Passive solar Design makes use of natural energy flows as the primary means of harvesting solar energy. Passive solar systems can provide space heating, cooling—load avoidance, natural ventilation, water heating and daylighting. Passive solar design is an approach that integrates building components, exterior walls, windows, and building materials to provide solar collection, heat storage, and heat distribution.

Designing the passive system:

**HEATING**
- DIRECT GAIN
- INDIRECT GAIN
- SUNSPACE
- COMBINED SYSTEM

**COOLING**
- SHADING
- NATURAL VENTILATION
- HEAT GAIN CONTROL
The greenhouse effect results from a process whereby short-wave solar energy is collected through glazing, absorbed by opaque elements in the building, and reemitted as long wave radiation which is prevented by the glazing from leaving the building.

Passive heat storage means that building parts with high heat capacity can absorb and emit heat when the temperature in the environment changes. This is a phenomenon that always takes place, even if no direct actions are carried out to utilize it at its full capacity.
Arch. Herzog- Low cost dwelling in Rome (ITALY) Atrium System
**Atrium (GROUP II: Interior Light Spaces)**

An atrium is a space enclosed laterally by the walls of a building and covered with transparent or translucent material.

**Light-duct (GROUP II: Interior Light Spaces)**

A light-duct can conduct natural light to interior zones of a building which are not otherwise linked to the outside but are not far from the exterior. Its surfaces are finished with light-reflective materials in order to direct and diffuse natural light downwards.

It is an inside living space of a building which permits the entry of light to other interior spaces linked to it by pass-through components. It provides a decreased and less contrasting light level to the spaces connected to the atrium.

Its dimensions may vary widely depending on building size. Normally it occupies the total height of the building.

The covering may consist of a metal structure supporting the glazing. The interior finishes should have high reflectances to ensure good daylight penetration into adjacent spaces.

Adjustable control elements may be added to the pass-through component to avoid overheating.

Usually the section of the duct is small, between 0.5 x 0.5 m and 2 x 3 m. The photograph below shows a series of such light-ducts separated by structural elements. The length depends on building size, although the luminous performance imposes a limit of about 10 m.

The top of the duct can be openable to permit natural ventilation or closed by transparent materials.
PASSIVE SYSTEMS: DIRECT GAIN- Trombe-Michelle Wall

A trombe wall puts the thermal mass directly behind the glazing to reduce glare and overheating in the occupied space. A sunspace keeps the glass and the mass separate from the occupied space but allows for the transfer of useful heat into the building by convection or a common mass wall; temperatures in a sunspace are allowed to fluctuate around the comfort range.
If an element of the wall has 9 hours of phase displacement (H) it has a good behaviour during Summer too. In fact 9 hours of phase displacement let the heat produced in the earlier hours of the afternoon arrive inside the house only during night, when it’s easier to dissipate it thanks to cross ventilation. It’s even superfluous to have bigger value of phase displacement.

Attenuation is important too, it’s convenient to have values under 35%, although it’s strictly connected to phase displacement, thus an external wall with di 9-10 hours of phase displacement will have a sufficient attenuation.

In Italy DPR 59/09 after the DLgs 192/05 introduces a new value “periodic thermal transmittance” (YIE). This parameter points out the capacity of a matt wall to dephase the thermal flow that cross it during 24 hours of a day. This value is defined by an European law UNI EN ISO 13786:2008 and puts together both phase displacement and attenuation.
PASSIVE SYSTEMS: DIRECT GAIN - Barra – Costantini Wall and Diode Wall
PASSIVE SYSTEMS: DIRECT GAIN - Rock-bed

The picture points out that the distance between a building and an obstacle is due to the solar angle and the height of the obstacle.

Latitude of Ravenna
A pond of water on a roof structure that cools a building by evaporation. Because the water increases the thermal mass of the building, it also increases the gain in solar energy, storing the absorbed energy during the day, when it is abundant, for later use.
PASSIVE SYSTEMS: DIRECT GAIN - Ventilated Wall
PASSIVE SYSTEMS: DIRECT GAIN- Ventilated Wall

Primary school in Riccione (RN)
Active heat storage is when the structural parts of the building are used as a part of the heat system, for example by letting the intake air pass through holes in slab elements or by embedding the pipes of the heating system in the structure. With such systems the advantages of heat storage increase. Up to 20% reduced heating needs are mentioned.
The two basic components are collectors, usually mounted on the roof or ground and an insulated storage tank. Active system contains mechanical pumps for circulating the collection fluid, which is either plain water or water containing antifreeze.
Amorphous photovoltaic cells on canadian tiles
ACTIVE SYSTEMS: Heat Pump

Winter

Summer

Heat in Water Loop
Transferred to Ground
(Closed Loop - No Water Movement to/from Ground)
ACTIVE SYSTEMS: geothermy heating and cooling system

You can install all loopfields at a depth of 40 cm, but it would be the size of a football field. The deeper you dig, less pipes you need. The goal is to find economicity by understanding the relationship between depth and loop length of pipes.

The horizontal slinky loop configuration
ACTIVE SYSTEMS: District heating and condensation boilers

Example of a shelter space for District heating
Example of sustainable design

Rooftop energy
With photovoltaic cells and solar hot water panels.

Shading + Light
Light shelf + balcony
Shading devices to protect from east + west light.
To reduce the greenhouse effect + temperature control by cross ventilation.

Vertical Garden
Green facade assists shading, glare + air quality.
Access to nature enhances quality of life by relieving stress.

Exhaust + Air Displacement
High level ceiling exhaust ensures complete emptying of warm air in ceiling spaces.
Fresh air fed at low speed through controllable floor or low vents.

Permeable surfaces
To avoid water runoffs and reduces heat radiation from the floor materials.

Water harvesting
Rain water collection to be reused for irrigation and cleaning purposes.