

Universitat de Lleida

Passive systems for energy savings of buildings in tropical climate

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20/01/2018

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- Energy simulation of an office building

Bioclimatic architecture

- What is bioclimatic architecture?

Bioclimatic architecture

- What is bioclimatic architecture?



Farmhouse in Catalonia



Village in Morocco



Hotel in Barcelona

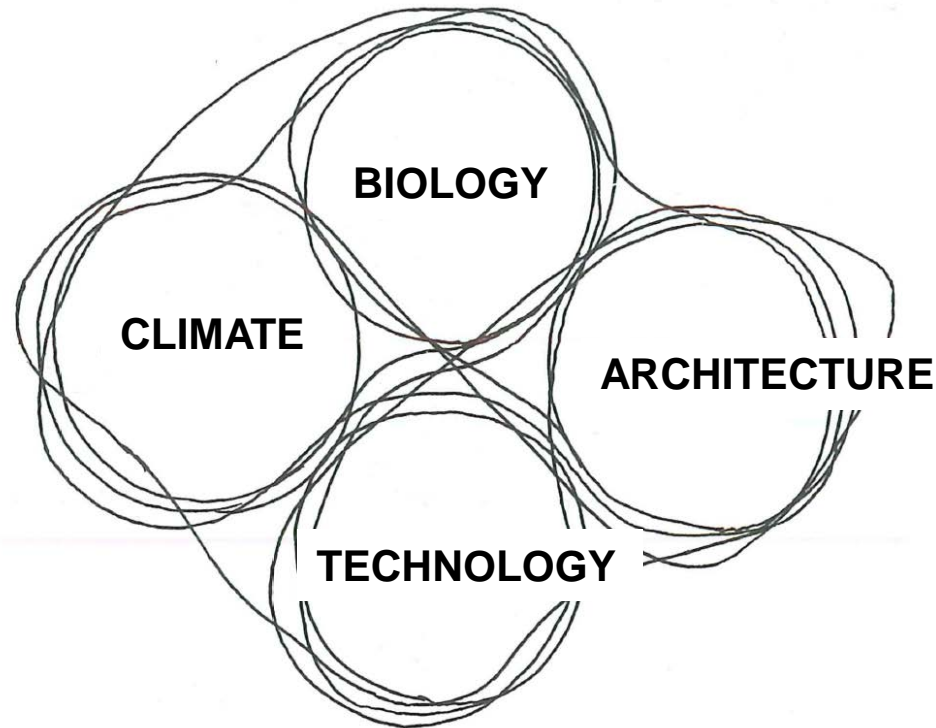


Hotel in Dubai

Bioclimatic architecture

- What is bioclimatic architecture?

Bioclimatic architecture takes into account the climate, architecture and human beings, but also it represents the use of materials with sustainability criteria and the concept of optimal energy management of buildings.



Source: Olgyay, V. Design with climate.

Bioclimatic architecture

- The climate and the architecture

COLD



MODERATE



DRY

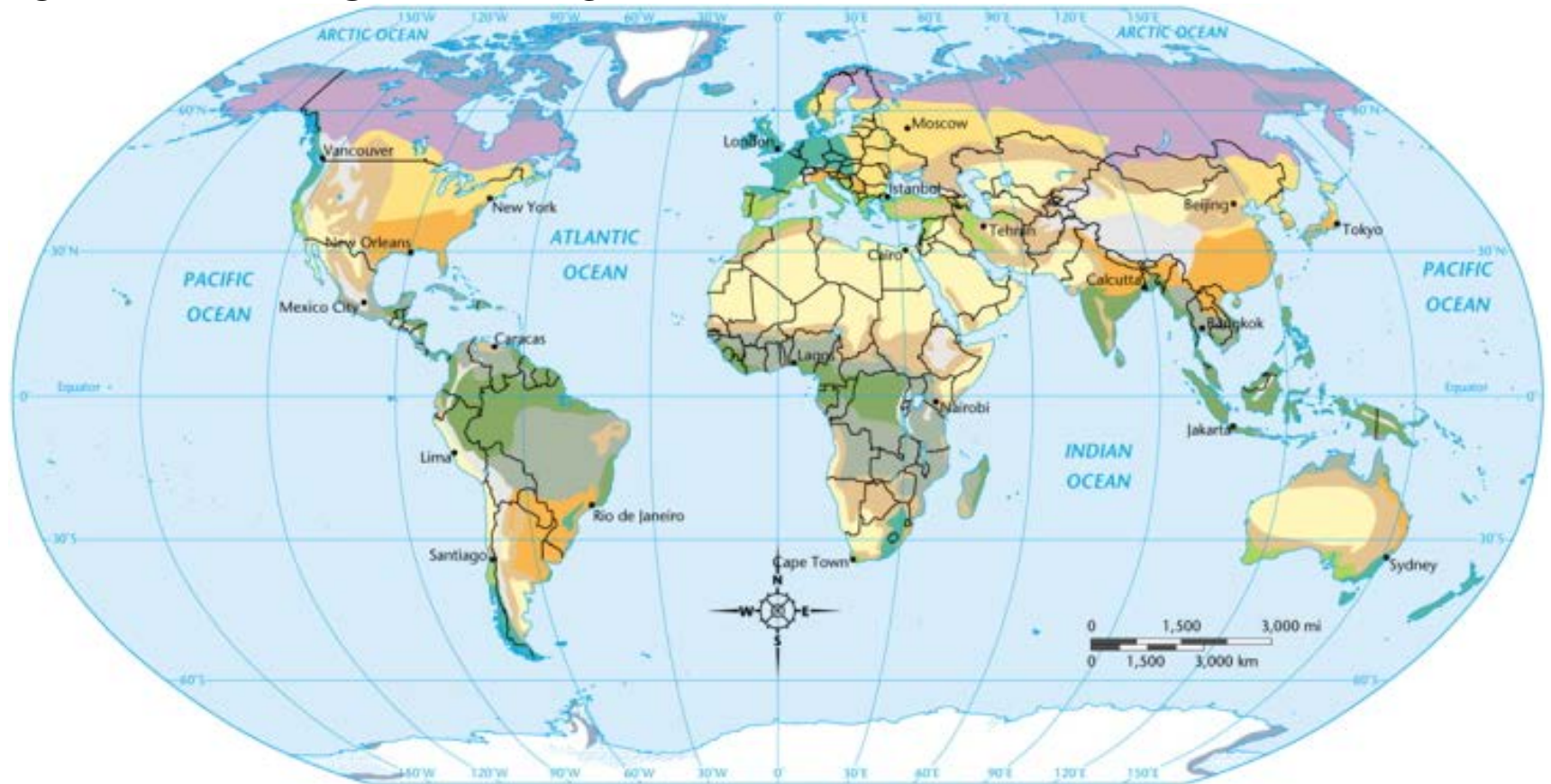


TROPICAL MOIST



Bioclimatic architecture

CLIMATE AREAS IN THE WORLD



Tropical

- Tropical wet
- Tropical wet and dry

Dry

- Semi-arid
- Arid

Moderate

- Mediterranean
- Humid subtropical
- Marine west coast

Continental

- Humid continental
- Subarctic

Polar

- Tundra
- Ice cap
- Highlands

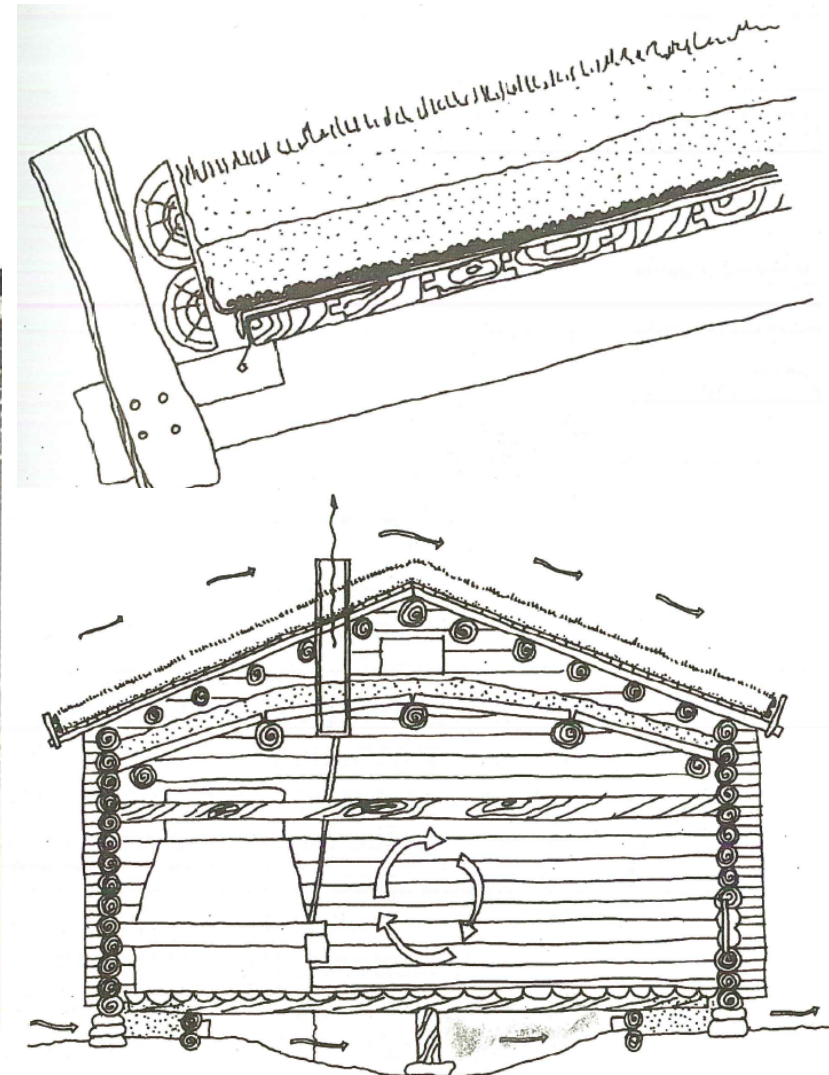
Non-permanent ice

Bioclimatic architecture

- Cold climate

Vernacular architecture in Norway

Wooden dwellings with green roof.

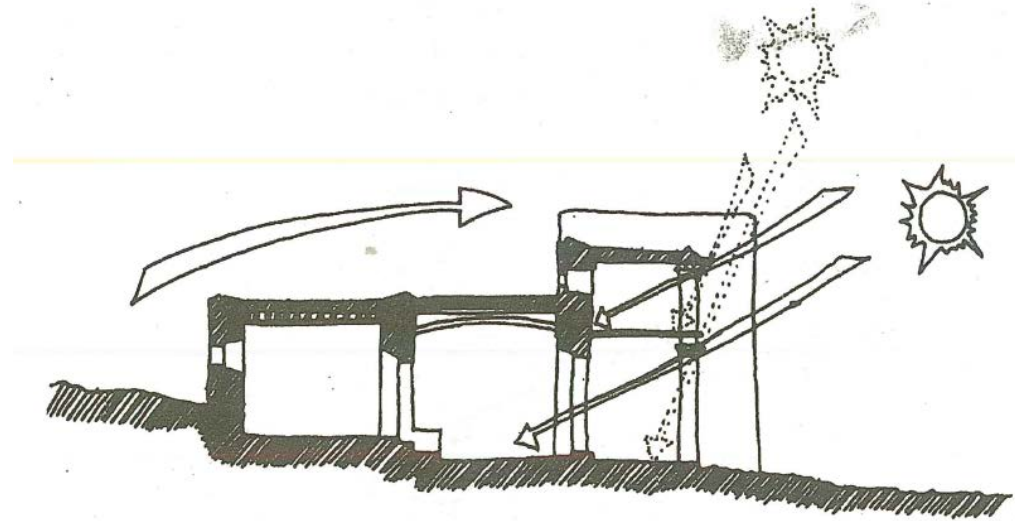
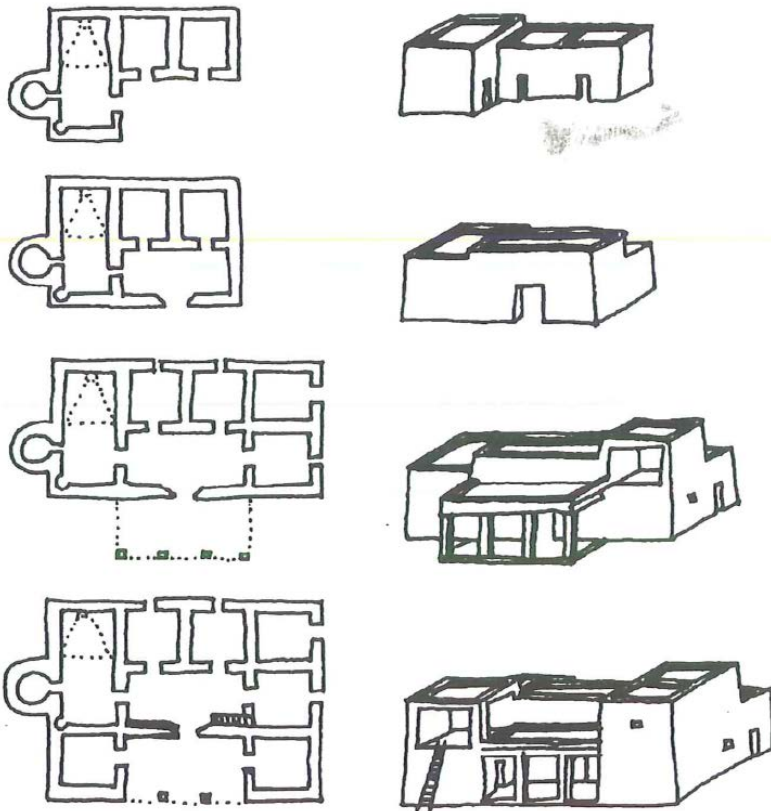


Source: Neila, F.J. *Arquitectura bioclimática en un entorno sostenible.*

Bioclimatic architecture

- Moderate climate

The Ibizan house.



Source: Neila, F.J. *Arquitectura bioclimática en un entorno sostenible.*

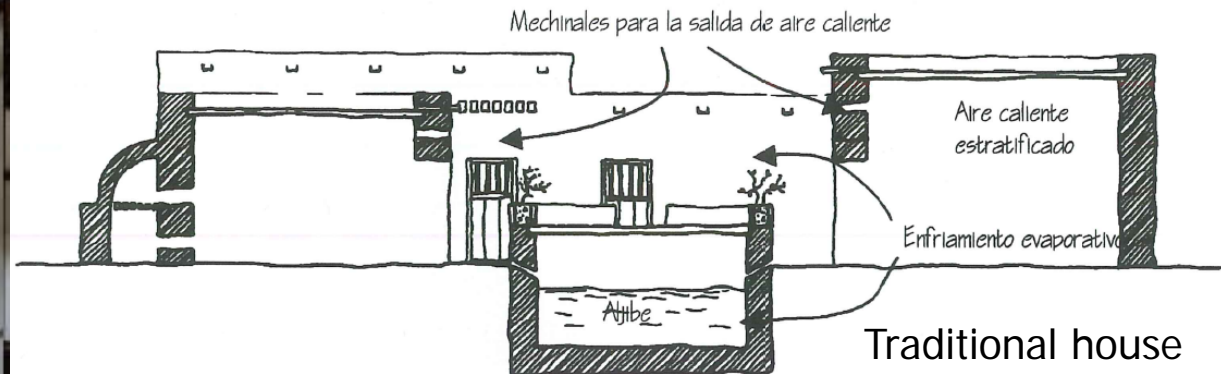
Bioclimatic architecture

- Dry climate

Museum-house of the César Manrique Foundation. 1991. Lanzarote.



Taliesin west, Wisconsin, USA. 1937-59. Frank L. Wright.

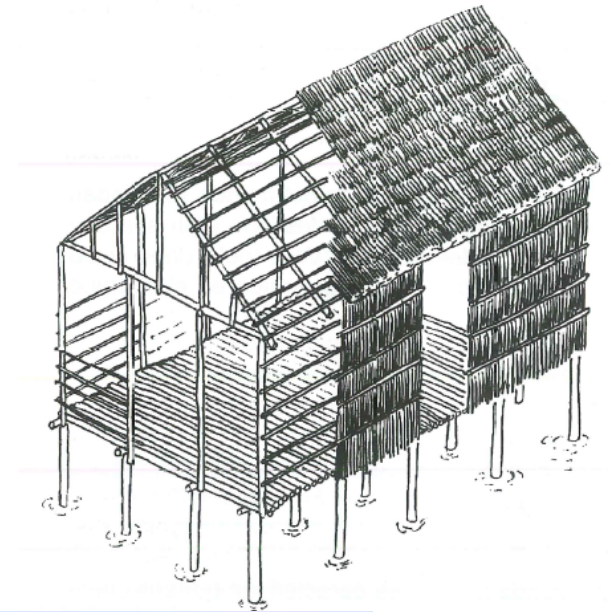
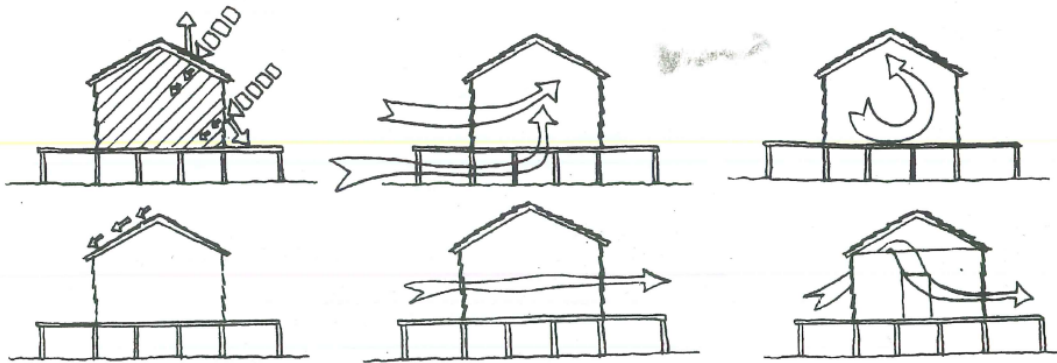


Source: Neila, F.J. *Arquitectura bioclimática en un entorno sostenible*.

Bioclimatic architecture

- Tropical climate.

Stilt houses in Venezuela



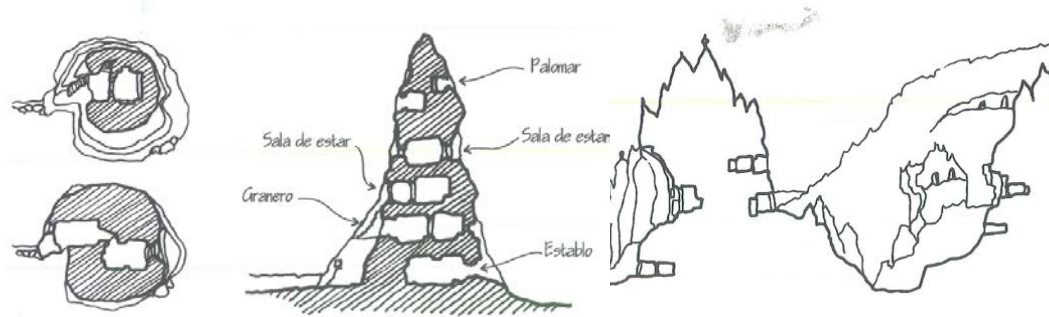
Source: Neila, F.J. *Arquitectura bioclimática en un entorno sostenible.*

Bioclimatic architecture

- Microclimate & topography



Fallingwater house, USA. 1936-39.
Frank L. Wright.



Source: Neila, F.J. *Arquitectura bioclimática en un entorno sostenible*.



Cave dwelling in Cappadocia, Turkey.

Bioclimatic architecture

Natural and built environment



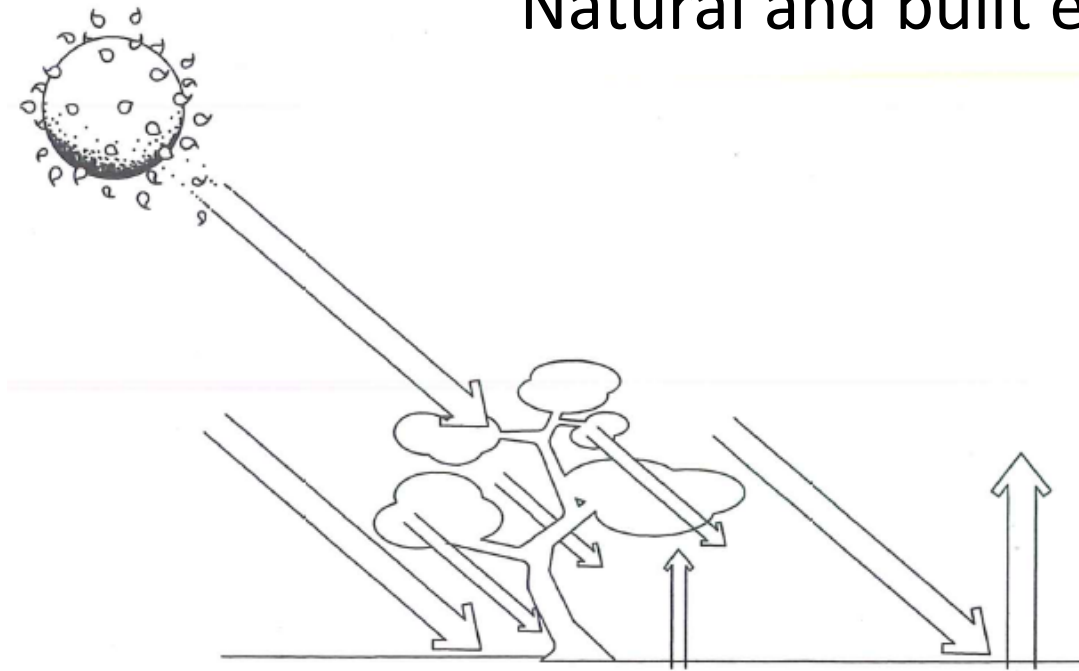
Centre Natura Caixa de Catalunya, Planes de Son.



Eixample, Barcelona.

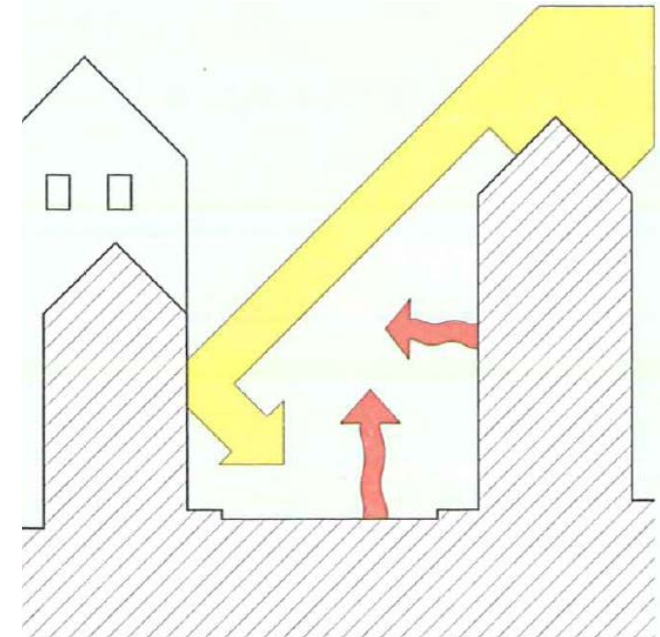
Bioclimatic architecture

Natural and built environment



Source: *Un Vitruvio Ecológico*.

The areas covered by vegetation keep the temperature of the soil surface more stable than the exposed ones.



The urban area receives direct solar radiation.

The dense materials store and radiate heat.

Bioclimatic architecture

- Microclimate
 - Temperature: heat island effect

Isotherms in Madrid, summer 2015.



Proyecto Modifica

Modelo predictivo del comportamiento de edificios de vivienda bajo los efectos de la isla de calor de Madrid

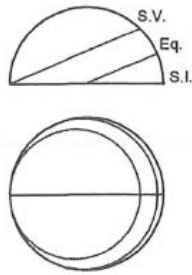
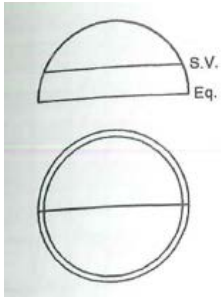
Source: ABIO-UPC. <http://abio-upm.org/project/modifica/>

Bioclimatic architecture

- Solar radiation

90 ° N
Pole

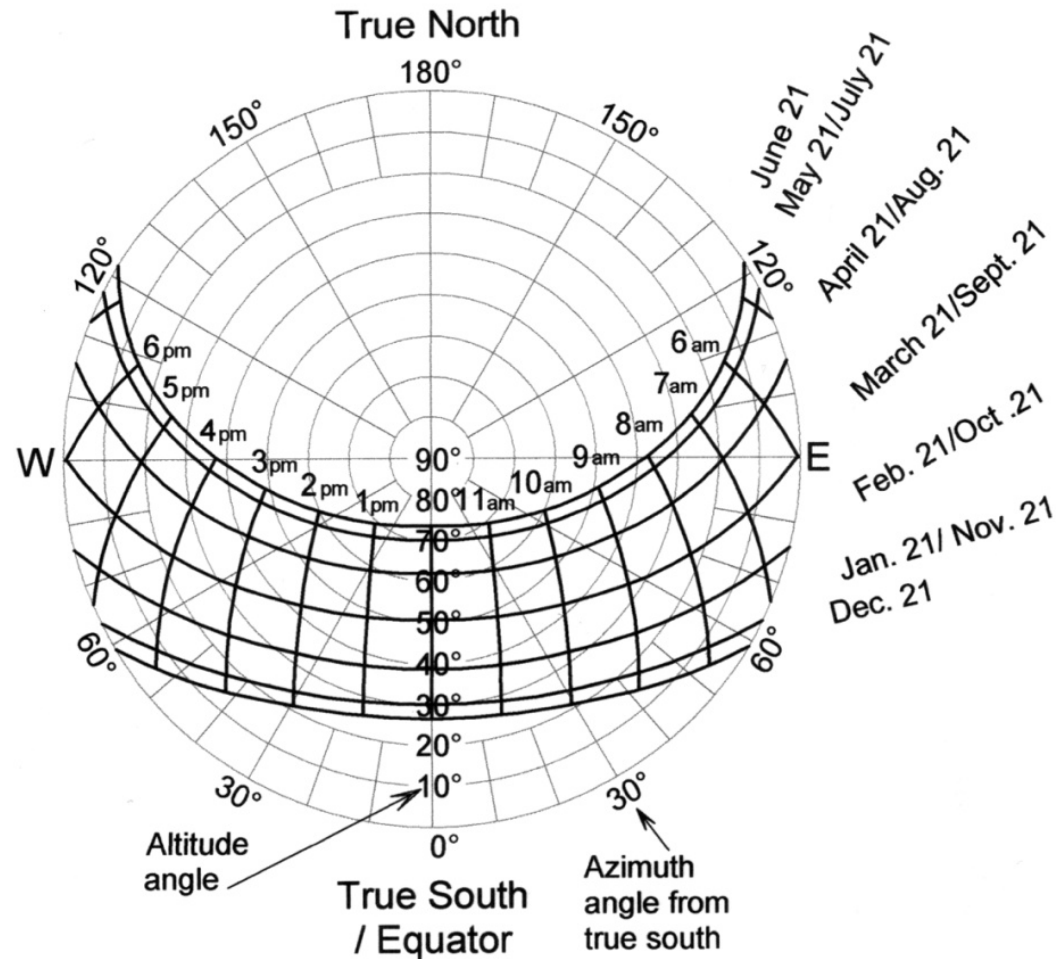
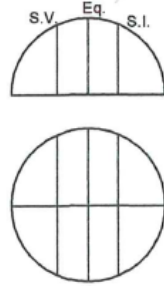
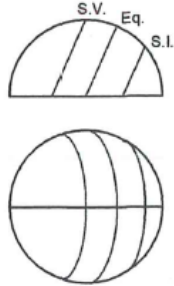
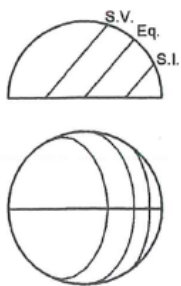
66° 63' N
Polar Circle



40 ° N
Madrid

23° 27' N
Tropic

0° N
Equator



Sun Path Diagram, 40° N Latitude

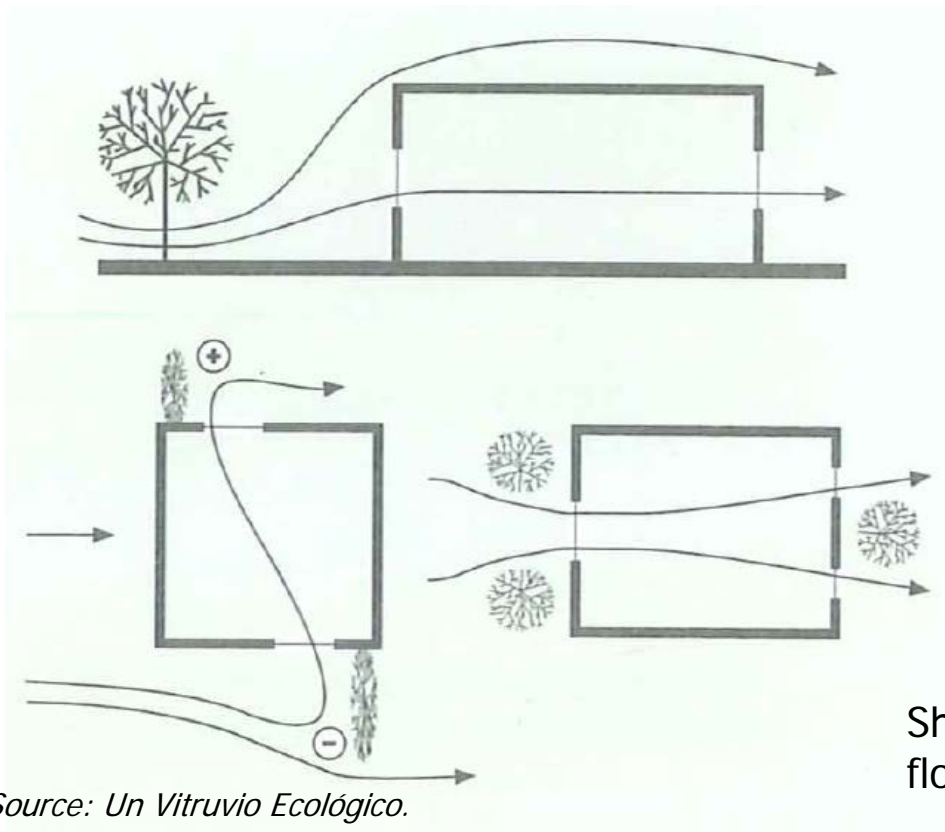
www.HarvestingRainwater.com

Source: Neila, F.J. *Arquitectura bioclimática en un entorno sostenido*

Bioclimatic architecture

- Wind and air quality

Natural ventilation of the building.



Source: *Un Vitruvio Ecológico*.

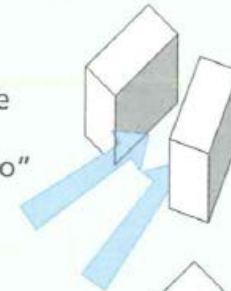
1. Oriente el eje longitudinal en paralelo al viento dominante



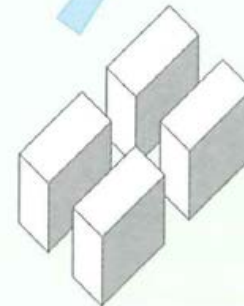
2. Evite orientar los amplios muros laterales hacia el viento dominante



3. Evite crear espacios entre los edificios que provoquen el "efecto embudo"



4. Evite filas largas y paralelas de edificios con muros lisos



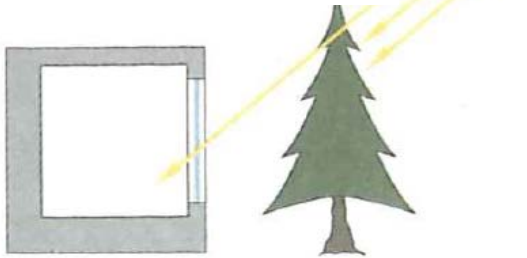
Shape and organization of buildings to avoid air flows and to protect outdoor spaces.

Bioclimatic architecture

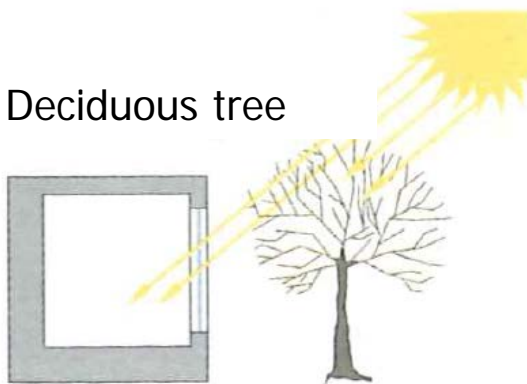
- Vegetation

The vegetation adjusts the radiation incidence on the building, and therefore the temperature of the environment. It improves air quality and prevents airstreams and noise.

Evergreen tree



Deciduous tree



Source: *Un Vitruvio Ecológico*.

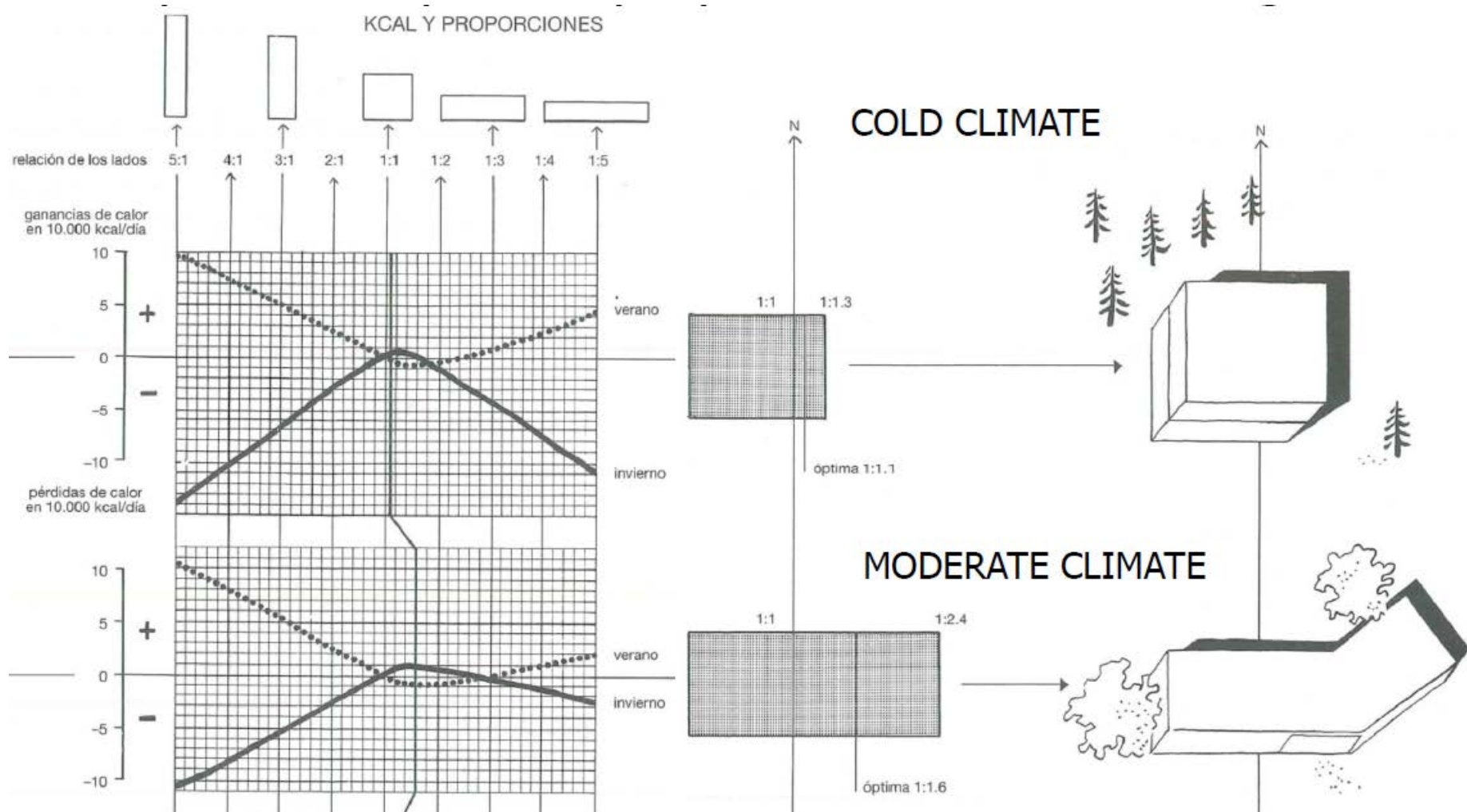


Green facade in Golmés, Lleida.

Source: Pérez, G. (2010)

Bioclimatic architecture

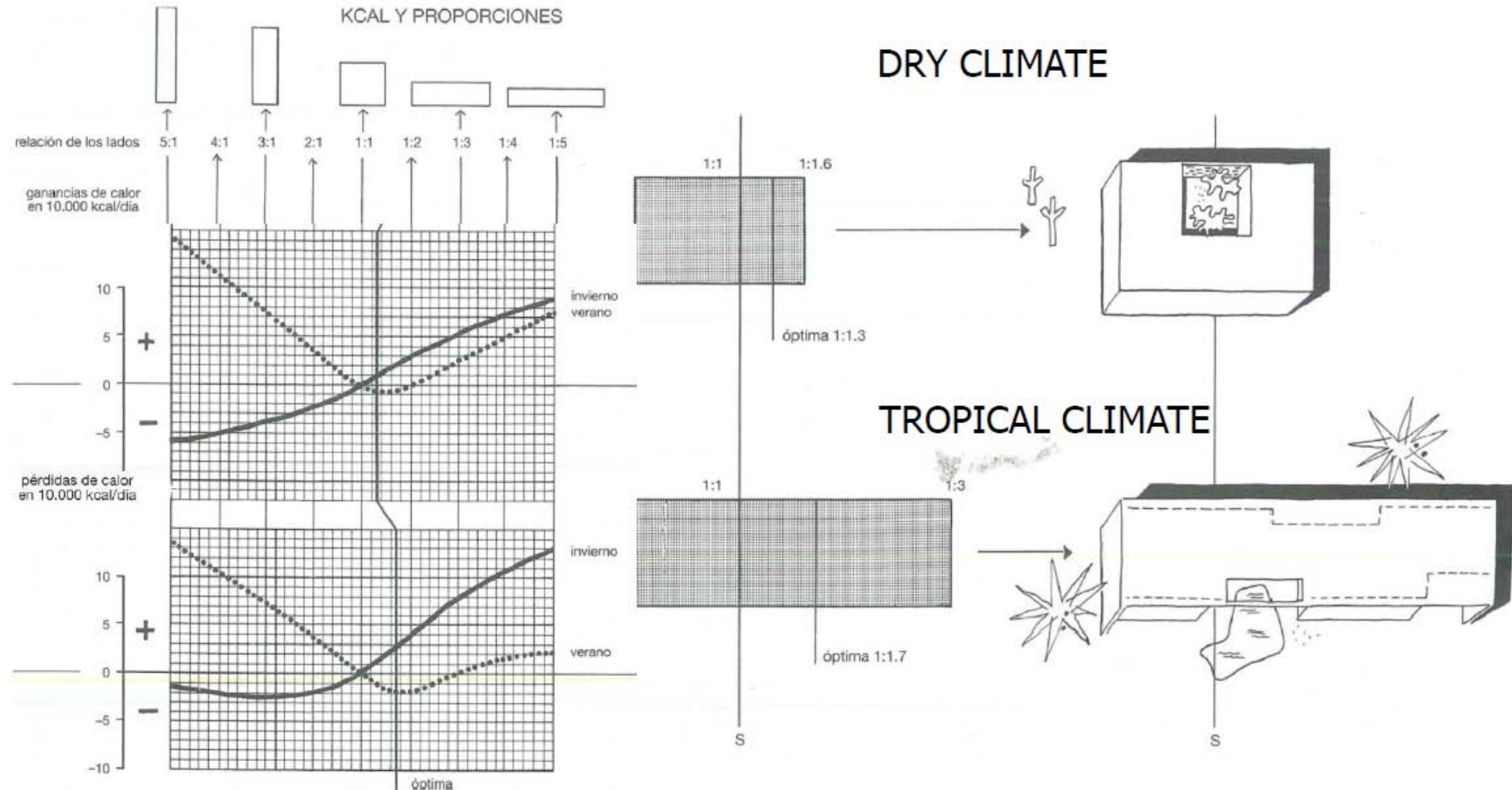
- Shape and volume: Optimal shape and proportions of the building



Source: Olgay, V. Design with climate.

Bioclimatic architecture

- Shape and volume: Optimal shape and proportions of the building

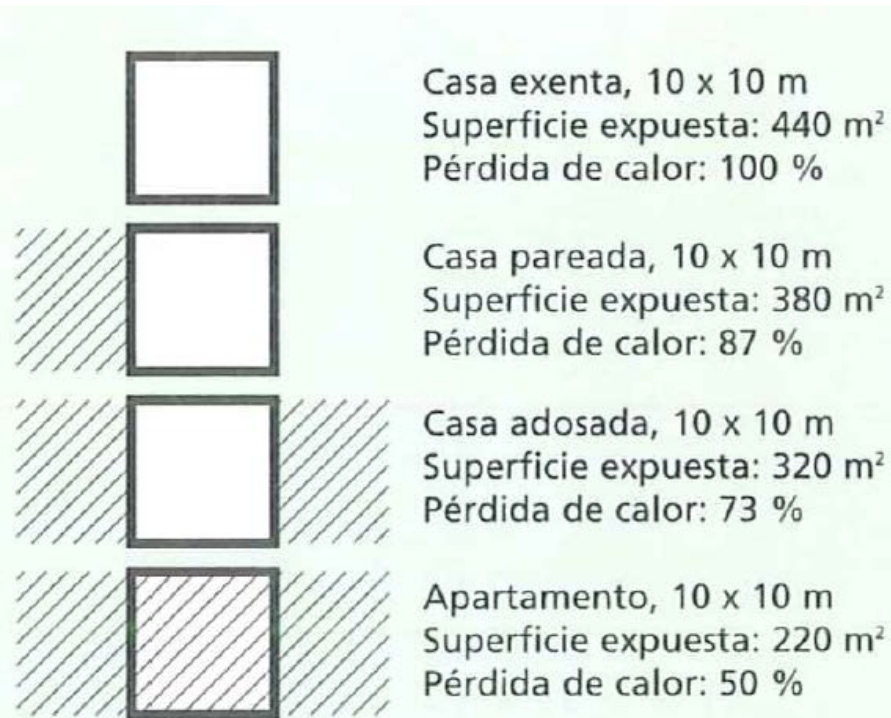


Source: Olgyay, V. *Design with climate*.

Bioclimatic architecture

- Shape and volume

The heat in the building is lost in accordance with the exposed surface.



Tipo de edificio y proporción de pérdida de calor

Source: *Un Vitruvio Ecológico*.

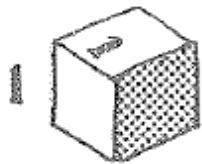


Bioclimatic architecture

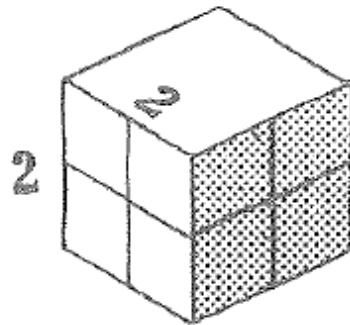
- Shape factor

The shape factor of a building is the ratio of the sum of the surfaces of the building elements of separation to the volume enclosed by them.

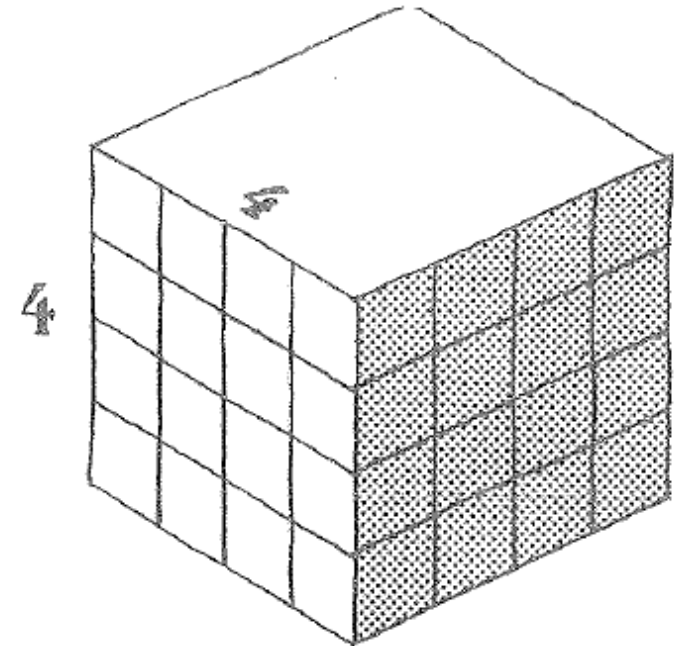
$$f = \frac{S}{V}$$



VOLUME: 1
SURFACE: 6
SHAPE FACTOR: 6
 $f=6/1$



VOLUME: 8
SURFACE: 24
SHAPE FACTOR: 3
 $f=24/8$



VOLUME: 64
SURFACE: 96
SHAPE FACTOR: 1.5
 $f=96/64$

Source: Neila, F.J. *Arquitectura bioclimática en un entorno sostenible.*

Bioclimatic architecture

• Shape factor

A high surface/volume ratio (i.e. more surface area in relation to volume) favors heat loss, while the opposite situation (lower surface in relation to volume) allows heat retention.

Polar climate: Igloo

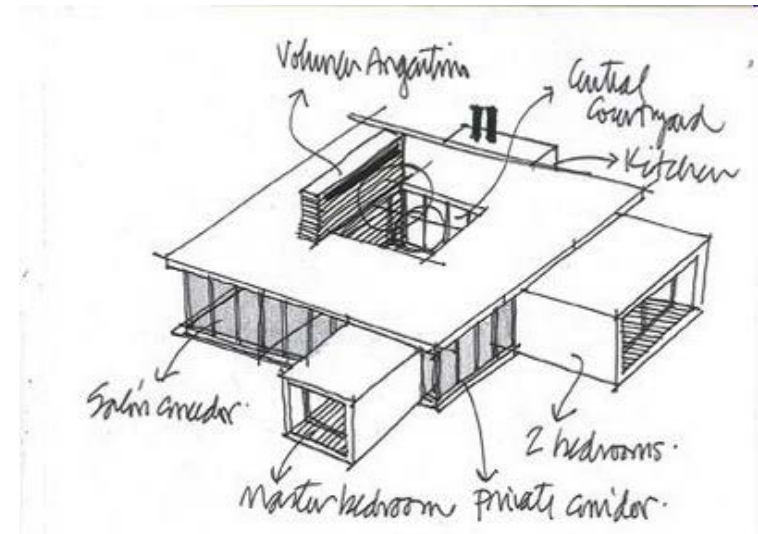
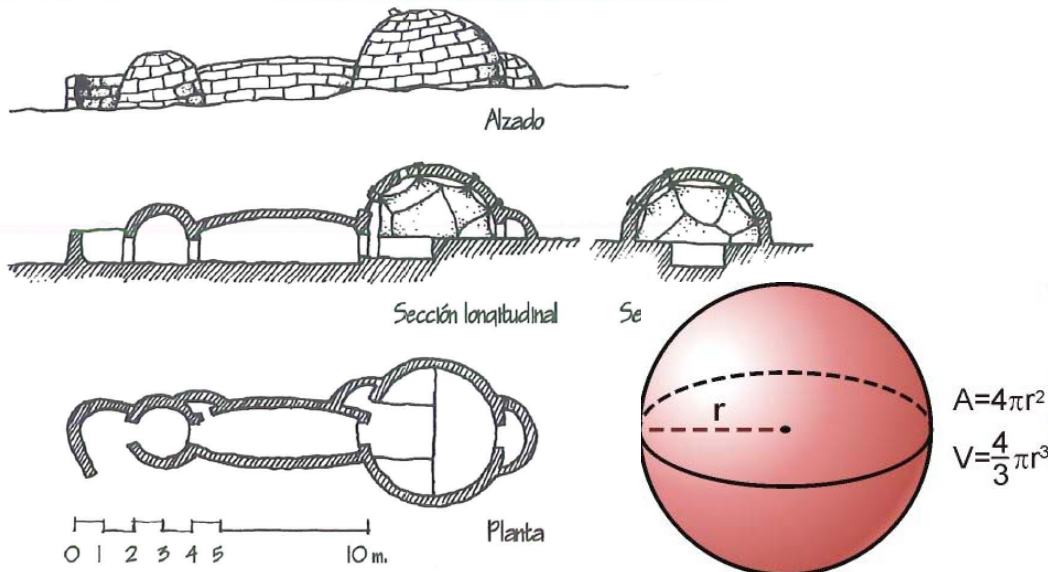
Low shape factor.

$$f = \frac{S}{V}$$

Tropical climate:

House with patio in Brazil

High shape factor.

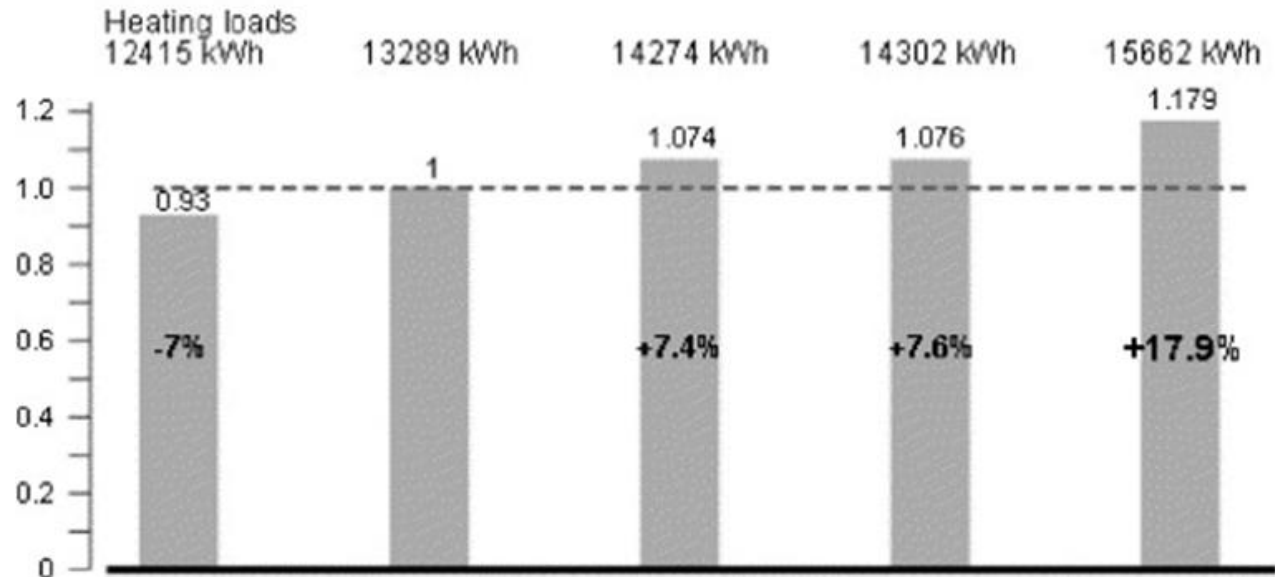
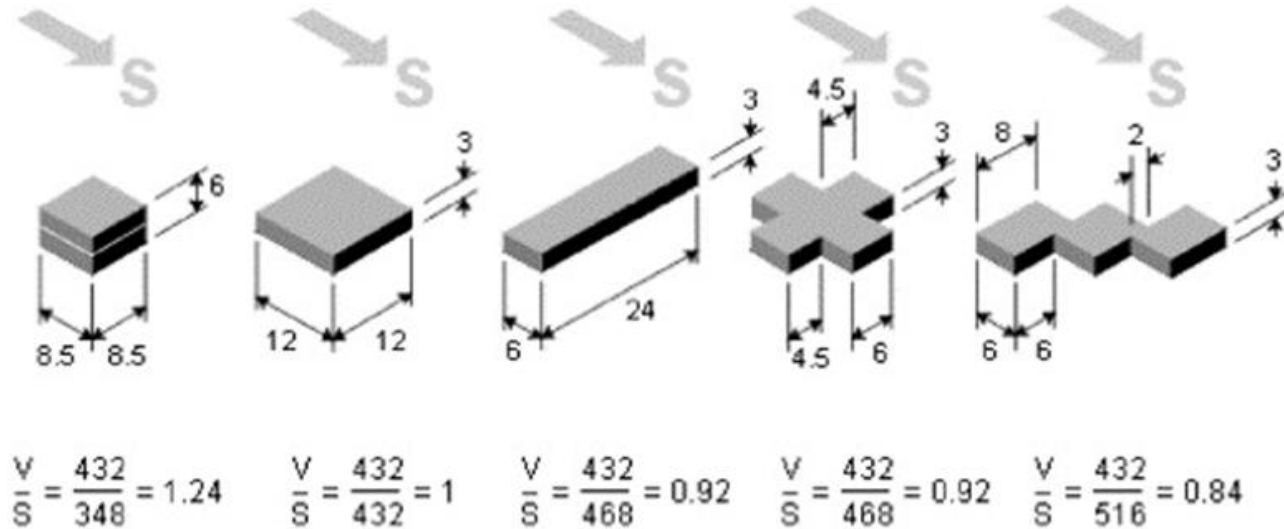


Source: Neila, F.J. *Arquitectura bioclimática en un entorno sostenible*.

Bioclimatic architecture

- Shape factor

Impact of the building shape on the heating loads.



Source: E. Gratia, A. De Herde.
Design of low energy office buildings.

References

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- Gratia, E., De Herde, A. “Design of low energy office buildings”. Energy & Buildings, Vol. 35 pp.473-491, 2003.