**PASSIVE SOLAR DESIGN**

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

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**Diagram: Passive Solar Design**

- **ROOF:** the uppermost surface of the building envelope. Very important for rejecting excess heat in hot weather.
- **CEILING:** the easiest location to insulate in the horizontal plane. Uninsulated ceilings allow 25-35% of heat transfer into and out of a house.
- **WALLS:** uninsulated walls allow 15-25% of heat loss and 10-20% of heat gain. After ceilings, the next most important element for control of internal climate.
- **GAPS AROUND WINDOWS AND WALL JUNCTIONS:** can be responsible for up to 20% of heat loss and gain.
- **INTERNAL WALLS:** can be the most influential building element for adding thermal inertia to a house.
- **WINDOWS:** responsible for 20-25% of heat loss and 15-20% of heat gain. Windows are a critical element for passive indoor climate control.
- **FLOOR:** the most significant building element for thermal inertia if made from heavy material. Can also be responsible for 10-20% of total heat loss if not insulated.
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
PASSIVE SYSTEMS: DIRECT GAIN- 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 opened to permit natural ventilation or closed by transparent materials.
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.
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.
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**

1. **Outdoor Fan & Coil**
2. **Supply Duct**
   - **Heated Air**
3. **Return Duct**

**Summer**

- **Cool Air Delivered to House**
- **Heat Pump Delivers Heat Removed from Air to Water Loop**
- **Heat in Water Loop Transferred to Ground (Closed Loop - No Water Movement to/from Ground)**

**Diagram Details:**
- **Evaporator**
- **Compressor**
- **Condenser**
- **Expansion Valve**
- **Recirculation**
- **Electricity**

**Process:**
1. **Evaporation**: Heat is removed from the indoor space.
2. **Compression**: The refrigerant is compressed, increasing its temperature.
3. **Condensation**: Heat is transferred to the outdoor space.
4. **Expansion**: The refrigerant expands, reducing its temperature, ready for the next cycle.

**Substantive Architecture**

DESIGN PROJECTS M - ARCH: DONATA BIGAZZI
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, the less pipe you need. Goal is to select the depth and loop length that is most cost effective to install.