3.2.4. Indirect passive solar heating systems

Indirect passive solar systems are also combined with the existing elements and structures adding absorption, accumulation and distribution of the received solar energy. This is a more efficient method to lower temperature fluctuations and overheating resulting from the direct solar energy absorbed by the walls surrounding inner spaces. This conception ensures heating from already absorbed solar radiation.

There are several varieties of indirect passive solar systems: solid wall, water wall, thermal diode, sunspace, accumulating water roof , etc.

Solid wall passive solar system consists of a solid wall placed on the south side of the building and darkened in colour and glazed to allow the wall to act as a solar collector and heat storage element. During the day, the wall slowly stores heat. By evening, heat will have been conducted to the inside face of the wall and will radiate in the adjacent rooms. If it is properly sized, the wall will continue to radiate until early morning. Often the wall is vented to the interior space at the top and bottom to create a thermosyphon loop. This venting keeps the wall’s surface cooler, allowing more efficient heat collection. This system is sometimes known as the Trombe wall, after its first designer. The characteristics of this system are:

Air flow in a thermal storage wall

Upper and lower vents should have traps as indicated to avoid night cooling by recirculation

- From the collection point of view, this system is less efficient than a direct gain system because of the high temperatures reached in the gap between wall and glass. This temperature excess induces high thermal losses and therefore for the same output an indirect gain system would require 50 to 90% more collector area than a direct gain system.
- Because of their good wall thermal conductivity, compared with conventional insulated walls, in cloudy–cold climates thermal walls will

lose too much heat during the day to be able to supply the expected heat at night time.

- In all climates very effective external shading is mandatory to avoid overheating at midday on sunny days.
- Because transmission of stored heat is delayed a number of hours, depending on the wall design, indirect gain systems are suitable for residential building where activity starts in the afternoon.
- Indirect gain systems do not have as many problems as direct gain systems regarding heat storage. This offers more freedom in design of the interior.
- Trombe walls can be expensive because of the cost of materials and the structural modifications required.

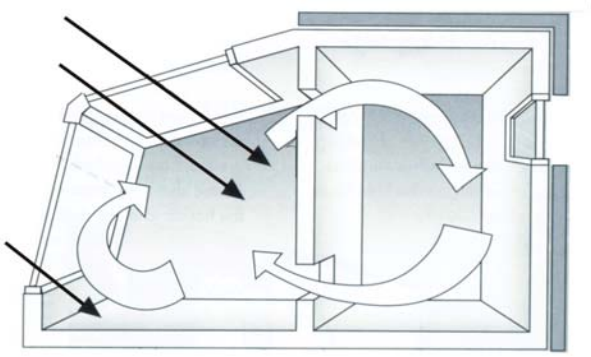
Water wall passive solar system: In this system instead of solid wall there is water-filled containers. As water is the substance with the highest heat absorption capacity, its use as accumulating element is very efficient and economic. Moreover, the convection in the water medium helps the transfer of heat in its entire volume much faster. As a result of this, there is reduction of thermal losses in the system and the losses can be additionally regulated in winter and summer seasons by heat insulating elements. Another advantage of the water wall solar heating system is that it allows penetration of solar radiation in internal spaces if the containers are transparent and provides for visual contact with the environment.

Thermal diode passive solar system: It is a variety of water wall passive solar systems. The thermal diode system consists of two containers separated by insulation and interconnected by pipes only at their lower and upper parts. The external container has a smaller thickness and acts as a solar energy absorber. The heated water is transferred from it by convection through the upper connecting pipes into the internal container, whereas cool water flows back through the lower pipes from the internal container. The internal container is in direct contact with the heated space and has a bigger size. An important component of this system is the supersensitive valve permitting only one-way water flow when the temperature of the external container exceeds the temperature of the internal container. The system can also operate with the internal container installed at the opposite wall and even in another room.

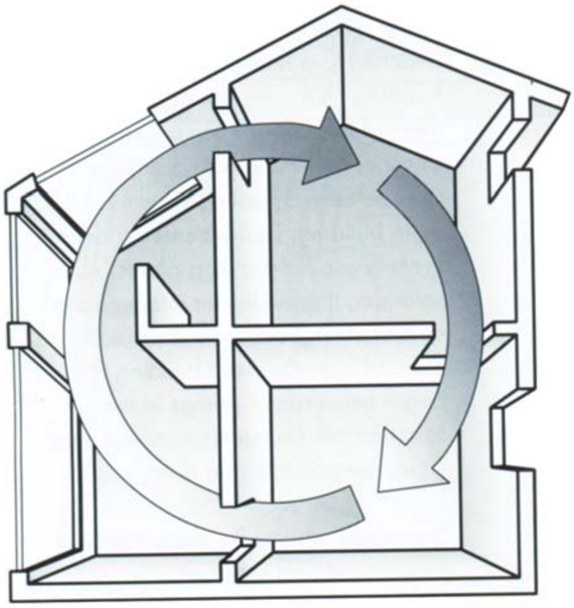
Accumulating roof passive solar system: The system with water roof storage can be regarded as a modified solid wall system, however positioned horizontally instead of vertically. The scheme of operation of this system is as follows: In sunny winter days the water reservoir on the roof is open and the water is heated, at night the reservoir is covered in order to preserve the accumulated solar energy. During the summer season the process is reversed: the reservoir is open at night to let accumulated energy out and closed during the day to prevent water heating. This system is suitable for one-store houses and for regions where temperatures are rarely below 0 °C and the sun stands high in the winter. Operating in the “cooling” mode, this system is particularly suited for places where temperature fluctuations are within a wide range and it is possible that for one hour the water temperature may become significantly lower than the air temperature.

"Sunspace" passive solar system:

"Sunspace" rooms that collect solar heat and provide sunny living spaces are among the most effective passive solar heating systems. They are also highly desirable architectural features. This system is in fact a combination of the direct and indirect passive solar systems with the solar collector element separated from the living space. Like a modified greenhouse that is attached to a house or other building, this sunspace carries out the thermal functions of collection, storage and transfer. It acts as a semi-detached heating system for the main building, besides serving as a greenhouse for growing plants. As a solarium, it provides an intermediate environment. Because it is partially isolated from the main building, larger temperature swings in the solarium can be accommodated than would be possible in a living room.



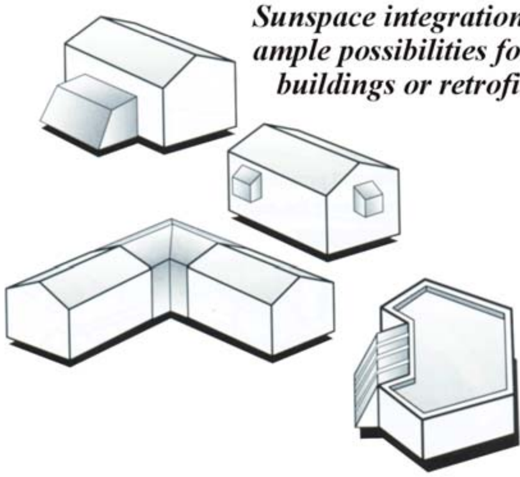
Sunspace system



Multiple level sunspace may be used. They allow additional thermal connections. Also they aid summer ventilation by allowing vents to be placed higher in the sunspace.

Sunspaces that effectively combine greenhouse and solarium characteristics are present in many of the existing passive solar homes. The following comments indicate the different options for sunspaces, depending upon whether they are to be used primarily as solar greenhouses or solariums. The need in either case is to optimize winter solar radiation and minimize summer radiation.

Sunspace integration offers ample possibilities for new buildings or retrofitting



- In the greenhouse option, there is some conflict between the plants' need for some shade and the required thermal input.

- In most cases plants are used more for their decorative than for their food producing capacity and therefore the plant space can be limited according to requirements of the energy needs.
- If the plants are of top priority, then the sunspace should be treated as a separate collector and the available heat transferred to the building using a fan and appropriate thermal storage.
- Sunspace system collects much more energy than the other systems because of the larger window area and its classic greenhouse shape.
- The sunspace's reaction to early sun is immediate. In cold winter zones, this produces an atmosphere that is highly enjoyable even in cold weather.
- The big area of glass has the negative factor of allowing large night heat losses. If the sunspace is separated from the house, this problem is of little importance except to the plants. If the sunspace is integrated into the house, then a night time insulation system has to be installed which works even more effectively than in other systems.

3.3. Use of active solar energy

In the EU market there are available solar water heating systems.

Solar thermal systems use energy from sun directly by the conversion of light into heat through "passive" systems, or by gathering the sunlight and transferring this by means of a working fluid to heat water or air in "active" systems.

Active solar thermal systems comprise equipment as solar collectors, storage tanks, pumps, piping, controllers, etc.

Active solar thermal systems can be characterized by the size of the installation:

- Small-scale systems: solar collectors are integrated into the roof, facade, etc., of individual dwellings or buildings for their private thermal energy consumption;
- Large-scale systems: larger central arrays are combined or incorporated in group heating systems for the supply of multi-family buildings and/or district heating.

Solar domestic water heating systems can meet up to 90% of water heating needs of household in Southern Europe and up to 60% of the water heating needs of typical households in Northern Europe.

When designing the solar installations the following factors have to be considered:

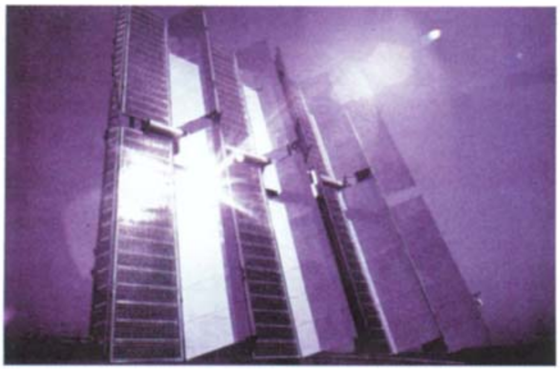
- the type of hot water consumers;
- the period of system operation;
- the distance from the consumers;
- the pre-determination of the supplementary heat supplier – boiler – house.

For low/medium heat systems, land use depends on system chosen. In the case of single – dwelling hot water or space heating/cooling, the system will usually be added to the roof of the existing building and no land will be required. Communal low-temperature systems might use some land, though again the collection surface might well be added on already existing buildings. The principal additional use of land might be for heat storage.

For high temperature systems, the land-use requirements of concentrating collectors providing process heat are more problematic.

3.3.1. Requirements to the orientation of buildings related to the installation of solar collectors

The location of solar collectors is a delicate issue connected frequently with contradictory aesthetically and technical requirements. The adequate position of collectors is a basic prerequisite to making collector operation efficient without switching off. The appropriate position depends from the following three parameters: orientation, angle and location of mounting. The architectural composition deals with all three, and when combined in an original way with the remaining elements, they may become an active element in the architectural project.



The orientation and angles of collector tilt are greatly depending on the monthly and daily solar radiation used for determining and calculating the conditions for solar collector location. The architect will have many more variants for positioning of collectors if he takes into consideration that identical values of radiation fallen on two collectors with different orientation yield solar energy at different times. The difference is smaller when the orientation is closer to pure south.

In the process of planning, the architect might, on the basis of his creative ideas for the composition of the respective building, select different locations for solar collectors. So the solar collectors can be located on the roof, facade, eaves, coping wall, sunshades and also on the terrain around the construction. Consulting the heat engineer can result in solar gain for each location.

The positioning on the roof must take into consideration the type of roof structure (sloping or flat) and also the roof configuration. The fixing details should be made in agreement with the solar system producer's instructions.

Flat roofs are advantageous for mounting of solar collector because the appropriate collector field orientation and angle of tilt can be followed easily even when the building's front part is not directly facing south.

The spacing between the individual rows of solar collectors is essential for the mounting procedure and for regular maintenance and it is dependent on their shading.

If solar collectors are positioned on facade surfaces a solar energy gain can be obtained. However this complicates the architectural composition and gives buildings a nontraditional appearance, which frequently would not be liked by the clients.

The positioning of solar collectors on eaves is not easy achieved. Moreover, the collector number is restricted in advance by eaves size.

The mounting of collectors on balcony railings is applied both to low rise and high rise buildings. The decision is particularly typical with high rise buildings because their roof area is not large enough to mount the necessary number of collectors. Balcony railings, on the other hand, allow easy access to the collector in case of cleaning, repairs or other maintenance.

The sunshade type collector can be applied to all types of constructions, and strips of solar collectors will shade southern facade. Thus a triple effect has been achieved. Firstly, the required collector area is provided; secondly, the shading has reduced the thermal load on the building, and thirdly, a most favourable shading of the glazed parts of the building has been attained by means of an appropriately chosen spacing between the collectors and the glass elements which ensures infiltration of necessary diffuse light in the inner spaces.

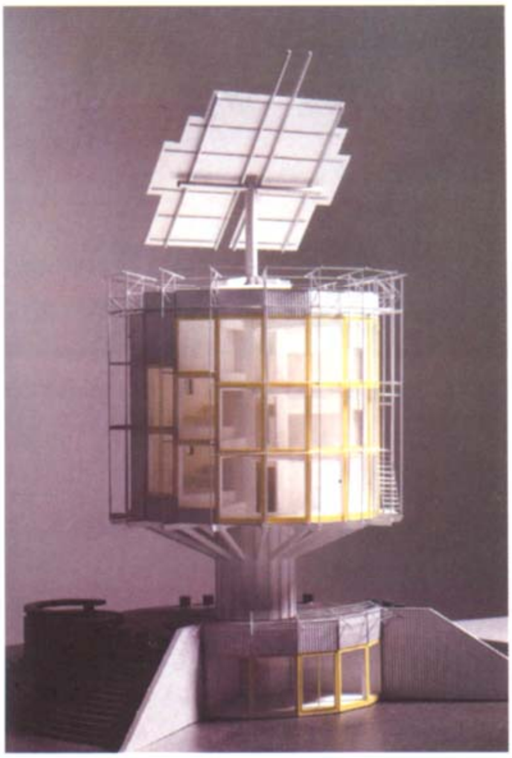
3.3.2. Determination of the required area for solar hot water systems

In the cases when solar hot water system is installed in the building the following initial data will be necessary for the architectural project:

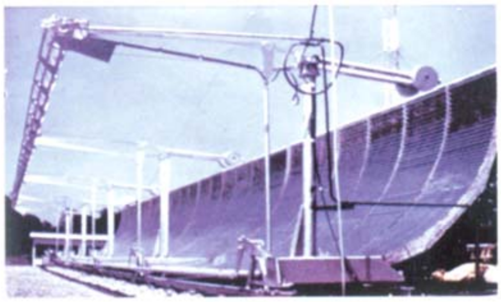
- Number of inhabitants in order to establish hot water consumption in each day;
- Hot water consumption in l/day/inhabitant;
- The building's function in order to define the mode of hot water consumption;
- The hot water temperature;
- The meteorological data for the territory (solar radiation for different months, solar energy zone – annual distribution of total solar radiation, heating degree days, etc.).

With these data it is possible to determine:

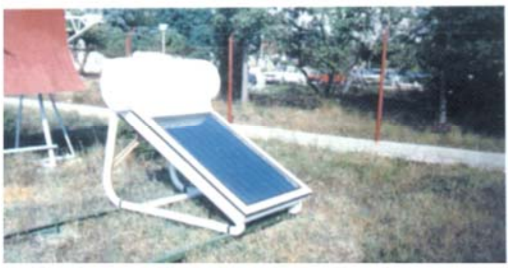
- The volume of accumulation;
- The needed energy;
- The appropriate collector number (net collector area);
- The area required for the mounting of the collectors.



Rotating solar panel with 65 modules; 100 000 W, Offenburg



Concentration solar collectors



Solar water heaters with heating pipes and accumulators