# BSI

**Building Science Insights**

BSI-026: PassivHaus Becomes Active—Further Commentary on PassivHaus

By John Straube *Created: 2009/10/05*

I have recently written about some aspects of the German Passiv Haus[1] housing standard (see BSI-025: The Passive House Standard and the GreenBuildingAdvisor.com) as it applies to cold climates (that is DOE Climate Zones 5 and higher) housing. The response to these ideas has been startling in its intensity and anger. I have received literally hundreds of emails and online forum postings. There are some who have tried hard to explain the intentions and science behind what is a very good low-energy house standard, and a remarkable number that have expressed outrage that someone like myself has the temerity to question the "Gospel according to Wolfgang."[2]

How can we, or anyone really, argue with houses that consume less energy by building with high levels of insulation, good airtightness, reduced thermal bridges, good windows, all while ensuring comfort, healthy air quality and cost-effectiveness? Of course we are not. This author personally, and Building Science Corporation through the US Department of Energy's Building America program, have been fervent advocates of this approach to housing for more than 15 years. The Building America program and others have sponsored millions of dollars of research that has resulted in literally hundreds of peer-reviewed scientific presentations and reports as well as tens of thousands of homes built exploring and developing exactly these attributes, and how far to exploit them, throughout all the climates zones of America.

The use of energy conservation in the building enclosure, and trading off these increased costs with lower heating and cooling systems cost is integral to our work. In fact, the "systems engineering approach" or "house as a system" has been promoted for 25 years in North America and pioneered in Canada by a BSC principal, Dr Joe Lstiburek. No less than Dr Amory Lovins has championed this approach to building low-energy buildings.

Research and field experience over the last two decades in all climate zones of the US have shown how to insulate and airtighten buildings. Research projects have built houses that demonstrate walls of R60, roofs of R100, airtightness levels of 0.3 ACH@50Pa, and triple-glazed windows. Although window performance has improved dramatically over time, the cost of high performance windows needs to improve further and this is one area where innovation is likely to drive costs down and performance up.

Much research work North America was begun 30 years ago, largely inspired by two or three projects. The influential Lo-Cal House, a 1976 design, and the 1977 Saskatchewan House, used very high-levels of insulation, airtight enclosures, triple-glazed windows, and air-to-air heat exchangers: the latter house even dispensed with a conventional furnace in a climate with 10 000 HDD (65°F). Experience with the many house designs inspired by these prototypes has taught us much about what does work, and what does not. The research in the last decades has been directed at delivering these types of houses economically while avoiding performance and durability problems that were identified.

All of the above is to point out that the German PassivHaus approach is in most of its general technical aspects neither unique nor innovative. Its primary distinction (and this important is that it prescribes a very low total primary energy consumption limit, 120 kWh/m$^2$/yr (38 kBtu/ft$^2$/yr), a separate site energy consumption limit of 15 kWh/m$^2$/yr (4.7 kBtu/ft$^2$/yr) for space heating/ cooling, and an airtightness target of 0.6 ACH@50 Pa. Despite claims that the PH standard is climate sensitive, these three absolute requirements are exactly the same in Miami as Minneapolis, Berlin, or Barcelona. There are potential arguments for and against setting climate-independent energy targets. I have just not seen them articulated.

Although not strictly required by the three performance targets, PH has been innovative in recommending the use of the ventilation air delivery system as the heating/cooling system and using heat recovery ventilation with more than 80% efficiency (this could now be a requirement in the US[3]). These recommendations have varying impacts on a home design, but the reasons why a design should not be acceptable without meeting these recommendations are not clear.

My apparently dangerous and provocative questions of the PH standard arise from the reasoning behind the choice of these targets and "requirements." The choice of 120 kWh/m$^2$/yr is essentially arbitrary, but that is fine: most other programs are also arbitrary in their aims such as 50% less than current housing (Architecture2030.org), or a 40% reduction over some code benchmark, or zero net energy consumption over a year (the Building America program goal). There are many homes that have achieved the 120 kWh/m$^2$/yr target by generating renewable energy on site, but this is not allowed in the Passiv Haus. Why not?

Relying on the purchase of large swaths of subsidized photovoltaic's or complex and expensive heating/cooling systems to reduce the energy signature of a building before using more economical strategies such as efficient appliances, good insulation, windows, and airtightness is widely accepted as a waste of resources (materials and money). Relying on excessive levels of insulation, airtightness, and window performance rather than considering the use of environmentally sound and more economical supplies of energy is also wasteful of resources and uneconomical (although until recently this has rarely been a problem).

Deciding on the optimum mix of conservation and generation is difficult because there are a range of costs and technologies available that depend on a building's location and occupancy. Compounding this challenge, the technology and cost of conservation and generation have changed over time and are expected to change in the future.

Renewable energy sources, such as photovoltaic (PV), wind, hydro, biomass, concentrating solar (CSP) and tidal are developing rapidly, and recent history suggests that the cost of these technologies will reduce the cost of renewable energy over time. Many expect the cost of PV and CSP to drop by half in the next 5 to 10 years as economies of scale are achieved. Wind power is already affordable. The Smart Grid being developed will allow widely dispersed, and millions of small power producers (such as homes) to distribute energy through the grid. The future for the vastly enhanced scale and lower cost of renewable energy look bright.

In contrast to PH, the Building America research program does not prescribe how a design in a specific climate should be assembled, only the primary energy target that must be reached. This focuses the design on reducing non-renewable energy depletion and minimizing environmental damage. It does require an economic analysis to demonstrate that efficiency measures have been fully exploited before renewable energy supply is added (e.g. all efficiency measures that are less expensive than the cost of generating renewable energy). Like PH, the goal is to provide cost-effective low-energy housing.

However, the requirement to limit the heating energy demand to only 15 kWh/m$^2$/yr is perplexing: depleting energy resources and environmental damage are already limited by the 120 number, why constrain the design further with no reduction in energy? And what is special about 0.6 ACH@50Pa? If a builder can deliver a house that uses less than 120 kWh/m$^2$/yr, with 1.5 ACH@50, why does this matter? Wolfgang himself offers some clues, as he states in an interview in the UK (at http://www.aecb.net/feist_videos.php) that the exceptionally low number is intended is to avoid interstitial condensation that can damage the structure. Far too many superinsulated homes of the past suffered this fate. Of course, we now have the practical and technical knowledge to completely avoid interstitial condensation in a house with 2 ACH@50 Pa and also know that dangerous rot could still occur at 0.6 ACH@50 if a double stud wall design is used. Again, there appears to be other lower-cost paths to reaching a low energy house target that are blocked by these prescriptive restrictions.

If cost is important to PH, why constrain designers? It should not come as a surprise that the relative cost of different strategies will be different in Minneapolis Minnesota than in Darmstadt, Germany (where the PassivHaus standard was developed) than in Bangor Maine or Boston Massachusetts. The rules of thumb that guide the "low cost" recommendations of the PH standard are often not low-cost in America.

When we have investigated the use of PassivHaus standards for some of our cold climate projects, we have found that the cost of some of the mandated conservation measures exceeded the cost of energy supplied by the lowest cost renewable energy source. In other cases, mandating the use of specific PassivHaus Institut approved products (imported from Germany) dramatically increases the cost while reducing the energy consumption by a trivial amount. The cost of local off-the-shelf equipment is often lower with essentially the same performance.

BSC is not the only research group to find that the PH standard may not always result in an optimal design. Two other Building America research groups, IBACOS and the Florida Solar Energy Center have concluded the same. Danny Parker's paper[4] found that "the Passivhaus concept risks overinvestment in conservation if a point is reached in the optimization process where adding solar electricity is a lower cost option than adding the next unit of insulation or air tightness." He also points out, as we have, that many other net-zero energy homes have over-invested in PV or ground-source heat pump technology. John Broniak of IBACOS presented the results of detailed energy analysis of typical American house design to Passiv Haus standards in six different US climates.[5] The conclusion was that following the PH Standard in the cold and hot-humid climate zone was "very challenging." Not surprisingly, these are the two climate zones that are the most different than the German climate where PH originated.

Another challenge is the PH program's use of German standards. While this is sensible in Germany, it causes confusion in North America. The floor area is measured according to a German standard, which was developed for different types of homes[6] than in America. The air leakage test referenced is EN 13829, rather than the very widely used ASTM test, the HRV efficiency is measured by the PassivHaus Institut in Germany rather than the HVI CAN/CSA C439, the window U-value is measured by ISO 12567, not the widely-used NFRC 500, ventilation is not by ASHRAE 62, and thermal comfort seems to differ from ASHRAE 55. Some of these standards are different in significant ways. For example, the German window U-value are based on an exterior temperature of 0°C, whereas the NFRC is based on an exterior temperature of -18°C (0°F ). Likewise, the HRV ratings in Germany are not at -13°F (-25 °C). The use of German or Euro standards result in small but sometimes significant impacts. Why would one not accept products based on North America standards if they are shown to be equal or better? There appears to be an assumption that all German standards are superior to North American ones, whereas in many cases the North American standards are just as strenuous or more so and more relevant to local conditions.

As I have repeated numerous times in numerous venues, the Passiv Haus standard has many excellent features. However, there are constraints to designers that raise the cost and complexity of delivering a house that do not result in lower energy consumption. The target of primary energy consumption before renewable energy use is rather strict, and appears to over emphasize conservation over energy generation in cold climates. Just as much a concern is that there appears to be a belief that the PH standard has some magic recipe or innovative approach that will make affordable low-energy houses. A discussion of the science and philosophy behind the PH standard can only help improve the standard and inform others, while an unquestioning belief that "it must be better" is helpful to no one. Lets hope the discussion can begin, and the dogma ends.

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## Footnotes

1. The German standard is called Passiv Haus and is essentially identical to that offered in the US. The US Passive House Institute prefers the term "Passive House," although this regularly is confused with passive houses popularized 20 years ago.
2. Two even claimed I must have some hidden financial or marketing interest to dare to question the Passiv Haus standard!
3. Katrin Klineberg of the Passive House Institute US recently blogged that "There are actually two PH requirements to assure the energy efficiency of the mechanical ventilation equipment". I could not find any limits in Chapter 14 the PHPP 2007, but perhaps there are some somewhere, which would mean there are more than three *requirements*.
4. *Energy and Buildings* 41 (2009) 512–520.
5. Broniek, J., "Could a European Super Energy Efficient Standard Be Suitable for the U.S.?", *BEST Conference*, Portland, 2008.
6. I spent a lot of time in 1991 at a German design-build firm calculating areas according to the Wohnflaechenverordnung. There are standard approaches in North America that also work well. I, and many real estate agents, simply value stairways and basements, dormers, and cathedral ceilings slightly differently than Germans.

**Related Documents**

BSI-025: The Passive House (Passivhaus) Standard—A comparison to other cold climate low-energy houses
BSI-014: Deciding on Energy Priorities When Building New

**Related External Links**

Housebuilder's Update: The Passive House: thoughts and reflections