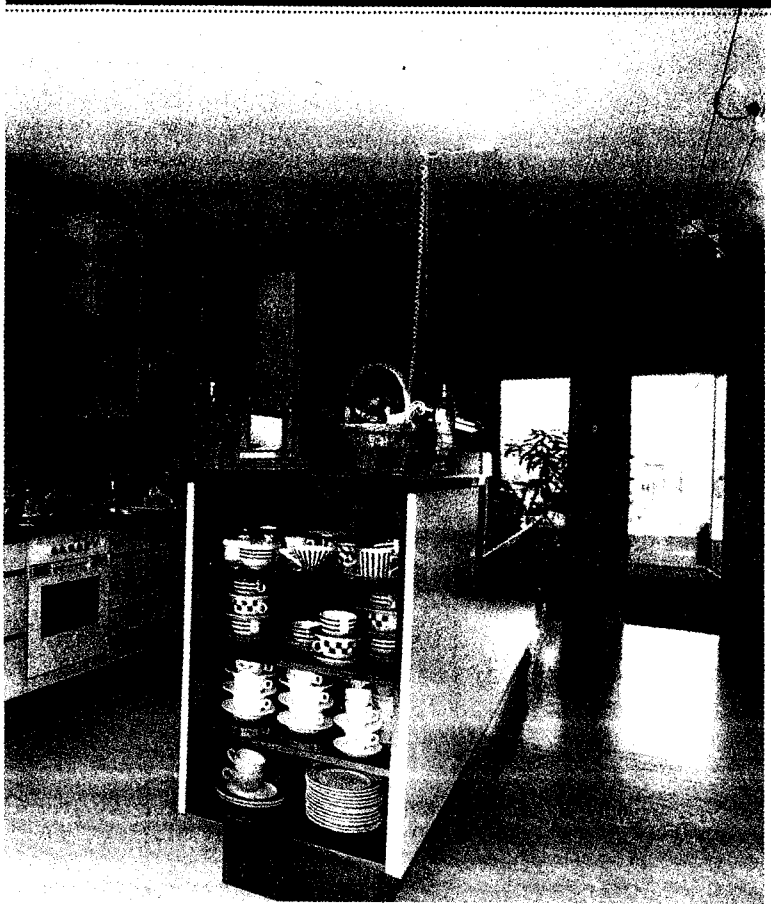
MAM 10

What Is a Passive House?



Interior view of Passive House in Darmstadt-Kranichstein, Germany
Photo: Pfäffinger

The term "Passive House" refers to a construction standard. The standard can be met using a variety of technologies, designs and materials. It is a refinement of the low-energy house (LEH) standard.

"Passive Houses" are buildings which assure a comfortable indoor climate in summer and in winter without needing a conventional heating system.

To permit this, it is essential that the building's **annual demand for space heating does not exceed 15 kWh/(m²a).** The minimal heat requirement can be supplied by heating the supply air in the ventilation system – a system which is necessary in any case. Passive Houses need about 80% less heating energy than new buildings designed to the standards of the 1995 German Thermal Insulation Ordinance (Wärmeschutzverordnung).

The standard has been named "Passive House" because the passive heat inputs – delivered externally by solar irradiation through the windows and provided internally by the heat emissions of appliances and occupants – essentially suffice to keep the building at comfortable indoor temperatures throughout the heating period.

It is a part of the Passive House philosophy that efficient technologies are also used to minimize the other sources of energy consumption in the building, notably electricity for household appliances. The target of the CEPHEUS project is to keep the total final energy demand for space heating, domestic hot water and household appliances below 42 kWh/(m²a). This is lower by at least a factor of 4 than the specific consumption levels of new buildings designed to the standards presently applicable across Europe.

Built Passive Houses

From left to right: Single-family house in Kaiserslautern-Erfenbach, Germany
Planning: BauWerk, Martin Ploss and Gerrit Horn; Photo: Pfäffinger
Terraced houses in Hörbranz/Vorarlberg, Austria
Planning: Richard Caldonazzi; Photo: Energieinstitut Vorarlberg
Passive house project in Wolfurt/Vorarlberg, Austria
Architect: Gerhard Zweier; Photo: Energieinstitut Vorarlberg
Passive house row in Neuenburg, Germany
Planning: Phasea, Freiburg and Rasch & Partner, Darmstadt; Photo: Pfäffinger
Single-family house in Köln-Weiss, Germany
Architect: Manfred Brausem, Cologne; Photo: Pfäffinger

Why Build Passive Houses?

The Passive House standard offers a cost-efficient way of minimizing the energy demand of new buildings in accordance with the global principle of sustainability, while at the same time improving the comfort experienced by building occupants.

It thus creates the basis on which it is possible to meet the remaining energy demand of new buildings completely from renewable sources – while keeping within the bounds set by the limited availability of renewables and the affordability of extra costs.

The Passive House philosophy builds upon two basic principles:

Principle 1:

Optimize what is essential anyway

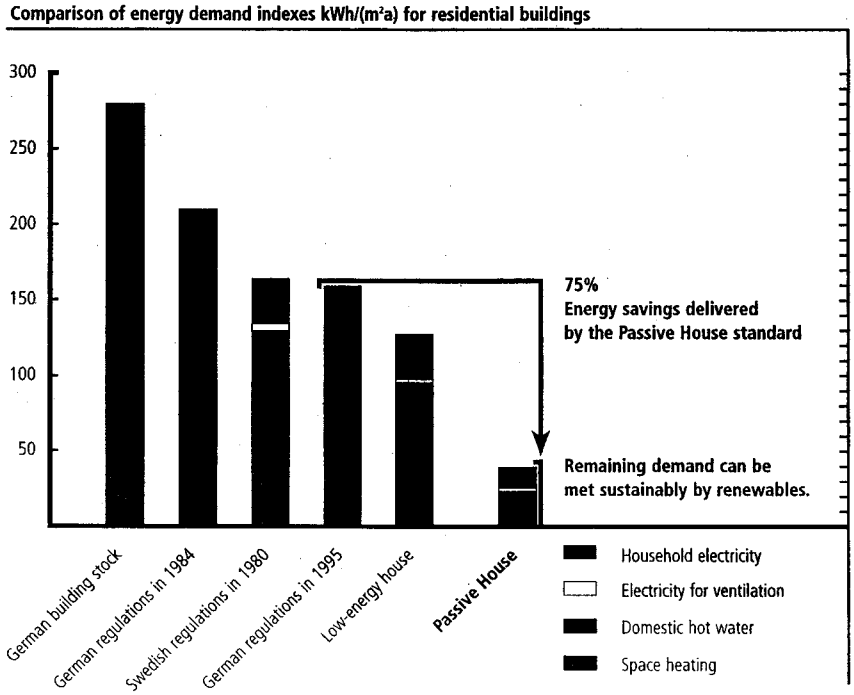
What makes the approach so cost-efficient is that, following the principle of simplicity, it relies on optimizing those components of a building which are necessary in any case: The building envelope, the windows and the automatic ventilation system expedient anyway for hygienic reasons. Improving the efficiency of these components to the point at which a separate heat delivery system can be dispensed with yields the savings which largely finance the extra costs of improvement.

Principle 2:

Minimize losses before maximizing gains

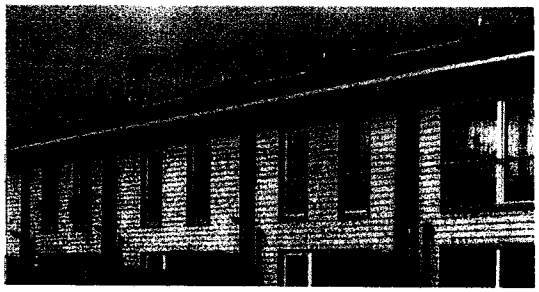
Passive Houses prevent available heat from escaping as rigorously as possible (i.e. give precedence to loss minimization). Both the computations carried out with theoretical models and the practical experience gathered with numerous projects show that, under Central European and comparable climatic conditions, such a strategy is fundamentally more efficient than strategies relying primarily upon passive or active solar energy use.

Comparison of energy demand indexes kWh/(m²a) for residential buildings



Passive Houses can be built cost-efficiently

The capitalized total costs (investments in the building including planning and building services plus running costs over a period of 30 years) are not higher than for an average new building.



What Makes a Building a Passive House?

Passive solar gain

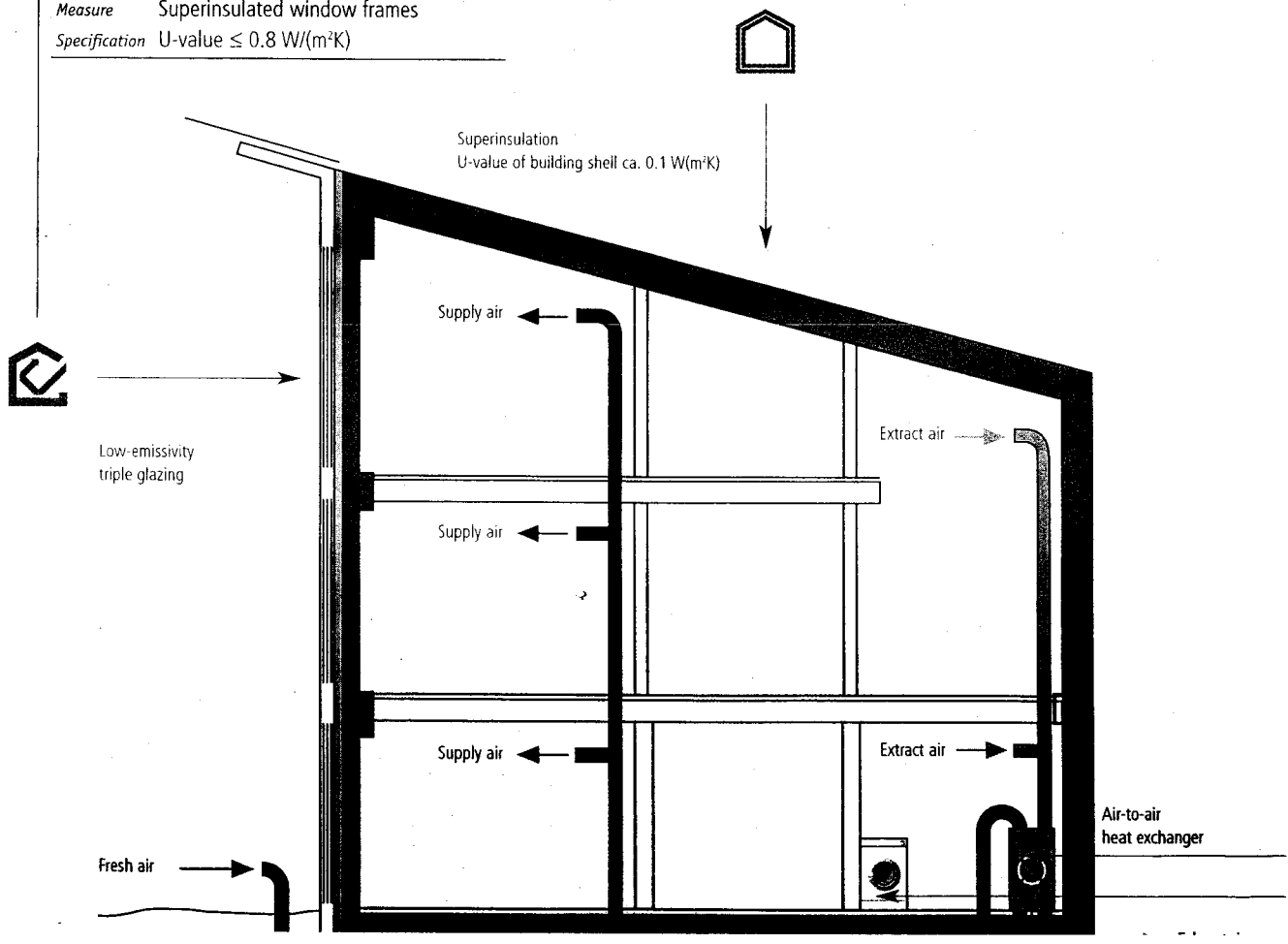
South-facing Passive Houses are also solar houses. Efficiency potentials having been exploited, the passive gain of incoming solar energy through glazing dimensioned to provide sufficient daylight covers about 40% of the minimized heat losses of the house. To achieve this, the – in most cases newly developed – windows have low-emissivity triple glazing and superinsulated frames. These let in more solar heat than they lose. The benefit is enhanced if the main glazing areas are oriented to the south and are not shaded.

Components	
Passive solar gain	
Measure	Optimized south-facing glazing
Specification	Close to 40% contribution to space heating demand
Superglazing	
Measure	Low-emissivity triple glazing
Specification	U-value ≤ 0.75 W/(m²K), solar transmission factor ≥ 50%
Superframes	
Measure	Superinsulated window frames
Specification	U-value ≤ 0.8 W/(m²K)

Superinsulation

Passive houses have an exceptionally good thermal envelope, preventing thermal bridging and air leakage. To be able to dispense with an active heating system while maintaining high levels of occupant comfort, it is essential to observe certain minimum requirements upon insulation quality.

Components	
Building shell	
Measure	Superinsulation
Specification	U-value ca. 0.1 W/(m²K)
Building element junctions	
Measure	Thermal-bridge-free construction
Specification	Ψ (linear thermal transmittance, exterior dimensions) below 0.01 W/(mK)
Airtightness	
Measure	Airtight building envelope
Specification	less than 0.6 air changes per hour at n_{50}



Combining efficient heat recovery with supplementary supply air heating

Passive houses have a continuous supply of fresh air, optimized to ensure occupant comfort. The flow is regulated to deliver precisely the quantity required for excellent indoor air quality. A high-performance heat exchanger is used to transfer the heat contained in the vented indoor air to the incoming fresh air. The two air flows are not mixed. On particularly cold days, the supply air can receive supplementary heating when required.
Additional fresh air preheating in a subsoil heat exchanger is possible, which further reduces the need for supplementary air heating.

	Components
Hygienic ventilation	
Measure	Directed air flow through whole building; exhaust air extracted from damp rooms
Specification	Around 30 m^3 per hour and person
Heat recovery	
Measure	Counterflow air-to-air heat exchanger
Specification	Heat transfer $\eta \geq 80\%$
Latent heat recovery from exhaust air	
Measure	Compact heat pump unit
Specification	Max. heat load 10 W/m^2K
Subsoil heat exchanger	
Measure	Fresh air preheating
Specification	Fresh air temperature $\geq 8°C$

Electric efficiency means efficient appliances

Through fitting the Passive Houses with efficient household appliances, hot water connections for washing machines and dishwashers, airing cabinets and compact fluorescent lamps, electricity consumption is also slashed – by 50% compared to the average housing stock, without any loss of comfort or convenience. All building services are designed to operate with maximum efficiency. The ventilation system, for instance, is driven by highly efficient DC motors. High-efficiency appliances are often no more expensive than average ones. As a rule, they pay themselves back through electricity savings.

Meeting the remaining energy demand with renewables

Cost-optimized solar thermal systems can meet about 40–60% of the entire low-temperature heat demand of a Passive House. The low remaining energy demand moreover makes something possible which would otherwise be unaffordable, and for which available supply would not suffice:

Over the annual balance, the remaining energy consumption (for space-heating, domestic hot water and household electricity) is offset completely by renewable sources, making the Passive House fully primary-energy and climate neutral. This is being achieved in the CEPHEUS housing development in Hannover-Kronsberg.