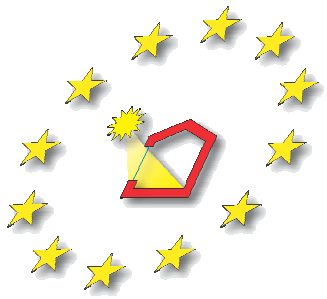

Germany

The Passive House

National Publication

proKlima
Der enercity-Fonds

What is a Passive House?

*In this age of **increased energy prices** and **emission excesses**, efficient energy use is becoming more and more important. This is no longer solely an environmental consideration, but increasingly also a financial one. Some **40% of our annual energy consumption** is used in buildings. The Passive House concept primarily focuses on residential buildings, though these principles are applicable in other building types as well. As the numbers show, **energy-wise**, there is **much to be gained in buildings**. For this reason, more and more building professionals have recognized the Passive House approach as the sensible way forward.*

The Passive House is a residence that has been optimally designed to retain energy. Much attention is paid to performance of the materials and components with respect to **indoor climate**. The advantage being that temperatures inside the residence have very few fluctuations, resulting in **notably higher indoor comfort.**

The **Passive House concept** applies **established techniques** and **solid design principles** to realize a residence that utilizes it's energy optimally.
By **reducing heat losses** to a minimum through optimal insulation and heat recovery techniques and **maximizing passive heat gains**, the Passive House is so efficient that it no longer requires a conventional heating system.
This means that the **cost savings** for the heating system can, in part, compensate for the higher cost of high performance building components.
Moreover, by using less energy over its lifetime, a Passive House not only generates a **smaller environmental impact**, it also incurs **lower energy costs** during use. In addition, a Passive House decreases the financial impact on occupants that rising energy prises may bring.

Introduction

What is PEP?

PEP, which stands for **'Promotion of European Passive Houses'** is a consortium of European partners, supported by the **European Commission**, Dictorate General for Energy and Transport.

Why Promotion of European Passive Houses?

It is generally recognized that, within the housing sector in Europe, **many building activities** can be expected over the coming decades. The old building stock will need to be refurbished or, in many cases, even demolished and new buildings erected. The existing housing stock is responsible for a **large share of our total energy consumption**, and therefore many **energy savings** can be accomplished in these upcoming reconstruction activities. As previous demonstration projects (such as CEPHEUS) have demonstrated, the **reduction of non-renewable energy demand** by a **factor 4** (compared to contemporary national standards) is not only **possible** but also **realistic**. The Passive House concept is a **sound** and relatively **low-cost method** to achieve these energy savings. To spread this knowledge throughout the professional building community, beyond the select group of specialists, PEP has set out to spread the experience gained throughout Europe on the Passive House concept.

What does PEP do?

Goal of P.E.P. is to promote regional economic activities, especially for SMEs (which perform a significant part of the work in the housing industry) in order to induce a substitution of expenses for energy use during the lifetime of houses with investment in the building envelope.

To achieve this goal, the consortium intends to:

- communicate the passive house concept and specific solutions in different European regions and climates

Introduction

- adapt the existing Passive House design tool (PHPP, Passive House Planning Package) to meet the demand of architects and planners in different countries
- develop practical information packages, such as building product documentation, design guides, research results, calculation methods and quality assurance activities to assist building professionals throughout Europe in the development of Passive Houses
- set up a certification program for Passive House buildings and technologies and a link to the national Energy Performance Certification system according to the EU building directive
- organize national workshops and the annual international Passive House Conference
- Create national Passive House websites for continuous up-to-date information provision

How can I find out more?

For more information, please contact:

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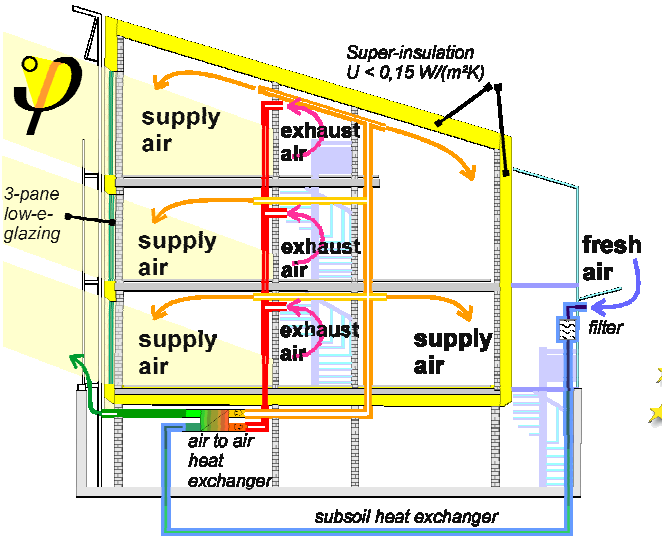
www.passiv.de, mail@passiv.de



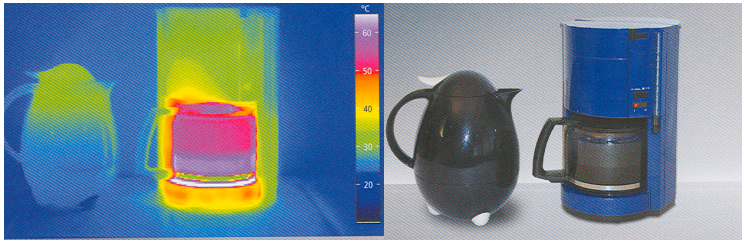
Passive House a definition

The term **Passive House** refers to a specific construction standard for residential buildings with good interior comfort conditions during winter and summer, without traditional heating systems and without active cooling. Typically this includes very good insulation levels, very good air- tightness of the building, whilst a good indoor air quality is guaranteed by a mechanical ventilation system with highly efficient heat recovery.

Thereby the design heat load is limited to the load that can be transported by the minimum required ventilation air. However space heating does not have to be carried through the ventilation system. For 40° - 60° Northern latitudes, under conditions specified in the PHPP calculation model[1]:

- the total energy demand for **space heating and cooling** is limited to **15 kWh/m² treated floor area**[2];
- the total **primary energy use** for all appliances, domestic hot water and space heating and cooling is limited to **120 kWh/m² treated floor area**[2]

A passive house has a **high level of insulation** with **minimal thermal bridges**, **low infiltration**, and utilizes **passive solar gains** and **heat recovery** to accomplish these characteristics. Consequently **renewable energy** sources can be used to meet the resulting energy demand.



The Passive House Concept illustrated: Passive (thermos) versus Active (stove)
Source:Informations-Gemeinschaft Passivhaus Deutschland

1 *Passive House Planning Package, Passiv Haus Institut*
2 Living area according to the German "Floor area Ordinance" within the thermal envelope

Passive House measures

Measure/ solution	*Passive House standard*
1. Super Insulation	
Insulation walls	U ≤ 0,15 W/(m²K)
Insulation roof	U ≤ 0,15 W/(m²K)
Insulation floor	U ≤ 0,15 W/(m²K)
Window casing, doors	U ≤ 0,8 W/(m²K)
Window glazing	U ≤ 0,8 W/(m²K)
Thermal bridges	linear heat coeff ψ ≤ 0,01W/(mK)
Air tightness	n50 ≤ 0,6 h-1
Minimal Shape Factor (Area TFA/ Volume TV)	
2. Heat Recovery/ IAQ	
Ventilation counter flow air to air heat exchanger	heat recovery ηHR ≥ 75 %
Ventilation air sub-soil heat exchanger	air outlet after sub-soil heat exchanger above frost temperature
Ventilation ducts insulated	
Other heat recovery (e.g. ventilation & DHW return pipes)	
DHW heat recovery	
DHW pipes insulated	
Minimal space heating	postheater ventilation air/ low temperature heating
Efficient small capacity heating syst.	biomass, heat pump, gas, co-generation (e.g. district heating), etc.
Air Quality through ventilation rate	min. 0,4 ach⁻¹ or 30 m³/pers/h or national regulation if higher
3. Passive (Solar) Gain	
Window glazing	solar energy transmittance g ≥ 50 %
DHW (solar) heater	
Thermal mass within envelope	
Solar orientation	
Night-time shutters	
Shading factor [%] (East & West)	

Measure/ solution	*Passive House standard*
4. Electric Efficiency	
Energy labeled household appliances [Labeling A - G]	Energy reduction 50% of common practice
Hot water connections washing machines/ dishwashers	
Compact Fluorescent lighting	
Regular maintenance ventilation filters	
Direct Current motor ventilation	
Efficient fans: SFP (Specific Fan Power)	≤ 0,45 W/(m3/h) (transported air)
5. On-site Renewables	
Wind turbine	
Photo Voltaics	
Solar thermal energy	
Biomass system	
Other	
	=basic measure/ solution
	=often applied optional measure/solution
	=other optional measure/ solution

Passive House publications

Barriers to build Passive Houses

- Investment costs are decisive.
  CEPHEUS showed that Passive Houses can be offered at competitive prices on the market. Even though the sales price differs only marginally from that of "normal-energy houses" that little price difference can be decisive. There is a trend to thriftiness and today's investment costs are the main criteria.

- Passive Houses are unknown. Customers don't know the comfort of Passive Houses and take the technology to be complicated.

- Life-long learning is not yet established in the buildung sector. Unemployment among architects is high and incomes are going down so that existing education offers are not affordable for an increasing number.

- Deficits in knowledge among architects, consultants, building contractors, sales staff

National publications (extract):

PHI-1997/2: Der Einfluß der Speichermasse von Außenwänden auf den Jahresheizwärmebedarf von Passivhäusern
PHI-1997/3: Effiziente Warmwasserbereitung beim Passivhaus
PHI-1997/4: Passivhaus Darmstadt Kranichstein - Planung, Bau, Ergebnisse
PHI-1997/4(E): The Passive House in Darmstadt Kranichstein - Planning, Construction, Results
PHI-1997/6: Solare Warmwasserbereitung in Passivhäusern
PHI-1998/2: Heizung im Niedrigenergiehaus - ein Systemvergleich
PHI-1998/3: Wirtschaftlichkeitsuntersuchung ausgewählter Energiesparmaßnahmen im Gebäudebestand
PHI-1998/7: Elektrische Geräte für Passivhäuser und Projektierung des Stromverbrauchs
PHI-1998/8: Die Öl-Heizung im Niedrigenergiehaus - Ergänzung zum Systemvergleich
PHI-1998/9: Untersuchung der Luftdichtheit in der NEH- und Passivhaussiedlung in Wiesbaden
PHI-1998/10: Passivhaus Sommerklima Studie
PHI-1998/11: Sparsames Wäschetrocknen
PHI-1998/12: Passivhaus-Reihenhäuser: Über die Zuluft beheizbar?

Passive House publications

PHI-1999/2: Heizlastauslegung im Niedrigenergie- und Passivhaus
PHI-1999/4: Untersuchung d. Luftdichtheit in der Passivhaussiedlung Hannover-Kronsberg
PHI-1999/5: Wärmebrückenfreies Konstruieren
PHI-1999/6: Luftdichte Projektierung von Passivhäusern - Eine Planungshilfe
PHI-1999/7: Luftführung in Passivhäusern - Planungsrichtlinien und Erfahrungen
PHI-1999/9: Für das Passivhaus geeignete Fenster
PHI-1999/11: Wärmebedarf und Komfort in einer Passivhaus-Altenwohnanlage
PHI-2000/3: Wäschetrocknen im Trockenschrank
PHI-2000/4 Ist Wärmespeichern wichtiger als Wärmedämmen?
PHI-2001/2 CEPHEUS: Meßtechnische Untersuchung und Auswertung - Kassel Marbachshöhe
PHI-2001/3 CEPHEUS: Projektdokumentation, Qualitätssicherung und Wirtschaftlichkeitsuntersuchung - Kassel Marbachshöhe
PHI-2001/4 CEPHEUS: Thermographische und strömungstechnische Untersuchung - Kassel Marbachshöhe
PHI-2001/9 CEPHEUS: Wissenschaftliche Begleitung und Auswertung - Endbericht
PHI-2001/10 CEPHEUS: Stellungnahme zur Vornorm DIN V 4108 Teil 6:2001
PHI-2001/11 CEPHEUS: Sommerliches Innenklima im Passivhaus Geschoßwohnungsbau - Kassel Marbachshöhe
PHI-2004/1 PHPP 2004: Passivhaus Projektierungs Paket 2004, Handbuch mit CD-Rom, Update für registrierte Nutzer
Protokollband Nr. 4: Lüftung im Passivhaus
Protokollband Nr. 5: Energiebilanz und Temperaturverhalten
Protokollband Nr. 6: Haustechnik im Passivhaus
Protokollband Nr. 7: Stromsparen im Passivhaus
Protokollband Nr. 8: Materialwahl, Ökologie und Raumlufthygiene
Protokollband Nr. 9: Nutzerverhalten
Protokollband Nr. 10: Meßtechnik und Meßergebnisse
Protokollband Nr. 11: Kostengünstige Passivhäuser
Protokollband Nr. 12: Das Passivhaus - Baustandard der Zukunft?
Protokollband Nr. 13: Energiebilanzen mit dem Passivhaus Projektierungs Paket
Protokollband Nr. 14: Passivhaus-Fenster
Protokollband Nr. 15: Passivhaus-Sommerfall
Protokollband Nr. 16: Wärmebrückenfreies Konstruieren
Protokollband Nr. 17: Dimensionierung von Lüftungsanlagen in Passivhäusern
Protokollband Nr. 18: Qualitätssicherung beim Bau von Passivhäusern
Protokollband Nr. 19: Stadtplanerische Instrumente zur Umsetzung von Passivhäusern
Protokollband Nr. 20: Passivhaus-Versorgungstechnik
Protokollband Nr. 21: Architekturbeispiele: Wohngebäude

Overview building stock

The existing residential building stock in Germany is around 17.3 million houses (base year 2003). The percentage of different types of houses that make up the existing building stock is shown in the table below.

Type of house	Existing building stock
Single family, row house or detached	63%
Semi-detached	17%
Apartment/flat	20%
Passive houses/ year	about 1.000

In 2003 around 160.000 houses were built, 94% are single family or semi-detached housings and 6% are multi-family housings.

Market potential of Passive Houses

In 1998 Fraunhofer ISE counted 70 Passive House buildungs and 120 dwelling units, mainly scientifically supervised demonstration projects.

Typical German dwellings

After dynamic growth during the last years the number of finished Passive Houses was around 4.000 at the end of 2003. A market potential survey by Fraunhofer ISE predicts an enormous potential for Passive Houses and expects fast dissemination. According to a trend scenario more than 137.000 dwellings will be constructed until 2010.

Source: Marktpotential für Passivhäuser und 3-Liter-Häuser, Fraunhofer ISE

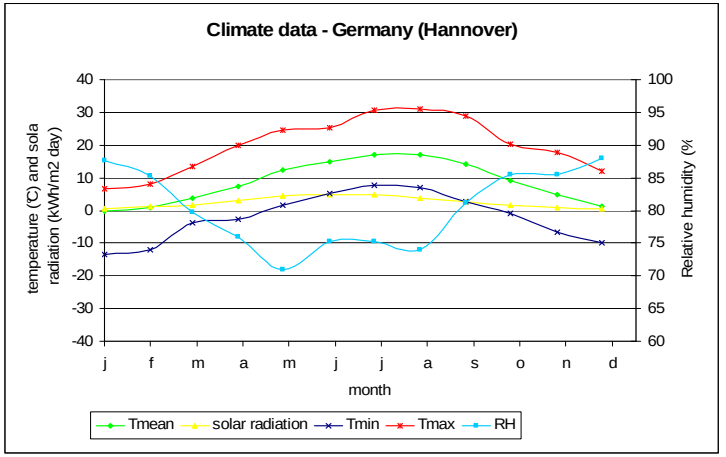
Germany climate

Germany's climate is moderate with precipitation in every season. Northwestern and coastal Germany have a maritime climate caused by westerly winds from the North sea. Further inland the climate is continental, marked by greater diurnal and seasonal variations in temperature. The Alpine regions in the south and, to a lesser degree, some areas of the Central German Uplands have a mountain climate characterized by lower temperature and greater precipitation.

The next graph shows the climate conditions in Hannover. In July and August, the highest temperatures occur, with an average daily maximum of 17°C. During the period of December until February, the temperatures are the lowest, with an average daily minimum about 0°C.

The minimum/maximum design temperature is

–13.4°C for winter and 31.2°C for summer.



longitude	9°44’
latitude	52°22’ 90
altitude	+55m

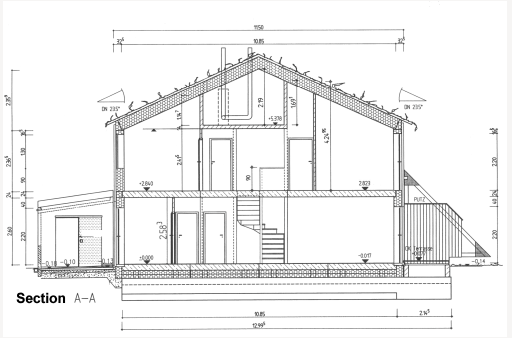
Germany Hannover Passive House

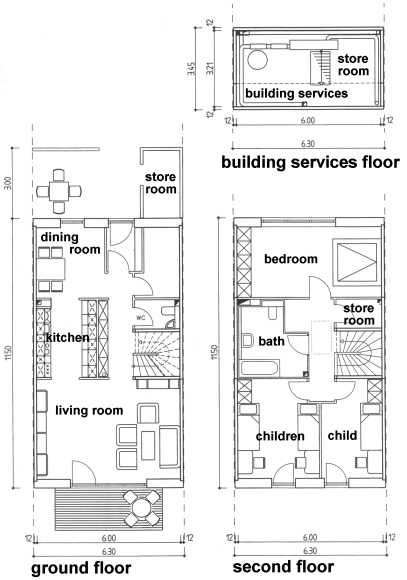
Type of dwelling: The non-basement 32 terraced houses with gabled roofs and external storage rooms are built using a mixed modular system: ceilings, partition walls between homes, gable walls and remaining load-bearing structures consist of prefabricated reinforced-concrete slabs; the highly insulated facade and roof are lightweight prefabricated wood elements.

Occupancy: 4 persons per dwelling unit.

Overall Measurements

Treated floor area	3576 m² (average 112 m² per dwelling)
Average ceiling height	2,7 m





Germany Hannover Passive House

Thermal mass:

Exterior walls: prefabricated concrete (partition walls, gable walls), light-weight wood elements (south and north facade) – medium thermal mass. Interior (separation) walls: wood frame – low thermal mass. Floors: concrete slab - high thermal mass

Compared to typical construction:
Solid constructions dominate the German house market. About 12 % of new residential buildungs are wooden constructions. (Source: Bund deutscher Zimmermeister)

Probably the distribution is similar among Passive Houses. Well documentated examples exist for leight-weight, mixed and solid constructions.

Air tightness Hannover PH (avg.)	n_{50} = 0.29 h^{-1}
Air tightness typical Germany	*n_{50} = 1-6 h^{-1}*

Thermal insulation

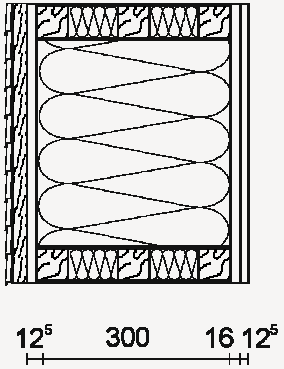
	Hannover Passive House	*Typical House Germany*
Envelope component	**U-value [W/(m²K)]**	
Facade	0,126/ 0,097	*0,2–0,35*
Wall-ground		*0,3–0,4*
Roof	0,095	*0,2–0,3*
Floor	0,091/ 0,125 (U_e/U_m)	*0,3–0,4*
Doors		*1,8*
Window frame	0,57	*1,8*
Windows	0,75 /Dual Pane	*1,1 /Dual Pane*

Overall measurements

	Area (m^2)
Facade	54/ 21
Roof	78
Floor	71
Doors	
Window frame	6
Glazing, dual pane	14

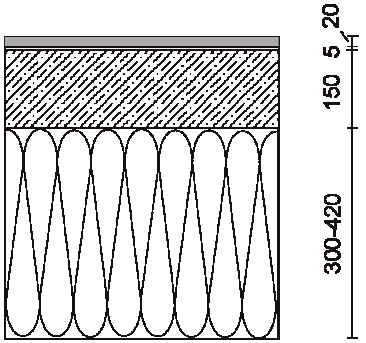
Envelope components, materials

Facade, exterior wall – South & North Facade



Materials (out → in)	*Thickness [cm]*
Ventilated board casing	
Particle board	1,25
Mineral wool insulation / box beam truss	30
Particle board	1,6
Plaster board	1,25

Floor

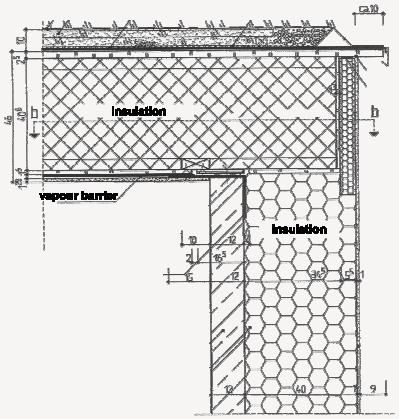


Materials (out → in)	*Thickness [cm]*
Wood flooring	
Tread absorbing insulation (PE-foam)	0,5
Concrete slab	15
Insulation	30/ 42 (final houses)

Envelope components, materials

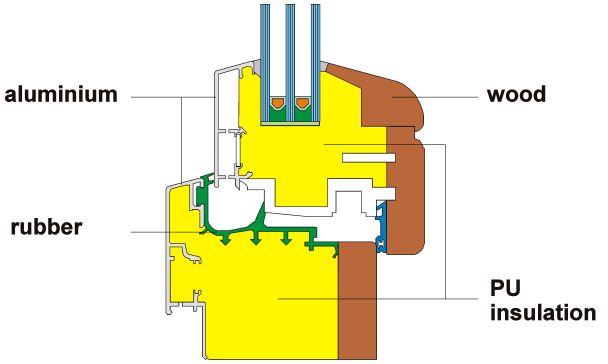
Roof

roof / end of the row / verge



Materials (out → in)	*Thickness [cm]*
Green roof system	
Roof sealing	
Particle board	2,5
Mineral wool insulation / I truss	40
Particle board	1,9
Plaster board	1,25

Glazing, frames



Dual pane window	
Material	Wood, aluminium, PU insulation
U_{frame}=0,57 W/m²K	U_{glas}=0,75 W/m²K

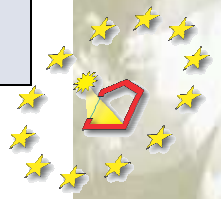
Equipment/ installations

All units have their own high-performance ventilation system with heat recovery. Space heat is provided via the supply air. The supplementary air heating register is downstream from the heat recovery unit in the supply air system. Beyond an additional radiator in the bathroom, no further heat transfer system are installed.
The heat supply for the hot water and space heating consumption takes place through the district heating transfer station as well as the flat collector systems for hot water.

Heating	Heat generator Heating fluid Temp. control Heating system	District heating Air, water (bath) Central room thermostat (supply air) Supply air / bath radiator
Domes-tic hot water	Heating Energy source	Storage District heating / solar thermal system
Ventila-tion	System Heat recovery Ventilation Rate	Mechanical Yes 0,43 h^{-1}

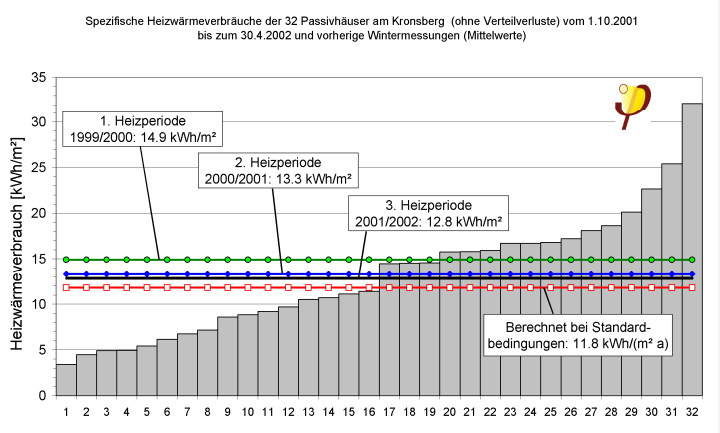
Compared to typical construction:
The most common heating system in German dwellings is central heating with radiators and/or under floor heating. The heating fluid is water, which is heated by a gas heater.
Whole-house mechanical ventilation systems are not common in Germany. Occupants still have to achieve fresh air by opening the windows. In 2002 about 10% of new dwellings obtained a ventilation system with heat recovery. Current development shows that sales are increasing.

Heating	Heat generator Heating fluid Temp. control Heating system	Condensing Boiler Water Thermostat Central/ radiators
Domestic hot wa-ter	Heating Energy source	Storage Gas
Ventilation	System Heat recovery Ventilation Rate	Natural No 0.5 h^{-1}



Energy Use

The next graph shows the space heat consumption of the 32 Kronsberg passive houses for three periods. The average value in the first period is 14,9 kWh/(m²a), 13,3 kWh/(m²a) in the second and 12,8 kWh/(m²a) in the third. The first period is slightly influenced by technical defect and operating mistakes of the inhabitants. All measured values correspond to the calculated demand value of 11,8 kWh/(m²a), the deviation is very low and proves the good suitability of the calculation method.



Compared to typical construction:
The total gas use for heating and domestic hot water is about 80-120 kWh/(m²a).

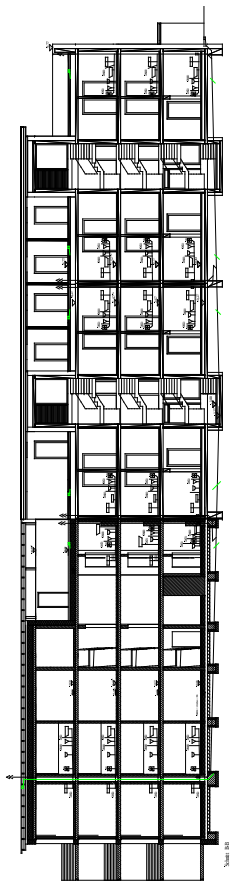
Germany Kassel Passive House Example

Type of dwelling: This apartment building with 23 dwelling units is located in Kassel. The construction is solid, sand-lime blocks with external insulation compound system.
The building has three full storeys and a compact floor plan which broadens to the South. The south building part is provided with another storey. The flat roof has partly a green roof and partly roof terraces.

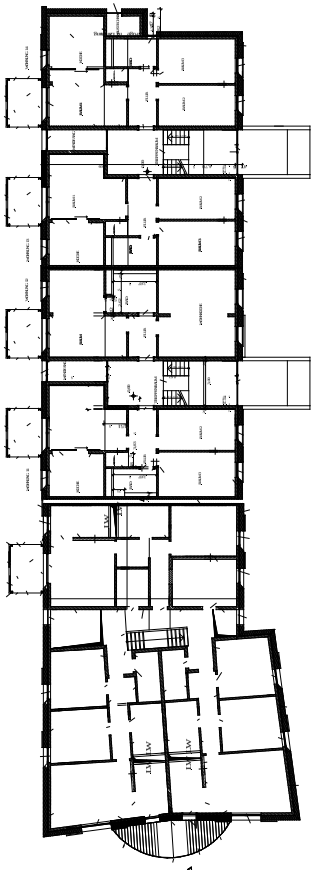
Occupancy: 3,4 persons per dwelling unit.

Overall Measurements

Treated floor area	1.802 m² (average 78 m² per dwelling unit)
Average ceiling height	2,5 m



Section



Ground floor

Germany Kassel Passive House Example

Thermal mass:

Exterior walls: sand-lime blocks – high thermal mass. Interior (separation) walls: sand-lime blocks – high thermal mass. Floors: concrete – high thermal mass

Compared to typical construction:
Solid constructions dominate the German house market. About 12 % of new residential buildungs are wooden constructions. (Source: Bund deutscher Zimmermeister)

Probably the distribution is similar among Passive Houses. Well documentated examples exist for leight-weight, mixed and solid constructions.

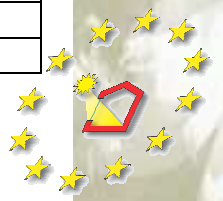
Air tightness Kassel PH	n_{50} = 0,35 h^{-1}
Air tightness typical Germany	*n_{50} = 1-6 h^{-1}*

Thermal insulation

	Kassel Passive House	*Typical House Germany*
Envelope component	**U-value [W/m²K]**	
Facade	0,126	*0,2-0,35*
Wall-ground		*0,3-0,4*
Roof	0,109	*0,2-0,3*
Floor	0,114	*0,3-0,4*
Doors to roof terrace	0,77	*1,8*
Windows	0,818	*1,1 /Dual Pane*

Overall measurements

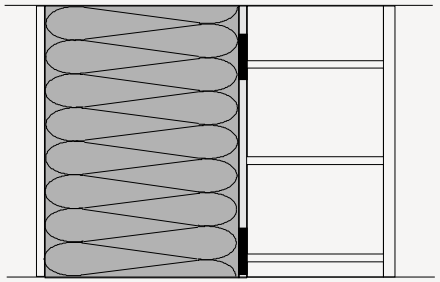
	Area (m²)
Facade	1.158
Roof	734
Floor	741
Doors	6
Window	337



Germany Kassel Passive House Example

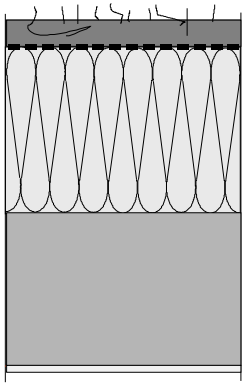
Envelope components, materials

Façade - exterior wall



Materials (out → in)	*Thickness [cm]*
Exterior plaster	1,5
Polystyrene foam	30
Sand-lime block	17,5
Interior plaster	1,5

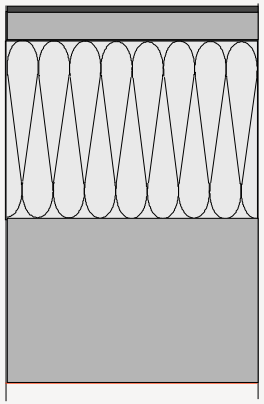
Roof



Materials (out → in)	*Thickness [cm]*
Green roof system	
Roof sealing	
Polystyrene foam	35
Concrete	18
Interior plaster	1.5

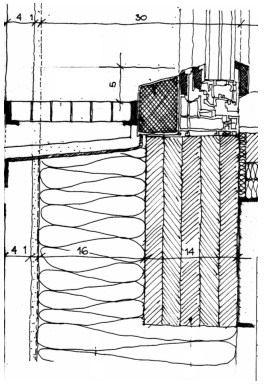
Envelope components, materials

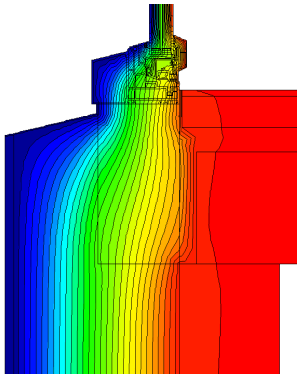
Floor



Materials (out → in)	*Thickness [cm]*
Screed topping	5
Vapour proof barrier	
Polystyrene foam	35
Concrete	35

Glazing frames





Dual pane window	U_{window}=0,818 W/m²K
Material	Wood, insulation

Germany Kassel Passive House Example

Equipment/ installations

The ventilation is designated semi-centralized because the functions heat recovery and air filter are central installed which is cost-efficient and service friendly. On the other hand are user-specific functions like air flow and individual post heat power adjustable in the dwelling units.
The building is supplied with heat from a district heat network. Space heat is provided via the supply air, the bathroom has an additional radiator. A 800 l hot water storage in the service room is supplied by district heat.

Heating	Heat generator Heating fluid Temp. control Heating system	District heating Air, water Sensor in each dwelling unit Supply air / bath radiator
Domes-tic hot water	Heating Energy source	Storage District heating
Ventila-tion	System Heat recovery Ventilation Rate	Mechanical Yes 0,53

Compared to typical construction:
The most common heating system in German dwellings is central heating with radiators and/or under floor heating. The heating fluid is water, which is heated by a gas heater.
Whole-house mechanical ventilation systems are not common in Germany. Occupants still have to achieve fresh air by opening the windows. In 2002 about 10% of new dwellings obtained a ventilation system with heat recovery. Current development shows that sales are increasing.

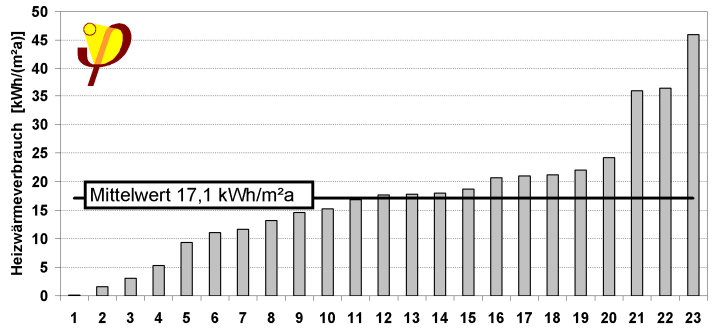
Heating	Heat generator Heating fluid Temp. control Heating system	Condensing Boiler Water Thermostat Central/ radiators
Domestic hot wa-ter	Heating Energy source	Storage Gas
Ventilation	System Heat recovery Ventilation Rate	Natural No 0.5 h^{-1}

Germany Kassel Passive House Example

Energy Use

The next graph shows the space heat consumption for each dwelling unit from October 2000 to March 2001. The differences between individual dwelling units are also known from measurements in the building stock. In addition to differences in the constructions they are caused by different indoor temperatures.
The average value for the building is 17,1 kWh/(m²a).

Compared to typical construction:
The total gas use for heating and domestic hot water is about 80-120 kWh/(m²a).



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Germany
The Passive House

Intelligent Energy Europe

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