

# Bioclimatic Architecture Principles

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# PASSIVE SOLAR PRINCIPLES



## • THERMAL BALANCE OF THE BUILDING



Buildings are characterized by thermal gains and losses. The thermal balance is a function of various terms like :

$$Q_s + Q_{in} - Q_t - Q_o - Q_v - Q_g$$

where :

$Q_s$  are the solar gains

$Q_{in}$  are the internal gains

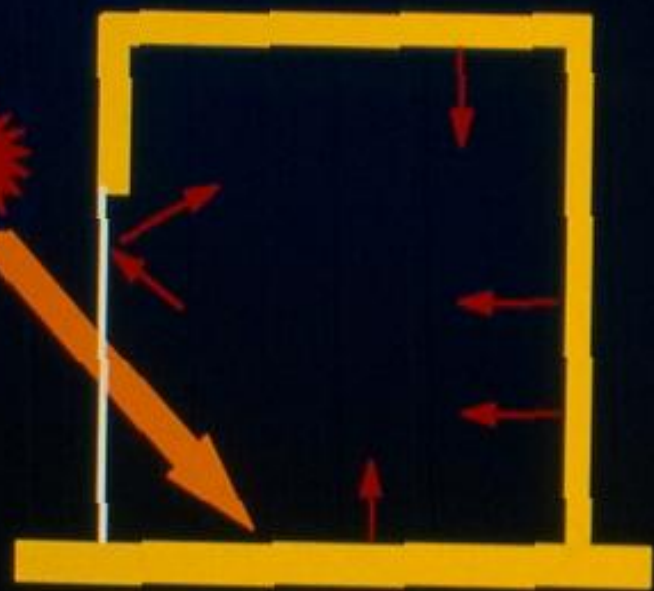
$Q_t$  are the ventilation losses,  $Q_o$  the losses through the opaque elements,  $Q_v$  the losses through the transparent elements and  $Q_g$  the losses to the ground.



# PASSIVE SOLAR PRINCIPLES



## • GREENHOUSE EFFECT



As glazing materials present a high transmittance to solar radiation, solar energy enters to the building and is absorbed by its thermal mass, (walls-roof, etc). Building materials and objects heated up by the sun emit long wave radiation which can not pass through glazing due to its low transmissivity to these wavelengths.

Factors affecting greenhouse effect are : The transmissivity of the glazing to the short and long wave radiation, the overall heat transfer coefficient of the window and the absorptivity and emissivity of the opaque elements of the building.





# PASSIVE SOLAR PRINCIPLES



## DIRECT GAIN SYSTEMS



It consists primarily of a well-insulated building with a relatively large expanse of south facing glazing. Direct gain systems use the occupied spaces of the building to collect, store and distribute solar heat. The building needs thermal mass to store heat during the day and re-emit it at night.

This thermal mass is usually in the form of externally insulated masonry walls and/or a solid floor with underfloor insulation.

The basic requirements of a direct gain system are :

1. A large south-facing glazed aperture with the living space directly behind.
2. Exposed thermal mass in the ceiling and or floor and or walls.
3. A means of isolating the thermal storage from exterior.



# PASSIVE SOLAR PRINCIPLES



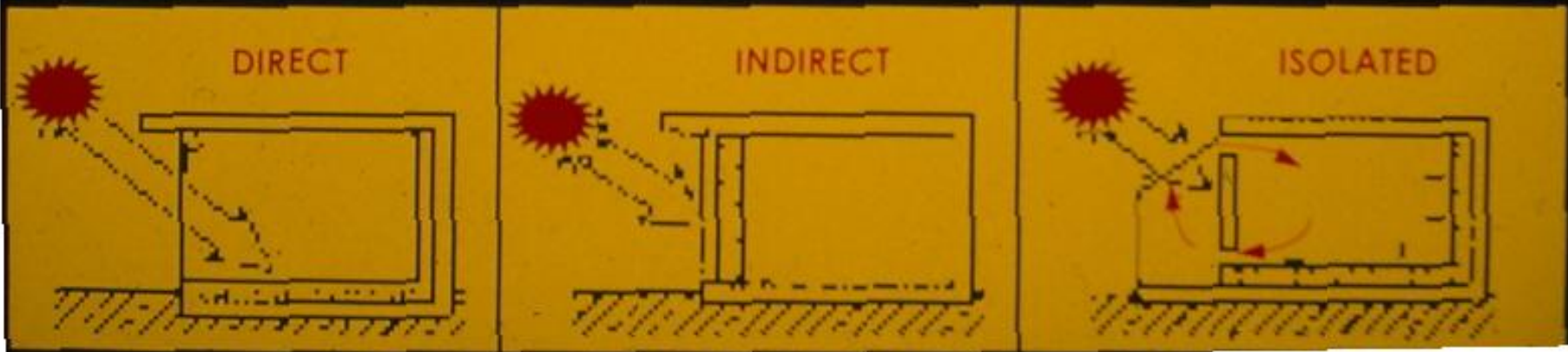
## PASSIVE SOLAR CONFIGURATIONS

Passive Solar Configurations can be defined by three factors :

1. The characteristics of the collection aperture
2. The interaction of incoming solar radiation and heat storage
3. The method of delivering energy to the heated space.

According to the above are classified to

## DIRECT - INDIRECT AND ISOLATED systems





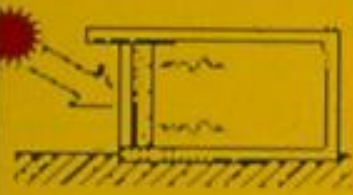


# PASSIVE SOLAR PRINCIPLES

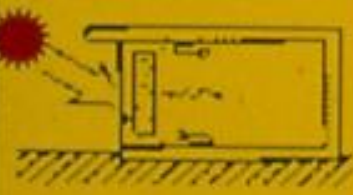


## • INDIRECT GAIN SYSTEMS

Mass Wall



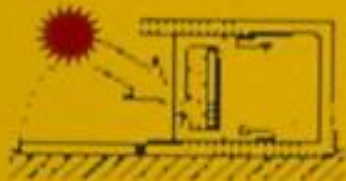
Trombe Wall



Water Wall



Remote Storage Wall



Roof Pond



Roof Pond



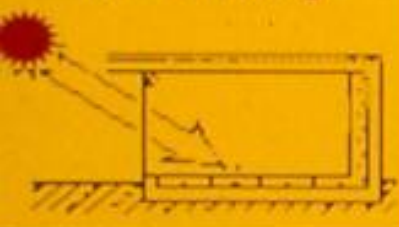
Indirect Gain Systems combine the collecting, storage and distribution functions within some part of the building envelope which encloses the living spaces. Some Indirect systems are : The Trombe Wall, The Mass Wall, The Water Wall and the Roof Pond. In the mass and Trombe wall systems, the thermal storage mass for the building is a south facing wall of masonry or concrete construction with the external surface glazed to reduce heat losses to the outside.



# PASSIVE SOLAR PRINCIPLES



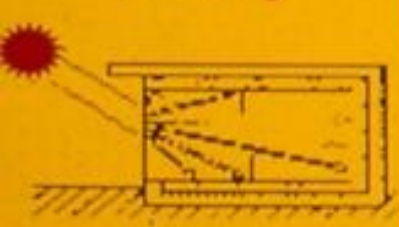
Non Diffusing



Clerestor



Diffusing



Direct Gain  
Roof



Direct Gain  
Sunspace



There is a series of variations which provides alternatives within direct gain systems. The most common variations are in the location of thermal mass. Mass can be in the floor, in free standing mass within the room, in the ceiling, or in the internal walls or insulated external walls.

It possible the sunlight to fall on a concentrated area of thermal mass or to diffuse or reflect the sunlight so that it is distributed over a large area of thermal mass.



# PASSIVE SOLAR PRINCIPLES

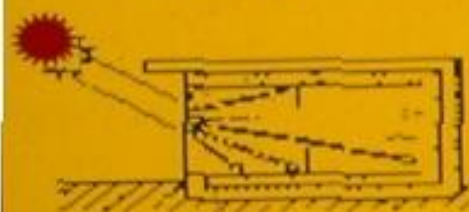


## ADVANTAGES AND DISADVANTAGES OF DIRECT GAIN SYSTEMS

Non Diffusing



Diffusing



Direct Gain  
Sunspace



### ADVANTAGES

1. Direct gain is the simplest solar heating system and can be the easiest to build.
2. The large areas of glazing allow high levels of daylighting and good visual connection.
3. The system can be one of the least expensive methods of solar space heating.

### DISADVANTAGES

1. Large areas of glass can result in glare by day and loss of privacy by night
2. Large amounts of thermal mass is required
3. Night time insulation is necessary



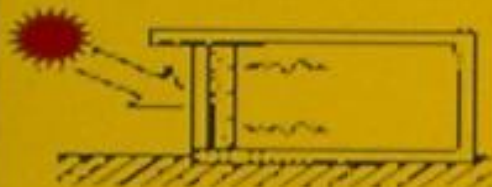


# PASSIVE SOLAR PRINCIPLES



## ADVANTAGES OF INDIRECT GAIN SYSTEMS

Mass Wall



Trombe Wall



Water Wall



- 1. Glare, privacy and ultraviolet degradation of fabrics are not a problem.**
- 2. Temperature swings in the living spaces are lower than with direct systems**
- 3. The time delay between absorption of the solar energy and delivery of the thermal energy to the living space can be an advantage for night time heating.**
- 4. For water walls the isothermal nature of heat storage results in a reduced temperature of the external surface and so less energy is lost to the night sky and to the outside air.**



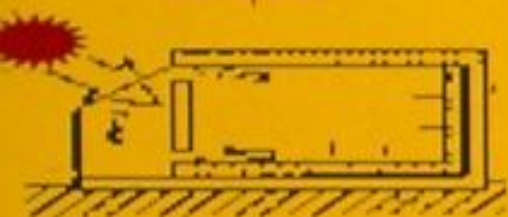


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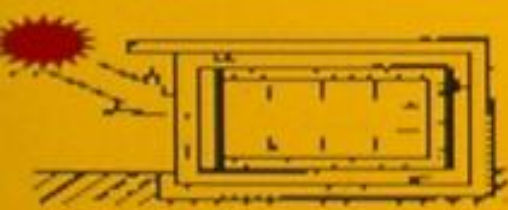


## ISOLATED GAIN SYSTEMS - ADVANTAGES

Sunspace



Barra-Constantin



Isolated Wall  
Collector



- 1. The interior climate of a building can be greatly improved by the addition of a thermal buffer between the living space and the outside air.**
- 2. Sunspaces also serve non energetic purposes ; for example as additional living space or as a greenhouse.**
- 3. Sunspaces are readily adaptable to existing houses.**
- 4. Sunspaces can be easily combined with other passive systems.**



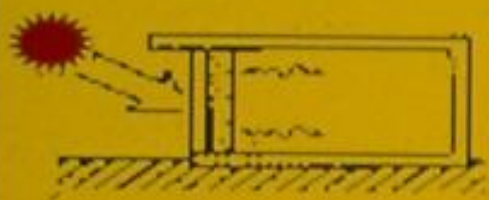


# PASSIVE SOLAR PRINCIPLES



## DISADVANTAGES OF INDIRECT GAIN SYSTEMS

Mass Wall



Trombe Wall



Water Wall



- 1. The external surface of the mass wall is relatively hot as conduction of energy through the wall is slow and can lead to considerable loss of energy to the external environment.**
- 2. The necessary controls can be expensive**
- 3. Two south walls, one glazed and one massive are required.**
- 4. Problems of view and daylighting**
- 5. Discomfort can be caused at the end of the heating season by overheated air**
- 6. Condensation on the glass can be a problem.**