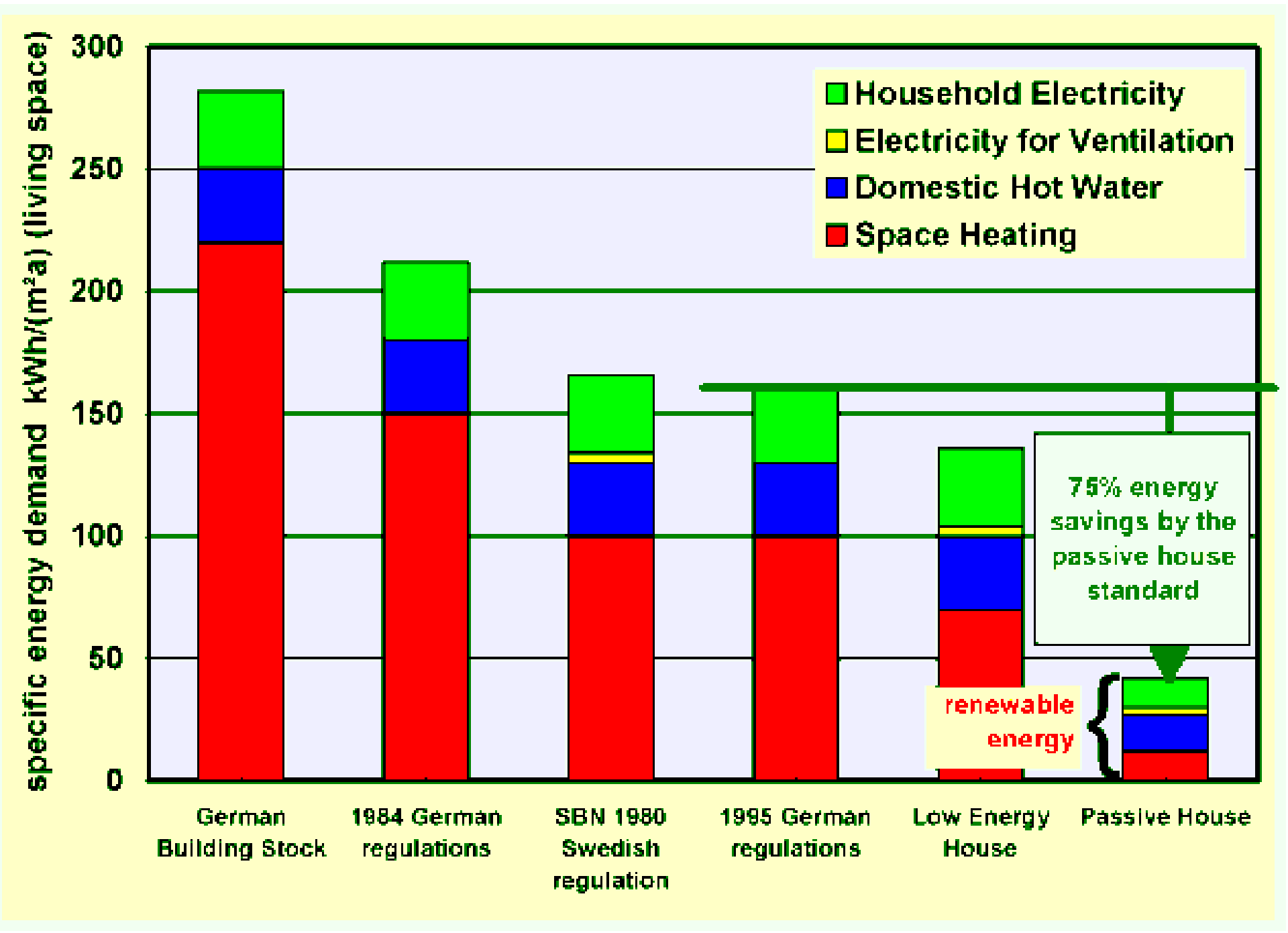
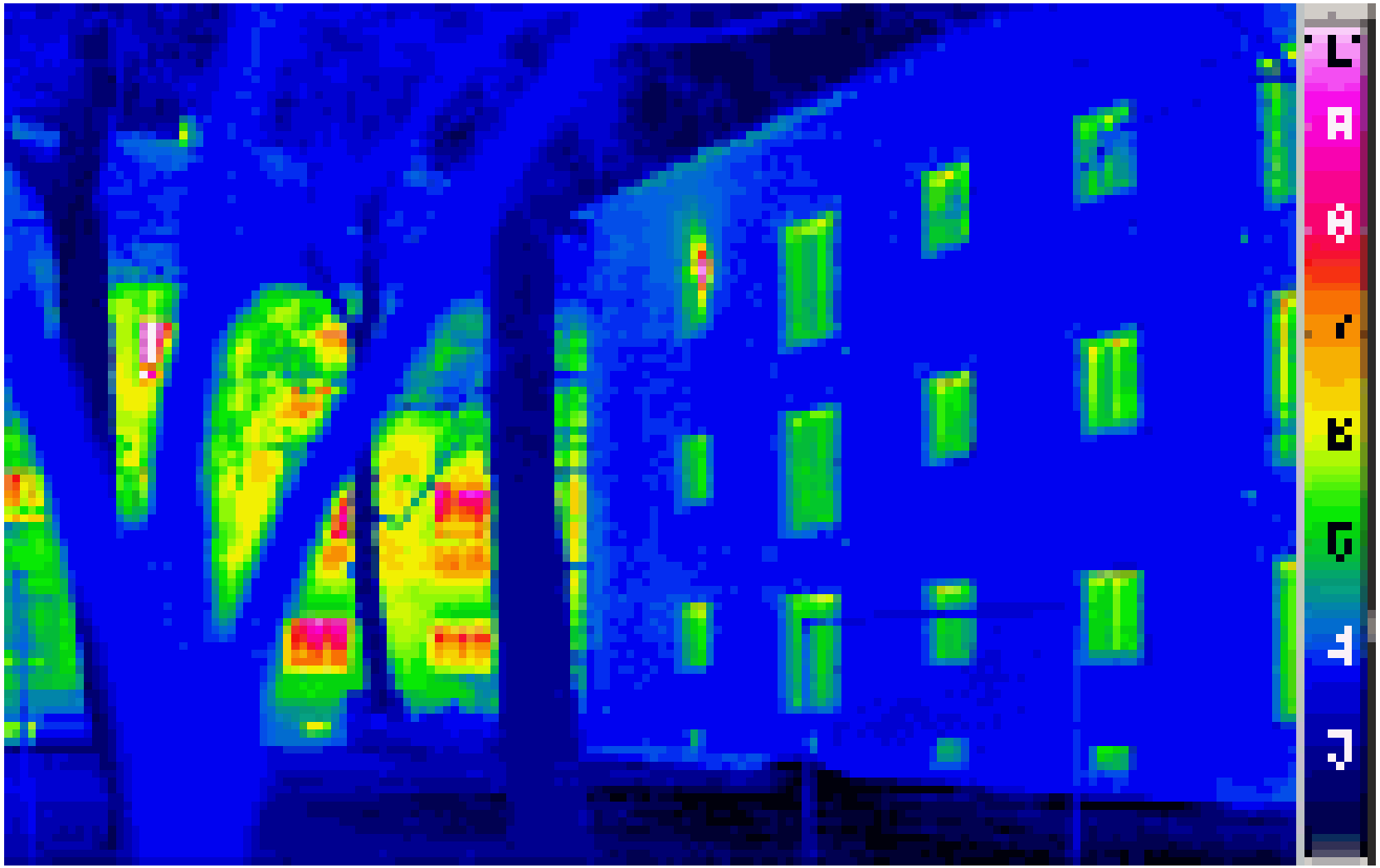
PASSIVE HOUSE

CEPHEUS

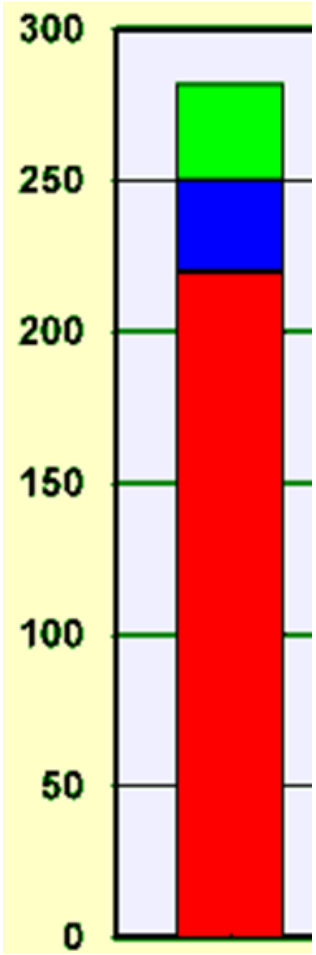

specific energy demand kWh/(m²a) (living space)
300
250
200
150
100
50
0
Household Electricity
Electricity for Ventilation
Domestic Hot Water
Space Heating
75% energy savings by the passive house standard
renewable energy
German Building Stock
1984 German regulations
SBN 1980 Swedish regulation
1995 German regulations
Low Energy House
Passive House

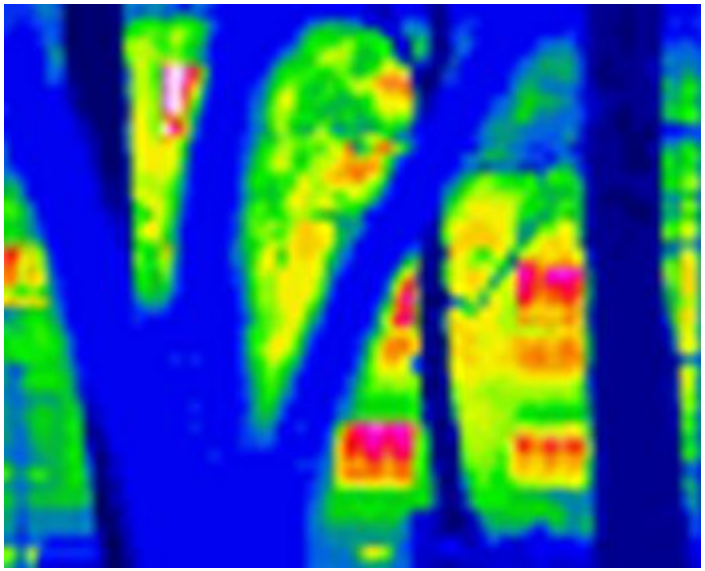
- The term **passive house** (***Passivhaus*** in German) refers to the rigorous, voluntary, *Passivhaus* standard for energy efficiency in buildings. It results in ultra-low energy buildings that require little energy for space heating or cooling. A similar standard, *MINERGIE-P*, is used in Switzerland. The standard is not confined only to residential properties; several office buildings, schools, kindergartens and a supermarket have also been constructed to the standard. Passive design is not the attachment or supplement of architectural design, but an integrated design process with the architectural design. Although it is mostly applied to new buildings, it has also been used for refurbishments.

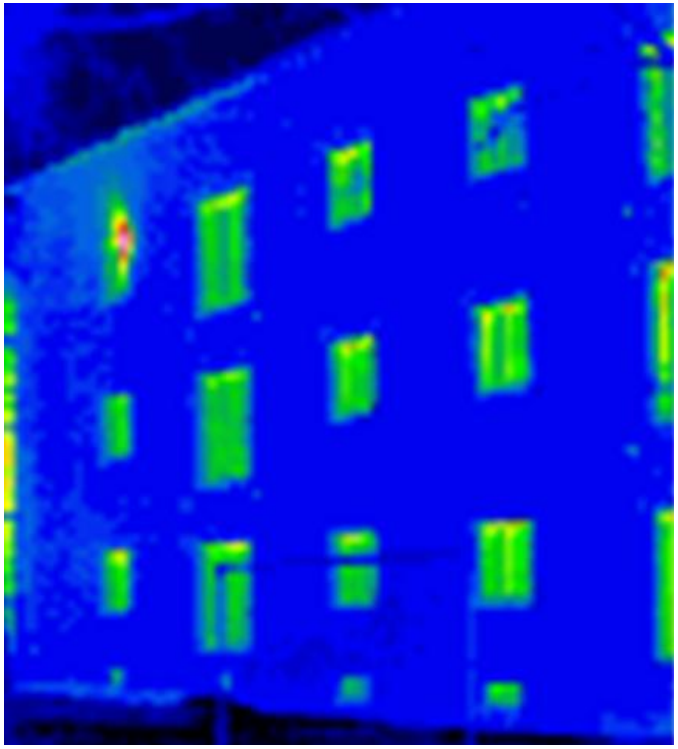
Thermogram of a Passive house



Explain the difference

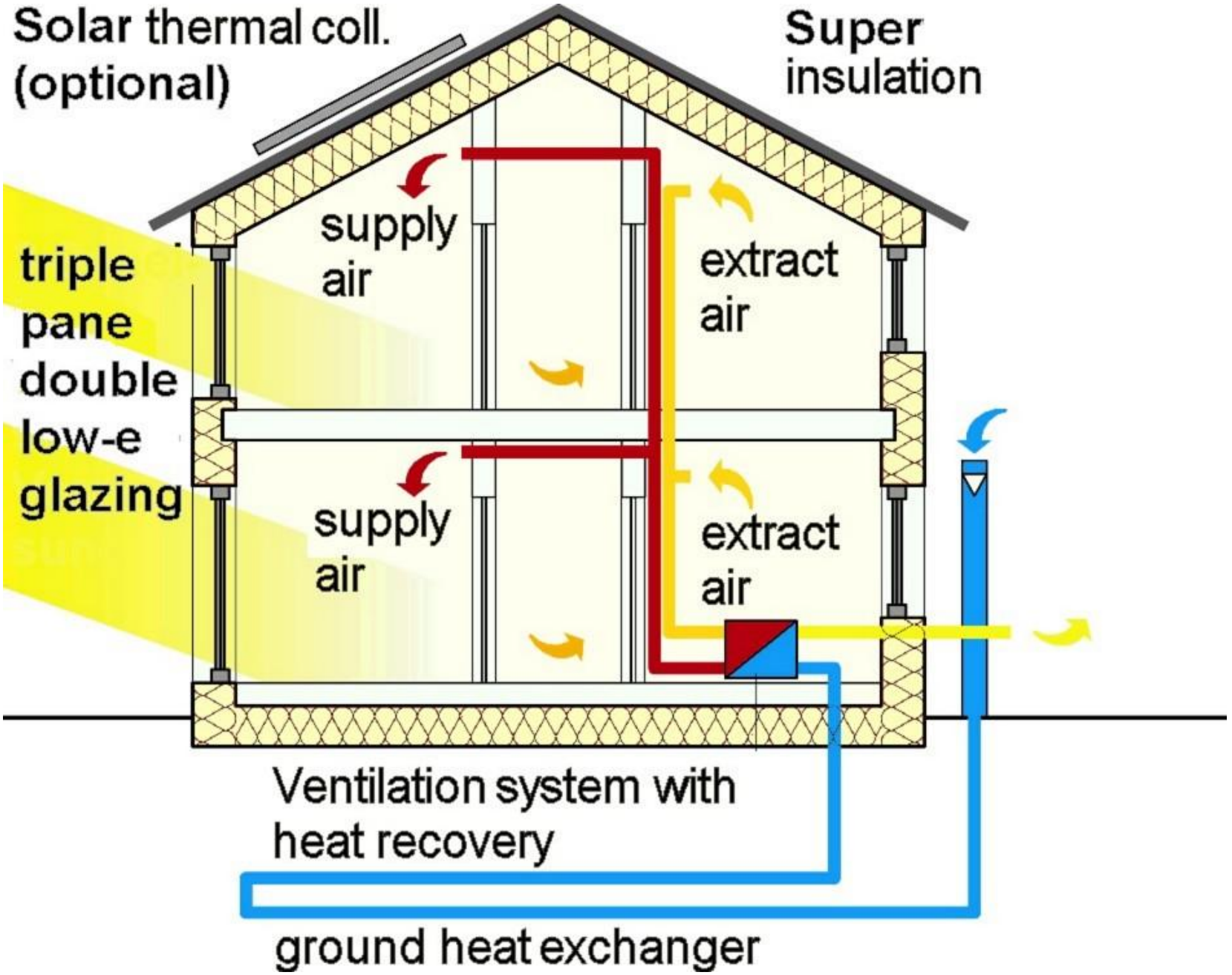




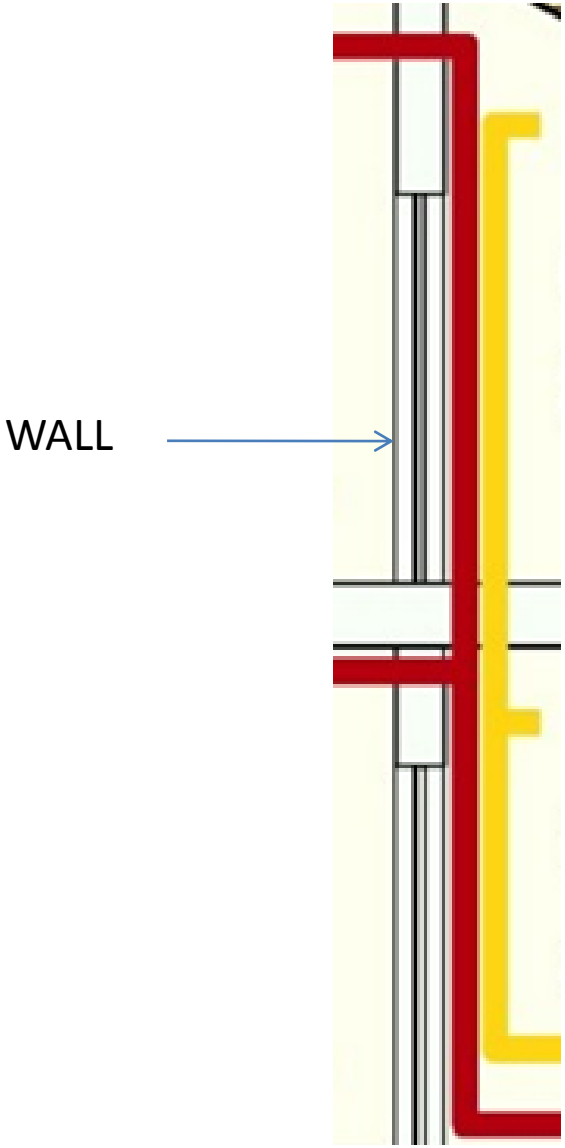


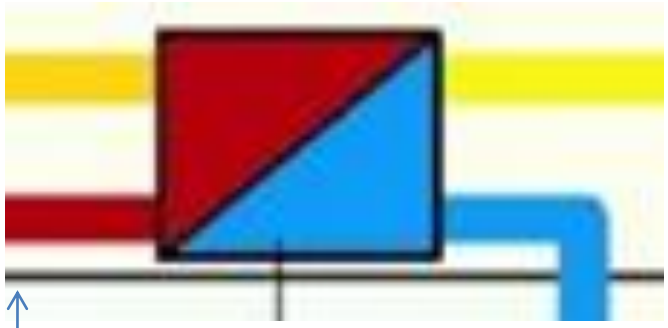
CEPHEUS - Passive Houses in Europe.mht

- Passive Houses require superior design and components with respect to:
- insulation
- design without thermal brigdes
- air tightness
- ventilation with heat recovery
- comfortwindows und
- innovative heating technology
- To realise an optimal interaction of all components, an energy balance of the building has to be worked out. And step by step any new design may be improved to meat Passive House sta


Solar thermal coll.
(optional)
Super
insulation
triple
pane
double
low-e
glazing
supply
air
extract
air
supply
air
extract
air
Ventilation system with
heat recovery
ground heat exchanger

HOW?

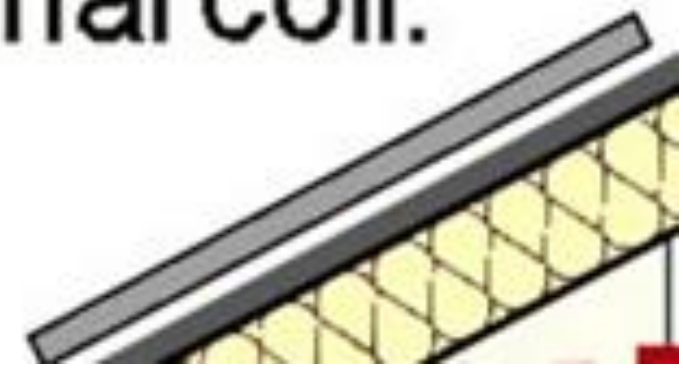

WALL



FLOOR

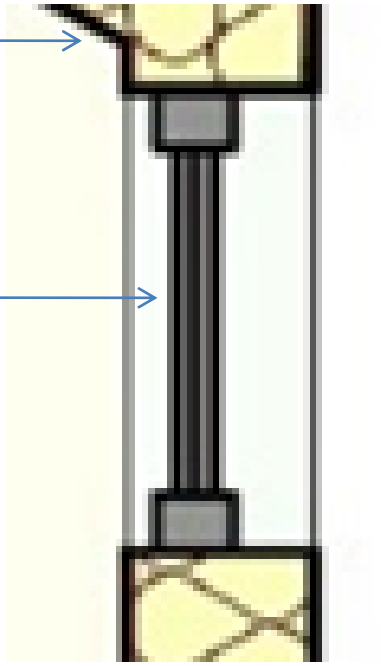
ground heat exchanger

Solar thermal coll.
(optional)



WALL

WINDOW



Space heating requirement

- By achieving the Passivhaus standards, qualified buildings are able to dispense with conventional heating systems. While this is an underlying objective of the Passivhaus standard, some type of heating will still be required and most Passivhaus buildings do include a system to provide supplemental space heating. This is normally distributed through the low-volume heat recovery ventilation system that is required to maintain air quality, rather than by a conventional hydronic or high-volume forced-air heating system, as described in the space heating section below.

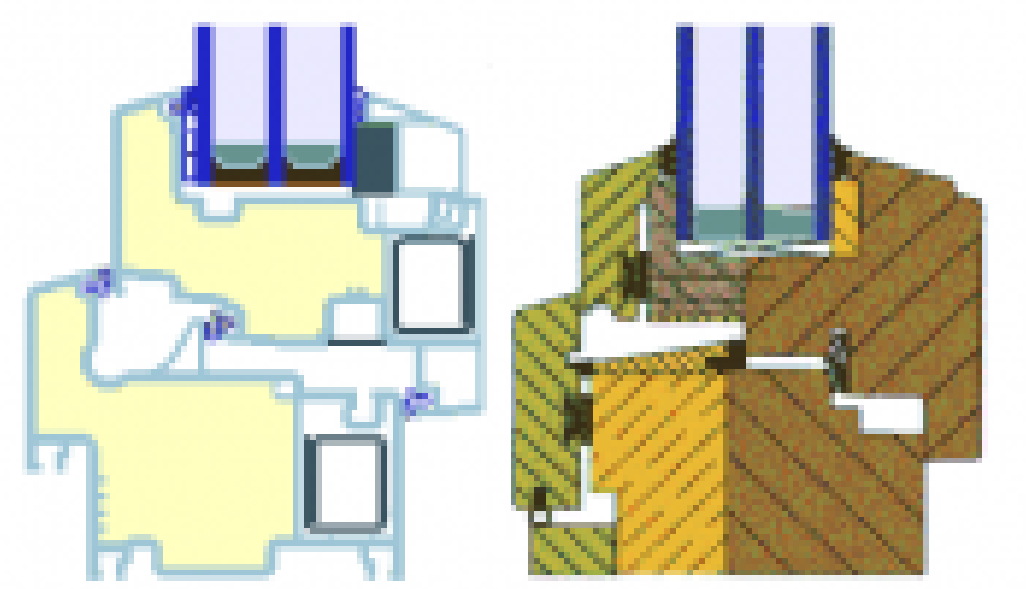
Construction cost

- In Passivhaus buildings, the cost savings from dispensing with the conventional heating system can be used to fund the upgrade of the building envelope and the heat recovery ventilation system. With careful design and increasing competition in the supply of the specifically designed Passivhaus building products, in Germany it is now possible to construct buildings for the same cost as those built to normal German building standards, as was done with the Passivhaus apartments at Vauban, Freiburg. On average, however, passive houses are still up to 14% more expensive upfront than conventional buildings.

Superinsulation

- Passivhaus buildings employ superinsulation to significantly reduce the heat transfer through the walls, roof and floor compared to conventional buildings. A wide range of thermal insulation materials can be used to provide the required high R-values (low U-values, typically in the 0.10 to 0.15 W/(m².K) range). Special attention is given to eliminating thermal bridges. A disadvantage resulting from the thickness of wall insulation required is that, unless the external dimensions of the building can be enlarged to compensate, the internal floor area of the building may be less compared to traditional construction. For example, in Sweden, to achieve passive house standards, the insulation thickness would be 335 mm (about 13 in) (0.10 W/(m².K)) and the roof 500 mm (about 20 in) (U-value 0.066 W/(m².K)).

Advanced window technology



- To meet the requirements of the Passivhaus standard, windows are manufactured with exceptionally high R-values (low U-values, typically 0.85 to 0.70 W/(m^2.K) for the entire window including the frame). These normally combine triple-pane insulated glazing (with a good solar heat-gain coefficient, low-emissivity coatings, argon or krypton gas fill, and 'warm edge' insulating glass spacers) with air-seals and specially developed thermally-broken window frames. Triple pane windows can be very heavy. Recently, the Empire State building used window systems that are double pane with suspended films inside to achieve higher R-values. Please refer to www.southwall.com as one example. In Central Europe, for unobstructed south-facing Passivhaus windows, the heat gains from the sun are, on average, greater than the heat losses, even in mid-winter.

Airtightness

- Building envelopes under the Passivhaus standard are required to be extremely airtight compared to conventional construction. Air barriers, careful sealing of every construction joint in the building envelope, and sealing of all service penetrations through it are all used to achieve this. Airtightness minimizes the amount of warm (or cool) air that can pass through the structure, enabling the mechanical ventilation system to recover the heat before discharging the air externally.

Ventilation

- Mechanical heat recovery ventilation systems, with a heat recovery rate of over 80% and high-efficiency electronically commutated motors (ECM), are employed to maintain air quality, and to recover sufficient heat to dispense with a conventional central heating system. Since the building is essentially airtight, the rate of air change can be optimized and carefully controlled at about 0.4 air changes per hour. All ventilation ducts are insulated and sealed against leakage.

- Although not compulsory, earth warming tubes (typically ≈200 mm (~7,9 in) diameter, ≈40 m (~130 ft) long at a depth of ≈1.5 m (~5 ft)) are often buried in the soil to act as earth-to-air heat exchangers and pre-heat (or pre-cool) the intake air for the ventilation system. In cold weather the warmed air also prevents ice formation in the heat recovery system's heat exchanger. Alternatively, an earth to air heat exchanger, can use a liquid circuit instead of an air circuit, with a heat exchanger (battery) on the supply air.

Space heating

- In addition to a heat exchanger, a micro-heat pump can extract heat from the exhaust air and hot water heats the ventilation air. The ability to control building temperature using only the normal volume of ventilation air is fundamental. In addition to using passive solar gain, Passivhaus buildings make extensive use of their intrinsic heat from internal sources – such as waste heat from lighting, white goods (major appliances) and other electrical devices (but not dedicated heaters) – as well as body heat from the people inside the building. (People, on average, emit heat energy equivalent to 100 watts). Together with the comprehensive energy conservation measures taken, this means that a conventional central heating system is not necessary, although they are sometimes installed due to client skepticism.

- Instead, Passive houses sometimes have a dual purpose 800 to 1,500 Watt heating and/or cooling element integrated with the supply air duct of the ventilation system, for use during the coldest days. It is fundamental to the design that all the heat required can be transported by the normal low air volume required for ventilation. A maximum air temperature of 50 °C (122 °F) is applied, to prevent any possible smell of scorching from dust that escapes the filters in the system.

- The air-heating element can be heated by a small heat pump, by direct solar thermal energy, annualized geothermal solar, or simply by a natural gas or oil burner. In some cases a micro-heat pump is used to extract additional heat from the exhaust ventilation air, using it to heat either the incoming air or the hot water storage tank. Small wood-burning stoves can also be used to heat the water tank, although care is required to ensure that the room in which stove is located does not overheat. Beyond the recovery of heat by the heat recovery ventilation unit, a well designed Passive house in the European climate should not need any supplemental heat source if the heating load is kept under $10W/m^2$.

- Because the heating capacity and the heating energy required by a passive house both are very low, the particular energy source selected has fewer financial implications than in a traditional building, although renewable energy sources are well suited to such low loads.

Lighting and electrical appliances

- To minimize the total primary energy consumption, low-energy lighting (such as compact fluorescent lamps or solid-state lighting), and high-efficiency electrical appliances are normally used.

Traits of Passive Houses

- Due to their design, passive houses usually have the following traits:
- The air is fresh, and very clean. Note that for the parameters tested, and provided the filters (minimum F6) are maintained, HEPA quality air is provided. 0.3 air changes per hour (ACH) are recommended, otherwise the air can become “stale” (excess CO_2, flushing of indoor air pollutants) and any greater, excessively dry (less than 40% humidity). This implies careful selection of interior finishes and furnishings, to minimize indoor air pollution from VOC’s (e.g., formaldehyde).

- Because of the high resistance to heat flow (high R-value insulation), there are no “outside walls” which are colder than other walls.
- Since there are no radiators, there is more space on the rooms’ walls.

- Inside temperature is homogeneous; it is impossible to have single rooms (e.g. the sleeping rooms) at a different temperature from the rest of the house. Note that the relatively high temperature of the sleeping areas is physiologically not considered desirable by some building scientists. Bedroom windows can be cracked open slightly to alleviate this when necessary.

- The temperature changes only very slowly – with ventilation and heating systems switched off, a passive house typically loses less than 0.5 °C (1 °F) per day (in winter), stabilizing at around 15 °C (59 °F) in the central European climate.

- Opening windows or doors for a short time has only a very limited effect; after the windows are closed, the air very quickly returns to the “normal” temperature.
- The air inside Passive Houses, due to the lack of ventilating cold air, is much drier than in ‘Standard’ Houses.

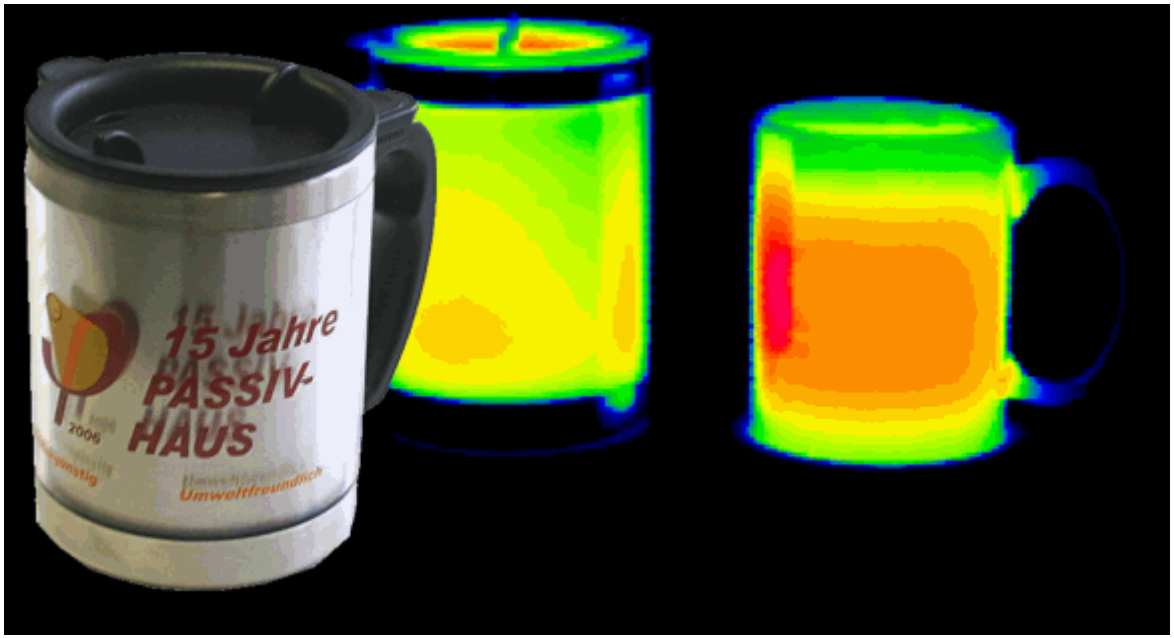
International comparisons

- In the United States, a house built to the Passive House standard results in a building that requires space heating energy of 1 BTU per square foot per heating degree day, compared with about 5 to 15 BTUs per square foot per heating degree day for a similar building built to meet the 2003 Model Energy Efficiency Code. This is between 75 and 95% less energy for space heating and cooling than current new buildings that meet today's US energy efficiency codes. The Passivhaus in the German-language camp of Waldsee, Minnesota uses 85% less energy than a house built to Minnesota building codes.

Comparison with zero energy buildings

- A net zero-energy building (ZEB) is a building that over a year does not use more energy than it creates. A ZEB requires the use of onsite renewable energy technologies like photovoltaic to offset the building's primary energy use.
- Estimates on the number of passive houses around the world range from 15,000 to 20,000. The vast majority have been built in German-speaking countries or Scandinavia.

Cadeau souvenir en fin de conférence



Retrofitting

School in Baiersdorf, Germany. Empire State Building

- http://susterrapartners.co.kr/new-page-test/green-building-technology-solutions/the-passive-house/

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.

What Makes a Building a Passive House?

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 ³ 50%
- ***Superframes***
  Measure Superinsulated window frames Specification U-value £ 0.8 W/(m²K) ***Superinsulation***

What Makes a Building a Passive House?

- *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 Y (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 n50

- **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 efficiency h ³ 80%
- **Latent heat recovery from exhaust air**
  Measure Compact heat pump unit
- Specification Max. heat load 10 W/m^2

- **Subsoil heat exchanger**
  Measure Fresh air preheating Specification Fresh air temperature ³ 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.

Travaux possibles

- A partir de ce travail sur l'isolation et la video sur l'Empire State Building, on pourrait étudier les moyens retenus, les coûts engendrés et surtout le retour sur investissements.
- A partir du lien vers Energy efficiency UK, on pourrait créer une simulation de maison dans le Royaume Uni et voir quelles solutions nous seraient proposées par le gouvernement britannique…

http://www.energysavingtrust.org.uk/Home-improvements-and-products/Home-insulation-glazing

Calculating Home Heating Energy

- http://hyperphysics.phy-astr.gsu.edu/hbase/hframe.html

http://www.cnrs.fr/cw/dossiers/dosbioville_E/biocity.html