Building with Awareness

THE CONSTRUCTION OF A HYBRID HOME

DVD & GUIDEBOOK

Ted Owens

Includes The Award-Winning DVD Video On Building A Straw Bale Solar Home

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DVD & GUIDEBOOK

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THE CONSTRUCTION OF A HYBRID HOME
DVD & GUIDEBOOK
CHAPTERS 1 AND 2 PREVIEW COPY

For my parents,
Peggy and Al Owens,
for their inspiration and encouragement

Ted Owens

DVD Video Contents

DVD SPECIAL FEATURES

- Second audio track with additional design and building commentary. This track is accessible by choosing Audio 2 with your DVD remote control.
- Narrated slide show of construction details
- Video sequence on how to split a straw bale

TOTAL RUNNING TIME OF MAIN PROGRAM
2 hours 42 minutes

TOTAL TIME OF ALL CONTENT
Over 5 hours 45 minutes

Guidebook Contents

1. Introduction

The winds and the waves are always on the side of the ablest navigator.

Edward Gibbon
English Historian

Building with awareness is recognizing the pros and cons of each decision made during the design and construction of a home. Only when informed decisions are balanced against one another can the energy efficiency, durability, and aesthetics of a structure be expected to outperform the "common" building techniques in use today. There are many different ways to design and build a green home. There are various materials and techniques to choose from, none of which is perfect for every area or structure. What is needed is awareness of the options. Decisions can then be based on the best information at hand. This is counter to a common approach to home construction that a structure is built a specific way mainly because it has always been done that way.

This book is the companion to the *Building With Awareness* DVD video. Whereas the DVD covers both aesthetics and construction techniques, the book leans towards the nuts-and-bolts of construction. A future publication in the *Building With Awareness* series will deal with the philosophy and implementation of aesthetic and energy-efficient design.

The DVD follows the construction of one straw bale, solar home from start to finish. Since this is a case study of the building of an actual home, it was essential to decide on specific design parameters and construction techniques. This differs from many books on straw bale construction and green building that tend to show a wide variety of techniques. Both methods have assets. The advantage of following the building of a single home is learning the real-world reasons why specific decisions were made and how each step related to the next. It would have been possible, and viable, to have used a different set of construction parameters than the ones used in this home and also have had an equally successful building project.

The ideas presented here are not advocating that this is the best way, or the only way, to build a home. It is just the way we chose to proceed—based on our research, needs, available materials, local climate, local experts, state and national codes, and budget. Some building techniques were mandated by local code. Some were just personal preference. Your design and construction techniques will vary as well.

If you are new to home building, you may decide to have a contractor do some or all of the work. If you decide to build most of the house yourself, you will want to find people with the appropriate knowledge to help you. It is es-

By taking advantage of what nature offers, instead of rejecting it, the mechanical heating and cooling system can be greatly reduced in size or even eliminated.

sential to find skilled people in your community who are knowledgeable in the specific areas of your project. By doing this, you will make fewer mistakes, work faster, and learn more.

One advantage in documenting this home is that, as the designer/documenter, I have been able to see how certain decisions are holding up with time. Having lived in the house for a few years, I now have first-hand experience as to what worked well and what I would do differently with the next construction project. Many times I have asked an architect or builder how a specific material held up after a few years of use. The usual answer was that no one knew. The home was sold upon completion, and no follow-up was done with the occupants. This is unfortunate because it slows down innovation due to the lack of resultant information. It is often the mistakes made that provide the best learning experiences, without which progress is impeded. To quote Barry LePatner: *Good judgment comes from experience, and experience comes from bad judgment.*

Sustainable homes create a comfortable living environment, regardless of the weather outside.

One purpose of the DVD, and especially this book, is to point out the lessons we learned so that others might benefit from our education—just as this project was often based on the lessons learned from the projects of others. Every construction project is a series of decisions based on the best information which one has at the moment. It is also an interconnected series of procedures which arise from on-the-spot problem solving. This is what innovation and progress are all about. Every time we create, we strive to do something better. There is no destination, only a direction.

In summary, there is always more than one way to solve a problem when building a hybrid home. It is important to consider how all of the elements work together and influence each other. Whatever your design choices, know why you came to a particular design decision. We will all be building better green homes in the future based on what we learn today.


The completed home is small, simple, elegant, and energy-efficient. The visual style arises from the use of natural materials and not from a complex shape.

2. Design

Hybrid structures are built using a wide variety of materials. The term "hybrid" is among a collection of many names used to indicate a different approach to building design. Sustainable design, green building, and energy-efficient design all move in the direction of doing more with less. Hybrid is a term that has evolved in the car industry as it combines older and newer technologies. An internal combustion engine, which is paired with an electric motor and battery, creates something more energy-and-cost-efficient than either element on its own. The hybrid aspects of this particular home use low-tech mud bricks and earth plaster to absorb heat and thus aid in both heating and cooling. High-technology photovoltaic panels on the roof convert sunlight into electricity without the need for moving parts or for the burning of fossil fuels.

The home was designed and built using both conventional and progressive building techniques and thus balances the best of both worlds by using what is most appropriate for each particular job. Despite the structure's small footprint of 800 square feet, each room feels spacious and bright. By building the home no larger than was needed, money could be put into aesthetic elements instead of square footage. Thus the utility bills for heating and cooling go down. Although the layout is very compact, these basic concepts can be scaled to a structure of any size.

Natural materials (materials that are mostly created by nature, such as mud, straw, bamboo, stone, and wood) have many advantages. They contain low-embodied energy, which is the amount of energy required to actually create the materials. Sunlight was the energy used for growing the straw, and the earth and clay were dug from the ground. Natural materials also tend to be non-toxic, and they lend themselves to the creation of aesthetically pleasing structures with a minimal amount of skill on the part of the home builder. In this home, the choice of materials was based on their visual appeal, ease of use, energy efficiency,

The straw bale wall with the window is coated with 1" of earth plaster and a finish coat of ¼" unpainted gypsum plaster. The rear wall is adobe which is finished in brown earth plaster. The section above the flagstone wainscotting has a skim-coat of white earth plaster on top of the brown-colored earth plaster. The floor is salvaged oak.

We shape our dwellings, and afterwards our dwellings shape us.
Winston Churchill

and the amount of embodied energy.

The materials and design parameters of a building will change, depending on the climate and region. This is also true for the aesthetic style of the structure. These factors must be taken into account when envisioning your own home, as the visual look of this project is not "the" style for straw bale or green building. The aesthetics presented here came from the region and the use of locally available materials.

For the sake of simplicity, the design can be broken down into two categories. First, there is the structural design. This consists of the physical structure itself and includes the materials, the engineering, and the actual position of the home in relation to the sun. The second category is the visual design—what the house looks like aesthetically.

In a conventionally built home, the structure and appearance are somewhat tied together. Usually the designer is able to proceed more freely since sun angles, room and window placement, and room function are frequently not connected to the ideology of energy efficiency.

In the past, solar homes could be unattractive because the problems of merging solar design with aesthetics were not properly addressed. This problem came to the public's attention in the 1970's when many individuals began to seriously experiment with solar home design. Appearance wise, the green building movement may have been set back by the perception that energy efficiency was synonymous with ugliness. Odd roof and ceiling angles, too many windows in one place and not enough in another, too many macramé-suspended hanging plants and free-form tree trunk beams, and little knowledge of how to balance appropriately these design elements led to houses that did not engender praise from the general public. Some called it the "hippie-look." The good intentions sometimes made it appear that the engineer and designer were not working in harmony. It is not uncommon for the aesthetics of a newly-designed object to suffer when the engineering is still in the early stages. Fortunately, this is not as often the case today. Being sustainable, energy efficient, and visually pleasing are all essential elements of good green design. One can give form to the other and can create beauty as a side benefit to enhancing the sustainable qualities of a home.

Top: All of the color in this room comes from the natural materials themselves, not from paint.
Left: The loft has a cozy tent-like feel. The deep window insets reflect soft light around the room and create a window shelf. According to code, if a loft is going to be used as a sleeping area, it is supposed to have a full-size staircase.
Below: In the entry hall, winter sunlight hits the adobe thermal mass wall to the left.

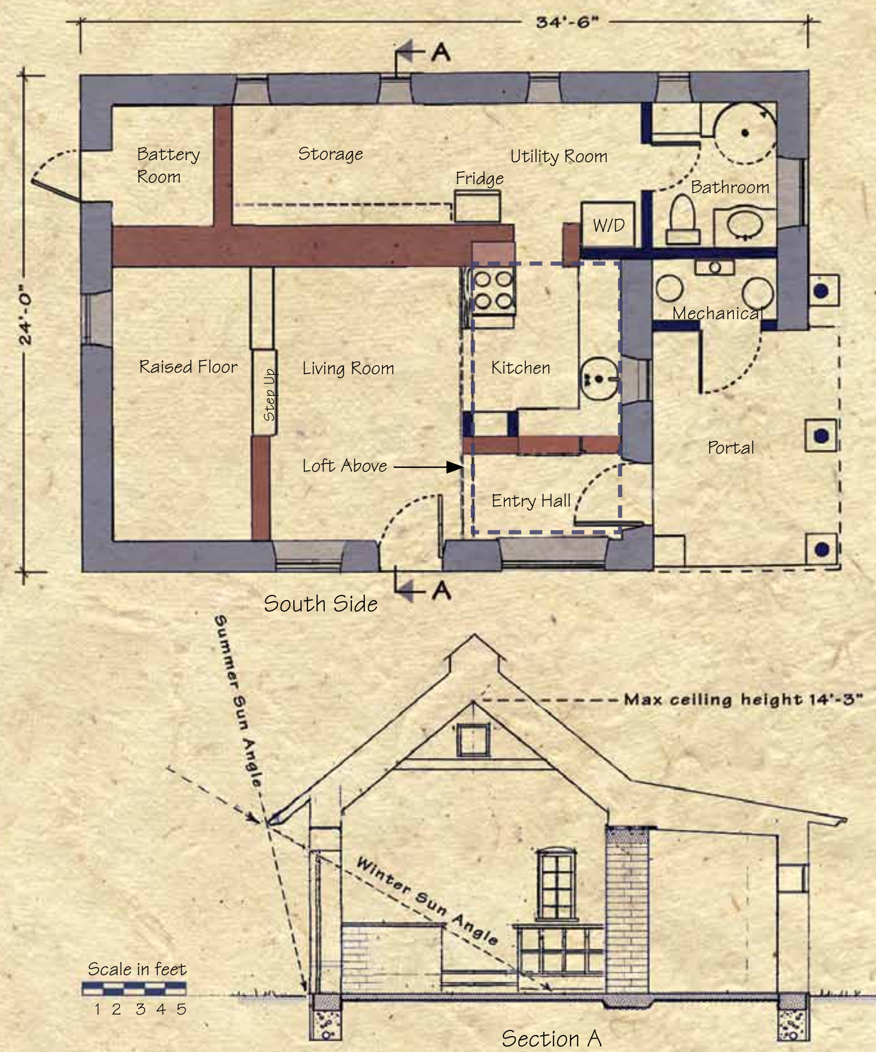
Notice in the floor plan to the right that all of the exterior walls are constructed of straw bales. This will reduce the heat of the summer and the cold of the winter indoors. For the interior walls it is very important to get as much thermal mass (thick, heavy walls of a material such as adobe or stone) as possible within the outer shell of the highly insulating exterior walls. The thermal mass walls absorb heat as sunlight enters through the south-facing windows. The heat is released back into the room when the air temperature of the room drops below the temperature of the warm walls. The windows and the thermal mass both contribute to the passive solar heating and cooling. In the summer, the cooler thick walls absorb heat from the warm rooms, thus cooling them.

This home has extensive thermal mass, and all of the direct sunlight entering the building hits these heat-storing materials. In the winter, much of this sunlight is absorbed directly by the thermal mass walls. (See the floor plan to the right and the time lapse cinematography sequence within the DVD.) The remaining sunlight warms the 4-inch-thick concrete, thermal mass floor. It is not necessary that all sunlight hit a wall or floor directly, as the home is designed to reflect light (and therefore heat energy) throughout the room. Although direct sunlight does not quite reach the center 24"-thick thermal-mass wall, this wall does absorb reflected heat. On the other hand, it acts as a cooling element in the summer.

Keep in mind that this home, despite being in a high desert area where many summer days reach the upper 90's (˚F), does not contain any mechanical air-conditioning system. Cooling of this home was considered a greater challenge than the heating—despite winter nights that can be in the mid-teens or lower. The inclusion of an air-conditioning system could have easily doubled the cost of the photovoltaic electrical system, so much attention was placed on thermal mass cooling. For about half of the year, the interior thermal mass is used exclusively for air cooling. Windows are opened at night to take advantage of the local climate's cool night air which will remove heat from the thermal mass. In the morning, the windows are closed, and the dense walls then absorb much of the day's heat that reaches the living space.

The room temperature in this home can remain at around 70° F even when the outdoor temperature peaks at 96°. If the average home built today could maintain a 26° temperature difference without mechanical cooling, the nation's summer electrical consumption would drop dramatically.

This home was an experiment in maximizing thermal mass. It would be difficult to add too much mass. That said, the 24" thick wall could be reduced to 14" or 10" (if using adobe) and still be very effective at heating and cooling while gaining more floor space at the same time. (See page 144 for more information.)



FLOOR PLAN AND ELEVATION

Total Square Footage (includes walls and loft)	832 square feet
Total Interior Square Footage *	647 square feet
Loft Square Footage (including side storage)	91 square feet
Angle of Roof and Photovoltaic Panels	40 degrees
Total Roof Area	1,064 square feet

Adobe
Straw Bale
Wood Frame

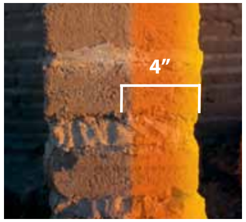
All measurments are approximate.
* Less exterior straw bale walls and mechanical room. Includes the loft.

Exterior Walls: Insulation

The advantages of using straw bale are: it is a waste product; it is an excellent insulator (R-30 to R-40 when plastered and depending on the thickness of the bale); it makes very thick walls that are aesthetically pleasing. (See pages 90-101.)

Interior Walls: Thermal Mass

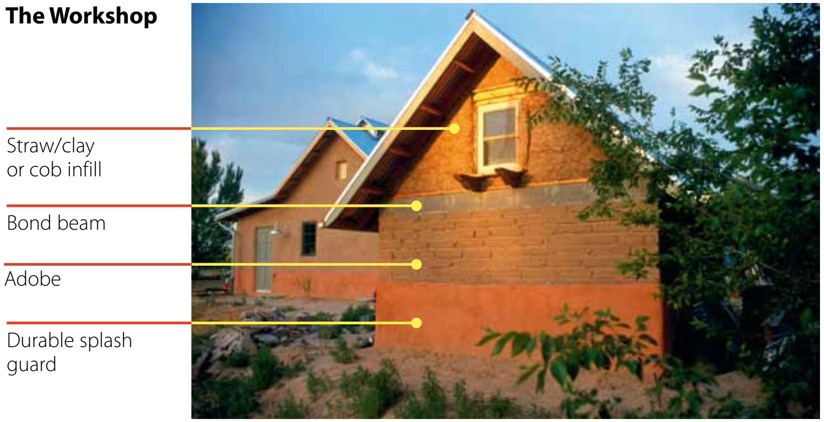
Instead of using conventional wood-frame walls and wallboard, it is best to have at least some thick and heavy walls that can absorb, hold, and release heat. This stabilizes the indoor temperatures, as the outdoor temperature may vary 40 degrees during the day. Depending on what is available in your area, the material might be adobe, rammed earth, stone, or brick. Concrete or cement block can also be used. However, they are less desirable due to the energy used and the pollution generated in the manufacturing process. Ideally, at least 1/2 to 2/3 of the interior surfaces (floor and walls) should be thermal mass. (See Concrete on page 29.)



Left: If your budget limits the thickness of your thermal mass walls, strive for about 4″ of solid wall thickness as this will give you good performance for your money. The indicated first 4″ of the wall thickness is most effective at storing and releasing heat over a 24-hour period.

R-value: A measure of the capacity of a material, such as insulation, to impede heat flow, with increasing values indicating a greater ability to insulate. Straw bales are about R-1.45 per inch. Some products, such as windows, are rated in U-values. The U-value is a measure of thermal conductance (the amount of energy that will be lost) and is inversely related to the R-value. Here is the formula to convert one value to the other:
U-value = 1 ÷ R value   R=1 ÷ U value

The Workshop

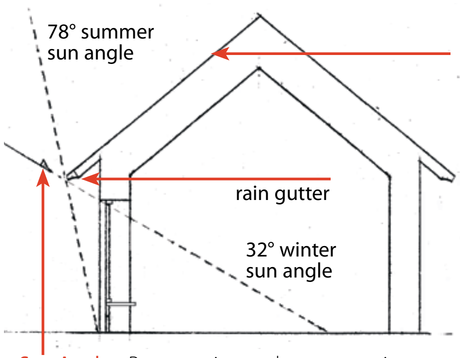


Upper Photo: The workshop was constructed before the home. It housed on its roof the photovoltaic electrical system that allowed us to build the home off the electric grid. This small structure also was a place to store tools and equipment. This is the view from the east side.
Lower Photo: This west view shows some of the materials that were used. Straw/clay has sufficient mud mixed with the straw to make it stick together (see the slide show on the DVD). Cob has more mud and is a denser material.

The Basics of Passive Solar Heating and Cooling

The sun is low on the horizon at high noon in winter. The roof overhang and windows allow sunlight to enter the home. When it strikes the darker-colored surfaces of the floor and walls, this light energy is converted into heat energy. The thermal mass absorbs this heat and slowly releases it back into the rooms at night.

The summer sun is high above the horizon at noon. The roof overhang now prevents direct sunlight from entering the home. This keeps the interior much cooler. You can actually design the overhang to cut out direct sunlight in the month that you choose. If your spring season is still cold, more sunlight can be allowed to enter.



Sun Angles: Pay attention to the construction details when designing your roof overhangs. Rain gutters, window molding, and the distance the window is inset from the outside wall surface will all influence the amount of sunlight that can enter the home. Include these details in your cross-section drawing.

Draw the angles by using a protractor. It is easiest to draw the sun angles and the cross section on two separate sheets of tracing paper and then overlay the sun angles over the cross section. This permits fine-tuning the overhang distance.

The southern wall of the home can vary 15° or so from true south and still work very well.

Roof Slope: Since the photovoltaic panels are attached to the roof, the angle of the roof was determined by the most efficient slope for pointing the panels towards the sun.
When winter electrical generation is the most important, the PV tilt angle should be set at the latitude angle plus about 15° degrees.
To maximize summertime production, orient the PV tilt angle at latitude minus about 15° degrees. As an example, the latitude of Albuquerque, New Mexico, USA, is about 35° N. The roof angle of this home, and thus the angle of the PV panels, is 42°. This was a compromise setting between the ideal winter and summer angles.

Determing Your Sun Angle: The sun angle in the northern hemisphere at noon on the longest day of the year (June 21) and on the shortest day of the year (December 21) may be determined from the following simple equations:
June 21 noon sun angle = 113.5° minus the latitude
December 21 noon sun angle = 66.5° minus the latitude
Example: Albuquerque, NM latitude = 35° N
June 21 noon sun angle = 113.5°—35 = 78.5°

For more information on sun and PV angles, visit: www.BuildingWithAwareness.com and click on References

Window Placement

South Side

The long south side of the house contains most of the window area for the collection of solar energy (sunlight) in the winter months. In this case, the glass area is approximately 17% of the floor area. The roof overhang is properly designed to keep direct sunlight out of the home in the summer. The southern orientation of the home is based on using true north, as opposed to magnetic north.

West Side

Windows on this side are kept to a minimum and as small as possible to prevent overheating of the home in the late afternoon of summer. Planting a large shade tree on this side would also help. Large windows would have created the need for an air-conditioning system. This, in turn, would have required a dramatically larger photovoltaic system for power.

North Side

Windows on this side are just large enough to supply daylight to the interior and to supply cross ventilation in the summer. In the winter, large north windows will only drain money from your bank account and transfer it to the utility company.

East Side

Like on the west side, the east-side windows, if too large or unprotected, will allow the home to gain heat on summer mornings. The portal gives some protection from the sun. The loft window vents out warm air at night while cooler air enters the lower windows. The horizontal bathroom window is high enough for privacy yet still permits a view of the mountains.

Overview of Materials

The southern side of the home collects solar energy for the purpose of heating and electrical power generation.

This adobe wall adds thermal mass, soft-divides the two living spaces, and adds shelf, counter, and sitting space.

Recycled wood beams eliminated the need for old-growth lumber. All large-dimensional lumber (6x6, 4x12, etc.) was salvaged.

Fast-growing aspen wood is used for the kitchen ceiling/loft floor and was painted with a non-VOC paint to reflect light. (See page 82.)

Note the angled steps on the ladder to the loft. The ladder swings out when in use and the steps become parallel to the ground.

This is a straw bale wall with earth-plaster base coat and 1/4" finish coat of gypsum plaster with a clear sealant to protect from stains around the sink.

The west wall of the living room has a skim coat of unpainted gypsum plaster. The lighter-colored walls help to distribute light and also add visual appeal. Since construction, there has been no cracking or separation of the materials.

The raised floor is surfaced with recycled oak. For protection it has a coat of shellac and wax. Panels in the floor lift up to gain access to additional storage below. (See page 129.)

Acid-stained concrete floors provide extra thermal mass for absorbing sunlight that enters through the south-facing windows. The 4"-thick floor also contains the backup hydronic radiant-floor heating tubes. (See page 45.)

Bamboo was used for the horizontal rungs of the loft railing.

Wood-frame cabinet has an earth-plaster finish on top. This transitions into an adobe thermal mass wall facing the south window.

The straw bale exterior wall features a three-coat earth plaster finish of 1-2". (See page 120.)

Cast-in-place concrete countertops sit atop simple wood-frame cabinets. The countertops absorb heat from the south-facing windows in the winter and add to the thermal mass. The cabinet doors were owner-built and feature bamboo within a wood frame.

Non-VOC paint: VOC stands for "volatile organic compounds." This is the solvent you smell in conventional house paints. Non-VOC paints are less polluting in the manufacturing process and while painting. This is a superior product----for the sake of the environment and the painter. Many of the major paint manufacturers now offer these products.
Shellac: A natural polymer secreted by the Lac insect. When mixed with alcohol, it becomes a natural varnish that can be painted on wood. Once dry, it is non-toxic (and even termed edible as it is sometimes used to coat pills).

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