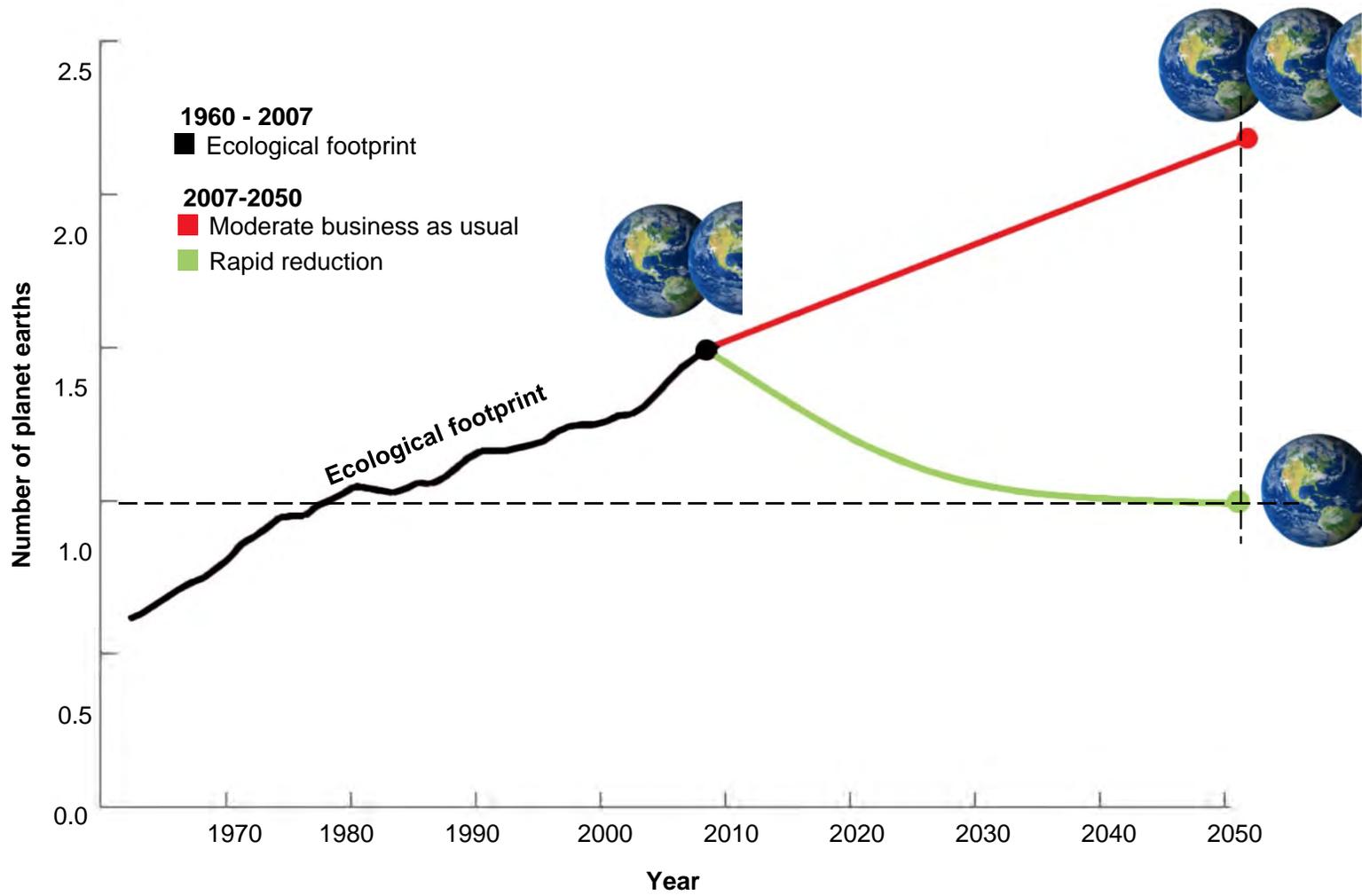


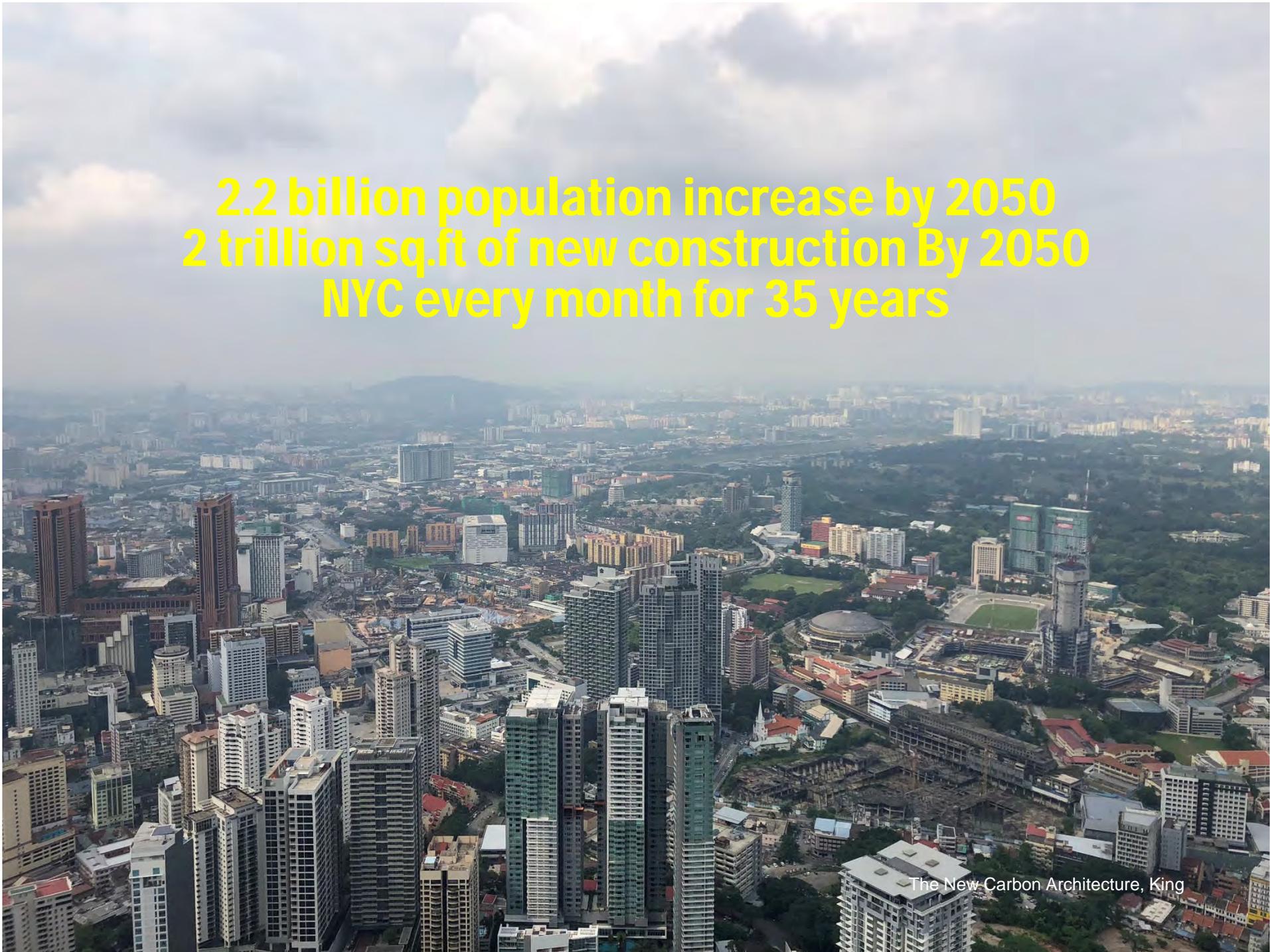


# Bioclimatic Design

Kyoung Hee Kim PhD AIA NCARB  
Professor of Architecture  
Ravin School of Architecture  
UNC Charlotte



**2.2 billion population increase by 2050**  
**2 trillion sq.ft of new construction By 2050**  
**NYC every month for 35 years**





• The Great Climate Migration Has Begun - The New York Times

## Sustainable Course Modules:

### **Building life-cycle assessment. 03.14.2023**

Circularity in the building sector

Carbon neutral design

Building resilience

### **Bioclimatic design. 03.07.2023**

Sustainable material system

Sustainable facade design

HVAC for tropical climates

Building integrated renewable energy systems



UNIVERSITAS  
GADJAH MADA



Ho Chi Minh City  
University of Technology

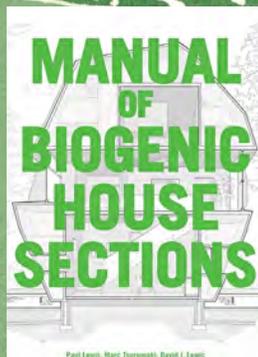


U.S.-ASEAN SMART  
CITIES PARTNERSHIP



# DESIGN WITH CLIMATE

BIOCLIMATIC APPROACH TO ARCHITECTURAL REGIONALISM



BY VICTOR OLGAY  
NEW AND EXPANDED EDITION



Google image



Google image

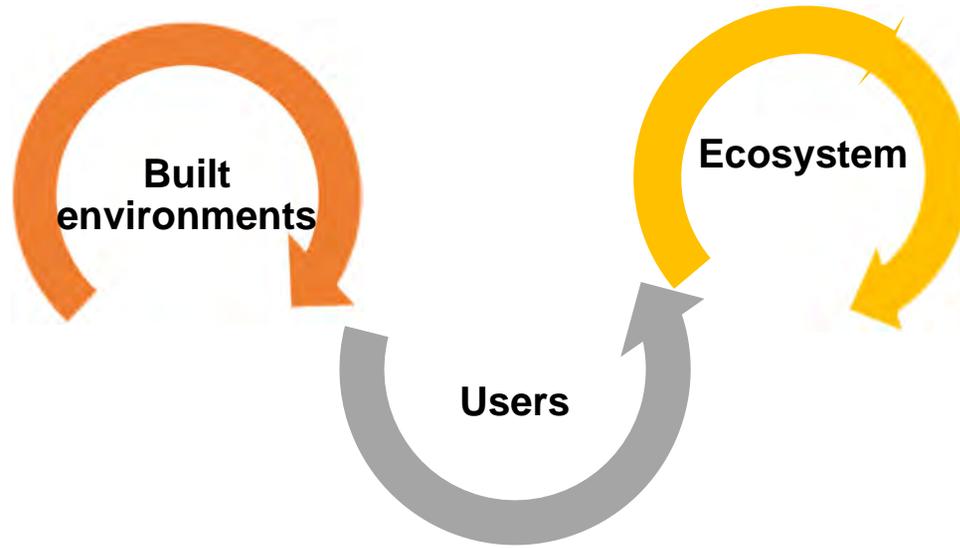


Google image

## Bioclimatic Design

- Bioclimatic Design is a green building design strategy that utilizes natural elements such as climate and site resources to create a **healthy, energy-efficient built environment**.
- Bioclimatic Design enhances **occupant comfort, health, and well-being** through:
  - natural ventilation (i.e., natural cooling and improved air quality),
  - shading (thermal comfort), and
  - daylighting.
- Bioclimatic Design minimizes the use of active systems or reduces energy consumption in heating, cooling, ventilation, and lighting energy.
- Bioclimatic Design conserves natural resources while protecting surrounding **ecosystems** (e.g. bodies of water, vegetation, and natural habitats).

# Bioclimatic Design



**Climate and Bioclimatic Design**

**Site and Bioclimatic Design**

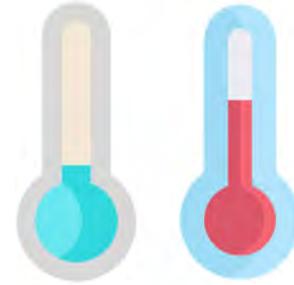
**Building Form and Bioclimatic Design**

**Materiality and Bioclimatic Design**

# Climate and Bioclimatic Design



**light**



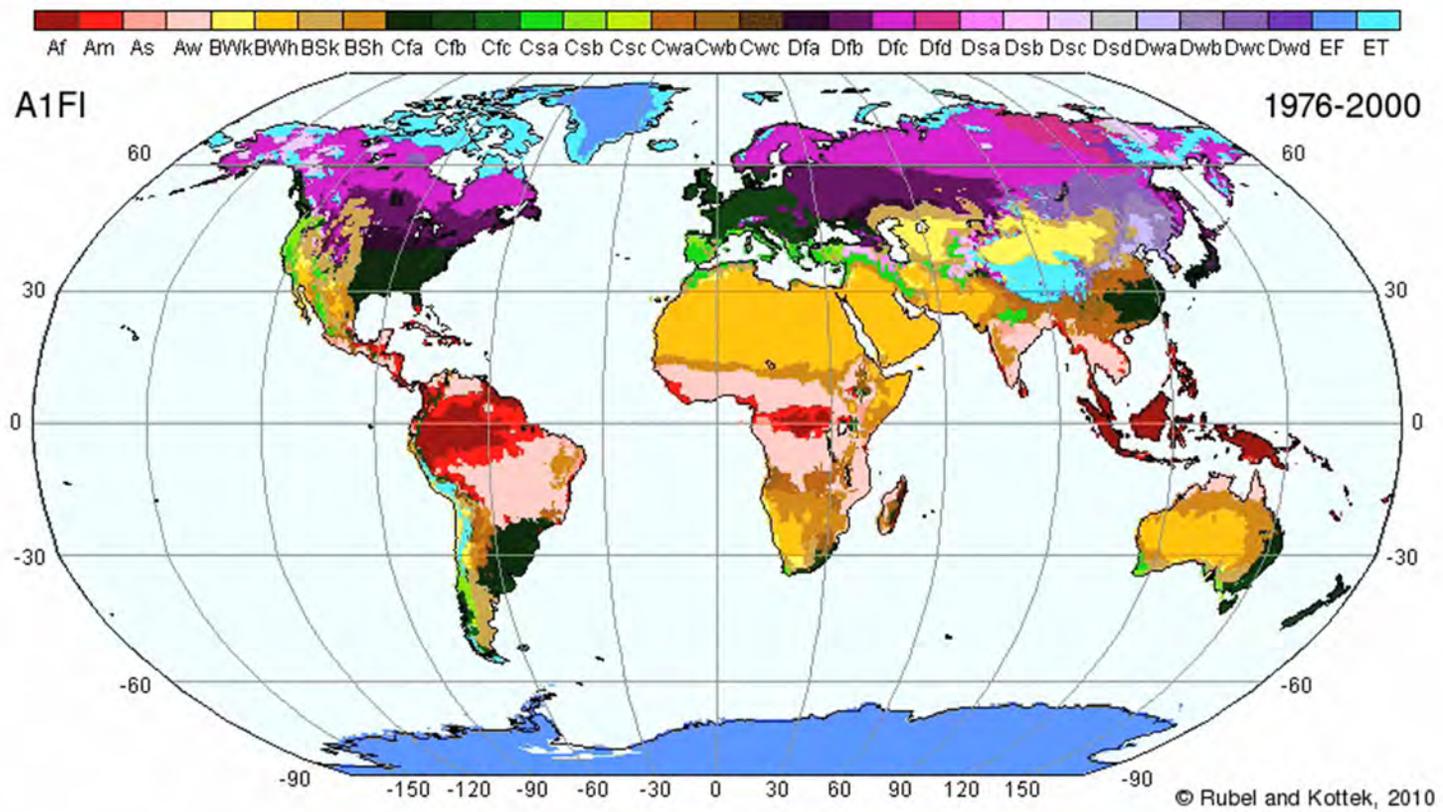
**heat**



**air**



**moisture**



Koppen Climate Classification System – temperature, precipitation, vegetation

# World Climate Classification

Code	Type	Description
A	Tropical climate	<ul style="list-style-type: none"> <li>Monthly average temperature &gt; 18°C</li> <li>No winter season</li> <li>Strong annual precipitations (higher than evaporation)</li> </ul>
B	Dry climate / Desert	<ul style="list-style-type: none"> <li>Annual evaporation higher than precipitations</li> <li>No permanent rivers</li> </ul>
C	Hot moderate climate	<ul style="list-style-type: none"> <li>The 3 coldest months average a temperature between -3°C and 18°C</li> <li>Hottest month average temperature &gt; 10°C</li> <li>The summer and winter seasons are well defined</li> </ul>
D	Cold moderate climate	<ul style="list-style-type: none"> <li>Coldest month average temperature of the coldest month &lt; -3°C</li> <li>Hottest month average temperature &gt; 10°C</li> <li>The seasons summer and winter seasons are well defined</li> </ul>
E	Polar climate	<ul style="list-style-type: none"> <li>Average temperature of the hottest month &gt; 10°C</li> <li>The summer season is very little different from the rest of the year</li> </ul>

Code	Description	Applies to
S	<ul style="list-style-type: none"> <li>Steppe climate (semi-arid)</li> <li>Annual precipitations range between 380 and 760 mm</li> </ul>	B
W	<ul style="list-style-type: none"> <li>Dry (Arid and semi-arid) climates</li> <li>Annual precipitations &lt; 250 mm</li> </ul>	B
F	<ul style="list-style-type: none"> <li>Wet climate</li> <li>Precipitations occur every month of the year</li> <li>No dry season</li> </ul>	A-C-D
W	<ul style="list-style-type: none"> <li>Dry season in winter</li> </ul>	A-C-D
S	<ul style="list-style-type: none"> <li>Dry season in summer</li> </ul>	C
m	<ul style="list-style-type: none"> <li>Monsoon climate:</li> <li>Annual precipitations &gt; 1500 mm</li> <li>Precipitations of the driest month &lt; 60 mm</li> </ul>	A
T	<ul style="list-style-type: none"> <li>Average temperature of the hottest month between 0 and 10°C</li> </ul>	E
F	<ul style="list-style-type: none"> <li>Average temperature of the hottest month &lt; 0°C</li> </ul>	E
M	<ul style="list-style-type: none"> <li>Abundant precipitations</li> <li>Mild winter</li> </ul>	E

Code	Description	Applies to
a: hot summer	<ul style="list-style-type: none"> <li>Average temperature of the hottest month &gt; 22°C</li> </ul>	C-D
b: moderate summer	<ul style="list-style-type: none"> <li>Average temperature of the hottest month &lt; 22°C</li> <li>The 4 hottest months average temperatures &gt; 10°C</li> </ul>	C-D
C: short and cold summer	<ul style="list-style-type: none"> <li>Average temperature of the hottest month &lt; 22°C</li> <li>Monthly average temperatures &gt; 10°C for less than 4 months</li> <li>Average temperature of the coldest month &gt; -38°C</li> </ul>	C-D
D: very cold winter	<ul style="list-style-type: none"> <li>Average temperature of the coldest month &lt; -38°C</li> </ul>	D
H: dry and heat	<ul style="list-style-type: none"> <li>Annual average temperature &gt; 18°C</li> </ul>	B
K: dry and cold	<ul style="list-style-type: none"> <li>Annual average temperature &lt; 18°C</li> </ul>	B

 Af	 BWh	 Csa	 Cwa	 Cfa	 Dsa	 Dwa	 Dfa	 ET
 Am	 BWk	 Csb	 Cwb	 Cfb	 Dsb	 Dwb	 Dfb	 EF
 Aw	 BSh		 Cwc	 Cfc	 Dsc	 Dwc	 Dfc	
	 BSk				 Dsd	 Dwd	 Dfd	



20°C ambient temp



30°C ambient temp

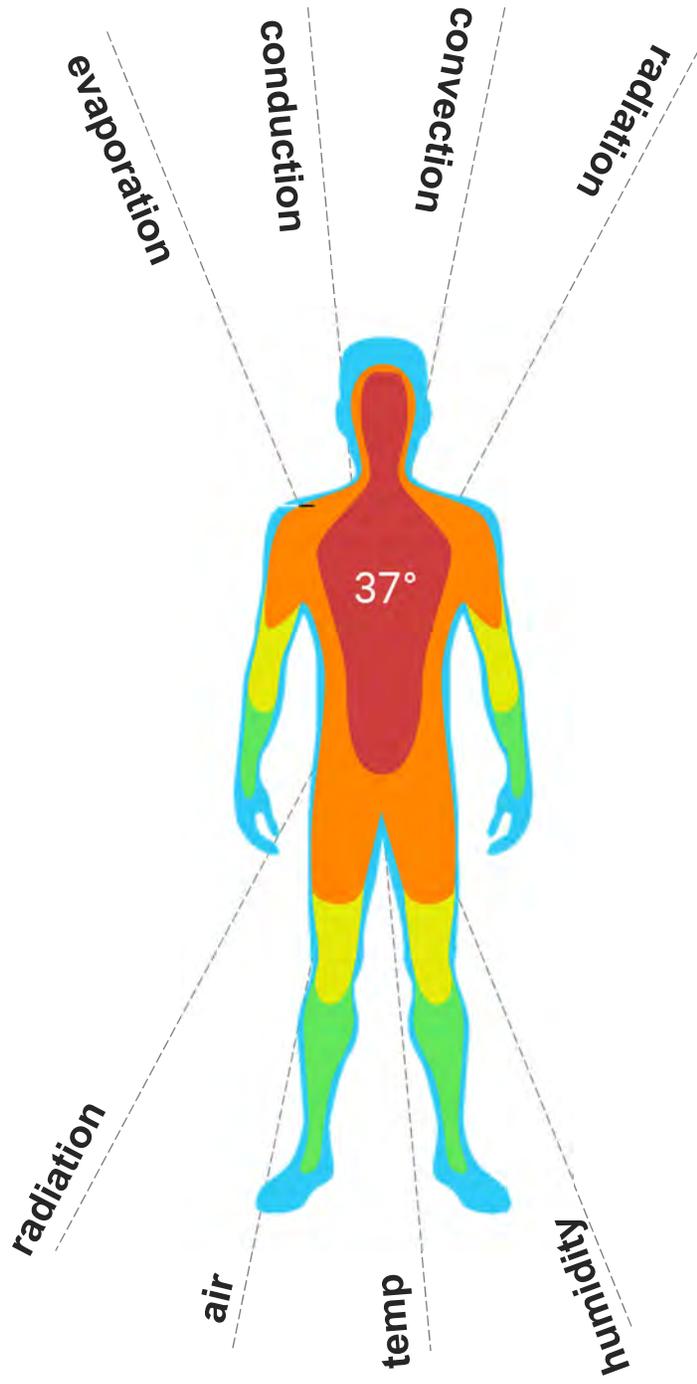
Human body reactions to main climatic elements

**Meteorology**

**Environmental  
technology**

**Biology**

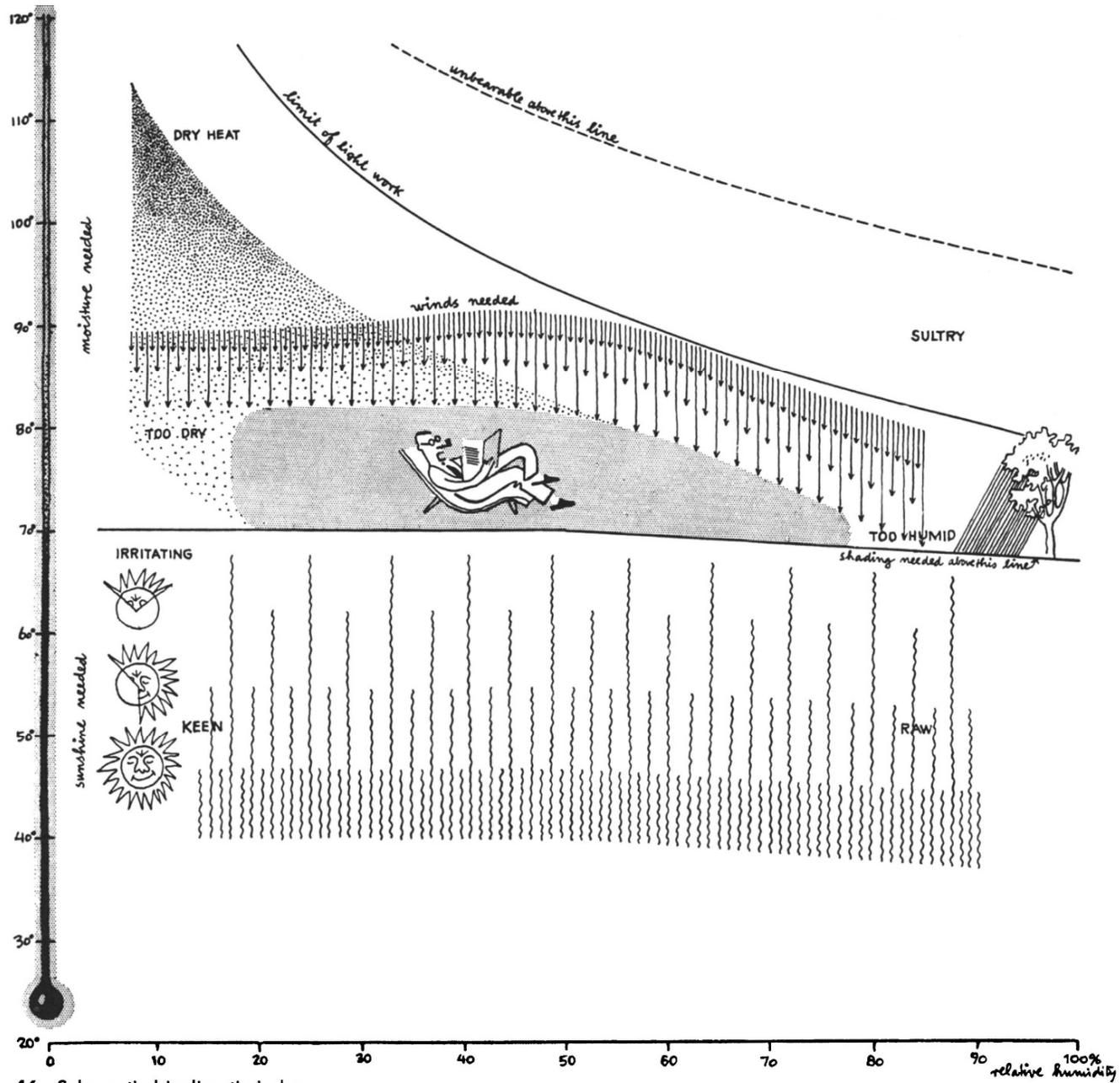
**Medical science**



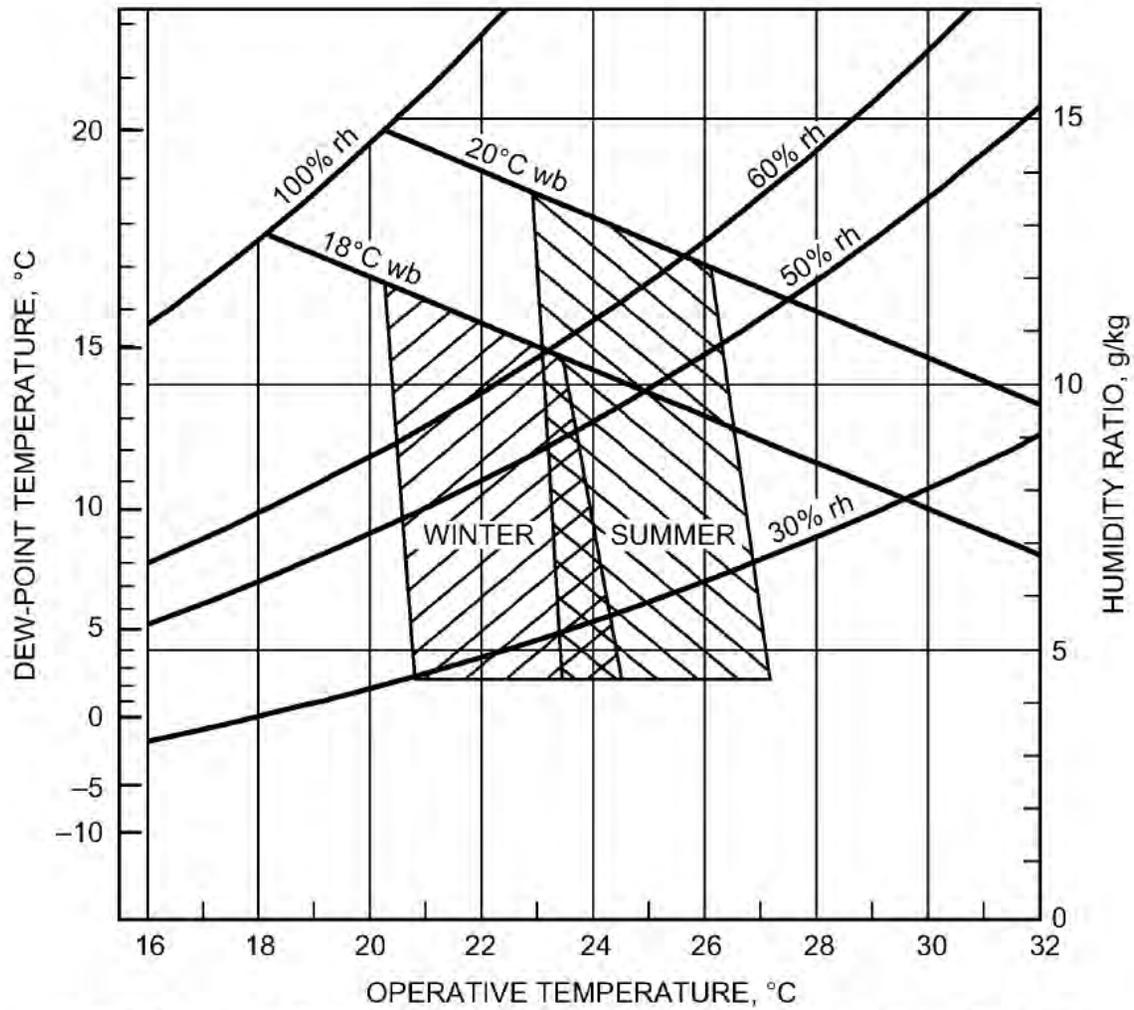
**Main climatic elements**

**Indices of comfort**

**Human reaction**



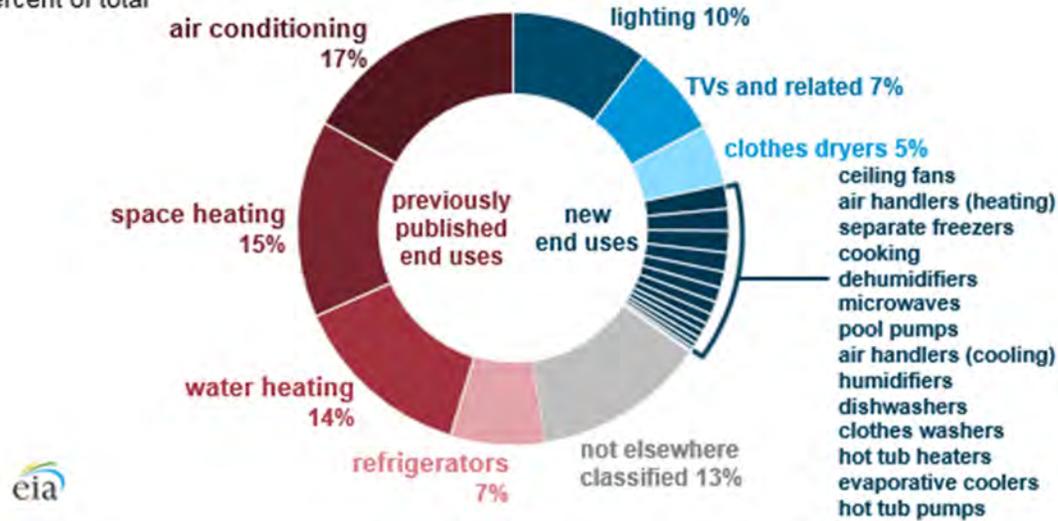
46. Schematic bioclimatic index.



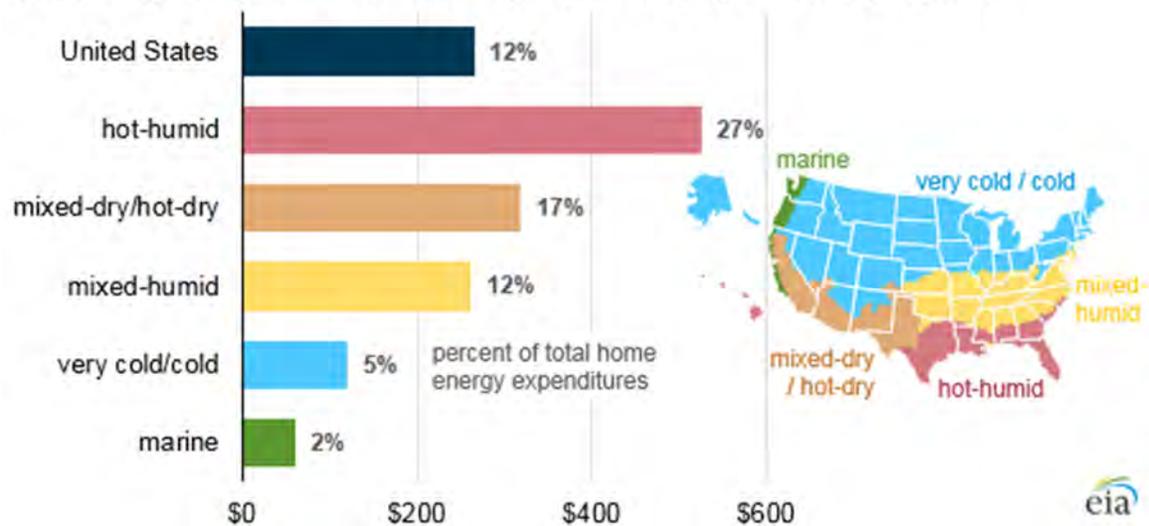
**Fig. 5 ASHRAE Summer and Winter Comfort Zones**  
 (Acceptable ranges of operative temperature and humidity for people in typical summer and winter clothing during primarily sedentary activity.)

### Residential electricity consumption by end use, 2015

percent of total



### U.S. average residential air-conditioning expenditures by climate region, 2015



## Light in Bioclimatic Design

- Aperture & daylighting
- Natural cooling
- Natural heating

Benefits Occupant comfort & energy savings



natural light illumination

## Heat Balance in Bioclimatic Design

- Thermal insulation
- Overheating protection

Benefits - Occupant Comfort & Cooling Energy Savings



Heat balance

## **Air in Bioclimatic Design**

- Natural ventilation
- Natural cooling

Benefits –Improved air quality & health, energy efficiency



Air movement

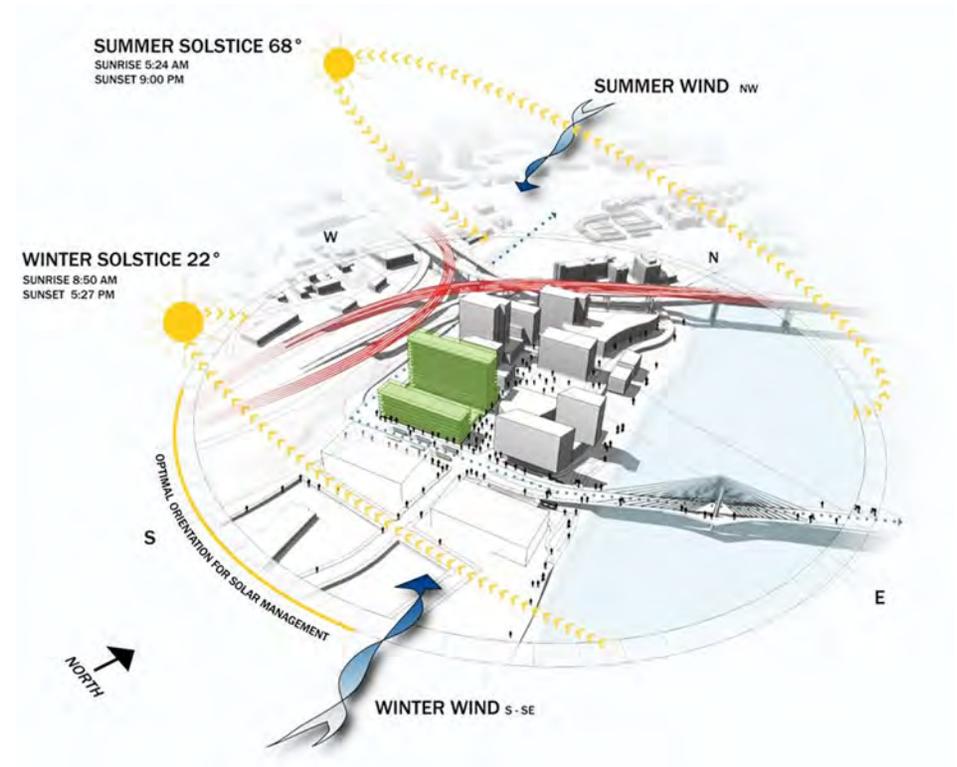
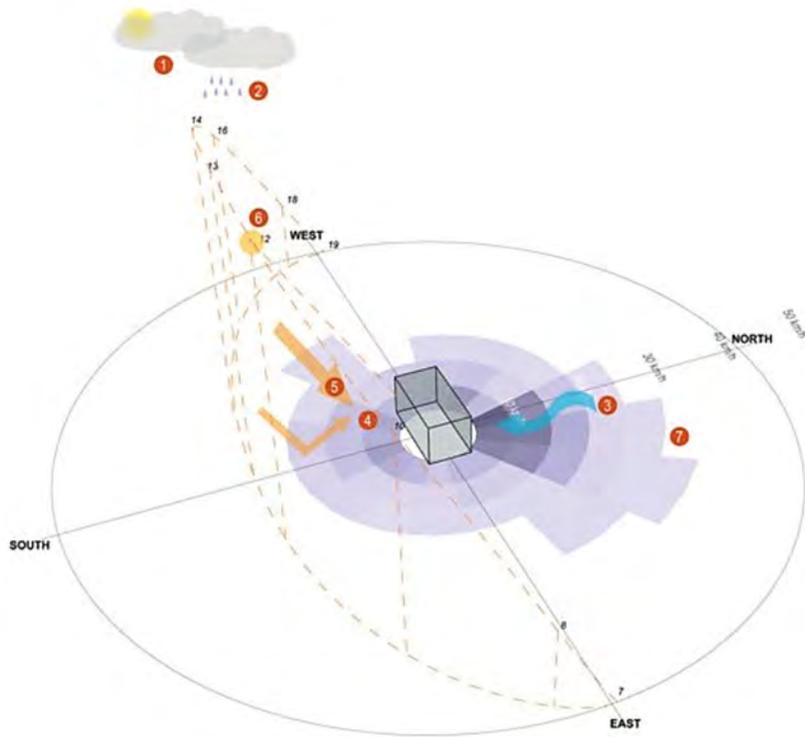
## Moisture Control in Bioclimatic Design

- Vapor barrier
- Ventilation

Benefits - Improved air quality & health, material longevity

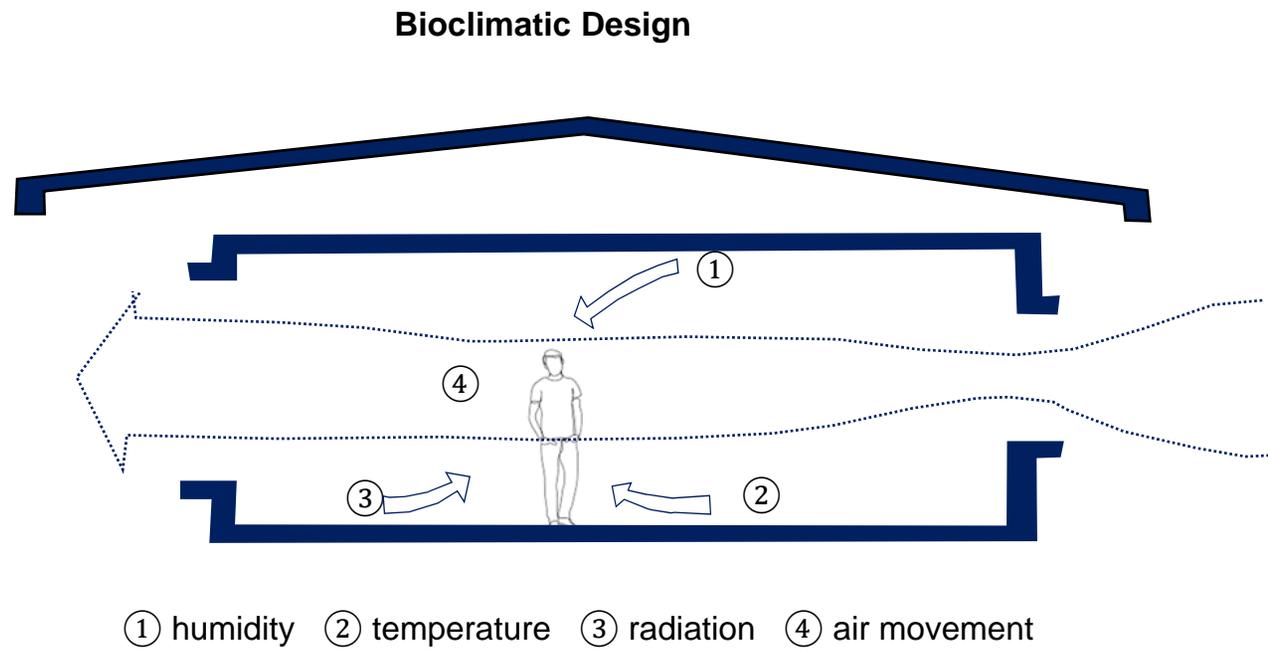


Moisture control



Key climate elements and climate analysis

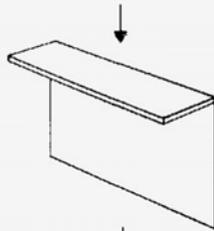
# Tropical Bioclimatic Design



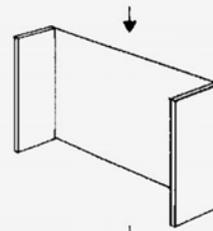
3.24 Antonin Raymond, diagram of tropical design principles, from Fry and Drew, *Village Housing in the Tropics*, 1947. Modern Architecture and Climate, Baber, 2020.

Type of device

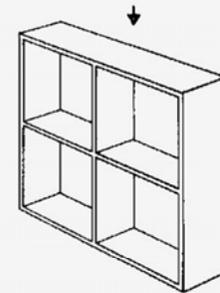
horizontal



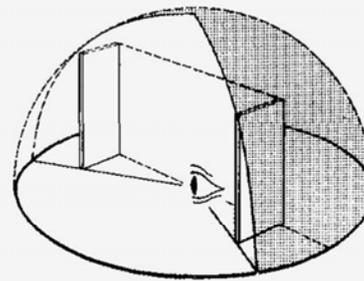
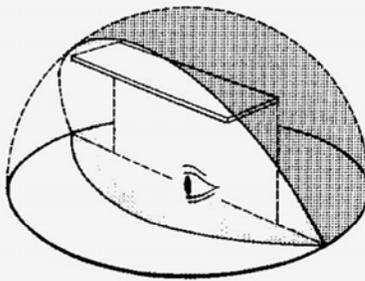
vertical



eggcrate

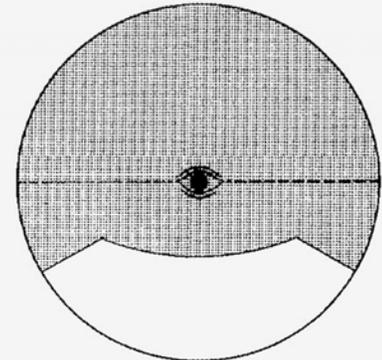
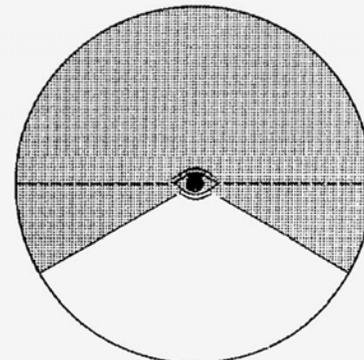
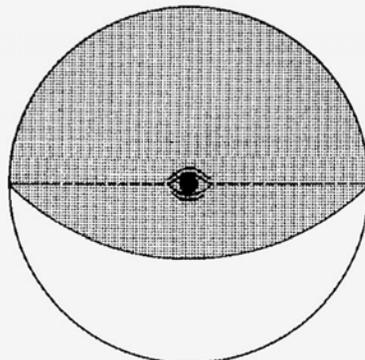


Devices obstructing areas of sky view



Obstructions of horizontal devices will show a segmental character, those of vertical fins will have a radial pattern, and eggcrate types will show a combination of these forms.

Shading mask.



segmental mask

radial mask

combinative mask

**HORIZONTAL TYPES**

VIEW:	SECTION:	MASK:	EXAMPLE:	CHARACTERISTIC:
				Horizontal overhangs are efficient toward south or southern orientations. Their mask characteristic is segmental.
				Louvers parallel to wall have the advantage to permit a circulation near to the elevation. Slanted louvers give better protection than vertical ones.
				Canvas canopies will have some characteristics as solid overhangs, and can be made retractable.
				Where protection is needed at low sun angles, louvers have a solid horizontal overhang efficient.
				A solid, or perforated screen strip parallel to wall cuts lower rays of the sun.
				Movable horizontal louvers change their mask characteristics according to their positioning.

82 169. Examples of various types of shading devices.

**VERTICAL TYPES**

VIEW:	PLAN AND SECTION:	MASK:	EXAMPLE:	CHARACTERISTIC:
				Vertical fins serve well toward east and west and near these orientations. Their mask characteristic is segmental.
				Vertical fins oblique to wall will result in asymmetrical mask. Separation from wall will avoid heat transmission.
				Movable fins can shade the whole wall, or open up in different directions according to the sun's position.

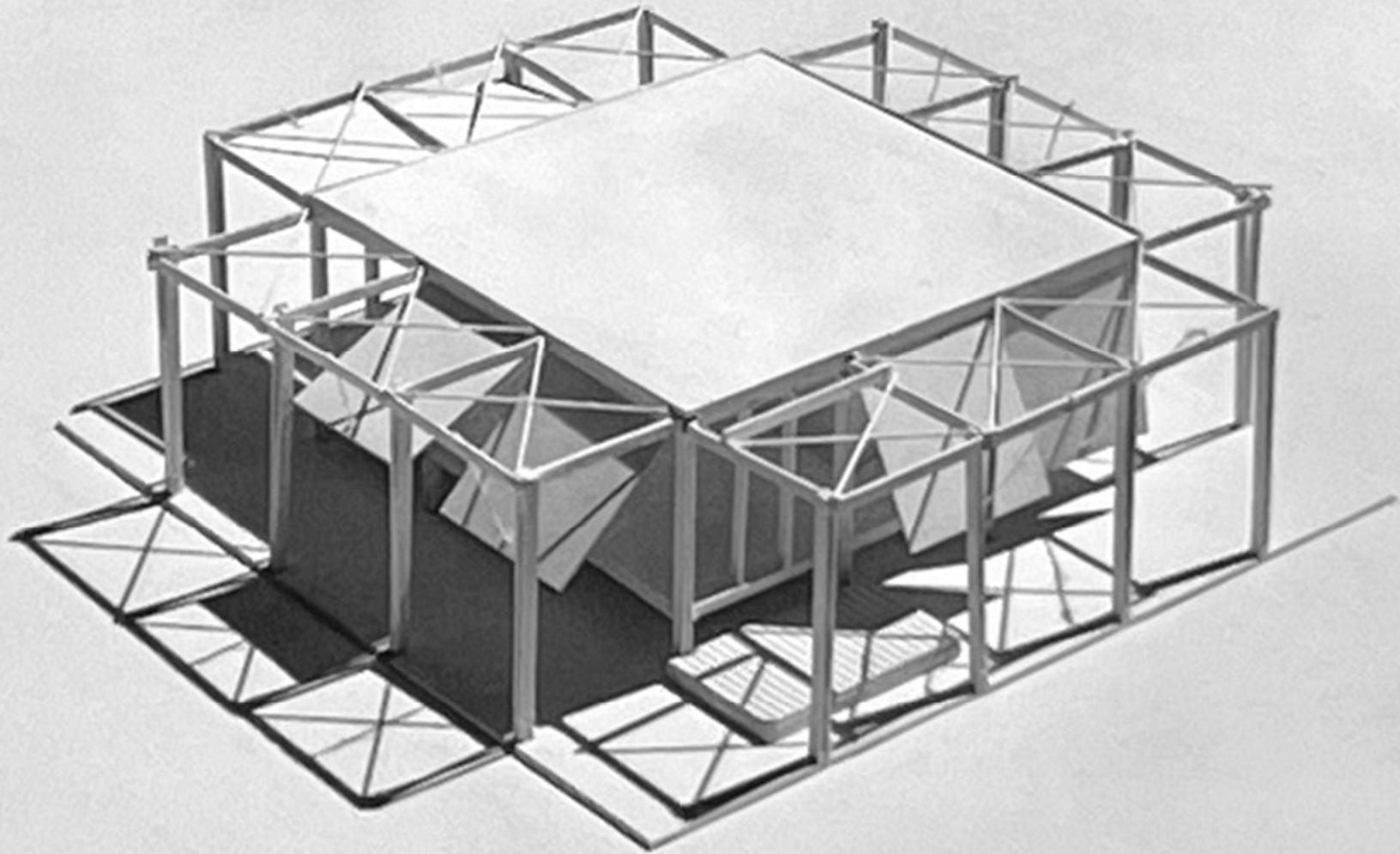
**EGGCRATE TYPES**

				Eggcrate types are combinations of horizontal and vertical types and their mask is a superimposed diagram of the two masks.
				Solid eggcrate with slanting vertical fins results in asymmetrical mask.
				Eggcrate device with movable horizontal elements shows flexible mask characteristics. Because of their high shading ratio, eggcrates are efficient in hot climates.

170.

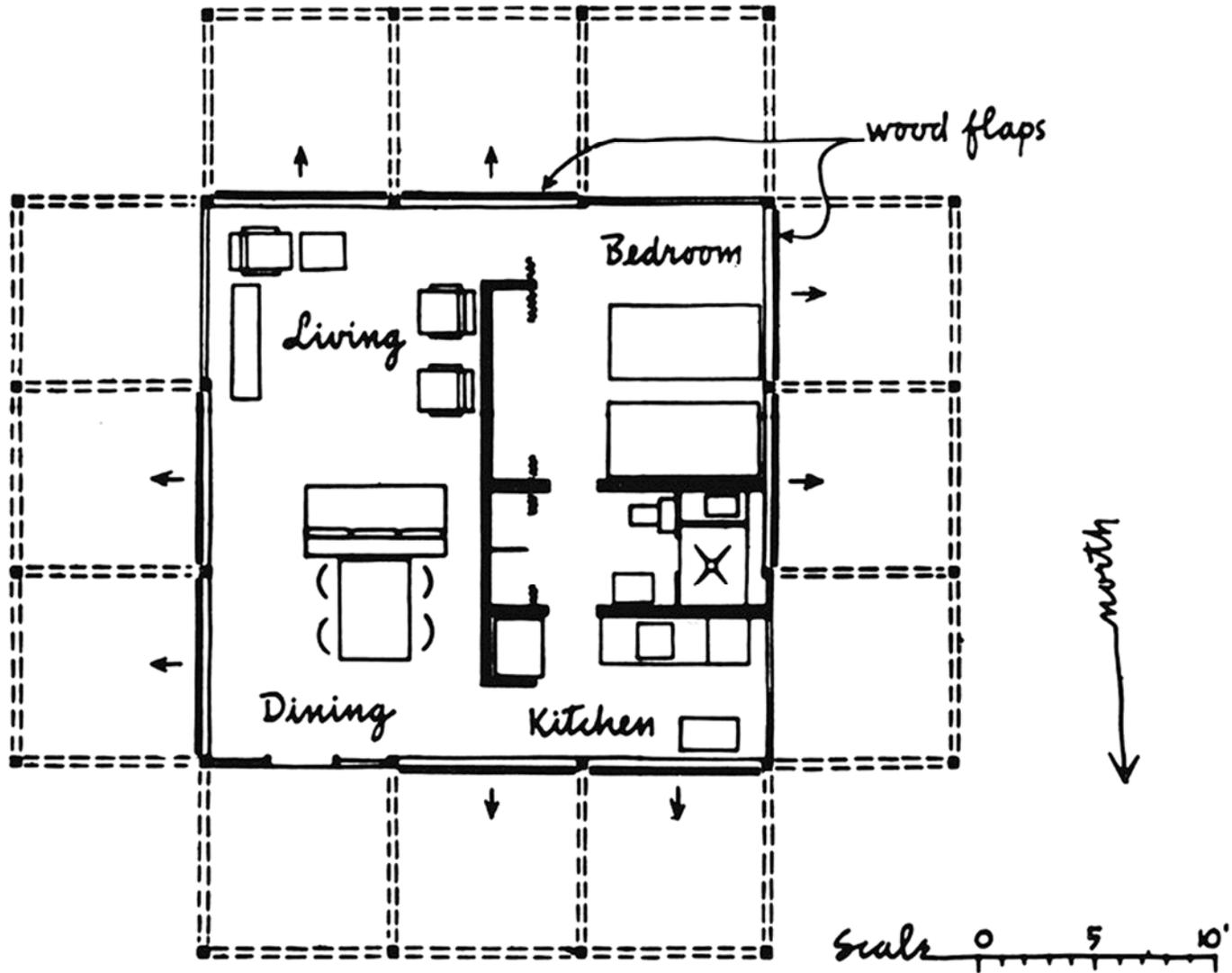


Walker Guest House, FL, USA (hot-humid climate), 1953, 53M<sup>2</sup>, Paul Rudolph  
Google image

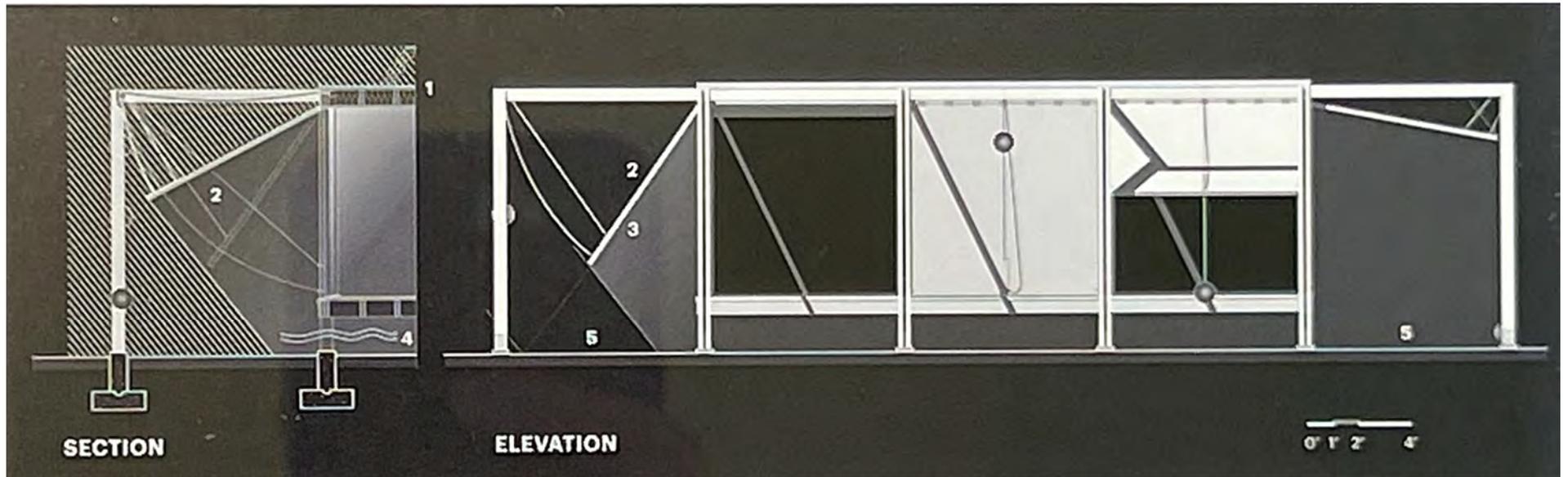


Walker Guest House, FL, USA (hot-humid climate), 1953, 53M<sup>2</sup>, Paul Rudolph

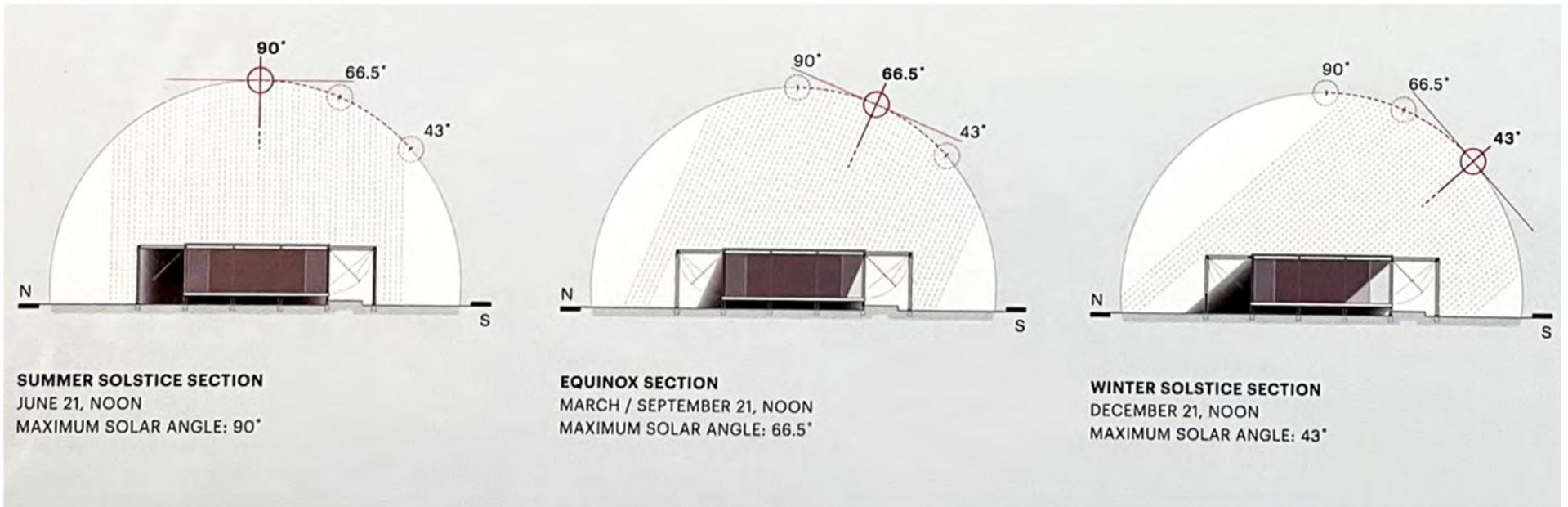
Lesson from Modernism, Boner, 2013



Walker Guest House, FL, USA (hot-humid climate), 1953, 53M<sup>2</sup>, Paul Rudolph  
 Google image



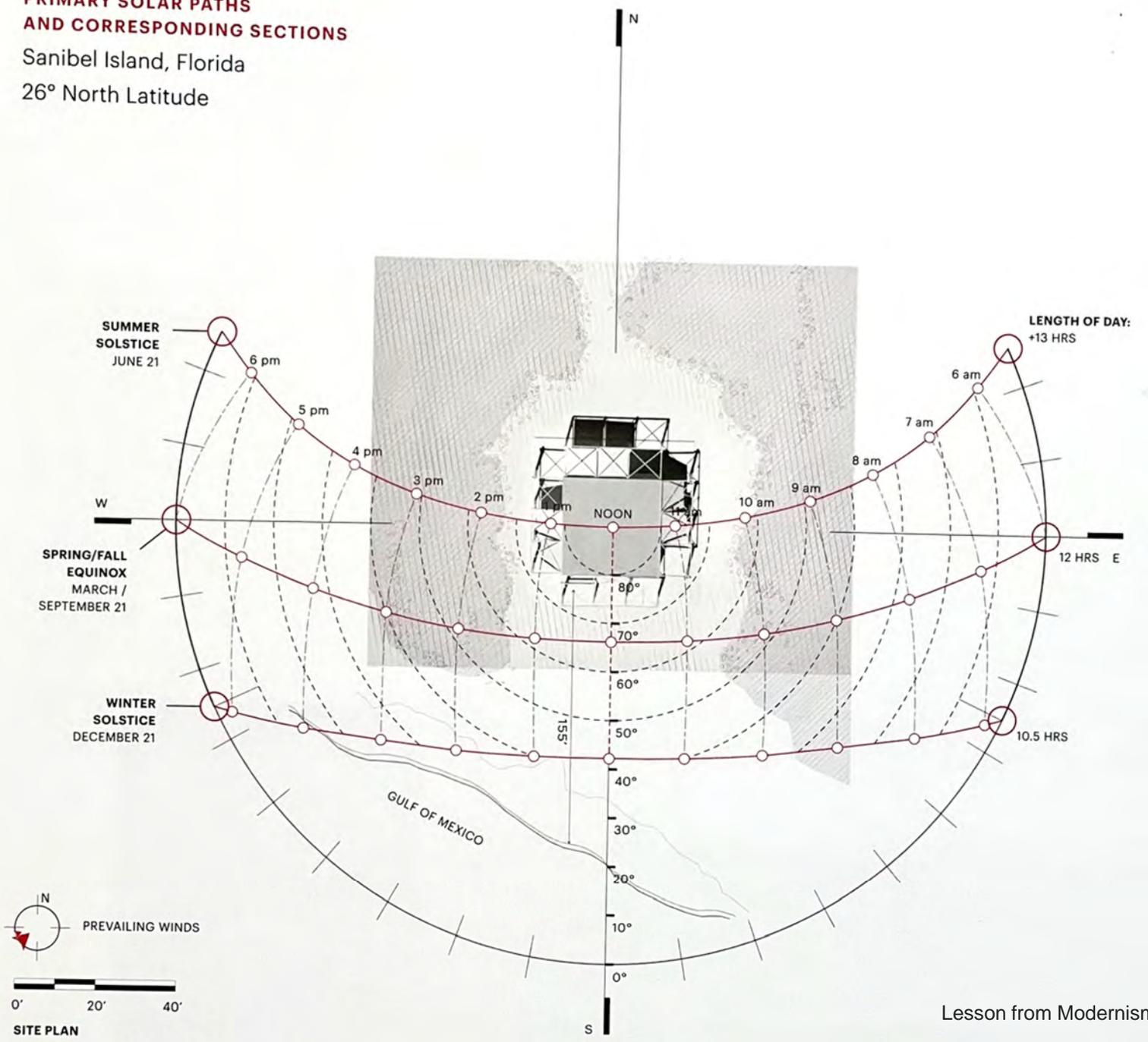
Walker Guest House, FL, USA (hot-humid climate), 1953, 53M<sup>2</sup>, Paul Rudolph



Walker Guest House, FL, USA (hot-humid climate), 1953, 53M<sup>2</sup>, Paul Rudolph

**PRIMARY SOLAR PATHS  
AND CORRESPONDING SECTIONS**

Sanibel Island, Florida  
26° North Latitude





Walker Guest House, FL, USA (hot-humid climate), 1953, 53M<sup>2</sup>, Paul Rudolph

Ezra Stoller, Walker Guest House Exterior, circa 1952-1953.  
Photo: Esto/Ezra Stoller.

Google image



Walker Guest House, FL, USA (hot-humid climate), 1953, 53M<sup>2</sup>, Paul Rudolph  
Google image



Walker Guest House, FL, USA (hot-humid climate), 1953, 53M<sup>2</sup>, Paul Rudolph  
Google image

**Climate and Bioclimatic Design**  
**Site and Bioclimatic Design**  
**Building Form and Bioclimatic Design**  
**Materiality and Bioclimatic Design**



**vegetation**



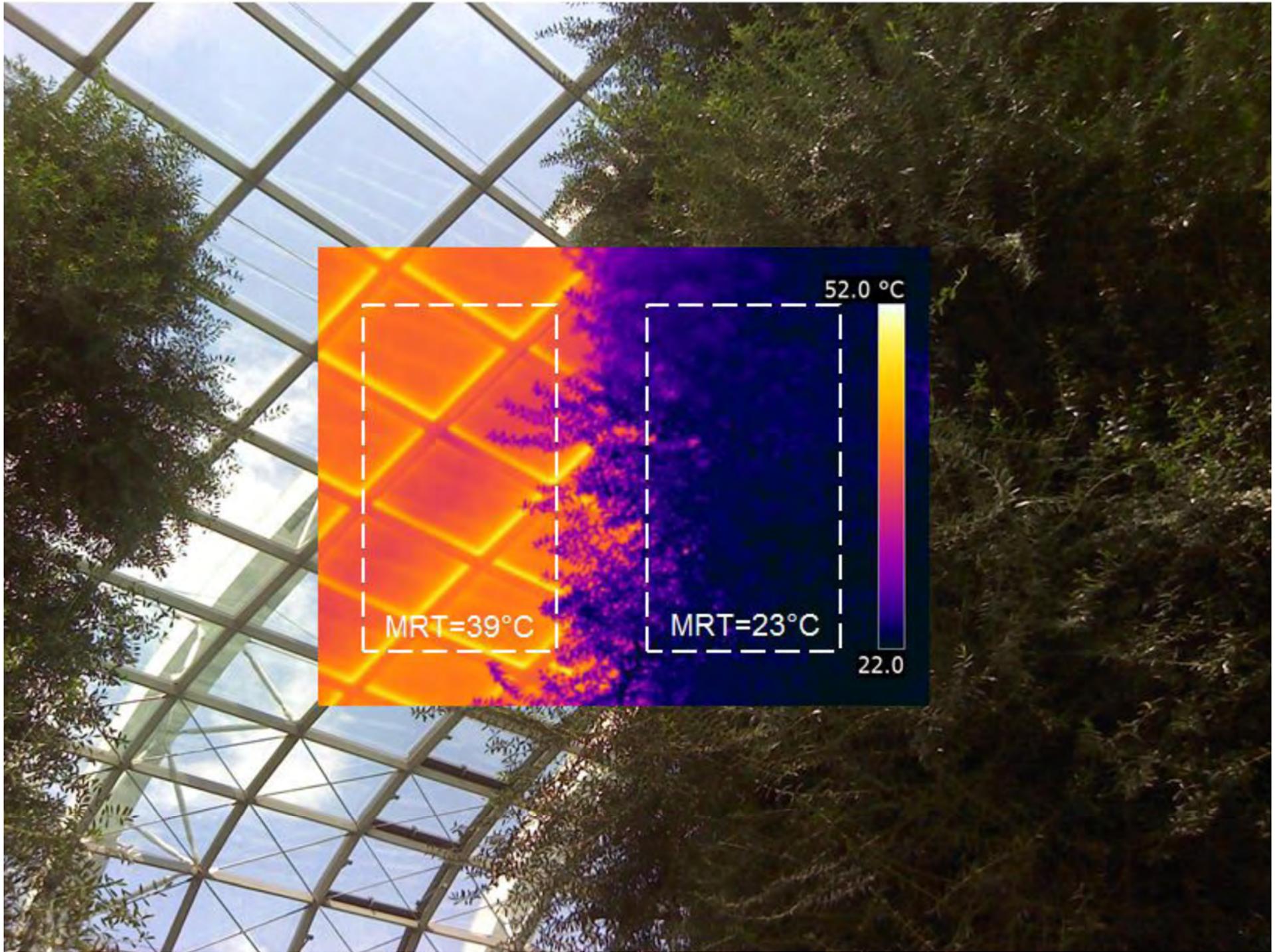
**topography**

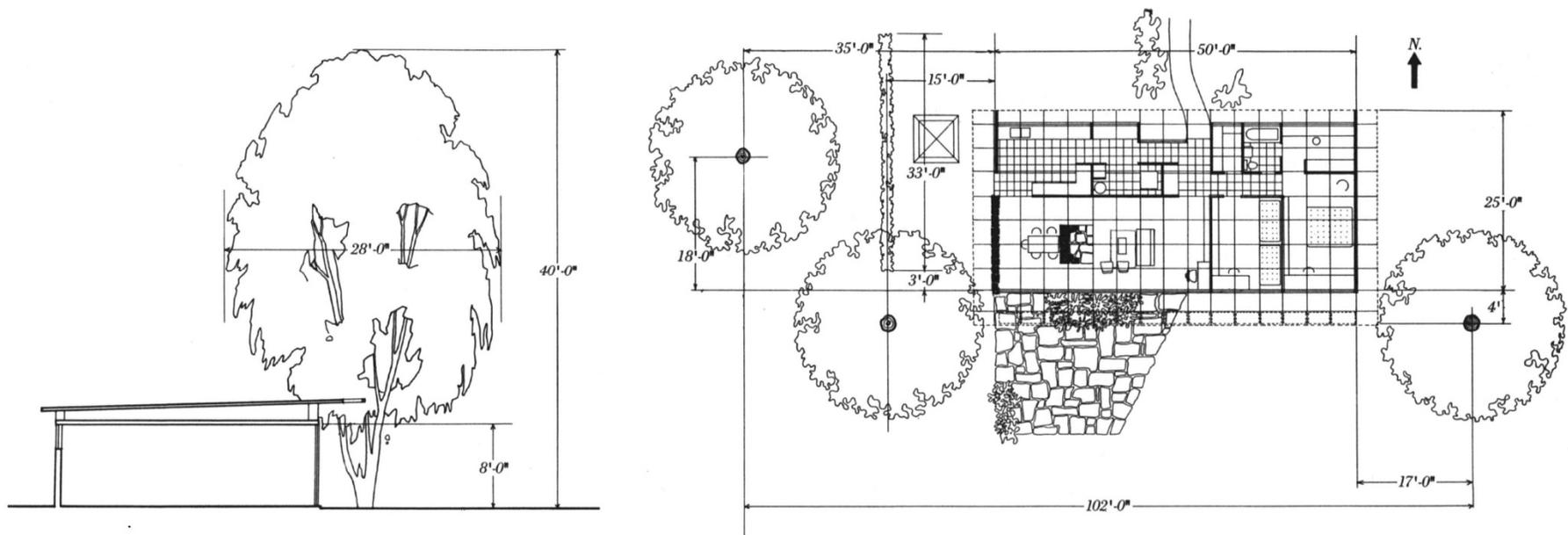


**water**

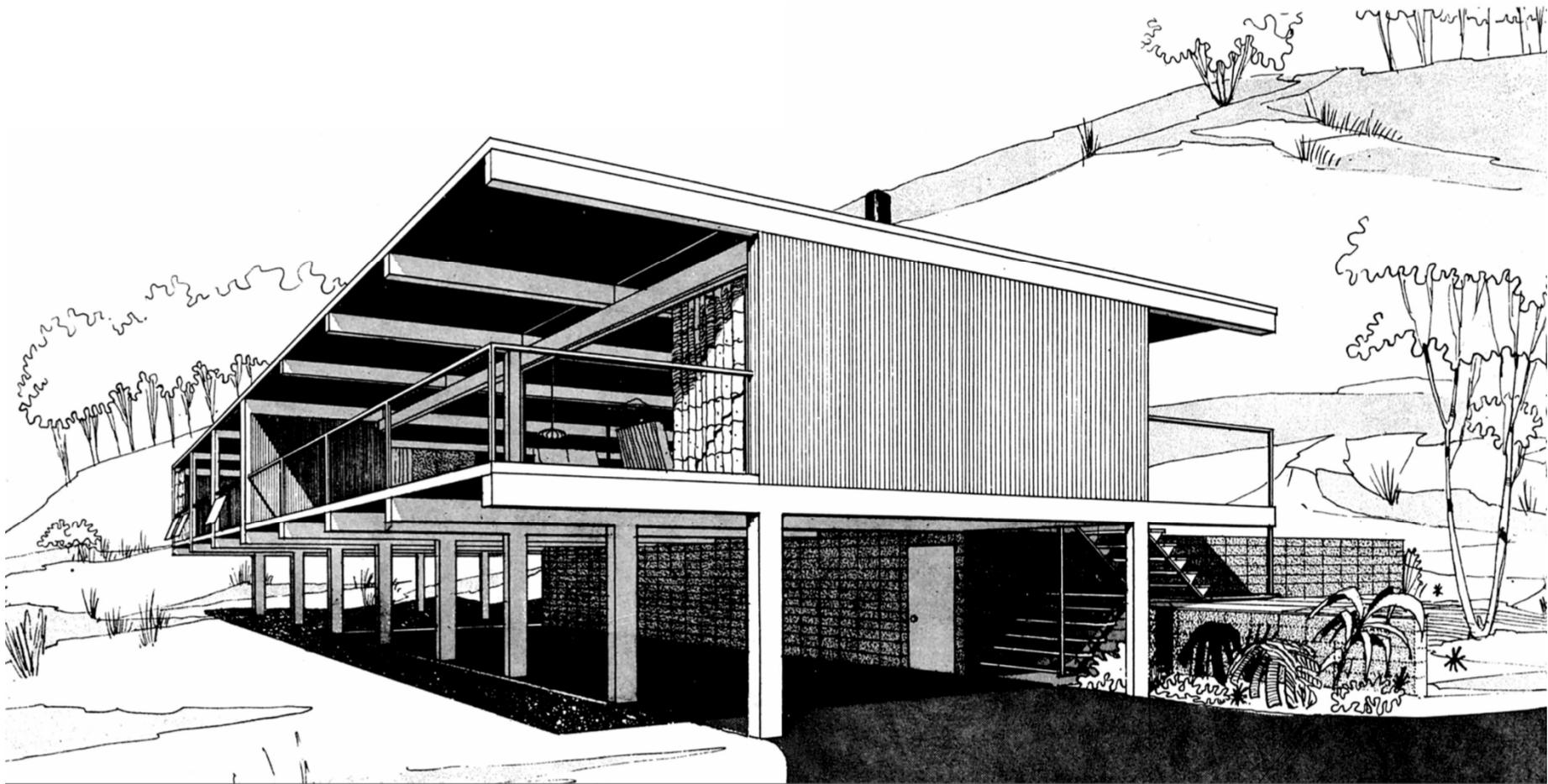


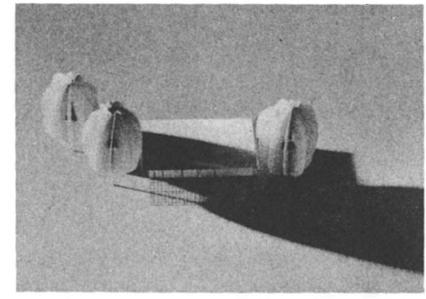
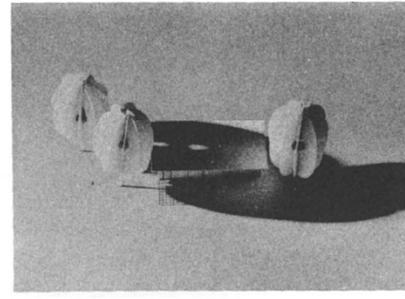
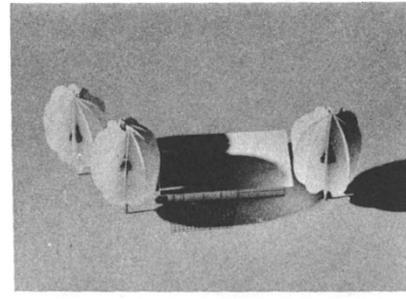
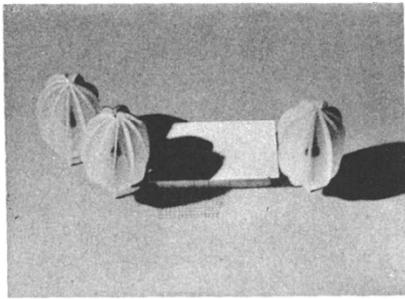
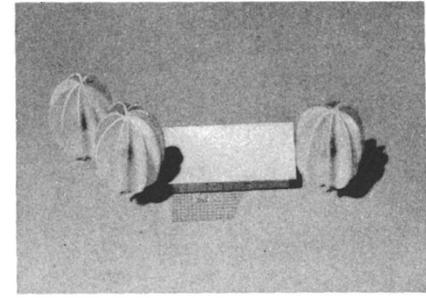
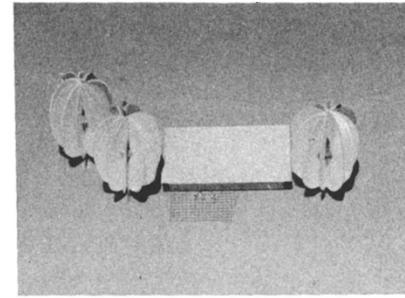
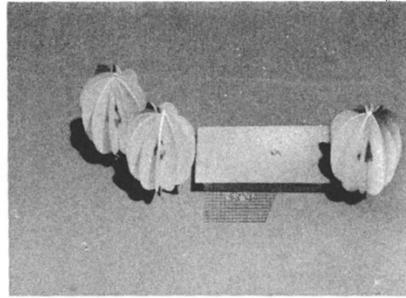
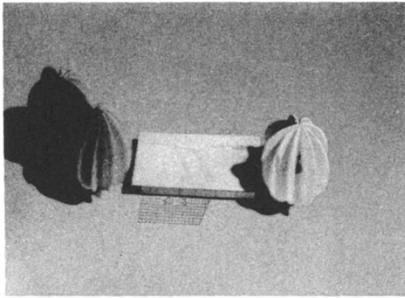
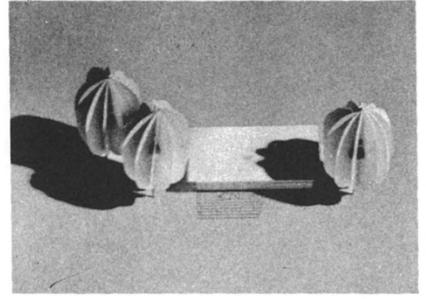
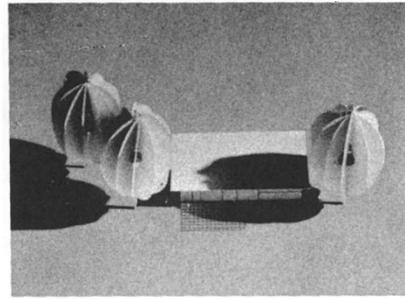
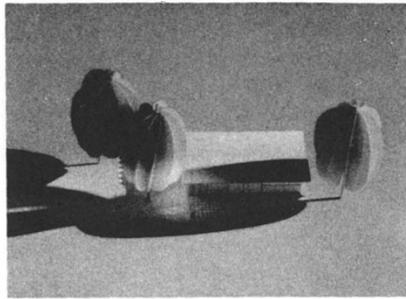
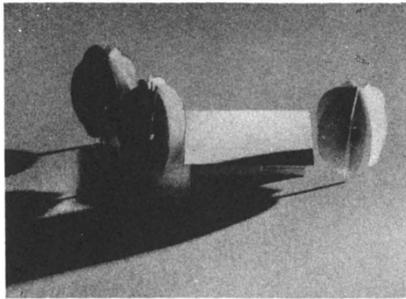
**wild habitat**



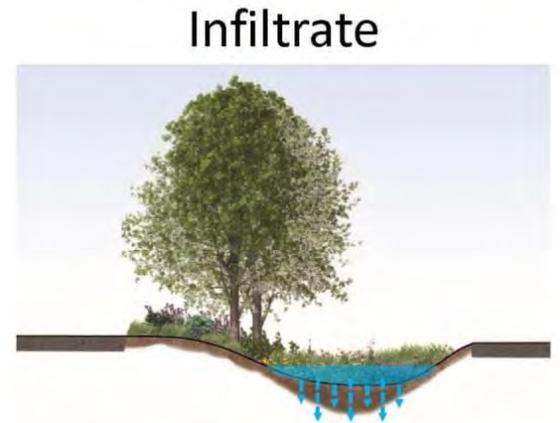
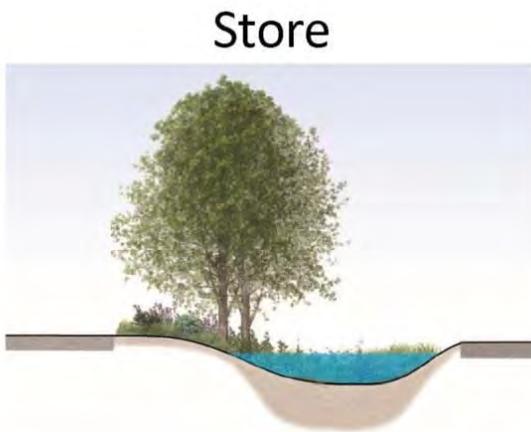
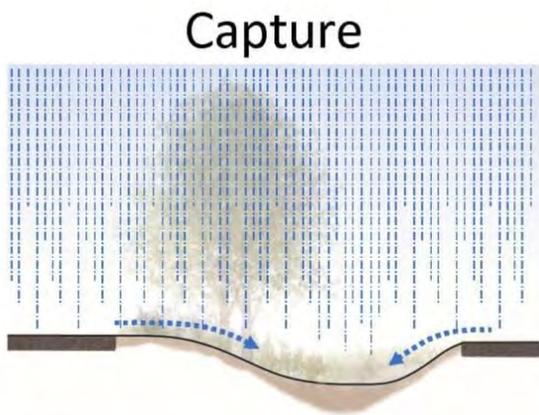


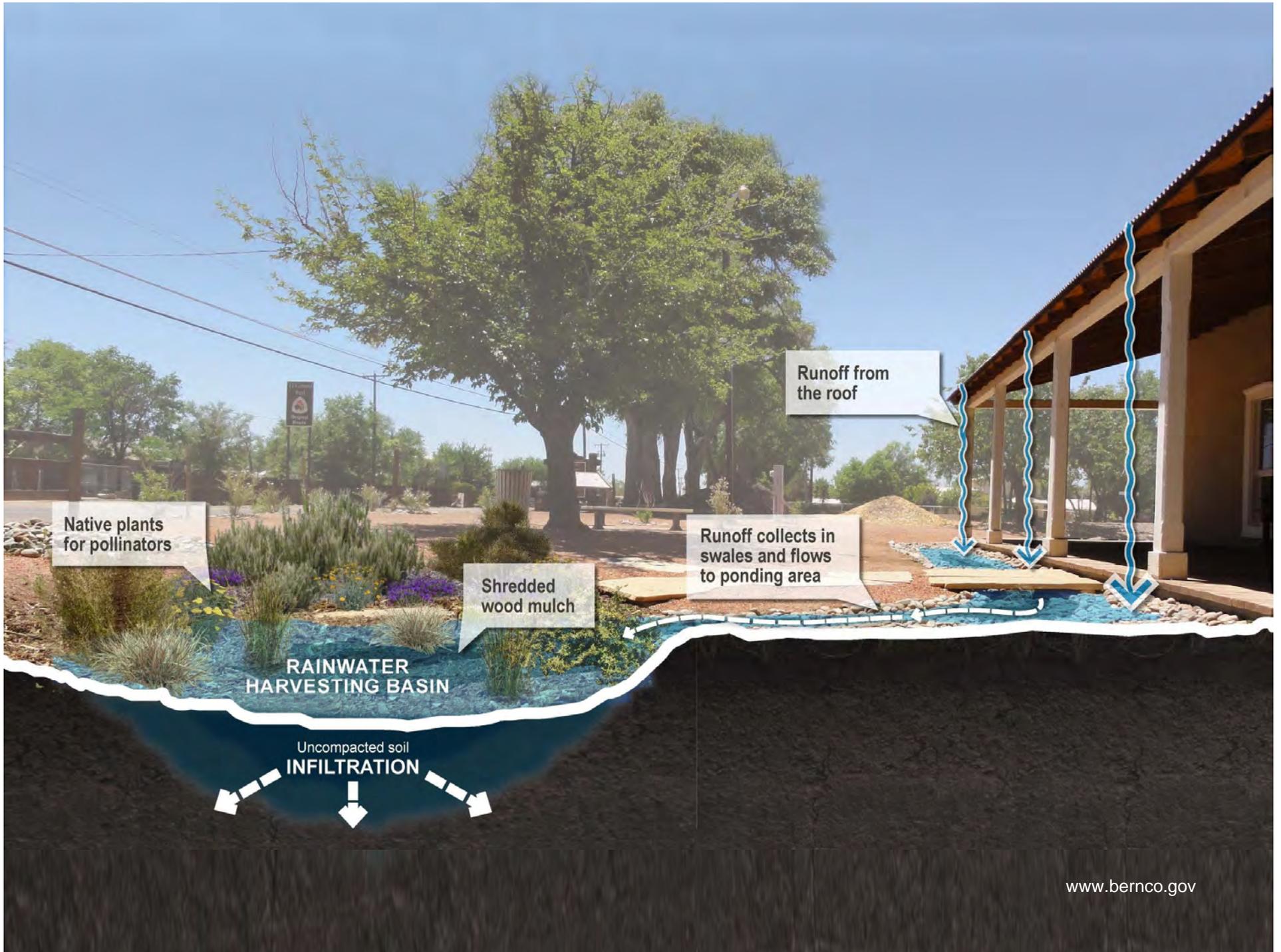
**157-158.** Section and plan of a house showing the location of vegetation and overhang measurement.

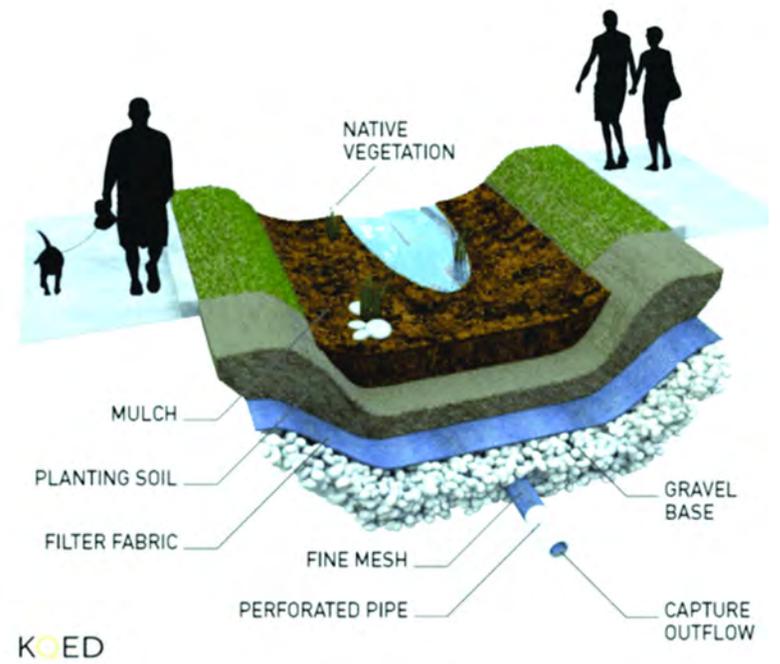




159. Summer shading from dawn to dusk.





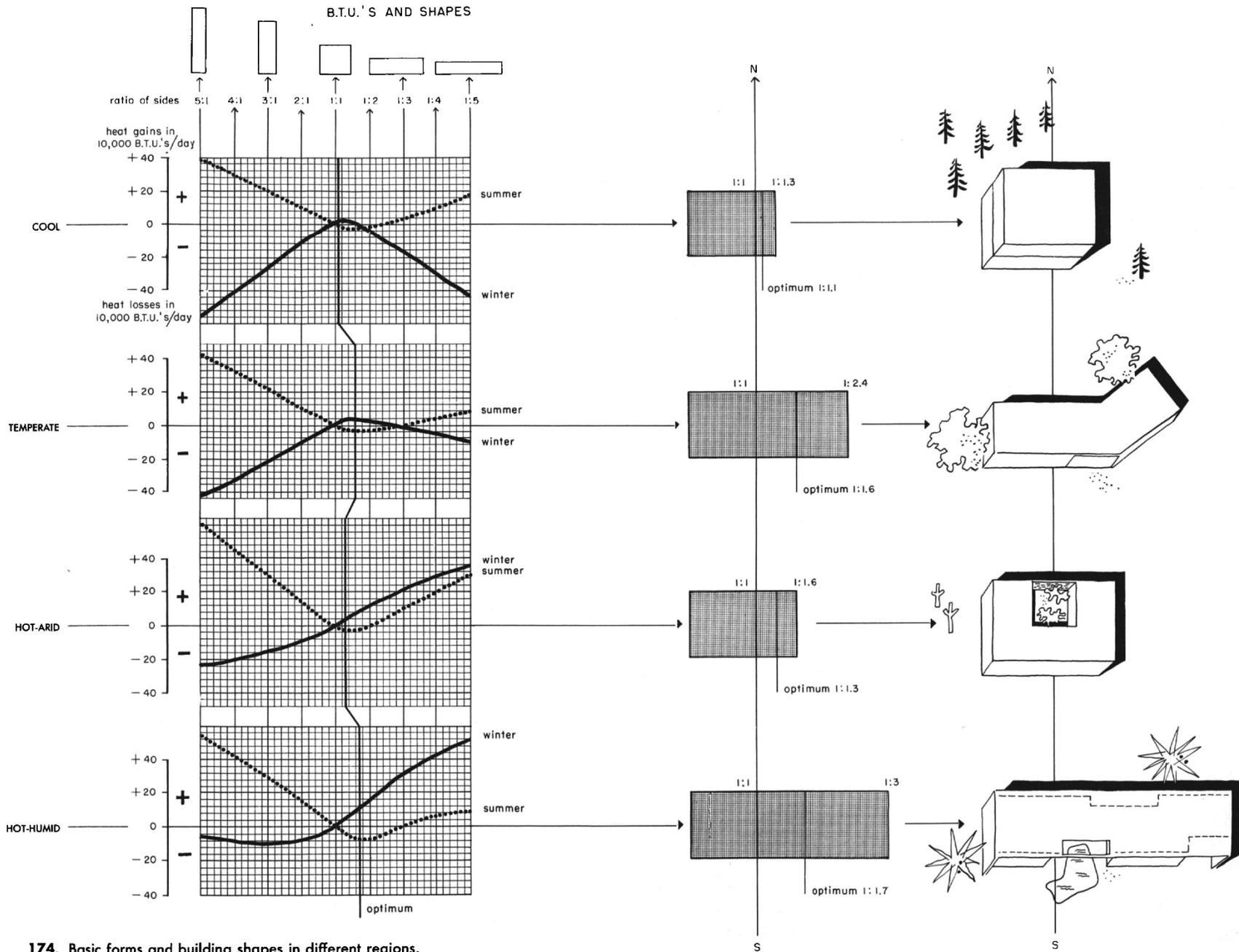


Typical design of a bioswale of city street



Southwest Montgomery Complete Street, Oregon. Nevue Ngan Associates

**Climate and Bioclimatic Design**  
**Site and Bioclimatic Design**  
**Building Form and Bioclimatic Design**  
**Materiality and Bioclimatic Design**



174. Basic forms and building shapes in different regions.

---

	N	NE	E	SE	S	SW	W	NW
bedrooms	●	●	●	●	●	●		
living				●	●	●	●	
dining			●	●	●	●	●	
kitchen			●	●	●	●		
library	●	●						●
laundry	●	●						●
play				●	●	●	●	
drying yd				●	●	●	●	
bathrooms	●	●	●	●	●	●	●	●
utility	●	●						●
garage	●	●	●	●	●	●	●	●
workshop	●	●						●
terraces			●	●	●	●	●	
sun porch				●	●	●	●	

---

**126.** Suggested sun orientation for rooms.

**Climate and Bioclimatic Design**  
**Site and Bioclimatic Design**  
**Building Form and Bioclimatic Design**  
**Materiality and Bioclimatic Design**



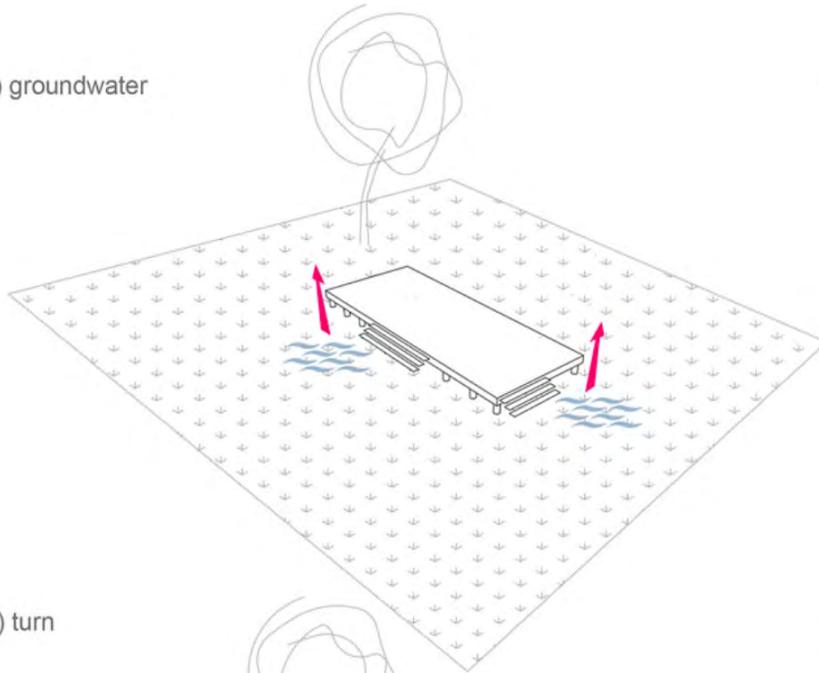


Zilvar House, Czech Republic (temperate climate), 83M<sup>2</sup>, 2013, ASGK Design.  
Archdaily image

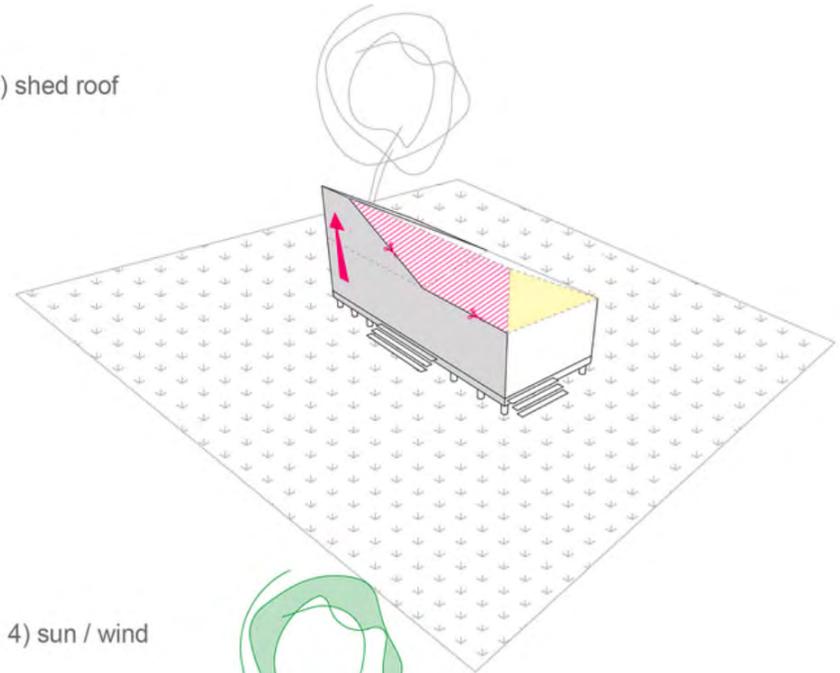


Zilvar House, Czech Republic (temperate climate), 83M<sup>2</sup>, 2013, ASGK Design.  
Archdaily image

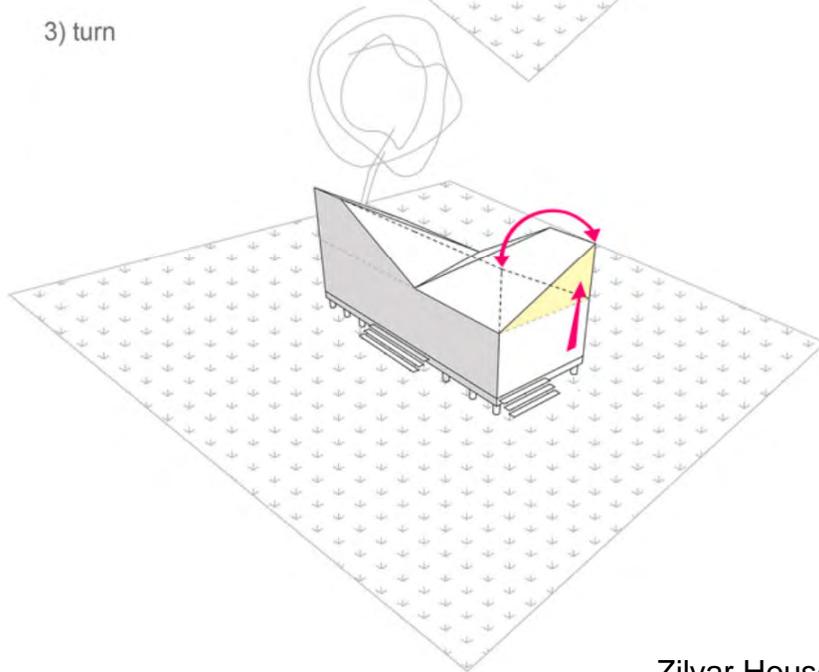
1) groundwater



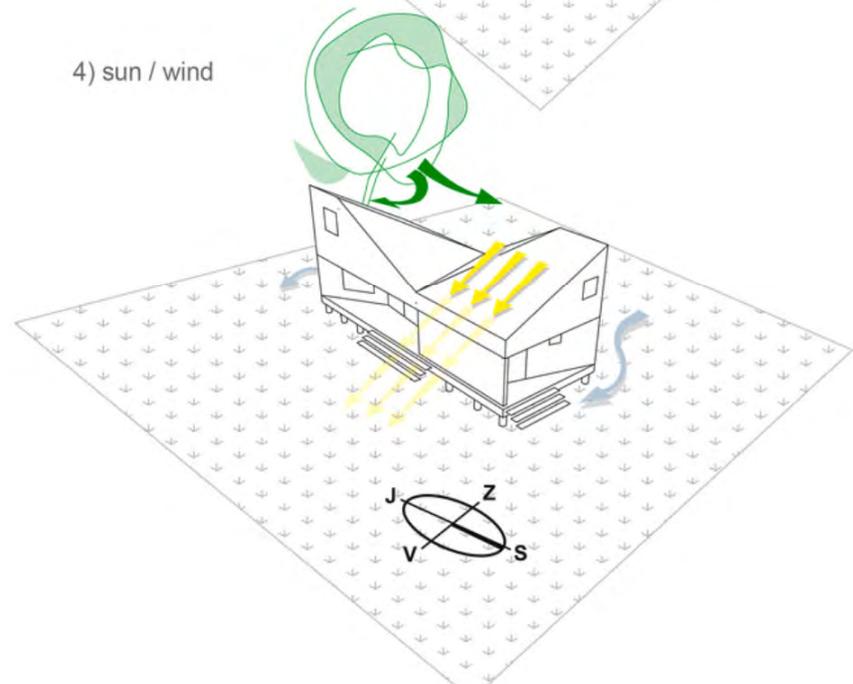
2) shed roof



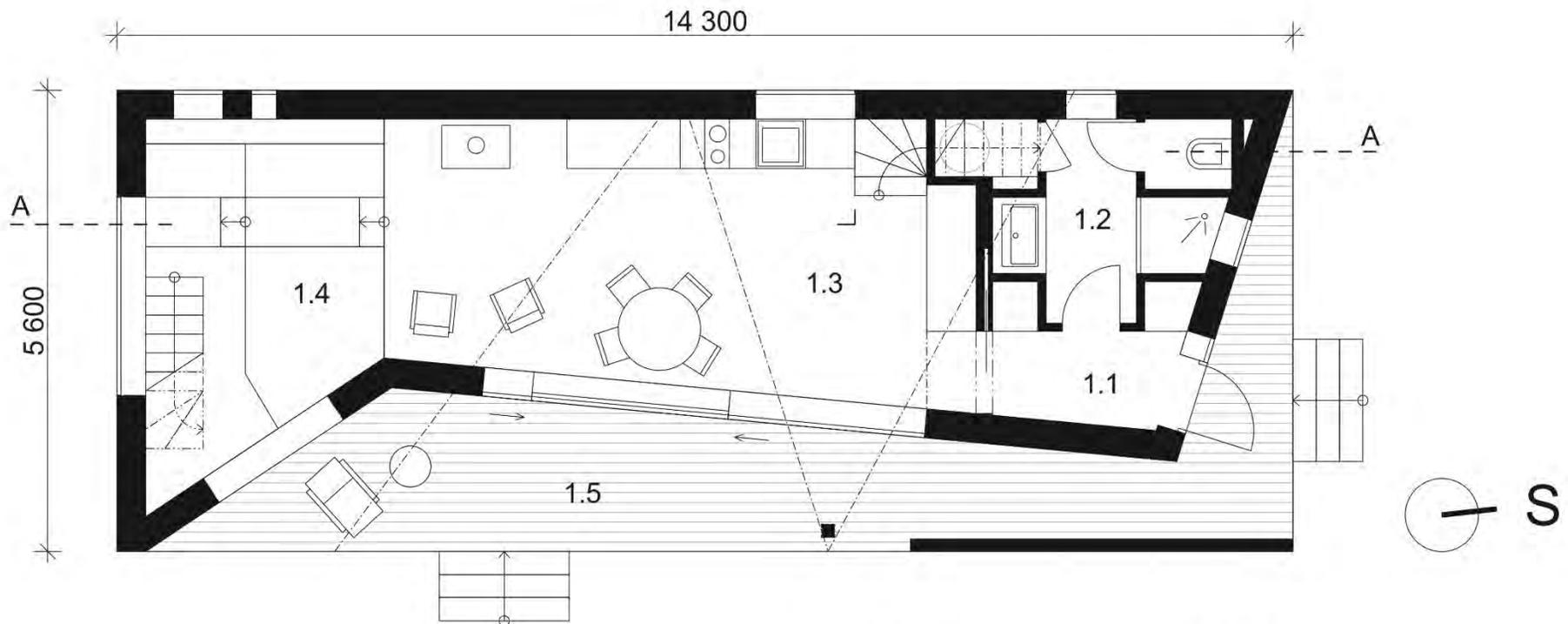
3) turn



4) sun / wind

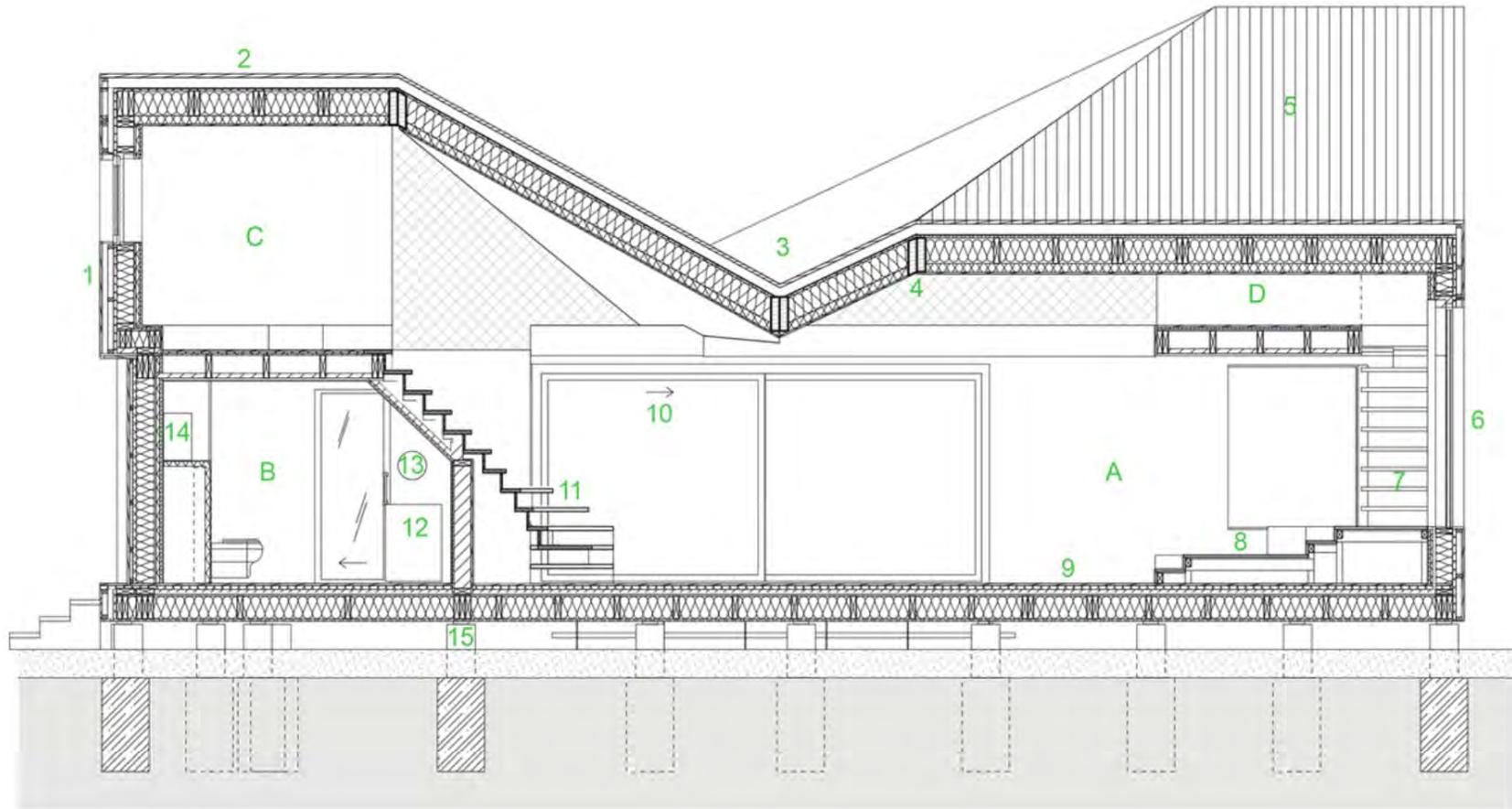


Zilvar House, Czech Republic (temperate climate), 83M<sup>2</sup>, 2013, ASGK Design.  
Archdaily image



1.1	Zádveří	2,65 m <sup>2</sup>
1.2	Koupelna	6,49 m <sup>2</sup>
1.3	Obývací pokoj	21,77 m <sup>2</sup>
1.4	Pódium - relaxace	10,34 m <sup>2</sup>
1.5	Krytá terasa	21,72 m <sup>2</sup>

Zilvar House, Czech Republic (temperate climate), 83M<sup>2</sup>, 2013, ASGK Design.  
Archdaily image



- |      |   |   |   |    |  |
|------|---|---|---|----|--|
| A    | lounge, kitchen and dining area   | 3 | roof valley heated when necessary   | 10 | sliding glass doors with high performance low - E coated glass / windows are designed with wood (inside) and aluminium (outside) frames and insulated triple glazing |
| B    | bathroom  | 4 | supporting roof structure - ULTRALAM beam   | 11 | plywood boxes staircase with a storage area  |
| C, D | open bedroom galleries  | 5 | the cladding goes all the way to roof level and forms a cover for the roof waterproofing sheet      | 12 | storage water heater   |
| 1    | 2 by 4 KVH larch timber construction / diffusion - open wall assembly / the facade wood cladding uses a "burn and stain" technique, for longer - lasting life | 6 | windows are designed with wood (inside) and aluminium (outside) frames and insulated triple glazing | 13 | recover unit   |
| 2    | roof construction - the larch timber - framed structure /hydro insulation is hidden under the roof wood cladding  | 7 | subtle stain industrial staircase in front of a large window enable view on the close oak tree      | 14 | water treatment  |
|      |   | 8 | podium with storage area  | 15 | circular monolithic concrete pillars   |
|      |   | 9 | larch timber strip flooring   |    |  |

Zilvar House, Czech Republic (temperate climate), 83M<sup>2</sup>, 2013, ASGK Design.  
Archdaily image



Zilvar House, Czech Republic (temperate climate), 83M<sup>2</sup>, 2013, ASGK Design.  
Archdaily image



Zilvar House, Czech Republic (temperate climate), 83M<sup>2</sup>, 2013, ASGK Design.  
Archdaily image



Zilver House, Czech Republic (temperate climate), 83M<sup>2</sup>, 2013, ASGK Design.  
Archdaily image



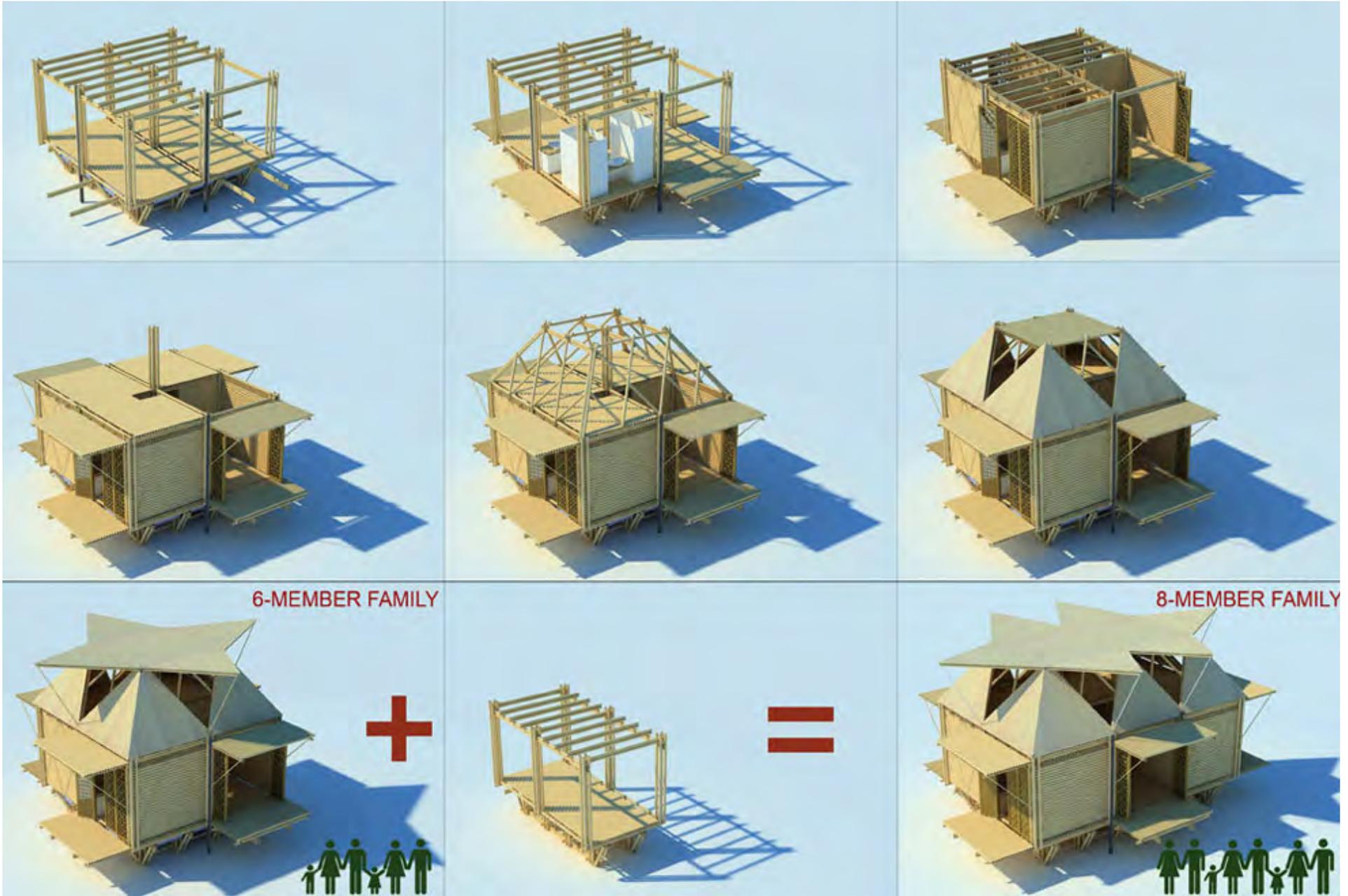
Zilvar House, Czech Republic (temperate climate), 83M<sup>2</sup>, 2013, ASGK Design.  
Archdaily image



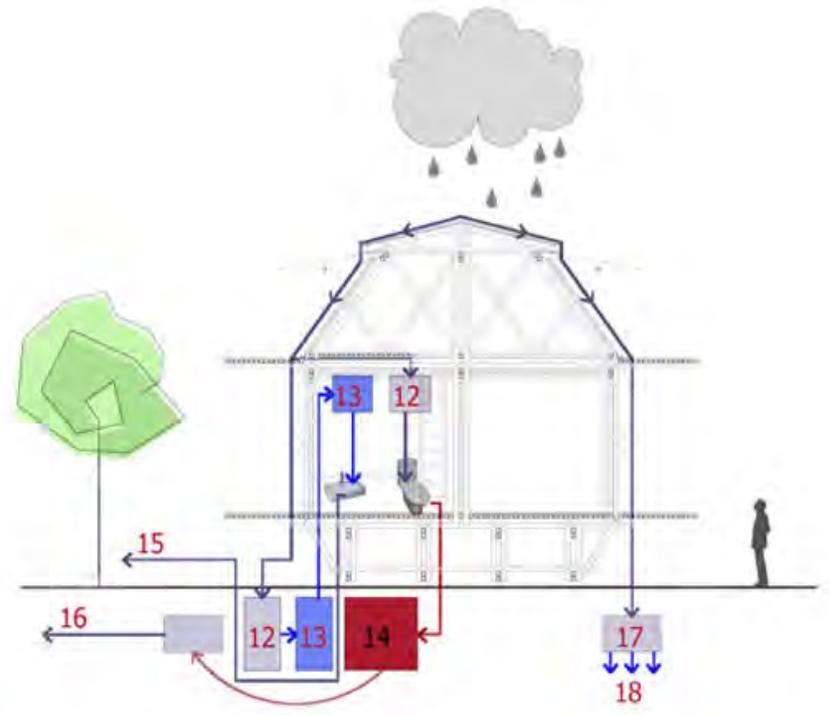
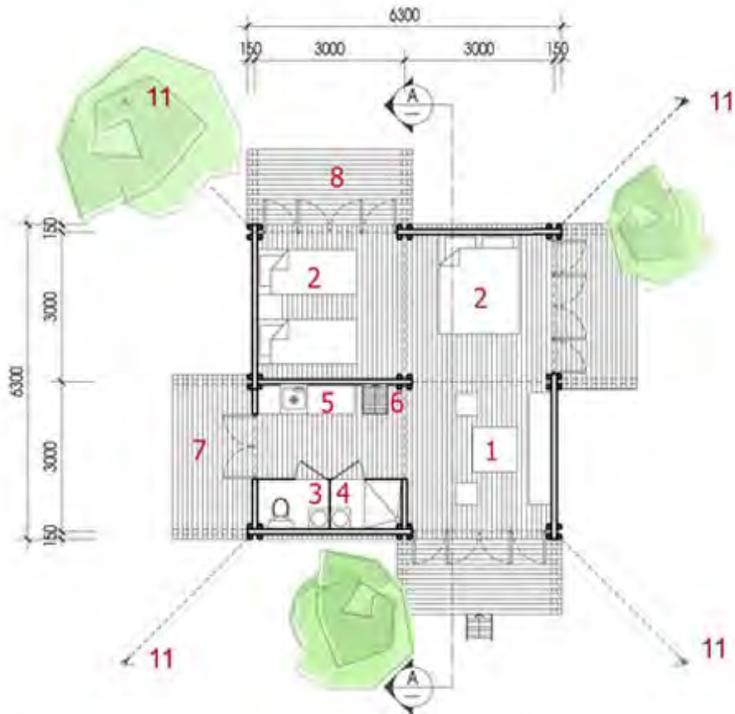
Bb Home, Hanoi Vietnam (hot humid), 44M<sup>2</sup>, 2013, H&P Architects.  
Archdaily image



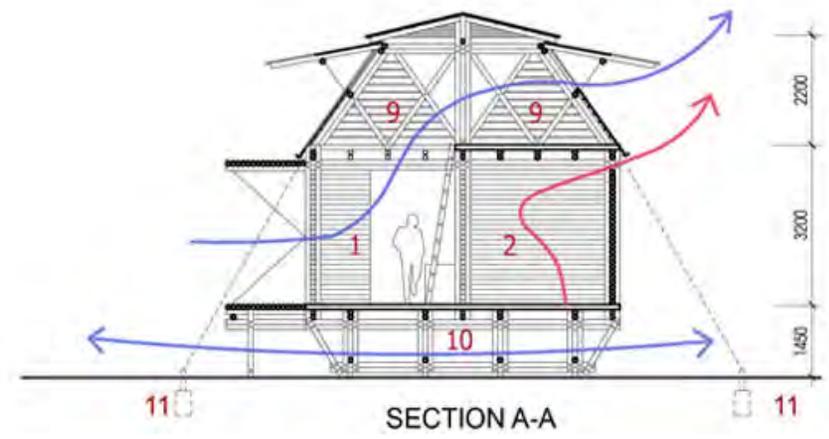
Bb Home, Hanoi Vietnam (hot humid), 44M<sup>2</sup>, 2013, H&P Architects.  
Archdaily image



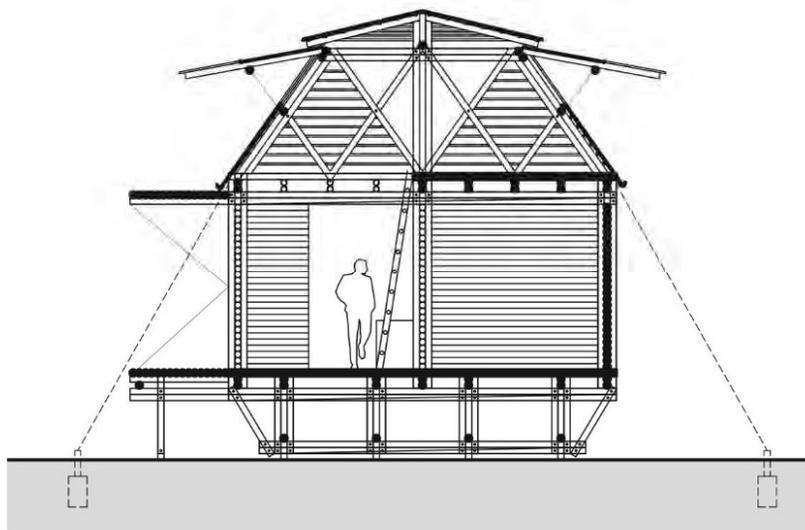
Bb Home, Hanoi Vietnam (hot humid), 44M<sup>2</sup>, 2013, H&P Architects.  
Archdaily image



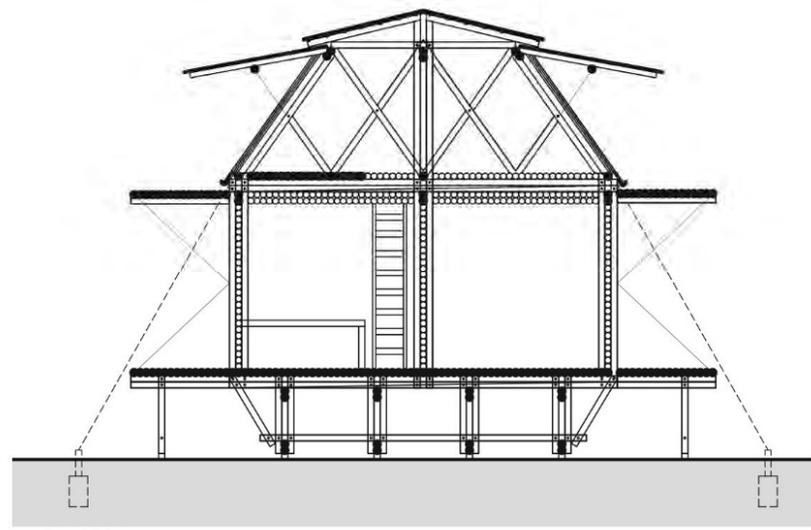
- |   |  |
|---|--|
| 1. Living room                                    | 11. Anchor steel   |
| 2. Bedroom  | 12. Rain water tank  |
| 3. WC   | 13. Clean water tank (filtered)  |
| 4. Bathroom                                       | 14. Waste water tank   |
| 5. Kitchen  | 15. Water for gardening  |
| 6. Stair  | 16. Discharged to (after treated)  |
| 7. Laundry + Drying                               | 17. Filter tank for rain water   |
| 8. Outdoor terrace                                | 18. Rain water cleaned and returned to the environment (underground reloading) |
| 9. Indoor terrace (sleeping + learning + worship) |  |
| 10. area breed animal / plant                     |  |



Bb Home, Hanoi Vietnam (hot humid), 44M<sup>2</sup>, 2013, H&P Architects.  
Archdaily image



**section AA**



**section BB**

Bb Home, Hanoi Vietnam (hot humid), 44M<sup>2</sup>, 2013, H&P Architects.  
Archdaily image



Bb Home, Hanoi Vietnam (hot humid), 44M<sup>2</sup>, 2013, H&P Architects.  
Archdaily image



**WALL MATERIALS**

1. Bamboo of 8 – 10cm diameter
2. Rope
3. Bamboo of 4 - 5cm diameter
4. Nylon sheet (rain shield)
5. Polycarbonate sheet
6. Vertical garden (vegetable, plant, flower,...)



Bb Home, Hanoi Vietnam (hot humid), 44M<sup>2</sup>, 2013, H&P Architects.  
Archdaily image



Power of 10 (Net zero energy home; passive house standard), Orebro, Sweden (cold),  
148m<sup>2</sup> / home, 0.4MWh/yr/home, 40kW battery.  
Street Monkey Architect



Power of 10 (Net zero energy home; passive house standard), Orebro, Sweden (cold),  
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## Bioclimatic Design Takeaways

- Bioclimatic Design is an approach to sustainable building design that takes into account the local climate, local environments, and user needs to create a comfortable, energy-efficient and sustainable architecture.
- Building shapes and enclosures respond differently depending on climate and site conditions.
- The benefits of the Bioclimatic Design are to improve user comfort, health and well-being by shading, natural ventilation, and daylighting.
- Bioclimatic Design minimizes the use of active systems and energy use in heating, cooling, ventilation, and lighting energy.
- Bioclimatic Design preserves the surrounding ecosystems by working with local vegetation, bodies of water, and natural habitats.

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