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University of Applied Sciences

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Green Solutions for the 21st Century

Sustainable Development in the Building Sector



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1. Introduction

Humanity is facing a problem that cannot be postponed or delayed any longer: global warming. The lower atmosphere and sea temperature have been continuously getting warmer in recent decades, causing a lot of devastating consequences, and contrary to the opinions of all disbelievers, the scientifically proven reason is human activity. We are combusting oil, natural gas and coal in huge amounts every day, and thus “CO₂ [and all the other greenhouse gases] keeps going up. It is relentless. And now we are beginning to see the impact in the real world.”¹ All the human-generated greenhouse gases are causing and intensifying the anthropogenic greenhouse effect, which in turn is the reason for the rise in the earth’s average temperature. Fortunately we have begun to notice this rape of Mother Earth slowly but surely, because of the myriad of obvious consequences, which indicate to us that it is time to embark on the fight against pollution. But the question is how should we approach that inescapable challenge? There are two major methods to reduce the combustion of fossil fuels. We can either generate more energy with renewable energy sources or we reduce our current consumption. However, one thing is a fact: The window for action is narrowing fast and it seems unrealistic that we will be able to generate all the energy required nowadays only with renewable energy sources in an appropriated timeframe. Thus we definitively have to reduce our energy consumption and therefore we have to have a look at its structure first.

Figure A illustrates the German energy consumption in 2006 classified by Usage. It is obvious that we require a huge amount of energy (more than 30%) only for heating our buildings. When considering the fact that most heating energy is used for the residential sector there is obviously a great opportunity for all of us to reduce CO₂ emissions.² This potential savings is often illustrated with a diagram similar to **Figure B**³, which shows that the heating energy of the building stock is 17 times higher than the heating energy of modern passive houses. And this huge opportunity to save energy is the key point of this article.

This article shows that energy efficiency in the building sector comes along with a lot of persuasive advantages. It is profitable and ecological, it leads to increased comfort and it is easy to put into practice. To convince the reader of the great potential of the building sector it is essential to give him first an overview of the meaning of the word “comfort” in the building sector. Afterwards the article illustrates the general building components which have to be changed for more comfort and energy efficiency and finally these changes will be concretized by the passive house standard.

¹ An Inconvenient Truth, 2006. Documentary Film. Starring: Al GORE. USA: Paramount Classics

² BMWi, 2007. Struktur des Energieverbrauchs.

³ KRIMMLING, J., 2007. Energieeffiziente Gebäude, page 16

2. Comfort

Whenever we plan a building, the comfort of the occupants has to play a decisive role, because we spend most of our time inside buildings. They are the “third skin”⁴ of a human and therefore a decisive factor for a higher quality of life and better health. Only a comfortable environment can result in the high performance of employees. This is illustrated by the fact that companies lose millions of euros, just because they do not provide an appropriate working environment.⁵ However, if people are considering the idea of building a house they often decide against a low-energy building, because they are thinking about a loss in comfort and unprofitable additional costs, but that is a big misconception. A low energy building leads rather to more comfort and pays off in an appropriated timeframe, which will be discussed in later chapters. To comprehend why a low-energy building leads to more comfort, it is important to know the factors that influence us in feeling comfortable or not.

Comfort is influenced by two major criteria: indoor air quality and indoor climate.

2.1 Indoor air quality

The indoor air quality depends on the quality of the external air (exhaust emissions), the materials used for the building shell (PCB, Radon), the materials used for interior fittings (coatings, adhesives), furnishings and utilization (detergents, hoover, cigarette smoke), i.e. the indoor air quality is predominantly generated from within. The most important aim is to identify the harmful substances and to avoid them or alternatively conduct them out of the building if they are inescapable, because excellent indoor air quality is essential for healthy living.

2.2 Indoor climate

The indoor climate is determined by four different physical influences.

Air speed: The rate of air movement resulting from joints and chinks in the building envelope.

Should be avoided by a hermetically sealed construction to increase comfort.

Humidity: The relative humidity should be between 35 and 70%. Lower humidity generates more dust and desiccates the mucous membranes. Higher humidity entails condensation water, which in turn can result in mould. Moreover a relative humidity above 70% constrains the heat emission of the human body, thus making us feel uncomfortable.

⁴ DRAKE, S., 2007. The Third Skin: Architecture, Technology & Environment

⁵ BAUER, M., 2007. GREEN BUILDING – Konzepte für Nachhaltige Architektur, page 22 ff

Air temperature: In general an air temperature between 18–24°C is said to be pleasant. The temperature of the air depends on how people are dressed, what they are doing, their age and the mean radiant temperature.

Mean radiant temperature (MRT): The mean temperature of the surrounding surfaces such as walls or windows, with which the occupant exchanges heat by radiant transfer.

The air temperature and the MRT have the same impact on the heat dissipation of the human body; their average is called operative temperature. In general they are supposed to be approximately the same for maximum comfort. According to **Figure C**, it is obvious that a lower MRT needs to be balanced by higher air temperature. E.g. a person might possibly feel cold by an air temperature of 24°C if the mean radiant temperature is only 17°C.^{6,7,8,9,10}

3. Key components

Heat losses can result either from transmission or convection.

Heat losses from transmission are influenced by the compactness of a building (A/V) and by the structure of the façade (U-Value).

Heat losses from convection result from joints in the building envelope and from open windows. Because of the physical aspect it is obvious that we need adequate ventilation, but an excessive change of air should be avoided by an improved airtightness and a mechanical ventilation system.^{11,12}

3.1 Airtightness

One of the basic requirements of a low-energy building is a hermetically sealed building shell. Airtightness helps to protect the fabric of a building against condensation water as a result of an uncontrolled air change through joints which is the most common reason for structural damage. Moreover, it helps to reduce draughts – the most common cause of local discomfort. It is furthermore essential for reducing energy consumption because with insufficient sealing the heat losses through convection can be up to thirty times higher than heat losses through transmissions. Even the heat losses through transmission increase if there is a lack in the hermetic sealing, because the effectiveness of insulation is based on unmoved air and if wind blows through the insulation it is very counterproductive. Furthermore a sealed building

⁶ BOHNE, D., 2004. Ökologische Gebäudetechnik, page 11ff

⁷ KRIMMLING, J., 2007. Energieeffiziente Gebäude, page 33 ff

⁸ KÖNIGSTEIN, T., 2004. Ratgeber energiesparendes Bauen, page 8ff

⁹ PREZIGER, D., 2002. Grundlagen und Bau eines Passivhauses, page 37 ff

¹⁰ BAUER, M., 2007. GREEN BUILDING – Konzepte für Nachhaltige Architektur, page 22 ff

¹¹ KRIMMLING, J., 2007. Energieeffiziente Gebäude, page 93 ff

¹² PREZIGER, D., 2002. Grundlagen und Bau eines Passivhauses, page 3

contributes to better indoor air quality because harmful substances which were used in the construction of the building shell cannot intrude into the building.^{13,14,15}

3.2 Insulation

Transmission heat losses through exterior walls and roofs are responsible for 70% of the total heat loss in the current building stock. The function of insulation is to constrain these heat losses; i.e. a better insulation is the main step for energy saving measures.

The sticking point with insulation is the U-value [$W/(m^2K)$], describing the amount of heating energy which goes through the wall (or roof) per square meter by an temperature difference of 1°K (Kelvin) in an fixed timeframe.

Critics often claim that improved insulation will never render the theoretically promised improvements in reality. They are still pessimistic in spite of every carefully carried out investigation having the same result: Improved insulation achieves its full effectiveness even up to a half meter. “Superinsulation”¹⁶ works! (See **Figure D**.) That in turn means that doubling the insulation is halving the transmission heat losses. In addition better insulation causes warm surfaces and thus you can reduce the air temperature without a loss in comfort. The comfort actually increases because the MRT and the air temperature are getting closer. The last huge advantage of better insulation is the protection of the fabric due to a switched dew point.^{17,18}

3.3 Window

The thermal conductivity of a window isn't comparable with any other part of the building envelope. Even the best glazing is far beyond a traditional wall. However, windows have a considerable advantage over the other components of a building – they can gain heat energy through solar radiation. This effect can cover a significant part of the heat demand.

Something that often is not considered in practice is the fact that a window is not only made up of glass but also made up of a frame, which represents a good 20–40% of the whole window. The frame is consequently an important part in an energy-saving building concept as well. As important as considering the frame itself is avoiding thermal bridges at the glass edge and any kind of leaking. Poorly designed windows are a reason for draughts and cold surfaces and therefore a reason for feeling uncomfortable. Needless to say, they are a reason for high energy consumption and high energy costs.

¹³ KÖNIGSTEIN, T., 2004. Ratgeber energiesparendes Bauen, page 54ff

¹⁴ SCHÄFER, H., 2006. Vom Altbau zum Passivhaus, page 22

¹⁵ BAUER, M., 2007. GREEN BUILDING – Konzepte für Nachhaltige Architektur, page 30

¹⁶ This expression was coined by Wayne Schick at the University of Illinois at Urbana-Champaign

¹⁷ KÖNIGSTEIN, T., 2004. Ratgeber energiesparendes Bauen, page 8ff

Hence it is always important for every new construction or renovation to set a high value on energy-saving glazing, insulated frame materials, a good sealing and so-called warm edge spacers (against thermal bridges) to save a maximum of energy.¹⁹

3.4 Ventilation System

Due to the sealed building shell there is no ventilation through the joints; otherwise the exhausted air has to be changed regularly. That means on the one hand the air change rate has to be high enough to provide excellent air quality but on the other hand the rate should not be higher than necessary with regard to the energy consumption. In general an air change rate of 0.55/h (the complete air is changed every two hours) is completely sufficient to provide good air quality. This can either be reached by opening the window at least a few times a day or by putting it on tilt. But window ventilation is definitely not the best opportunity. Putting the window on tilt means an air change rate of more than 3/h (average) which equals energy dissipation by the factor of five or six. A more sophisticated solution is a mechanical ventilation system (see **Figure E**), which reduces excessive heat losses through ventilation. However, saving energy is not the only advantage of a mechanical ventilation system over window ventilation:

Through a mechanical ventilation system that provides fresh air continuously, air quality is kept at a good level even at night or when it is cold outside, whereas intermitting ventilation provides good air quality only for a short time. Smells can be directly extracted in contrast to window ventilation, which takes a longer time. An opened window faced to the street brings annoyance due to noise and opened windows in general enable insects and pollen to get into the house. A further problem is, that we do not open our windows often enough because it is just too annoying and therefore the air quality is not adequate most of the time. Another advantage is the possibility of cooling down the building during the night in summertime, whereas windows are often closed at night because of thieves or noise.

All in all, a mechanical ventilation system both conserves energy and improves comfort.^{20,21,22}

¹⁸ FEIST, W., http://www.passivhaustagung.de/Passivhaus_D/Daemmung_Passivhaus.html

¹⁹ KÖNIGSTEIN, T., 2004. Ratgeber energiesparendes Bauen, page 62ff

²⁰ KLIMA, M. Lüftung. In: GABRIEL, I & LADENER, H., 2006. Vom Altbau zum Niedrigenergiehaus. p.209ff

²¹ KÖNIGSTEIN, T., 2004, Ratgeber energiesparendes Bauen, page 72ff

²² PREZIGER, D., 2002. Grundlagen und Bau eines Passivhauses, page 24 ff

4. Passive House

The concept of a passive was established in the early '90s by the Passivhausinstitut in Darmstadt/Germany. According to the founder and chairman Wolfgang Feist passive houses are buildings that are comfortable in summer and wintertime without having a heating system or air conditioning, as the building is heated and cooled passively.²³

Passive house (or the German "Passivhaus") is not a trade name but a building concept available for everyone and for any kind of building except for excessive glass architecture.

The concept is very simple: Heat loss is reduced to a point where the free heat gains inside a building, such as passive solar energy through the windows, heat that results from using electronic equipments, or the heat emitted from people, are enough to keep the temperature at a comfortable level. In other words, heat losses are equal to the free heat gains. Thus a heating system becomes unnecessary. In practice a passive house is allowed to use less than 15kWh/(m²a) for heating, which amounts to energy savings of almost 80% compared to buildings which already obey the new energy standards (see **Figure A**). For the heat losses to be small enough to be compensated by the free heat gains, special windows, high-efficiency insulation and airtightness are essential! A heat recovery ventilation system provides constantly good air quality.²⁴

4.1 Key components (Passive House)

4.1.1 Airtightness (Passive House)

An airtight building shell is one fundamental prerequisite for the operativeness of a passive house. The demands for a passive house are higher than they are for normal buildings, because heat losses due to leaks cannot simply be compensated by a heating system.

4.1.2 Insulation (Passive House)

In spite of the fact that good insulation is the heart of every passive house, no special technical improvement is required. The insulation is simply made so thick that the U-value of all components from the ground along the walls up to the roof is less than 0.15W/(m²K) and as mentioned above superinsulation works!

Figure F shows the U-values being regulated in the new German energy-saving ordinance (EnEV). The U-value of the passive house is up to three times lower than the u-values of the EnEV; thus the transmission heat losses are reduced by a half or even two-thirds. This not only produces enormous savings, but it also allows heating the building only with the free

²³ FEIST, W. 1. Passivhaustagung ; Passivhausinstitut Darmstadt, 1996

²⁴ FEIST, W., 2007. http://www.passivhaustagung.de/Passivhaus_D/passivhaus.html

heat gains. Another advantage of thick insulation are the warm surfaces leading to the same comfort with a lower air temperature and to less structural damages. In a conventional building the surrounding surfaces are often below 16°C; i.e. you need a high air temperature for balancing. On the other hand, the surface temperature of a passive house is often above 18°C; thus the air temperature can be two degrees lower by the same level of comfort (see **Figure G**). This is an amazing savings potential, considering the fact that you can save approximately 6% of your heating consumption by reducing the room temperature by 1°C. Good insulation definitely pays off both ecologically and economically. The invested energy in insulation material often pays off within a heating period (see **Figure D**). The financial amortization period can take 10 to 20 years for some insulation measures. However, if you treat the investment as a loan, comparing the annual cost savings from the lower energy consumption with the annual credit costs (interest + redemption), then it is obvious that the investment pays off, with a durability of the insulation of 30 years and more.^{25,26}

4.1.3 Window (Passive House)

Most buildings in the early '70s were still equipped with single glazing. The U-value was about 5.6W/(m²K), which equals an annual energy input of 60l heating oil per square meter and a surface temperature far beyond a comfortable limit. The first progress was made by double glazing (thermopane glazing) consisting of two panes with an insulating cavity between them. The next giant step forward was the invention of the so-called low-e (emissivity) double glazing – a gauzy metal coating (low-e coating) on the glass pane that enables solar radiations in the form of light waves to pass through but reflect the energy radiated back in the form of infrared waves. Moreover, the cavity is filled with a noble gas instead of normal air, which reduces the transmission heat losses. With this new technology, the U-value could be reduced to 1.1-1.9W/(m²K) and the MRT during the winter was improved to 13°C. However, the heat losses of standard windows are still too high for a passive house– they need a U-value of 0.8W/(m²K) for the whole window. With three basic changes it is possible to halve the transmission heat losses of a double low-e glazing and to increase the surface temperature on 17°C. (**Figure H**: Comparison of glazing)

The conventional frames used for low-energy buildings are insufficient for a passive house due to the heavy heat losses. For a passive house window frame you either use sophisticated plastic frames (vinyl or PVC) or wooden frames, both with integrated insulation. Due to the integrated insulation, heat loss is noticeably reduced. The second technical innovation is the

²⁵ PREZIGER, D., 2002. Grundlagen und Bau eines Passivhauses, page 37 f

²⁶ LADENER, H. and SIEPE, B. Die energietechnischen Maßnahmen. In: GABRIEL, I and LADENER, H., 2006. Vom Altbau zum Niedrigenergiehaus, page 46

so-called warm edge technology. A conventional low-e double glazing has aluminum spacers to separate the panes of glass. These aluminum spacers are always forming thermal bridges and hence come along with high energy losses. Thus, passive house windows usually use plastic spacers with a lower conductivity to avoid thermal bridges and to achieve the desired U-value. The third improvement is triple instead of double glazing, including two noble gas filled cavities and two low-e coatings. The three components are coordinated in such an effective way that the annual energy input is only seven liters of heating oil per square meter—one-eighth of the initial value and half of the current standard. Besides the high energy efficiency there is consequently improved comfort due to the high MRT. Therefore passive house windows are a perfect example of effective energy-saving technology. By the way a triple low-e glazing pays off just because of the saved energy costs.^{27,28}

4.1.4 Ventilation System (Passive House)

The average convection heat losses in a normal building are approximately 35 kWh/(m²a); i.e. they are twice as high as the heating energy demand for a passive house (15kWh/(m²a)).

In a normal ventilation system (see **Figure E**) the fresh air is directly aspirated through inlets and afterwards warmed by the already existing indoor air which in turn is normally heated by a heating system. The heating energy demand for compensating the heat losses of such a system would be much too high for a passive house and therefore it uses the more sophisticated ventilation system with heat recovery (see **Figure I**). In contrast to a normal ventilation system, the fresh air does not stream directly into the building but gets previously heated by a heat exchanger. The (cold) fresh air and the (warm) exhausted air flow through the heat exchanger, which is based on a simple counter flow system. The energy transfer, where the thermal energy of extracted air is recovered and given to the fresh air, enables it to get from 75% to 95% of the thermal energy back. Depending on the heat exchanger, the recovered energy is eight to fifteen times higher than the electricity needed. After the fresh air is heated by the heat exchanger it flows to the desired room by a pipe system.

To optimize the installation it is reasonable to add a ground heat exchanger. This enables preliminary heating of the fresh air in wintertime (soil temperature ca. +5°C) and it enables the cooling of the fresh air temperature in summertime (soil temperature ca. 8–12°C) and thus contributes significantly to summer heat protection.^{29,30,31}

²⁷ FEIST, W., 2006. http://www.passivhaustagung.de/Passivhaus_D/PassivhausFenster_06.htm

²⁸ KÖNIGSTEIN, T., 2004. Ratgeber energiesparendes Bauen, page 64ff

²⁹ KÖNIGSTEIN, T., 2004, Ratgeber energiesparendes Bauen, page 79ff

³⁰ PREZIGER, D., 2002. Grundlagen und Bau eines Passivhauses, page 17

³¹ BOHNE, D., 2004. Ökologische Gebäudetechnik, page 83ff

4.2. General points to consider

One key component that is not addressed in this article is the thermal bridge, because the avoidance or minimization of thermal bridges is essential for every low-energy construction and moreover it is rather a problem of implementation directly at the construction site (botch) than a problem of design.

Another section which would go beyond the scope of this article but should be generally addressed is the choice of the building materials with regard to both the environment and the health of the occupants. Selection criteria for eco-friendliness should be energy, water and raw material consumption during the production of a material, the possibilities for reuse, recycling or disposal and the energy used for the transportation of materials.

However, the energy consumption during the production should not be overrated, because the heating energy required is ten times higher.^{32,33}

4.3 Resulting advantages of the improved Key Components (Passive House)

So far, this article has pointed out the different changes of a passive house in comparison to a normal one and the resulting advantages of every single step. But how big are the cumulative contributions of the single steps for low-carbon living? We have to look back at **Figure A** and **Figure B**. The heating energy of the current building stock could be reduced by 73% if every building obeyed the new German energy-saving ordinance and it could be even reduced by 94% if every building utilized leading-edge technology in the building industry, the passive house standard. We also remember the huge proportion of the heating energy, which is more than 30% of the entire energy consumption. Of course it would be a naïve fallacy to multiply the heating energy savings with the 30% to get the overall savings because we would not mind the additional primary energy input for more insulation and a ventilation system. But as already shown in **Figure D** the additional insulation pays off after a very short period and the additional energy input for a ventilation system is redressed by the missing heating system. Thus a passive house is ecological contrary to the opinion of ill-informed critics. **Figure J** illustrates the energy input of a low-energy building and the first passive house (built in 1990) over a timeframe of 80years. The primary energy input (PEI) of the passive house is a smidgen above the low-energy building and the energy input for maintenance (R-PEI) is a bit higher, but the decisive point is the sum of the PEI, the R-PEI and the cumulative energy input (CEI) which is 60% lower than the sum of the values of the low-energy

³² GLÜCKLICH, D., 2005. Ökologisches Bauen, page 120ff and page 130

³³ RÖTZEL, A., 2005. Praxiswissen umweltfreundliches Bauen, page 19

building. So **Figure J** proves that a passive house is actually the best solution nowadays for low-carbon living even when considering the whole building life cycle.

Economic point of view: Indeed the percentage of passive houses is still quite low, but there is definitely high potential for more. The more passive houses are built, the more suitable products will make inroads in the market. The quality will increase and the prices will fall – and the variety of realized buildings will increase. Since 1990 the additional acquisition costs have been reduced by a factor of seven compared to the current official building standards: From 50,000€ down to 7,500€ per accommodation unit.³⁴ These additional costs virtually pay off with every passive house due to the saved energy costs; i.e. a passive house is affordable for everyone. The financial profitability particularly applies for Germany, because passive houses are supported by the “Kreditanstalt für Wiederaufbau” with low-interest loans. Moreover, passive houses will become more profitable by considering the development of the energy prices. According to the “Tagesschau” (**Figure K**) they will double in the next twelve years.³⁵ Consequently, the saved energy costs due to the passive house standard will also double. Furthermore, it is better to be more independent of the oil and gas exporting countries, especially when you consider the political situation of the countries we get our oil from or the recent suspension of gas delivery from Russia.

So far, these are the individual advantages, but the whole local industry benefits due to created jobs. Three-quarters of the additional costs go to local builders and the remaining 25% to the purchase of extra materials which probably also come from local suppliers. So it is our turn to decide whether we want to spend money for energy from far away countries or to support the local industry.³⁶

5. Conclusion

The passive house is a well-proven and easily realisable concept. It leads to increased comfort, to considerable cost savings and to serious energy savings. The additional money and energy investment during the construction period are relatively low in comparison to the whole life cycle of a passive house, which is proven by several calculations. So, finally one can say that the passive house construction is definitely one of the most interesting and lucrative ways of building

³⁴ KÖNIGSTEIN, T., 2004. Ratgeber energiesparendes Bauen, page 99

³⁵ Tagesschau, 03 January 2008. Ölpreise, a report from POLANSKY, M.

³⁶ FEIST, W., 2007. Is it profitable to build a passive house? [online].

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Appendix

FIGURES

Figure A

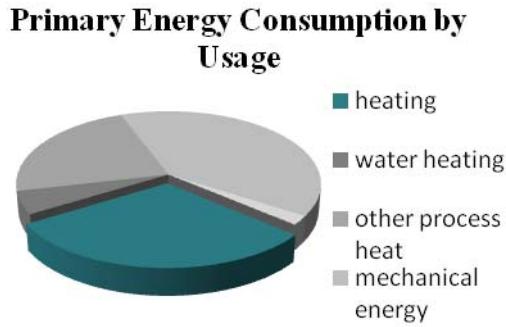


Figure B

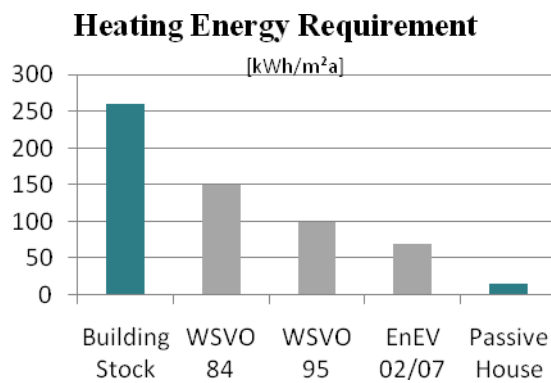
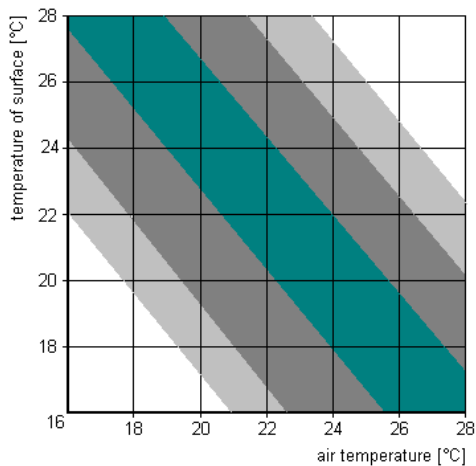


Figure C



SOURCE

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Endenergieverbrauch nach Anwendungsbereichen I

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Bundesministerium für Verkehr, Bau und Stadtentwicklung, 2008.
Energieausweis für Gebäude – nach Energieeinsparverordnung (EnEV 2007).

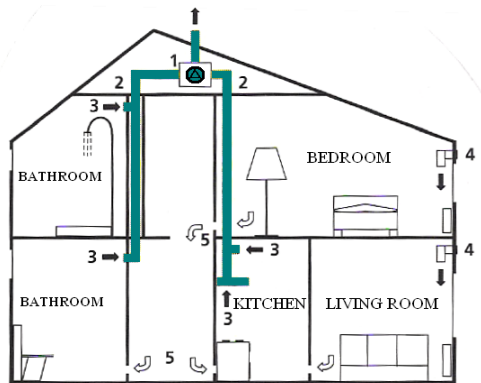
based on (but edited)
BAUER, M. and MÖSLE, P. and SCHWARZ, M., 2007. GREEN BUILDING – Konzepte für Nachhaltige Architektur.

Figure D

period of amortization (energy)		
Insulating material	Λ [W/mK]	month
cellulose	0.045	0.1-0.3
mineral fibre	0.035-0.040	1.5-13
polystyrene	0.035-0.040	7-20

based on (but edited)
**KÖNIGSTEIN, T., 2004. Ratgeber
 energiesparendes Bauen, page 24**

Figure E



based on (but edited)
**KÖNIGSTEIN, T., 2004. Ratgeber
 energiesparendes Bauen, page 77**

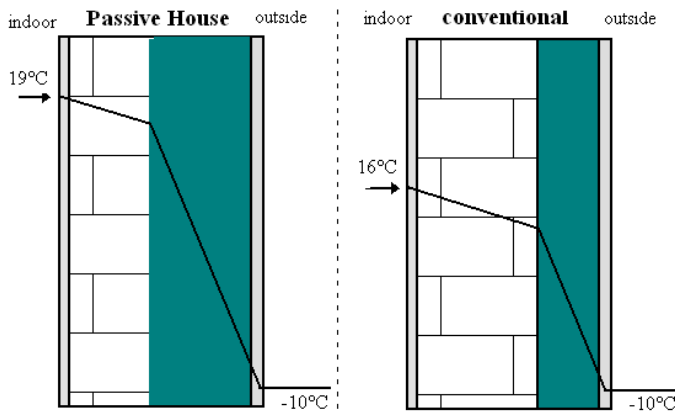
The exhausted air is extracted out of the kitchen and the bathroom (3) through short pipes (2) by an ventilator (1). Fresh air from inlets (4) disperses in the house (5) because of the low pressure in the bathroom and the kitchen.

Figure F

Component	U-Value [W/m ² K]	Insulation thickness
roof	0.25-0.3	12-16cm
Wall (external insulation)	0.35	8-10cm
Wall (internal insulation)	0.45	5-6cm
Basement ceiling	0.45	6-8cm
Passive House	0.15	-

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Figure G



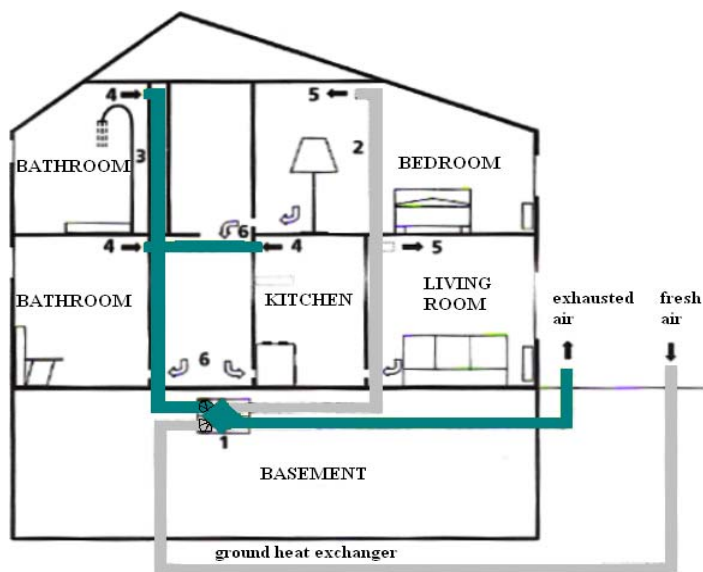
based on (but edited)
**KÖNIGSTEIN, T., 2004. Ratgeber
 energiesparendes Bauen, page 12f**

Figure H

Type of glazing	U _{glass} -Value [W/(m ² K)]	Surface temperature (outdoor temperature -10°C indoor temperature +20°C)
single	5.6	-1.0°C
double	2.9-3.1	8.4°C
double low-e	1.1-1.9	15.5 up to 12.8°C
triple low-e	0.4-0.9	17.3 up to 16.5°C

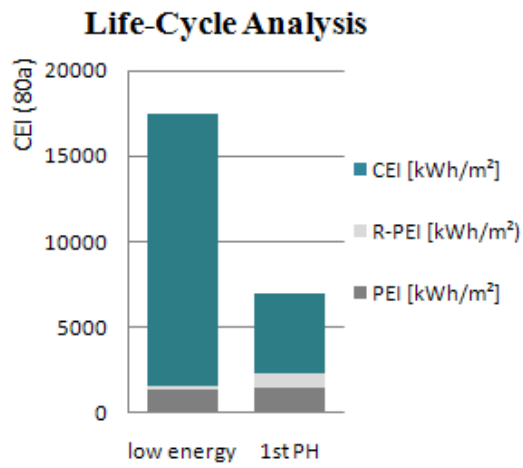
based on (but edited)
**KÖNIGSTEIN, T., 2004. Ratgeber
 energiesparendes Bauen, page 64**

Figure I



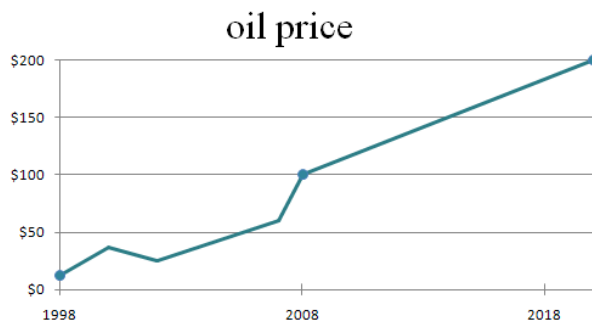
based on (but edited)
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 energiesparendes Bauen, page 81**

Figure J



based on (but edited)
FEIST, W., Life-Cycle Energy Analysis

Figure K



based on (but edited)
Tagesschau, 03 January 08. Ölpreise, a report from POLANSKY, M.