*Energy and Buildings*, 7 (1984) 309 - 314



# Living in a Passive Solar Home

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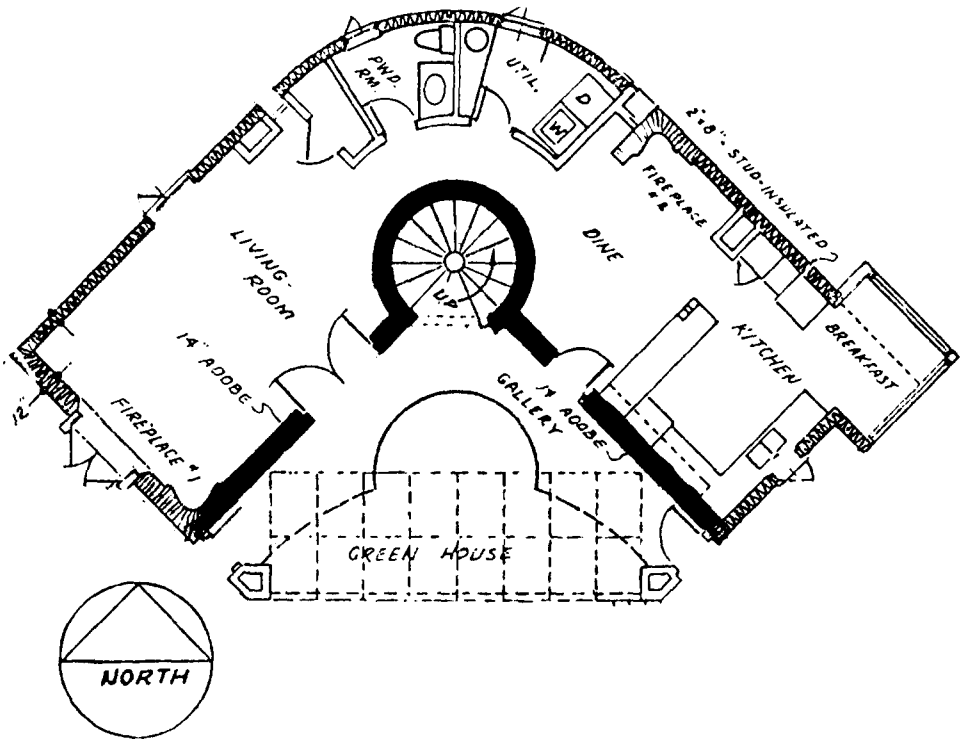
Much has been said and written about the mystique of living in a passive solar home. The general impression is that this requires a radical change in lifestyle, an accommodation to a decreased comfort standard, or a great deal of participation and effort on the part of the occupant. The purpose of this paper is to relay experiences in a passive solar home, to dispel some of the myths regarding such homes, and to lend an air of realism to the presentation of the passive solar concept to a broad section of the public who are generally receptive to the use of solar energy, but often skeptical of a system which claims to work with no moving parts.

Living in a passive solar home is indeed a different experience, and if one's goal is a change in lifestyle, then a passive home provides an ideal means toward that end. However, the two are not necessarily wedded and should not be confused. It is entirely possible to do either one without the other, perhaps even desirable.

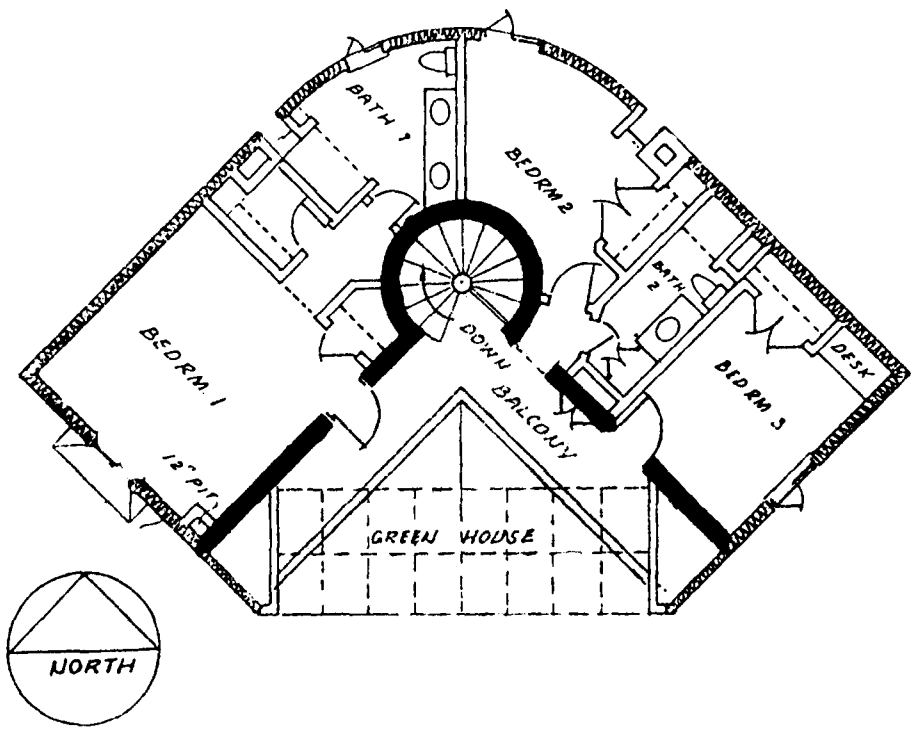
What a passive home offers its occupants is a delightful new kind of freedom and comfort. Freedom from dependence on ever dwindling and ever more costly fossil fuels. Freedom from excessive dependence on external utilities for comfort. Freedom from worry about frozen pipes, power outages, temperature extremes, thermostat settings, soaring utility bills. The passive solar home also offers several options. One can live in a direct gain home and be quite involved in the daily operation of the building, always aware of the weather, the intensity of the sunlight, the changing seasons. Or there is the choice of the thermal storage wall, a buffer between the occupants and the elements, eliminating much of the individual involvement in the performance of the house, but also, by eliminating much of the direct sunlight from the living spaces, affording a greater choice of furnishings and materials which can be used in the home. And there is the sunspace or solar greenhouse which combines some of the better elements of both and provides a year-round garden as well. A combination of some or all of these methods can and usually should be used. There is no one ultimate passive solar system, and the passive option offers an incredibly broad range of styles and methods from which to choose.

My own solar home is technically a hybrid system. The primary heating and all of the cooling is handled passively, but there is an active component. Our 186 square meter home is heated by a 37 square meter sunspace which is an integral part of the house. It is two stories high, and adjoins all the principal rooms of the house. Heat is transferred into the living spaces by convection through open doors during the daylight hours, and is stored for sunless hours in a 36 cm thick adobe wall which forms the north wall of the sunspace and the south wall of the living spaces. It takes about eight hours for the heat to move through the wall, and we are warmed at night by a 27 °C wall. Secondly, the wall provides a thermal isolation from the temperature extremes in the greenhouse. In mid-winter, it is not unusual for the greenhouse to fluctuate 20 degrees during a 24-hour period (typically from around 10 °C to nearly 30 °C). These temperatures are fine for plants but not for people, and the mass of the wall combined with its double-glazed windows and solid doors effectively shields us from those temperature swings. Third, the wall, and the other mass in the greenhouse, provides a thermal inertia which keeps the temperatures in the living areas very stable. It takes at least two days for outside weather changes to affect the house. During the entire month of December 1979, the temperatures in the living areas varied only 3 degrees — from 19 °C to 22 °C — and it is very rare for the house to swing more than 4 degrees in any 24 hour period. Thus our primary heating system is entirely natural — convection through doors and conduc-

Elsevier Sequoia/Printed in The Netherlands




(a)




(b)

Fig. 1. Balcomb House, floor plans. (a) First floor plans; (b) second floor plans.

tion and radiation from the wall — there are no buttons to push, nothing to move or alter, nothing to breakdown or repair (Fig. 1).

As mentioned, we do have a small active component. Two small fans remove excess heat from the top of the greenhouse and store it in rockbeds located directly under the floors in both wings of the house. This system provides only 9% of the heating for the house, but greatly increases our comfort by prevent-

ing stratification in the greenhouse and by keeping the floors at ground level warm. Typically, the floors are 21 °C to 22 °C, about 5 degrees warmer than they would otherwise be. The heating system of the house will function perfectly well without this active system, but the temperature swings would be greater. The system is very efficient; we store 11 times more energy than is used by the fans.

It is difficult but very important to try to describe the quality of the heat we get from our passive system. It is a natural warmth. There are no drafts, no hot spots, no dry air blowing though the house. Many of the discomforts usually associated with winter are now things of the past for us. We have found that we simply take our comfort for granted, never having to worry about cold feet, dry skin, drafts, or chills.

Our home is located in the foothills outside Santa Fe, New Mexico at an altitude of 2200 meters. The climate is continental and mountainous, with about 3300 degree days, about 70% of possible sunshine, and an average annual snowfall well in excess of one meter. We do have a great deal of winter sunshine, but the house has been designed to carry through about two days of no sun without requiring auxiliary heating.

We have a complete electric heating system, with resistance heaters in every room except the greenhouse. Each heater is on a separate thermostat, and during the winter, we simply set the thermostats at 18 °C and leave them there, so that the auxiliary heating is entirely automatic. Initially, this was done as an experiment to find out exactly how much extra energy it would take to maintain the house at the comfort level that most Americans have come to expect. During the entire twelve-month period from February 1977 to February 1978, we used 875 kWh for heating. During successive winters, we have used slightly more or less than that amount, depending primarily on the cloud cover, not on the ambient temperature. It is also important to note that almost all of the auxiliary heating is required during the hours between midnight and 7 a.m., the off-peak hours for our electric utility. During the past seven years, three of the rooms in the house have never required any auxiliary heat.

Our passive solar home also keeps us cool in the summer. Because the mass wall is shaded all day by the roof and a second floor balcony, and because it can radiate its stored warmth to the greenhouse at night, it stays cool all the time, averaging the daily ambient average which is approximately 20 °C in summer in Santa Fe. In addition, the sunspace is very well ventilated with fresh outside air drawn in at ground level and vented through a large window at the top of the stair. Typical summer temperatures in the greenhouse range between 16 °C and 32 °C, with the highest recorded temperature at 36 °C. The living areas remain quite stable and cool. The warmest summer temperature in the living room has been 26 °C and that was on a day when the outside temperature was 37 °C. Such a temperature difference is hard to achieve even with a conventional airconditioner, but we achieve it naturally, without the use of fans or any other external energy source, and without the discomfort of icy drafts or hot spots.

As for the greenhouse itself, it is completely self-sufficient thermally, having no auxiliary heating system, no night insulation, and no shading. Sunlight is admitted through 38 square meters of double glazing, and the heat is stored in the two-story adobe wall, in the stone floor, and in the planting beds. Temperatures in this space vary widely, averaging a swing of 15 degrees daily. The lowest temperature recorded in the space during the past seven years has been 7 °C, and the highest has been 36 °C.

Our family thoroughly enjoys the additional benefits of a sunspace, roses and gardenias in bloom in mid-winter, the pleasant aroma of fresh greenery, the sound of water splashing in the small fountain, and fresh fruits and vegetables all year round. One need not be a dedicated gardener to enjoy these delights. It takes only about 5 hours a week to keep such a greenhouse producing and running smoothly. Of course, such a sunspace might not be a greenhouse at all. It could easily function as a play room, a multi-purpose area, an old-fashioned sunroom, almost anything. It is, however, a sun-dominated space, an area where the sun really determines the environment and one is somewhat limited by that consideration. It would not, for example, be a good room for a piano, good paintings, antique furniture, or heirloom rugs. The living spaces of the house, buffered from the sunspace by the mass wall, have no such limita-

tations, and such personal treasures can easily be kept there.

There are a number of myths related to living in a passive solar home, and as President Kennedy said, the enemy of truth is not falsehood but myth. A partial list of these myths includes:

*Myth 1:* "Living in a passive home requires a change in lifestyle". This is simply not the case. A passive home does tend to make one more aware of the weather, the seasons, all the natural surroundings, but this heightened awareness does not necessarily imply a change in lifestyle any more than, say, getting glasses does for someone who is nearsighted.

*Myth 2:* "Passive solar homes work well only in sunny climates." Again, not true. Admittedly, they work better with more sun than with less. Similarly, it is easier to design a vehicle which will only travel downhill, but the challenge of driving uphill has been solved, and so has the problem of warming buildings on cloudy days. Remember that our sunspace warms up to a comfortable temperature even on days when the snow falls all day.

*Myth 3:* "People who live in passive houses must become accustomed to cooler temperatures and wear heavy clothes in winter." I believed this myth myself until I had spent my first winter in a passive home. In this case, it depends either on the design or on how much auxiliary energy one is willing to use, and is a matter of choice. The truth is that many passive solar homes do see a temperature swing of between 8 and 11 degrees during clear winter weather, but many others have more stable temperatures, and many passive solar home occupants report that their homes are more stable in temperature — and warmer — than conventionally heated buildings. Our own passive home is by far the most comfortable home we have ever had.

*Myth 4:* "If you live in a passive solar home, you can't have carpets or upholstered furniture or artwork." Indeed, such things should never be placed in the direct sun, in any home, but a passive home is not a solar furnace. If such items are important to one's way of life, then there are passive designs in which they can be included just as in any conventionally heated home.

*Myth 5:* "Living in a passive solar home takes a lot of time and involvement on the part of the homeowner." Again, this is a matter of choice. If one wants to be involved in the workings of the living environment and to take an active part in the operation of the home, fine. There are passive design options

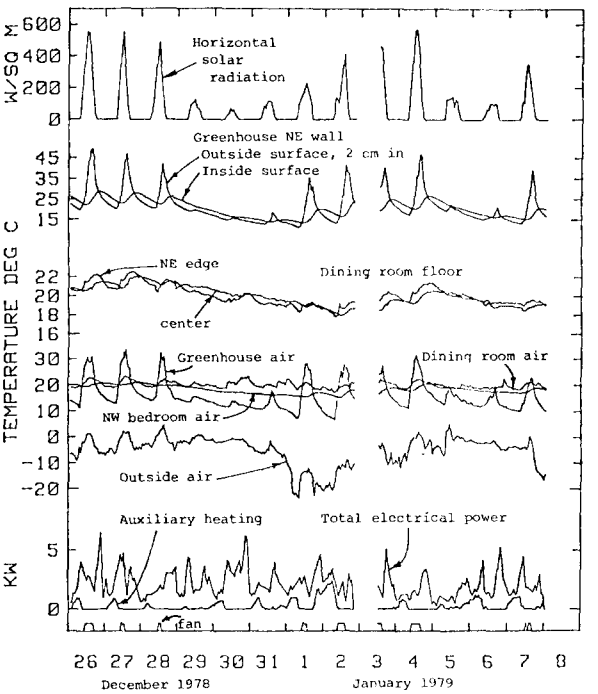



Fig. 2. The graph below is a sample of data taken by the Los Alamos Scientific Laboratory in my home during a period of mixed weather. The previous several days had been clear and repetitive so the house is in a quasi-steady condition. The total measured electrical energy used in the house during this 13 day period was 751 kW h. Of this approximately 230 kW h was for water heating and a measured 74 kW h was for auxiliary baseboard electric heating, used primarily in the dining-kitchen area. The fireplace was used occasionally in the evening. The large spikes in the total electrical power consumption are due primarily to the water heater which draws 4 kW. The recorder was off during the data gap in the center. The average outside temperature over this time period is −5.2 °C and the calculated heat load, in the absence of all solar internal sources, is approximately 2400 kW h.

which encourage or even require such participation. If, on the other hand, one is unwilling or unable for whatever reason to become so involved, then there are passive designs which require virtually no active concern on the part of the occupants but which will still respond to sporadic input. Our own home requires no action on our part other than the once a year

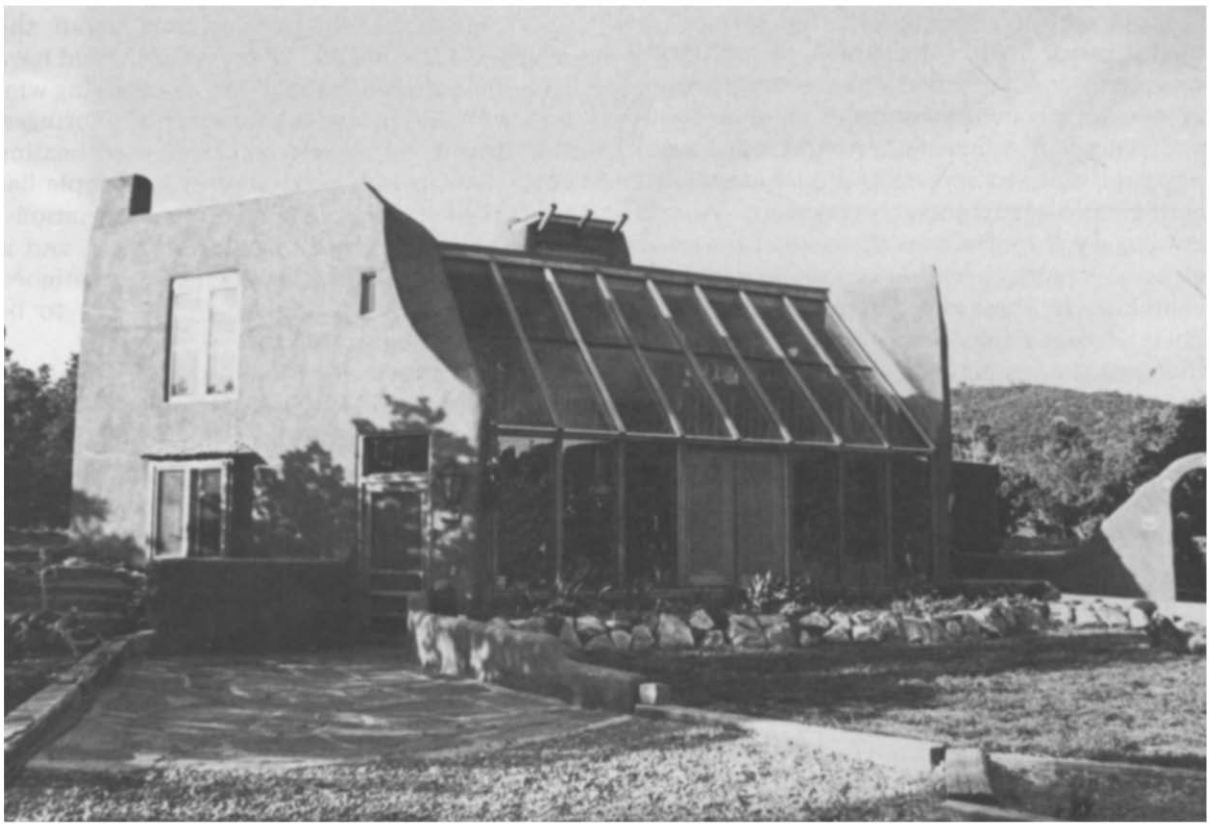


Fig. 3. Balcomb House, Santa Fe, New Mexico, USA. View from the southwest, summer.

opening and closing of one vent in the sunspace. One of the best things about our home is that it conserves energy — my energy. This is a particularly important feature for the modern woman who no longer can afford the luxury of staying at home all day to supervise the operation of her house. The house must now be the servant of the people who occupy it, providing them with shelter and comfort with a minimum of time and effort on their part. Some passive homeowners do enjoy a direct interaction with their solar heating system, but again, it is a matter of choice and design strategy.

*Myth 6:* "Solar homes are too expensive." On the contrary, I believe that we have reached a point where one cannot economically justify a non-solar home. While it is true that a passive solar system typically adds 5 to 10 percent to the cost of new construction, the total monthly cost of housing a family, that

Fig. 4. Balcomb House, Santa Fe, New Mexico, USA. View of the greenhouse interior looking down from the balcony to the ground floor.

is, mortgage or rent, taxes, utilities, etc., is usually lower in a solar home. In addition, solar components — particularly sunspaces — are proving to increase rapidly in value (50% in 2 years is not unusual). At the same time, they add value to the entire house, thus protecting an already large investment. This is particularly important in the case of the solar retrofit. Finally, a major economic factor is reliability. In these days of planned obsolescence, homeowners have developed a somewhat justifiable paranoia with regard to maintenance, repair and replacement. This, of course, is where passive solar really comes into its own. With virtually nothing to replace or repair, the passive solar home-dweller is free from all those worries (Figs. 2 - 4).

So much for the myths, how about the realities? The people of the entire world have recently suffered through record-breaking winters with the attendant miseries of shortages, shut-downs, blackouts, and increased heating costs. The health and comfort of people has been held hostage to the politics of nations. Much of this hardship is unnecessary, and is not experienced by those who have designed their living and working environments to be climatically responsive and responsible.

Mere shelter is insufficient for human needs, and the irresponsible use of our resources and technologies in an attempt to enhance shelter is inexcusable. A well-designed passive solar home is a sophisticated yet incredibly simple answer.