01.03_PH-SUMMER SCHOOL

FROM LOW-ENERGY HOUSE TO THE PASSIVE HOUSE

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Language support: William GALLAGHER,
Date: 2009-07-16

CONTENT OF THIS PRESENTATION:

What is a Low-Energy House?

„The meaning of the term 'low-energy house' has changed over time, but it generally refers to a house that uses around half of the German & Swiss low-energy standards mentioned below for space heating, typically in the range from

30 kWh/m²a to 20 kWh/m²a

(9,500 Btu/ft²/yr to 6,300 Btu/ft²/yr).

This term is focused on energy values.

Source: http://en.wikipedia.org/wiki/Low-energy_house

What is environmental architecture?

- As much comfort as possible
  - physiological
  - social

- As much resource-efficiency as possible
  - material
  - energy
  - living space

This term is focused on “soft” facts, too.
It also includes traditional buildings.

What is environmental architecture?

Definition of “Environmental Architecture” by TU Dortmund

“Environmental architecture is the totality of solutions for building design that directly determine the climate of constructed interior and exterior spaces and which directly influence our natural environment (as well as the global climate). A pleasant and healthy environment can be created for the spaces people use, both outside and especially inside of buildings.

The creation of a comfortable climate for people which does not have lasting negative impact on the environment requires solutions which are compatible with the building's use and especially its surrounding environment, as the archaic structural forms of the igloo or the tent impressively demonstrate. Environmental architecture requires, on the one hand, the knowledge of appropriate and specific solutions that take the current standards of technology and the newest scientific findings into consideration, but requires moreover the integration of design solutions that lead to an optimal whole.”

Source: **www.bauwesen.uni-dortmund.de/ka/en/Chair/index.html**

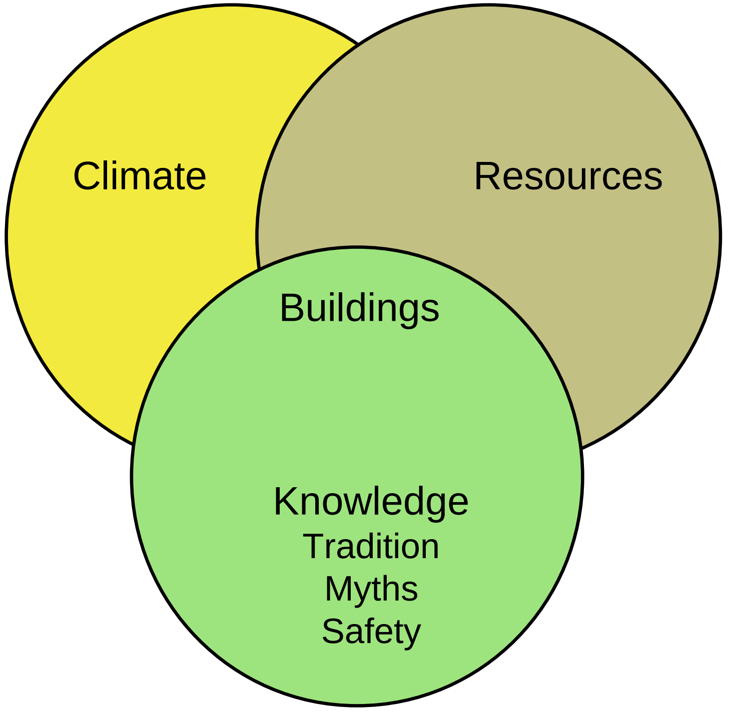
What is environmental architecture?

Main points of environmental architecture

- **CLIMATE**

- **RESOURCES**
    - **Material**
        - natural restrictions
        - by law or social restrictions
    - **Energy**

- **KNOWLEDGE**
    - **Know how, Tools**
    - **Tradition**
    - **Myths**
    - **Safety**



What is environmental architecture?

Climate and Comfort

Marcus Vitruvius Pollio

80/70 b. Chr. - 15 b. Chr:

De architectura libri decem, lib. VI, c. I

1. Haec autem ita erunt recte disposita, si primo animadversum fuerit quibus regionibus aut quibus inclinationibus mundi constituantur. namque aliter Aegypto, aliter Hispania, non eodem modo Ponto, dissimiliter Romae, item ceteris terrarum et regionum proprietatibus oportere videntur constitui genera aedificiorum, quod alia parte solis cursu premitur tellus, alia longe ab eo distat, alia per medium temperatur. igitur uti constitutio mundi ad terrae spatium inclinatione signiferi circuli et solis cursu disparibus qualitatibus naturaliter est conlocata, ad eundem modum etiam ad regionum rationes caelique varietates videntur aedificiorum debere dirigi conlocationes.

1. If our designs for private houses are to be correct, we must at the outset take **note of the countries and climates** in which they are built. One style of house seems appropriate to build in Egypt, another in Spain, a different kind in Pontus, one still different in Rome, and so on with lands and countries of other characteristics. This is because **one part of the earth is directly under the sun's course, another is far away from it**, while another lies midway between these two. Hence, as the position of the heaven with regard to a given tract on the earth leads naturally to different characteristics, owing to the inclination of the circle of the zodiac and the course of the sun, it is obvious that designs for houses ought similarly to conform to the nature of the country and to diversities of climate.

Source: Translation: Morris Hicky Morgan (1914) Public domain. www.payer.de/tropenarchitektur/troparch012.htm

What is environmental architecture?

Climate and Comfort

Marcus Vitruvius Pollio

80/70 B.C. - 15 B.C.:

De architectura libri decem, lib. VI, c. I

2. sub septentrione aedificia testudinata et maxime conclusa et non patientia sed conversa ad calidas partes oportere fieri videntur. contra autem sub impetu solis meridianis regionibus, quod premuntur a calore, patentiora conversaque ad septentrionem et aquilonem sunt faciunda. ita quod ultra natura laedit, arte erit emendandum. item reliquis regionibus ad eundem modum <debet> temperari, quemadmodum caelum est ad inclinationem mundi conlocatum.

2. **In the north, houses should be entirely roofed over and sheltered as much as possible, not in the open, though having a warm exposure. But on the other hand, where the force of the sun is great in the southern countries that suffer from heat, houses must be built more in the open and with a northern or northeastern exposure**. Thus we may amend by art what nature, if left to herself, would mar. In other situations, also, we must make modifications to correspond to the position of the heaven and its effects on climate. .

Source: Translation: Morris Hicky Morgan (1914) Public domain. www.payer.de/tropenarchitektur/troparch012.htm

Climate and Comfort

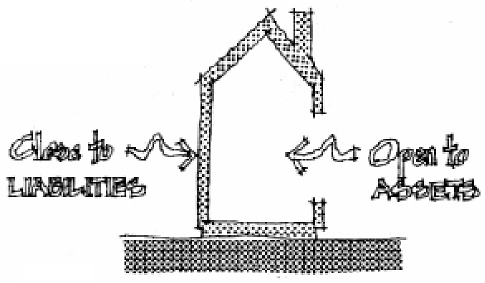
Guidelines of the U.S. Dept. of Housing and Urban Development

1978 A.D.:

Assets and Liabilities:
Whatever your predominant heating and cooling requirements are, some climatic forces will act as assets to conditioning your home for comfort and others will act as liabilities.

If it's just too cold, and you're heating,

- consistent temperatures can be a liability
- winds can be a liability
- moisture/precipitation can be a liability
- sun is rarely a liability
- diurnal temperatures can be an asset
- winds are rarely an asset
- moisture/precipitation can be an asset
- sun can be an asset



Source: Regional guidelines for building passive energy conserving homes / by the AIA Research Corporation for the U.S. Dept. of Housing and Urban Development, 1978--S.11

What is environmental architecture?

Climate and Comfort

Guidelines of the U.S. Dept. of Housing and Urban Development

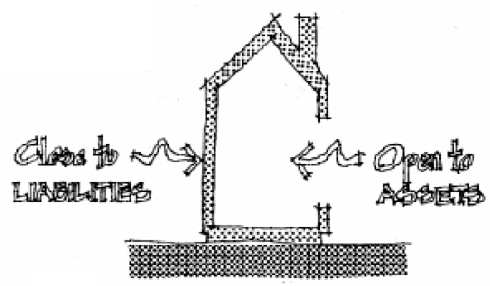
1978 A.D.:

If it's just too hot, and you're cooling,

- consistent temperatures can be a liability
- winds can be a liability
- moisture/precipitation can be a liability
- sun can be a liability
- diurnal temperatures can be an asset
- winds can be an asset
- moisture/precipitation can be an asset
- even sun can be an asset

If you're comfortable,

- temperatures are rarely a liability
- winds can be a liability
- moisture/precipitation can be a liability
- sun can be a liability



Source: Regional guidelines for building passive energy conserving homes / by the AIA Research Corporation for the U.S. Dept. of Housing and Urban Development, 1978--S.11

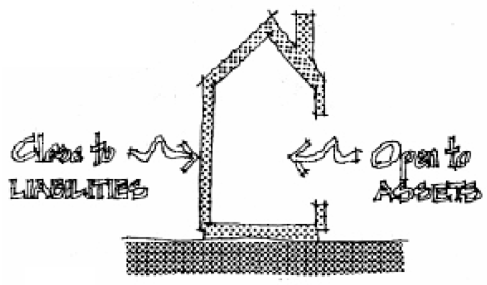
What is environmental architecture?

Climate and Comfort

Guidelines of the U.S. Dept. of Housing and Urban Development

1978 A.D.:

Some of these assets and liabilities will be important to your climate and some will not. You must know whether you are designing for significant heating or cooling or both. You must then look at what climatic forces (sun, wind, temperature, humidity) make it worse, and which forces make it better, and how frequent those forces are.

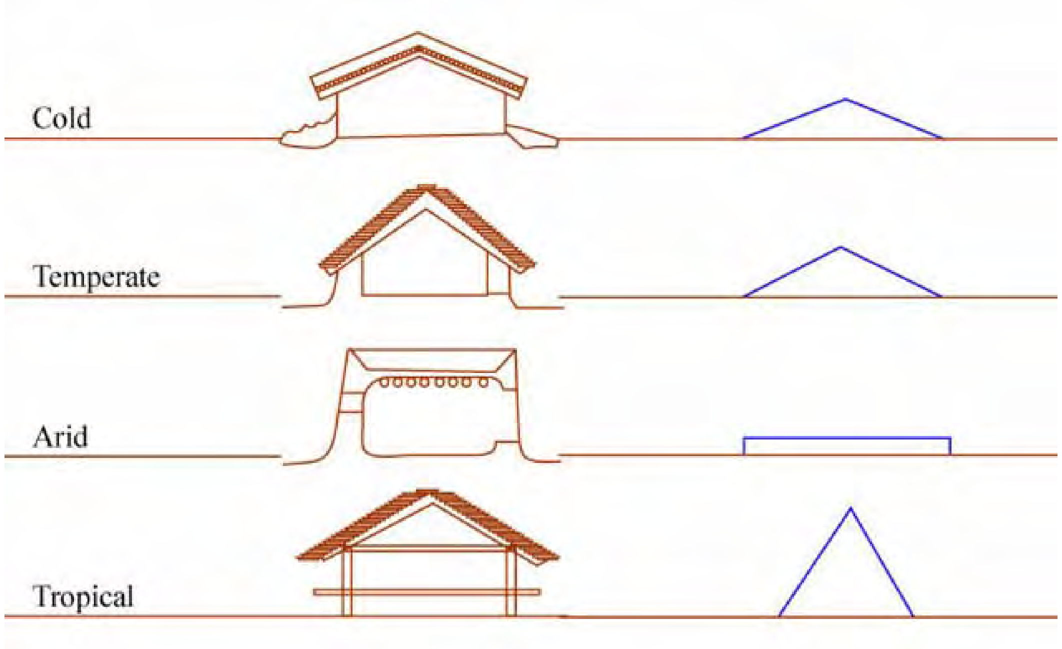


Source: Regional guidelines for building passive energy conserving homes / by the AIA Research Corporation for the U.S. Dept. of Housing and Urban Development, 1978--S.11

What is environmental architecture?

Climate and Design

Depending on resources and knowledge, historically we see these basic building designs in different climates.



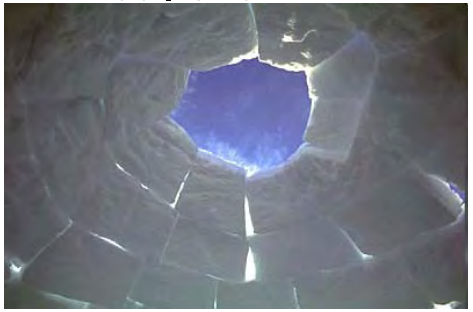
Source: Marilyne Andersen, MIT OpenCourseWare

What is environmental architecture?

Climate and Material

Depending on the local resources (and sometimes social restrictions) we see historical buildings in different materials

Ice / snow



Wood / bamboo / reed

Stone

Clay / bricks

http://home.claranet.de/achim1604/transafrika/images/net/ae-180lehmziegel.jpg

Different mixed constructions

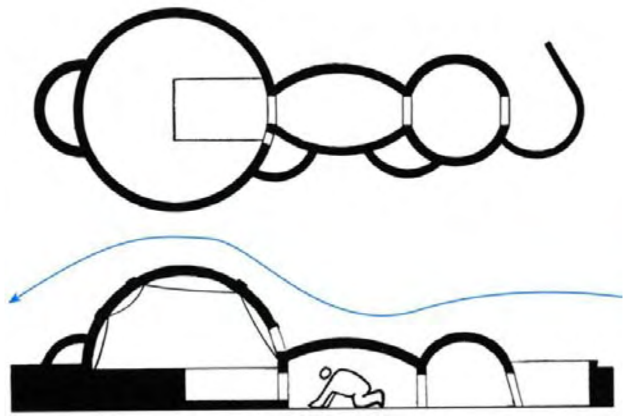
BUT

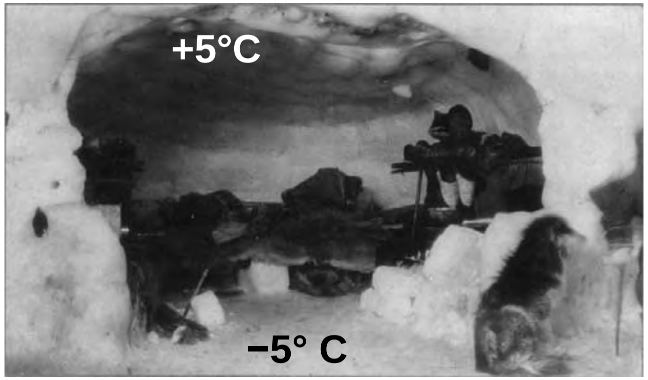
NO GLASS !!!

Source: www.walter-steinberg.de/Tipps/Iglu/iglu.htm www.bambus.de/forum/19943.html http://krukkikurs.wordpress.com/

Some examples of environmental architecture

Cold climate - Igloo





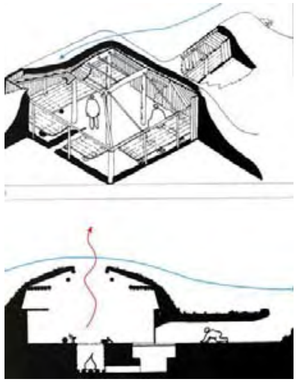
- compact form, less surface
- less exposure to the wind
- airtight shell
- small volume to „heat“
- heating with internal gains
- no „modern“ comfort temperature inside

Source: http://de.wikipedia.org/wiki/Iglu

Some examples of environmental architecture

Cold climate – Peat houses

- compact form, less surface
- less exposure to the wind
- nearly airtight shell
- Good heat insulation (peat)
- small volume to „heat“
- heating with internal gains
- orientation to the sun



Reconstructed early farmhouse of the Vikings, Eiriksstadir

One room with an open fireplace

Grenivik, Island 19th century

Source: www.burg-assum.de/articles.php?article_id=110 www.itcwebdesigns.com/norstead02.htm www.treehugger.com/iceland-houses-green-001.jpg

Some examples of environmental architecture

Cold and temperate climates – Log houses

- compact form, less surface
- less exposure to the wind
- Good heat insulation (wood)
- small volume to „heat“
- nearly airtight shell , filling the gaps with moss and clay

Rural log house

Reconstruction of Abraham Lincoln Birthplace National Historic Site, Hodgenville Kentucky

Log house of early American settlers
www.nps.gov/ozar/historyculture/index.htm

Source: www.floorplans.cc/wp-content/uploads/2009/12/log-cabin.jpg http://commons.wikimedia.org/wiki/File:Abraham_Lincoln_Birthplace_abli-ImageF.00001.jpeg

Some examples of environmental architecture

Cold and temperate climates – Log houses

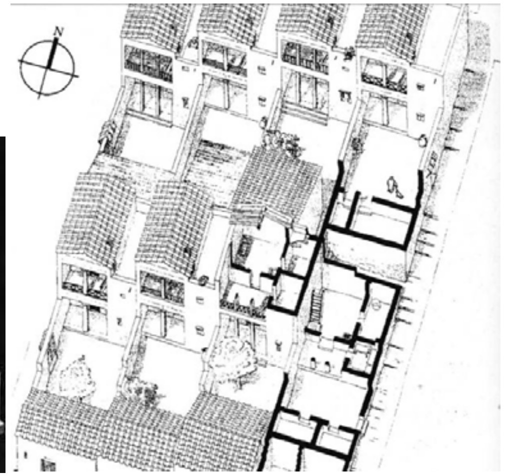
- Good heat insulation (wood)
- nearly airtight shell , filling the gaps with moss, hemp and clay

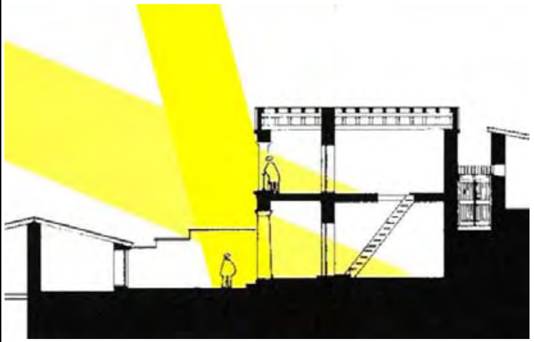
Source: http://de.wikipedia.org/wiki/Blockhaus www.hanffaser.de/hanf/Bau_Kalfater.htm www.blockhaus-barth.de/naturstammhaus.php

Some examples of environmental architecture

Temperate and arid climates - Antique houses and urban design

- orientation to the winter sun
- protection from the summer sun
- compact form, less surface
- less exposure to the winter wind
- ventilated by the summer wind
- nightly cross ventilation in summer





Some examples of environmental architecture

Tropical climate – Log and bamboo house

Toba-Batak-House, Sumatra, Indonesia

- protection from the strong rain
- protection from the wet ground
- protection from the tropical sun
- protection from earthquakes by a flexible structural framework
- exposed to and ventilated by the wind and
- ventilation by a high gabled room with stack effect

Source: Herve M. -- http://www.flickr.com/photos/herve13/2994192081/

Some examples of environmental architecture

Tropical climate – “Modern” prefab house

Modern design of this "traditional" Architecture by Jean Prouvé (1901–1984): “La maison tropicale” 1951 for Brazzaville, Republic of the Congo reconstruction in London

- protection from the strong rain
- protection from the wet ground
- protection from the tropical sun
- protection from earthquakes by a flexible structural framework
- exposed to and ventilated by the wind and
- ventilation by high rooms and some stack effect

This is a “modern” passive house for the tropical climate.

Source: Jim Linwood. -- http://www.flickr.com/photos/brighton/2329766830/

Some examples of environmental architecture

Historical environmental architecture – The main barrier

We see there a lot of very important principles like

- orientation to the winter sun
- protection from the summer sun
- compact form, less surface
- less exposure to the winter wind
- ventilated by the summer wind
- nightly cross ventilation in summer.

and in the cold and temperate regions

- good heat insulation
- small volume to „heat“
- nearly airtight (as well as possible)

but only

- small openings / windows
- less natural light inside
- no passive solar gains inside
- and a “restricted comfort.”

The main barrier to a higher comfort in all these historical examples was the lack of flat glass.

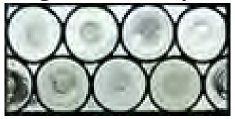
As a result of this the very important use of passive solar gains for the buildings was also very limited or non-existent.

Source:

Some examples of environmental architecture

Historical environmental architecture – The main barrier

"Until the 16th century, window glass or flat glass was generally cut from large discs (or rondels) of **crown glass**".



Bauhaus Dessau

"Larger sheets of glass were made by blowing large cylinders which were cut open and flattened, then cut into panes. Most window glass in the early 19th century was made using the **cylinder method**.
The 'cylinders' were 6 to 8 feet (1.8 to 2.4 m) long and 10 to 14 inches (250 to 360 mm) in diameter, limiting the width that panes of glass could be cut, and resulting in windows divided by transoms into rectangular panels".

This limited the size of flat glass panes and it was a very expensive product.

"From the early 1920s, a continuous ribbon of plate glass was passed through a lengthy series of inline grinders and polishers, reducing glass losses and cost.
Between 1953 and 1957, Sir Alastair Pilkington and Kenneth Bickerstaff of the UK's company Pilkington Brothers developed the first successful commercial application for forming a continuous ribbon of glass using a molten tin bath. Full scale profitable sales of float glass were first achieved in 1960".

High quality glazing is a very new development !!!

Source: http://en.wikipedia.org/wiki/Crown_glass_%28window%29 http://en.wikipedia.org/wiki/Float_glass

The first passive house

The first “modern” passive house (in a cold climate) was already built in the year 1892

„ ... and in addition, thermal insulation of ceilings, floors and walls had been made thick by many layers.

<Next to the warm room> airtight linoleum was put around everywhere to prevent the warm, humid air from condensing to moisture which would otherwise freeze to ice very soon. The walls are covered with tarred felt. Then follows a cork filling, then pine wood panelling, then again a thick layer of felt, then airtight linoleum and finally again some panelling. The ceilings .... have a thickness of approximately 40 cm altogether. The window, by which the cold could penetrate particularly easily, was protected by triple plates and in other ways.

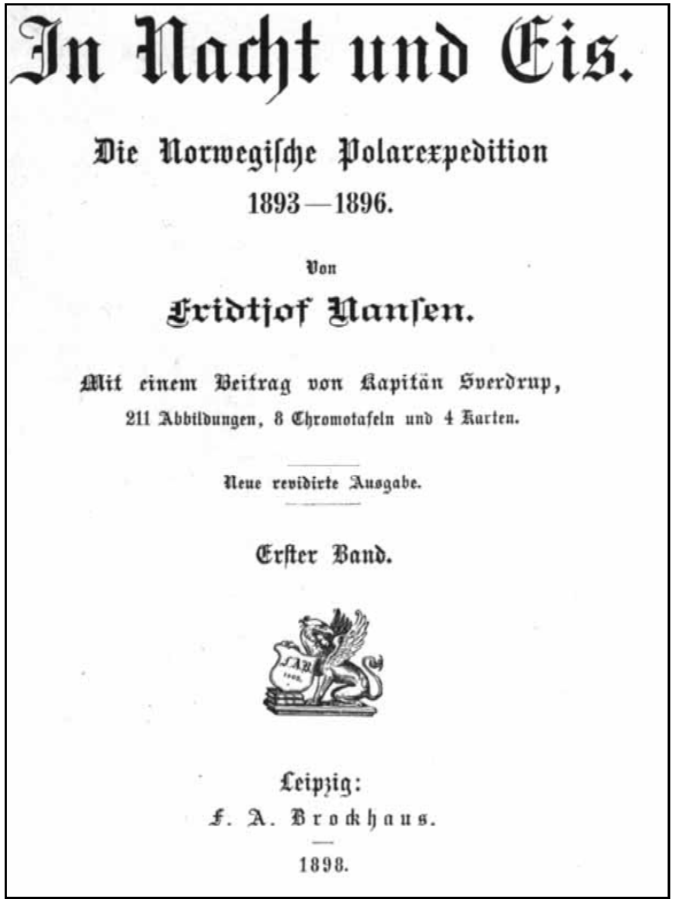
(There) is a warm, comfortable living area. Whether the thermometer is 5° or 30° under the freezing point, we have no fire in the stove. The ventilation is excellent, ... since it drives down fresh winter air by the ventilator.

I am therefore considering - take the stove away completely; it only is in the way."

Source:

The first passive house

It had the name “Fram” and was a Norwegian polar ship.


In Nacht und Eis.

Die Norwegische Polarexpedition
1893—1896.

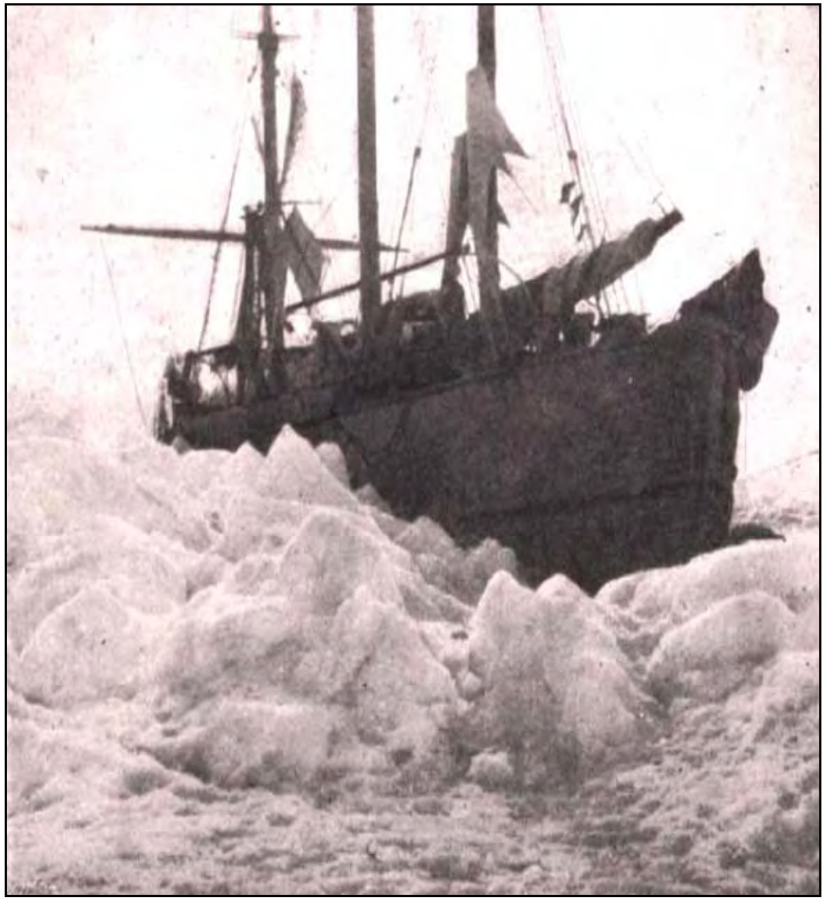
Von
Fridtjof Nansen.

Mit einem Beitrag von Kapitän Sverdrup,
211 Abbildungen, 8 Chromotafeln und 4 Karten.

Neue revidirte Ausgabe.

Erster Band.

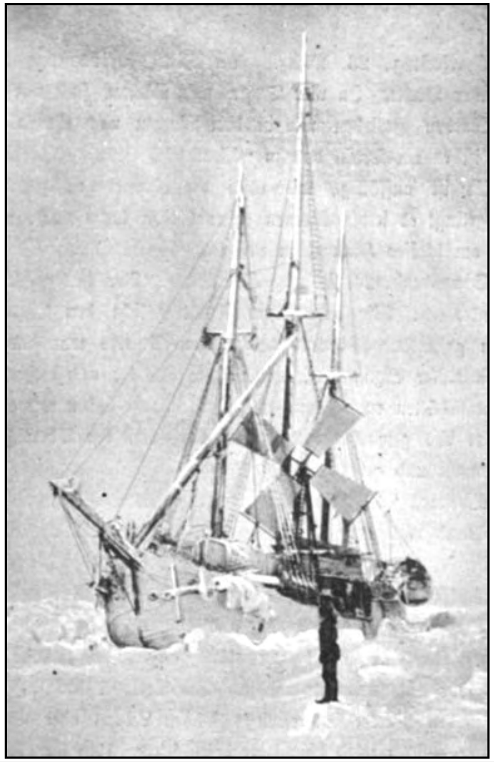
Leipzig:
F. A. Brockhaus.
1898.



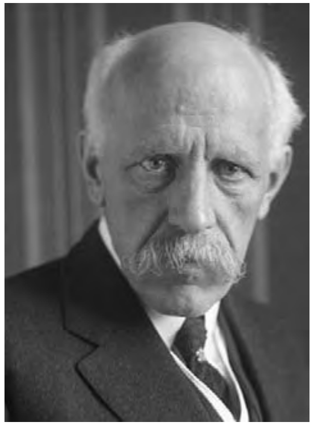
Source: http://de.wikipedia.org/wiki/Bild:Fram_March_94.jpg

The first passive house

It was the ship of the Norwegian scientist Fridtjof Nansen.



The special three-masted schooner for arctic regions was built by Colin Archers at the shipyard Larvik in Norway in 1892.
On board the “Fram” Nansen had living areas installed to survive the arctic winter and a wind rotor with a Generator. This supplied the ship (temporarily) with electrical energy.



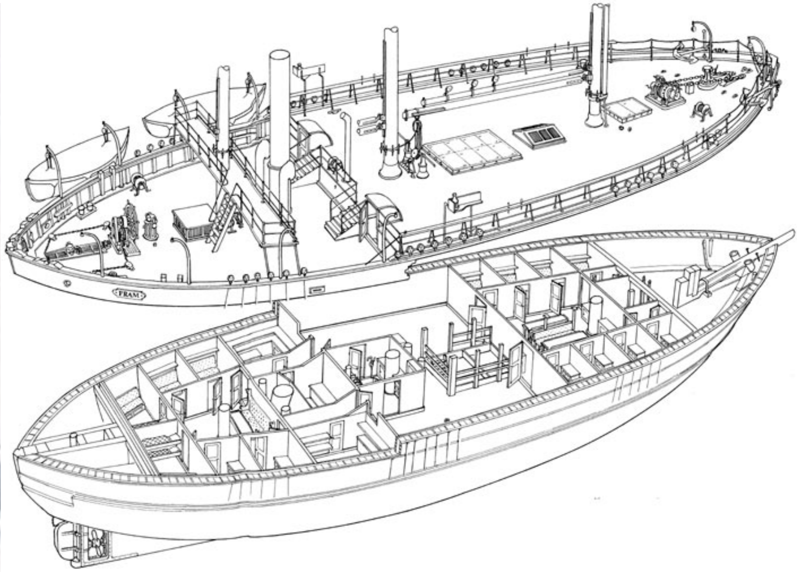
Fridtjof Wedel-Jarlsberg Nansen, 1861 – 1930 Norwegian Zoologist and Polar scientist, Founder of the Neurone theory, Peace Nobel Price 1922, First High Commissioner of the United Nations for refugees, “Passivhaus” pioneer !!!

Source: http://de.wikipedia.org/wiki/Bild:Fram_March_94.jpg

The first passive house

It was used from 1893 till 1912 in the Arctic and Antarctic regions.

1st Fram-Expedition 1893-1896 (Head: Fridtjof Nansen, Arctic expedition)
2nd Fram-Expedition 1898-1902 (Head: Otto Sverdrup, Canadian Arctic islands)
3rd Fram-Expedition 1910-1912 (Head: Roald Amundsen, South Pole expedition)



“Fram” advanced further north and further south than any other surface vessel (total 54000 nautical miles) and gave good accommodation to the crew in 9 arctic winters.

Source: www.fram.museum.no/en/default.asp?page=97 www.fram.museum.no/en/default.asp?page=92

The principles of the construction are:

- compact form
- good heat insulation
- air-tight layers
- ventilation system
- (renewable/wind energy) and
- use of internal gains !!!!!

q3c022

The crew at the supper table, on board the «Fram». f3c025

3c061

Even the dogs have had “Passive Houses” of snow and ice and the use of internal gains !!!!!

Source: http://nabo.nb.no/trip?_t=0&_b=NANSEN_ENG&_s=E&_n=0&_q=10&_l=www_eng_l&_r=M424

The principles of the construction are:

q3c022

- compact form
- good heat insulation
- air tight layers
- ventilation system (???)
- (renewable/wind energy) and
- use of internal gains !!!!!

The crew at the supper table, on board the «Fram». f3c025

3c061

… also the dogs have had "Passive Houses" from snow and ice and use of internal gains !!!!!

Source: http://nabo.nb.no/trip?_t=0&_b=NANSEN_ENG&_s=E&_n=0&_q=10&_l=www_eng_l&_r=M424

The first passive house

In this special case the concept worked without

- **passive solar gains !!!!**
  (because there is no sun in the arctic winter)

The main focus of the following research object are the solar gains (active and passive).

Modern research objects

List of pioneering solar buildings in Wikipedia

The following buildings have been recognised as being of international significance in pioneering the use of modern engineered solar building design:

- MIT Solar House #1, Massachusetts, USA (HC Hottel, 1939) [3] [1]
- Boulder House, Colorado, USA (G Löf, 1945)[1]
- MIT Solar House #2, USA, (HC Hottel, 1947)[1]
- Dover House, Massachusetts, USA (Telkes, Raymond & Peabody, 1948)[1]
- MIT Solar House #3, USA, (HC Hottel, 1949)[1]
- New Mexico State College House, New Mexico, USA (L Gardenshire, 1953)[1]
- Lefever Solar House, Pennsylvania, USA (HR Lefever, 1954)[1]
- Amado House, Arizona, USA (Denovan, Raymond & Bliss, 1954)[1]
- University of Toronto House, Toronto, Canada (EA Allcut, 1956)[1]
- Solar House, Tokyo, Japan (M Yanagimachi, 1956)[1]
- Solar House, Bristol, United Kingdom (L Gardner, 1956)[1]
- Rickmansworth House, Rickmansworth, United Kingdom (E Curtis, 1956)[1]
- MIT Solar House #4, USA (HC Hottel, 1958)[1]
- Solar House, Casablanca, Morocco (CM Shaw & Associates, 1958)[1]
- Solar House, Nagoya, Japan (M Yanagimachi, 1958)[1]
- Denver House, Colorado, USA (G Löf, 1959)[1]
- Princeton University House, New Jersey, USA (, 1959)[1]
- Solar Office House, Tucson, Arizona, USA (R Bliss, 1959)[1]
- Thomason Solar House #1, Washington D.C., USA, (A Thomason, 1959)[1]
- Passive Solar House, Odeillo, France, (Trombe & Michel, 1967)
- Skytherm House, Atascadero, California, USA (Harold R. Hay, 1973)[2] [3]
- Lee Porter Butler, Double Shell Houses (1975)[*citation needed*]
- IEA Task 13 Solar Low Energy Buildings (various, 1989)
- Passive Houses in Darmstadt, Germany, (Bott, Ridder & Westermeyer, 1990) **(German)**[4]
- The Druk White Lotus School in Ladakh, India, (World Architecture Awards, 2002)[4]

Source: http://en.wikipedia.org/wiki/List_of_pioneering_solar_buildings

Modern research objects

Solar houses of the MIT (Massachusetts Institute of Technology)

Solar I, completed in 1939, was the first house in America to be heated by the sun's energy. A single story house-like structure on the MIT campus, Solar One used solar radiation as a heat source for the winter, but projects were also conducted on summer air conditioning and power generation.
This house is featured by the U.S. Department of Energy's Building Technology Program as a "Milestone Building of the 20th Century."

In 1948, **Solar House II** was built as part of the MIT Solar Research Project.

Source: MIT News Office and the MIT Museum http://mit.edu/solardecathlon/solar1.html http://mit.edu/solardecathlon/solar2.html

Modern research objects

Solar houses of the MIT (Massachusetts Institute of Technology)

In 1949, Solar House II was converted into **Solar III**, which returned the heat collectors to the roof. Aesthetically more pleasing, Solar III was the first solar house to be used as a home, and was inhabited by a student family with one child. The house was demolished after it caught on fire in December, 1955.

Solar IV, located in Lexington MA, was completed in 1959 after the Department of Architecture held a contest on solar house design. After collecting data for three heating seasons, MIT sold the house to a private owner.

Source: MIT News Office and the MIT Museum http://mit.edu/solardecathlon/solar3.html http://mit.edu/solardecathlon/solar4.html

Modern research objects

Solar houses of the MIT (Massachusetts Institute of Technology)

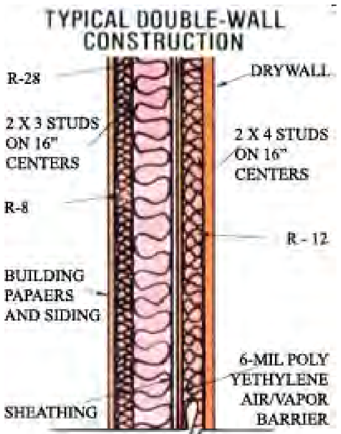
Solar V was erected in 1978 on the MIT campus and used as an experimental studio/classroom by the Department of Architecture. Unlike the first four solar houses, Solar V did not require mechanical equipment such as solar collectors, pumps or fans: all elements of solar heating were incorporated into the building materials.

The **Solar VI** house is the Dover Sun House. The heating storage device was Glauber salts (sodium sulphate decahydrate). After 3 years the system failed.

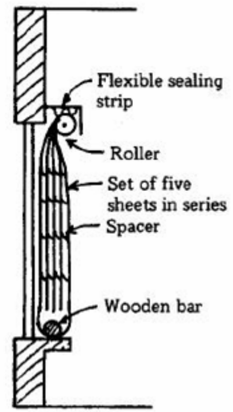
Source: Calvin Campbell, the MIT News Office, and the MIT Museum http://mit.edu/solardecathlon/solar5.html http://mit.edu/solardecathlon/solar6.html

Modern research objects

An example of a “Super-insulated Home” in the USA



www.motherearthnews.com/multimedia/image-gallery.aspx?id=68420&seq=5

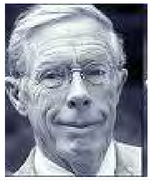


William Shurcliff
"Thermal Shades and Shutters"

In the late 70`s and early 80´s a lot of North American developments (“Super-insulated Houses") were very close to the Passive House Concept.

„The term "super-insulation" was coined by Wayne Schick at the University of Illinois at Urbana-Champaign. In 1976 he was part of a team that developed a design called the "Lo-Cal" house, using computer simulations based on the climate of Madison, Wisconsin“.

The Lo-Cal (Low Calorie) house was designed to illustrate how good planning and construction detailing could reduce residential energy consumption.



One Pioneer in North America:
William A. Shurcliff

Source: [Shurcliff 1980] Super Insulated Houses and Double Envelope Houses, Brick House, Andover, 1st edition 1981

http://en.wikipedia.org/wiki/Superinsulation

Modern research objects

The Saskatchewan Conservation House in Canada

Saskatchewan Conservation House ca. 1977 Regina Leader-Post
in Regina, Saskatchewan

"Saskatoon typically experiences close to 11,000 heating degree-days annually (by comparison. New York, San Francisco, and Chicago have - respectively - 4,870, 3,000, and 6,175 HDD/a), and is therefore an almost ideal spot to test the mettle of any purported energy-efficient housing concept".

www.motherearthnews.com/Green-Homes/1982-05-01/Saskatoons-Superinsulated-Houses.aspx

"In 1977, a group of Canadian researchers built a demonstration home known as The Saskatchewan Conservation House. This was a nearly airtight building that was super-insulated, featured triple paned windows, passive solar design, and one of the world's first heat recovery ventilators. Not long after a similarly designed home, The Leger House was built in Pepperell, Massachusetts. When progressive builders and energy researchers saw the dramatically reduced energy demands of these homes they sat up and took notice".

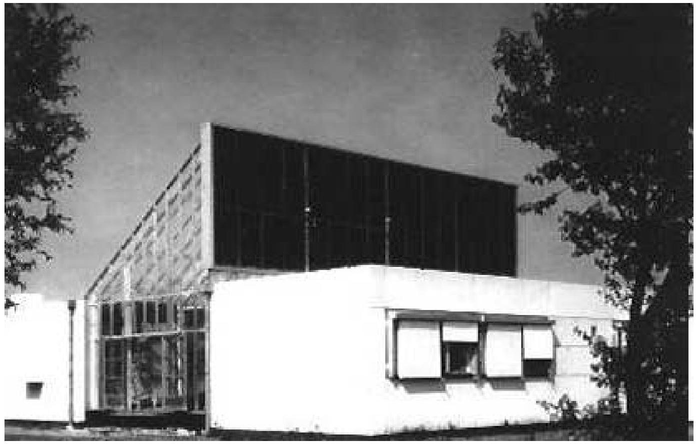
"The Canadian builders found that the most convenient way to incorporate all the features necessary to minimize air leakage and retain heat inside a dwelling (and a super-insulated house is, above all else, an airtight structure) is to use double-wall construction".

www.motherearthnews.com/Green-Homes/1982-05-01/Saskatoons-Superinsulated-Houses.aspx?page=2

Source: http://greendwellingseattle.com/resources/green-builders/growing-green-building-from-saskatchewan-to-seattle/

Modern research objects

The Technical University of Denmark DTH-Zero-Energy-House



Professor Vagn Korsgaard

The Dansk "DTH-Zero-Energy-House,“ built in 1973 in Lyngby by Vagn Korsgaard and Torben v. Esbensen from the Thermal Insulation Laboratory, was a Passive House designed according to simulation calculations.
The evaluation was successful and published in 1978 [Korsgaard et al], but after damage to the active solar system, it was not repaired and without it, it is “only" a good low-energy-house. It is still used for the guests of the university.

It was a very important step for further Passive House research and development.

Source: up: www.passivhaustagung.de/Passivhaus_D/Geschichte_Passivhaus.html down.: www.polytechphotos.dk/index.php?CatID=874&PicID=615

Modern research objects

The Philips Experimental House

At the same time a research group for energy-efficient houses was established. H. Hörster, B. Steinmüller and others calculated the parameters for the German climate.
The result was the Philips Experimental House, a super-insulated one-family house with active solar elements. It was used for the evaluation, but it was uninhabited. This was published in 1980 “Wege zum energiesparenden Wohnhaus.”

It was also a very important step in further Passive House research and development.

Source: www.passivhaustagung.de/Passivhaus_D/Geschichte_Passivhaus.html

Modern research objects

The Rocky Mountains Institute of Amory & Hunter Lovins

Amory Lovins

Amory Lovins, a well known author of books for alternative energy use, built in Old Snowmass, Colorado (2164 m high) a super insulated house with super windows (heavy-gas-filled Heat Mirror® windows) and passive solar gains. The active solar panels drive an under-floor radiant heating system and the domestic hot water system. Tropical plants grow in the winter garden and the oven is used very rarely.

“Constructed between June 1982 and January 1984, the building was something of an experiment. It was designed to make the most of the energy efficiency and alternative energy technologies available at that time”.

This was also a very important field test for further Passive House research and development.

Source: Foto: rmi www.passivhaustagung.de/Passivhaus_D/Geschichte_Passivhaus.html www.rmi.org/rmi/Amory's+Private+Residence

Modern research objects

Super-Low-Energy-Houses of Hans Eek

In 1985 the Swedish pioneer and architect Hans Eek built super-low-energy-houses with 30 kWh/(m²a) heating demand in Ingolstadt-Halmstadt.
With a lot of bad experiences with unreliable technologies he paid special attention to the air-tightness, super heat insulation, high quality windows and a solid mechanical ventilation system with heat recovery.

Since then he has been an important partner in further Passive House research and development.

In 2001 he built this Passive House estate in Göteborg-Lindås.

Source: Foto: rmi www.passivhaustagung.de/Passivhaus_D/Geschichte_Passivhaus.html www.rmi.org/rmi/Amory's+Private+Residence

Modern research objects

The Zero-Energy-House of Erhard Wiers-Keiser

The Zero-Energy-House of Erhard Wiers-Keiser and the association "Ökologische Zukunftswerkstatt Minimal- und Nullenergiehäuser e.V." (1989) was calculated to have lower energy demands than a Passive House, but in actual use the energy requirement is higher. Problems are the air-tightness, inside insulation elements for the windows and the solar storage technology. The 10 m³ solar tank for annual storage is now removed and it is now a "nearly passive house".

Important inputs for the development are from Robert Borsch-Laaks.

Source: www.passivhaustagung.de/Passivhaus_D/Geschichte_Passivhaus.html

Modern research objects

The Energy-Autarc-Solar-House in Freiburg

The “Energy-Autarc-Solar-House” (ISE, Freiburg 1991/92, by Wilhelm Stahl) was built at the same time as the Passive House Darmstadt-Kranichstein. It is very near to the Passive House Standard. The very complicated hydrogen-storage technology is no longer used. The passive technology and the heat recovery ventilation are working well and today it is used as a Passive House.
The Institute for Solar Energy (ISE) is field testing Passive House Compact Units in this house.

Between the ISE with Wilhelm Stahl and the Passive House-Group there was an exchange of knowledge for mutual support.

Source: www.passivhaustagung.de/Passivhaus_D/Geschichte_Passivhaus.html

From Low-Energy House to the Passive House

Substantial problems of these “early” houses:

- The missing awareness of the necessity of long-term air-tightness. Important knowledge was collected in Sweden by the pioneer Prof. Arne Elmroth of Lund University.

- Missing solutions for energy-efficient windows. As a result windows are small and must be closed with temporary insulation elements during the night. Both are reasons why the concept did not receive widespread acceptance.
- Lack of reliability in the energy-efficiency of the used technology. In some of the projects we have seen a "technological Christmas tree” for engineers - too much complicated technology not working well in the end.

Source: www.passivhaustagung.de/Passivhaus_D/Geschichte_Passivhaus.html

From Low-Energy House to the Passive House

Development of the Passive House Concept:

„The highlight of the 1980's was the low-energy building which had a legally required energy standard for new buildings in Sweden and Denmark.

At that time, many elements necessary for reducing building energy consumption had been developed, i.e. thick insulation, minimized thermal bridges, air-tightness, insulated glazing and heat recovery ventilation.

On this basis, the “Passive House" concept was developed in May 1988 by the author host Professor Bo Adamson during a research stay in the field of building construction at the University of Lund in Sweden”.

Robert Hastings

Bo Adamson

Wolfgang Feist 1998

Source: www.passivhaustagung.de/Passivhaus_D/Geschichte_Passivhaus.html

From Low-Energy House to the Passive House

Passive Solar Homes and the Passive House Concept:

"Passive House" is not just a new name for "Super-insulated Houses", although a Passive House in cold climate regions is very similar to a super-insulated house.

The Passive House concept does not stipulate the technology with which the functional goal should be reached. "Passive Solar Homes" of all styles can also serve as a basis for a functioning Passive House.

"Passive Solar Homes" and "Super-insulated Houses" were regarded by their respective proponents as competing concepts for a long time.

Robert Hastings, pioneer of the American “Passive Solar Architecture," gave decisive help in reconciling these opposing directions.

Source: www.passivhaustagung.de/Passivhaus_D/Geschichte_Passivhaus.html

From Low-Energy House to the Passive House

The Passive House Concept:

„The Passive House is not an energy performance standard, but a concept to achieve highest thermal comfort conditions at low total costs - this is the correct definition:

A Passive House is a building, for which thermal comfort (ISO 7730) can be achieved solely by post-heating or post-cooling of the fresh air mass, which is required to fulfil sufficient indoor air quality conditions (DIN 1946) - without a need for re-circulated air.

This is a purely functional definition. It does not need any numerical value and it is independent of climate. From this definition it is clear that the Passive House is not an arbitrary standard enacted by somebody, but a fundamental concept. Passive Houses have not been "invented," but the conditions to use the passive principle have been discovered.”

Source: www.passivhaustagung.de/Passive_House_E/passivehouse_definition.html

From Low-Energy House to the Passive House

The Passive House Concept:

„In a Passive House the consumption for space heating is reduced by 90% compared to average houses of the building stock and by 75 % compared to ordinary new construction – the energy requirement for heating Passive Houses is
15 kWh/m² of living space each year and thus far less than in low energy houses. But, at the same time the comfort in a Passive House is significantly better.

The Passive House Standard is
- energy efficient,
- cost effective,
- comfortable,
- affordable,
- economic and
- sustainable."

Source: www.passivhaustagung.de/Passive_House_E/passivehouse_definition.html

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer

The research project:

A team of scientists (Wolfgang Feist, Bo Adamson in cooperation with Gerd Hauser and others) took part on the project "Building preparation research for Passive Houses.

Supported by the Country of Hessen (Germany) the requirements for energy-efficient houses were explored systematically and prototypes of new building elements were developed and produced.

An accompanying measuring program shows the results for the concept and for all building elements.

Feist, W. (Hrsg.): **Bauvorbereitendes Forschungsprojekt Passive Häuser; IWU, Darmstadt, 1992**
Feist, W. und Werner, J.: "Gesamtenergiekennwert < 32 kWh/(m²a)"; Bundesbaublatt 2/1994

Source:

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer

Architectural concept:

Southern facade

The “first” Passive House in Darmstadt-Kranichstein has been constructed in 1990/91 on design plans by architects Prof. Bott/Ridder/ Westermeyer for 4 private clients 4 row house units .

These 4 families that have occupied the first Passive House since 1991, have been very pleased with the experience.

Northern facade

Source: www.passivhaustagung.de/Kran/Passive_House_Spring_Winter.htm

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer
Architectural concept:

- Compact volume
- Orientation to the Sun
- “Super”windows

South View in Winter

When the outside temperature is -10°C (14°F), the heating system still doesn't need to be turned on.

Source: www.passivhaustagung.de/Kran/Passive_House_Spring_Winter.htm

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer

Architectural concept:

The fresh air inlets at a height of 2.80 m can be seen.

The Northern part of the house has a spacious glazed space which is not heated. This is not important for the energy balances - its an architectural feature. There are only single pane windows used - during frost there will be frost patterns on the panes. The thermal envelope of the house is the northern separation wall to the glazed space. There are big triple glazed windows in that wall and the wall is insulated almost at the same level (27.5 cm) as all the other external walls. Therefore it is cold in the glazed space during winter.

Source: www.passivhaustagung.de/Kran/Passive_House_Spring_Winter.htm

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer

Architectural concept:

"The earth buried tubes and the heat recovery of the ventilation system keep the temperature of the fresh air entering the room to be higher than 18 °C. The air inlets are positioned near to the ceiling of the rooms. The air has already mixed up with room air before it enters the living space. To deliver space heating, in this building small radiators placed at internal walls are used. That can be done in a Passive House, because all indoor surfaces, especially those of the windows, are comfortable warm. The surfaces do not lose a lot of heat, and the envelope is really airtight, all this together guarantees that there are no cold drafts in this building."

An interior view of a spacious living area on the ground floor

Source: www.passivhaustagung.de/Kran/Passive_House_Spring_Winter.htm Foto: HG Esch

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer
Architectural concept:

South View
in Summer

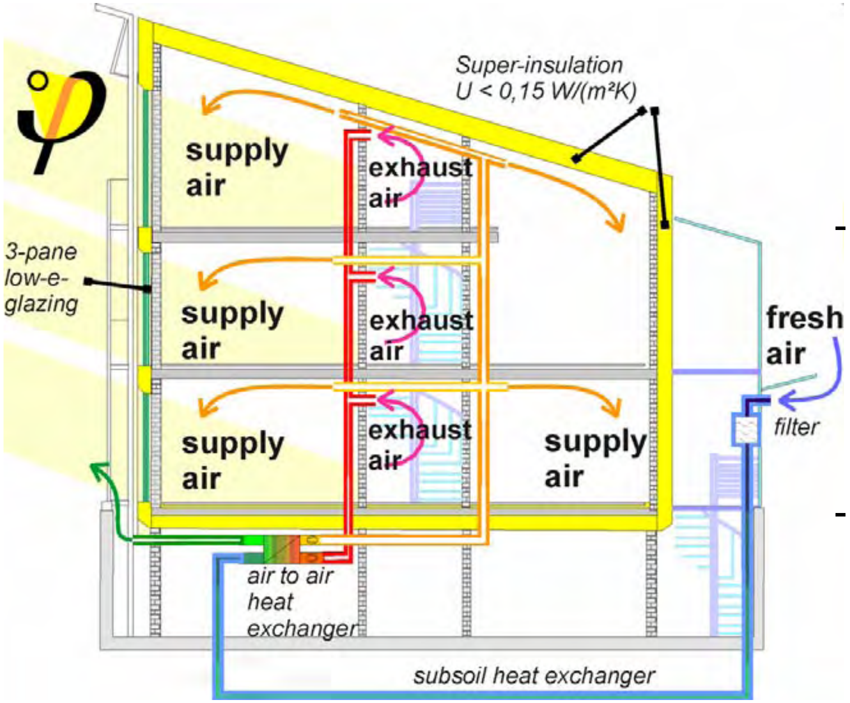
Inside temperature on the top floor never exceeds 26°C (79°F), even when outside temperatures are 35°C (95°F)!

Source: www.passivhaustagung.de/Kran/First_Passive_House_Kranichstein_en.html

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer

Building concept:

This is a section showing the most important essentials:



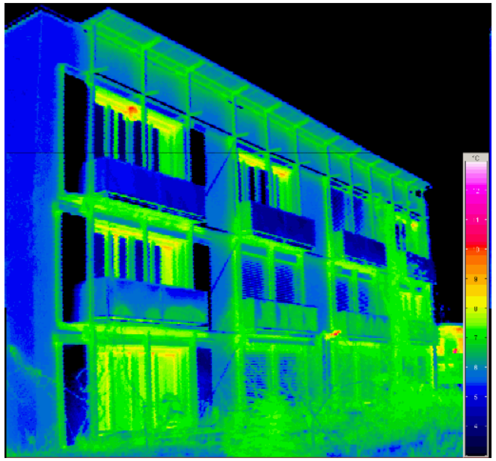
- A very good thermal insulation all around the heated space (in the roof 450, on the external walls 275 and beyond the basement ceiling 250 mm of thermal insulation).
- Triple pane windows with a special insulation of the window frames (built by handicraft work) have been used. Nowadays these Passive House windows are available on the market.
- The fresh air ventilation system with the air inlet at the Northern facade, filter, earth buried ducts to preheat the fresh air ("subsoil heat exchanger"), air-to-air heat exchanger in the basement and supply ductwork.

All this works as designed unchanged since 18 years of operation.

Source: www.passivhaustagung.de/Kran/Passive_House_Spring_Winter.htm

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer

Building concept:



External thermographic photo

The hot water is heated using a vacuum tube solar collector (5.3 m² for each household or 1.4 m² per person). Secondary heating is done using natural gas. The solar thermal system provides about 66% of the hot water used in the house. Because domestic hot water represents the highest energy draw of this house, an efficient hot water distribution network is of great importance so the pipe network was designed to be compact, within the thermal envelope, and well insulated.

Source: www.passivhaustagung.de/Kran/Passive_House_Spring_Winter.htm

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer

Building concept:

Design features of the Darmstadt Kranichstein passive house

Roof:
U-value: 0.10 W/(m²K)

Grass roof: Humus, filter fabric, root protective membrane, 50 mm formaldehyde-free chip board, wooden I-Joist rafter (Flange made of dimensional lumber, web mad of high density fibre board), framing, polyethylene air-tightness barrier, gypsum plasterboard 12.5 mm, wallpapers, painted with emulsion paint, entire cavity (445 mm) filled with blown-in mineral wool insulation.

Exterior walls:
U-value: 0.14 W/(m²K)

Fabric reinforced external plaster; 275 mm of expanded polystyrene insulation (EPS), (installed in two-parts, 150 +125 mm); 175 mm sand-lime brick masonry; 15 mm continuous interior gypsum finish; wallpapers, painted with emulsion paint

Source: www.passivhaustagung.de/Kran/First_Passive_House_Kranichstein_en.html

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer

Building concept:

Design features of the Darmstadt Kranichstein passive house

Basement ceiling:
U-value: 0.13 W/(m²K)

Fiberglas reinforced plaster skim coat;
250 mm polystyrene -insulation;
160 mm on site concrete;
40 mm of polystyrene acoustic insulation;
50 mm cement floor finish;
8-15 mm of parquet, adhesive; sealing solvent-free .

Window :
Ug-value: 0.70 W/(m²K)

Triple pane glazing with Krypton filling
Wooden window with polyurethane foam insulated framework (CO2foamed, HCFC free, handcrafted)

Source: www.passivhaustagung.de/Kran/First_Passive_House_Kranichstein_en.html

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer
Building concept:

Design features of the Darmstadt Kranichstein passive house

Heat Recovery Ventilation :
Heat recovery efficiency of approx. 80%

Counterflow air-to-air heat exchanger;
Located in the cellar (approx. 9°C in the winter),
carefully sealed and thermally insulated, the first one to use electronically commutated DC fans.

Air-tightness:

A blower door test resulted in an n50value below 0,3 h-1.
When the building was tested again in October 2001,
we result was that air-tightness had not diminished [Peper 2005].

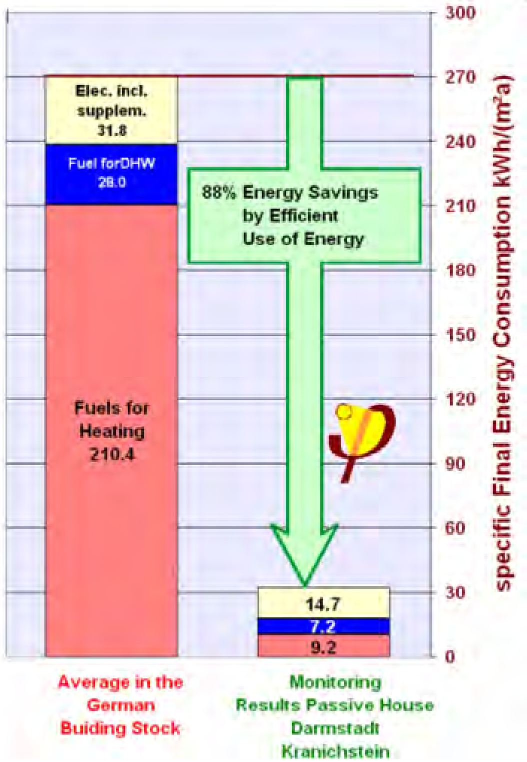
The modelled value for the Passive House of 10,5 kWh/(m²a) is in good agreement with the measured value.

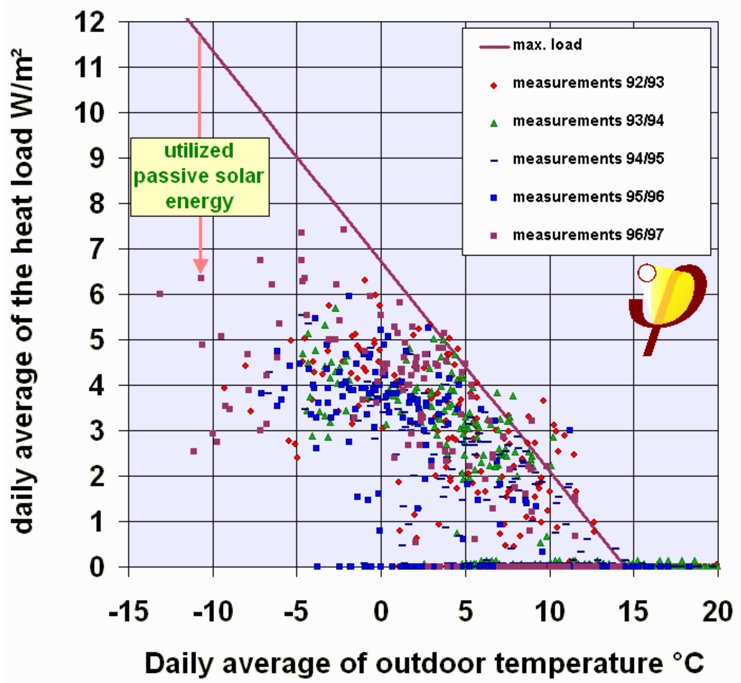
Source: www.passivhaustagung.de/Kran/First_Passive_House_Kranichstein_en.html

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer

Results:

An accompanying measuring program produced new insights into super heat insulated construction elements, windows, ventilation heat recovery, user behaviour, indoor air quality, Internal heat gains and much more.

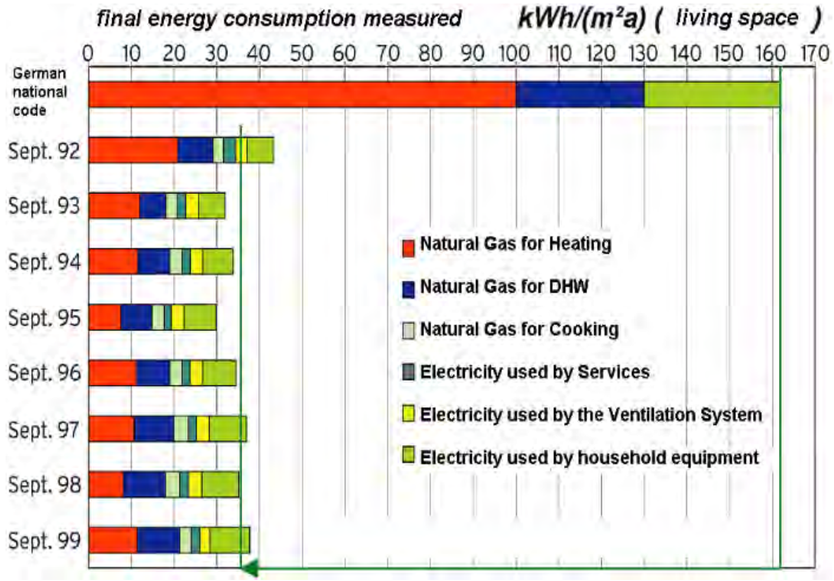




Results of heating load measurements, the heat load has never exceeded 7.4 W/m²

Source: www.passivhaustagung.de/Kran/Passive_House_Spring_Winter.htm

The Passive House Darmstadt-Kranichstein Architects:Bott/Ridder/Westermeyer
Results:



19.8 kWh/(m²a) in the first operational year 1991/92 or only 8% of the consumption of comparable dwellings,

11.8 kWh/(m²a) in the second operational year 1992/93 or only 5.5% of the consumption of comparable dwellings.

less than 10 kWh/(m²a) on the average all subsequent years

Results of the energy consumption measurements in the passive house Darmstadt Kranichstein; not only the heating energy is drastically reduced (over 90% compared to a "normal" new building of the same vintage), but also the gas consumption for domestic hot water (due to good insulation and a solar thermal collector) and house-hold electricity consumption (by particularly efficient appliances, e.g. the "Low Energy Refrigerator" of Gram after a development by J. Nørgard).

Source: www.passivhaustagung.de/Kran/Passive_House_Spring_Winter.htm

The Passive House Darmstadt-Kranichstein

Results:

The success of this test building was the beginning of a dynamic and worldwide development of the Passive House concept. This is being done in an “open-source strategy” by numerous people and is permanently being further developed.