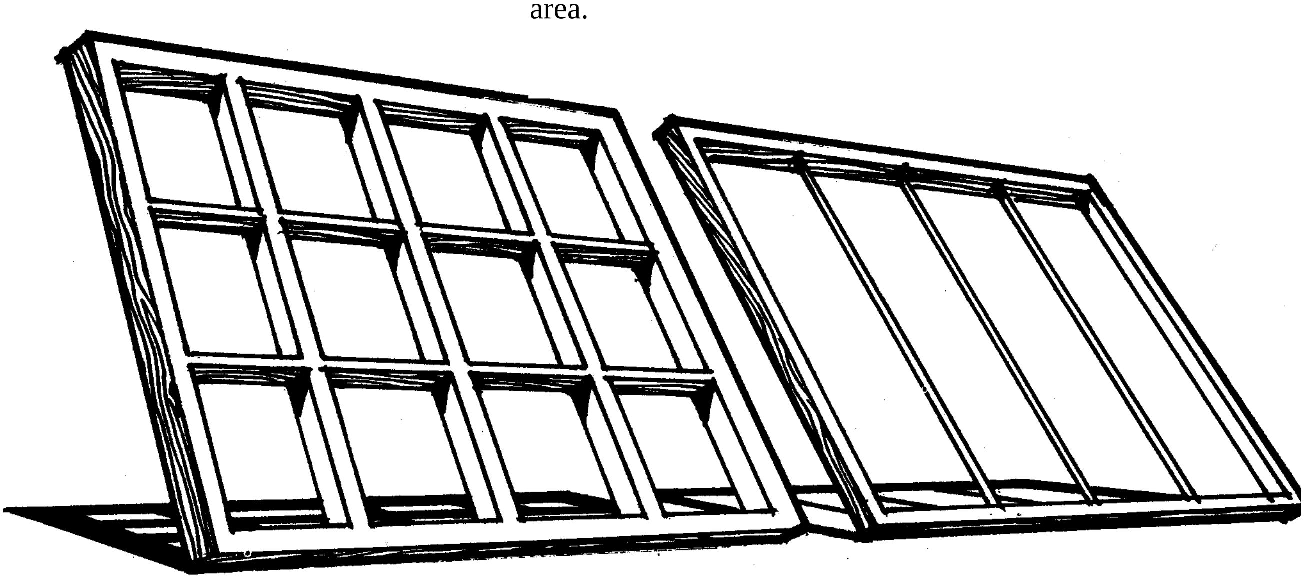
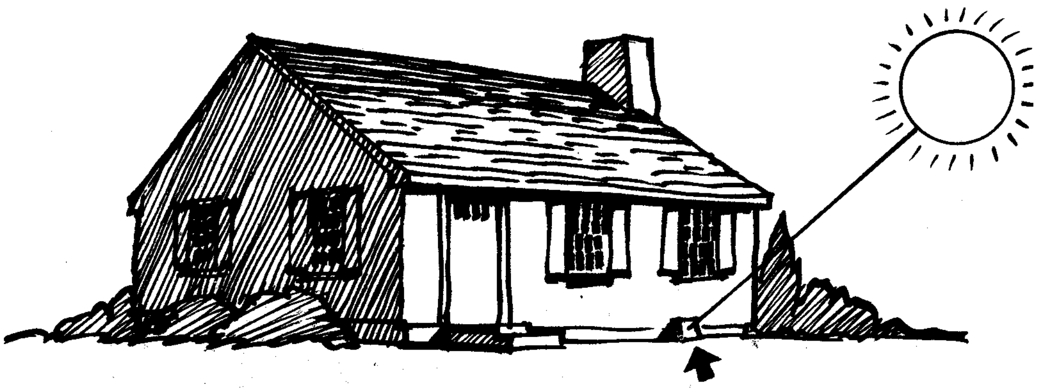
Chapter 10

The Hard Choices of Cost

HowLarge?

We are now prepared to determine the proper size of a passive system. "Size" almost always refers to square footage of all glazed surfaces facing the sun, within 30 degrees east or west of due south. Other dimensions, such as the thickness of a solar wall or the floor area of a greenhouse, are fairly standard, and we have already covered them. The size of a system is the net square footage of glazed surface after subtracting the framing and trim. A wall of solar windows 8 feet high and 20 feet long (160 square feet may be as much as 40 percent framing and 60 percent glazing, leaving but 96 square feet of window to catch the sun. It is possible, but difficult, to minimize framing to 5 or 10 percent of the surface area.





There are many ways to size a passive system. As with active systems several years ago, engineers and scientists are producing dozens of documents crammed full with charts, graphs, and tables for determining the precise optimal size and performance of passive systems. This detailed information has its uses, but do not feel obligated to use it or to rely on it. Remember that Nature is forgiving and does not require nearly the precision that our computers tell us we do! Instead, review again some of the earlier pages that discuss size, and you will have a good "feel" for the surface area you need.

The first question you should answer is this: How large do you *want* the system to be? Believe it or not, answering this question is by far the most common, direct, and useful method of determining size. Most people want their system to be as large as possible to save as much energy as possible. In general, this is an excellent approach to take, and you may want to determine how to cover the entire south side of your house with passive devices. Many people do, just as the size of the roof often determines the size of active solar heating collectors.

You need hot go to this extent, of course. A superinsulated house can be 50 percent solar heated with only slightly oversized south windows. But if you desire to reduce fuel bills to a minimum, large systems are generally in order. The trick is to design them right so that you save as much energy as possible with the least expense, and so that you are pleased with the appearance and comfort of your home.

Generally speaking, an optimal size for a passive system is that which supplies the same portion of heat as the " average percent of the time that the sun shines during the winter. " For example, if your heating season is October through April, determine your local average winter sunshine from the U.S. monthly sunshine maps in Appendix 3. This percentage, say 55 percent for much of the country, is the portion of your heating load that can be supplied by a passive system in a well-insulated house with good assurance that the design can look beautiful, perform well, and be cost effective.

This is not to say that you should not try for larger percentages to be supplied by solar. But the design gets trickier, so consider obtaining additional advice from a

Oil, Electricity, Gas

A gallon of oil would supply 135,000 to 140,000 Btus if your furnace burned at 100 percent efficiency. It doesn't. Most furnaces, in fact, burn at between 40 and 70 percent annual efficiency, supplying the house with between 56,000 and 100,000 Btus per gallon burned. A useful average to use is 70,000.

One kwh of electricity is equivalent to 3400 Btus. Most electric resistance heating is 100 percent efficient (although three to four times more energy is expended at a power plant than what finally enters your house as electricity). Thus, 20 kwhs (68,000 Btus) of electric resistance heating supplies the heat obtainable from one gallon of oil (70,000 Btus). A proper application of an electric heat pump can supply twice as much energy per kwh as resistance heating.

One cubic foot of gas contains 1000 Btus of heat. One hundred cubic feet(1 ccf) contain 100,000 Btus (1000 cubic feet is represented by 1 mcf). At 60 percent annual furnace efficiency, each ccf of gas supplies 60,000 Btus, close to that of one gallon of oil or 20 kwh of electric resistance heating. For comparison, 1 gallon of oil may cost $1.25,20 kwh of electricity $1.20 (6¢/kwh), and 1 ccf of gas $0.50.

local" expert," a workshop, or more books. The resources at the back of the book can provide some helpful hints on where to look next.

The next step is to determine your annual fuel consumption in gallons of oil, kilowatt hours (kwh) of electricity, or hundreds of cubic feet of gas (cd). For an existing house, look at fuel bills. For new houses, calculate heat loss (get help or consult books-it's easy!). It's not unusual for an old, rambling Victorian house during a cold winter to use several thousand gallons of oil, 40,000 kwhs of electricity, or several hundred thousand cubic feet of gas. But a compact, super-insulated house may use as little as one fifth this amount-before the addition of passive.

The next step is to determine the energy output of the system. This is usually considered the hardest step, requiring the charts and graphs we mentioned earlier. However, it need not be difficult. In fact, it can be relatively easy.

Each square foot of a design that is appropriate for the climate (for example, a design that has the proper number of glazing layers), will supply the heat obtainable from roughly one gallon of oil (60,000Btus). In cloudy climates, such as Buffalo, the amount can be half that. In the sunny Southwest, the output can double.

Thus, a house with an annual heat loss of 500 gallons in a climate of average (50%) sunshine will require 250 square feet of passive system to cut its fuel bill in half.

When selecting among the various passive applications, review the previous chapter for their appropriateness to your climate. In general, start with windows as the basic system and add other systems as needed or desired. In the previous example, the home may be designed for 100 square feet of south windows. * They will replace 100 gallons of oil or 20% of the total 500 gallon load. As discussed in earlier chapters, no special effort needs to be taken to add thermal mass since conventional construction usually provides adequate storage for solar windows, which supply 20 percent or less of the heat.

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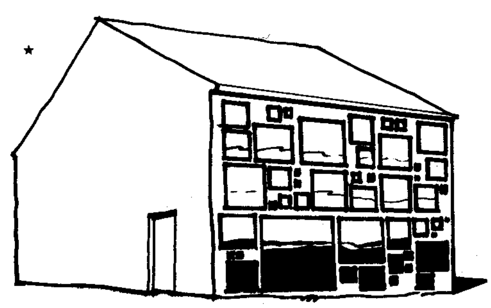


The next 150 square feet, supplying the next 50 percent of the load, might, for example, consist of a greenhouse, a solar wall, or a combination of the two. Remember to take into account the trim and framing when determining square footage.

What Does Passive Cost?

It seems that many people are willing to spend far more money on solar than on energy conservation (buying *more* energy rather than using *less!).* Conservation and solar are both important, and both can reduce your fuel bills enormously. But if you are willing to spend $3,000 on solar to save $200 of fuel per year, you should be willing to spend $2,000 on energy conservation measures to annually save $200 of fuel. Conversely, if you spent $1,000 for insulation and saved $200 last year on fuel, then think about spending $1,000 on solar to save $200 more next year.

Don't be fooled by the glamour of solar energy. Energy conservation, perhaps less glamorous, can go a long way toward solving our energy problems. We can economically super-insulate homes so that they use as little as 20 percent of the energy that conventional homes use, without significant use of solar energy. In moderately cold climates, walls and roofs should have R-values of at least 25 and 40, respectively. Use triple glazed windows, and caulk and weather strip. In cold climates, increase these R-values of the walls and roofs by 50 percent and add movable insulation over the windows. If you do anything less than these measures, you should restrict your expenditures on solar to $1,500. If you meet these measures, go all out with passive solar. However, you probably won't need to spend more than $5,000.

From a practical point of view, energy conservation measures are necessary in most of the U.S. climate to keep the required solar heat collection area small enough so that it can be easily and economically added to the average house. Properly-designed solar glazing totaling 20 to 40 percent of the floor area of your house (depending on the climate), will provide 50 to 80 percent of the heat. This is for a well-insulated house with adequate thermal mass for heat storage. (Super-insulated houses need less southern exposure to achieve this.) Thus, the collection glazing can cover much of the south-facing walls (or roof). Poorly insulated houses cannot normally obtain a large percentage of heat from the sun except in mild climates.

In cold, cloudy climates, energy conservation measures are usually more cost effective than are solar heating devices, at least until heating loads of a house are reduced by 40 to 60 percent compared with previous heating bills.

But the house is still a "conventional" and compared with super-insulated houses. In mild, sunny climates, solar heating and cooling may be a more cast effective means of reducing fuel bills than energy conservation since the climate permits passive systems to. have fewer layers of glazing.

Passive system casts can vary enormously} depending an size} design} materials, and construction methods} and passive system type. Keep the sizes manageable. For example, a 15 foot-high wall of glass is harder to build than an 8-foot-high wall. Dan}t make the design complicated. *Keep it simple!* An occasional fan to. help move air from and part of the house to. another-far example, from the south side to. the north or from upstairs to. downstairs can keep floor plans from becoming contorted and passive systems from becoming crude contrivances.

Use basic, easy-to-handle materials, preferably locally produced. Build the systems yourself} if passable. This can save 40 to. 60 percent of the cast. Contractor-built systems are mast cast effective an new housing rather than an existing. However} additions and major remodeling are excellent opportunities for improving the cast effectiveness of contractor-built systems for existing houses.

Which of the various passive system types you choose also. affects cast. *Solar windows* cost nothing if what would have been a north window is instead placed facing south. Solar windows can also be inexpensive if you are willing to have some of them fixed in place, non-operable. Fixed glass can be one third the cost of operable windows.

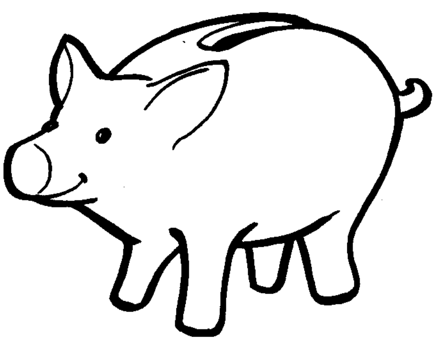
If you intend to build of heavy materials regardless of using solar, your thermal mass comes free. On the other hand, concrete floor slabs or brick partitions added to. conventional wood-framed construction can add to. the cast.

In mild climates, the windows need have only two. layers. In severe climates, triple glazing and movable insulation are usually necessary (and cast effective!). Shades or awnings may add to the cast in southern climates.

Solar windows, then, can cast nothing or as much as $20 per square foot.

If you are able to easily convert your south wall to a *solar chimney* by simply adding a single layer of glazing, the materials will cost but a few dollars per square foot. If you buy a solar collector and hire someone to install it, the final cost could well be three to four times more. Either way, if the collectors are large enough to provide only 15 to 20 percent of the heat, no new thermal mass will be needed. The cost of making your south wall into a solar chimney, then, will be primarily that of just the collector or glazing. When more than 20 percent heating is obtained, however, thermal mass must be added to accommodate the heat. This makes solar chimneys a whole new ball game, and, of course, costs increase.

The cost of building a *solar wall* is less when the south wall would have been built of concrete block, brick, stone, or adobe anyway. Keep in mind that stronger foundations are needed to support the weight and that extra floor area may be needed to accommodate the thicker-than-normal wall. In mild climates, only single glazing may be needed, while in cold climates, as many as three layers of glass or movable insulation may be necessary. Thus, solar walls may cost only a few dollars per square foot for the glazing or up to $25 per square foot.



Cost estimates for *solar roofs* are more elusive. A strong support structure, the water ponds, and the movable insulating covers can be costly. On the other hand, Harold Hay's "Skytherm" house in Atascadero, California, if built in large numbers, might cost no more than conventional housing since, in that climate, it requires no back up heating or cooling systems. According to Mr. Hay, these cost savings completely pay for the passive system. In fact, the conventional heating and cooling system can be greatly reduced in size and complexity, or can be eliminated entirely from many energy-conserving, passive solar homes throughout much of the country, saving several thousand dollars in first cost and hundreds of dollars in maintenance costs. Small space heaters or wood burning stoves often suffice in the winter, and fans or modest-sized window air conditioners or evaporative coolers do the job in the summer.

A single glazed *solar room* can cost only a few dollars if the frame is built of used lumber and covered with a thin sheet of plastic. Commercially sold greenhouses, however, can cost thousands of dollars. Solar rooms reduce the cost of other building components. For example, when protected by a solar room, walls that would otherwise be exposed to the weather can be simplified and reduced in cost.

Whatever system or combination of systems you choose, "shop around" fully. Seek advice and look for the best prices. Pay attention to detail and use passive systems to enhance the beauty of your house.

Will you be satisfied with the fuel savings resulting from your expenditures for passive systems? The easy answer is "Yes!" However, everyone's expectations and needs are different. For example, some people require that passive pay for itself in five years (say a fuel savings of $100 per year on a first cost of $500). Others can afford to be more far-sighted and can view conservation and solar costs as investments in the future. Such people realize that shortsightedness got us into our energy mess, and longer term investments of 15 to 25 years can help get us out. Keep in mind that energy prices keep doubling every few years, and as they do, your "minimum energy dwelling" is perceived as more and more valuable by your friends, neighbors, ... and the next buyer.

As a matter of fact, you can disregard the energy savings from many passive systems in determining whether they are good investments. Instead, they can be viewed as an integral part of your house, increasing in value along with the whole house. Thus, when the value of a house inflates by 50 per cent in say, five years, so will its solar greenhouse! If the house is then sold, the owner receives back his entire investment in the greenhouse and then some ... plus, five years of lower energy bills, too.

In this sense, solar energy is indeed free. But passive solar is also convincing on the basis of dollars spent for the energy saved.

A conventional house may use $1,500 of fuel per year, and perhaps twice that in a few years as energy prices rise. For the many solar and conservation measures recommended in this book, an expenditure up to $10,000 may be necessary, depending on climate, the size of the house, and which conservation and solar features are selected. The result will be fuel bills reduced by 70 to 90 per cent, or $1,350 per year, and as much as $2,700 when prices double. Even if you must spend $10,000-and most people will spend less than $ 7,000- your annual mortgage payment will increase about $1,000 ($85 monthly) for the solar/conservation investment, but the energy savings more than compensates. Federal energy tax credits of 15 per cent for conservation measures and up to 40 per cent for solar, will offset the extra down payment you need as a result of the somewhat higher cost of the low energy house due to its energy-saving measures.

Thus, your cash flow is positive and the annual cost of owning an energy-conserving, passive solar home is less than owning a conventional one.

Afterword

You have now reached the end of the book and are at least 7 percent smarter than you were when you started it. Now it's time to put all your new-found knowledge to work. The things you've learned are of great value for they can affect not only *your* pocketbook, *your* comfort, and *your* way of life, but global politics, environmental quality, and the value of the dollar as well. We are in a great period of transition-from the fossil-fuel age to the solar age. Standing right up close to that transition, it's sometimes hard to sense the magnitude of the changes now taking place. But each day brings a bit more perspective to our view of the revolution. Each day makes solar energy systems look better and the nuclear nightmare look worse. Each step we take in the direction of a solar civilization will have untold benefits to us, to our children, and to all the generations to come, not to mention the benefits to all the other creatures of the world, whose fate is so inextricably tied, now, to ours.

Photo Section

The houses in the photographs on the following pages are representative of the thousands of passive solar homes being built or retrofitted throughout the country. The variety of approaches is truly astounding; proof that solar offers new opportunities for innovation, creativity, and beauty.