GIVEN AT "BUILDING ENERGY 2000"

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Good afternoon: I am pleased to be speaking to you today about my experiences in passive solar design and engineering. I would hope that this knowledge in passive solar gained from experience during the past thirty years will be helpful to the current generation.

My name is Bruce Brownell and I have spent all of my adult life doing the best solar structures I could engineer. It's interesting to me that for the first time in more than a decade interest is increasing in this field. Since the recent upturn in energy costs my office phone has been ringing regularly. Why is it, when this is the third energy price upswing in three decades, that we can't take a longer view?

Solar housing is not a new idea. In fact, following the learnings from the Egyptians and Greeks, the Romans devised and implemented in their cities the best and most complete solar code known to this day. Our early history in the colonies indicates awareness of these principles as most farmhouses were properly orientated south. This basic solar building principle was later vastly diminished in a decade by the adoption of a wonderful new and efficient technology, the cast iron wood stove made in the manufacturing centers of Albany and Troy New York during the last half of the 1800's. In fact, this wood burning method was so revolutionary that the stove required only one half the wood of fireplaces. A traveling salesman pitching this claim to my grandfather was met with the reply "Great, I'll take two and won't cut any wood". The cast iron stove was the forerunner of today's most common central furnace that offers near trouble free automatic operation. In America we have always been very quick to embrace new technology, while forgetting the lessons of the past.

During the last three decades the publics energy awareness has gone through three major swings. There was no one to talk to about my interest in solar in the 60's, but shortly after the energy crisis in the 70's thousands became involved. Within two months of the oil price increase each town had a new entrepreneur. He had a pickup truck, some carpenter tools but most importantly a shiny new sign "Solar Home Builder". Collectively these guys success with their hundreds of methods and ideas based on intuition and a cheaper price led to the construction of thousands and thousands of "so called" solar homes. A substantial portion of this "instant" solar design work was flawed. The houses performed poorly with large south glass areas, huge temperature swings and multiple problems never anticipated. Much was written about this solar period in books still on the shelves today.

Many do-it-yourself solar homes and commercially produced solar hot water collectors appeared everywhere across the American landscape. This was further encouraged by tax credits from Washington. The following administration eliminated the tax credits, but worse, told us that energy was abundant and cheap, and in short order, ended most interest in alternate energy and solar. After that we spent the decade of the 80's where public interest disappeared. My weekly solar home educational tours, which started in 1964, went from having attendance of over 100 people in the 70's to 2-4 people in the 80's and 90's. I spoke to thousands cheering on the original Earth Day in 1970 at Flushing Meadows about solar homes. My message was sincere and strong. "I have been building solar homes (this was before we used the words "active" and "passive") for 10 years (big cheer), 10 years from now most homes being built will be solar (big cheer), and some of these homes will have photovoltaics, wind power and water power (big cheer)." Boy was I wrong! I also had the experience of seeing the course I taught for over 10 years with thousands of students at Union College be cancelled from lack of interest in the mid-80"s.

Those of us who lived through these times and stayed in the field paid a heavy price. This early experience damaged the reputation of creditable solar homebuilders and has taken decades to recover from.

Fortunately, we are past most of this and if we are wise we will combine the best of the old proven solar ideas with the best of the new technologies on the horizon. The mature PV field with the anticipation of fuel cell availability and the near advent of super windows with R values of 10 or more will truly create a solar home environment enabling tomorrows homeowner to live wherever he chooses, off the gird, without any compromise in lifestyle. This will be the revolution of the new century.

I would like to tell you about my endeavors. I have spent my adult life as an engineer trying to design and build the best solar home possible. I accomplished the first solar home in 1961 while in college, and after graduating in 1964 created a 74 lot solar home development in the vacation area of Great Sacandaga Lake in the southern Adirondacks of upstate New York. I also built a solar home on spec in 1965.

literature or my college experience about solar homes. Since it was obvious one had to construct a well-insulated structure, it was going to be very tight and, therefore, could lead to air-quality problems. Further research on tight spaces revealed that almost no information was available except some data with a military mentality concerning spacecraft and atomic subs. My consideration in contrast, was the average family. I then began to monitor and measure the few buildings that I had completed. A lot of time was spent talking to the new occupants about their experiences of living with the sun. A company was formed called Adirondack Alternate Energy. The alternate referred to our intention to utilize wind power, waterpower or photovoltaics with solar homes. Our concept led to the creating of the term "Low Energy Requirement Home" which described what we were trying to do. As with any new venture we naturally became educators, explaining and demonstrating our ideas and solar homes to a skeptical public. Much learning occurred and our advances were quite rapid during these early years. A solar "test home" was built

and monitored in1974 and 130 families lived in it in three-day sessions during the next two winters. We participated in years of monitoring of these homes with Brookhaven National Lab, General Electric, NYS Power Pool, Niagara Mohawk and in 1981 the Harvard School of Medicine which did an extensive indoor air quality study on our tight homes. Harvard's findings were that we had the tightest homes but also the best air quality. These monitoring efforts led to many improvements.

These early efforts were of a solo nature as there was very little information in the

The solar homes were based on simple, physical principles so the solutions address basic laws of science. This leads to three areas one must address: Insulation, proper placement of glass and mass storage.

FIRST: Insulation-The sun does not make available very much energy, especially during the heating season, and it sure does not shine all the time. It was logical to orient the home with the long wall south and site the home so that the land southerly of the structure could be cleared of trees to allow maximum solar energy reception just as our forefathers did. In order to have the limited energy of the sun contribute the majority of the heating season's needs, one had to insulate far better than the requirements and use better materials to seal with. Following the idea of "The Low Energy Requirement Home" calculations showed we should have performance insulation level of R40. Crudely a 1" thick wood board is about 1R. Our design needed the equivalent of 40" of wood everywhere.

From 1958-1962, we had tried the traditional fiberglass insulation in earlier homes, even in 6" and 8" thickness, and had found it did not perform as claimed. There were air infiltration and moisture problems. In 1963-64 there were newly available several "foam" type insulations. We tried bead board, then Styrofoam, then urethane and found each in turn performed better. Urethane was clearly the best, with and R rating of 8 per inch. We still use this product which saw many improvements during the late 60's and through the 80's. This insulation currently meets all fire codes and is more properly referred to as a polyisocyanurate and is CFC free. It is important to note that we wrap the structure with two 2" layers yielding 4" of foil face polyisocyanurate on all six sides of the structure (including underneath) creating a total envelope. Much effort is devoted to taping all the joints with aluminum tape, creating "two" overlapping shiny foil boxes. This creates a moisture proof home that can be called the "Low Energy Requirement Home". Other products installed in this envelope must be equally moisture resistant for differential vapor pressure causes a moisture drive generally out in winter and in, in summer. Wood and concrete are common building materials that readily pass moisture vapor through them. One must carefully select products such as vinyl covered Andersen windows and urethane insulated, steel faced doors with modern seals to complete the sealing of the envelope.

A SECOND important design effort in our passive solar homes is relating to the solar collectors-windows facing south. South windows always gain energy-north windows are total losers and east and west glass represent a 50/50 situation if the sun sees them. By no means do we want to place a lot of glass in the south wall-a mistake most early solar homes made. We would want to have roughly 20-30% of the area of the south wall in glass. We do not shade south glass north of 40^0 latitude. Much thought is given to daylighting all the spaces. This leads to the usual amount of east and west glass, but we would try to hold north glass to 4 or 5 smaller windows. In passive solar one must be careful with west glass which can lead to late day summer over heating. The largest increase in energy efficiency we have experienced in years came from advances in window efficiency during the mid-80's where the insulation level doubled from R2 to R4. This single change, at no cost, improved our homes performance by 20%. Another equal advance in R-value soon to come will make many of our homes totally solar in 7-8000 DD climates.

Once we have 120-150 square feet of glass in the south side of our typical 2400 sq. ft. Low Energy Requirement Home with its R40 insulation level we have created a large problem on any sunny winter's day. The space drastically overheats. To solve this we must incorporate a THIRD design element-mass storage. Since hot air rises and our insulation system goes up the peaked roof this highest area naturally collects the warm air which is then moved down a central air shaft using a small fan-usually less than 1/5 HP. This air is blown through an extensive grid work of pipes in sand or concrete under the lowest floor (it could be the basement). The air is then directed back up inside the outside walls of the house with outlets under windows to eliminate downdrafts. Our mass storage system called the "Heat Energy Battery" is very heavy, typically 80-120 tons for the average home. It is a thermal flywheel keeping the house from overheating during sunny times and returning stored energy that night or the next day. This insulation system coupled with mass storage creates a cocoon, wrapping families in a different kind of warmth. We do not use rock storage as mass due to its tendency for spore and mold growth. We do need some back up heat which supplies 10-15% of the home's needs. This back up energy can come from electric heat, a ground source heat pump or sometimes wood burning, first directed to the mass and then to the house. One, therefore, never feels the heat "come on". The house stays in a comfortable 4-6 degree F range everywhere inside during a 24 hour period. We have filtration yielding excellent air quality as part of this fan system moving air internally about three times per hour.

Hundreds of these Low Energy Requirement Homes now exist in 15 eastern states, housing about 1000 happy people. The sun never sends them a bill. These homes bring to their occupants an unparalleled level of human comfort. The total insulation envelope yields an even relative humidity level of 45-50% all winter which is a by-product of the "daily living cycle". The homes can be left any winter month simply by turning the key in the door-they will not freeze. These homes bring their occupants piece of mind and immediate rewards.

The Low Energy Requirement house also brings rewards to our society, as each average 2400 sq. ft. house does not use approximately 1500 gallons of fuel oil every year. This results in about 18 tons of CO^2 not dumped downwind. More than 300 homes, since 1964, have saved over 100,000 tons of CO^2 from polluting our earth. That's good for America's energy future. Perhaps equally important, any LER homeowners not spending $1500.00 on oil spend it in their communities.

Most western countries have held a competitive advantage over America in the world because their high-energy costs led to efficient use of energy which taught them that it was the difference between long-term affordability or being forced to accept a diminishing lifestyle. At long last, we must learn to live on our solar allotment. In order to achieve this we must do a better job of educating the general public, most importantly young students beginning with 7th and 8th grade science classes focused on the simple values of solar energy. This solar educational accomplishment will result in the fulfillment of our dreams as expressed on the first Earth Day in 1970.

AFTERWARD:

We have recently completed homes near:

1. Stowe Vermont –Langbo
2. Watertown, New York-Wetterhahn
3. Schenectady, New York-Stecher
4. Susquehanna, Pennsylvania-Rockwell
5. Geneva, New York-McGowan
6. Lyme, New Hampshire-Ketteridge
7. Albany, New York-Geisinger
8. Cleveland, Ohio-Hoshiko

We currently have houses in the planning stages near:

1. Mt. Desert Island, Maine
2. Stowe, Vermont
4. Youngstown, Ohio
5. Oldwick, New Jersey

Scotia, New York