Reassessing
Passive Solar Design
Principles

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Back in the 1970s...

Everybody knew that **passive solar design** was the essential first step to home design. **Passive solar** was always contrasted with **active solar**.
Active solar systems are complicated

Active solar hot water system

Active solar hot air system
Passive solar is simple
I built several passive solar homes
What about air sealing?

Early books that promoted passive solar designs usually failed to mention the need for good air sealing details.

[Illustration below from Your Engineered House, 1964, by Rex Roberts.]
What about “Passivhaus”?
(It’s something different.)
Passivhaus buildings aren’t passive

Every Passivhaus building includes an active space heating system.
Five bedrock principles of passive solar design

1. The long axis of the house should be oriented in an east-west direction.
Five bedrock principles of passive solar design

2. The rooms where people will spend most of their time should be located on the south side of the house, while utility rooms, bathrooms, closets, stairways, and hallways should be located on the north side of the house.
Five bedrock principles of passive solar design

3. There should be lots of **extra glazing** area on the south side of the house, and little or no glazing on the north side of the house.
Five bedrock principles of passive solar design

4. The **roof overhang** on the south side of the house should be designed to shade the south windows during the summer solstice, but to allow the sun to shine through the south windows on the winter solstice.
Five bedrock principles of passive solar design

5. The house should include **extra interior thermal mass** to soak up some of the solar heat gain that comes through windows on a sunny day.
The superinsulation vs. solar debate

During the late 1970s and early 1980s, advocates of superinsulation raised questions about the validity of passive solar design principles.
An interview with the former editor of Solar Age

Steve Bliss, former editor of Solar Age: “For one of my first articles for Solar Age, I interviewed two college professors living in a solar house in the Boston suburbs. When I got there, they were sitting in the house freezing — they were wearing down booties and down vests. They were suing their architect, who had used solar glazing formulas developed for houses in the Southwest.”
An interview with the former editor of *Solar Age*

Steve Bliss: “These passive solar houses just didn’t work in New England. A lot of people were building solar houses that weren’t working. Companies started inventing things to fix these houses — solar shades, insulating shutters, rock bins. *Solar Age* analyzed all of these things, and we wrote that all of them failed. I wrote a lot of articles about what wasn’t working.”
An interview with the former editor of *Solar Age*

Steve Bliss: “There was a new perpetual motion machine every six months. Proprietary things, magic things. We used to call these house ‘smart air houses’ — where the air would follow the blue arrows and the red arrows. The smart air knew where to go.”
An interview with the former editor of *Solar Age*

Steve Bliss: “What emerged over time was that the smart money was putting more effort on conservation. Passive solar is a weak heating system — so it’s really important to hang on to the heat you have. There was more and more interest in the building shell. Insulate really well and build a tight house. If you reduce the amount of glazing, you reduced a lot of your problems — overheating in the summer and excessive heat loss in the winter.”
An interview with the former editor of *Solar Age*

- *Solar Age* magazine ceased publication in 1986.

- Steve Bliss: “At that time, interest in solar technology was dropping and interest in energy-efficient construction was growing.”
Superinsulation won the debate

A superinsulated house without passive solar features works fine.

A passive solar house without superinsulation doesn’t perform very well.
Old habits die hard

I side with the superinsulation crowd.

But until recently, I always advised:

• East-west orientation
• Proper roof overhangs
• More south-facing windows than north-facing window.

These principles seem embedded in my DNA.
Is these principles don’t save energy, why follow them?

Is there any technical justification for these design principles?

Do these design principles result in energy savings?

Or am I just dragging around the stubborn legacy of my hippie past?
Forget thermal mass

- Thermal mass is expensive.
- Thermal mass complicates remodeling.
- Thermal mass makes a home unresponsive to sudden changes in the weather.
High-mass floors have disadvantages

High-mass floors keep your house cold when you’re trying to warm it up, and keep your house hot when you’re trying to cool it off.
High Mass vs. Low Mass – a roundtable discussion

“High mass systems offer less design flexibility in architecturally challenging buildings. ... High temperatures in slabs can create problems because of the buildup of heat and how to disperse the heat.”
Gary Proskiw’s 2010 paper

Proskiw asked: Should we add extra south-facing windows to increase solar gains and reduce the space heating load?

He analyzed the cost of this measure and compared the cost to the energy benefit.
Cost/benefit analysis: an example...

Let’s say that a house has only 4 inches of insulation in the attic. Adding 6 more inches of insulation costs $1,000.

Energy modeling software shows that adding these 6 more inches of insulation saves $100 in energy costs per year.

So this energy saving measure has a 10-year payback.
Proskiw’s assumptions

Proskiw used energy modeling software to determine savings. He assumed the house was superinsulated – a net-zero energy house – and was located in a cold climate.
A very long payback period

Proskiw:
A south-facing triple-glazed window that costs $318 to install saves only $1.90 per year.

Payback period = 167 years.
Other measures yield better returns

Get a PV system.
Low-load houses have little opportunity for savings

Proskiw wrote, “The reason the window upgrades fared so poorly, from an economic perspective, is that the space heating load in a NZE house is very small compared to any other type of house ... [and] there is little opportunity for further savings.”
Proskiw: “The window area should be limited to that necessary to meet the functional and aesthetic needs of the building.”
Superinsulated houses are different

Conventional house = 9-month heating season

Net-zero house = 4-month heating season
You don’t need to heat a building if the internal sources of heat (body heat, heat from lighting, heat from appliances like refrigerators and TVs) keep the building warm enough.
In winter, solar gains are at their minimum

Proskiw: “In the conventional house, that means the windows could theoretically reduce the heating load over a nine-month period. But in the net-zero-energy, the ‘window’ during which these benefits can be realized is less than one-half that of the conventional house. Further, the months in which the net-zero house could theoretically use these additional solar gains occurs during the period of the year when solar gains are at a minimum.”
There isn’t much sun in the middle of winter
Some solar gains are unwanted

Proskiw: “The percentage of the solar gains which were actually usable by the house ... was 33% for the conventional house and 28% by the net-zero house, as calculated by HOT2000.”
Money down the drain

Every extra square foot of glazing beyond what is needed “to meet the functional and aesthetic needs of the building” is money down the drain.
When sizing windows, focus on aesthetics.

There is no “magic ratio” for sizing the area of south-facing windows.

Windows are not heat-collecting devices.
Many energy experts, including Joe Lstiburek, say that orientation doesn’t matter. Back in the 1970s, why did we think it mattered?
They never worked well

Even back in the 1970s, passive solar buildings never worked all that well.
Cold on winter mornings...

They were cold on winter mornings and hot on sunny afternoons.

But most of us were so excited by the idea of “free heat” that we accepted uncomfortable conditions as a necessary part of the brave new solar future we were all busy creating.
What’s changed since the 1970s?

Today’s houses are:
• better insulated and
• more airtight.

That makes newer homes more susceptible to overheating.
Four facts undermine the passive solar idea

1. In a well-designed house, the energy required for space heating represents a smaller percentage of a home’s energy budget than it did in the 1970s. In many low-energy homes, **domestic hot water** requires more energy than space heating.
Four facts undermine the passive solar idea

2. While large expanses of south-facing glass help heat up a home on a sunny day, the **solar heat gain doesn’t come when heat is needed**. Most of the time, a passive solar home has either too much or too little solar heat gain, so much of the solar heat gain is wasted.
Four facts undermine the passive solar idea

3. At night and on cloudy days, **large expanses of south-facing glass lose significantly more heat than an insulated wall.**

![Diagram showing heat loss through different parts of a house: Roof (25-30%), Walls (25-30%), Windows (25-30%), Floor (10-20%).]
Four facts undermine the passive solar idea

4. These days, investing in a photovoltaic array yields more useful energy than an investing in a south-facing window.
Reassessing the 5 bedrock principles

1. East-west orientation?

It won’t save any energy, but it creates sunny rooms, and makes it easier to put PV modules on the roof.
Reassessing the 5 bedrock principles

2. Locate rooms where people will spend most of their time on the south side of the house?
It won’t save any energy, but it allows for pleasant rooms.
Reassessing the 5 bedrock principles

3. Put extra glazing area on the south side of the house? There is no reason to do this. It’s money down the drain.
Reassessing the 5 bedrock principles

4. Plan your roof overhang to shade windows during the summer solstice?

You can try, but the results are always imperfect.
Reassessing the 5 bedrock principles

5. Include extra thermal mass? It’s a waste of money and it won’t save any energy.
Focus on the envelope

In the 1970s, we built poorly insulated, leaky houses and tried to gather “free” heat using solar collectors and south-facing windows.

These days, we need to build well-insulated, tight homes that don’t need as much energy to stay warm.
Musings of an Energy Nerd

My book, *Musings of an Energy Nerd*, will be released on March 28
Thanks!

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