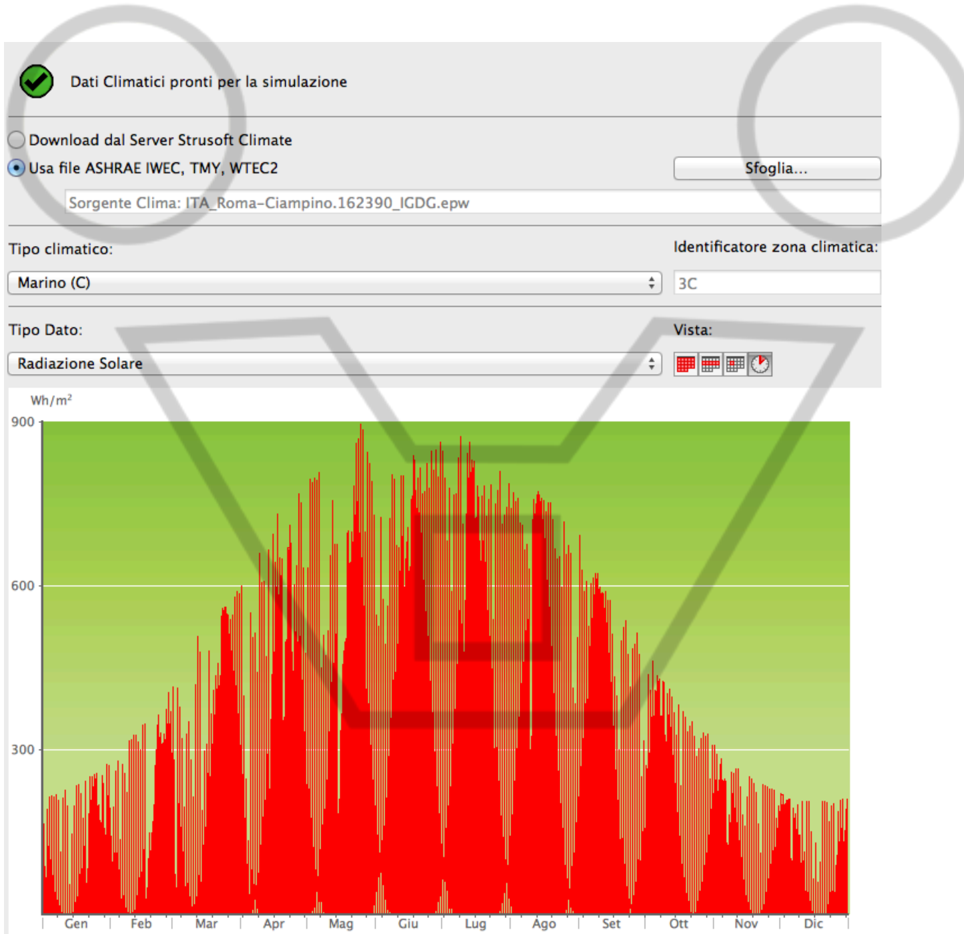
	Condizioni atmosferiche							
Radiazione solare	Cielo sereno	Nebbia	Nuvoloso	Disco solare giallo	Disco solare bianco	Sole appena percettibile	Nebbia fitta	Cielo coperto
								
globale	1000 W/m²	600 W/m²	500 W/m²	400 W/m²	300 W/m²	200 W/m²	100 W/m²	50 W/m²
diretta	90%	50%	70%	50%	40%	0%	0%	0%
diffusa	10%	50%	30%	50%	60%	100%	100%	100%

http://www.sunsim.it/

Environmental parameters affecting thermal comfort: : SOLAR ENERGY

SOLAR ENERGY= **f** (power, angle of incidence, sky conditions)= **World Location**

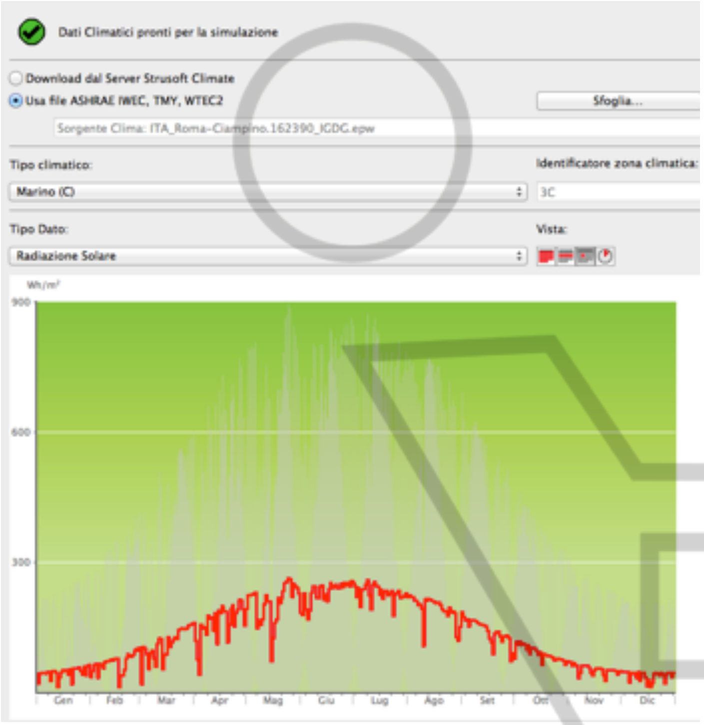
Environmental parameters affecting thermal comfort: : SOLAR ENERGY

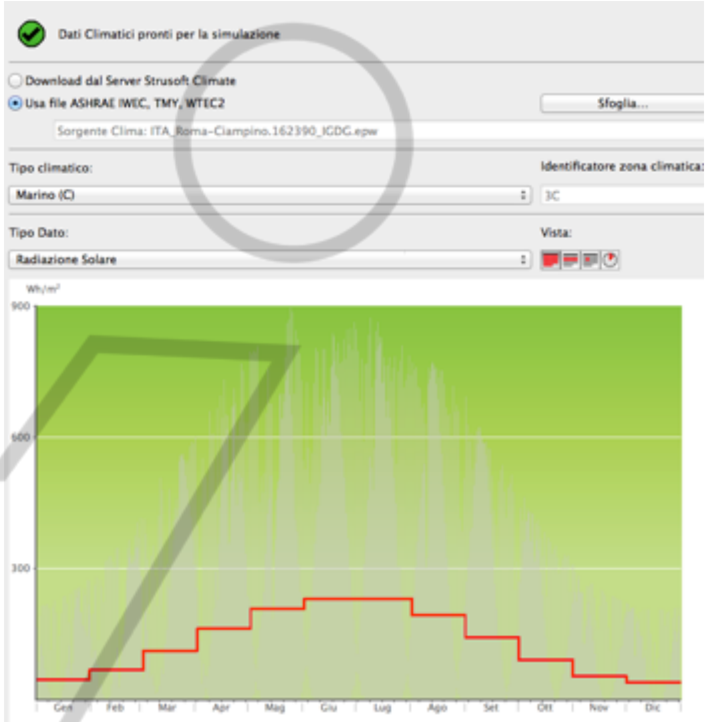


Environmental parameters affecting thermal comfort: : SOLAR ENERGY

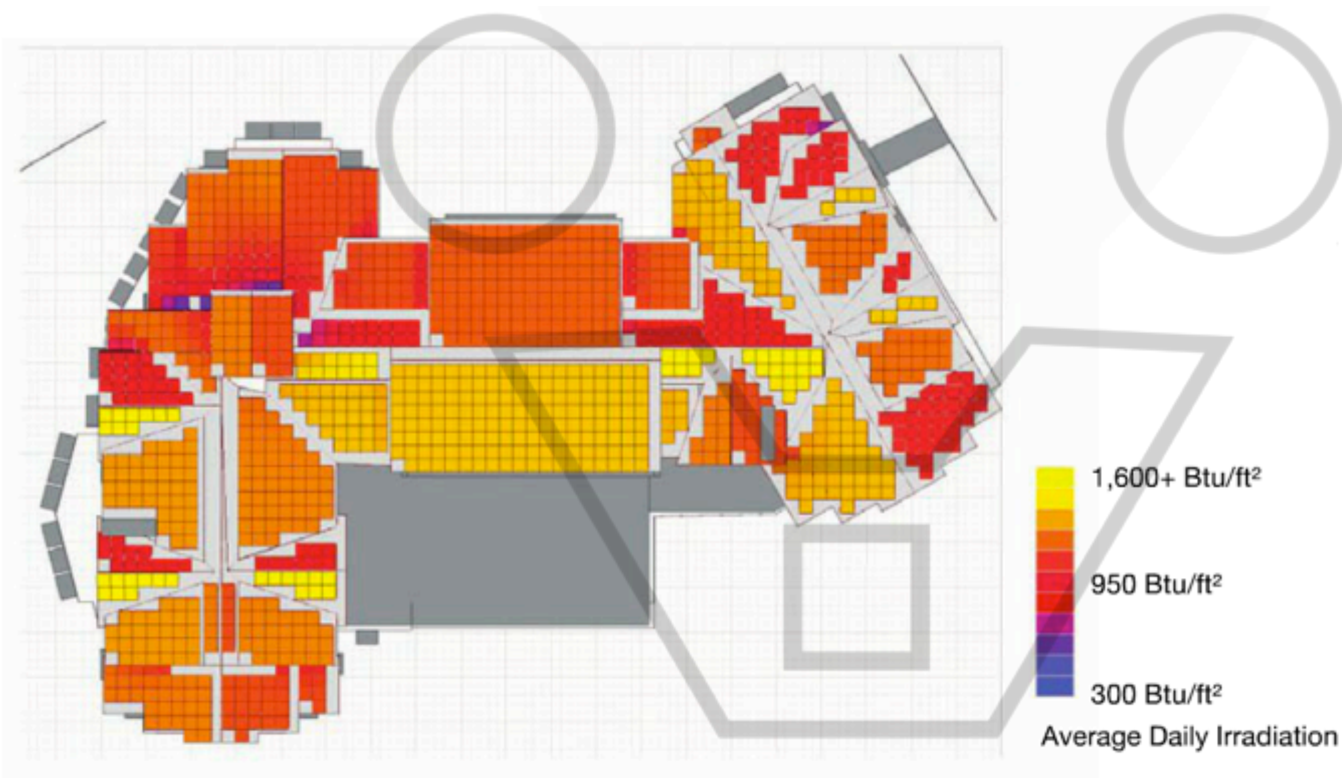
THERMAL ANALYSIS FACTORS: SOLAR RADIATION

Detailed and average





Irradiation analysis

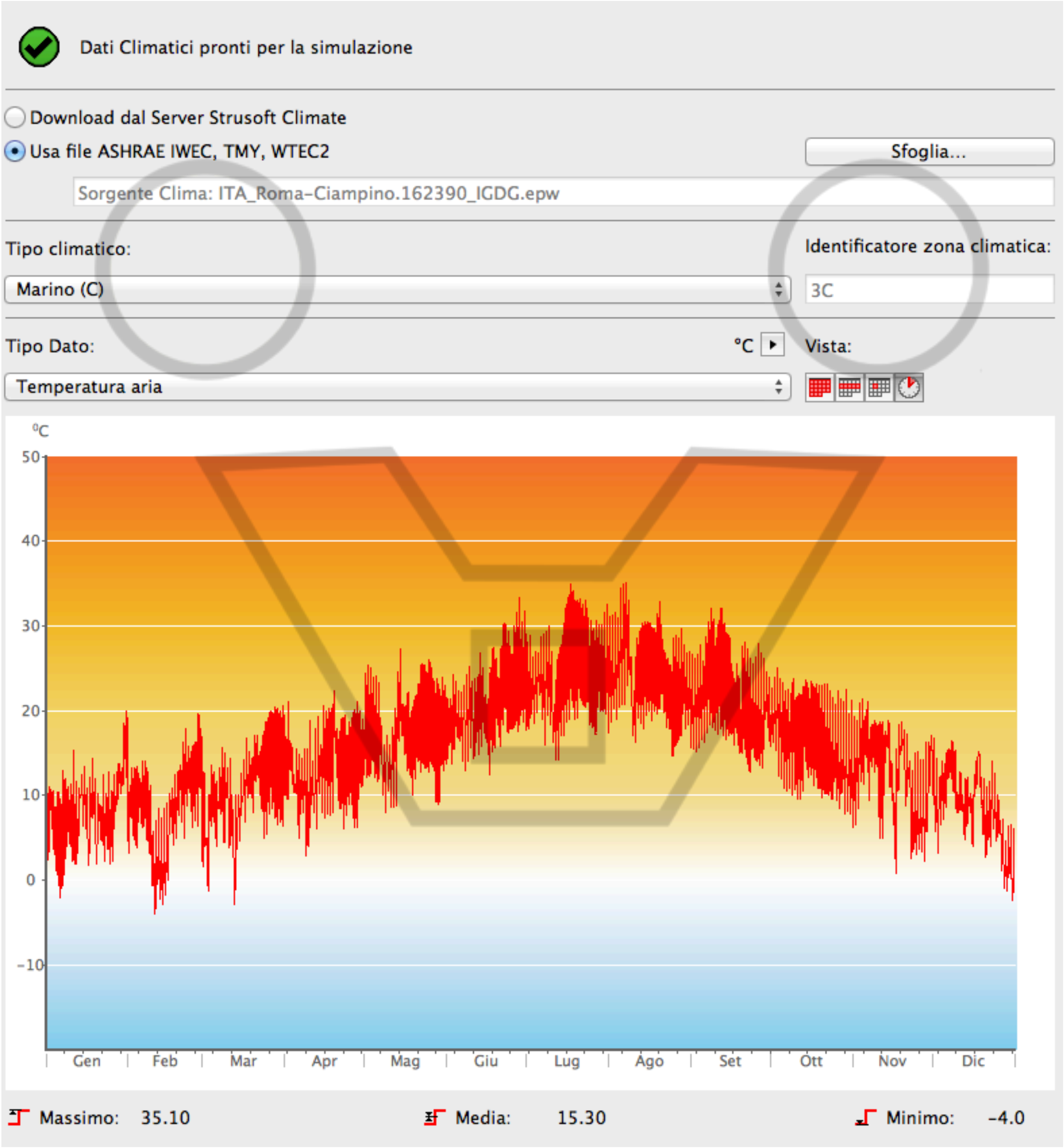


7.8

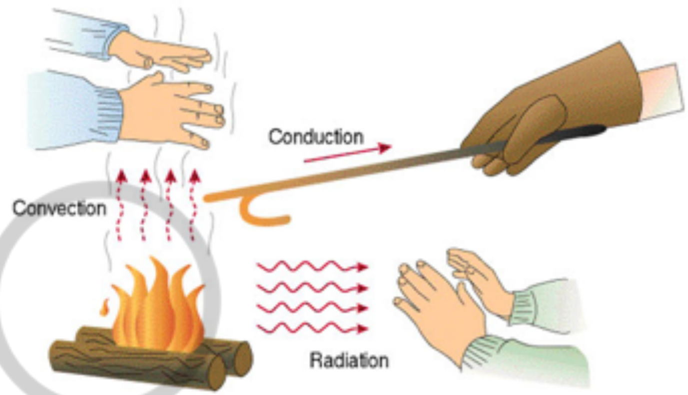
Roof plan with annual solar irradiation analysis to show ideal orientations and roof forms for renewable energy collection using Autodesk Ecotect.

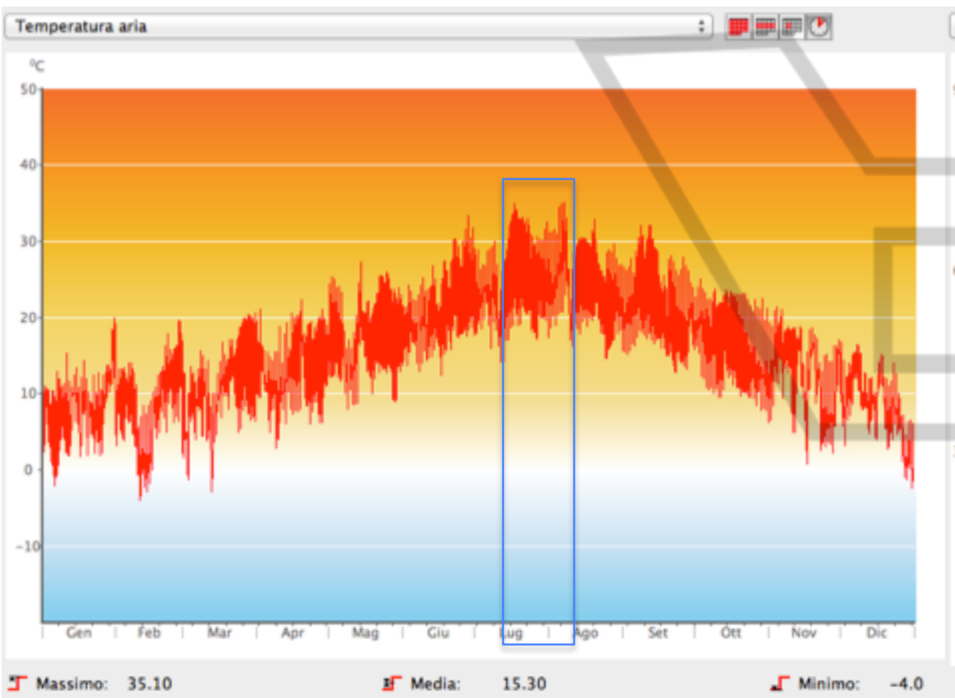
Source: Courtesy of Callison.

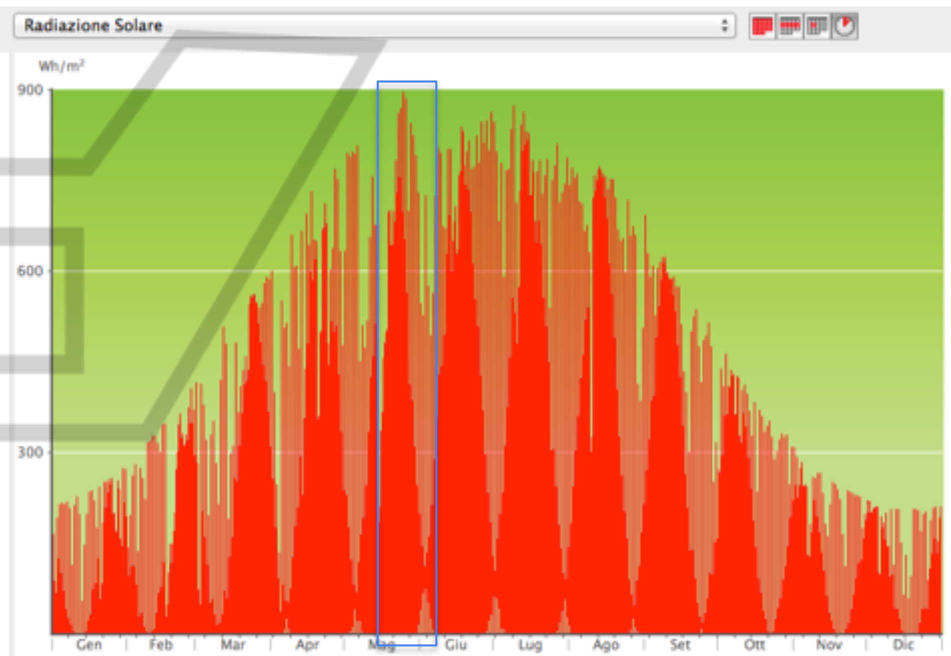
THERMAL ANALYSIS FACTORS: AIR TEMPERATURE



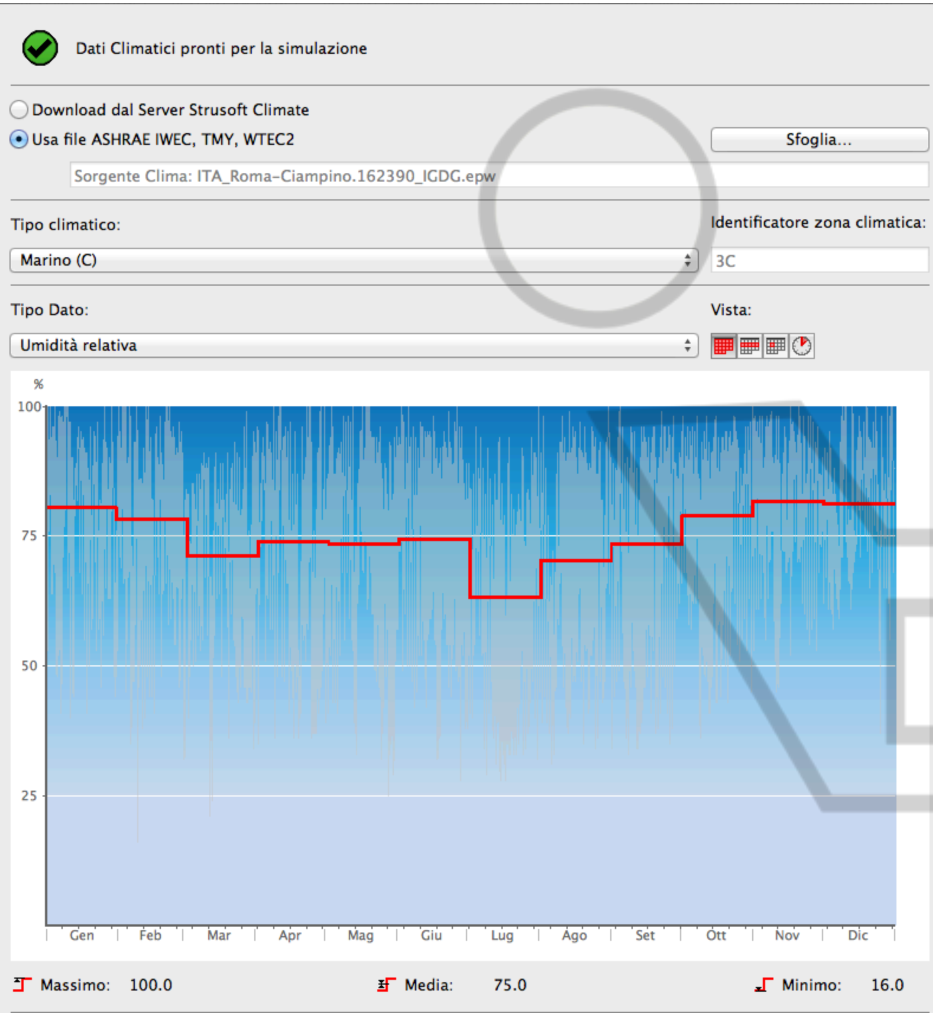
THERMAL ANALYSIS FACTORS: AIR TEMPERATURE

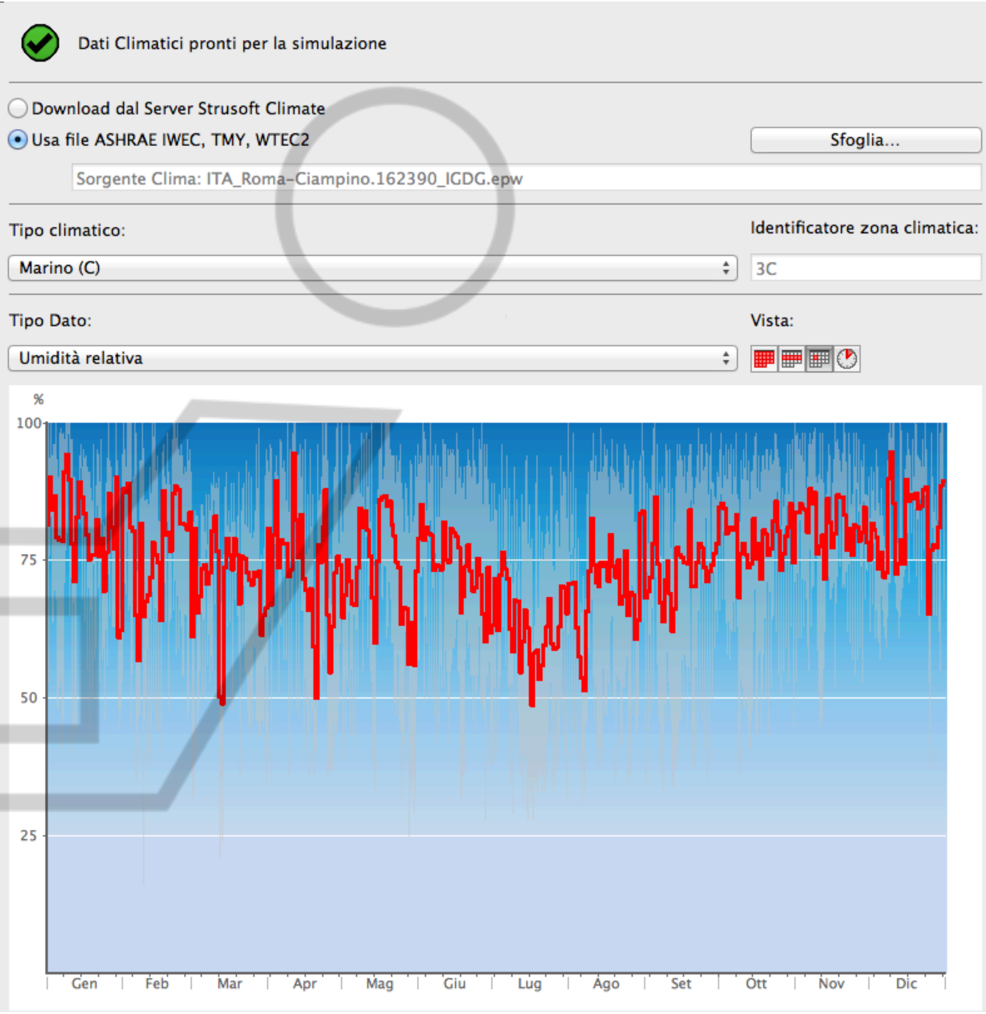






THERMAL ANALYSIS FACTORS: HUMIDITY
Relative and absolute

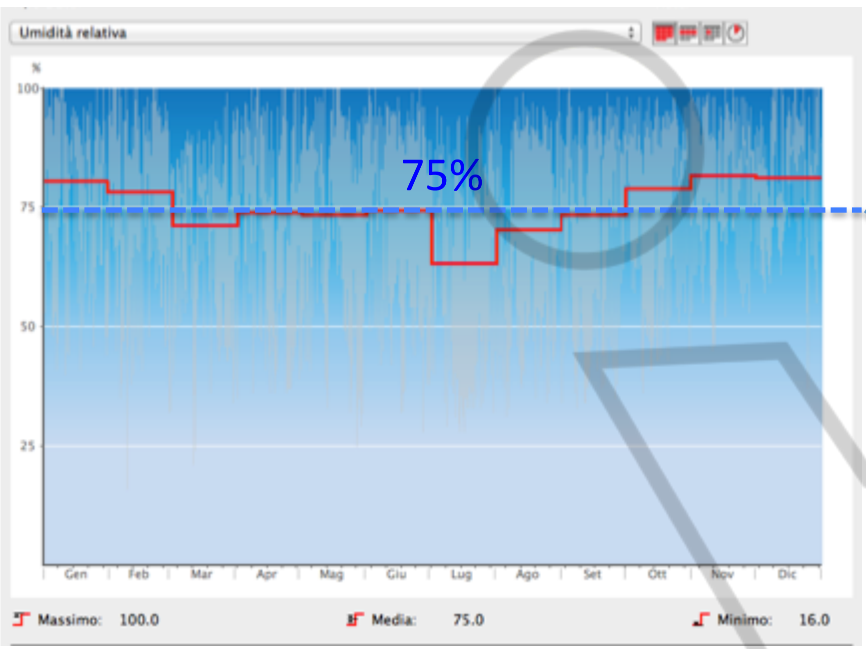




The Apparent Temperature (AT)

The **AT** is defined as; the temperature, at the reference humidity level, producing the same amount of discomfort as that experienced under the current ambient temperature and humidity.

Basically the **AT** is an adjustment to the *ambient temperature* (**T**) based on the level of humidity.



	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
42°	48	50	52	55	57	59	62	64	66	68	71	73	75	77	80	82
41°	46	48	51	53	55	57	59	61	64	66	68	70	72	74	76	79
40°	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73	75
39°	43	45	47	49	51	53	55	57	59	61	63	65	66	68	70	72
38°	42	44	45	47	49	51	53	55	56	58	60	62	64	66	67	69
37°	40	42	44	45	47	49	51	52	54	56	58	59	61	63	65	66
36°	39	40	42	44	45	47	49	50	52	54	55	57	59	60	62	63
35°	37	39	40	42	44	45	47	48	50	51	53	54	56	58	59	61
34°	36	37	39	40	42	43	45	46	48	49	51	52	54	55	57	58
33°	34	36	37	38	40	41	43	44	46	47	48	50	51	53	54	55
32°	33	34	36	37	38	40	41	42	44	45	46	48	49	50	52	53
31°	32	33	34	35	37	38	39	40	42	43	44	45	47	48	49	50
30°	30	32	33	34	35	36	37	39	40	41	42	43	45	46	47	48
29°	29	30	31	32	33	35	36	37	38	39	40	41	42	43	45	46
28°	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
27°	27	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41
26°	26	26	27	28	29	30	31	32	33	34	34	35	36	37	38	39
25°	25	25	26	27	27	28	29	30	31	32	33	34	34	35	36	37
24°	24	24	24	25	26	27	28	28	29	30	31	32	33	33	34	35
23°	23	23	23	24	25	25	26	27	28	28	29	30	31	32	32	33
22°	22	22	22	22	23	24	25	25	26	27	27	28	29	30	30	31

Fino a 29 C°	Nessun disagio
Da 30 a 34 C°	Sensazione di disagio
Da 35 a 39 C°	Intenso disagio. Prudenza: limitare le attività fisiche più pesanti
Da 40 a 45 C°	Forte sensazione di malessere. Pericolo: evitare gli sforzi
Da 46 a 53 C°	Pericolo grave: interrompere tutte le attività fisiche
Oltre 54 C°	Pericolo di morte: colpo di calore imminente

Apparent temperature (AT) as a Wind Chill - after Steadman 1994

Temperature (°C)

Wind Speed (km/h)	-5	-4	-3	-2	-1	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
0	-8	-7	-6	-5	-4	-3	-2	-1	1	2	3	4	5	6	8	9	10	11	12	14	15	16	17	19	20	21
2	-9	-8	-6	-5	-4	-3	-2	-1	0	1	2	4	5	6	7	8	10	11	12	13	15	16	17	18	20	21
4	-9	-8	-7	-6	-5	-4	-2	-1	0	1	2	3	4	6	7	8	9	10	12	13	14	15	17	18	19	21
6	-9	-8	-7	-6	-5	-4	-3	-2	-1	1	2	3	4	5	6	8	9	10	11	12	14	15	16	18	19	20
8	-10	-9	-8	-7	-5	-4	-3	-2	-1	0	1	2	4	5	6	7	8	10	11	12	13	15	16	17	19	20
10	-10	-9	-8	-7	-6	-5	-4	-2	-1	0	1	2	3	4	6	7	8	9	10	12	13	14	16	17	18	20
12	-11	-9	-8	-7	-6	-5	-4	-3	-2	-1	1	2	3	4	5	6	8	9	10	11	13	14	15	16	18	19
14	-11	-10	-9	-8	-7	-5	-4	-3	-2	-1	0	1	2	4	5	6	7	8	10	11	12	13	15	16	17	19
16	-11	-10	-9	-8	-7	-6	-5	-4	-3	-1	0	1	2	3	4	6	7	8	9	11	12	13	14	16	17	18
18	-12	-11	-10	-8	-7	-6	-5	-4	-3	-2	-1	1	2	3	4	5	6	8	9	10	11	13	14	15	17	18
20	-12	-11	-10	-9	-8	-7	-6	-4	-3	-2	-1	0	1	2	4	5	6	7	9	10	11	12	14	15	16	18
22	-13	-11	-10	-9	-8	-7	-6	-5	-4	-3	-1	0	1	2	3	4	6	7	8	9	11	12	13	15	16	17
24	-13	-12	-11	-10	-9	-7	-6	-5	-4	-3	-2	-1	1	2	3	4	5	6	8	9	10	12	13	14	15	17
26	-13	-12	-11	-10	-9	-8	-7	-6	-4	-3	-2	-1	0	1	2	4	5	6	7	9	10	11	12	14	15	16
28	-14	-13	-12	-10	-9	-8	-7	-6	-5	-4	-3	-1	0	1	2	3	5	6	7	8	9	11	12	13	15	16
30	-14	-13	-12	-11	-10	-9	-7	-6	-5	-4	-3	-2	-1	1	2	3	4	5	7	8	9	10	12	13	14	16
32	-14	-13	-12	-11	-10	-9	-8	-7	-6	-4	-3	-2	-1	0	1	3	4	5	6	7	9	10	11	13	14	15
34	-15	-14	-13	-12	-10	-9	-8	-7	-6	-5	-4	-3	-1	0	1	2	3	5	6	7	8	10	11	12	13	15
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60	-20	-19	-18	-17	-16	-14	-13	-12	-11	-10	-9	-8	-6	-5	-4	-3	-2	-1	1	2	3	5	6	7	8	10
62	-20	-19	-18	-17	-16	-15	-14	-13	-11	-10	-9	-8	-7	-6	-5	-3	-2	-1	0	2	3	4	5	7	8	9
64	-21	-20	-19	-17	-16	-15	-14	-13	-12	-11	-10	-8	-7	-6	-5	-4	-2	-1	0	1	2	4	5	6	8	9
66	-21	-20	-19	-18	-17	-16	-14	-13	-12	-11	-10	-9	-8	-6	-5	-4	-3	-2	0	1	2	3	5	6	7	9
68	-21	-20	-19	-18	-17	-16	-15	-14	-13	-11	-10	-9	-8	-7	-6	-4	-3	-2	-1	0	2	3	4	6	7	8
70	-22	-21	-20	-19	-17	-16	-15	-14	-13	-12	-11	-10	-8	-7	-6	-5	-4	-2	-1	0	1	3	4	5	6	8
72	-22	-21	-20	-19	-18	-17	-16	-15	-13	-12	-11	-10	-9	-8	-6	-5	-4	-3	-2	0	1	2	3	5	6	7
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76	-23	-22	-21	-20	-19	-18	-16	-15	-14	-13	-12	-11	-10	-8	-7	-6	-5	-4	-2	-1	0	1	3	4	5	7
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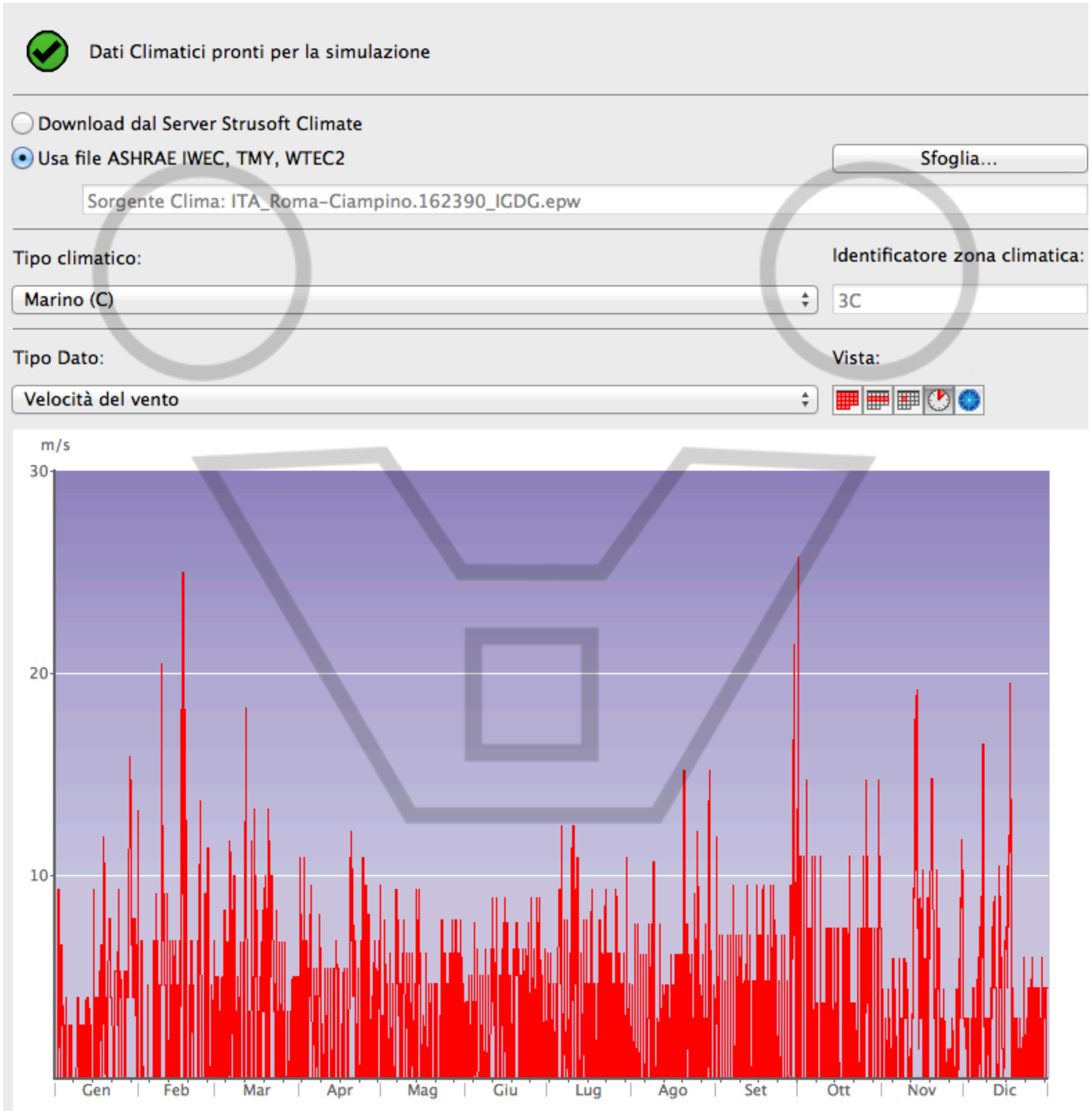
80	-24	-23	-22	-21	-19	-18	-17	-16	-15	-14	-13	-12	-10	-9	-8	-7	-6	-4	-3	-2	-1	1	2	3	5	6

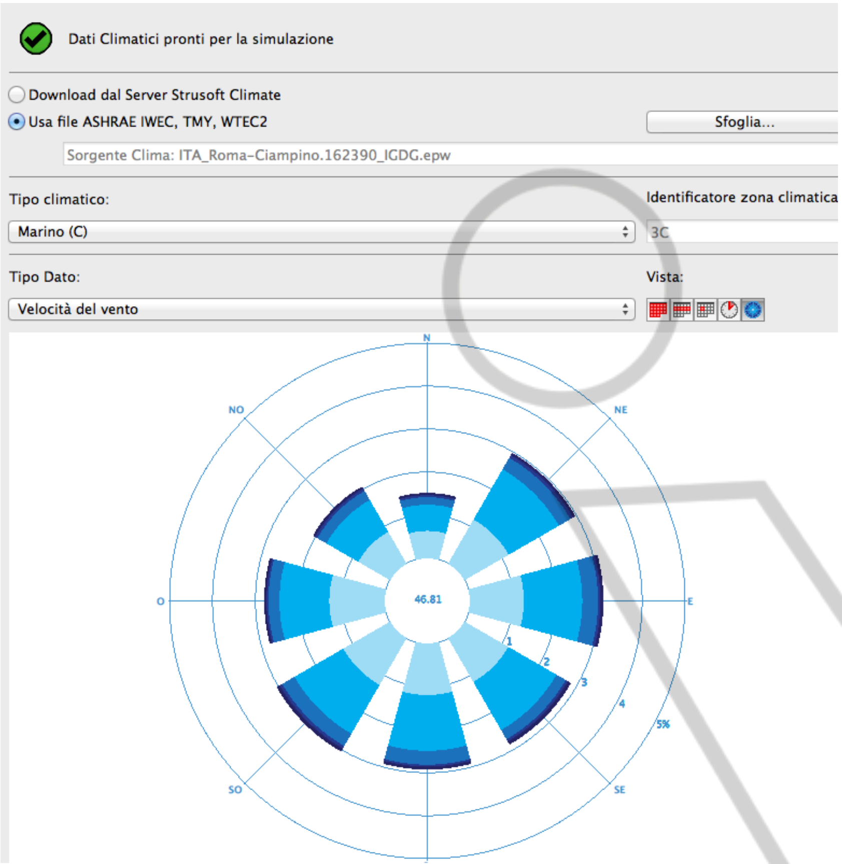
Apparent temperature with no radiational heating and relative humidity fixed at 70%

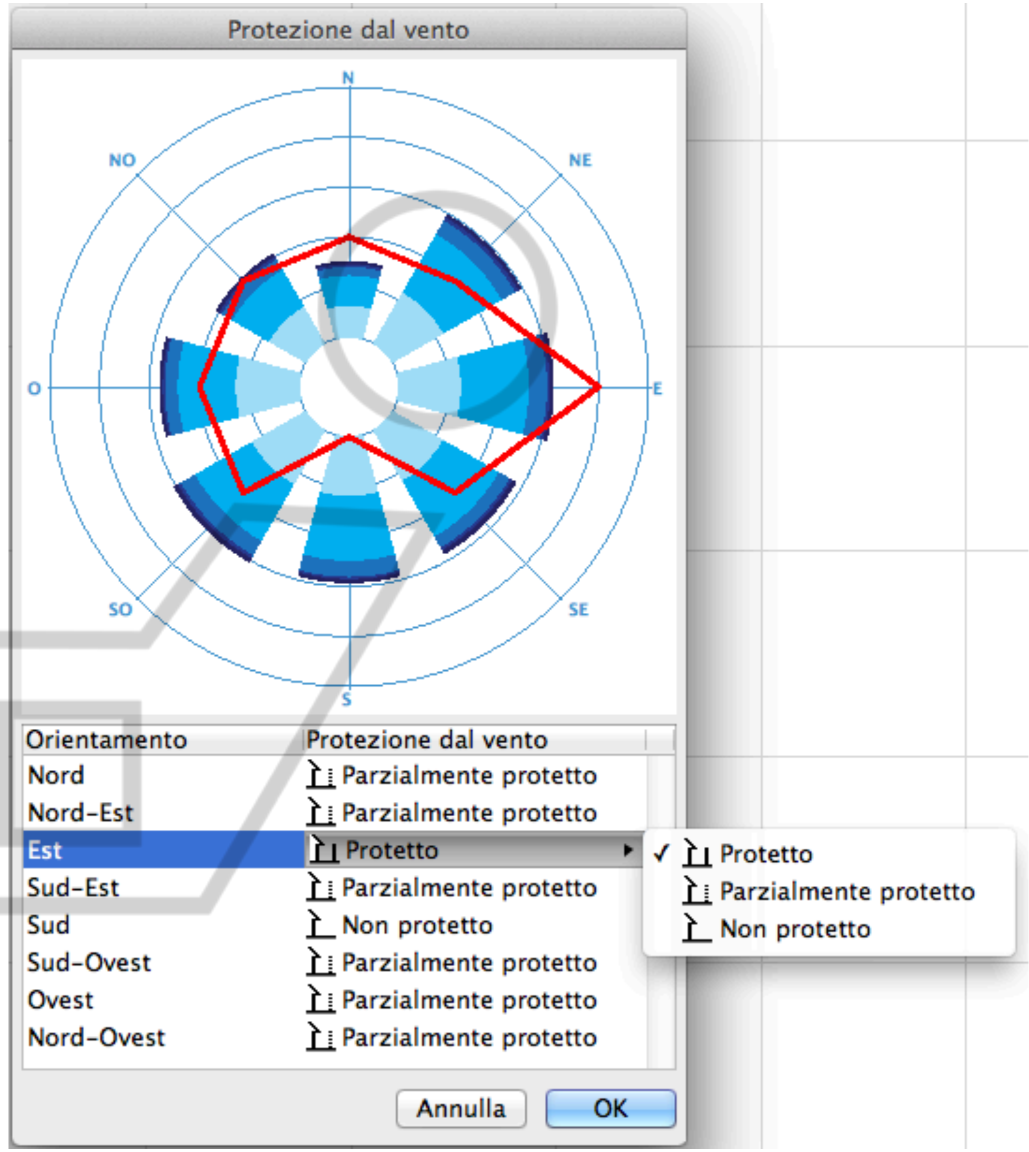
Formula from *Norms of apparent temperature in Australia*, **Aust. Met. Mag**, Vol 43, 1994, 1-16.

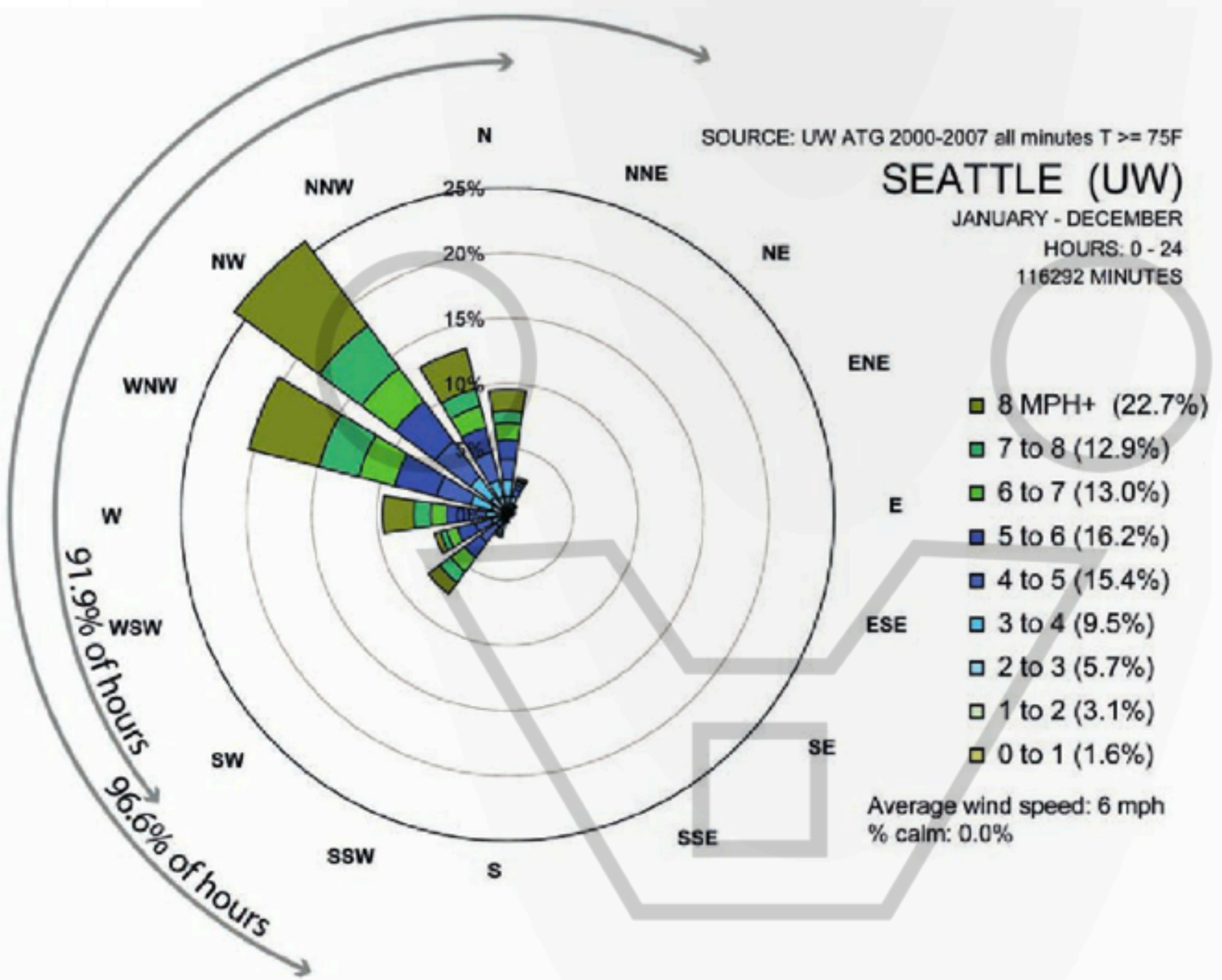
Environmental parameters affecting thermal comfort: WIND & VENTILATION



Environmental parameters affecting thermal comfort: WIND & VENTILATION







9.11

Wind rose for occupied hours where the outdoor temperature >75°F.

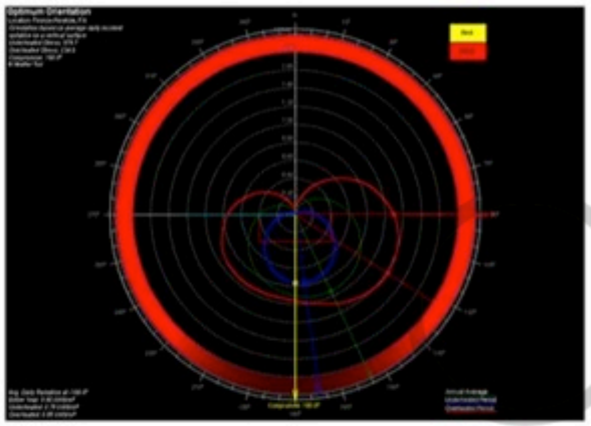
FIND THE PREVALENT WIND IN THE HOTTEST PERIOD WHEN VENTILATION IS MOSTLY REQUIRED
FIND THE PREVLENT WIND IN THE COLDEST PERIOD TO PROTECT THE BUILDING

Environmental parameters affecting thermal comfort: WIND & VENTILATION

Figure 5-16 Climate analysis for a coastal land-planning project in India. Source: The HOK Planning Group.

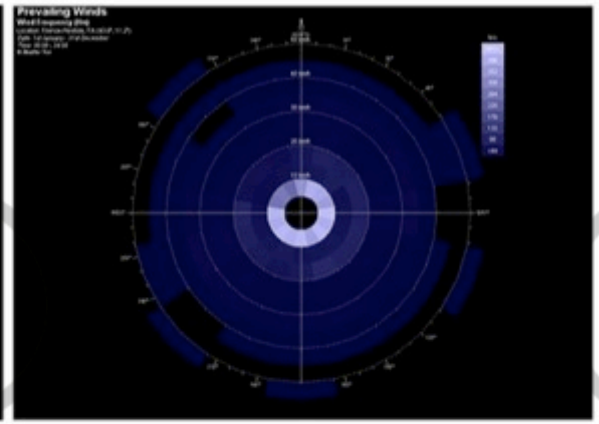
Environmental parameters affecting thermal comfort: ORIENTATION

Optimum Orientation

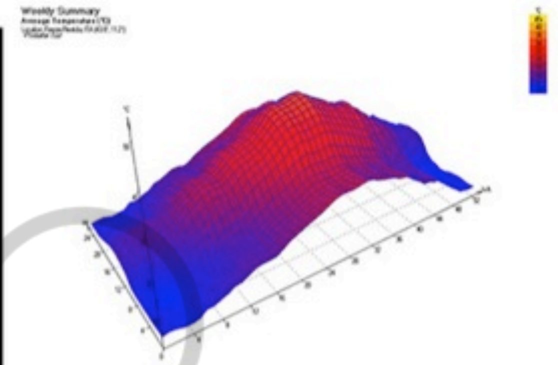


Best ,average and worst orientation

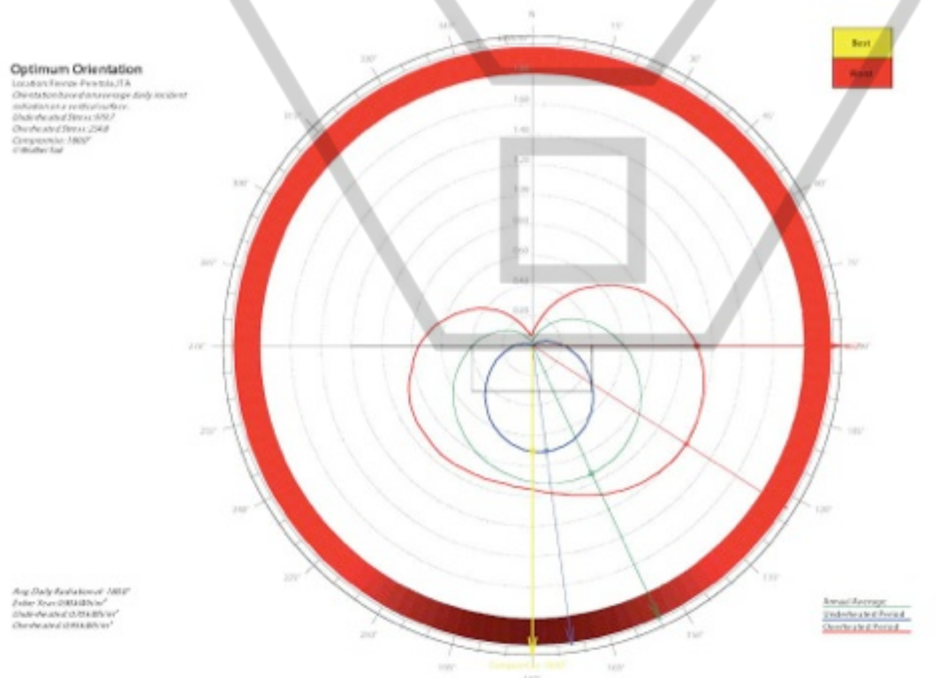
Wind Analysis



wind speed and direction plot



Weekly average tempreture

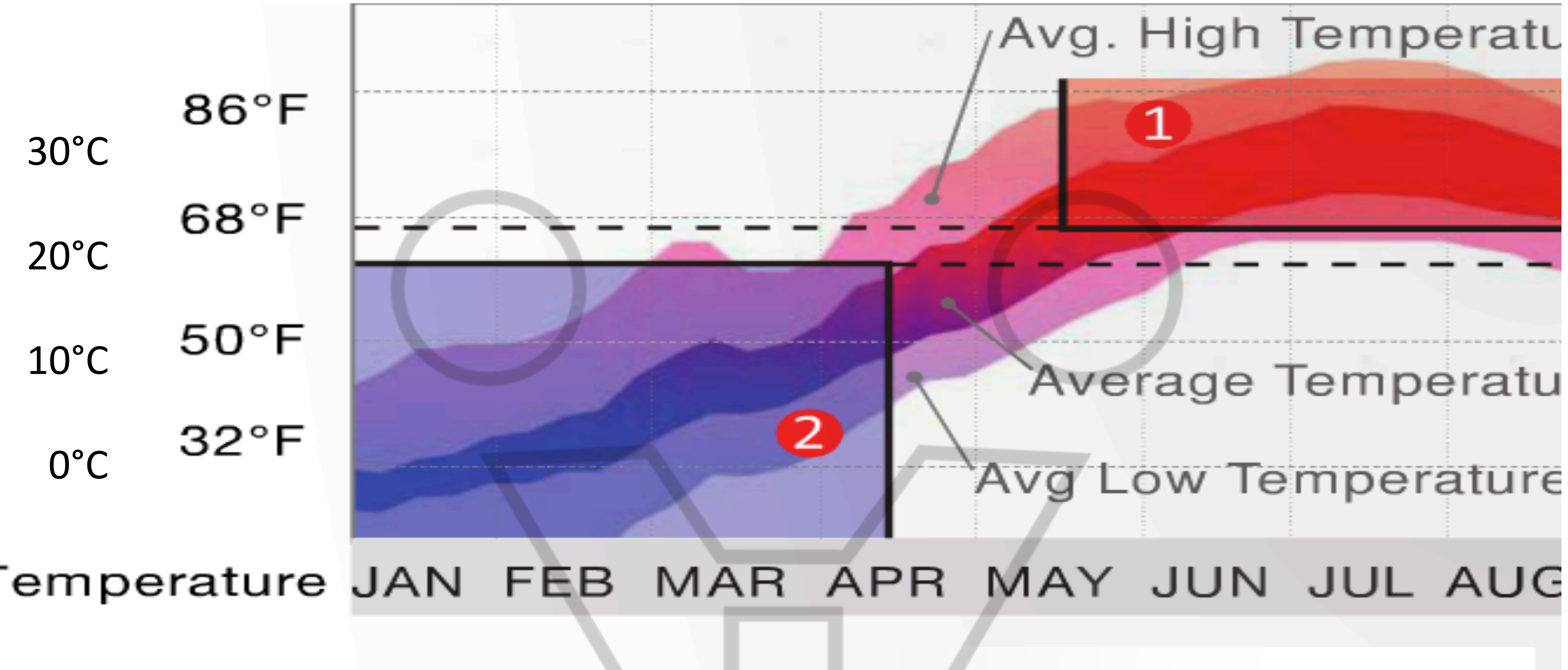


gbxml

COOLING OR HEATING ?

WHAT IS THE PREVALENT NEED IN THAT SPECIFIC BUILDING?

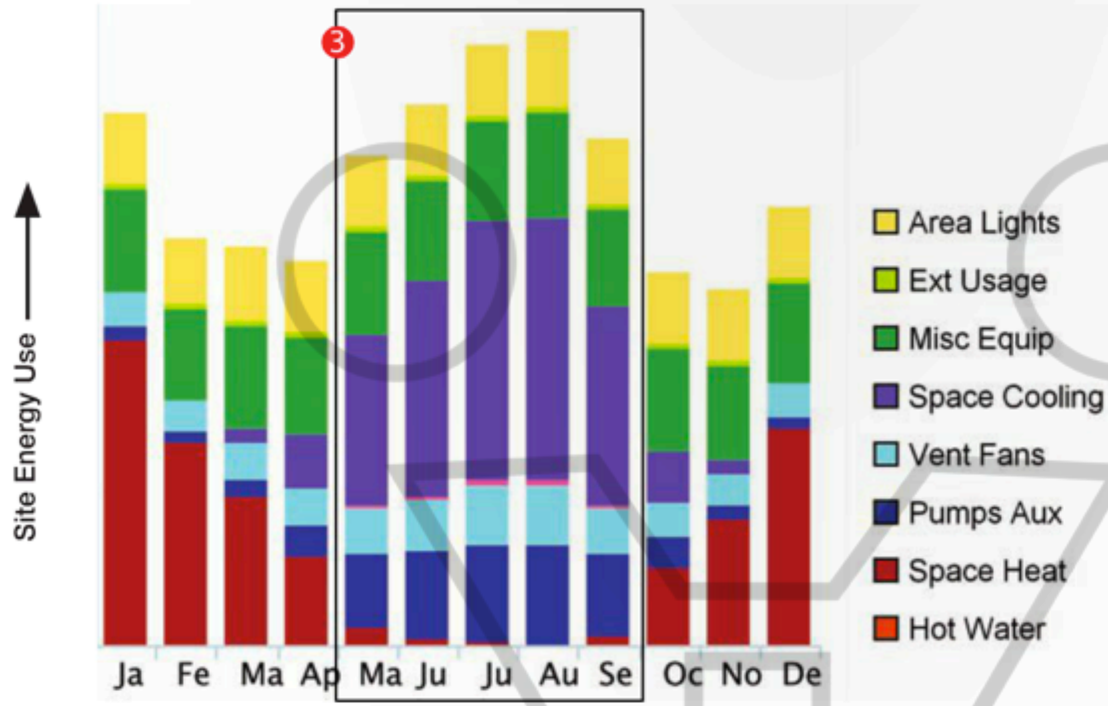
COOLING VS HEATING: A GENERAL ESTIMATION TEMPERATURE METHOD



7.3 Temperature Method. Annual temperature profile, with estimated heating and cooling seasons highlighted.

Source: Ecotect outputs of annual weather data from Central Park in New York City.

COOLING vs HEATING: a detailed estimation using Shoebox model



7.4

Shoebox Model Method. Monthly energy use profile for an office floor plate in New York City. The simulation was performed in Green Building Studio using a shoebox model.

The Shoebox Model

A simple, automated shoebox model can generate a more accurate illustration of months requiring shading design. For this analysis, a thermal zone with glazing was uploaded from Autodesk Ecotect to the Green Building Studio to run an EnergyPlus simulation. Months where cooling energy is high (3) are chosen for shading. This example seems to require more cooling than the temperature method example because the shoebox model uses an office typology, where people, equipment, and lighting add heat during the day.

WEATHER AND CLIMATE COMPUTATIONAL MODELING
DATA ANALYSIS IN RELATIONSHIP WITH HUMAN COMFORT

- DAYLIGHT FACTOR

Environmental parameters affecting daylight quality

- DAYLIGHT AVERAGE
- GLARING
- SHADING

The most relevant daylight effect on thermal condition
The green house phenomena.
LA CONDUZIONE DEL CALORE
Prima avevo fatto la radiazione

Radiazione raggi incidenti
Convenzione quando questo equilibrio si realizza attraverso l'aria
Conduzione materiali a contatto

si equilibrano talvolta molto
lentamente a causa di una specifica inerzia del materiale sia condurre che delle capacità di a
e tempi di assestamento con il sistema circostante.
La prima è una proprietà isolante ovvero di trasferire energia termica
La seconda capacità di …latenza….

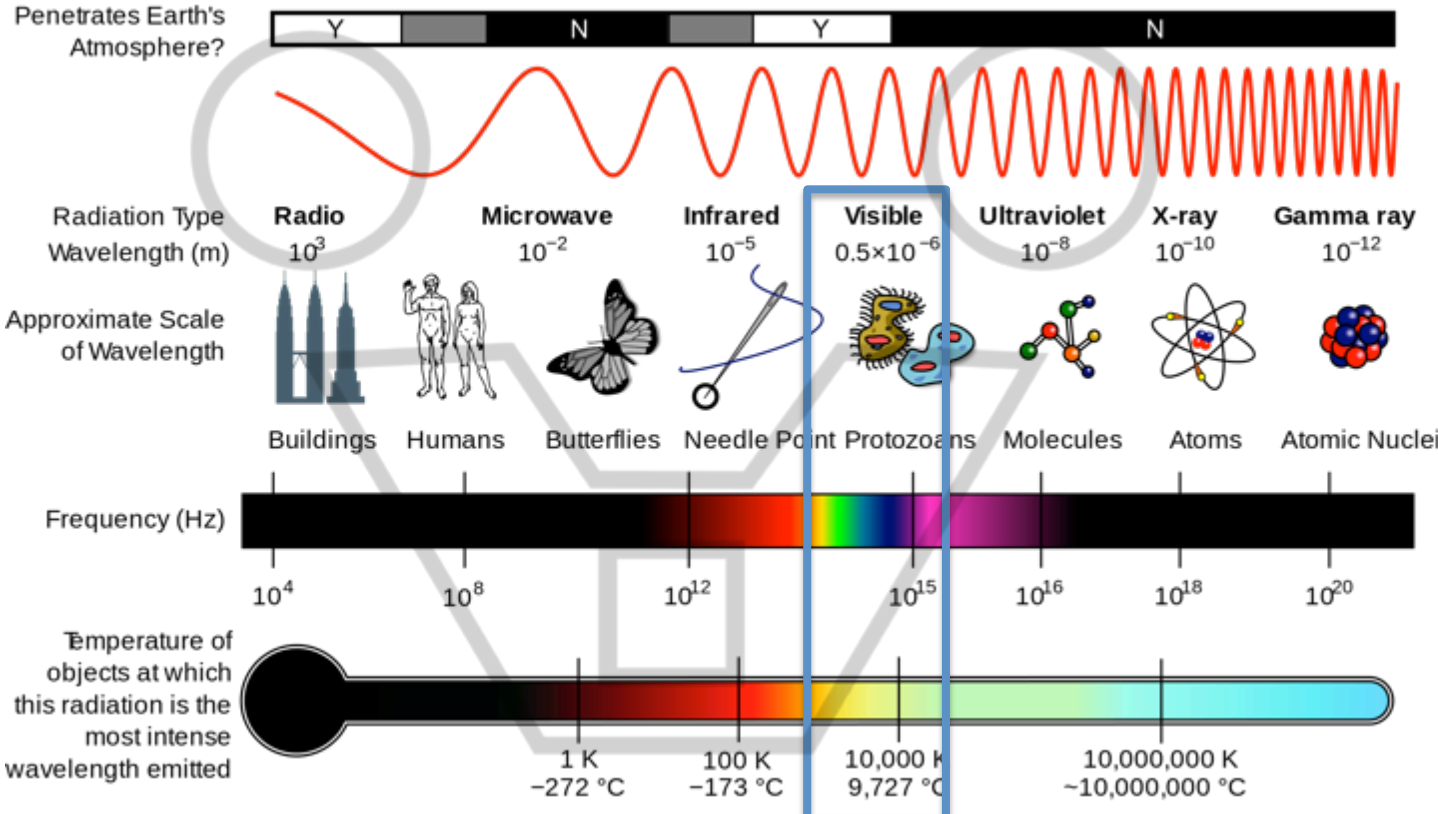
Environmental parameters affecting daylight

GLAZING GEOMETRY & MATERIALS

- DAYLIGHT AVERAGE
- GLARING
- SHADING

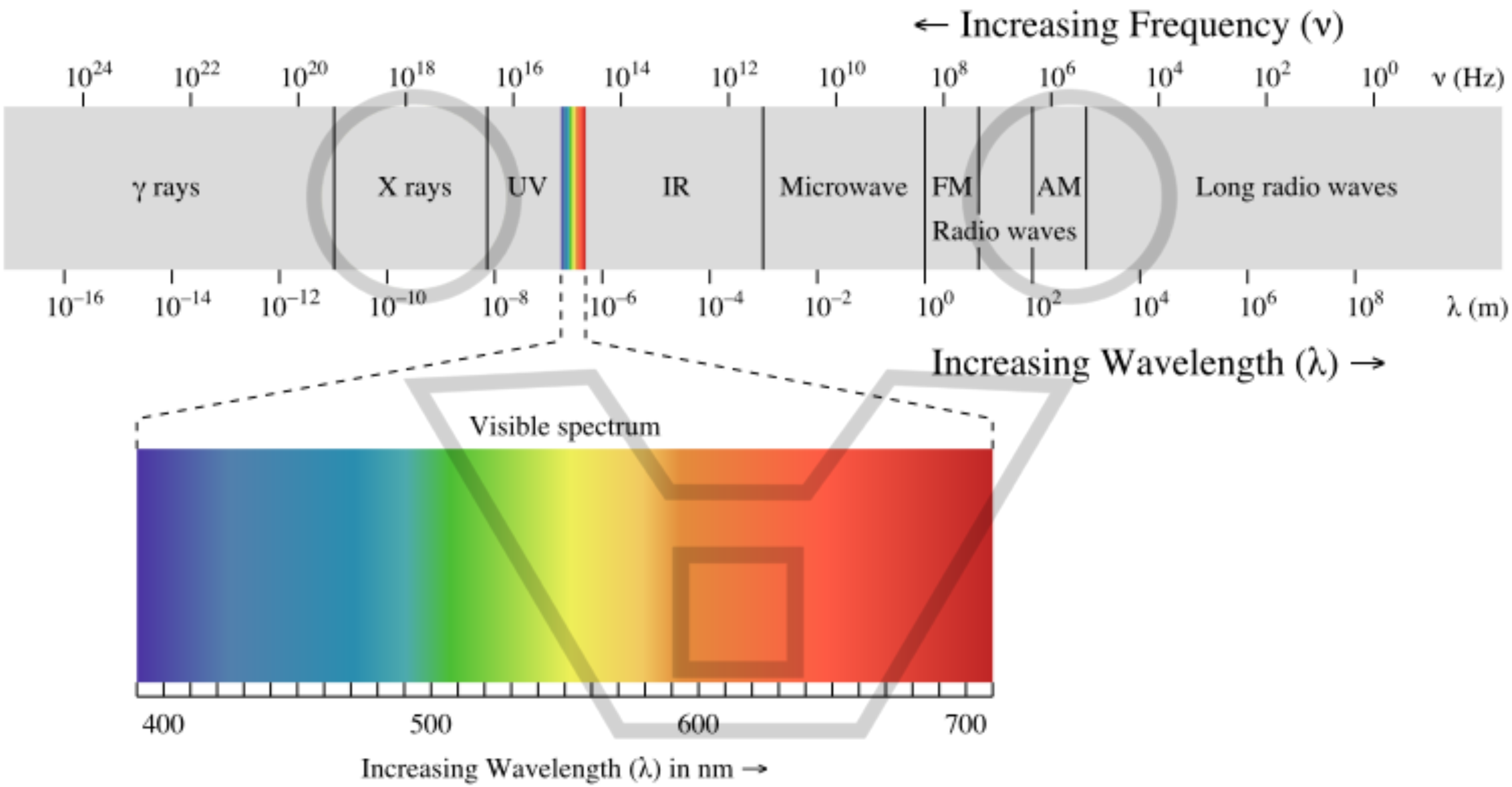
Environmental parameters affecting daylight

VISIBLE RADIATION

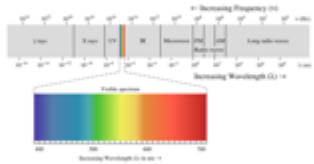


Environmental parameters affecting daylight

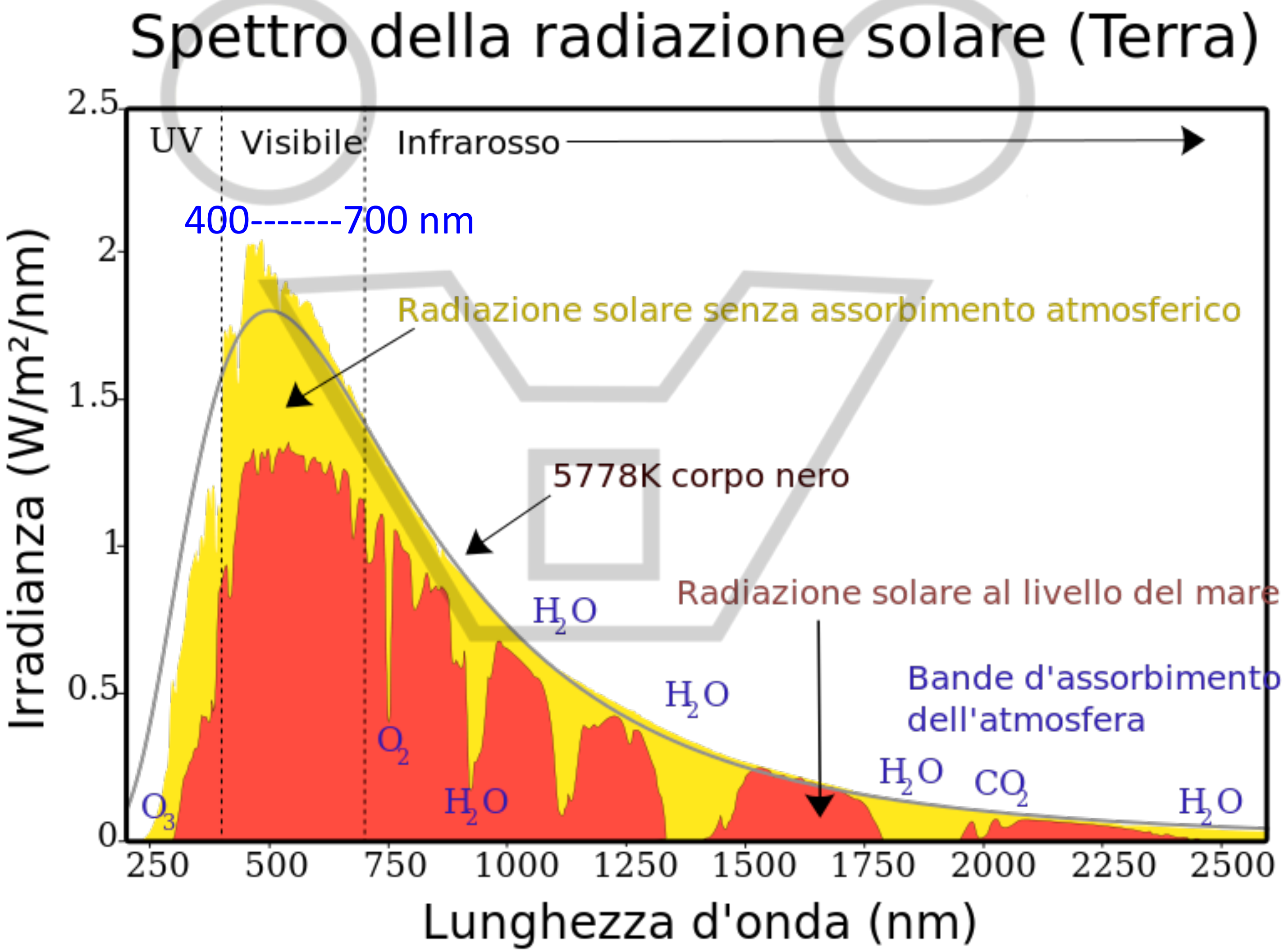
VISIBLE SPECTRUM



Environmental parameters affecting daylight

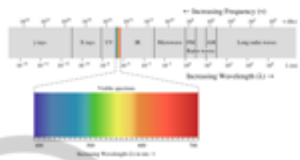


ABSOLUTE ENERGY IN THE VISIBLE SPECTRUM



Environmental parameters affecting daylight

RELATIVE ENERGY IN THE VISIBLE SPECTRUM



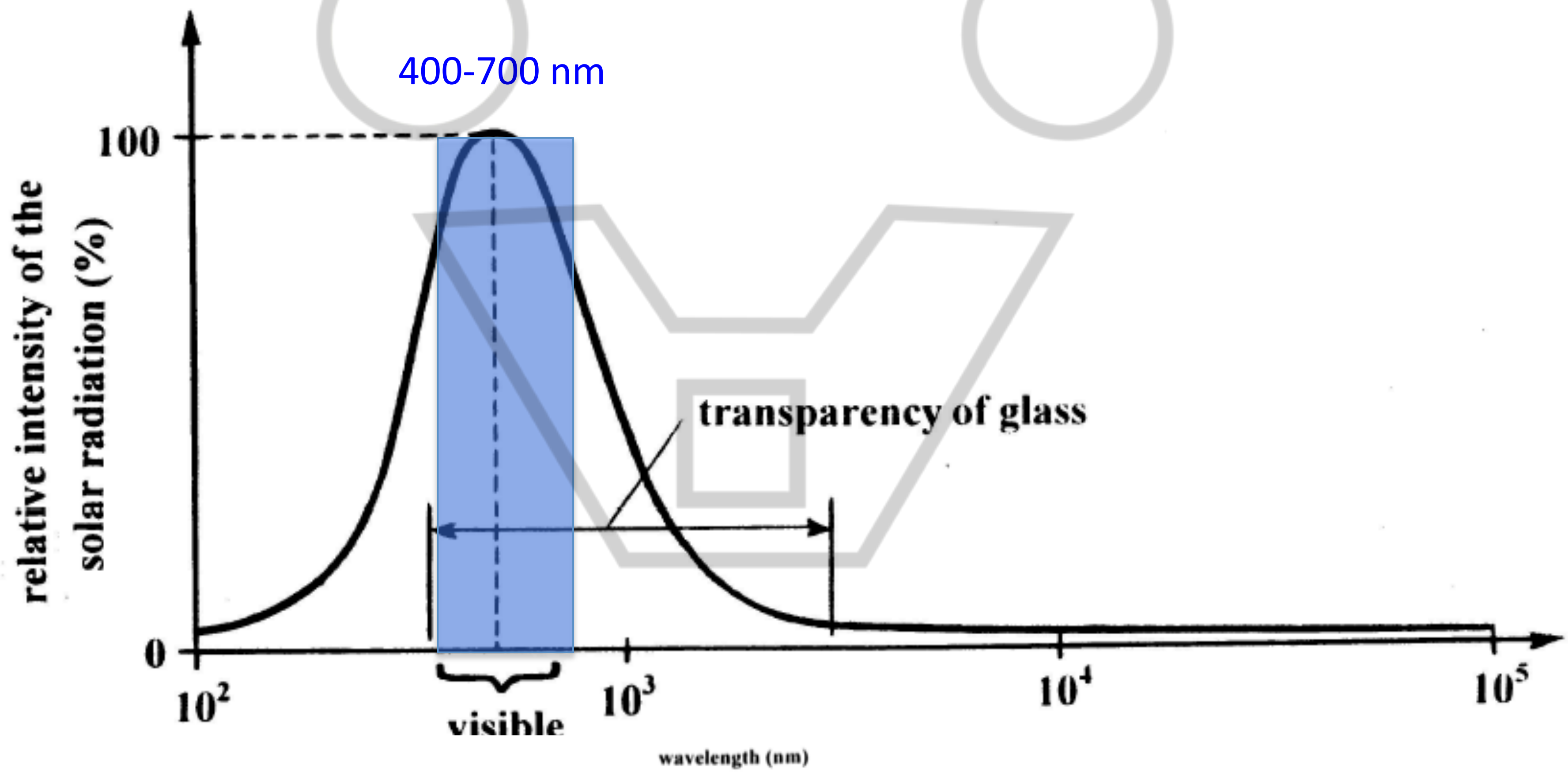


Fig. 7. Range di trasparenza del vetro rappresentato sullo spettro della radiazione solare. Un confronto con la figura precedente mostra che il vetro non è trasparente nel range di emissione dei corpi a temperatura ambiente o di poco superiore.

Environmental parameters affecting daylight

TRASPARENCY OF GLASS &
% OF RADIATION PASSING THROUGH GLASS

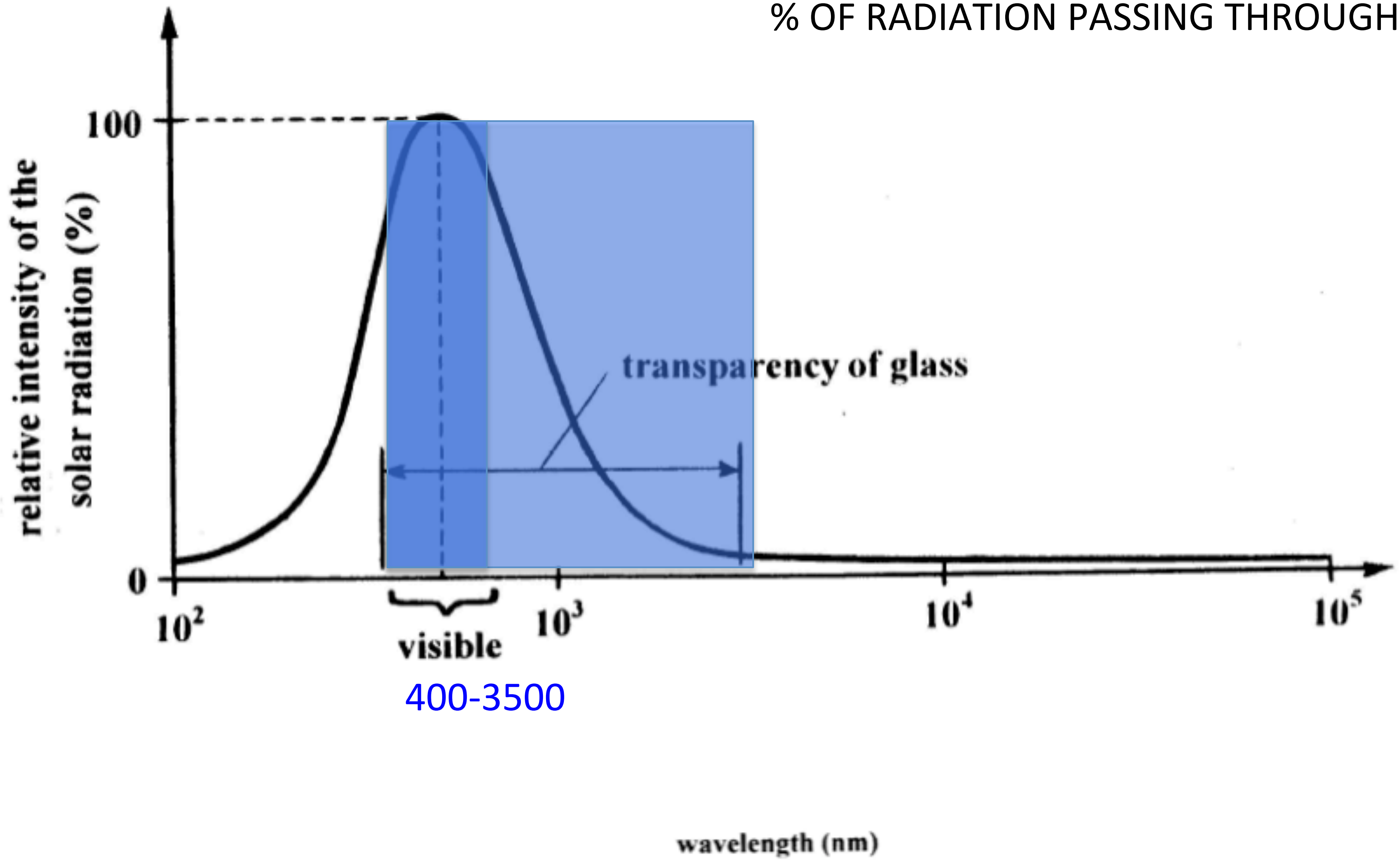


Fig. 6. Spettro della radiazione solare.
Sull'asse orizzontale è indicato il range di emissione relativo ad un corpo a 300 K. Lo spettro di emiss questo corpo non è rappresentato e sarebbe interamente sotto la curva dello spettro solare.

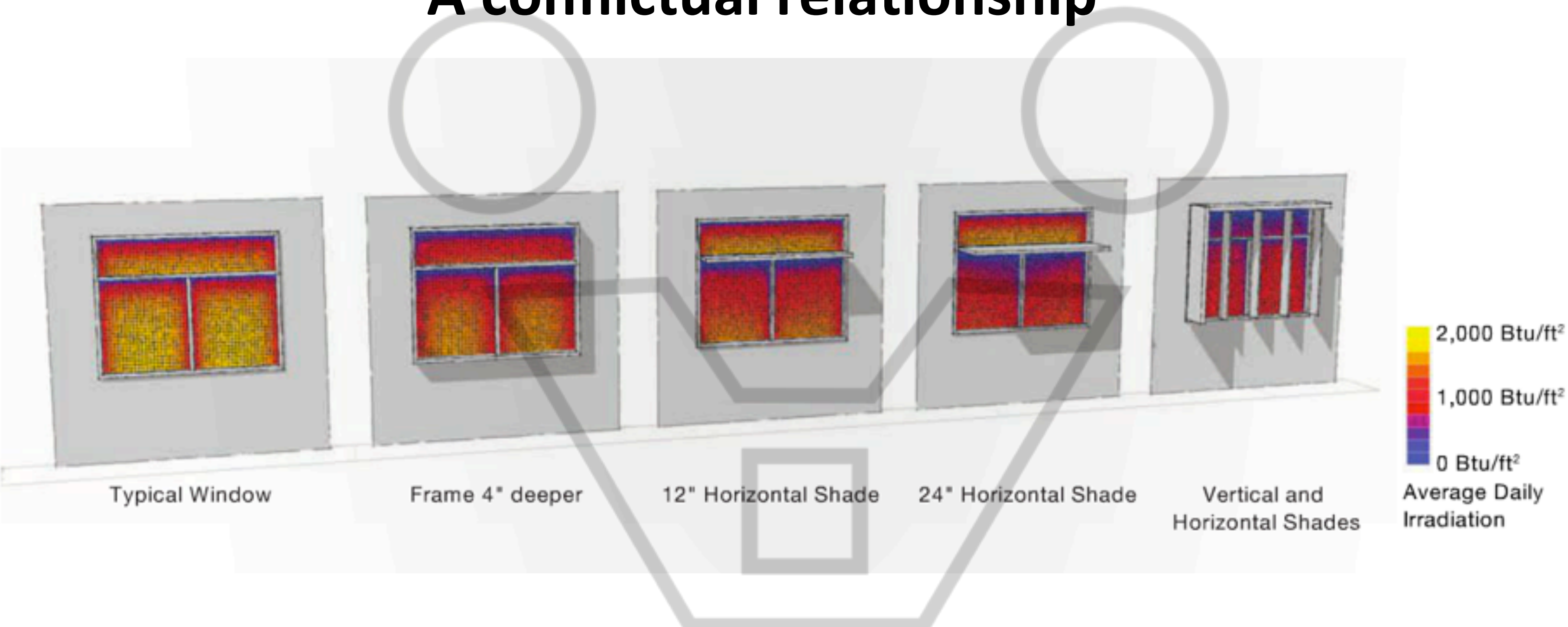
Environmental parameters affecting daylight

GLAZING GEOMETRY & MATERIALS

Daylight vs thermal (and visual) comfort
A conflictual relationship

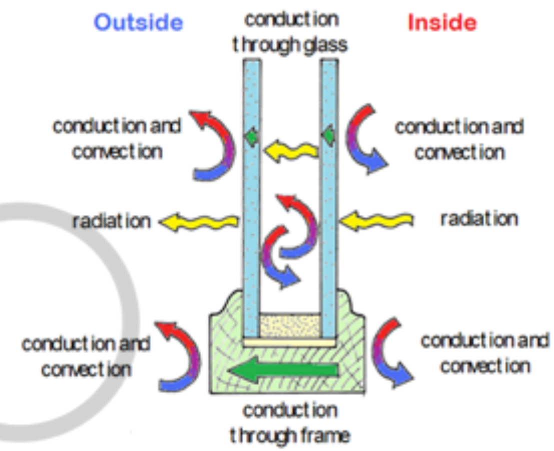
Environmental parameters affecting daylight

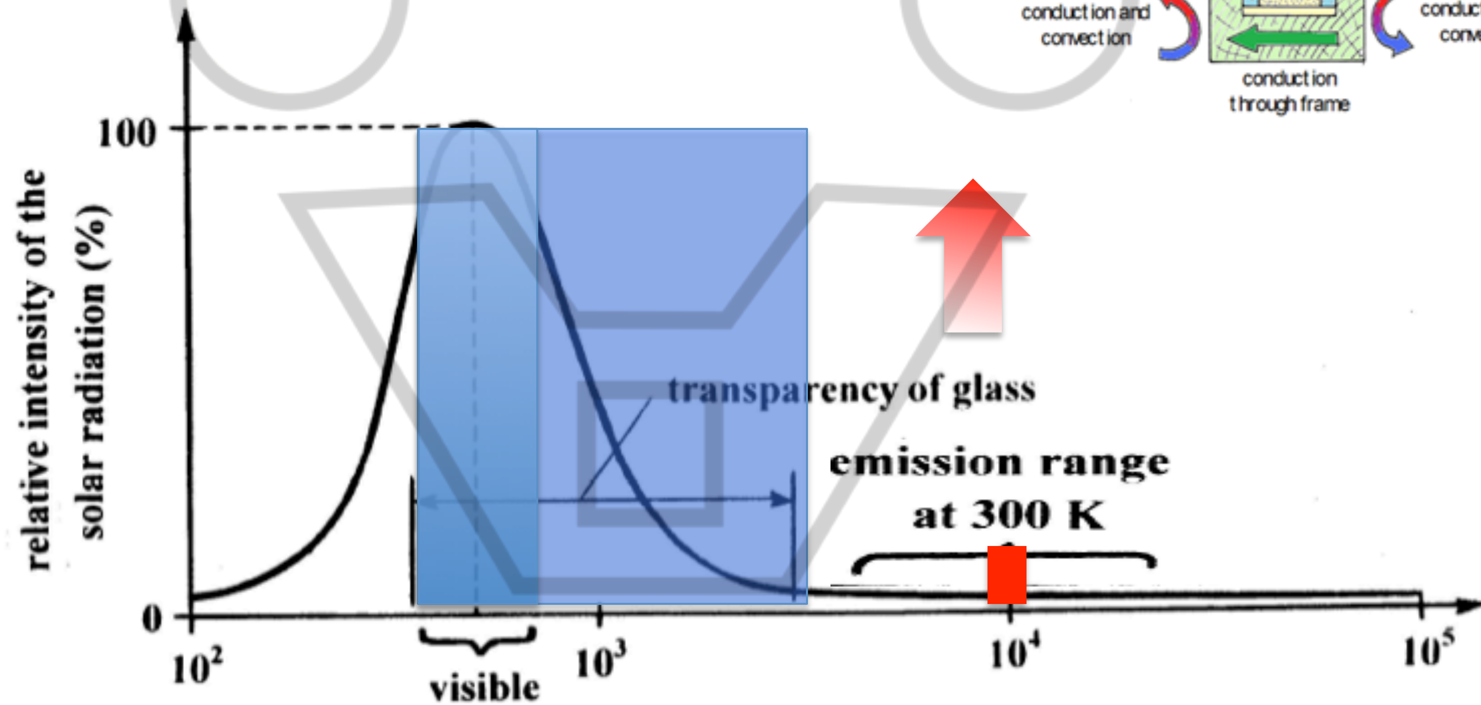
Daylight vs thermal (and visual) comfort
A conflictual relationship



Environmental parameters affecting daylight

THE GREEN HOUSE EFFECT





400-3500

Environmental parameters affecting daylight

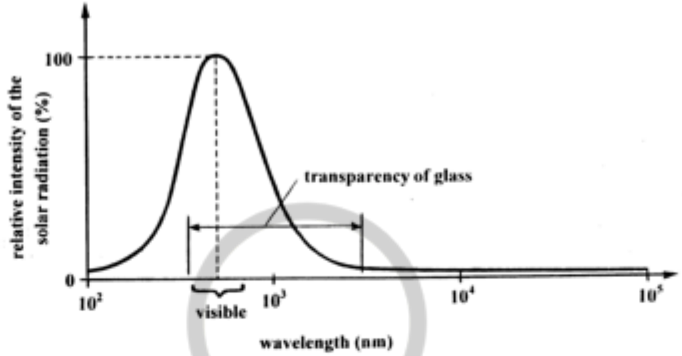
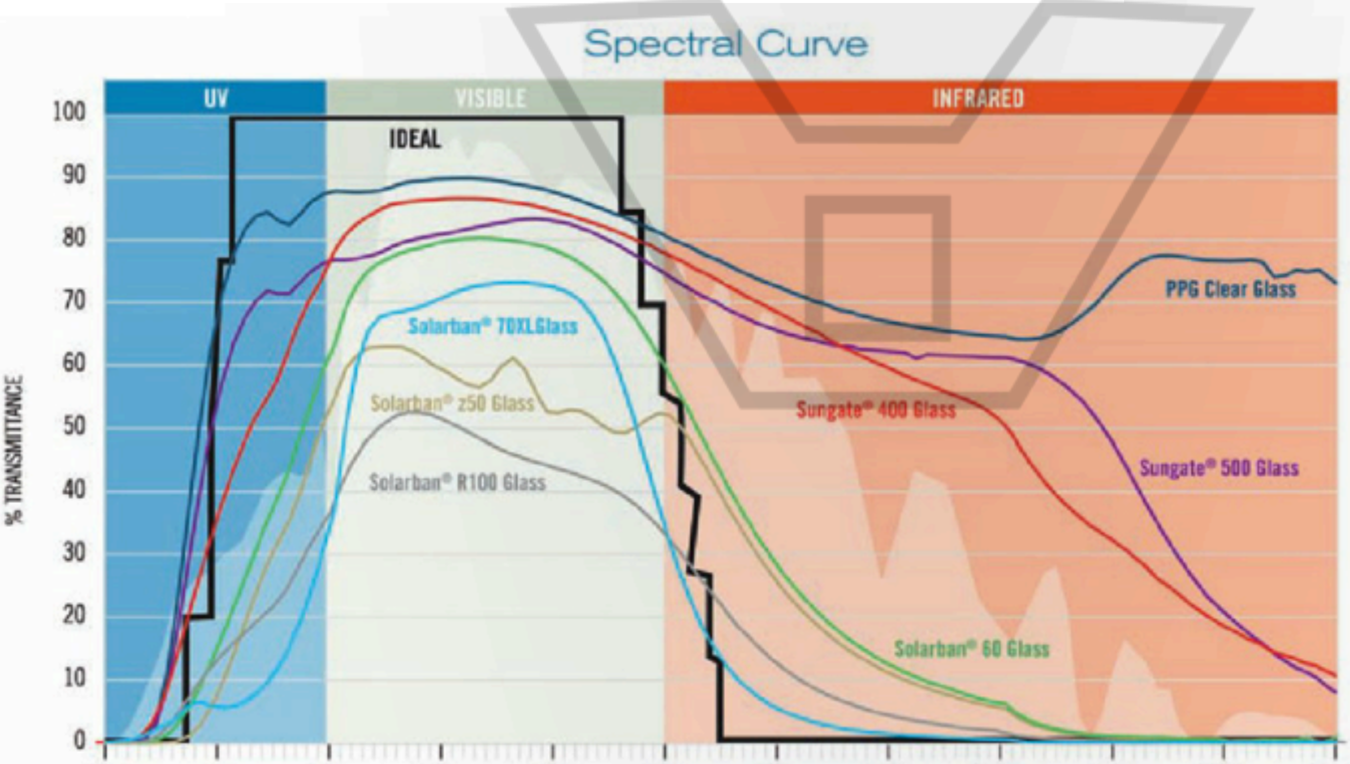


Fig. 7. Range di trasparenza del vetro rappresentato sullo spettro della radiazione solare. Un confronto con la figura precedente mostra che il vetro non è trasparente nel range di emissione dei corpi a temperatura ambiente o di poco superiore.



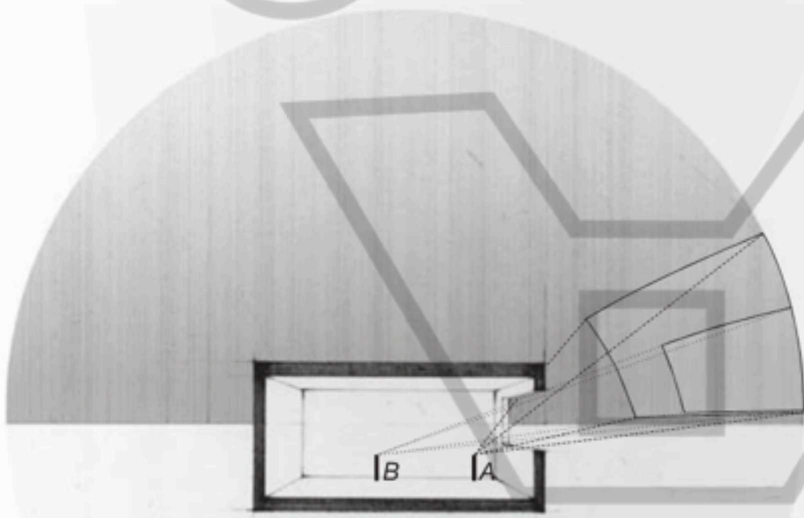
6.5

Spectrally selective coatings allow glazing products to reflect solar irradiation outside the visible spectrum without significantly reducing visible light transmittance. This allows low-SHGC products with high Tvis.

Source: Courtesy of PPG Industries.

Environmental parameters affecting daylight

GLAZING GEOMETRY & MATERIALS



8.7

Daylight factor is based on the amount of indoor light as a percentage of outdoor light levels. Using a CIE overcast sky, it reports the percentage of outdoor light that arrives at a given point. Point A has access to significantly more sky than point B, with a proportionally higher daylight factor.

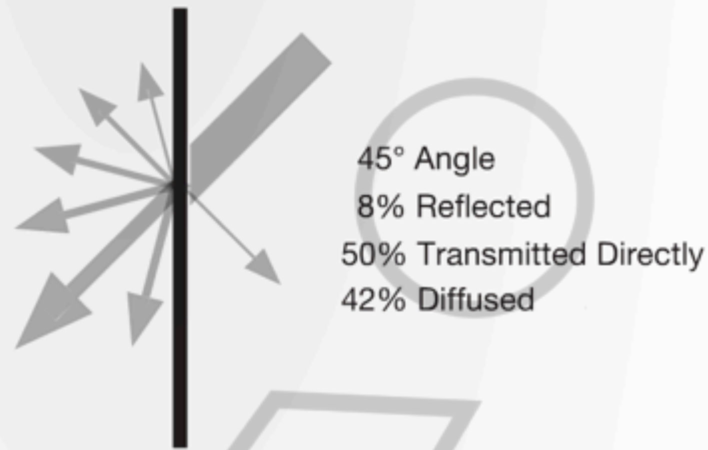
Source: Illustration by Amal Kissoondyal.

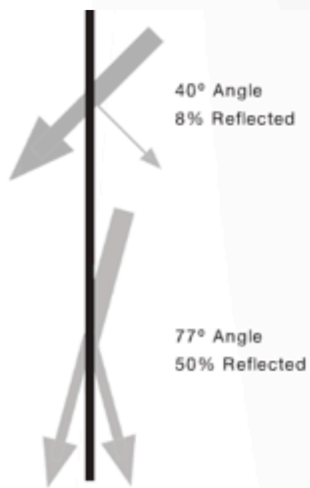
Environmental parameters affecting daylight: GLAZING GEOMETRY

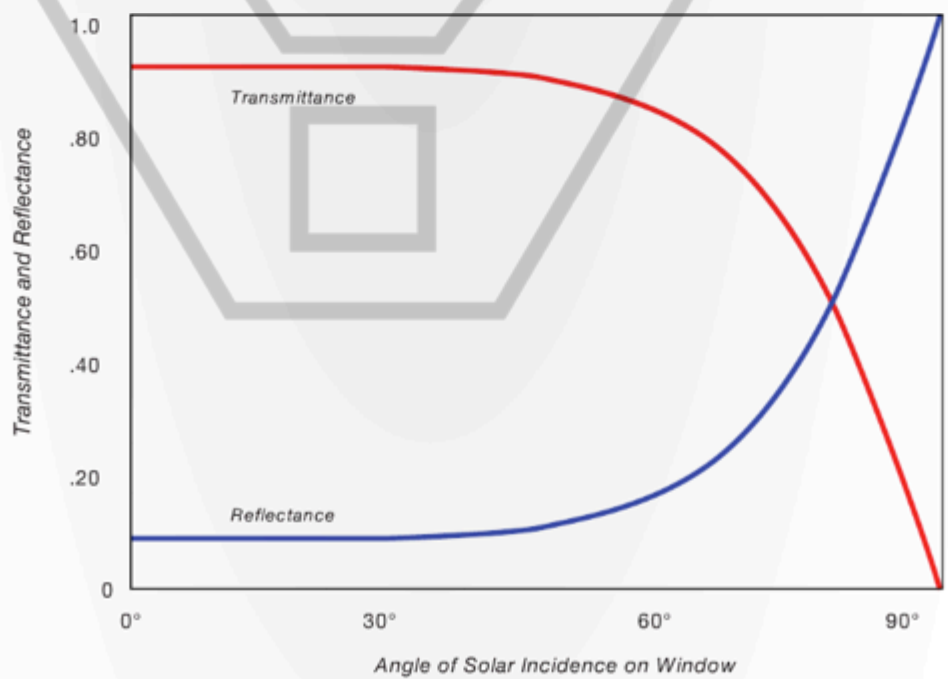
Reflectance & Trasmittance f(angle of incidence)

6.6

Translucent materials transmit some light and heat directly, and diffuse the rest of the transmitted light. In most cases, the diffused light is more concentrated around the directly transmitted light.





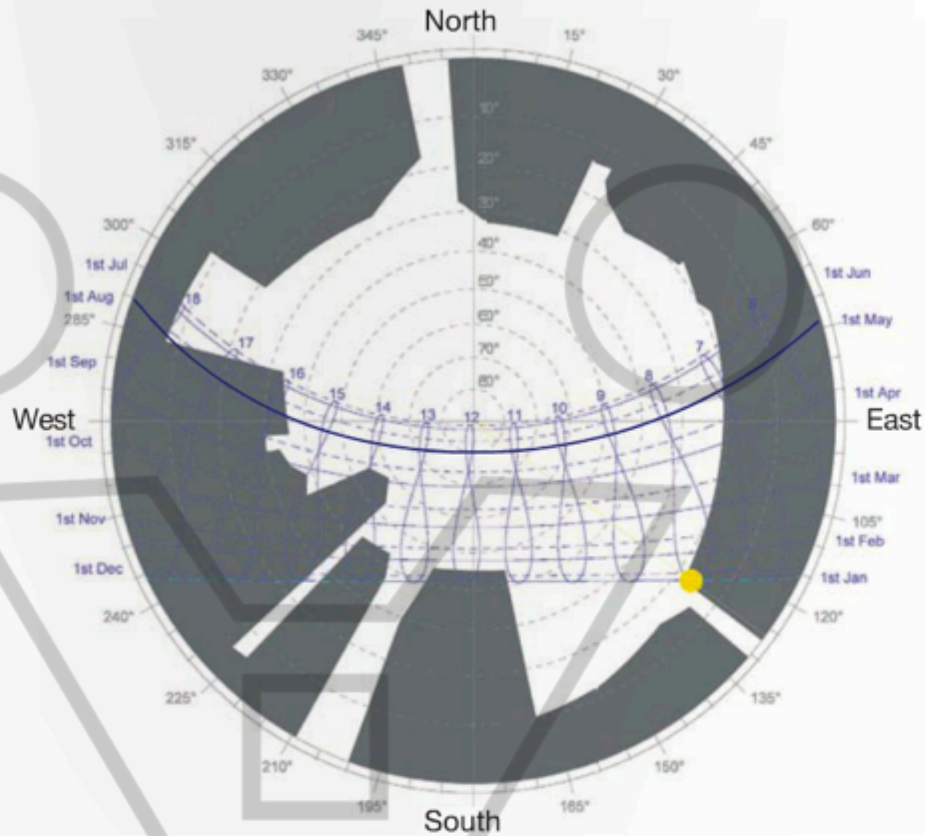


Environmental parameters affecting daylight: GLAZING GEOMETRY

7.9

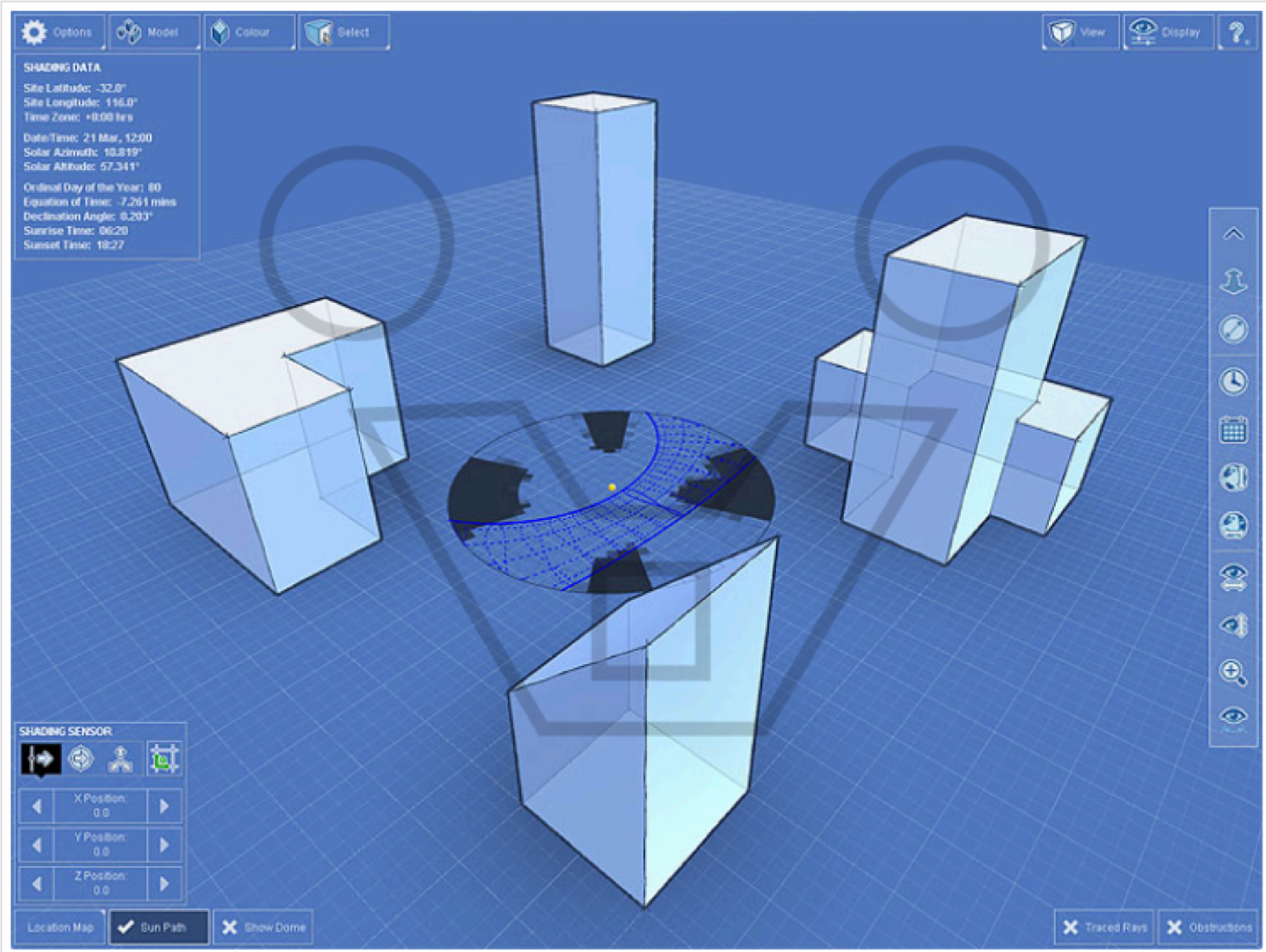
Fish-eye image showing annual solar path and adjacent buildings that shade a location within an urban context. Afternoon hours in the summer are mostly shaded, while the first two hours of each day are also shaded. The peak summer cooling date is highlighted, showing full shade after 4 p.m.

Source: Modified Autodesk Ecotect output. Courtesy of Callison.



The influence of the site: Shade analysis and effective daylight

Environmental parameters affecting daylight: GLAZING GEOMETRY



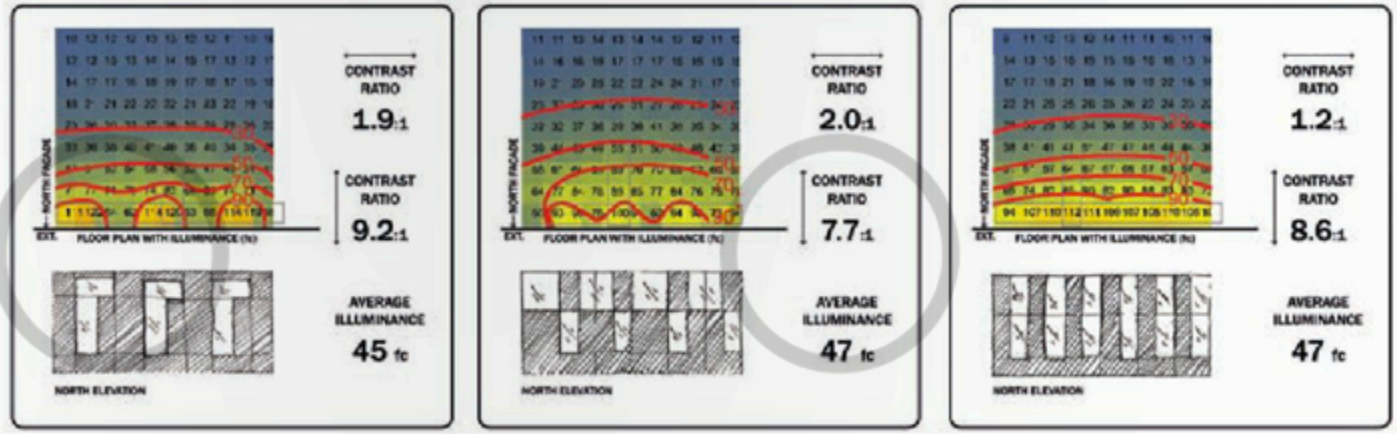
http://andrewmarsh.com/software/app-shading/

Environmental parameters affecting daylight

SKY CONDITIONS

Radiazione solare	Condizioni atmosferiche							
	Cielo sereno	Nebbia	Nuvoloso	Disco solare giallo	Disco solare bianco	Sole appena percettibile	Nebbia fitta	Cielo coperto
globale	1000 W/m^2	600 W/m^2	500 W/m^2	400 W/m^2	300 W/m^2	200 W/m^2	100 W/m^2	50 W/m^2
diretta	90%	50%	70%	50%	40%	0%	0%	0%
diffusa	10%	50%	30%	50%	60%	100%	100%	100%

Environmental parameters affecting daylight: GLAZING GEOMETRY



8.4

Plan-view studies showing illuminance levels for three window options on a north façade under overcast skies. The room's contrast ratios across width and depth are also shown, with lower contrast being preferable, but difficult to achieve, with side-lighting. Lighting designers typically include a room's contrast ratio in their studies to ensure even lighting throughout a space.

Source: Courtesy SERA Architects.

geometric aspects that define the daylight zone. For skylights, useful daylight will spread approximately half the ceiling height beyond the edge of the skylight in plan view.

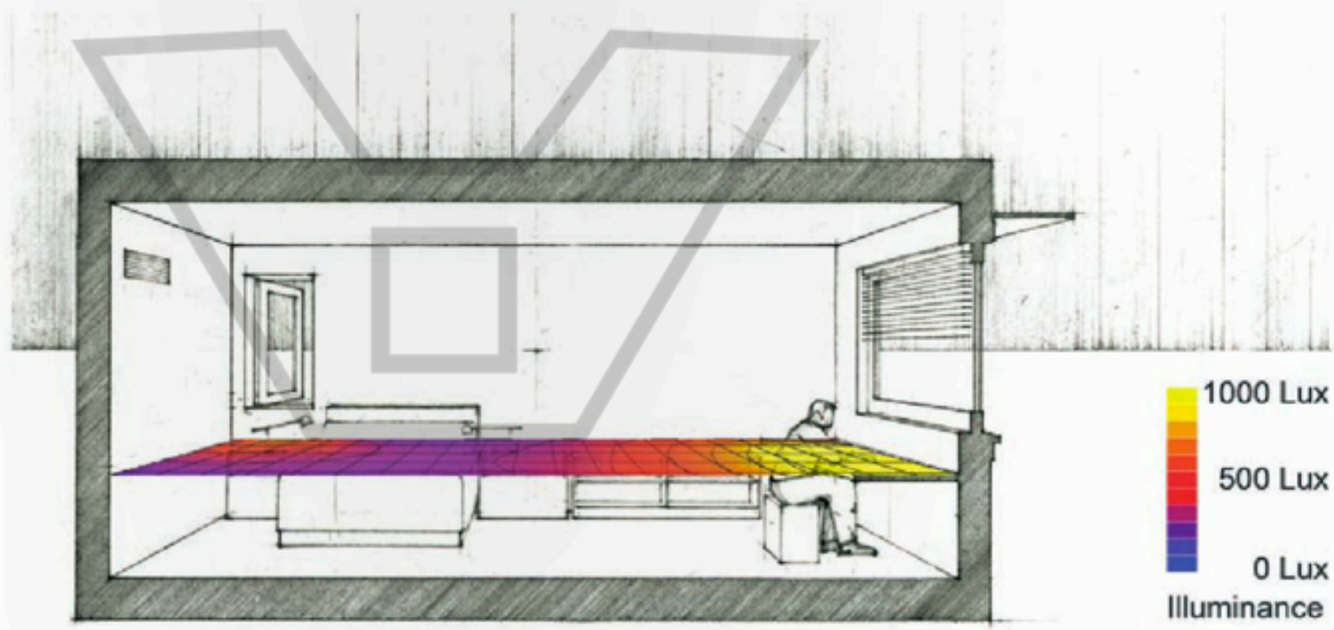
For sidelighting, the daylight zone will generally be the depth equal to 1.5 to 2.5 times the window head height, or sometimes the first 15′ inside a façade. The electric lights in this area are usually on a

Environmental parameters affecting daylight: GLAZING GEOMETRY

8.8

False color illuminance levels for 2 p.m. on March 21 at a work plane height of 30" above floor level show that the majority of the space is at or above 250 Lux, meaning the space is well daylit and likely needs no electric lights to be on.

Source: Autodesk Ecotect output of Radiance data overlaid on an illustration by Amal Kissoondyal.



8.9

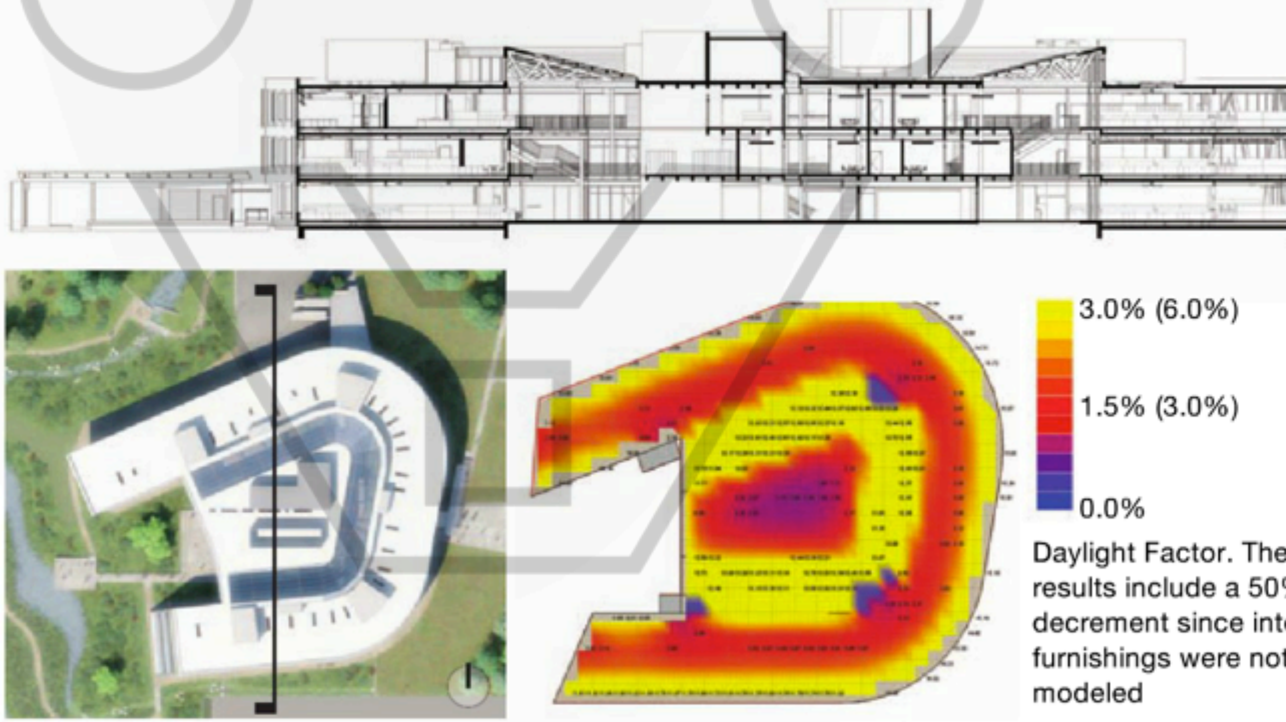
Federal Center South, Building 1202, is a 60'-wide office plate in the form of a U-shape around a daylit atrium. The false color

Environmental parameters affecting daylight: GLAZING GEOMETRY

DAYLIGHT FALSE COLOR ANALYSIS

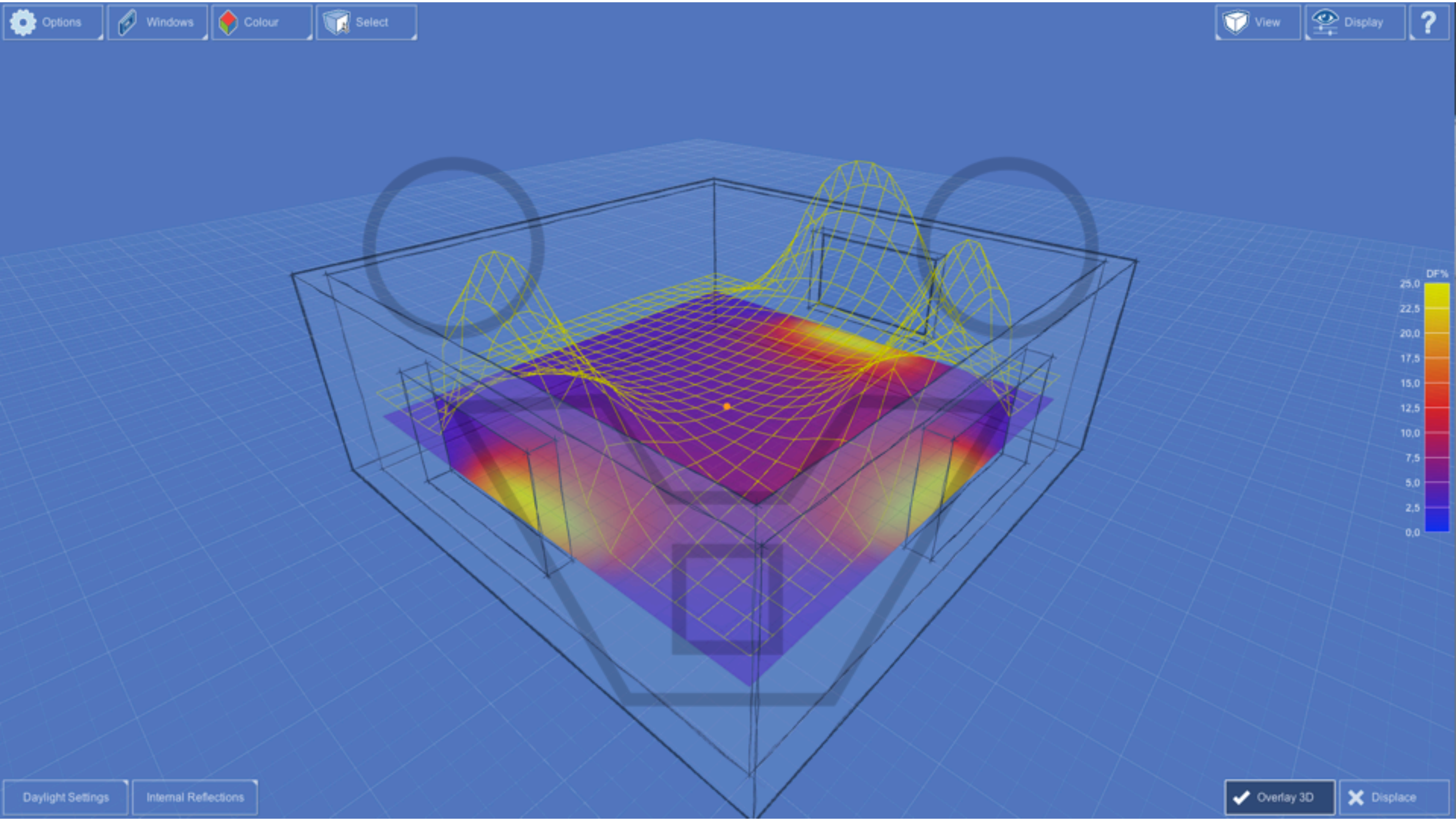
Federal Center South, Building 1202, is a 60'-wide office plate in the form of a U-shape around a daylit atrium. The false color results of a daylight factor simulation on the ground floor show good daylight based on sectional properties, including: office plate width, skylight geometry and glazing properties.

Source: Courtesy of ZGF Architects LLP.



Daylight Factor. The results include a 50% decrement since interior furnishings were not modeled

Environmental parameters affecting daylight: GLAZING GEOMETRY



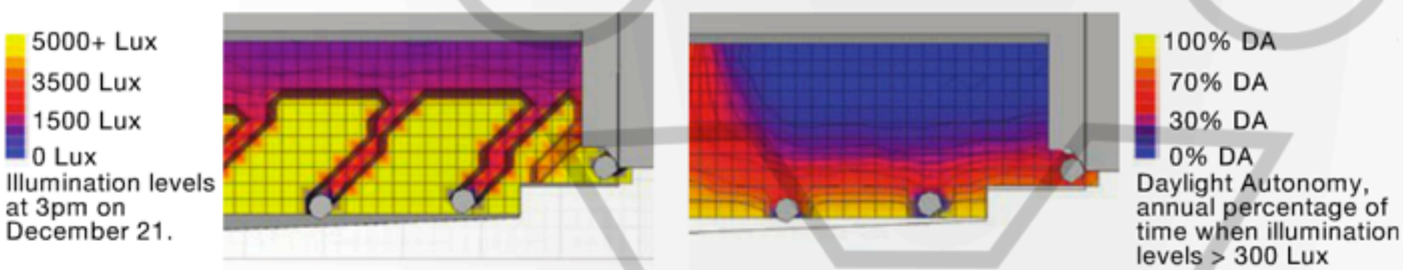
http://andrewmarsh.com/software/app-daylight/

Environmental parameters affecting daylight:

GLARING & SHADING

Environmental parameters affecting daylight: WINDOWS GEOMETRY

Daylight assessment: Point-in-time vs annual analysis

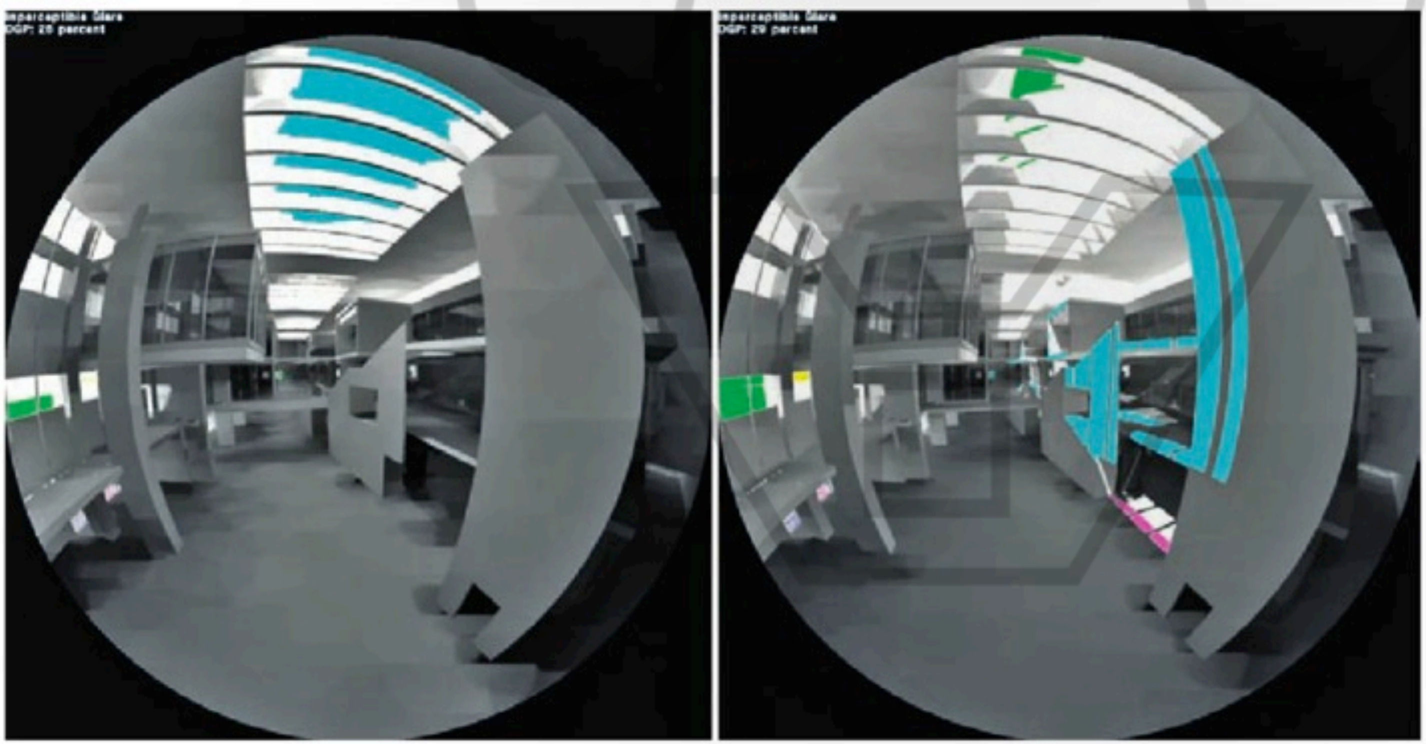


2.6

Plan view of an open office space, showing a façade with columns at the bottom. A point-in-time (PIT) analysis (left) provides information about daylight levels and potential for glare at 3:00 p.m. on the winter solstice, for example. An annual daylight autonomy analysis (right) shows areas that are successfully daylit for a certain percentage of the year. Both use false colors to illustrate lighting levels; they are Autodesk Ecotect outputs of Radiance and Daysim analyses, respectively.

on investment of 3 years. If the project team assumes that occupants will turn off the lights when they leave at night, occupancy sensors may only be projected to reduce lighting energy use by 20%, with a return on investment of 10 years. As a broader example, ASHRAE 90.1's baseline building energy use is unique to every design, leading to industry-wide misunderstanding regarding a building's modeled

Environmental parameters affecting daylight: WINDOWS GEOMETRY



8.12

Daylight glare probability studies of atrium skylight options using DIVA software shows .26 and .29, both considered imperceptible glare. Each area within a field of view that contributes to glare is assigned a random color to show its location.

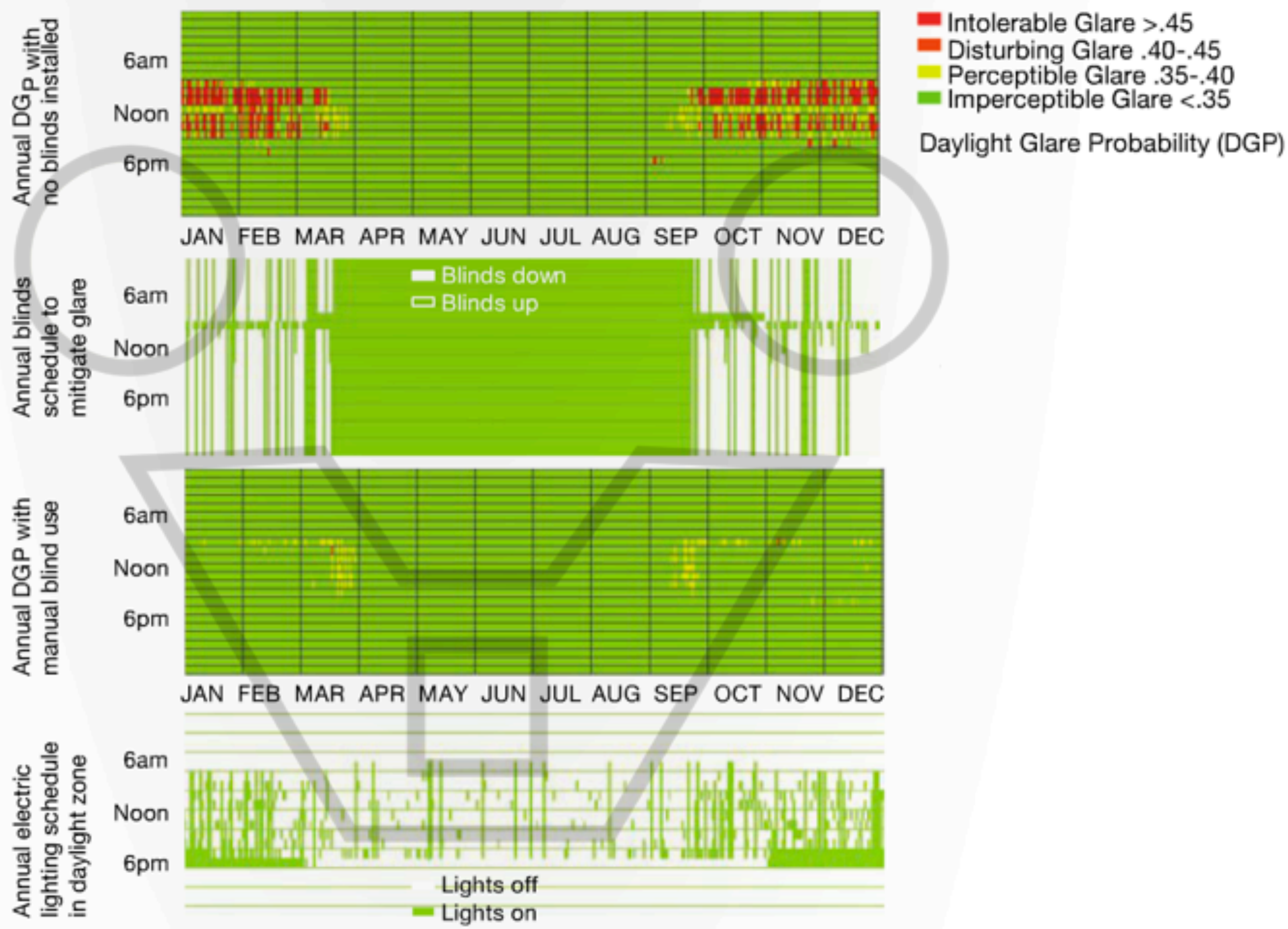
Source: Courtesy of SERA Architects.

Environmental parameters affecting daylight: WINDOWS GEOMETRY

8.13

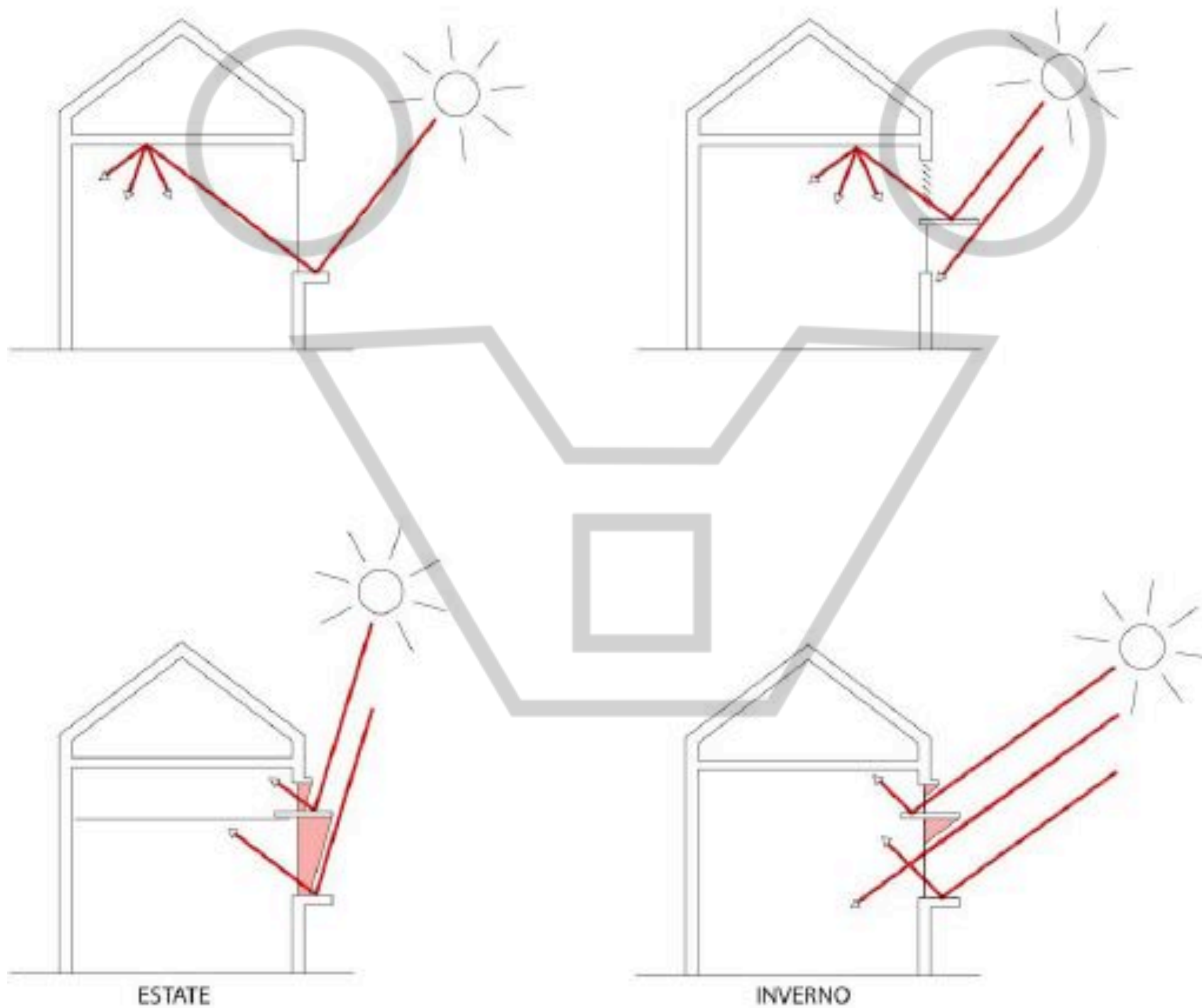
An east-facing viewpoint within a south-facing office space experiences glare primarily during times with low-angle sun in the Fall and Winter. Diva for Rhino software creates a blinds schedule to minimize glare, based on research of building occupants' tendency to lower them based on glare but raise them infrequently, per the Lightswitch model (Reinhart, 2002). The blind schedule helps create a lighting usage schedule that can estimate lighting energy use savings to compare design options.

Source: Courtesy of Jeff Niemasz.



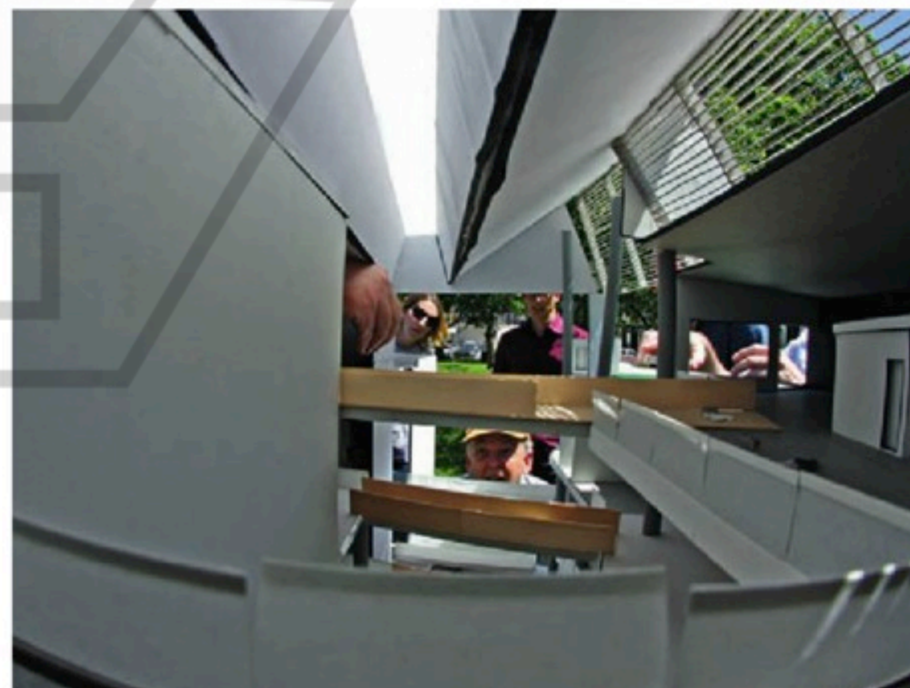
Environmental parameters affecting daylight: WINDOWS GEOMETRY

Systems for daylight diffusion



Environmental parameters affecting daylight: WINDOWS GEOMETRY

Physical scale model to evaluate daylight and glare

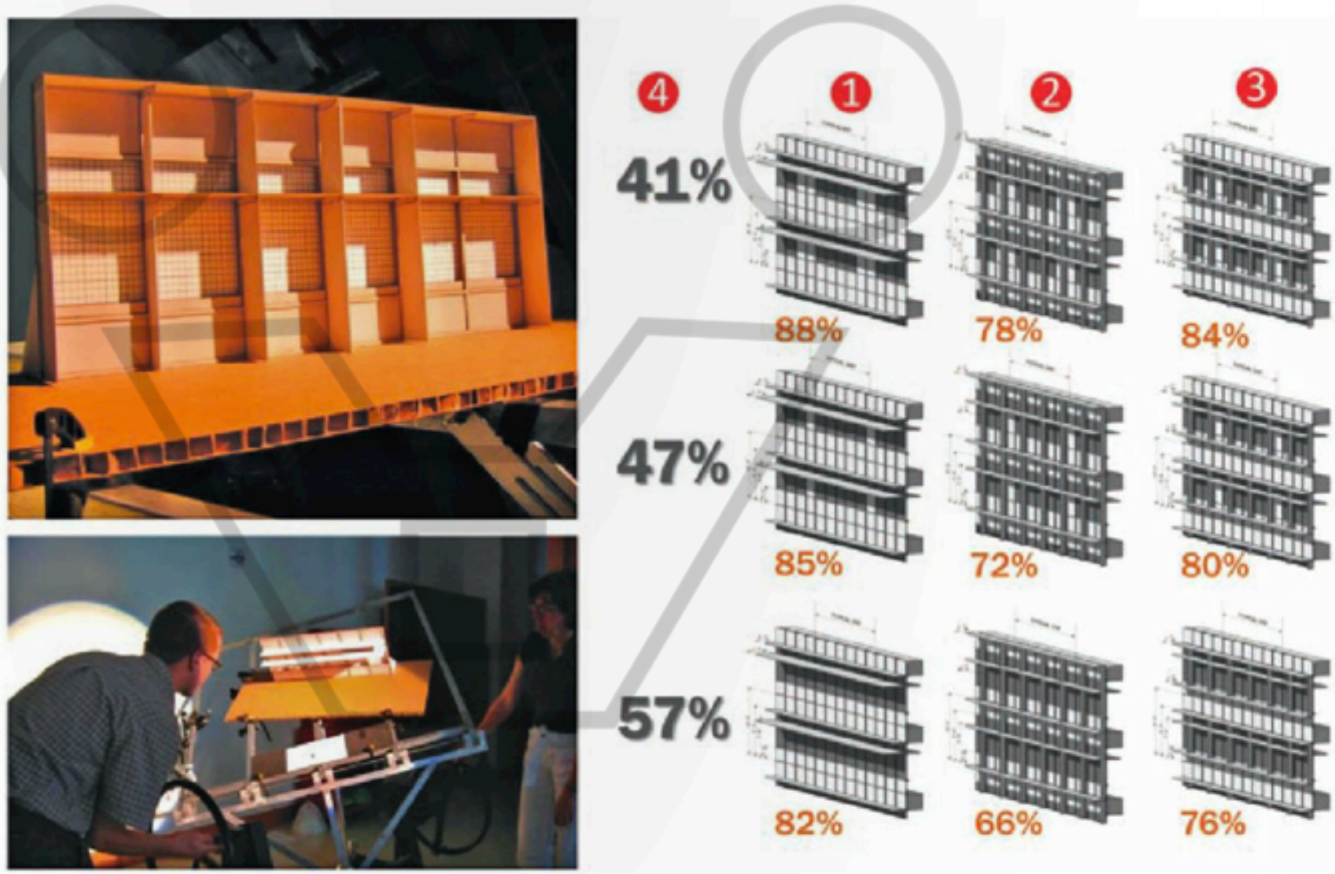


Environmental parameters affecting daylight: WINDOWS GEOMETRY

LIGHTING vs GLARING: Shaping windows and shading

7.17

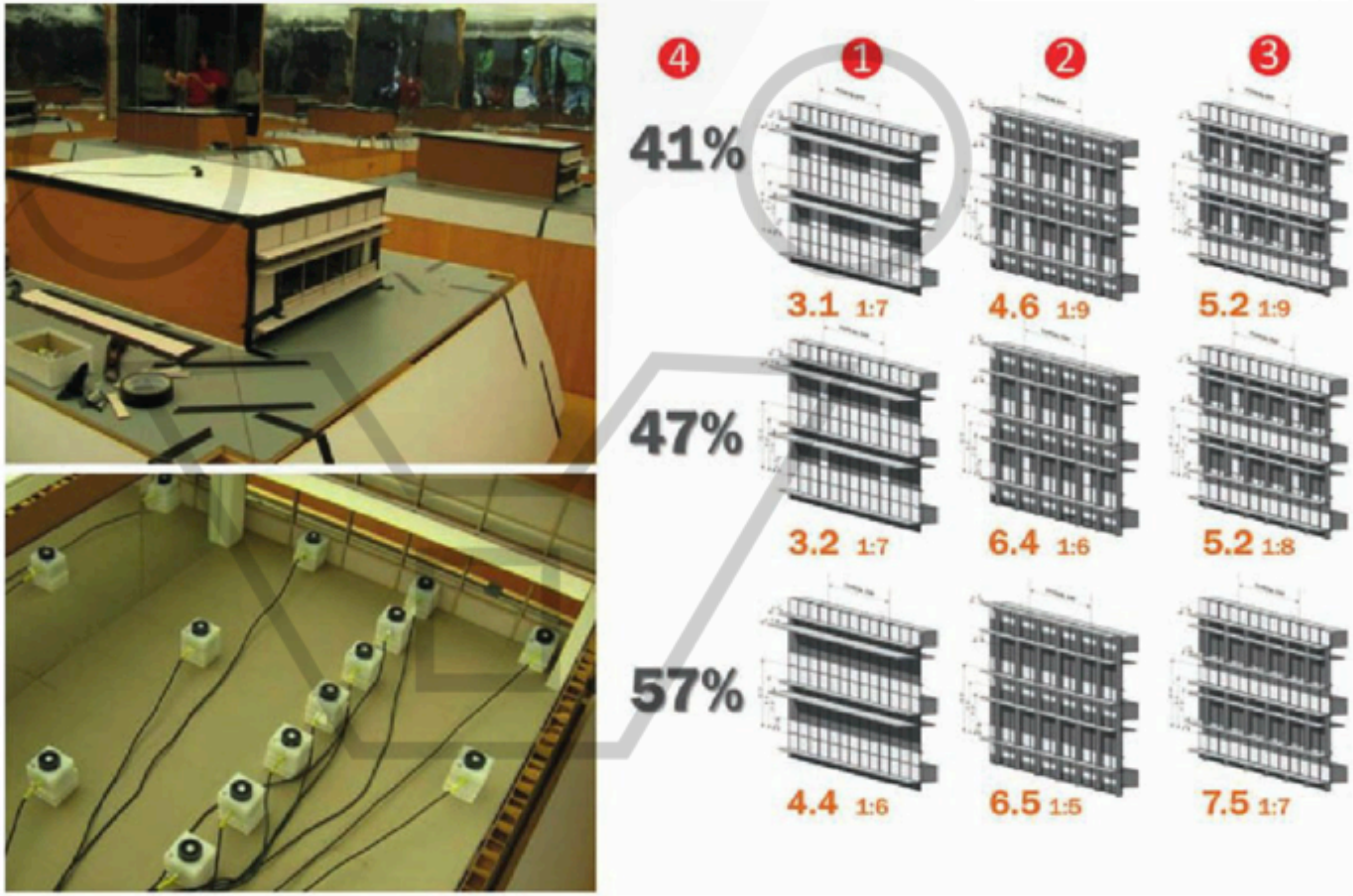
Façade shading studies testing options with (1) horizontal shade only, (2) vertical and horizontal fins with the horizontal element as a light shelf, and (3) vertical and horizontal fins with the horizontal as sill reflector. Each option was tested with 3 glazing percentage options (4). The orange number shows the percentage of the glazing that is shaded in each option.



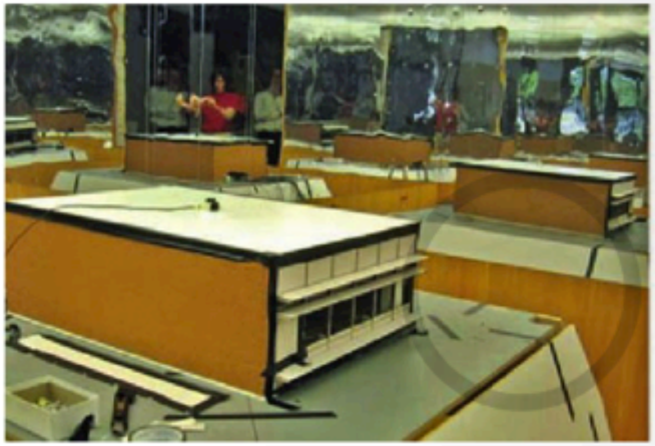
Environmental parameters affecting daylight: WINDOWS GEOMETRY

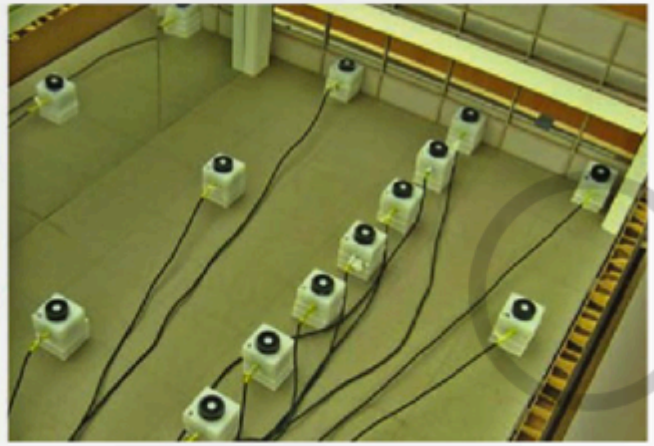
7.18

Daylighting studies testing the same 9 shading options as 7.17. The large orange number shows the average daylight factor in the 16′ perimeter zone, and the small number shows the contrast ratio across this area.



Environmental parameters affecting daylight: WINDOWS GEOMETRY





8.14

A physical daylighting model showing use of light meters to calculate the daylight factor. An overcast sky is simulated by the light box, which has highly reflective ceiling and walls to create uniform light levels.

Source: Courtesy of SERA Architects.

And a physical daylighting model showing use of a heliodon at the Energy Studies in Buildings Laboratory in Portland, Oregon, to predict daylighting levels under sunny sky conditions. The large wheels rotate the model through specific solar angles in relation to a bright electric light.

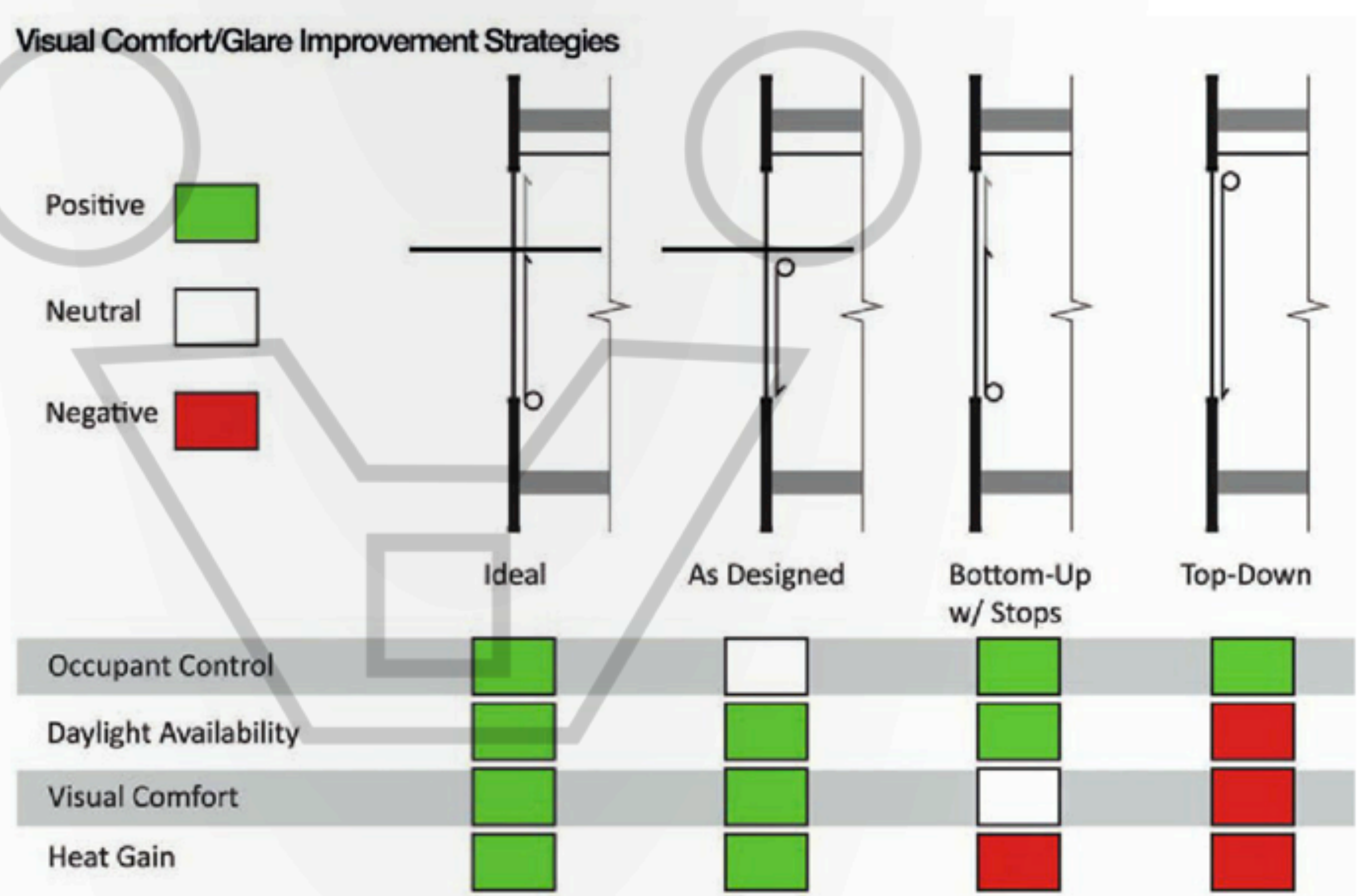
Source: Courtesy of SERA Architects.

Environmental parameters affecting daylight: WINDOWS GEOMETRY

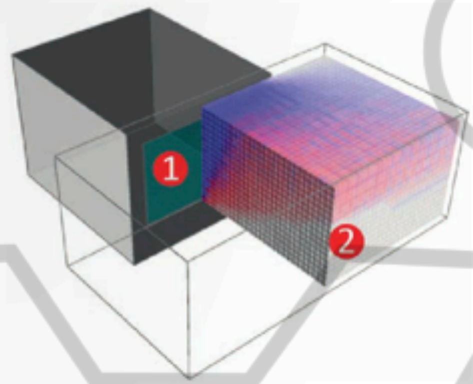
3.6

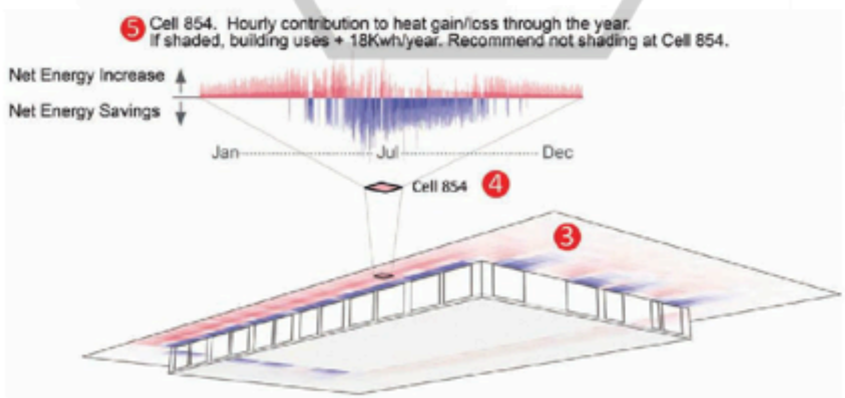
A study prepared for Iowa State University by ZGF Architects LLP rates four window options for user controllability, daylight availability, visual comfort, and heat gain. While simulations predict lighting energy savings due to the use of daylight, these savings are only realized when the system successfully blocks glare or allows users to block glare without blocking daylight.

Source: Courtesy of ZGF Architects LLP.



Environmental parameters affecting daylight: Envelopes parametrical generated





7.30

The Aqua Tower. The parametric aesthetic of the Aqua Tower was investigated using the Shaderade method of shading design.

Source: Photo by Jeff Niemasz.

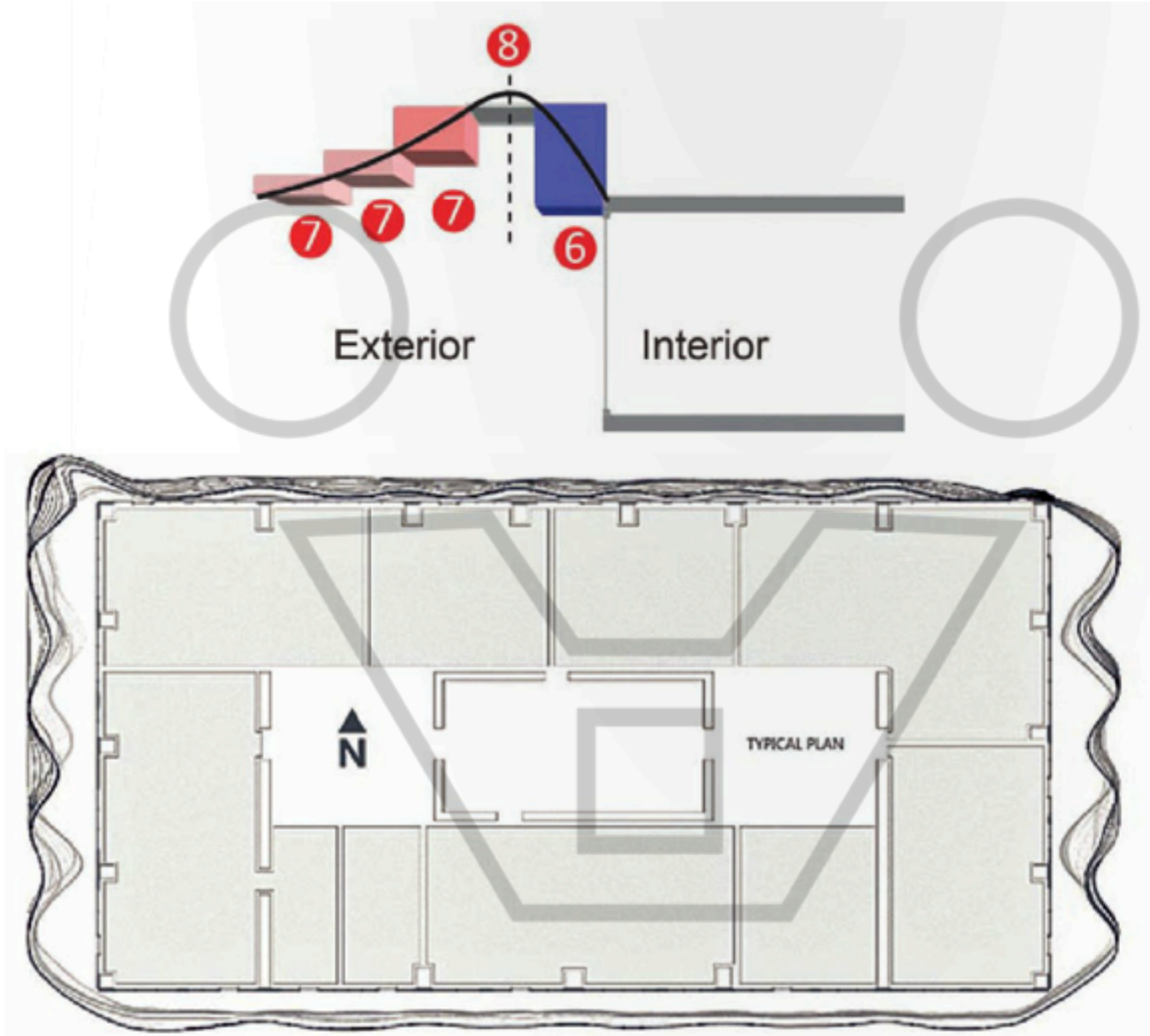
7.31

Shaderade Boston cube. Each colored cell shows net higher (red) or lower (blue) energy use if a shading device occupied its area.

7.32

Section through a typical window, showing ideal shading device depth at the inflection point of higher and lower energy use.

Environmental parameters affecting daylight: Envelopes parametrical generated



7.33

The inflection point.

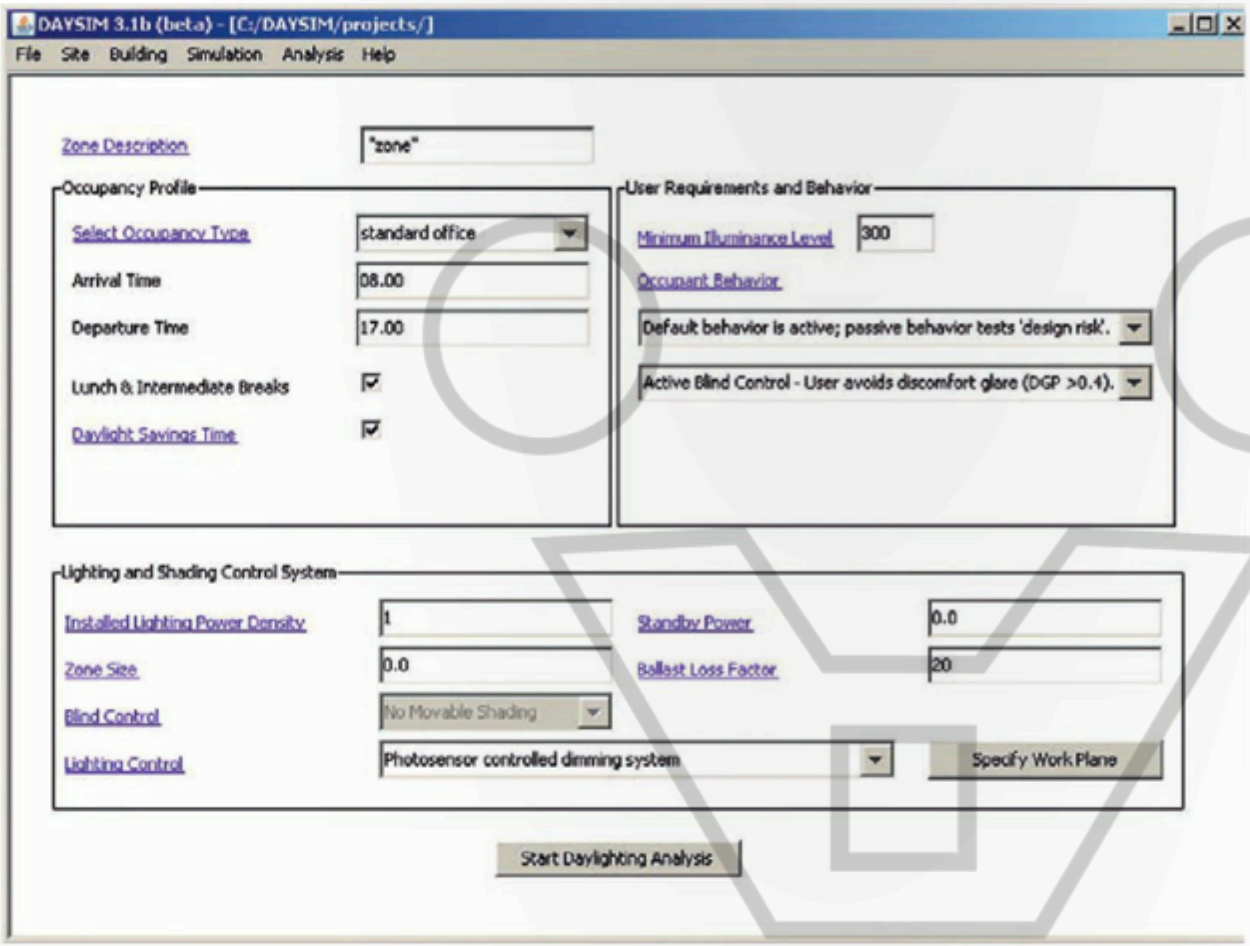
7.34

Plan view of optimized shading.

The Shaderade approach, which advanced earlier work by Eran Kaftan and Dr. Andrew Marsh, involves mapping the annual energy consequences of each position where a shade could affect energy transmission through a window (1) in two or three dimensions (2).

The method begins by running a single simulation of a building shaded only by context, which yields hourly information about thermal loads and heat gains transmitted through the windows from

Environmental parameters affecting daylight: Dayligth Autonomy estimation



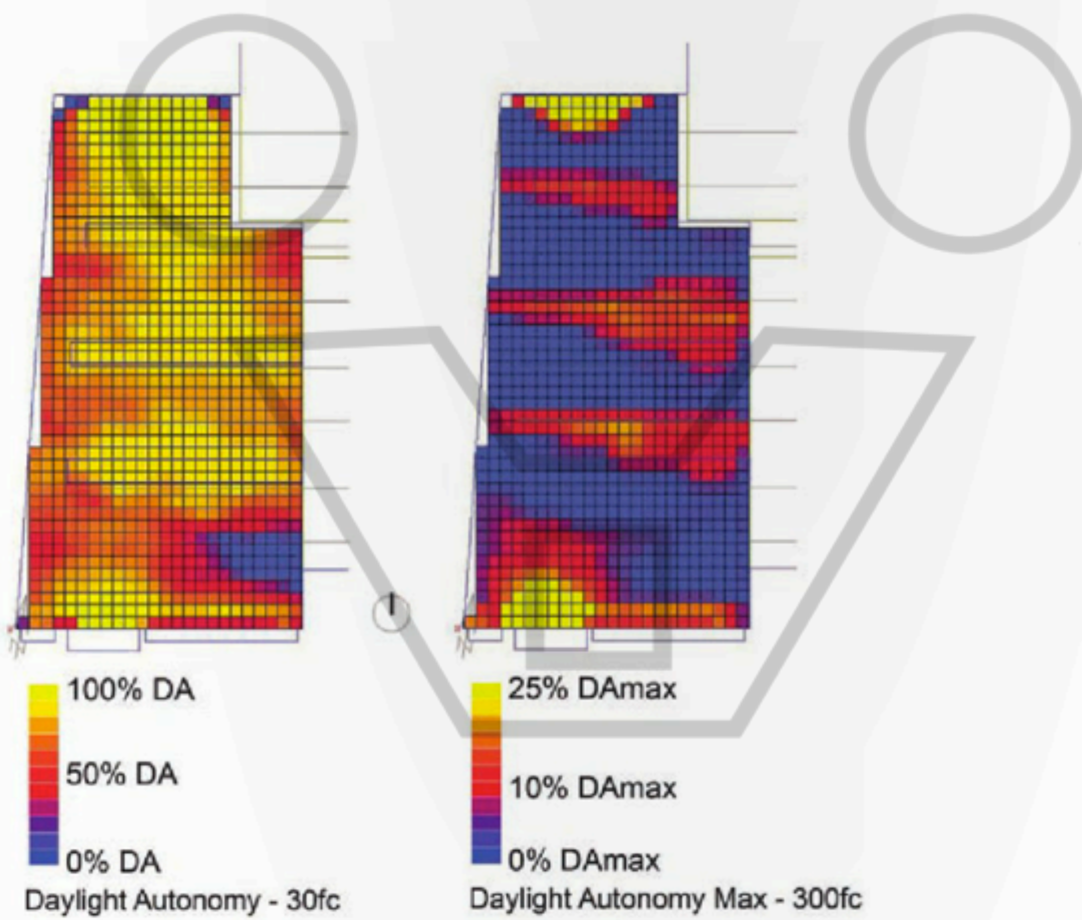
8.10

Daysim software, that estimates daylight autonomy, has a user-inputted minimum lighting threshold, generally the illuminance level recommended for electric lighting. The characteristics of the occupants, the hours of operation, and other information are necessary to accurately estimate when electric lights may be dimmed or off on an annual basis.

A given sensor that reports a DA of 75% means that electric lights would not be necessary at the sensor during 75% of the occupied hours each year. DA presents a best case scenario for lights to be dimmed or off, since glare may cause blinds to be deployed, reducing light levels at the sensor. DA software requires the input of various assumptions about the building or users' operations of blinds as

Environmental parameters affecting daylight: Dayligth Autonomy estimation

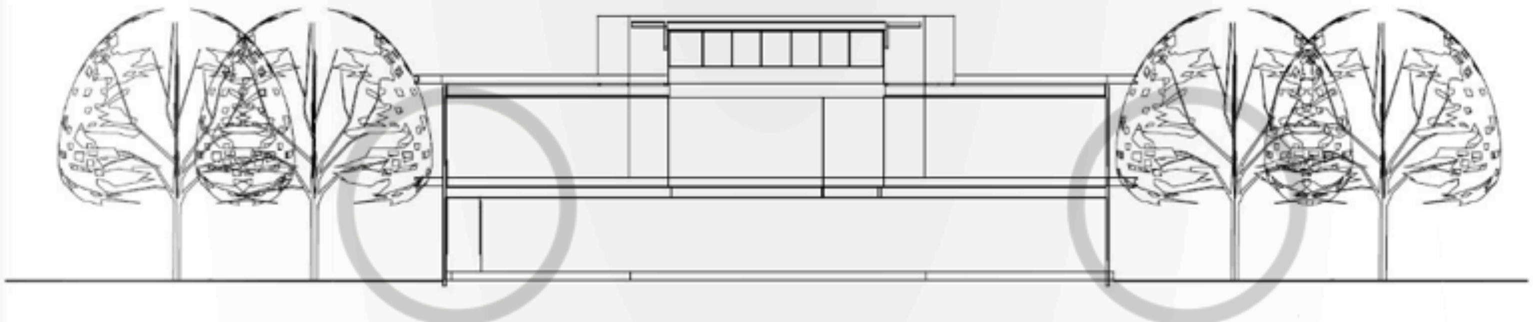
DAYLIGHT AUTONOMY vs DAYLIGHT AUTONOMY MAX ANALYSIS



8.24

Plan view of reading room showing annual DA and DAmax. The skylight geometry is shown to provide enough daylight throughout most of the year with over-lighting in only a few places for only around 10% of occupied hours.

Environmental parameters affecting daylight: GREEN SHADING MODELING



8.53

Sectional line drawing looking south, showing trees at two potential distances from the façade.

Courtesy of Skidmore, Owings & Merrill, Chicago.

8.54

Creation of digital tree geometry.

Courtesy of Skidmore, Owings & Merrill, Chicago.

Simulation

This simulation was performed by SOM's Design Performance Group, which specializes in early design simulations. The Revit-based model was imported and re-built in Rhino for this tree canopy study in the design development phase.

Research was conducted into modeling and defining the optics and seasonal behavior of a Thornless Honeylocust to create a simulated tree. A vector outline (1) of the species was projected onto two sides of a 3D volume. The canopy openness was approximated in the Rhino model (2) to allow direct, dappled light from various directions and a variation of light passing through and reflecting off leaves. This approach reduced meshed surfaces and simulation time.

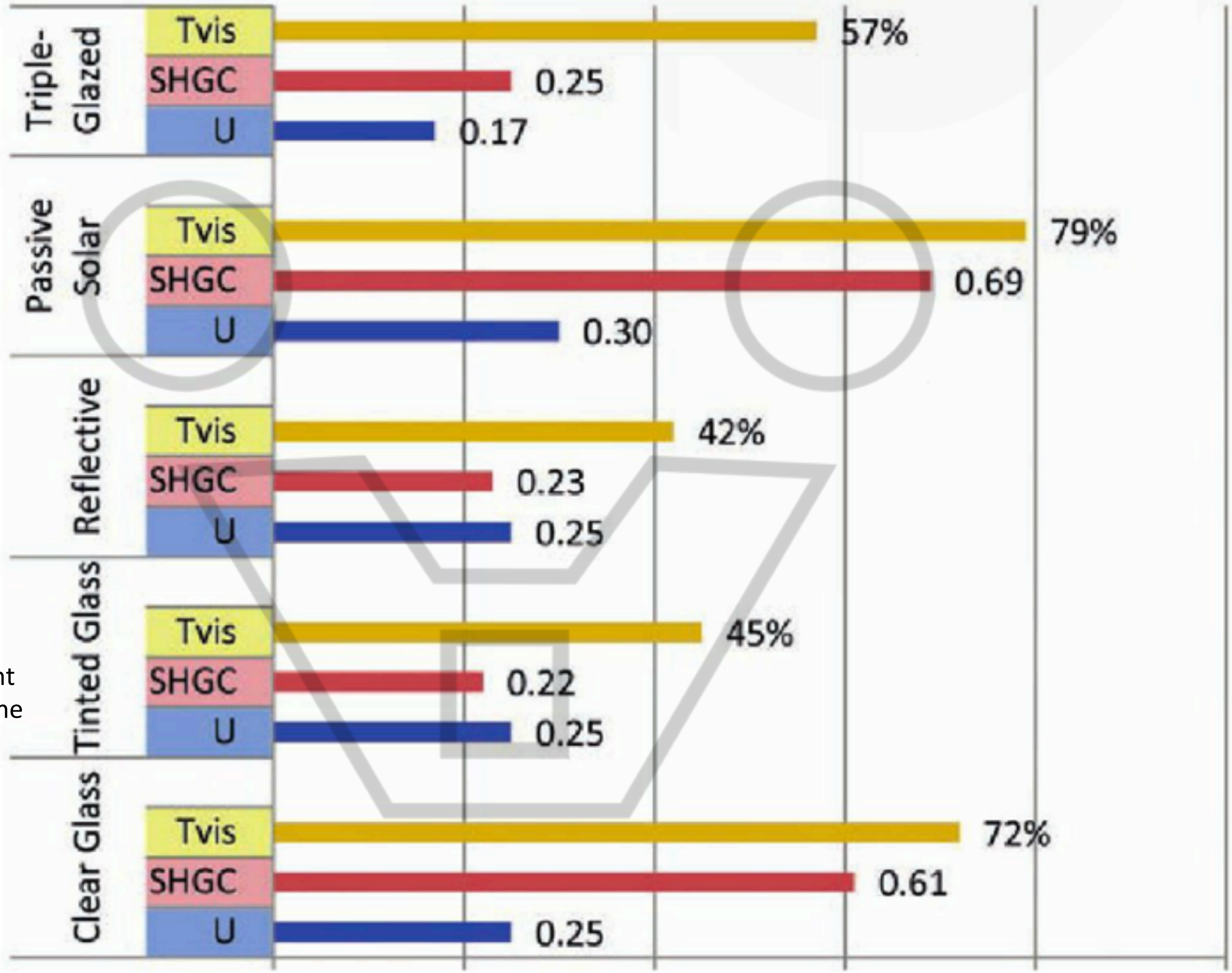
Research and guidance from Christopher Meek at the University of Washington Integrated Design Lab (IDL) into the optical properties (3) of the leaves were used to create a Radiance material (4) for the leaves using Optics 6 Software. The tree leaves were scheduled to be present in the model between May 15th and October 15th to simulate deciduous vegetation.

Environmental parameters affecting daylight: GLAZING PROPERTIES

visible Trasmittance (TVis) for daylighting)

Solar Heat Gain Coefficient (SHGC)

Solar Heat Gain COefficient (SHGC) is the fraction of the incident solar radiation trasmitted through a windoes plus the portion absorbed and subsequentially released iward



6.4

Glazing properties from some widely manufactured insulated glazing units (IGUs).

Source: Courtesy of Callison. Chart based on ©ASHRAE Handbook of Fundamentals (2005), 31.20.

COOLING OR HEATING ?

WHAT ARE THE PASSIVE STRATEGIES FOR A SPECIFIC BUILDING?

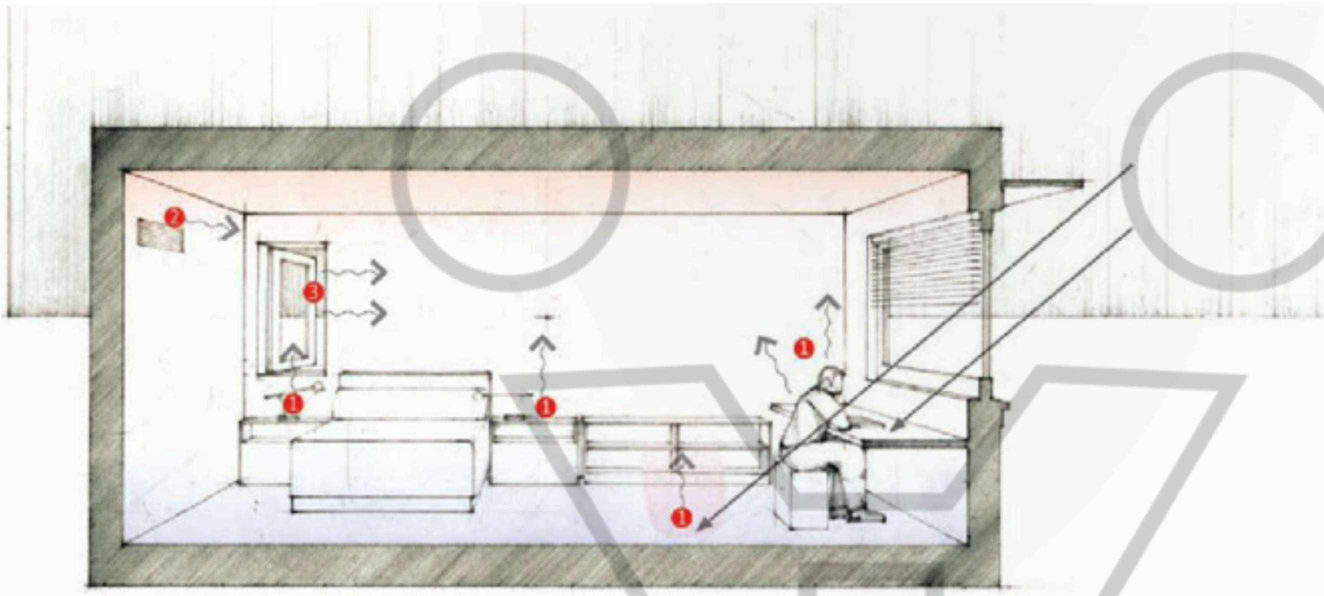
- Ventilation >> Working with WIND (convection)
- Latent Heat >> Working with WATER (evaporation)
- Thermal Lag >> Working with MASS (heat storage)

WORKING WITH NATURAL VENTILATION

- To heat/cool through thermal convection
- to refresh through the sweating acceleration
- to clean exhausted indoor air
- to prevent condensation, moisture, and germs

Environmental parameters affecting indoor comfort: VENTILATION

WORKING WITH NATURAL VENTILATION



office and conference room spaces in plan and section. CFD was used to verify the potential for natural ventilation to provide adequate cooling even when outdoor windspeeds are low.

Source: Courtesy of KEMA Energy Analysts.

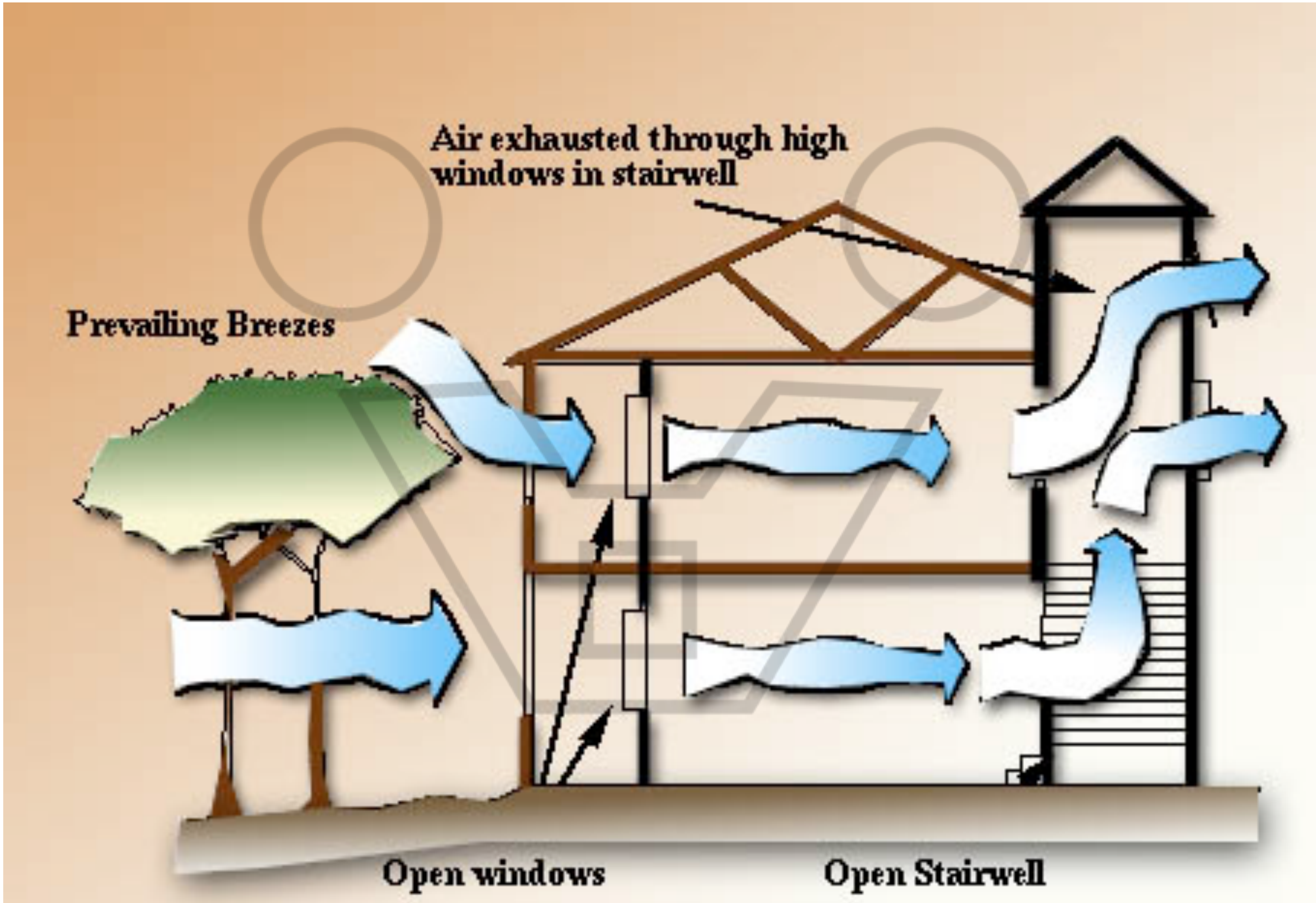
9.2

Airflow within a room is created by multiple sources air rising from (1) heat sources (such as a lamp, person, or a floor warmed by solar irradiation) due to buoyancy creating thermal stratification (red and blue overtones); the interactions of forced air from a (2) fan or a mechanical system and (3) outdoor air speed and direction, channeled by building geometry into and out of a room.

NATURAL VENTILATION AND MIXED-MODE OPERATION

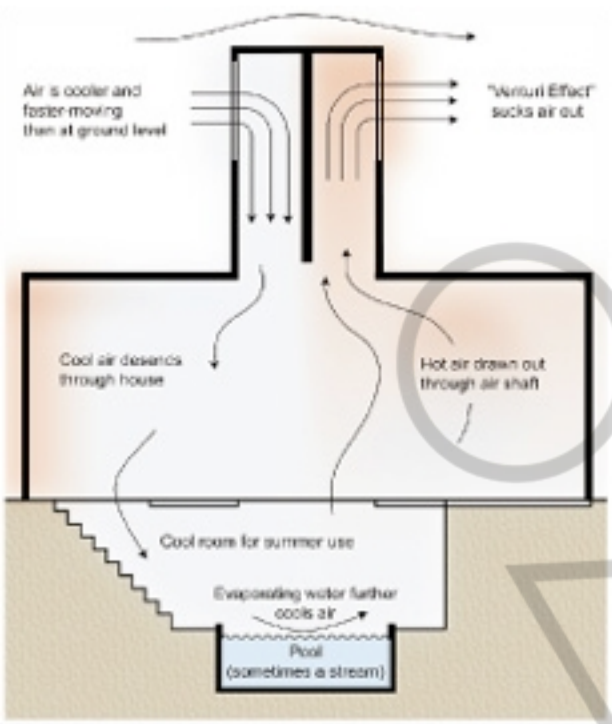
Natural ventilation channels direct outside air to do one or more of the following: provide fresh air, provide cooling, or provide airflow to increase human comfort levels. The ability to use natural ventilation depends climate-wise on peak interior temperatures, and the humidity, solar radiation, and wind

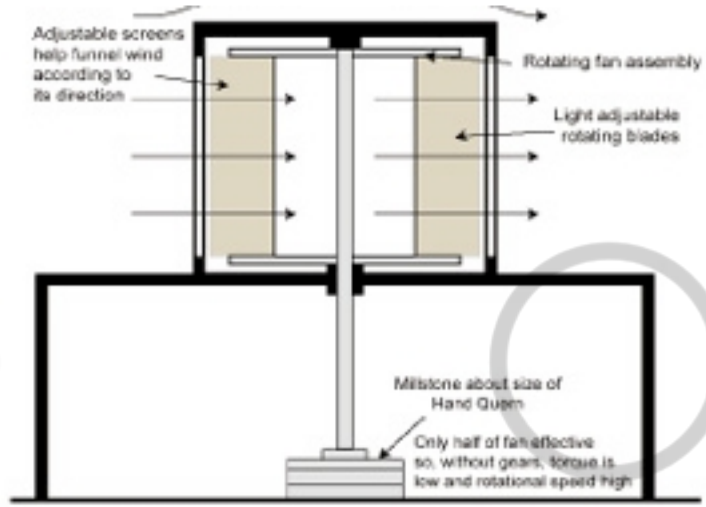
Environmental parameters affecting indoor comfort: VENTILATION

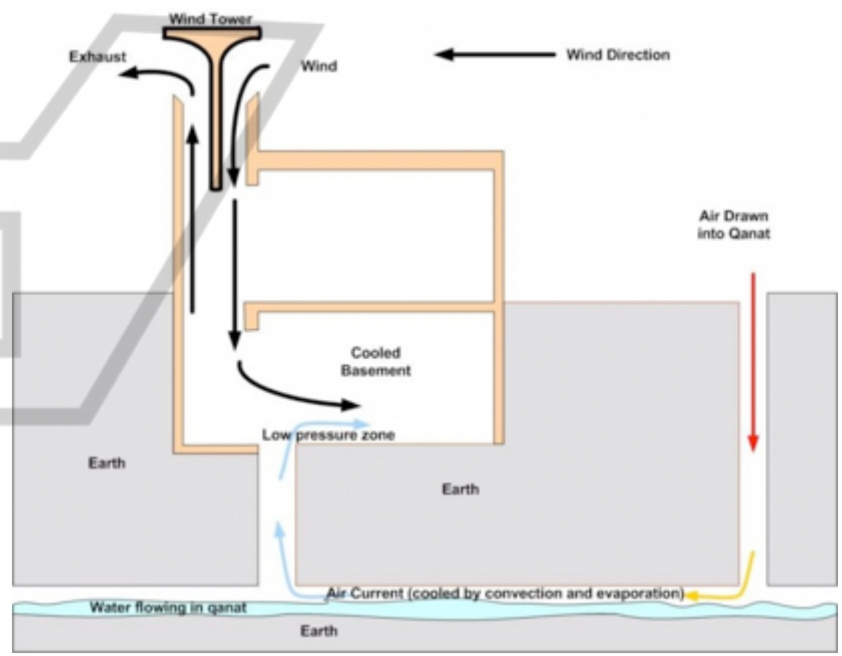


Environmental parameters affecting indoor comfort: VENTILATIONC

Environmental parameters affecting indoor comfort: VENTILATION



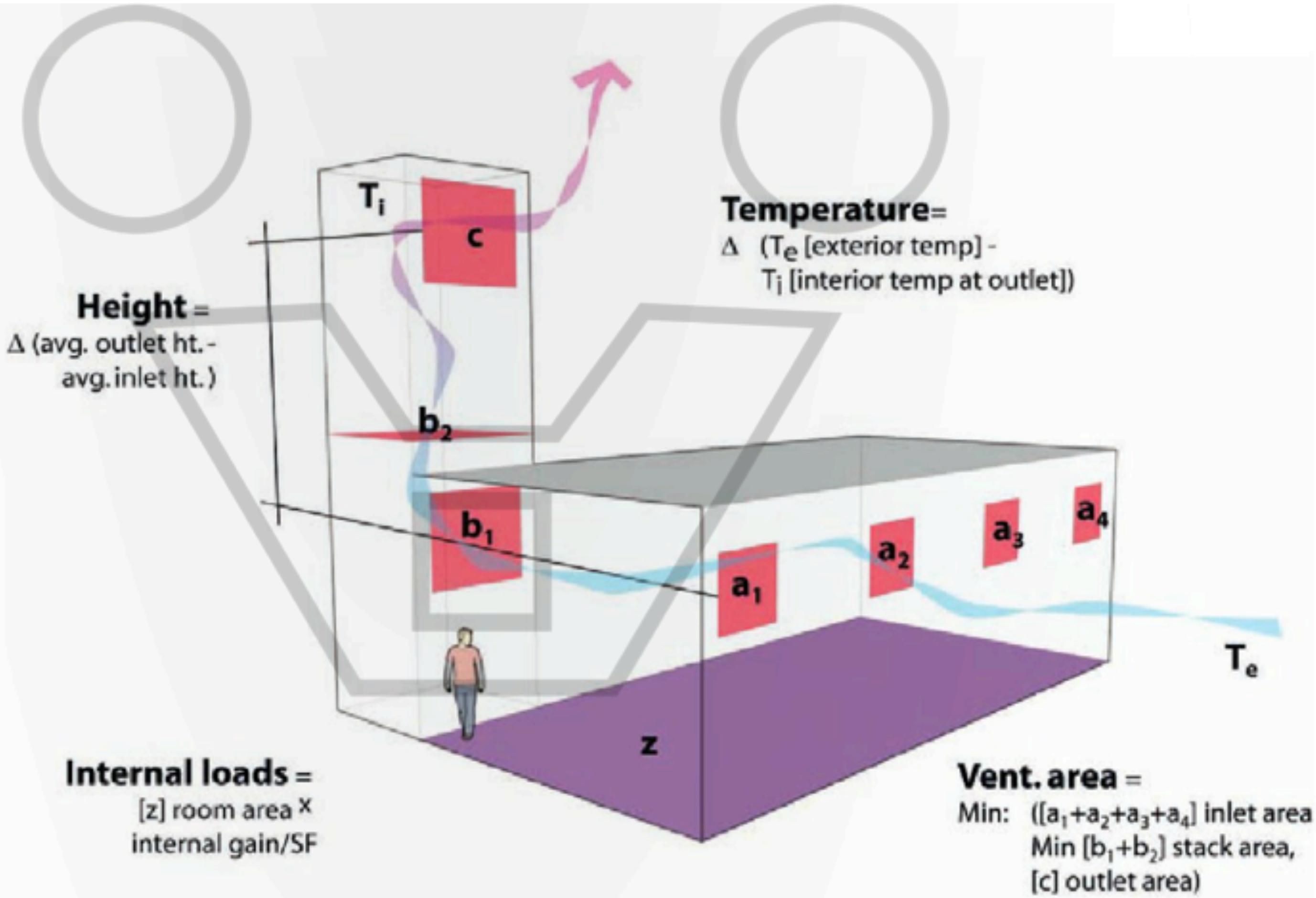


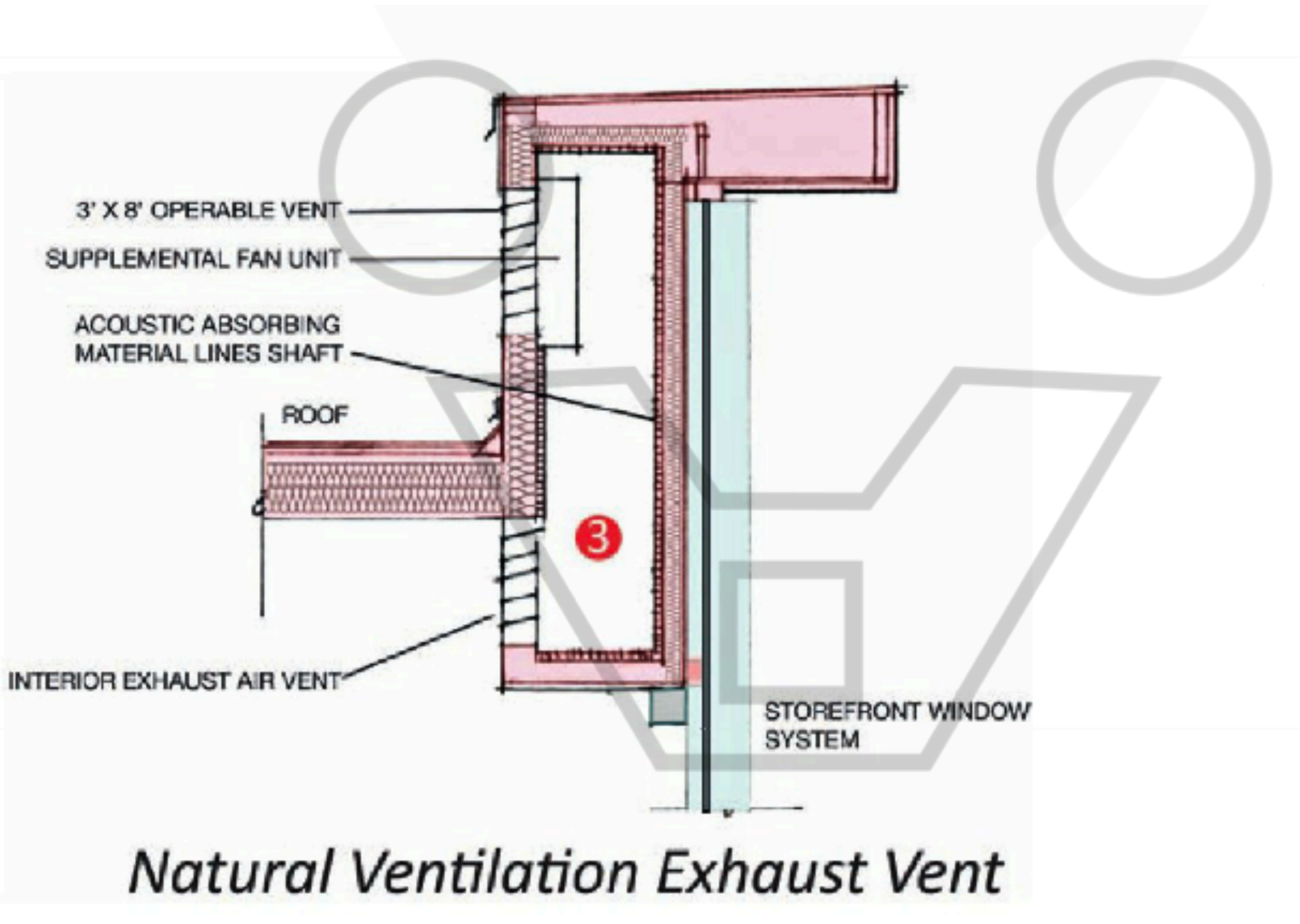


WORKING WITH NATURAL VENTILATION

9.12

Stack diagram showing the important inputs into a natural ventilation model.

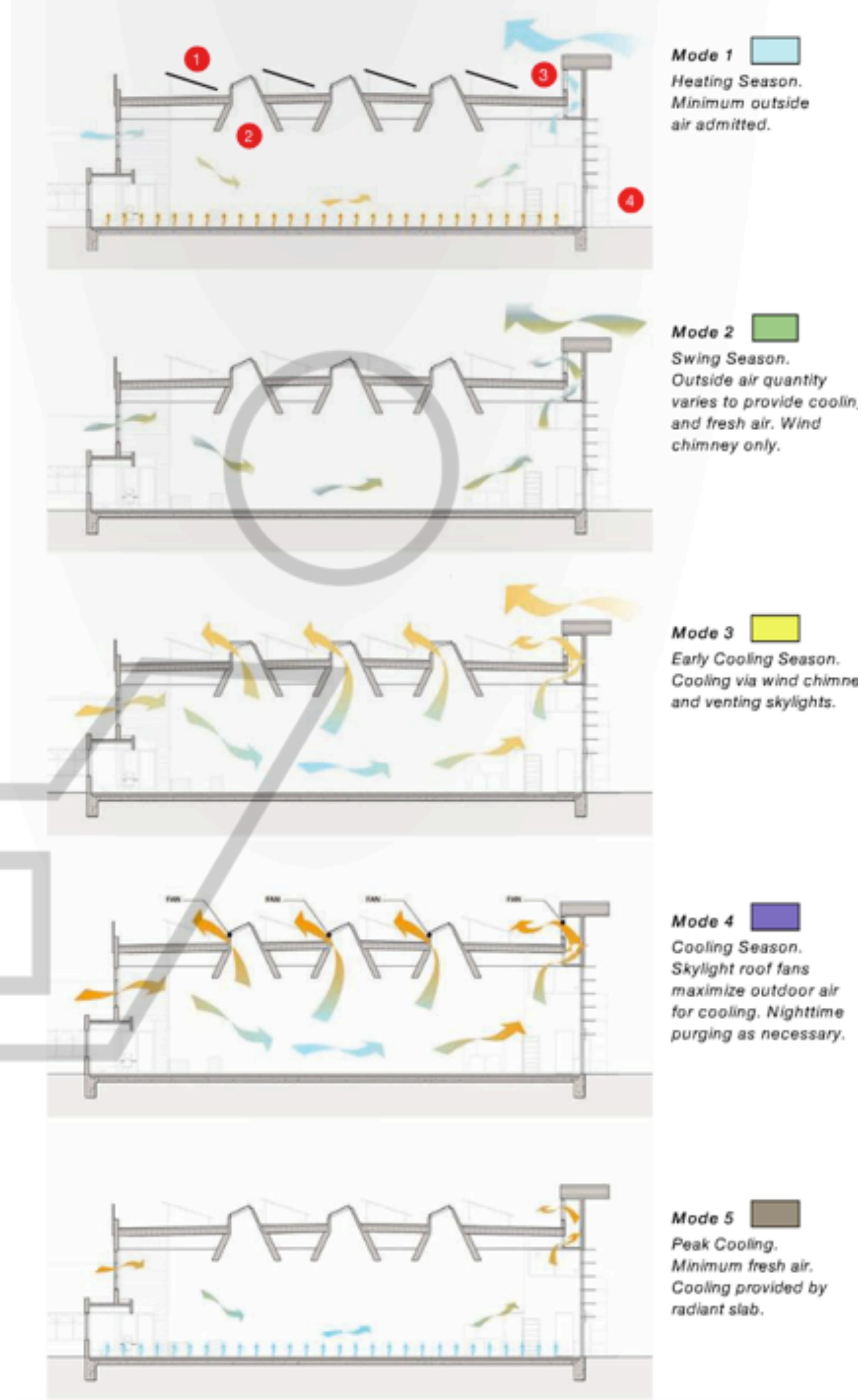




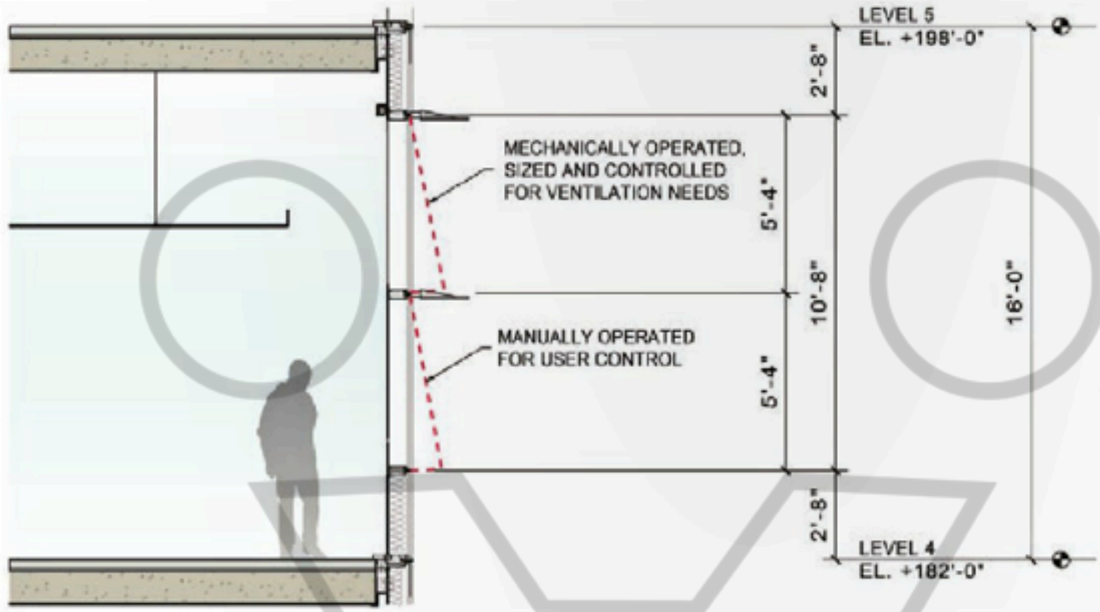
9.5

Natural ventilation exhaust vent.

WORKING WITH NATURAL VENTILATION

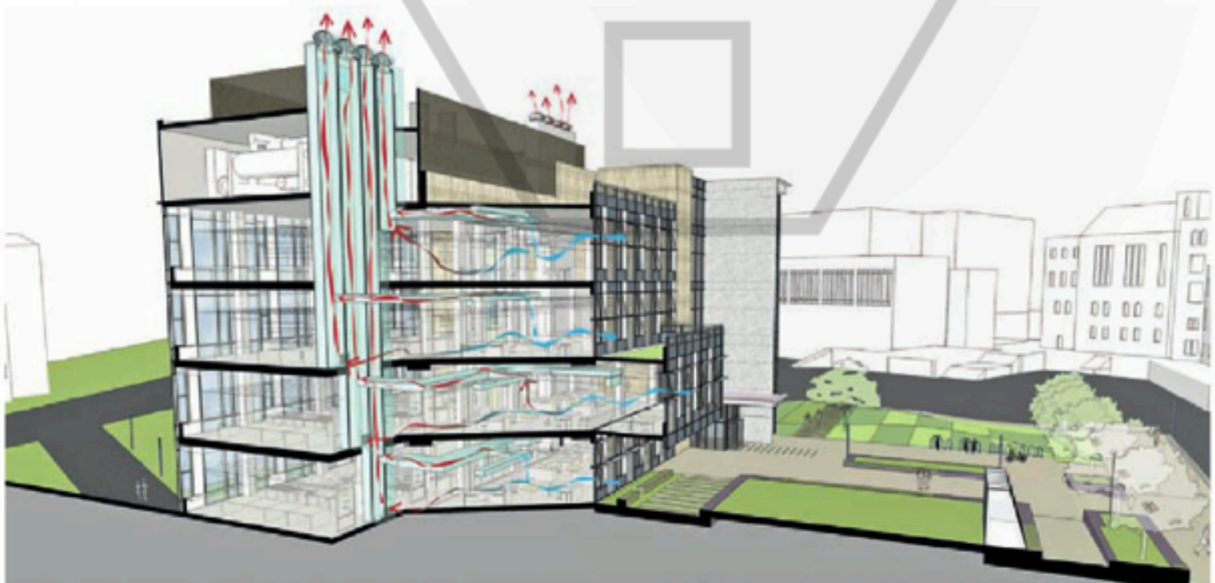


WORKING WITH NATURAL VENTILATION



9.13

Section through window showing window uses and sizes.



9.14

Natural ventilation diagram showing airflow into the offices and up through each floor's stacks.

WORKING WITH NATURAL VENTILATION

9.16

Photograph of the type of operable windows used at the Bullitt Center. Window diagram shows equal opening size around window's perimeter to reduce wear and provide even, controlled airflow.

Source: Photo and diagram courtesty Shuco.

9.17

Wind rose for Seattle Boeing Field, showing frequency (darker color) of wind direction and velocity during summer afternoons.

WORKING WITH WATER EVAPORATION

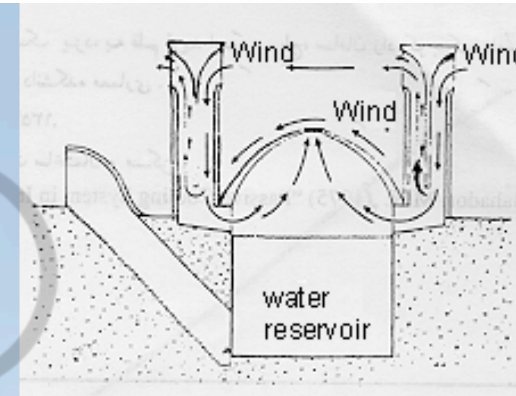
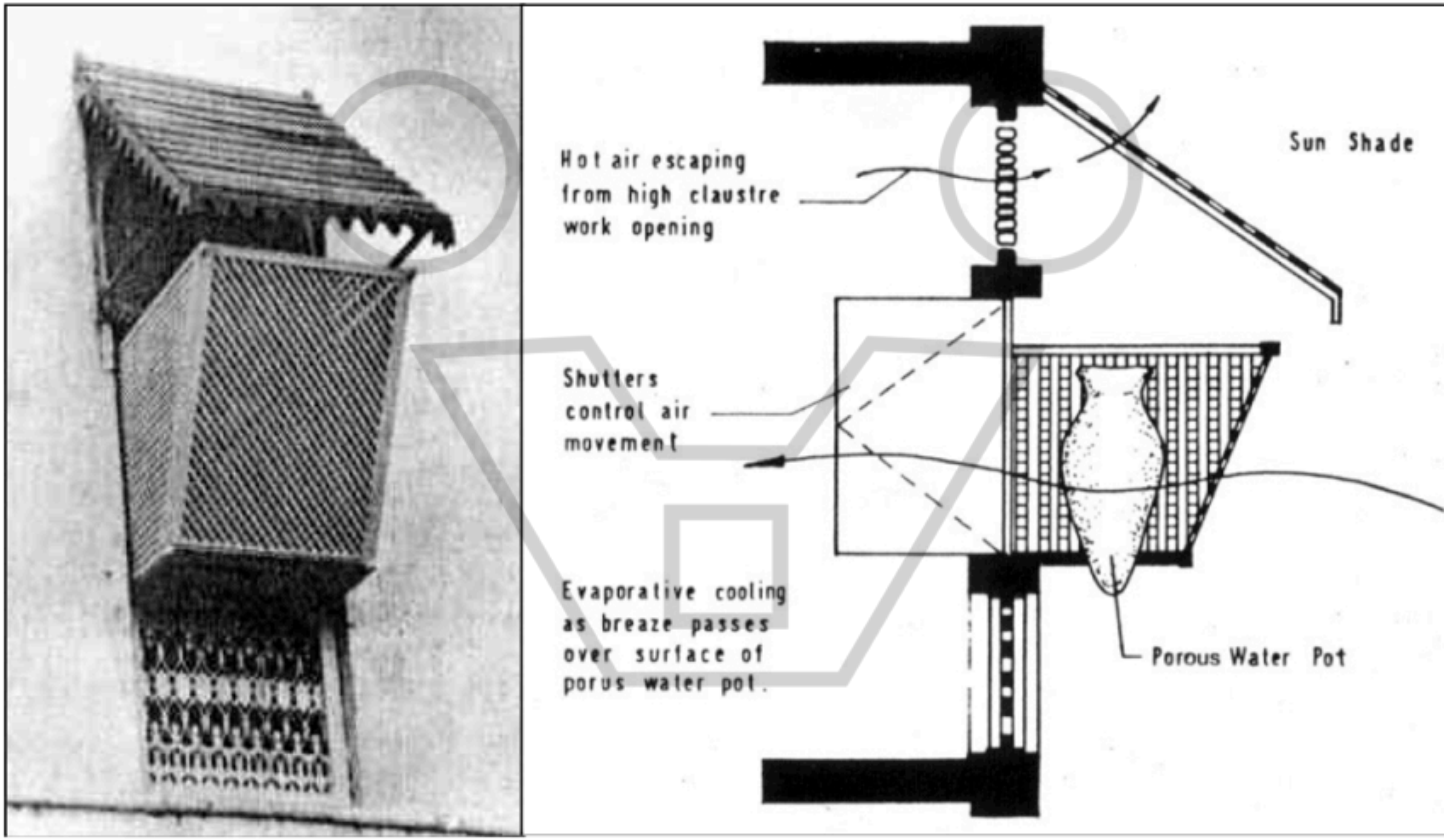
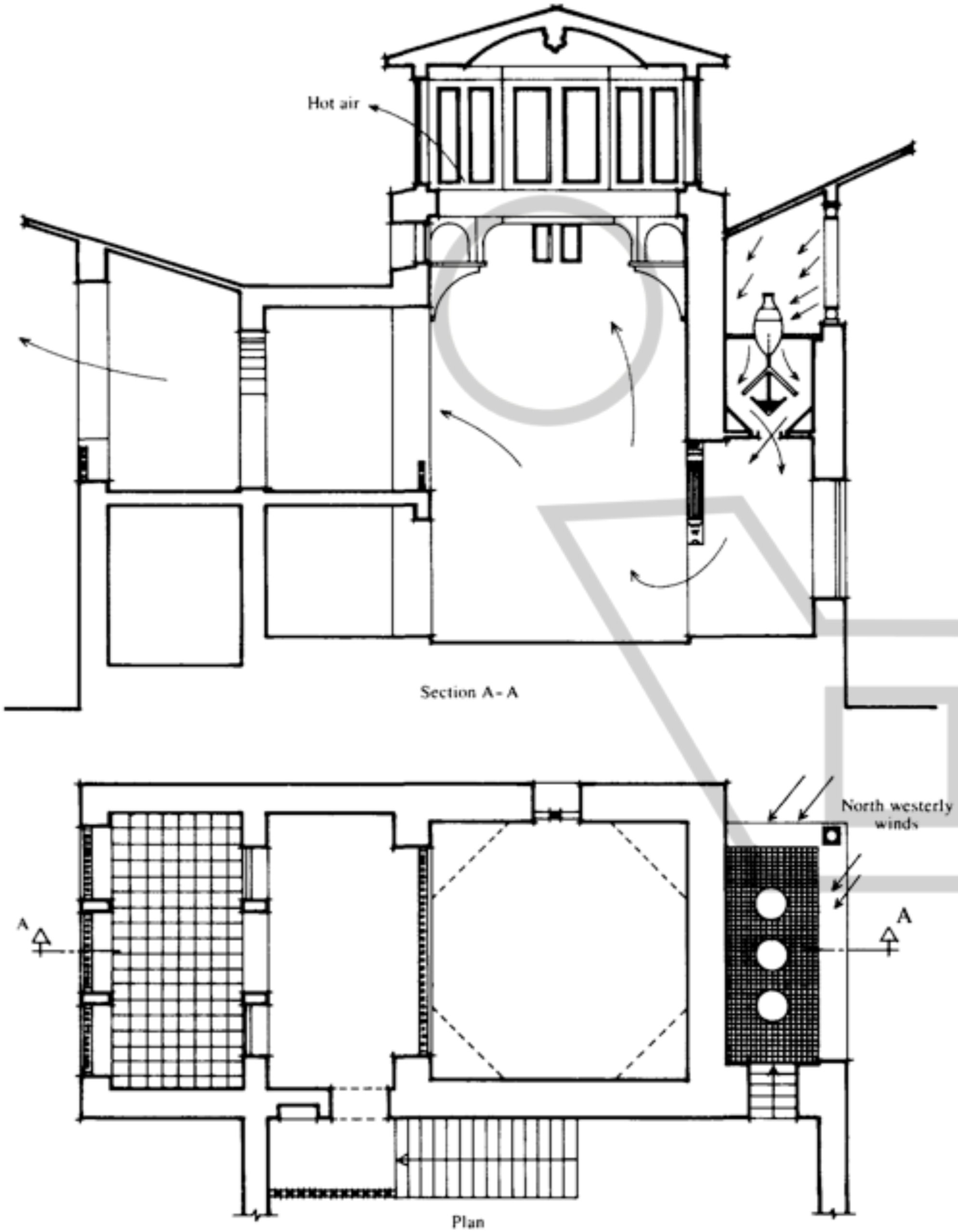
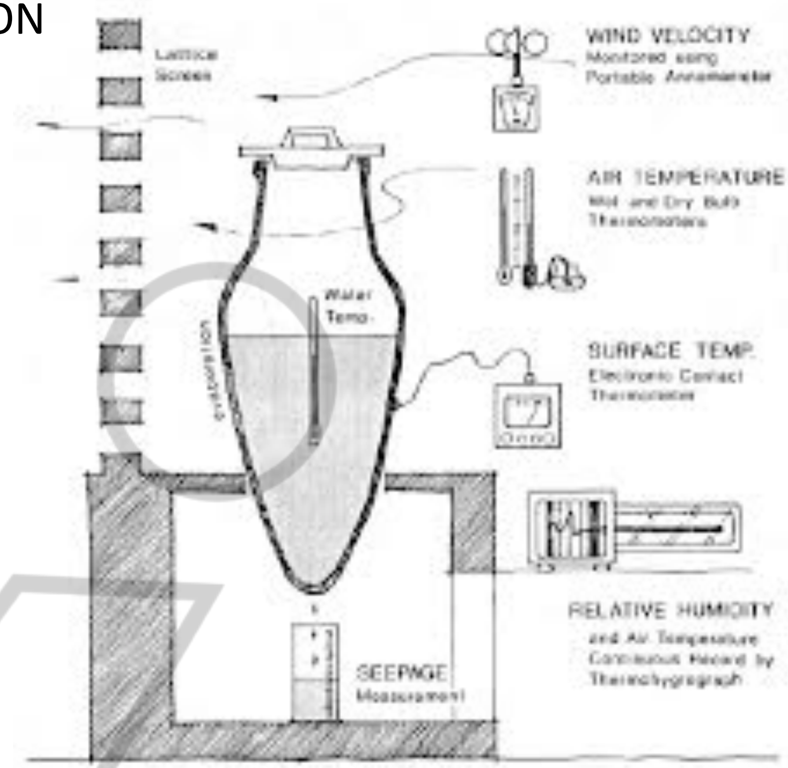

Wind
Wind
Wind
water
reservoir

Figure : Muscatese Evaporative cooling window system (Rosa Schiano 2007)



WORKING WITH NATURAL VENTILATION





What is LATENT HEAT?

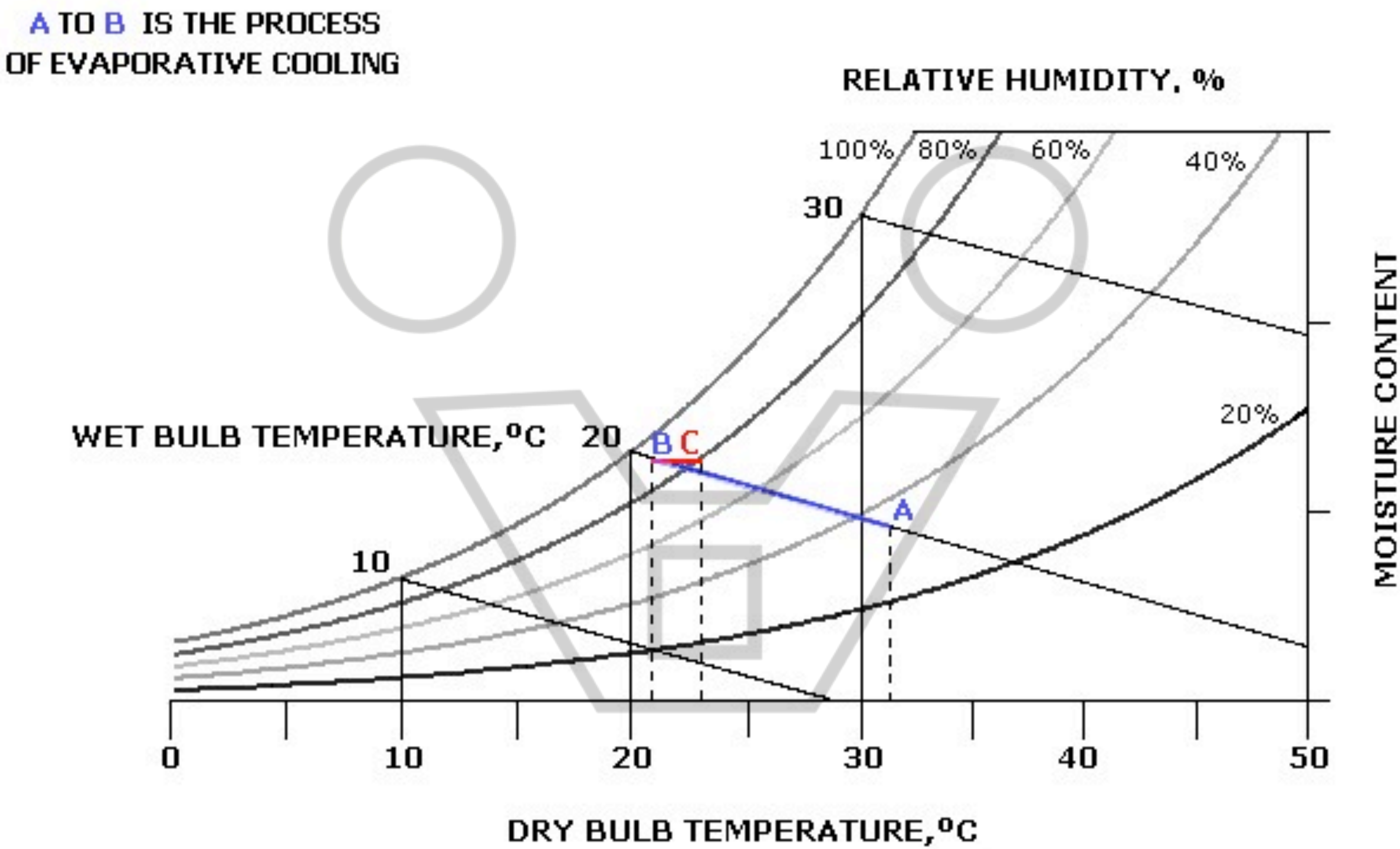
Latent heat is the energy absorbed by or released from a substance during a phase change from a gas to a liquid or a solid or vice versa. If a substance is changing from a solid to a liquid, for example, the substance needs to absorb energy from the surrounding environment in order to spread out the molecules into a larger, more fluid volume. If the substance is changing from something with lower density, like a gas, to a phase with higher density like a liquid, the substance gives off energy as the molecules come closer together and lose energy from motion and vibration.

Sensible heat **is the energy required to change the temperature of a substance with no phase change**. The temperature change can come from the absorption of sunlight by the soil or the air itself. Or it can come from contact with the warmer air caused by release of latent heat (by direct conduction). Energy moves through the atmosphere using both latent and sensible heat acting on the atmosphere to drive the movement of air molecules which create wind and vertical motions.

WORKING WITH NATURAL VENTILATION

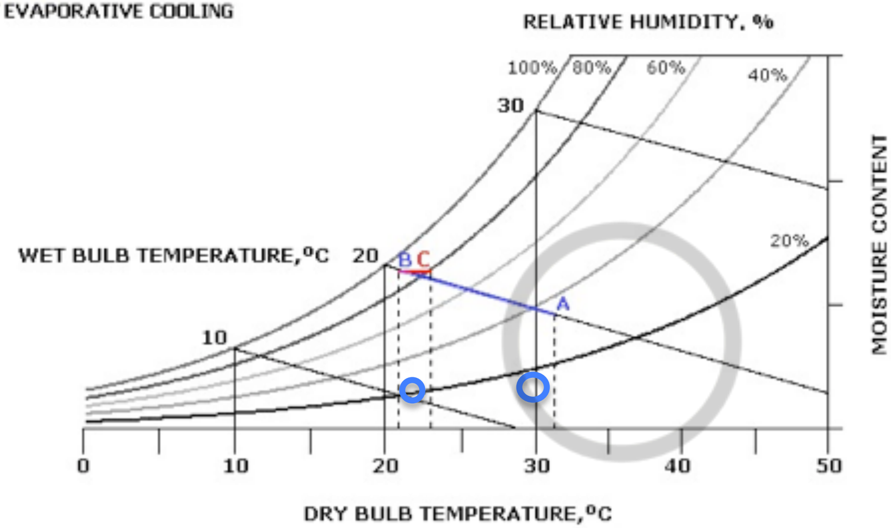
Sostanza	Calore latente di fusione (J/g)	Temperatura di fusione (°C)
Acqua	333,5	0
Azoto	25,7	-210
Alcol etilico	108	-114
Ammoniaca	339	-75
Mercurio	11	-39
Zolfo	54	115

WORKING WITH NATURAL VENTILATION



WORKING WITH NATURAL VENTILATION

A TO B IS THE PROCESS OF EVAPORATIVE COOLING



REAL TEMPERATURE:

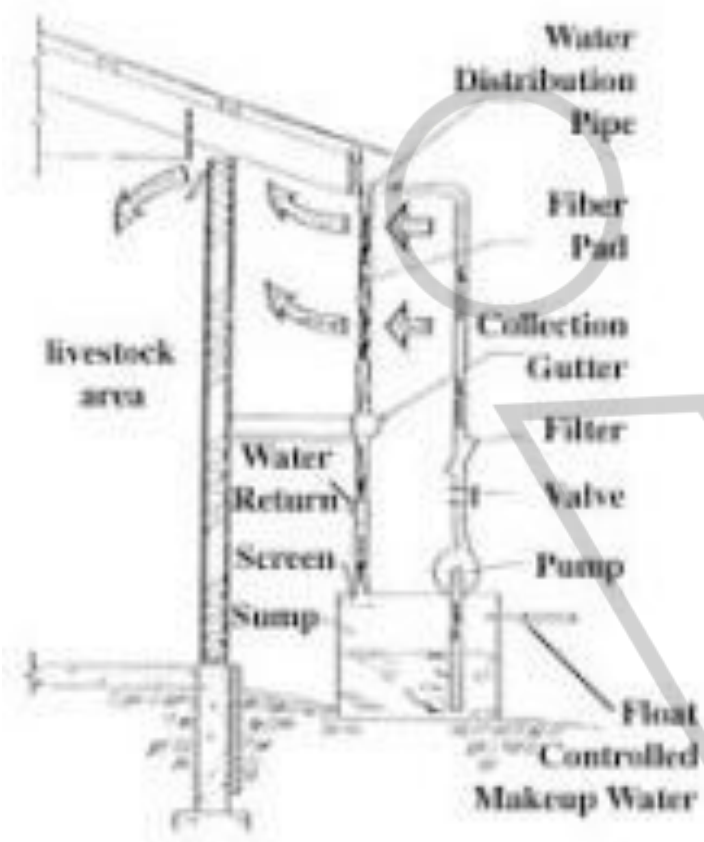
30° (40%) >> 22°(80%) >> diff -8°

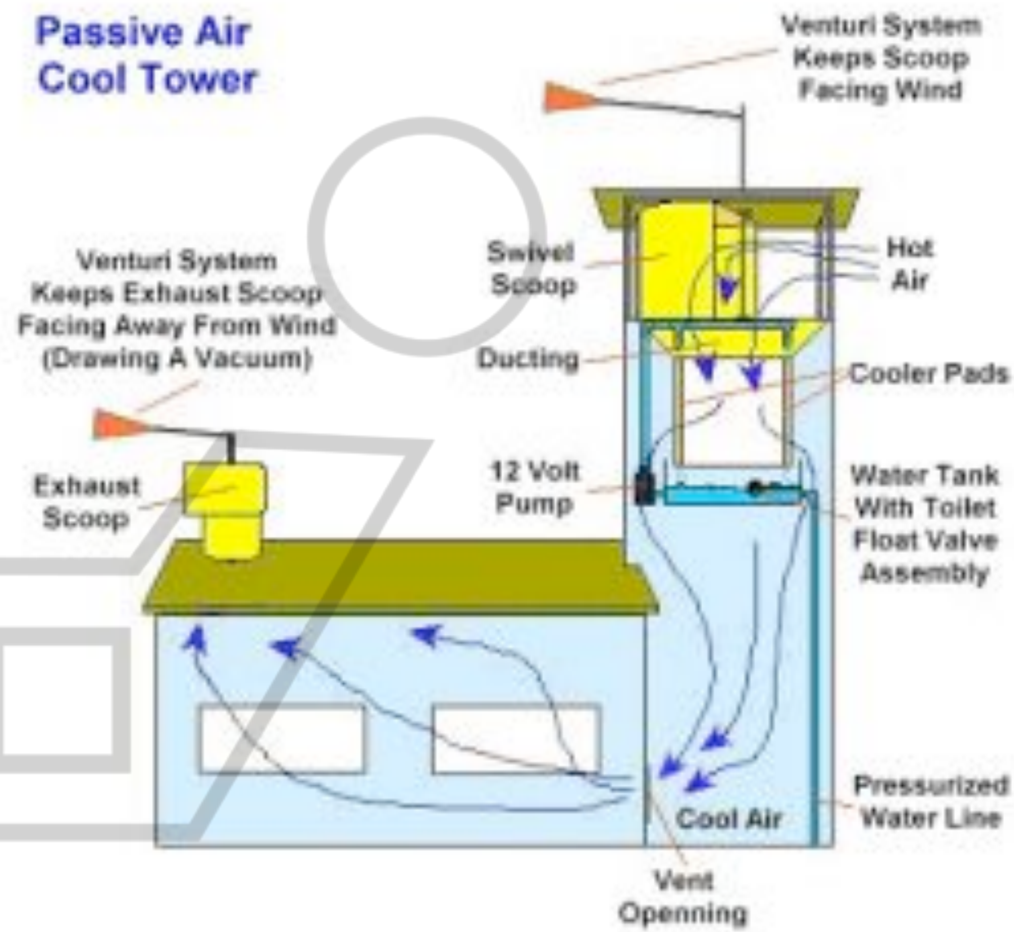
APPARENT TEMPERATURE

34° >> 28° >> diff -6°

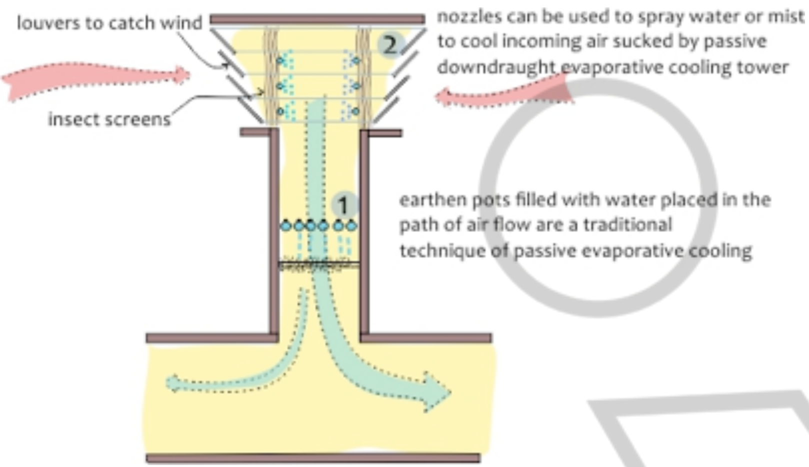
	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%
42°	48	50	52	55	57	59	62	64	66	68	71	73	75	77	80
41°	46	48	51	53	55	57	59	61	64	66	68	70	72	74	76
40°	45	47	49	51	53	55	57	59	61	63	65	67	69	71	73
39°	43	45	47	49	51	53	55	57	59	61	63	65	66	68	70
38°	42	44	45	47	49	51	53	55	56	58	60	62	64	66	67
37°	40	42	44	45	47	49	51	52	54	56	58	59	61	63	65
36°	39	40	42	44	45	47	49	50	52	54	55	57	59	60	62
35°	37	39	40	42	44	45	47	48	50	51	53	54	56	58	59
34°	36	37	39	40	42	43	45	46	48	49	51	52	54	55	57
33°	34	36	37	39	40	41	43	44	46	47	48	50	51	53	54
32°	33	34	36	37	38	40	41	42	44	45	46	48	49	50	52
31°	32	33	34	35	37	38	39	40	42	43	44	45	47	48	49
30°	30	32	33	34	35	36	37	39	40	41	42	43	45	46	47
29°	29	30	31	32	33	35	36	37	38	39	40	41	42	43	45
28°	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42
27°	27	27	28	29	30	31	32	33	34	35	36	37	38	39	40
26°	26	26	27	28	29	30	31	32	33	34	34	35	36	37	38
25°	25	25	26	27	27	28	29	30	31	32	33	34	34	35	36
24°	24	24	24	25	26	27	28	28	29	30	31	32	33	33	34
23°	23	23	23	24	25	25	26	27	28	28	29	30	31	32	32
22°	22	22	22	22	23	24	25	25	26	27	27	28	29	30	30

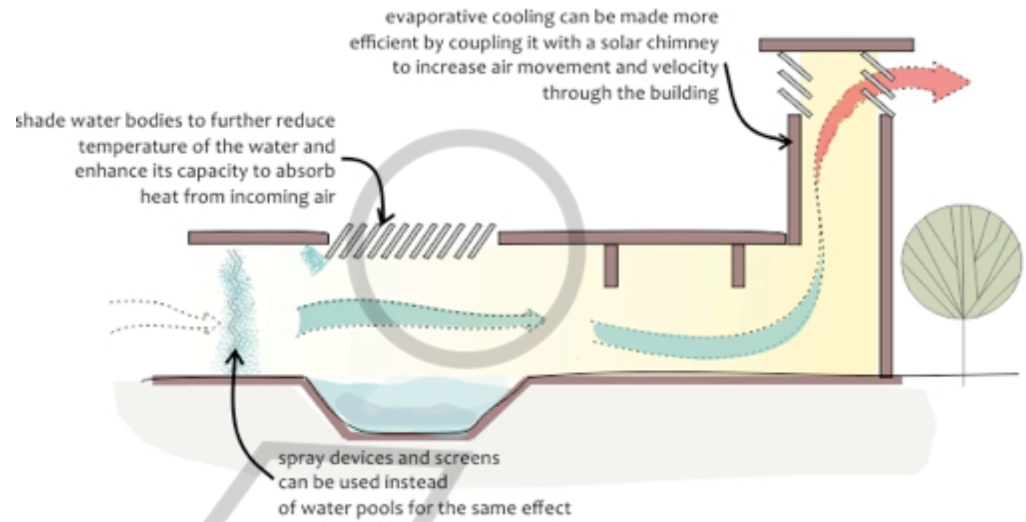
WORKING WITH MASS

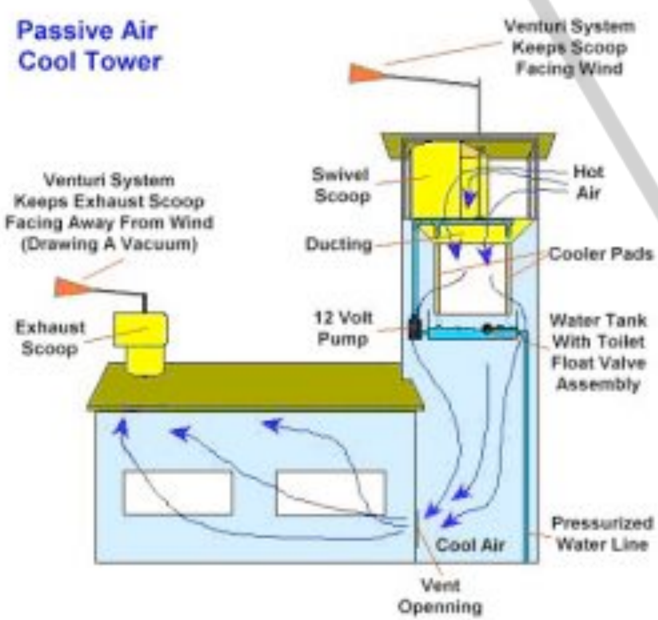


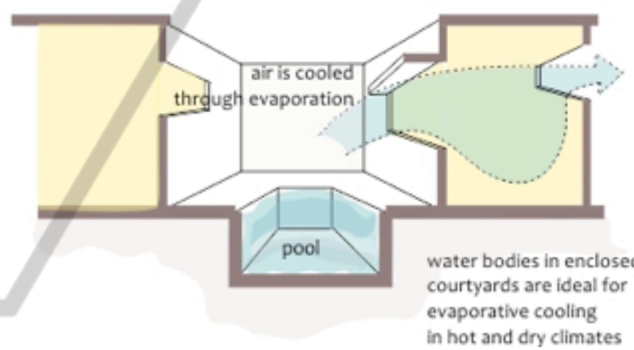


WORKING WITH NATURAL VENTILATION

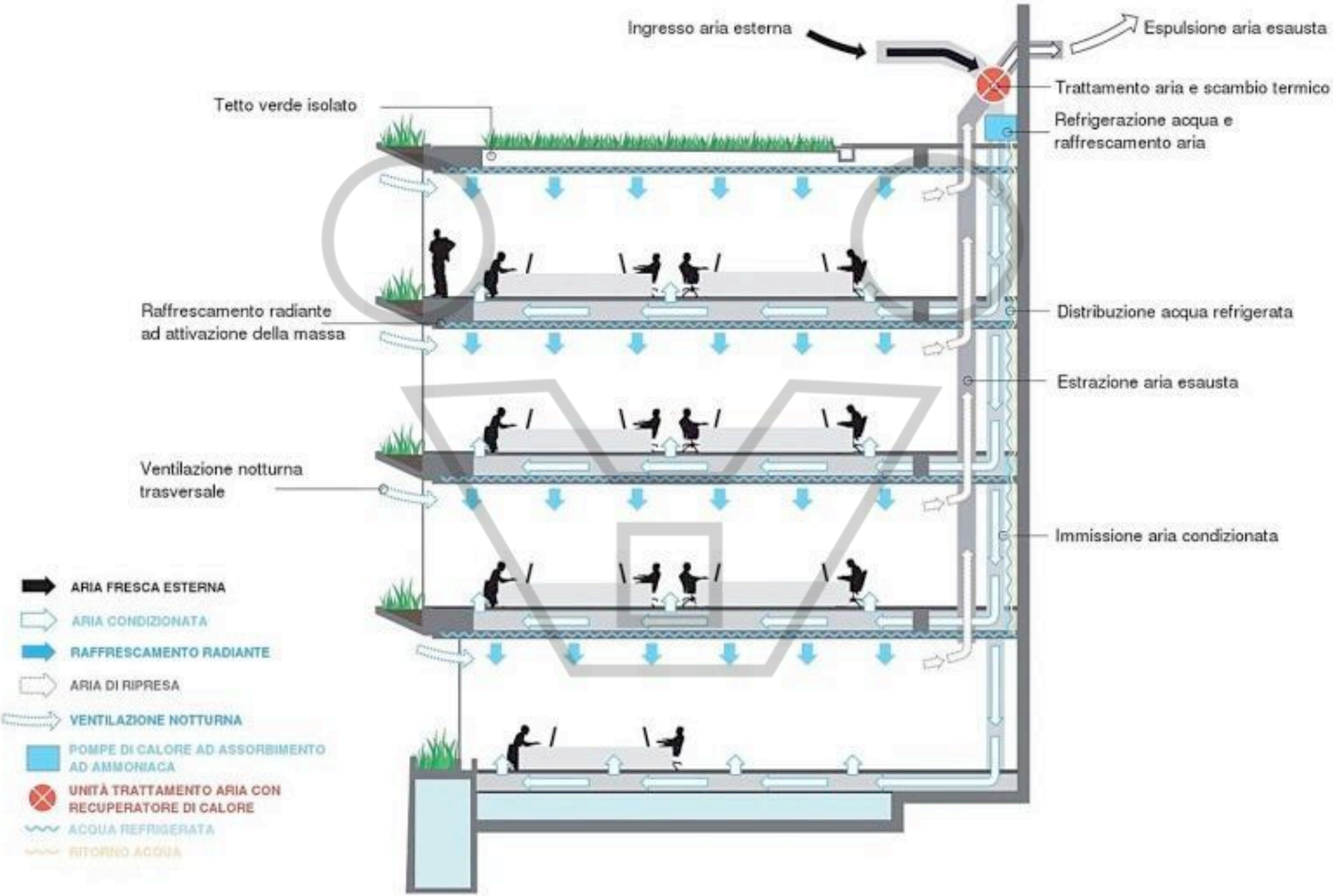








WORKING WITH NATURAL VENTILATION



WORKING WITH MASS vs INSULATION

What is THERMAL LAG?

Thermal Lag describes a body's thermal mass with respect to time. A body with high thermal mass (high heat capacity and low conductivity) will have a large thermal lag.

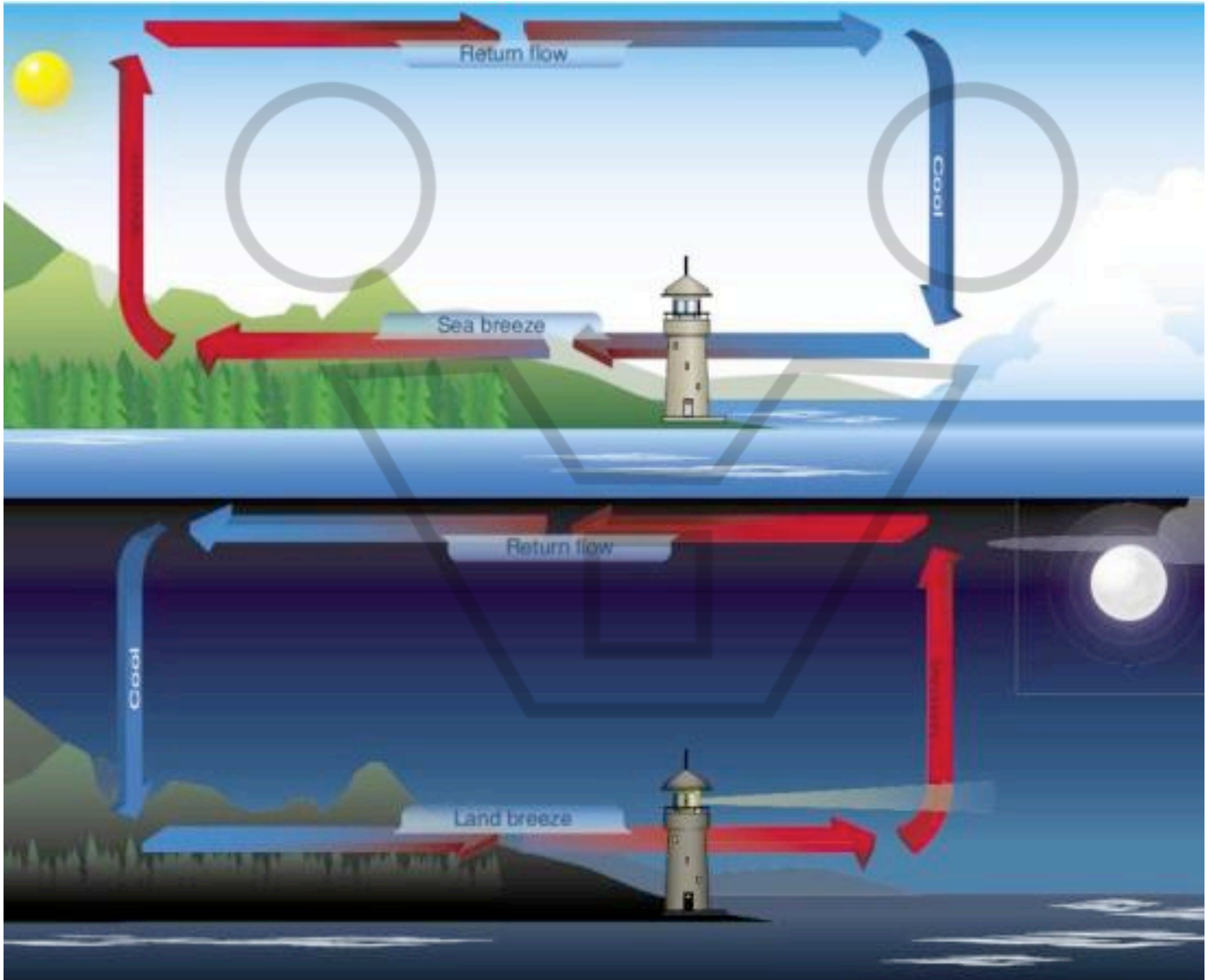
Thermal diffusivity is the thermal conductivity divided by density and specific heat capacity at constant pressure

thermal mass is a property of the mass of a building which enables it to store heat, providing "inertia" against temperature fluctuations. It is sometimes known as the *thermal flywheel effect.*

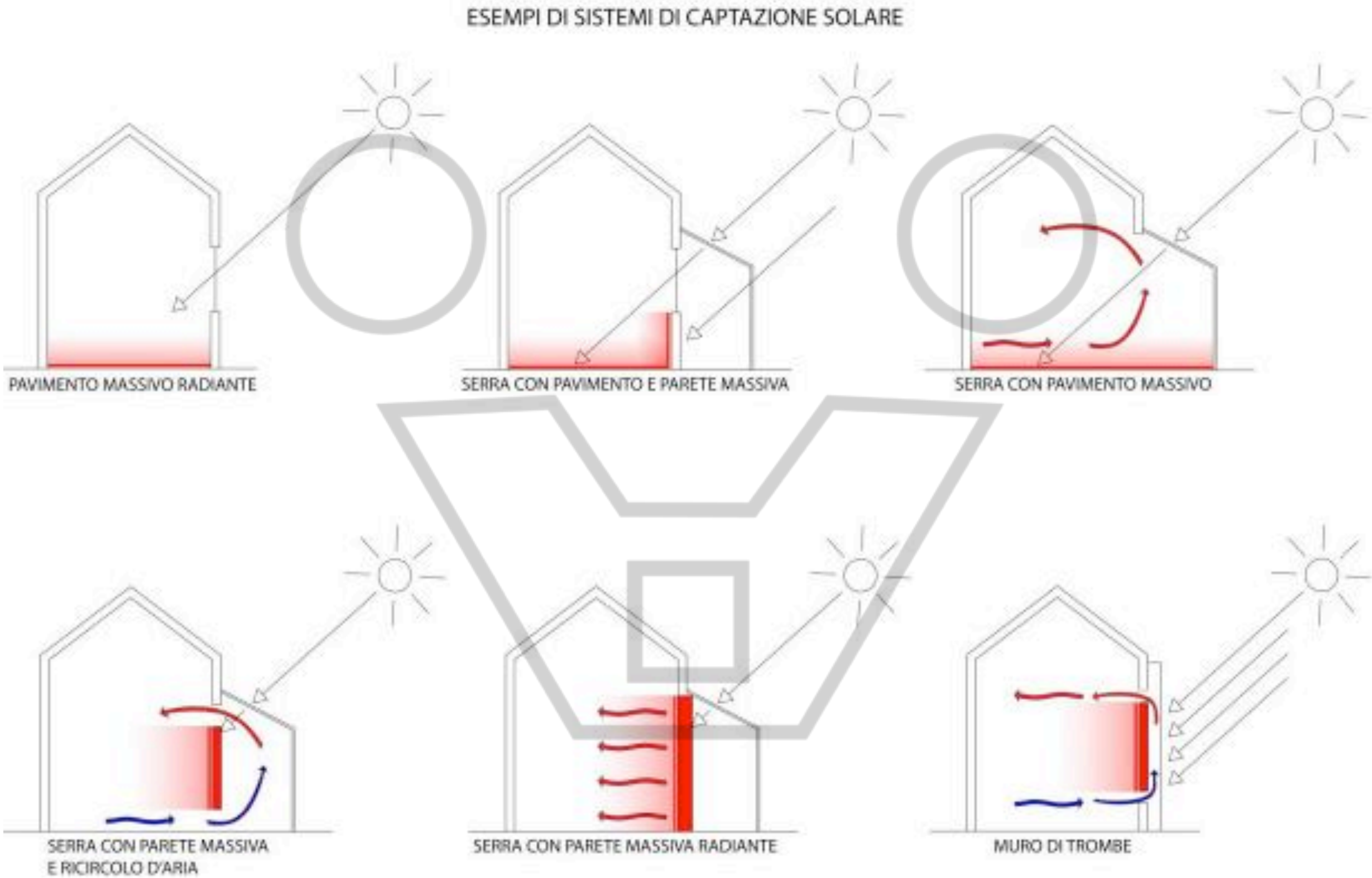
This is distinct from a material's insulative value, which reduces a building's thermal conductivity, allowing it to be heated or cooled relatively separate from the outside,

WORKING WITH NATURAL VENTILATION

Marine breezes

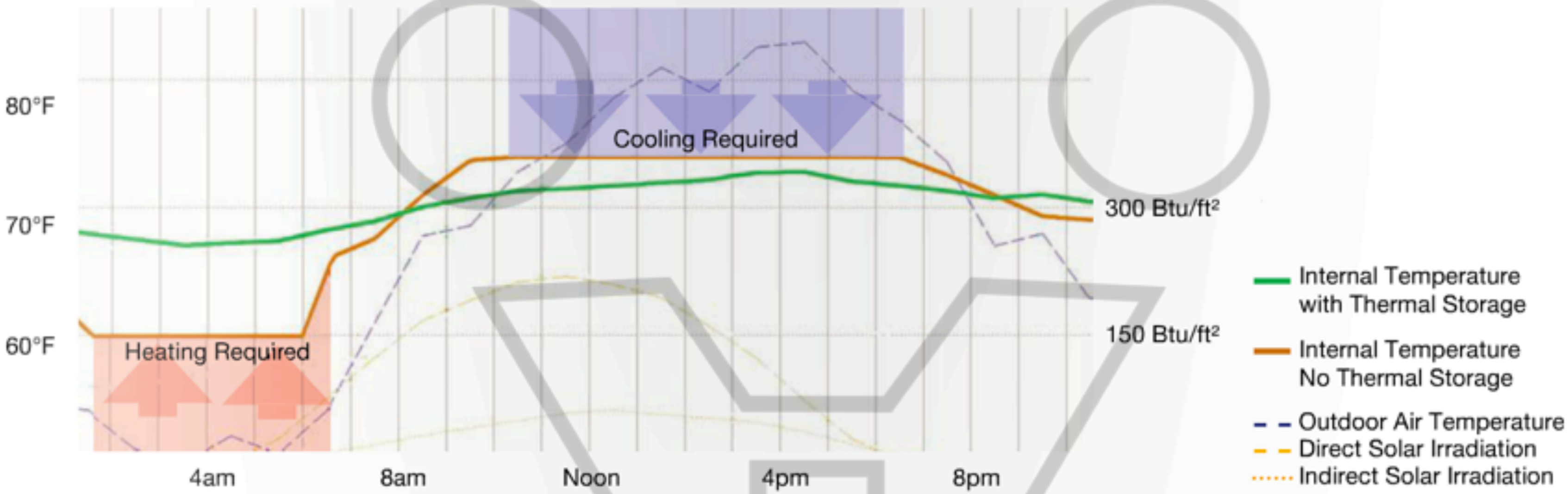


WORKING WITH THERMAL MASS & DIFFUSIVITY



WORKING WITH THERMAL MASS & DIFFUSIVITY

COOLING vs HEATING: Thermal storage strategy



7.11

Diagram showing air temperatures over a 24-hour period for an office with and without thermal storage.

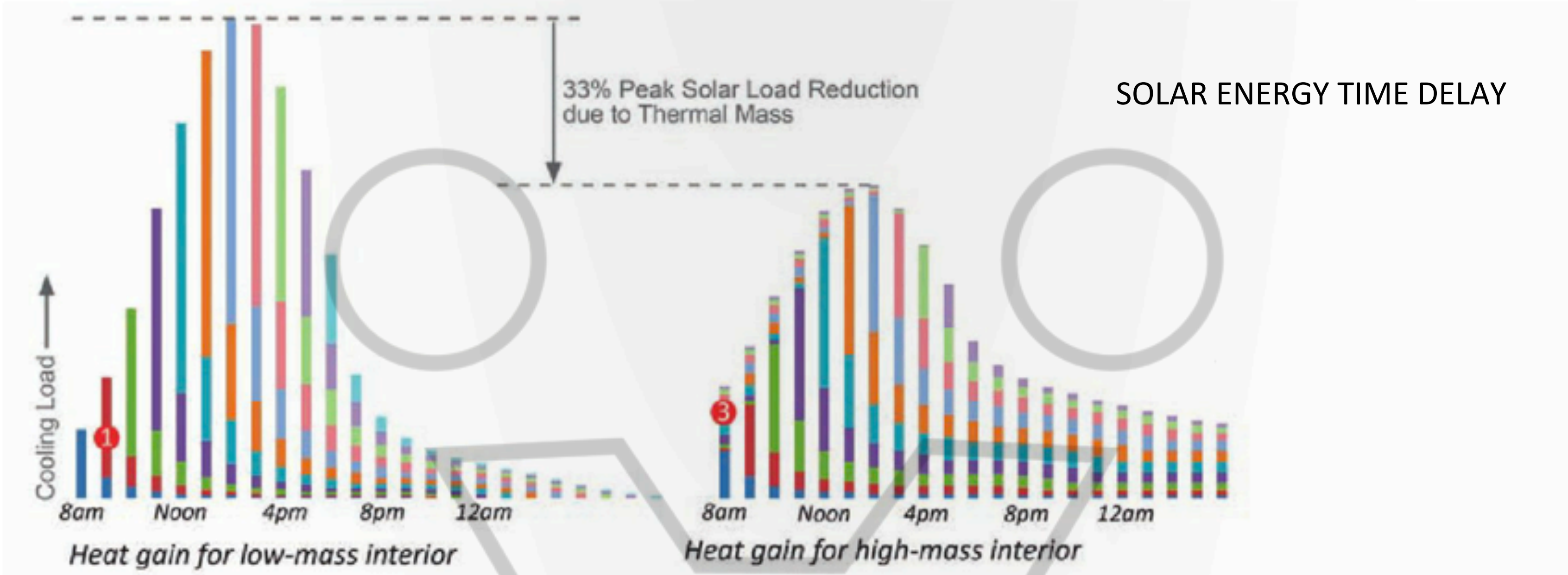
Source: Modified output from an Autodesk Ecotect building model. Courtesy of Callison.

THERMAL STORAGE

Although thermal storage can be an important part of maintaining comfort with minimal energy inputs, over the past 200 years construction in much of the First World has tended towards lightweight, insulated buildings. Lightweight buildings are typically less able to use solar energy, since they cannot delay or

WORKING WITH THERMAL MASS & DIFFUSIVITY

SOLAR ENERGY TIME DELAY



Percentage of Solar Gain released during each hour after being transmitted through glazing

	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
High Thermal Mass Example	27%	13%	7%	5%	4%	4%	3%	3%	3%	3%	3%	3%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	2%	1%	1%
(2) Low Thermal Mass Example	55%	17%	9%	5%	3%	2%	2%	1%	1%	1%	1%	1%	1%	1%	-	-	-	-	-	-	-	-	-	-	-

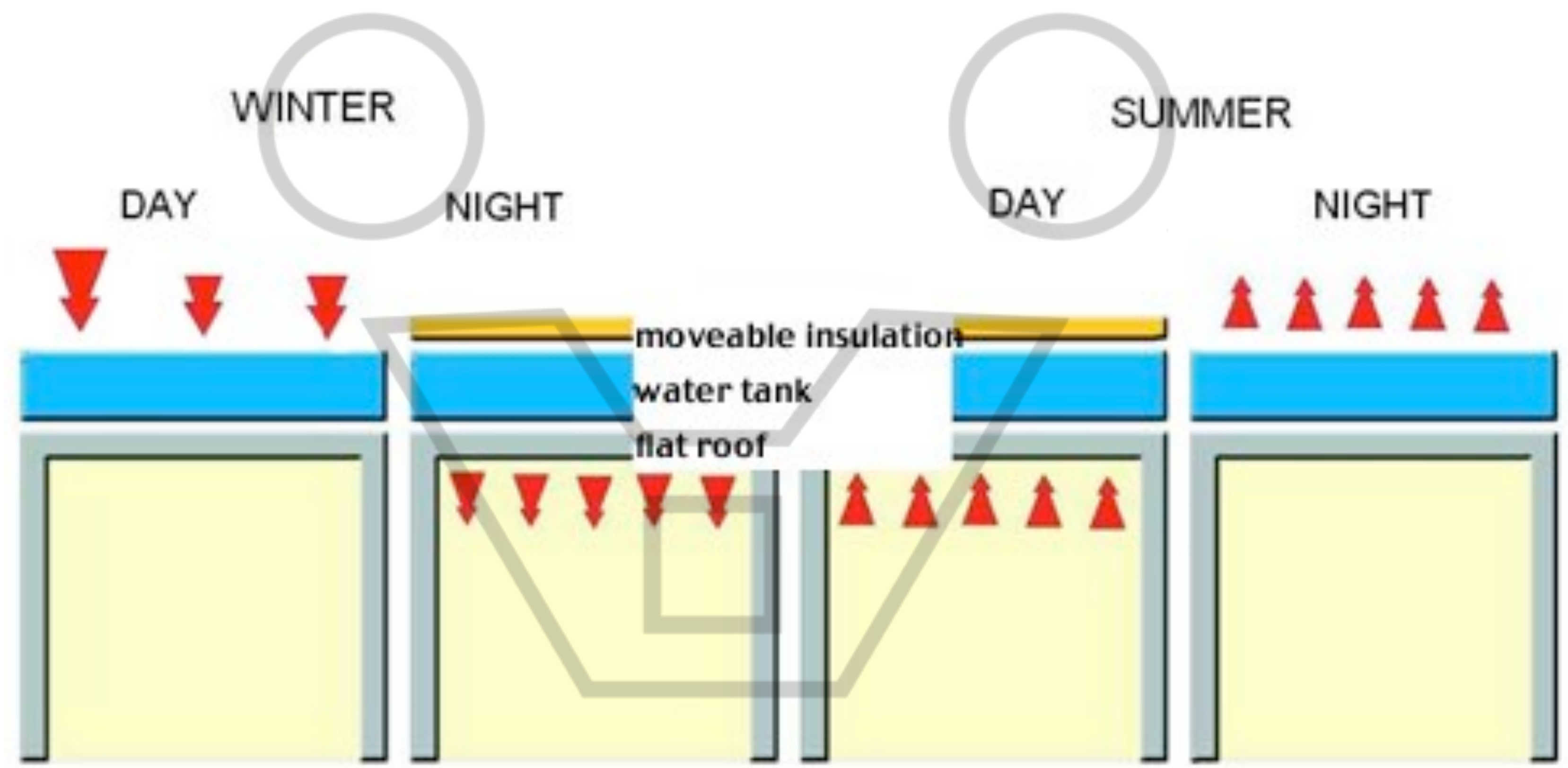
7.12

Solar irradiation values on a south-facing window in Toronto with a .50 glazing to wall ratio were imported onto a spreadsheet to calculate thermal mass effects on peak solar loading using the Radiant Time Series (RTS) method. Each hour's transmitted solar energy becomes a cooling load to the zone over the next 24 hours according to the percentages below for a low-mass and high-mass interior, which are color-coded to show the cumulative effects. At 9am, the solar irradiation that enters is colored red (1), and can be tracked over the next several hours until it becomes nearly negligible. For the low-mass option (2), 55% of the solar energy becomes a cooling load within the same hour it reaches the zone, and 27% is delayed until the second hour, with 9% becoming a cooling load in the third, etc. Each hour has been assigned a color to track it through the day, with the high-mass system including a small remaining solar load from the previous day (3) over the first several hours. The Radiant Time Series method (ASHRAE, 2013) is used to estimating peak cooling loads and contains an accurate but simplified version of estimating the time-delay of solar gain in low-, medium-, and high-mass constructions. The low-mass construction contains carpet, while the high-mass construction exposes concrete floors. The time-delay of other elements, such as exterior walls and solar energy absorbed by the glazing, was not considered. Solar irradiation values calculated in Autodesk Ecotect.

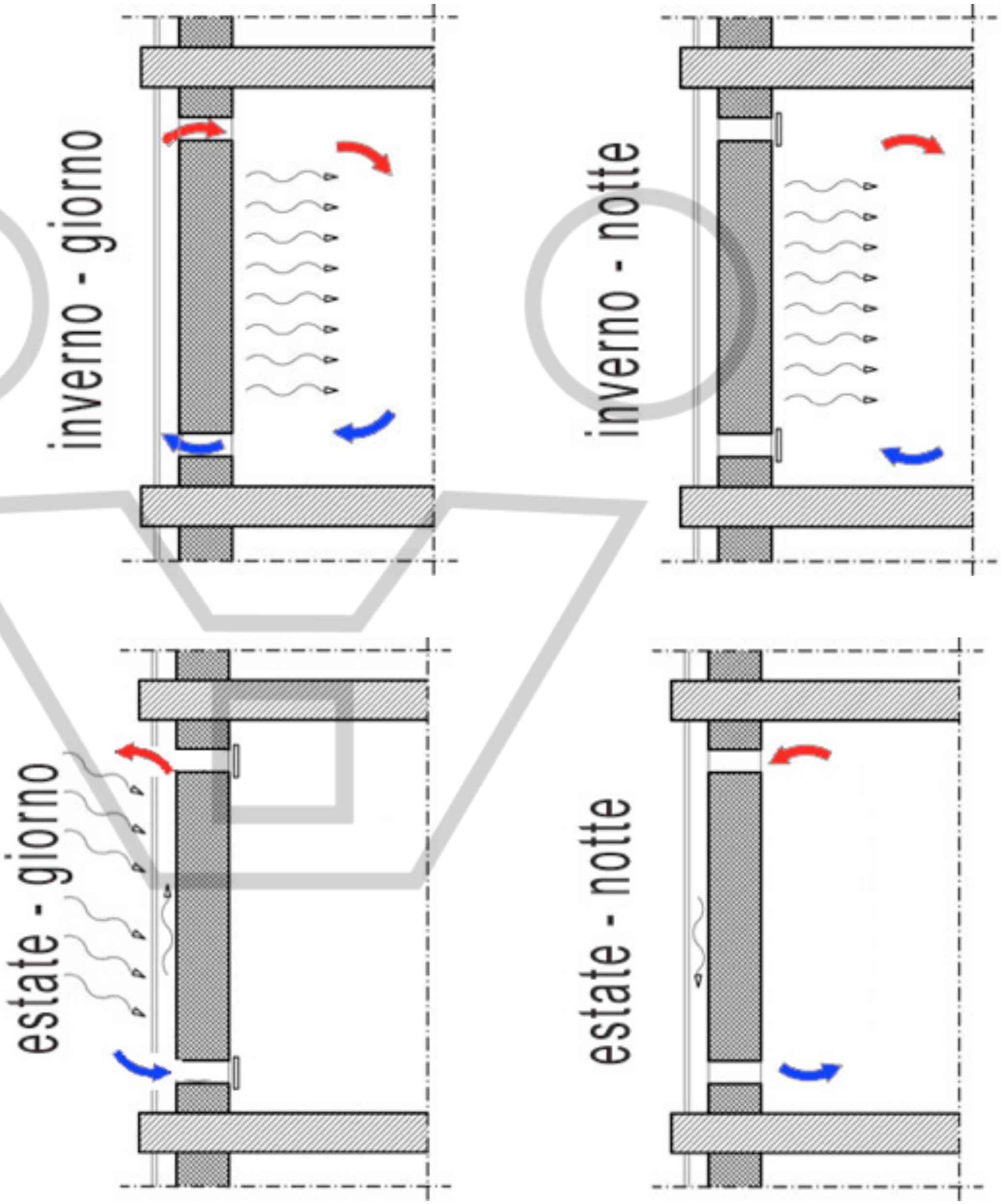
Source: Courtesy of Callison.

WORKING WITH THERMAL MASS & DIFFUSIVITY

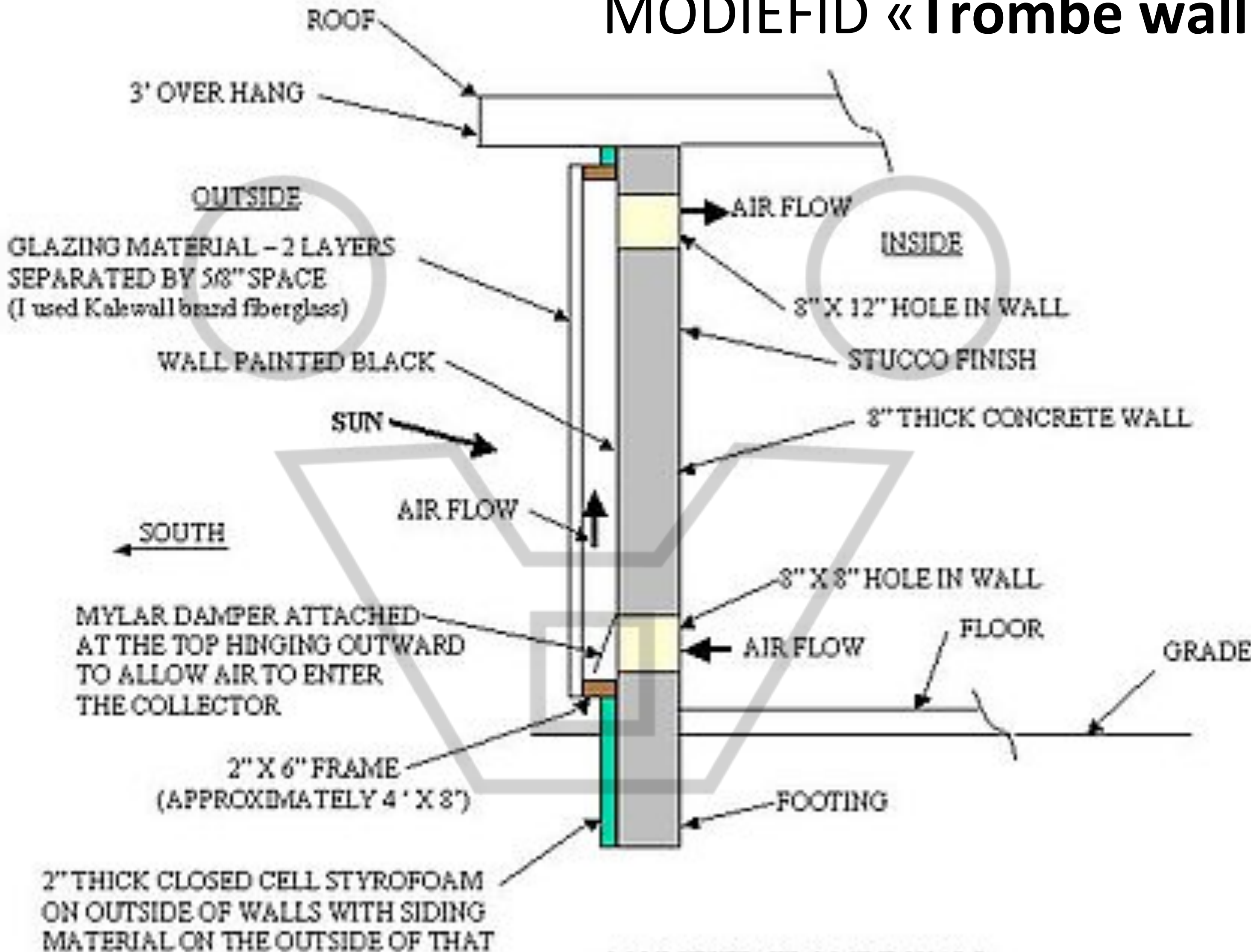
THERMAL STORAGEFOR HOT CLIMATE



Trombe wall



MODIEFID «**Trombe wall**»



MODIFIED TROMBE WALL

WORKING WITH THERMAL MASS & DIFFUSIVITY

ASSIGNMENT #02:

- Choose a geographical location
- Download his related weather data, analyze them, and describe which decisions could be taken to optimize a concept design for a simple architectural box in the early stage phase.

Decision should cover the following aspects:

- Which is the acceptable thermal zone using psychometric diagram
- Which kind of thermal behavior should have the building (heated Vs cooled)
- Orientation (exposition & cold wind consideration)
- % percentage of glazing and the location of the windows
- According with the hottest period and prevalent wind, which windows should be operable to assure ventilation

Textbook: https://issuu.com/jesic/docs/design_energy_simulation_for_archit

Other resources: :

http://andrewmarsh.com/software/sunpath-on-map-web/
http://andrewmarsh.com/software/app-shading/
http://andrewmarsh.com/software/app-daylight/
http://web.mit.edu/jaimelee/Public/ECOTECT_TUTORIAL_Fall09.pdf
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