Chris van Uffelen

Passive Houses

energy efficient homes

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Layout: Theresa Beckenbauer

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Preface

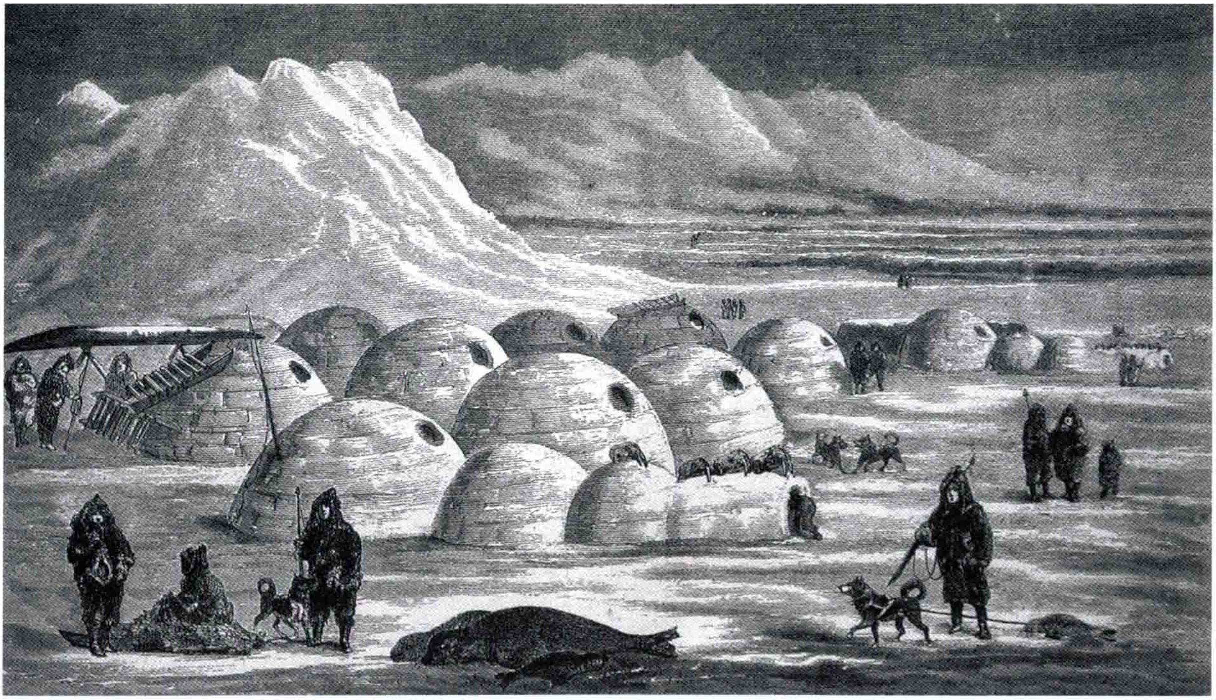
Since the 1970s, energy-saving and ecological techniques have come to affect all aspects of life; even becoming an integral part of politics. The first regulated and standardized low-energy houses appeared first in Sweden and then in Denmark. Since 1991, the Passive House has been setting new standards for architecture, especially in terms of single-family homes. The first standardized Passive House, designed by Wolfgang Feist and built by the architects Bott, Ridder and Westermeier, comprised four semi-detached houses in Darmstadt-Kranichstein. It was in 1988 that Feist, together with Swedish professor Bo Adamson, first defined what a Passive House should entail. He later founded the German Passivhaus Institut in Darmstadt in 1996; today, this institution still sets the standards for Passive House certification. Between 1999 and 2001, the CEPHEUS program (Cost Efficient Passive Houses as European Standards) was responsible for the construction of 221 residential units across in five European countries, increasing the total number of Passive Houses threefold. Oehler Faigle Archkom built the first standalone Passive House family home in Bretten in 1998, one year before the less rigorous low-energy standard regulation was introduced in Germany. Low-energy housing standards demands an annual heating requirement of less than 70kWh per square meter, whereas a Passive House requires less than 15 kWh/(m^2a) – this minimal heating demand (or cooling in warm regions) makes conventional central heating (or air conditioning) unnecessary. The conventional "active" systems get replaced by "passive" systems, systems that function due to the organization of building parts and systems, these do not use external primary energy but are operated by the house itself.

The definition of Passive House permits 15kWh/(m^2a) maximum heating or alternativly a peak heat load of 10 W/m^2. Further demands of the Passive House standard are that the building envelope has an air tightness of n50 ≤ 0,6/hour (blower door test) and that the primary energy demand is below a 120kWh/(m^2a) limit including all electrical appliances (heating/cooling, water and electricity). It is plain to see that Passive Houses around the world use different techniques to meet these requirements. While a house above 60° latitude would need a 335 milimeter thick insulation to stay below the required 10 W/m^2 peak load, a house in Australia needs intensive cooling, this can be achieved by gathering rainwater, for example. In Thailand, a Passive House needs Energy Recovery Ventilation to reduce the humidity load and meet the last demand, which requires that all the demands are met with no loss of comfort.

The open definition of a Passive House neither confines it to one particular building type – Passive House offices have become popular recently, as have kindergartens and factories – nor to one particular material – wood can be used, as can concrete or even snythetics. Passive Houses are environmentally-friendly because of their energy-saving properties, meaning that they do not necessarily need to be ecological in other aspects as well, they also do not have to be sustainable or 'green' (e.g. in terms of ecological footprint, life cycle assessment). The embodied energy involved in constructing a temporary summer pavilion from local recycled materials naturally makes it a much 'greener' option than building a highly-insulated shelter for one season. However, in terms of more usual and durable buildings, the Passive House is one of the most advanced sustainable building options. The extra cost of passive building pays off within a few years and, of course, the more expensive energy prices become, the faster the extra building expense is paid off. Furthermore, passive buildings guarantee quiet, constant ambient conditions, which makes working and living in them more comfortable: opening a window just has a very temporary effect on temperature and humidity, which quickly stabilize after windows are closed. Finally, most Passive Houses are ecological in more than just the passive aspect. Being aware of the advantages of this kind of building often goes hand-in-hand with awareness of other aspects of 'green' design (graywater, recycling and low-pollution materials) and intensive solar harvesting by efficient new solar modules. Combining this awareness with Passive House regulations can then result in a Zero- or even Plus-Energy House.

Different techniques can be used to build a Passive House; some of these are suitable for all climates, others just for specific regions. To meet the four demands listed above, the houses usually employ are range of techniques, although with different prioritization. The most important factor is the use of Superinsulation, which reduces heat transfer to a minimum (high R-values like Rip40 for walls and Rip60 for the roof and low U-values from 0.10 to 0.15 W/(m^2/K) are typical). This accompanies an Airtight Construction with air barriers that control air leakage into and out of the building and the careful air sealing of construction joints. Airtightness demands Controlled Ventilation: a mechanical heat recovery ventilation system that constantly provides fresh air is typical for a Passive House. Sometimes the intake air for the ventilation system is pre-heated or pre-cooled by earth warming tubes in the soil (earth-to-air exchangers). The ventilation system incorporates fresh air temperature control as the only kind of heating/cooling system, no radiators or air conditioners are installed. Different heating and cooling elements and a mechanical dehumidifying system can be part of the air supply system. Usually, Space Heating by waste heat from lighting, household appliances and other electrical devices should suffice. In addition to Superinsulation, the building envelope often features Advanced Window Technology: triple-pane, double-low-e insulated glazing, air-seals and specially developed thermally broken window frames result in high R-values and low U-values (from 0.85 to 0.70 W/(m^2K) for window pane plus frame). Optimized Daylighting (windows, skylights light tubes, reflective surfaces) reduces the primary energy consumption and provides comfort. When additional light is needed, the use of energy-saving lighting techniques, like light-emitting diode-lamps is preferred. Windows used in Passive Solar Design are oriented towards the equator to make use of direct sunlight, while on the other building side the envelope is as kept as closed as possible. In Central Europe, the northern façade faces the colder conditions, while the south often features large, glazed façades that gain heat even in midwinter. To prevent overheating in summer peaks, cantilevered roofs provide shade when the sun is high. In warm regions, Passive Solar Design uses brise soleils to reduce the heat. However, Passive Solar Design goes further than direct sun-use and shielding: walls and floors are used to collect, store, and distribute the solar energy all over the house (internal thermal mass). A massive heat storage can collect heat in summer and disperse it in winter (or the other way round). Another aspect of Passive Solar Design is the compact shape of the buildings. This reduces the surface size, so that the area to be insulated is smaller. Especially in warm regions, Energy-Efficient Landscaping is another important technique: trees and pergolas outside the building provide shade and vertical gardens on the walls and greened roofs are a natural source of insulation, absorbing solar energy. The positioning on the plot of land is also an important factor to be taken into consideration.

However, differences do not just exist between the climatic zones, even Germany, Austria and Switzerland have their own requirement specification for Passive Houses; despite the first two being members of the European Union. So being a Passive House or not can differ by a few kilometers (politically and climatically). The certification by the Darmstadt Passivhaus Institut (this has recently broken ties with the only Passive House certifier in the USA) is voluntary, so there is no final indication of what a Passive House should be like, despite the fact that energy use is measurable.



Inuit village Oopungnewing near Frobisher Bay on Baffin Island based on sketches by Charles Francis Hall, mid-19th century.