Passivhaus Requirements: Logical or Arbitrary?

Martin Holladay, senior editor

GreenBuildingAdvisor.com

Passive House Northwest - Spring Regional Meeting
Olympia, Washington
March 18, 2011

Passivhaus buildings in the U.S.

Superinsulated houses are not new

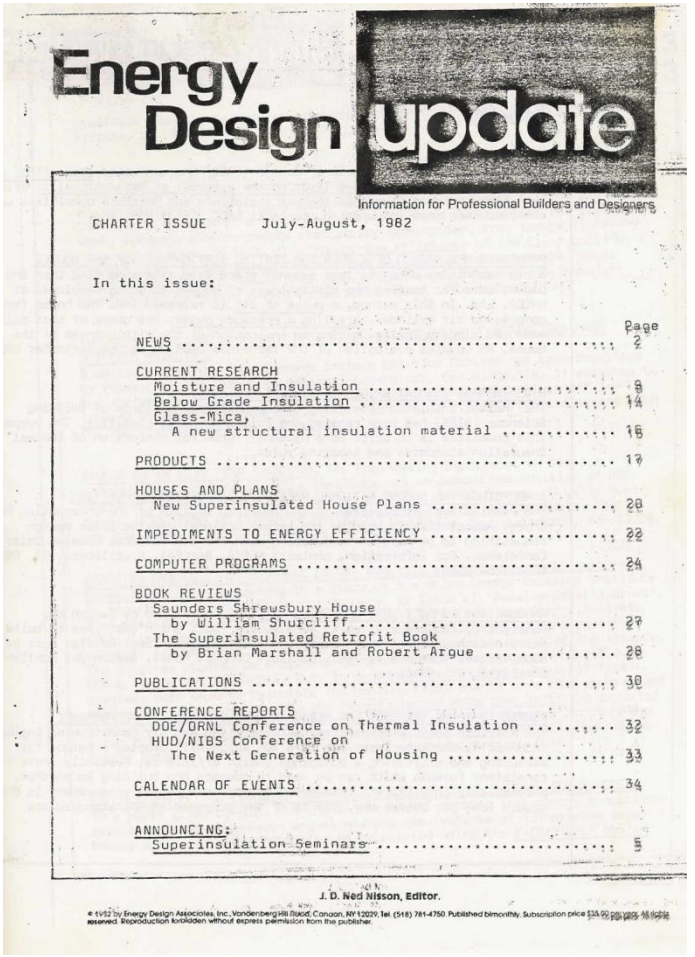
1977:
The Saskatchewan Conservation house.

(Just like the Passivhaus buildings of the 21st century, it was boxy and ugly.)

A historical perspective

In July 1982,
J. Ned Nisson began publishing a superinsulation newsletter, *Energy Design Update.*

I took over as editor in Jan. 2002.



Energy Design update

Information for Professional Builders and Designers

CHARTER ISSUE July-August, 1982

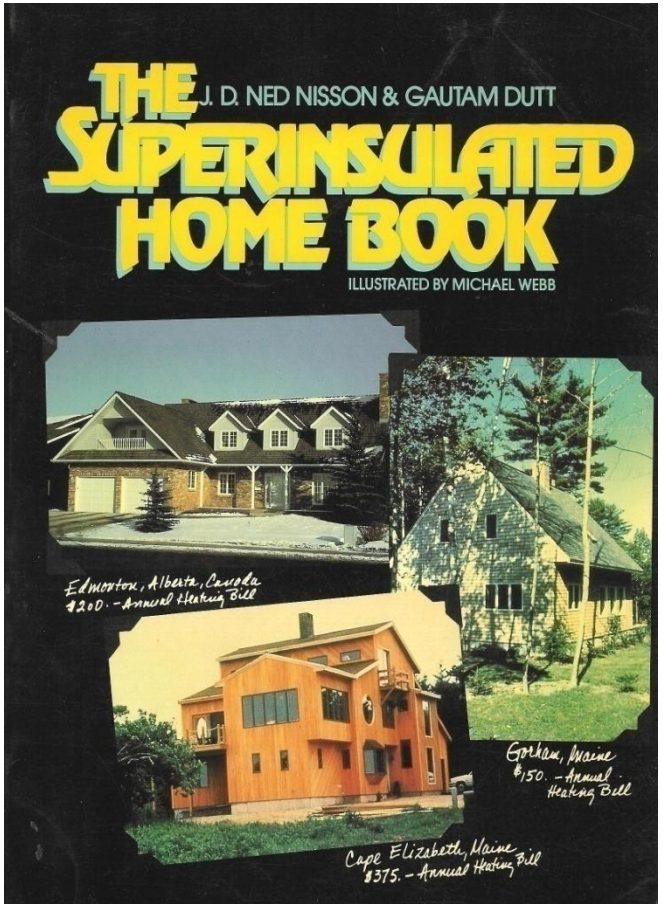
In this issue:

J. D. Ned Nisson, Editor.

1985: *The Superinsulated Home Book*

Authors:

- J. Ned Nisson
- Gautam Dutt, an engineer at Princeton University's Center for Energy & Environmental Studies.



1985: *The Superinsulated Home Book*

The book emphasized air sealing and provided details for:

- Double-stud walls
- Larsen-truss walls
- Foam sheathed walls
- Low-e coatings and argon-gas-filled glazing
- Triple-glazed windows

Superinsulation concepts were well understood in 1985

- Researchers had studied and quantified air leakage.
- Books and magazines with superinsulation details were widely available.
- Builders could buy low-e windows, triple-glazed windows, HRVs, and blower doors.
- Builders had developed techniques for building homes with very low rates of air leakage.
- Many high-performance homes with R-40 walls and R-60 ceilings were being built.

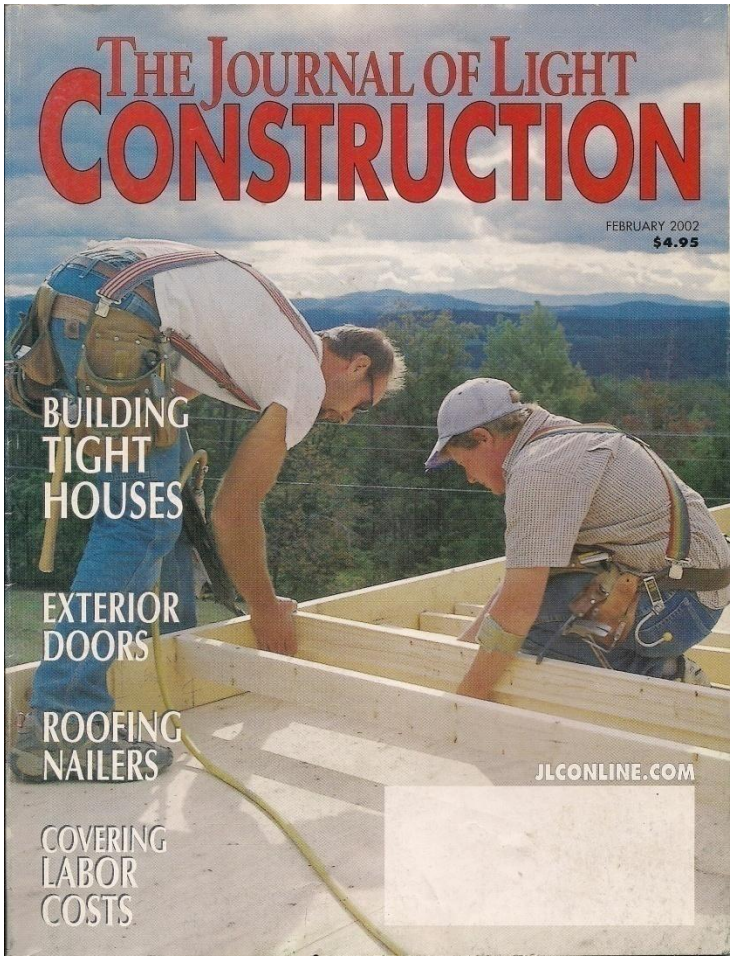
Eleven years later

In 1996,
Wolfgang Feist
founded the
Passivhaus Institut
in Germany

Fall 2001: David Hansen's house

Ten years ago, I reported on the construction of David Hansen's house in Vermont, which had:

- Double stud walls insulated with cellulose (R-35)
- R-60 ceiling
- Careful air sealing
- Triple-glazed Thermotech windows
- A Venmar HRV



EDU, Feb. 2002: A report on the Passivhaus project in Lindås, Sweden

I was the first American journalist to report on the Passivhaus standard:

"The holy grail of cold-climate energy-efficient design is **the house without a heating system**. In March 2001, in Lindås, Sweden, a nonprofit company completed construction of a 20-unit multifamily housing project that is said to have attained that goal."

RESEARCH AND IDEAS

Swedish Homes Without Heating Systems

The holy grail of cold-climate energy-efficient design is the house without a heating system. In March 2001, in Lindås, Sweden, a nonprofit company completed construction of a 20-unit multifamily housing project that is said to have attained that goal (see Figure 4). The Lindås homes, which were built by the local municipal housing authority, Egnahemsbolget, are so well insulated that the heat from occupants, appliances, and lighting is adequate to keep the houses warm, even through several weeks of cloudy winter weather. Moreover, the construction cost was not significantly more expensive than the cost of standard Swedish residential construction.

Winter Sunlight Is Scarce

The climate in Lindås (about 12 miles south of Göteborg) is not particularly cold. The winter design temperature is 5°F, about the same as for Boston, Massachusetts. But since the latitude of Lindås is 57.4° north — the same latitude as Sitka, Alaska — winter sunlight is rare. In December, Lindås has an average of only 0.26 kilowatt hours (kWh)/m²/day of insolation, a scant 20% of Boston's December average of 1.32 kWh/m²/day.

Although the Lindås houses have their long axis aligned east-west, and most of their glazing faces south, they do not depend on passive solar principles for winter heating. The project architect, Hans Eek of Göteborg Energy has a simple design philosophy: "There are three types of heat loss from a building: first,

Figure 4 — The municipal housing authority in Lindås, Sweden, recently built 20 housing units that are so well insulated that heat from the residents, lighting, and appliances provides all of the space heating requirements.

Spec Sheet: Lindås Housing

All specifications are per housing unit.

Location: Lindås, Sweden

Price: $200,000

Size: 120 m² (1,292 ft²)

Wall insulation: R-57 rigid polystyrene and mineral wool, total thickness 43 cm (17 in)

Roof insulation: R-71 rigid polystyrene and mineral wool, total thickness 48 cm (19 in)

Floor insulation: R-63 rigid polystyrene, 25 cm (10 in) thick, under concrete slab

Windows: U-0.15 wood-framed windows with triple-pane krypton-filled low-e glazing, manufactured by Överums Fönsterfabrik (Överum, S-590 96 Överum, Sweden; Tel: +011-46-0493-30420)

Domestic hot water: Solar with electric backup; storage tank size, 500 liters (132 gallons)

Solar thermal collector: 5 m² (54 ft²)

Heat recovery ventilator: Temovex unit with 85% heat recovery

Heating system: None

Estimated annual electrical use:

- Domestic hot water: 1,500 kilowatt-hours (kWh) (50% of 3,000 kWh, with balance provided by solar thermal collectors)
- Fans, pumps, etc.: 1,000 kWh
- Remaining household electricity: 2,900 kWh
- Total electrical budget: 5,400 kWh

Heat input design criteria:

- Estimated heat from occupants: 1,200 kWh per year
- Estimated heat from appliances: 2,900 kWh per year

Cost of energy-efficiency features (in US $):

- Extra insulation: $1,500-$2,000
- Heat-recovery ventilator: $1,000
- High performance windows (U-0.149, R-6.68): $1,500-$2,000 (cost over typical)
- High-efficiency appliances: $1,000 (cost over typical)
- Solar thermal system: $2,000

Total: $7,000-$8,000

Savings from omitting heating system: $4,000-$5,000

Net extra cost: $2,000-$4,000

EDU, Feb. 2004: A Passivhaus overview: "Superinsulated Houses in Europe"

"More than 3,000 superinsulated housing units have been built in Europe … [complying with] construction standards developed at **the Passivhaus Institut**."

Energy Design Update®

The Monthly Newsletter on Energy-Efficient Housing, from Aspen Publishers

Vol. 24, No. 2 February 2004

INDUSTRY NEWS

Superinsulated Houses in Europe

Over the past decade, more than 3,000 superinsulated housing units have been built in Europe as part of a program to build homes without conventional heating systems. The buildings follow construction standards developed at the Passivhaus Institut, a private research and consulting center in Darmstadt, Germany (see Table 1, page 2).

The Passivhaus Institut was founded in 1996 by engineer Wolfgang Feist, who designed his first "passive house" in 1991. As an increasing number of European builders adopted the Passivhaus superinsulation standards, Feist spearheaded a research project called CEPHEUS (Cost-Efficient Passive Houses as European Standards). The CEPHEUS initiative, which received funding from the European Commission from 1997 to 2002, promoted the construction and evaluation of 221 superinsulated housing units built to Passivhaus standards at 14 locations in five countries (Austria, France, Germany, Sweden, and Switzerland). Feist acted as CEPHEUS's scientific director.

As part of the CEPHEUS project, Swedish architect Hans Eek designed a multi-family residential development without heating systems in Lindås, Sweden (see *EDU*, February 2002). Eek and Feist were recently awarded the 2003 Göteborg International Environment Prize for their work promoting the development of houses without heating systems.

IN THIS ISSUE

What's a "Passive House"?

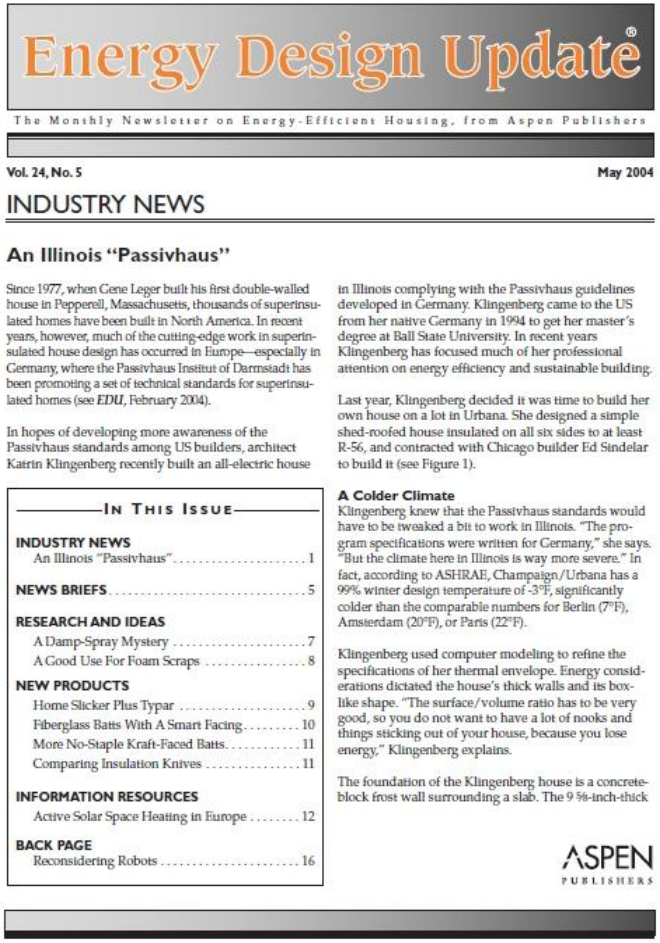
As used in Europe, the term "passive house" (German *Passivhaus*, French *maison passive*) refers not to what North Americans call a passive solar house, but to an energy-efficient superinsulated house. Some European advocates of "passive" houses prefer other terms, including "houses without heating systems" and "zero-energy houses," neither of which is strictly accurate. The Passivhaus Institut defines a "passive house" as a tight, superinsulated house with a design heating load no greater than 10 watts per square meter (equivalent to 3.17 Btuh per square foot, or 6,340 Btuh for a typical 2,000 square foot house).

The Passivhaus standards cover not only factors affecting the heating load, but also overall energy use, including baseload electricity use and energy used for domestic hot water. The overarching Passivhaus stan-

ASPEN PUBLISHERS

EDU, May 2004: An interview with Katrin Klingenberg and a report on the Smith house

"Architect Katrin Klingenberg recently built an all-electric house in Illinois complying with **the Passivhaus guidelines developed in Germany**."



Energy Design Update®

The Monthly Newsletter on Energy-Efficient Housing, from Aspen Publishers

Vol. 24, No. 5 May 2004

INDUSTRY NEWS

An Illinois "Passivhaus"

Since 1977, when Gene Leger built his first double-walled house in Pepperell, Massachusetts, thousands of superinsulated homes have been built in North America. In recent years, however, much of the cutting-edge work in superinsulated house design has occurred in Europe—especially in Germany, where the Passivhaus Institut of Darmstadt has been promoting a set of technical standards for superinsulated homes (see *EDU*, February 2004).

In hopes of developing more awareness of the Passivhaus standards among US builders, architect Katrin Klingenberg recently built an all-electric house in Illinois complying with the Passivhaus guidelines developed in Germany. Klingenberg came to the US from her native Germany in 1994 to get her master's degree at Ball State University. In recent years Klingenberg has focused much of her professional attention on energy efficiency and sustainable building.

Last year, Klingenberg decided it was time to build her own house on a lot in Urbana. She designed a simple shed-roofed house insulated on all six sides to at least R-56, and contracted with Chicago builder Ed Sindelar to build it (see Figure 1).

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A Colder Climate

Klingenberg knew that the Passivhaus standards would have to be tweaked a bit to work in Illinois. "The program specifications were written for Germany," she says. "But the climate here in Illinois is way more severe." In fact, according to ASHRAE, Champaign/Urbana has a 99% winter design temperature of -3°F, significantly colder than the comparable numbers for Berlin (7°F), Amsterdam (20°F), or Paris (22°F).

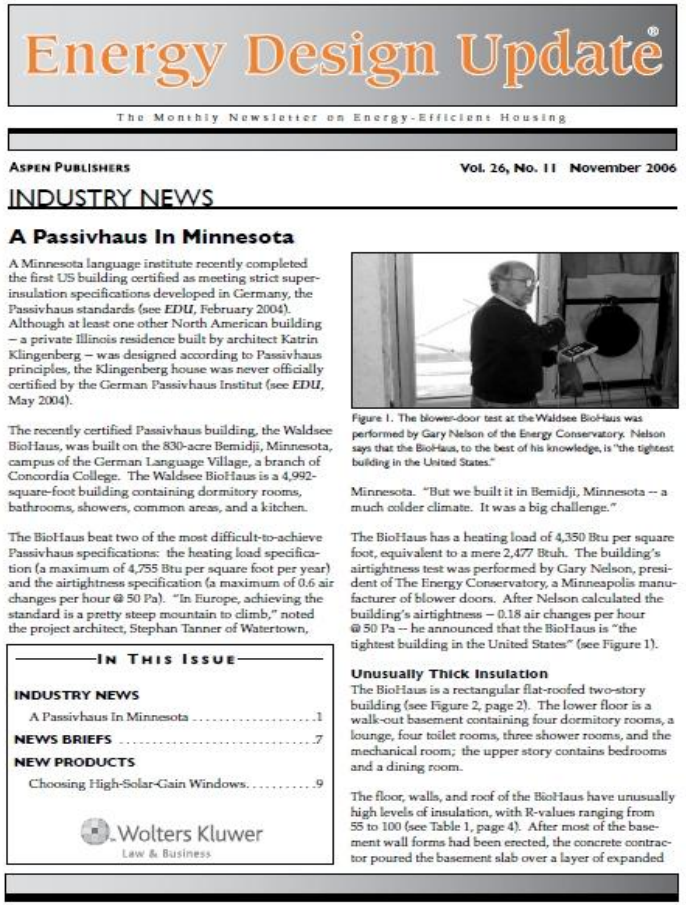
Klingenberg used computer modeling to refine the specifications of her thermal envelope. Energy considerations dictated the house's thick walls and its box-like shape. "The surface/volume ratio has to be very good, so you do not want to have a lot of nooks and things sticking out of your house, because you lose energy," Klingenberg explains.

The foundation of the Klingenberg house is a concrete-block frost wall surrounding a slab. The 9 ⅝-inch-thick

ASPEN PUBLISHERS

EDU, Nov. 2006: A report on the Waldsee BioHaus in Minnesota

"A Minnesota language institute recently completed **the first U.S. building** certified as meeting strict superinsulation specifications developed in Germany, the Passivhaus standards."



Energy Design Update®

The Monthly Newsletter on Energy-Efficient Housing

ASPEN PUBLISHERS — Vol. 26, No. 11 November 2006

INDUSTRY NEWS

A Passivhaus In Minnesota

A Minnesota language institute recently completed the first US building certified as meeting strict super-insulation specifications developed in Germany, the Passivhaus standards (see *EDU*, February 2004). Although at least one other North American building – a private Illinois residence built by architect Katrin Klingenberg – was designed according to Passivhaus principles, the Klingenberg house was never officially certified by the German Passivhaus Institut (see *EDU*, May 2004).

The recently certified Passivhaus building, the Waldsee BioHaus, was built on the 830-acre Bemidji, Minnesota, campus of the German Language Village, a branch of Concordia College. The Waldsee BioHaus is a 4,992-square-foot building containing dormitory rooms, bathrooms, showers, common areas, and a kitchen.

The BioHaus beat two of the most difficult-to-achieve Passivhaus specifications: the heating load specification (a maximum of 4,755 Btu per square foot per year) and the airtightness specification (a maximum of 0.6 air changes per hour @ 50 Pa). "In Europe, achieving the standard is a pretty steep mountain to climb," noted the project architect, Stephan Tanner of Watertown,

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Figure 1. The blower-door test at the Waldsee BioHaus was performed by Gary Nelson of the Energy Conservatory. Nelson says that the BioHaus, to the best of his knowledge, is "the tightest building in the United States."

Minnesota. "But we built it in Bemidji, Minnesota -- a much colder climate. It was a big challenge."

The BioHaus has a heating load of 4,350 Btu per square foot, equivalent to a mere 2,477 Btuh. The building's airtightness test was performed by Gary Nelson, president of The Energy Conservatory, a Minneapolis manufacturer of blower doors. After Nelson calculated the building's airtightness – 0.18 air changes per hour @ 50 Pa -- he announced that the BioHaus is "the tightest building in the United States" (see Figure 1).

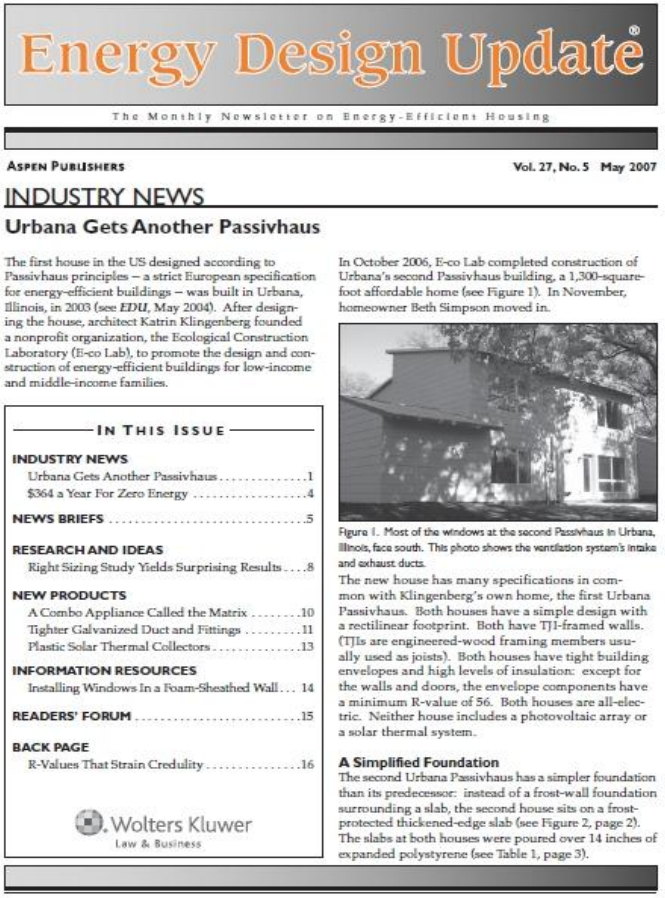
Unusually Thick Insulation

The BioHaus is a rectangular flat-roofed two-story building (see Figure 2, page 2). The lower floor is a walk-out basement containing four dormitory rooms, a lounge, four toilet rooms, three shower rooms, and the mechanical room; the upper story contains bedrooms and a dining room.

The floor, walls, and roof of the BioHaus have unusually high levels of insulation, with R-values ranging from 55 to 100 (see Table 1, page 4). After most of the basement wall forms had been erected, the concrete contractor poured the basement slab over a layer of expanded

EDU, May 2007: A report on the Fairview I project in Urbana, Illinois

"In October 2006, E-co Lab completed construction of **Urbana's second Passivhaus building**, a 1,300-square-foot affordable home."



Energy Design Update®

The Monthly Newsletter on Energy-Efficient Housing

ASPEN PUBLISHERS — Vol. 27, No. 5 May 2007

INDUSTRY NEWS

Urbana Gets Another Passivhaus

The first house in the US designed according to Passivhaus principles – a strict European specification for energy-efficient buildings – was built in Urbana, Illinois, in 2003 (see *EDU*, May 2004). After designing the house, architect Katrin Klingenberg founded a nonprofit organization, the Ecological Construction Laboratory (E-co Lab), to promote the design and construction of energy-efficient buildings for low-income and middle-income families.

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Wolters Kluwer Law & Business

In October 2006, E-co Lab completed construction of Urbana's second Passivhaus building, a 1,300-square-foot affordable home (see Figure 1). In November, homeowner Beth Simpson moved in.

Figure 1. Most of the windows at the second Passivhaus in Urbana, Illinois, face south. This photo shows the ventilation system's intake and exhaust ducts.

The new house has many specifications in common with Klingenberg's own home, the first Urbana Passivhaus. Both houses have a simple design with a rectilinear footprint. Both have TJI-framed walls. (TJIs are engineered-wood framing members usually used as joists). Both houses have tight building envelopes and high levels of insulation: except for the walls and doors, the envelope components have a minimum R-value of 56. Both houses are all-electric. Neither house includes a photovoltaic array or a solar thermal system.

A Simplified Foundation

The second Urbana Passivhaus has a simpler foundation than its predecessor: instead of a frost-wall foundation surrounding a slab, the second house sits on a frost-protected thickened-edge slab (see Figure 2, page 2). The slabs at both houses were poured over 14 inches of expanded polystyrene (see Table 1, page 3).

EDU, Jan. 2008: An interview with Wolfgang Feist

"The building process for the first Passivhaus prototype started in 1990."

Energy Design Update®

The Monthly Newsletter on Energy-Efficient Housing

ASPEN PUBLISHERS — Vol. 28, No. 1 January 2008

INDUSTRY NEWS

An Interview With Wolfgang Feist

In the 1990s, a movement arose in Germany and Austria to build extremely well insulated houses. Equipped with R-50 walls and triple-glazed U-0.14 windows, with maximum air leakage rates of 0.6 ACH @ 50 Pa, these homes have envelope specifications that beat most buildings in the world. The houses are performing very well, providing residents with a high degree of thermal comfort and extremely low energy bills.

The buildings adhere to standards promoted by Dr. Wolfgang Feist, a physicist from Darmstadt, Germany (see Figure 1). Feist calls these buildings, which can now be found in a dozen countries, "Passivhaus" buildings; the name was chosen because the buildings, in theory, have no active heating systems.

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Figure 1. Dr. Wolfgang Feist, the founder and director of the Passivhaus Institut in Darmstadt, Germany, traveled to the US in November 2007 for speaking engagements in Washington, DC, and Urbana, Illinois.

Like the term "zero-energy home," the "Passivhaus" label has been challenged by some critics. As it turns out, almost all Passivhaus buildings in Central Europe include an active heating system — usually, a heating coil in the home's ventilation supply duct. Most of these heating coils circulate hot water produced by a gas-fired water heater or a heat-pump water heater; in some cases, electric resistance heat coils are used.

Early promoters of the Passivhaus standards often bragged that Passivhaus buildings were so energy-efficient that they did not require a heating system. More accurate writers explained that they did not require a "conventional" heating system; in Europe, a conventional heating system is understood to mean a hydronic system fueled by a gas-fired or oil-fired boiler.

What I like about the Passivhaus standard

1. It is based on the concepts championed by the North American pioneers of superinsulation.
2. It sets a high bar for airtightness.
3. It requires high-performance windows.
4. It addresses thermal bridging.

What I like about the Passivhaus standard

5. It focuses on envelope improvements rather than fancy equipment.

6. It sets an energy goal that is in the ballpark of what will be necessary to achieve required carbon reductions.

7. PHPP is an extremely useful and accurate design tool.

What I like about the Passivhaus standard

8. The Passivhaus standard is now attracting wide attention, and designers are thinking and talking about design details in a new way.
9. The number of Passivhaus buildings is growing.

Hooray!

Seven Passivhaus missteps

1. Calling these superinsulated houses “passive” is problematic.
2. The claim that these are “houses without heating systems” is false.
3. Delivering heat through ventilation ducts makes no sense.
4. The annual space heat limit of 15 kWh/m²·year is arbitrary.
5. PHPP has no cost-effectiveness feedback.
6. The standard has a small house penalty.
7. The standard doesn’t distinguish between energy sources.

Misstep #1: The word “passive”

- Both “Passivhaus” and “passive house” are problematic descriptors.
- Passivhaus buildings can easily be confused with passive solar buildings, especially if English writers use the “passive house” spelling.

Misstep #1: The word “passive”

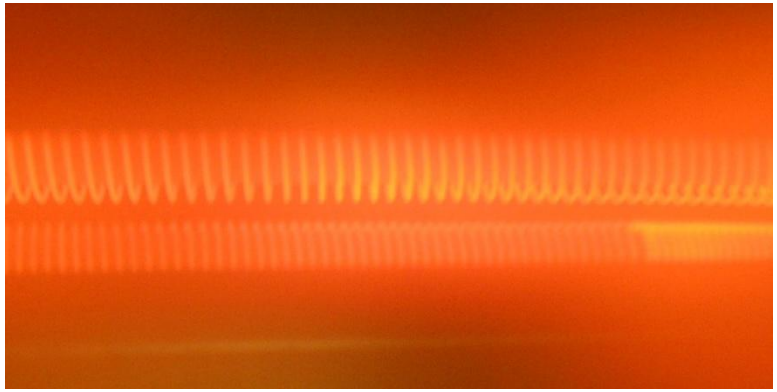
European promoters of Passivhaus buildings falsely claim that these buildings were “passive” because they do not require a heating system.

Misstep #2: “No heating system”

I was snookered by Hans Eek, who told me in a phone interview that the Lindås development was “the first project in Sweden without any heating systems.”

Oops — Lindås project needs space heat

EDU, July 2005: "Total mean electrical energy use per apartment [at the project in Lindås] was 8,200 kWh per year, including 1,800 kWh per year for space heating, 700 kWh per year for ventilation, and 1,700 kWh per year for domestic hot water."



Space heating requirements are very low — so why exaggerate?

Misstep #2: “No heating system”

- Is it accurate to say that these are “homes without heating systems” — or “Häuser ohne Heizung”?

- The claim is plastered all over the Web, in articles posted by writers from Germany, Ireland, Sweden, Denmark, Norway, and the U.S.

Germany: “Häuser ohne Heizung” – www.bauen.de

Passivhaus: Häuser ohne Heizung

Passivhäuser versprechen deutlich reduzierte Energiekosten. Aber es geht noch besser. Speziell nachgerüstete Häuser sind sogar in der Lage, ein Plus an Energie zu erwirtschaften.

von Michael Gneuss

Passive House: Houses without heating

Passive houses promise significantly reduced energy costs. But it gets even better. Specially retrofitted houses are even able to earn an increase in energy.

Michael Gneuss

Ireland: “Passive Aggressive” by Jason Walsh - www.constructireland.ie

Imagine moving into a house without a heating system – what would you do? Contact the developer and demand they put one in immediately? Call a solicitor and sue the builder? Or sit back and enjoy living in a house, designed to meet your expectations of comfort without any recourse to a space heating system. **Jason Walsh** met the people behind Ireland’s drive toward the passive house.

Ireland: “A Day In the Green Life” by Jennifer O’Connell

Tomas O’Leary runs an architectural practice, MosArt. He lives with his family in Wicklow in Ireland’s first ‘passive’ house - a new home without a heating system which he designed himself. There are 7,500 of these houses in Europe, and the first was built in the United States four years ago. He is married to Mairead, and they have three daughters - Aoife (7) and twins Ciara and Siofra (4).

Ireland: “Going Blue for Green” - www.corkindependent.com

This, however, is exactly what a new group are proposing. The Passive House Association of Ireland (PHAI) this week said that people could save themselves thousands of euro each year by building one of these passive houses. That is a rather unremarkable claim considering you are leaving out one of the most integral systems of the modern home. Without a heating system with all the costs in plumbing, maintenance and restocking whatever fuel source one goes for, of course it’s going to be cheaper. Why not really crunch the numbers and live in a wendy house in the garden and rent out the house to greedy gas-guzzlers?

Sweden: "Zero Energy Housing With Low Environmental Impact"
by Niels Welmer and Michiel Ham - architecture.ucd.ie

2.5 Lindas Sweden (2002)

The Lindas project of architect Hans Eek in Sweden provides insight in how to make a house without a heating system.

Fig 7. Houses at Lindas Sweden

The principle for creating a house without a heating system is also remarkable simple. Thick insulation and airtight detailing combined with optimal use of passive solar energy provide the basis. A heat recovery ventilation system and the internal heat production provide a comfortable home, even during the winter. The balcony

Sweden: “What Is a Passive House?” – www.rec-indovent.se

What is a passive house?

Interest in energy efficiency has increased significantly in recent years. Regardless of the application area, there is discussion of how the same function can be obtained but with considerably less energy used. These ideas are also applicable to the housing sector and there has been talk of reducing energy needs created by electrical devices, hot water generation and heating. For all three functions, there are technical alternatives for reducing energy needs.

The idea behind the passive house concept is that no distributed energy whatsoever should be needed. Buildings instead are heated passively by energy from occupants, electrical appliances and sunshine, in short, a building without a heating system. Passive houses can be nearly self-heating.

Sweden: “Houses Without Heating Systems” - www.energieffeckttivabyggnader.se

Houses without Heating Systems

20 low energy terrace houses in Göteborg

Denmark: “How is a Passive House Built?” – Saint-Gobain Isover - www.komforthusene.dk

Passive houses

A passive house stands out by having an incredibly warm and comfortable indoor climate, and by having very limited energy consumption.

Each passive house thus actively contributes to the protection of the climate.

The concept of the passive house is to build a house that can retain heat and use the heat from the sun, also known as passive heating, so that ultimately there is no need for heat supply or a heating system.

By building in accordance with the passive house concept and adding the best principles of the building physics, we get a building that is warm, comfortable and healthy to live in.

Hence the name COMFORT HOUSES.

Norway: "Passive Houses in Norway" by Andreas Halse – www.lavenergiboliger.no

One of the solutions currently being developed is the passive house. A passive house is defined as a house without a heating system. It is designed and constructed in a manner that makes it possible to maintain satisfactory indoor temperatures even without a heating source. Passive houses are currently being built in several different European countries, both commercially as well as on a more scientific basis. Germany and Austria are so far the two countries where the passive house concept has reached the highest degree of penetration, with more than 4000 houses built. In Norway no commercial passive houses have been built as of date.

U.S.A.: A PowerPoint presentation by Dylan Lamar (2005) - ewb-uiuc.org

PASSIVE HOUSE

LIVING WITHOUT A HEATING SYSTEM

U.S.A.: “Passive Homes Take Green Building to the Next Level” by Sarah Rigg – www.mlive.com

Passive homes take green building to the next level

Published: Thursday, May 14, 2009, 6:10 AM Updated: Thursday, May 14, 2009, 10:54 AM

NO IMAGE

By Sarah A. Rigg

Follow

Building a home in Michigan without a heating system might sound like a strange thing to do, but a handful of so-called "passive houses" already exist and more may be on the way.

These houses capture and store heat from the sun in extremely tight building envelopes, negating the need for a furnace.

They're built with thick walls, south-facing windows and energy-storing materials including concrete.

Misstep #3: Space heat should be delivered through ventilation ducts

To bolster the claim that these houses don't require heating systems, it was proposed that all space heat should be delivered through ventilation ducts.

Later, this proposal was effectively rescinded.

Misstep #3: Space heat should be delivered through ventilation ducts

The rationale:

1. We've decided to call these houses "passive," so they can't have a furnace or a boiler.
2. If we add heat to the ventilation system, it's disguised, so we can still claim that the house has no heating system.

Misstep #3: Space heat should be delivered through ventilation ducts

Problems with this idea:

- Ventilation airflow requirements are quite low — often only 40 cfm — while the delivery of space heat or cooling generally requires higher air flows.
- In a cold climate, air-flow limitations and limitations on the maximum temperature of ventilation air make this heat-delivery method impossible.

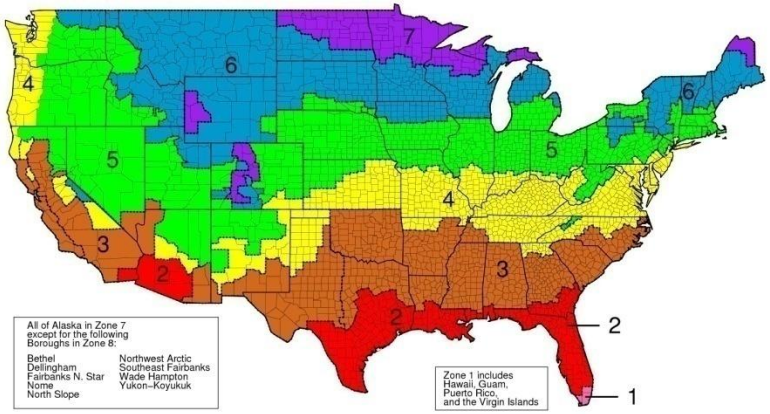
Misstep #3: Space heat should be delivered through ventilation ducts

Some Passivhaus documents make a fetish of requiring that all duct systems deliver 100% outdoor air and ridicule systems that include partial recirculation of indoor air.

Misstep #3: Space heat should be delivered through ventilation ducts

- The concept is arbitrary. Who cares how heat is delivered?
- The Passivhaus Institut has released contradictory statements on whether the delivery of heat through ventilation ducts is required.

Misstep #4: 15 kWh/m²·year is arbitrary



What is the basis for the annual space heat limit of 15 kWh/m²·year? It's easy to achieve in a mild climate, but difficult to achieve in a cold climate — leading many builders to argue that energy-use targets should vary by climate.

Misstep #4: 15 kWh/m²·year is arbitrary

Where did this limit come from?

1. Space heat must be delivered through ventilation ducts.
2. Ventilation rate = 0.3 to 0.4 air changes per hour.
3. Temperature of ducted air = no higher than 122°F.
4. The best windows in Europe are U-0.14 windows; the best achievable air tightness is 0.6 ach50.

With these limits specified, the best houses in a central European climate need 15 kWh per square meter per year for heating.

Misstep #5: PHPP has no cost-effectiveness feedback

- The standard design approach used by North American designers of net-zero-energy buildings is to compare the energy savings attributable to each measure under consideration with the energy production of a PV array.
- If $1,000 of insulation saves less energy on an annual basis than the energy produced by a $1,000 PV array, it's not worth installing.

Misstep #5: PHPP has no cost-effectiveness feedback

- Because PHPP has no cost-effectiveness feedback, cold-climate Passivhaus designers end up installing very high levels of insulation.

- The first few Passivhaus buildings in the U.S. had surprisingly thick layers of sub-slab foam — foam that was more expensive than PV.

Misstep #5: PHPP has no cost-effectiveness feedback

A warning bell went off: More expensive than PV?

Remember, when building a net-zero energy home, the cost of energy is known; it equals today's cost for PV-generated electricity.

The cost of PV-generated electricity is variously calculated at $0.28 to $0.75 per kWh.

Misstep #5: PHPP has no cost-effectiveness feedback

Thick sub-slab foam:

- 2004: The Smith house in Urbana, Illinois has 14 in. of sub-slab EPS foam.
- 2006: The Waldsee BioHaus in Bemidji, Minnesota has 16 in. of sub-slab EPS foam.

Misstep #5: PHPP has no cost-effectiveness feedback

2007: A house in Duluth, Minnesota, designed by Rachel Wagner and Michael LeBeau has R-60 sub-slab foam (12" of XPS) — and the home's thermal envelope *still falls short of the Passivhaus standard*

Misstep #5: PHPP has no cost-effectiveness feedback

2011: Ben Southworth's Lancaster, N.H. house:

- Floor is insulated with 12 inches of polyiso (about R-78).
- Walls: 12 inches of cellulose plus 2 inches of EPS (about R-51).
- Ceiling: 40 inches of cellulose (about R-148).

Misstep #5: PHPP has no cost-effectiveness feedback

	Vancouver	Winnipeg	Toronto	Yellowknife
Architectural features				
Thermal mass	Light weight framing	Light or medium weight framing or heavy masonry		
Orientation	South			
South-facing glass area	6% of floor area			
Building Enclosure				
Airtightness	0.50 ac/hr or as tight as possible			
Main walls	R-30 (RSI 5.28)	R-60 (RSI 10.57)	R-60 (RSI 10.57)	R-60+ (RSI 10.57+)
Attic	R-70 (RSI 12.33)	R-80 (RSI 14.09)	R-80 (RSI 14.09)	R-80+ (RSI 14.09+)
Basement walls	R-24 (RSI 4.23)	R-24 (RSI 4.23)	R-24 (RSI 4.23)	R-50 (RSI 8.81)
Basement floor	Uninsulated	R-10 (RSI 1.76) perimeter	Uninsulated	R-10 (RSI 1.76) perimeter
Windows	High ER units (see text)			
Mechanical systems				
Heating	Electric baseboard	Electric baseboards or Ground source heat pump (GSHP), COP = 3.0 Electric baseboards or GSHP, COP = 3.0		Electric baseboards or GSHP, COP = 4.0
Domestic hot water	a) Conservation package & b) Grey water heat recovery c) Thermal solar d) Domestic hot water heat pump system (possibly)			
Ventilation system	Ultra high-efficiency HRV			
Base loads	40% of R-2000 defaults or lower			
Cooling system	A/C, SEER=18			

Gary Proskiw and Anik Parekh, *Solplan Review*, Jan. 2011

Misstep #5: PHPP has no cost-effectiveness feedback

Gary Proskiw and Anik Parekh, *Solplan Review*, Jan. 2011:

Recommendations for insulation under a basement slab (assuming that all measures less expensive than PV are implemented):

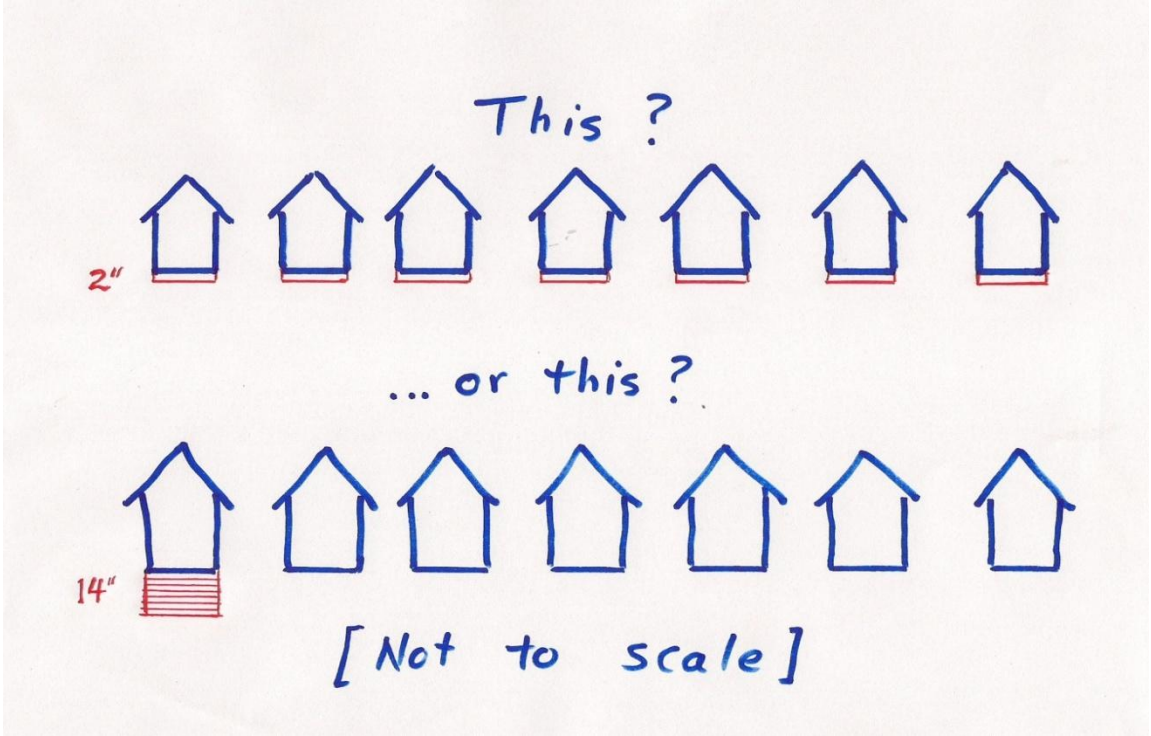
Vancouver: No insulation

Winnipeg: R-10 vertical insulation at slab perimeter

Toronto: No insulation

Yellowknife: R-10 vertical insulation at slab perimeter

Misstep #5: PHPP has no cost-effectiveness feedback

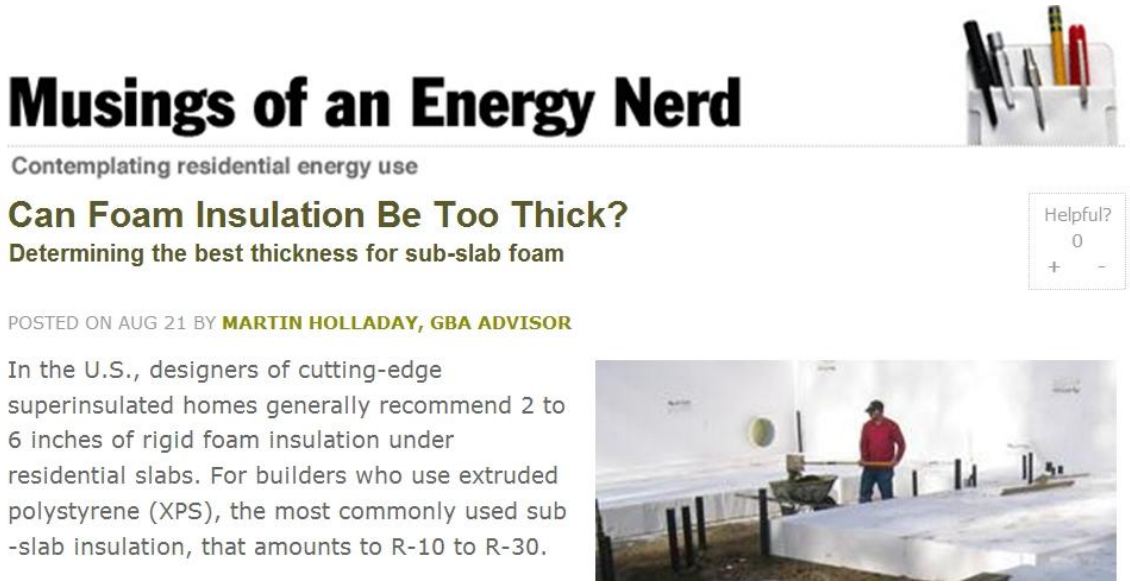


Passivhaus builders are "foam hogs":

When you install 14 inches of foam, the last 4 inches isn't saving much energy. Don't be greedy!

Misstep #5: PHPP has no cost-effectiveness feedback

A blog and a response



Musings of an Energy Nerd

Contemplating residential energy use

Can Foam Insulation Be Too Thick?

Determining the best thickness for sub-slab foam

Helpful? 0 + -

POSTED ON AUG 21 BY **MARTIN HOLLADAY, GBA ADVISOR**

In the U.S., designers of cutting-edge superinsulated homes generally recommend 2 to 6 inches of rigid foam insulation under residential slabs. For builders who use extruded polystyrene (XPS), the most commonly used sub-slab insulation, that amounts to R-10 to R-30.

Wolfgang Feist's response: "There are those deliberately spreading disinformation. What about spreading such nonsense as 'PV is more cost efficient' than slab insulation? Get real guys! … Not nice enough? Offer something better! Contribute to the development. And stop blaming others."

Misstep #5: PHPP has no cost-effectiveness feedback

Misstatements:

Dennis Wedlick, the architect who designed New York state's first passive house: "It's **the most cost-effective way** of accomplishing the least energy use."

Misstep #5: PHPP has no cost-effectiveness feedback

Misstatements:

Michael Hindle, certified PH consultant:
"Passive House provides **the most cost-effective means** of achieving the highest goals of LEED's energy performance criteria."

Misstep #5: PHPP has no cost-effectiveness feedback

Misstatements:

Web site of Solar Knights Construction in Napa, Calif.: "Passive House Construction: This standard has become our baseline for building near-zero, net-zero and carbon-neutral structures **in a cost-effective manner**."

Misstep #5: PHPP has no cost-effectiveness feedback

Misstatements:

Glenn Haupt, certified PH consultant: “Glenn strongly believes that Passive House design coupled with modest scale renewable energy generation is **the most cost-effective approach** for achieving net zero energy homes and carbon neutral homes today.”

Misstep #5: PHPP has no cost-effectiveness feedback

Misstatements:

The Artisan's Group Web site claims there is "growing national interest in Passive House as **the most cost-effective**, sensible solution to net-zero energy housing."

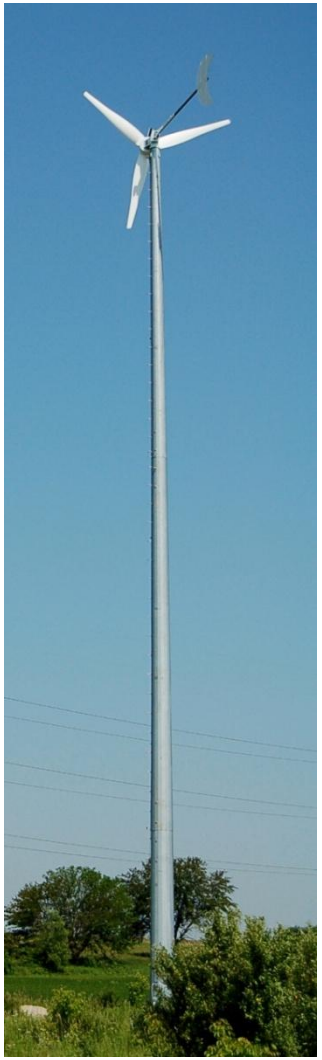
But the standard *ignores* cost effectiveness!

Misstep #6: The small-house penalty

Marc Rosenbaum: "Why should energy budgets be calculated on a per square meter basis instead of a per person basis?"

Misstep #7: The standard doesn't distinguish between energy sources

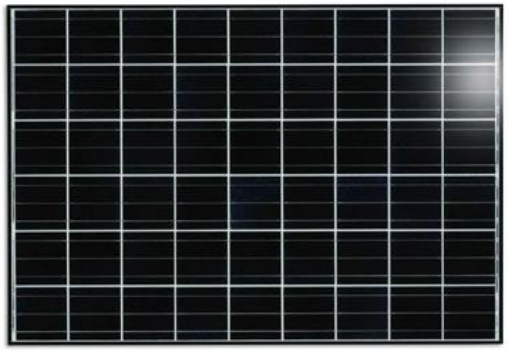
- If the source of a home's energy is biomass or a wind turbine, there is less of a need to design a heroic envelope than when the source of a home's energy is coal.
- Marc Rosenbaum: "There is certainly a point where load reduction should hand the baton over to renewable generation."



An all-or-nothing posture stifles legitimate questions

- A warning sign: watch out for **explanations that don't make sense**.
- Passipedia says that to be a Passive House, heating should be delivered through the ventilation system.
- Dr. Feist: A Passivhaus building needs to achieve 0.6 ach50 "because you get structural damage without airtightness."
- Dr. Feist: "The reason for the [window U-value] number which we now use in Europe is the comfort of the occupants."

Conclusions

$ <  = OK

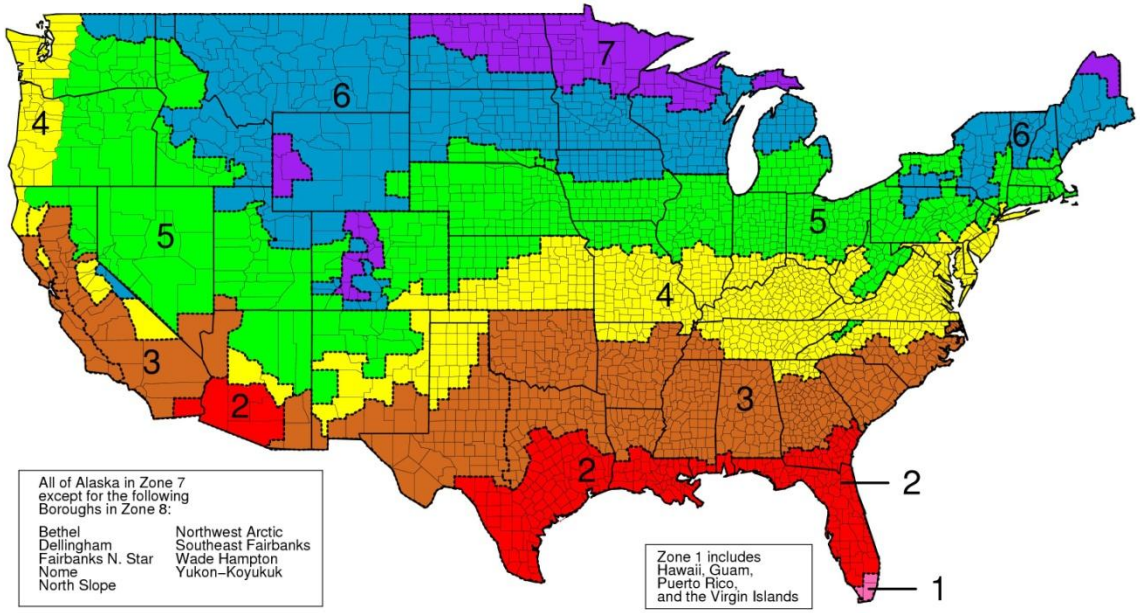
- If the Passivhaus standard can be achieved with insulation that doesn't cost more than PV, it's well worth achieving.
- However, saving BTUs at a higher cost than PV is wasteful of resources.

Conclusions

- We need to start talking about energy use per person, not per square meter.
- Let’s stop calling these “homes without heating systems.”
- Let’s start spelling “Passivhaus” the way it’s spelled in Britain.

Conclusions

How about climate-specific standards?



Upper Austria altered the standard

- Upper Austria (and 7 other Austrian states) decided to modify the Passivhaus standard.

- Area is calculated by measuring the outside area of a building (gross area) rather than using PHPP's "treated floor area" method.

Conclusions

Let’s change the standard, not abandon it.

Thanks

Martin Holladay

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