PASSIVE SOLAR DESIGN

Passive Solar Design is the process of designing structures to passively employ solar energy in such a way as to save energy and improve efficiency. The building's integrated structure is designed so that the sun is used to light the building, and temperature is controlled by convection.[1]

Overview

Design Elements

The four main design elements to accomplish this include:[2]

- Building siting and orientation
  - Geographic location, and orientation to the sun with respect to walls and windows[3] Some areas of the world have a high level of sunlight, whereas others are often overcast. Buildings in the northern hemisphere benefit from south-facing windows.[4] These can heat the building in winter, and keep them cool in the summer, when the sun is directly overhead.[5]
- Building Envelope
  - Insulation of the building and air leakage:[6] There is no use in heating a building using the sun if the heated air simply leaks outside and the building loses heat because of poor insulation.
- Windows
  - The main tool of passive solar energy to allow heat and light into the building:[7] Windows are great for allowing heat and light in, but can also lose energy if not insulated properly.
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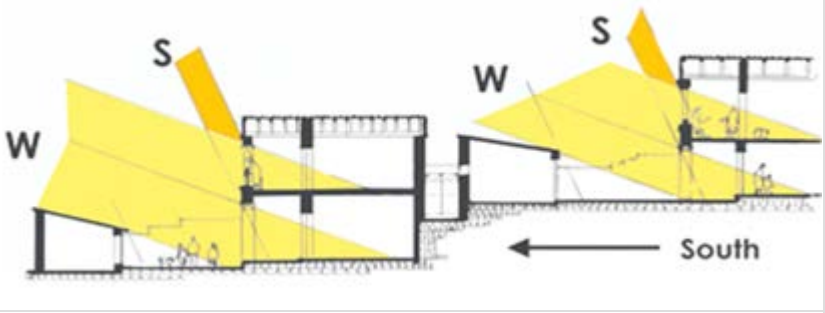


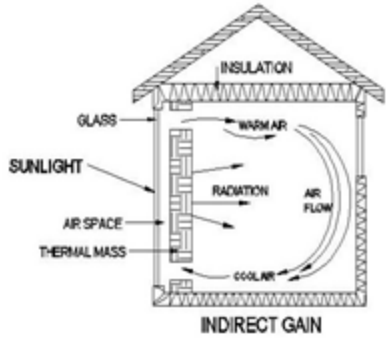
S stands for summer sun, and W for winter sun. These buildings e passively designed to let in the sun in winter and keep it out in summer.

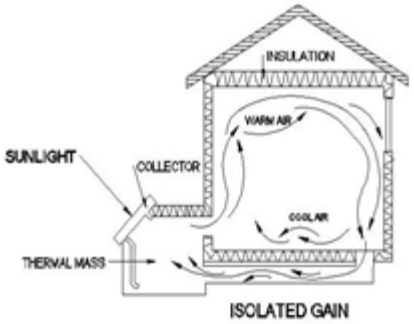
- Thermal Mass
  - Amount of mass present in the building which can absorb and retain thermal energy:[8] Certain materials (such as water) retain heat better, and can hold more for longer.

Ways to Gain

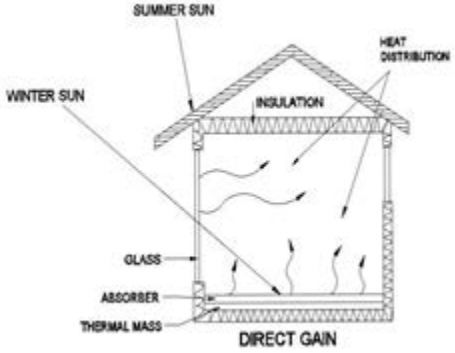
There are three different general ways to gain heat and light from solar energy.[9] The first is direct gain, and the second is isolated gain, and the third is indirect gain.[10]

In **direct gain**, solar energy is allowed to enter directly and be absorbed by the thermal mass of the house.[11]In **isolated gain**, solar energy is absorbed and stored in a collector which is not inside the room being heated, and this energy is slowly released through convection or ventilation.[12]When using **indirect gain**, a wall or some type of thermal mass has one side facing the sun directly, and the other side faces the room being heated. The heat absorbed from the sun then transfers through the thermal mass and radiates into the room.[13]





Sustainability



Structures built using passive solar design save a great deal of energy.[14] Some structures built with passive solar design in mind can be as much as 90% less energy consumptive than comparable structures.[15] This is a huge benefit to sustainability.

Economic

Economically, high energy usage is very costly. Passive solar design is an inexpensive way to efficiently cut the energy usage of a structure dramatically, and can be implemented on almost any structure to help save money. Many buildings which employ passive solar design in conjunction with other sustainable designs can be made to operate completely off the energy grid. This can be very beneficial if there is an energy shortage.

Social

Passive solar design is also beneficial socially. Psychology studies have shown that workers work better in an environment with high natural lighting.[16] People are happier working in the warm sun, rather than in a cold unnatural light. generations can benefit from passive solar design in that they will have more energy available for their uses. Passive solar design, in many cases, does not wear out. The placement of a window or skylight can last as long as a building.

Environmental

Environmentally, high energy usage can be very harmful. Most energy is consumed in the form of electricity which comes from power plants. These power plants often pollute the atmosphere, and use up limited natural resources.

History

Early

Ruins of a Roman bath house

Early stages of Passive Solar Design were used as early as the 15th century BC by the Egyptians.[17] Later civilizations also used passive solar design for practical uses such as lighting fires, cooking, and heating homes.[18] In the 5th century AD, Socrates realized that houses facing south were warmed by the sun in the winter, but the sun was directly overhead in the summer.[19] The Romans implemented passive solar design often.[20] One example is the many homes that were built with a bath house with a large south-facing window, where the baths would be kept warm by the sun.[21] After the fall of the roman empire, there were almost no records of passive solar design.

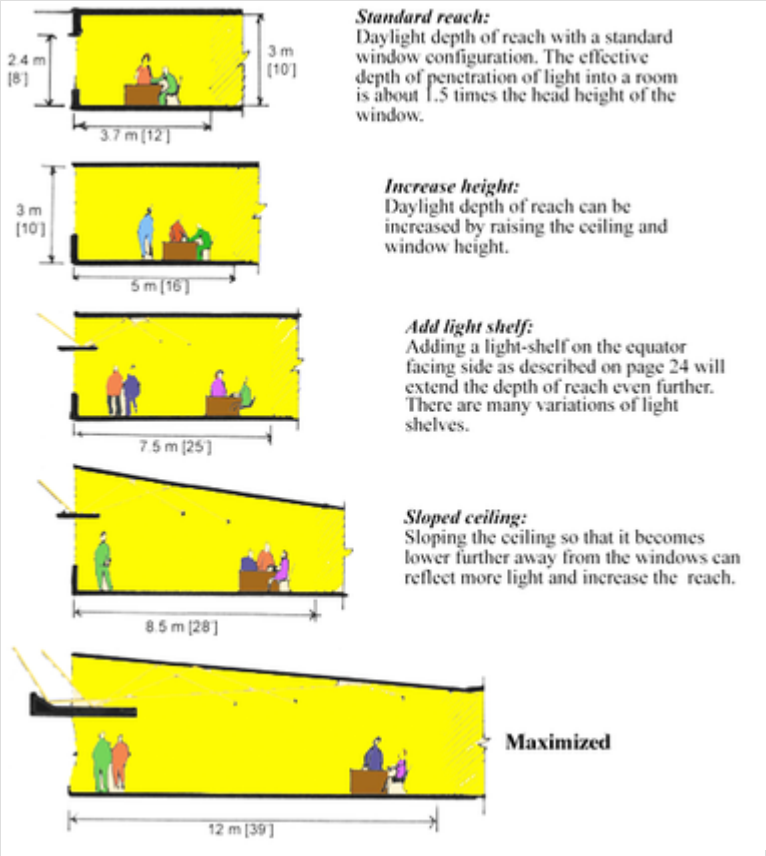
Pre-modern

In the 17th to 18th centuries, interests arose anew for solar design.[22] There were not many implementations or available technologies in this time, but there was research. Many noteworthy scientists did experiments and made inventions using solar energy.[23]

Modern

By the 19th century, actual implementation and usage of passive solar design began.[24] New technologies were invented and used.[25] Just before World War II, sealed windows, key tools in solar design, became much cheaper, so passive solar design soared in popularity.[26] Since then, there have been many implementations of passive solar design, using inventions such as the trombe wall.[27] In the late 1900's, many new organizations to monitor energy usage were formed, including the Leadership in Energy and Environmental Design (LEED).[28]

Application and Construction



Light design options

There are a few applications for Passive Solar Design in construction and design.Insulation is fairly self explanatory, however, windows and walls bear a little more in-depth explanations. All of these designs may be used in construction or almost any building.

Windows

The first way to apply Passive Solar Design to a building is to carefully design windows to both heat and light the building.

Heat is allowed in through windows by convection through the glass. Overhangs may be designed to allow heat into the building more in winter and less in summer.

Light from the sun also enters windows or skylights and can be extended and reflected using various designs.[29] First, the window shape and size may be optimized to allow more light in.[30] Second, the ceiling directly next to the window may be sloped to reflect more light.[31] Third, a light shelf may be added to further reflect light into the room.[32]

Advantages to using windows to increase heating and lighting include saving energy, and increasing aesthetics in buildings. They are not usually very expensive, but they can help save a great deal of money.

Disadvantages are usually due to geographic location.[33] Some areas of the world are already very sunny

and hot. Putting in windows which allow in more heat and light would be harmful in these situations.[34] However, other window designs which minimize heat and light intake would help.

Walls

Trombe walls are walls which act as large thermal masses used to absorb heat during the day and release it at night.[35]

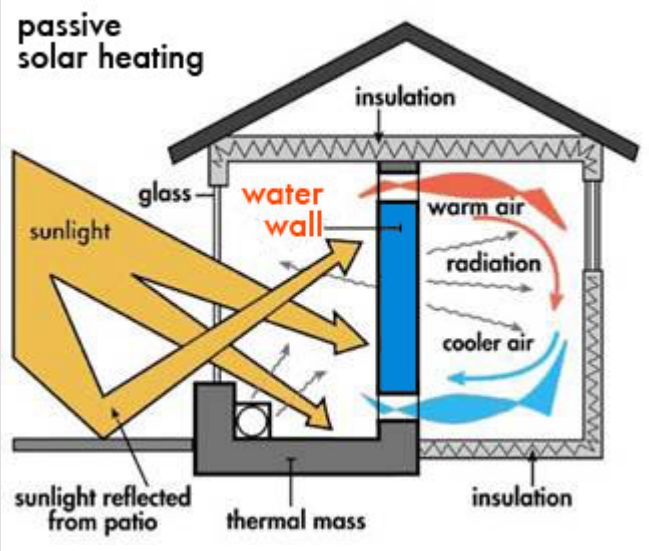


Diagram of a water wall.

They have been implemented since their invention in the 19th century.[36]

A water wall is a variation of a trombe wall.[37] The insulating and absorbing material in this case is water.

[38] Water walls are very good at retaining heat for long periods, or keeping a home cool in hot weather.

Advantages to wall solutions are mostly in the heat storage.[39] They slowly build up stored heat, and then release it slowly when needed.[40] This allows for less sunlight while maintaining good heating.[41] It also ensures that the room will not become over-heated quickly.[42]

Some of the advantages are also disadvantages at times. With a wall, heat is conducted very slowly, so it may take a while to warm up a room.[43] Also, light it completely cut out of the room.

Successful Projects

There have been several very successful projects implementing passive solar design.

First of these was completed in 1976 by a man named Steve Baer.[44] He built a home in Corrales, New Mexico which used a combination of solar

tools, including a water wall, overhangs to control lighting, and a thermal mass floor.[45] The home used 90% less energy than other homes, and his business is still working today.[46]

The second example is in Nuremberg, Germany.[47] It is called the Prisma building, was designed by Dr. W. Stahl, is 140,000 square feet, and completely lit, heated, and cooled with passive solar design.[48] This is an excellent example of how this may be implemented on a large scale and even excel aesthetically.

Recent Research

Passive Solar Design is something that is so simple and old that not much in the way of technology had changed for a while. However, small changed come, although gradual. New research in this area is less specific research about passive solar design, and more research about simple efficiency. For example, one article said that new technology for coating windows to make them better insulated have dramatically reduced the need for large windows with which to heat homes.[49] So, as technologies and insulators get better, less and less older design technologies may be needed or used.[50]

Source : http://letu-cefs.wikispaces.com/Passive+Solar+Design