Case Study 3

ZEBAU GmbH
Germany and Sweden

Eco-buildings – European projects for ecological building, Germany and Sweden

1 The Importance of the Building Sector

Introduction

The production and use of buildings and infrastructure represents a considerable portion of the material flows and resource use in our societies. The housing sector is typically responsible for close to 40% of total energy use, and construction work places for a large part of solid waste and material flows. The introduction of ecological methods for building and living is therefore essential to sustainable development. Below a number of projects with this purpose will be described and a few general conclusions drawn.

The Life cycle of a House

The life cycle of a house consists of resource extraction, the construction of the building itself, the use and maintenance of the building, and finally its demolition.

The *resource extraction* of the material for a house is an important phase, since different building materials have very different ecological rucksacks. Considerable dematerialisation may be achieved merely by selecting better materials. Also, the transport of materials to the building site is important and may give rise to substantial environmental impact.

The *construction phase* also constitutes an opportunity for improvement in many cases. It should be noted especially that construction waste is a large share of solid waste in our societies. With proper care and planning this can be reduced dramatically and in fact almost eliminated (See Chapter 10).

The *use phase* is normally by far the most important for the resource use and environmental impact of a building. It may last for very many years; it includes most importantly energy for heating (and cooling) the house. It is obvious that, in the design of a building, not only its appearance, but even more so its use, should be in focus. Here the existing education of architects leaves much to be desired.

Traditionally *the demolition* of a house was not much of an environmental concern, since the material could be reused for new buildings or burned for energy purposes. In more modern houses, and especially houses built in the period about 1930 and 1980, this may be very different. Many buildings from this period contain asbestos in large amounts, have PCB in seals of building elements, and contain lead or other heavy metals in electric cables. The problems with these and other toxic materials may appear long before demolition if the houses are renovated. In particular old industrial buildings may be a big problem during renovation if one suspects toxic material. It may be very costly, require extensive monitoring, and give rise to considerable amounts of hazardous waste.

The Weak Link in House Design

When developing infrastructure in general the connections between the user and the producer are strong, and the producer has to fulfil a number of criteria for construction. This is not often the case with houses for living. In this respect houses for living are more similar to ordinary products offered on a market. The market, however, does not work in the same way for houses as for products. The selection of a particular house or apartment is done for many reasons other than its quality or function. It is more often related to where the house is situated, the costs of living, the availability of apartments of the size needed, etc. Those who will use a house or apartment seldom have an opportunity to influence its construction. Instead it is the developer who sets up the requirements for the builder. Those requirements more often have to do with economy of production – the cheaper the better – than function and maintenance. Then ecological criteria become unimportant. This so-called *implementation gap* is a serious problem in the development of ecologically good housing.

Sometimes however this is gap is bridged. Ecologically good housing projects are typically promoted by local authorities, by NGOs or through private initiatives, seldom by builders or developers.

In Hamburg a *self-built programme* has successfully promoted direct contacts between future users of residential houses and the builders. The projects in the programme are supported by the city of Hamburg and rely on properties, plots, owned by the city. The future users often aim to reduce costs by contributing to the construction work personally. At the same time they are participating in the design of the buildings and of course consider carefully how future life in the buildings may be improved. Such self-built projects, in spite of – or perhaps because of – the efforts to reduce costs, have typically been in the forefront of ecological building. Energy costs, and also social settings of the new buildings, have been seriously addressed and optimised. The self-built approach is old and exists in many places.

In Malmö, Sweden, the project *frivilligdialogen* has been devised as a voluntary dialogue between builders (developers) and city representatives on energy standards in buildings. In practice, the city has few strong means to force a builder to adapt a specified energy standard in the planned building. Thus voluntary means are used. Future European Union energy licensing of new buildings will introduce minimum legal requirements.

Sustainable Architecture

Architecture has addressed the sustainability challenge in what is called sustainable architecture. Items most often addressed under this heading include energy and heating, indoors climate, ventilation, lighting, and materials selection. Regrettably, sustainable architecture seems not to have a strong position in traditional architecture curricula.

A house promoted by sustainable architecture considers how the house is positioned relative to the compass points. It has larger windows to the south and smaller to the north. The planning of the rooms is such that daylight contributes essentially to the lighting. Often part of the house has an opening between two floors to allow more light to enter and improve ventilation. Houses are often self-ventilated. Energy use is much less than average, and may rely at least partly on clever use of sun and solar panels.

The indoor climate in sustainable architecture houses is typically very comfortable. In several cases, particularly at work places such as offices, arrangements are made to allow flowing water inside the building. The use of indoor green plants is promoted.

Buildings developed according to the concepts described include e.g. the Department of Technology and Natural Sciences of Kalmar University in Kalmar, Sweden, and the main office of Scandinavian Airlines north of Stockholm, Sweden, as well as a series of residential housing areas in e.g. Germany and the Netherlands.

2 Resource Use and Construction Materials

Choice of Materials

There is a great variety of construction materials used and only a few comments on these are possible here. Among the most common building materials are concrete, wood, brick and steel. These materials have quite different environmental profiles and life cycles.

Concrete is one of the most important building materials. It is a mixture of sand, gravel and crushed stones, and cement. Some 5% of global carbon dioxide emissions originates from cement production, about half from calcination and half from combustion when the raw meal forms cement clinker in a kiln at 900-1500 °C. The energy consumption of the cement industry is estimated at about 2% of the global primary energy consumption, or almost 5% of the total global industrial energy consumption. Concrete is also a heavy material to transport and thus leads to environmental impact during transport, as well as wear on roads.

Bricks and tiles made out of clay are important in European building traditions. The conversion of the clay in the kiln to ceramic produces, as well as drying and firing, consumes considerable amounts of energy, mostly as natural gas or fuel oil, and gives rise to emissions of e.g. hydrochloric, hydrofluoric, sulphuric acids and most importantly carbon dioxide. Clay-based material is used for a large variety of purposes, for the construction of walls, roofs and in the buildings as tiles on floors, walls etc.

Wood, in comparison, has less environmental impact. Wood was not used for multi-storey houses for a long period due to the risk of fire in cities. With proper safety measures, however, since the 1990s this is much less of a problem and wood is again an alternative for regular construction work. Wood is less heavy than concrete and compared to concrete the building of wooden houses corresponds to a considerable dematerialisation, about 50%.

Iron is a material that is needed in many situations. It can, however, today be replaced in many of its traditional functions, e.g. by beams made of wood.

Wooden Houses

In the Bo01 area in Malmö, Sweden several wooden houses were erected as demonstration projects. The house built by *Ekologibyggarna*, consisted of pre-fabricated solid wooden elements which were assembled on site. In the same area Skanska, one of the largest construction companies in the Baltic Sea region, built a whole block of three- and four-storey wooden multi-family houses. It is one of the first modern examples of a complete block of multifamily houses built entirely of wood. Also boards of wood were produced (to replace the more often used gypsum boards) and mounted on the houses to achieve a smooth facade. Thus the whole building was recyclable.

The upstream environmental impact of wooden material has been carefully studied in a project by the Swedish Wood Institute. The results prove the impact to be small and that all energy and material involved can be renewable.

Figure 3.2 Environmental management in the building sector has resulted in some remarkable results. *One of the many advantages of multi-storey wooden houses, here being built outside the Swedish city of Norrköping, is many times lower consumption of the natural resources, less handling of heavy material, easy transport etc. Photo: Holger Staffansson, Skanska.*

The *House of Design* in Hällefors, Sweden, opened in 2005, was carefully designed to achieve dematerialisation. According to a first evaluation it is a factor 1.85 house. This means that close to 50% or about 18,000 tons less material was used. It illustrates the dramatic potential the building sector has in reducing material flows. Here dematerialisation was mostly achieved carefully selecting the best material possible, e.g. from local suppliers.

Other Materials

A building has hundreds of different materials. These make up the building itself, as well as its walls, carpets, ceiling materials, equipment, furniture, lamps etc. its water, sanitary and electric installations, and its surface treatments with varnish, paints etc. The choice of right material is an important aspect of ecological construction. It may also be important for the wellbeing of those living and working in the house.

The choice of materials can today be supported by extensive databases (see Box *Tools for Ecological Buildings,* page 294). A guide how to work with material selection is available on the US Dept of Energy web site. A guide to healthier material is provided by the Healthy Building Network Green design and construction standards.

One particularly interesting aspect of this is carpets and flooring materials. Environmentally safe carpets are produced today. One source is the Building For Health Materials Center, a national and international provider of healthy and environmentally friendly alternatives to standard construction materials.

The Building Site – Transportations

Considerable environmental benefits can be gained by proper management at the building site itself.

Transport of materials to the site of construction may be a very important part of the entire environmental impact from the building phase. By using local and regional materials as much as possible transport is minimised. This is especially relevant if the material is heavy. Brick may often be produced locally in the entire Baltic Sea region. In the northern parts also production of wood building material may be fairly local. One may also specify the requirements of trailers, equipment, storage, and traffic at the building site. It is also important to monitor construction site energy and water use, and develop a construction waste management and recycling plan.

In the building of the Kronsberg area (at Expo 2000) in Hannover, Germany, an agreement was made with the companies to reduce transport and use local producers when possible. In addition all soil removed was deposited locally to create small mounds etc, much used for childrens' playing grounds. A similar approach was adopted for the extensive rebuilding of residential areas carried out in Hällefors, Sweden.

3 Building Low and Passive Energy Houses

European Energy Efficient House Projects

The current internationally recognised standard of heating energy demand for new buildings is 100 kWh/m^{2}a. This is equivalent to e.g. German Heat Protection Regulation EnEV 2002 and the Swedish Construction Standard SBN. But it is possible to be much more efficient. A number of projects have proven that it is possible to build very low energy houses. Projects of low or passive energy houses include the ALTENER programme of the European Commission in which 12 European cities take part, the Lindåsen project in west Sweden, and the BedZED, the Beddington Zero Energy Development of energy-efficient mix of housing and work space in Beddington, Sutton, UK (see Internet Resources).

One of the first European projects, CEPHEUS (Cost Efficient Passive Houses as EUropean Standard) coordinated in Hannover, Germany, tested and proved the viability of the Passive House concept at the European level. In 2001, when the project was finalised, a total of 221 housing units in 14 building projects in Germany, Sweden, Austria, Switzerland and France had been built to Passive House standards and were in use. The scientific evaluation concluded that CEPHEUS was a complete success in terms of: the functional viability of the Passive House concept at all sites; actual achievement of the heat savings target, with savings of more than 80% already

Figure 3.1 Passive energy houses. *Multiple family dwellings.*

in the first year; practical use of Passive Houses standard in a broad variety of building styles and constructions; project-level economics; and satisfaction of the occupants of the buildings.

The Solar Building Exhibition Hamburg 2005, to be described below, was part of the ALTENER programme implemented in 6 countries in Europe. In two areas in Hamburg: Hamburg-Heimfeld and Hamburg-Wilhelmsburg, either passive houses or very low energy houses were constructed. An external quality control was organised with the help of Hamburg Building Authority in order to achieve, if possible, a faultless higher standard in comparison with ordinary new buildings. The monitoring of the energy planning and construction was originally done by the Technical University of Hamburg-Harburg and since the beginning 2005 the Detmold Low Energy Institute, while the inspection of the construction work was done by the Low Energy Institute.

Passive Energy Houses

A passive house is a building in which a comfortable interior climate can be maintained nearly without active heating and cooling systems. The house heats and cools itself, hence "passive".

According to European standards a passive house is a house, whose need for heating, i.e. annual amount of heating, is not higher than 15 kilowatt hours per square meter and annum (kWh/m^{2}a). In a 150 m^2 house this amounts to 2250 kWh/a, and corresponds to 225 liters of oil or 225 m^3 gas. Warm water consumption, the electricity consumption as well as losses in heat production and distribution are not included in the energy balance. With this as a starting point, additional energy requirements may be completely covered using renewable energy sources. The combined primary energy consumption of the living area of a European passive house may not exceed 120 kWh/m^{2}a for heat, hot water and household electricity. The current Passive House standard was developed for Northern (heating load dominated) climates and indeed most existing passive houses are found in Austria, Germany, northern France, Sweden and Switzerland.

The combined energy consumption of a passive house is less than the average new European home requires for household electricity and hot water alone. The combined end energy consumed by a passive house is therefore less than a quarter of the energy consumed by the average new construction that complies with applicable national energy regulations.

In Germany the heating demand for a passive energy house is calculated using the PHPP software (passive house project package, Dr. Wolfgang Feist, Passive House Institute, Darmstadt). The following factors are included in the calculation:

- Heat losses over the building cover (control areas and heat bridges).
- Heat losses through ventilation subtracting heat recovery by a heat exchanger and the containment of the building.
- Heat recovery through passive solar heating through windows.
- Heat recovery from people, equipment, hot water, etc.

This method of calculation is used e.g. when applying for loans for construction in Germany.

Very Low Energy Houses

A very low energy house, also called a KfW-40-house, should fulfil the following requirements:

1) The specific transmission heat loss must be at least 45% lower than the upper limit of the German Energy Economy Establishment (EnEV) standard valid for the building. The calculation of the need for heating for a KfW-40 house is carried out according EnEV software. Ventilation losses as well as solar and internal recoveries are not taken into account in this case. The heat losses can consequently only be reduced by improving the insulation of the building, or by using smaller windows, or windows with lower U values, and the reduction of heat bridges. Heat losses indicate primarily this "construction heat protection" and can only be taken as an indicator for the general energy saving.

Figure 3.3 Building of a passive energy house. *The house is insulated to achieve a U-value that does not exceed 0.15 W/m^{2}K (0.026 Btu/h/ft^2/°F) which typically corresponds to 20-40 cm of insulation.*

2) The primary energy consumption may not exceed 40 kWh/m^2 of the usable floor area and year. This includes heating, hot water and electricity, all losses during transformation and distribution, and added the contribution of other sources such as active solar technologies. The demand for a low primary energy use can be met by a low need for heating, as in the case of the passive house, or by a particularly efficient or renewable energy supply.

The requirements of the KfW-40 houses originate from the promotional program "ecological construction" of the Kreditanstalt für Wiederaufbau (KfW) (Credit Institution for Reconstruction in Berlin), which provides reduced construc-

Tools for Ecological Buildings – Life Cycle Assessment Tools for Buildings and Architecture

For building professionals, LCA applications become most useful when a database of product information has already been assembled from which to compare products or building assemblies.

In early design phases, a whole-building analysis can help with basic questions like structural system selection. In later phases, product-to-product comparisons can help fine-tune a building's environmental performance.

Most of the information below was extracted from **Architecture on-line**, a leading architecture reference site on the web, as well as from the individual webpages.

http://www.architectureweek.com/2003/0813/environment_2-2.html

Greening the building life cycle is a collection of links for LCA software and databases for building and construction work established by the Department of Environment and Heritage of Australia. The collection is global and very useful.

http://buildlca.rmit.edu.au/links.html

Idea is an interactive database for energy-efficient architecture developed by the Dept. of Building Physics and Solar Energy at University of Siegen, Germany. The site features a some 60 building projects with photos, detailed description of concepts, plans etc. It carries a series of tools for construction of energy efficient buildings.

http://nesa1.uni-siegen.de/wwwextern/idea/main.htm

LISA (LCA in Sustainable Architecture) is a simplified streamlined LCA decision support tool to develop optimum construction systems by the Centre for Sustainable Technology, University of Newcastle, Australia. Some 20 cases with LCA data are shown. Software and cases can be downloaded.

http://www.lisa.au.com/

Envest II is a whole building LCA created by BRE Sustainable Consulting for application in the United Kingdom in 2003. LCC is a major addition to its environmental analysis capability. Envest II consolidates assessment results into the eco-points scoring system, with a single point scale for the building. It has UK regional data, cost basis, construction methods, and regulatory information built in.

http://www.bre.co.uk/service.jsp?id=52

Estimator (**Environmental Impact Estimator, EIE)** is the only North American software for life cycle assessment of buildings. Released in 2002, the software covers 90 to 95 percent of the structural and envelope systems typically used in both residential and non-residential buildings. It has databases for energy use and related air emissions for on-site construction of a building's assemblies; for maintenance, repair and replacement effects through the operating life; and for demolition and disposal. Demo version available.

http://www.athenasmi.ca/tools/index.html

Athena Life Cycle Inventory Product Databases is a material life cycle inventory database developed by the Athena Sustainable Materials Institute (SMI) based in Ontario, Canada, together with the Environmental Impact Estimator (EIE) software. The database represents a major activity of the Institute to provide model users with a great level of detail and specificity. The data are mostly from Canadian sources, with an option of specifying U.S. average.

http://www.athenasmi.ca/tools/database/index.html

LEED rating system for lowering environmental product impact awards points for recycled content, local, and low-VOC materials. In reality, it's not always easy to do select right thing. LCA can identify areas where the simple LEED-approved response may not actually be the most sustainable.

http://www.usgbc.org

BEES 3.0 from the National Institute of Standards and Technology allows users to selectively apply weighting factors to environmental and economic impact, and then to weight various environmental factors such as water intake, fossil fuel depletion, or ecological toxicity. A direct comparison of alternatives is displayed as either a chart or graph. BEES has about 200 products in its database, heavily represented by carpet and flooring products.

http://www.bfrl.nist.gov/oae/software/bees.html

Eco-Quantum is a residential-only analysis tool from the IVAM consultancy affiliated to the University of Amsterdam, the Netherlands. An demo is available in English on the web site.

http://www.ivam.uva.nl/uk/

tion loans for particularly energy-saving houses (see Internet Resources).

The calculation of energy demand should be made according to the EnEV software, not those of the PHPP. This is important, since the need for heating a KfW-40 house can vary greatly. Depending on the house technology and kind of fuel, it can approximate a passive house or be considerably higher.

The minimum insulation standard of a KfW-40 house is still considerably less than for a passive house. Solar benefits and efficient ventilation are relatively unimportant for the KfW-40 house. The primary energy consumption requirements can most often be achieved by using renewable energy sources, such as pellet furnaces. This was frequently the case at the exhibition. The costs connected with that can make heating costs three or four times higher than for a passive house, despite a low level of primary energy consumption.

How to Build a Passive Energy House

To meet the current Passive House standard, the construction of the houses must follow certain general principles, here briefly explained:

Highly insulated building shell and compact form. All components of the exterior shell of the house are insulated to achieve a U-value that does not exceed 0.15 W/m^2K (0.026 $Btu/h/ft^2/°F$) which typically corresponds to 20-40 cm of insulation.

Southern orientation and shade considerations. Passive use of solar energy is a significant factor in passive house design. Shading is absolutely necessary in all climates with high levels of solar radiation.

Highly insulated windows. Windows are constructed of low-e triple glazing (U-value of 0.75 W/m^2K and a solar transmission factor of 50%) and highly insulated frames (U-value of 0.8 W/m^2K).

Elimination of thermal bridges. By suitable application of insulation, linear thermal transmittance is reduced to below 0.01 W/mK (exterior dimensions).

Air-tight building shell. Air leakage through unsealed joints must be less than 0.6 times the house volume per hour at 50 Pa. This should be checked with a blower door test.

The house has forced ventilation with exhaust air heat recovery.

If comfortable indoor climate conditions differ greatly from outdoor conditions, it is always recommendable to use a ventilation system with heat recovery (or vice versa with cold recovery) to maintain a high indoor air quality without the need for huge heating or cooling demands in accordance with ISO 7730 for a definition of “comfortable indoor climate”.

Renovation of the Built Environment

The toxic and persistent substance polychlorinated biphenyl, PCB, has been used in buildings especially in connection with the massive production of cheap housing in the 1960s and 1970s in the Baltic Sea region. PCB was outlawed in Sweden in 1972 and soon thereafter in the other countries in the region. It is now on the black list of chemicals. It was used mostly to seal the space between concrete elements and between these elements and windows. Likewise asbestos has been used for building purposes for more than 100 years. It became very popular since it did not require and maintenance and was used for facades and as roofing material. Asbestos was also used in roofing materials and in paint. As asbestos causes lung cancer if inhaled, the security arrangements when removing asbestos elements from buildings are rigorous.

In Sweden *Solna bostäder Inc* developed technology to deal with these material in renovation of the building area Blåkulla from the 1960s .

Passive houses have a continuous supply of fresh air, optimized to ensure the comfort of those living in the house. The flow is regulated to deliver precisely the quantity required for excellent indoor air quality. A high performance heat exchanger (efficiency > 80%) 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 pre-heating in a subsoil heat exchanger is possible, which further reduces the need for supplementary air heating. Fresh air may be brought into the house through underground ducts that exchange heat with the soil. This preheats fresh air to a temperature above 5°C (41°F), even on cold winter days.

Finally it should be added that the building companies contracted to build the area agreed to refrain from using fossil fuels. Likewise, fossil fuels were abandoned on the exhibition sites of Heimfeld and Wilhelmsburg. Thus no gas and oil is used.

The shift from conventional energy demands to solutions described here is not necessarily very expensive. It is sufficient to minimize energy use with simple systems from conventional sources. The passive house is the most energy efficient standard with only 10% additional construction costs in Germany and a very good combination with renewable energy supply.

There is always the possibility of finding your individual energy standard using the principles of the passive house idea. But don’t forget, if you build your energy efficient building 20 km away from your office and there is no chance to use public transport, the energy demand for the car is as high as PE-electricity.

The Zero-energy House in Lindåsen

Another example of passive houses is found in western Sweden, close to Gothenburg, in an area called Lindås Park. These houses do not have any heating systems. The thickness of the walls is 40 cm (compared to 20 cm present standard). It allows the houses to maintain 20°C indoors through a combination of measures. These include heat recovery from outgoing air in a heat exchanger, the body heat of the residents, solar radiation and other internal gains such as heat from compressors in refrigerators.

This project has inspired many followers. In particular it is interesting that in many places throughout the country today multi-family passive energy houses are being built.

4 Using the House – The House as an Ecosystem

The House and the Site

Building and living ecologically in harmony with nature must always begin with an adjustment to the topographical conditions. Nature should be an ally and not an enemy. Thus it is preferable to have large windows to the south and smaller to the north, both for light and heat preservation. The prevailing wind direction is important for ventilation.

The house we live in may be seen as an ecosystem of its own. It is a system with in- and outflows of materials and energy. An important objective is to minimize these flows, clean them and improve re-circulation. Solutions which reduce the amount of energy, water and waste that are needed to sustain our daily lives will yield environmental and economic benefits.

Figure 3.4 Solar panels. *Warm water may be provided by using solar panels, a solution which is growing more economically competitive as the technology develops.*

The way the house relates to the sun is important as in all ecosystems. Thus an ideal house is much more open to the south than the north. It uses the opportunities to produce warm water through solar panels and maybe also electric current through photovoltaic (solar) cells.

Total Energy Supply in a Built Area

Energy flows can be minimised in several ways. Little or no energy is needed for heating in passive energy houses (see above). Warm water may be provided by using solar panels, a solution which is growing more economically competitive as the technology develops. Also electricity may be provided locally as is more often the case through photovoltaic cells.

The buildings of the Solar Building Exhibition Hamburg 2005 were, on the average, well insulated, well sealed and equipped with ventilation units, mostly with efficient heat recovery. The need for heating and expected consumption of heating energy was therefore considerably lower than in normal new houses. The living comfort is noticeably higher. However support heating was available as in Heimfeld the houses were supplied with three central pellet heating boilers, used for a common heating system. This system was supported by thermal solar panels. In Wilhelmsburg many houses were heated by pellet furnaces or heat pumps, each supported by thermal solar panels. Energy for hot water and heating was thus provided from solar collectors, wood pellets or heat pumps.

The electricity need for the two areas was partly met by two big photovoltaic plants.

Water Supply

Water use per person in western Europe is typically close to 200 litres per day and person. In Poland, Estonia, Latvia and Lithuania water was previously free of charge and consumption huge, over 400 lit/day cap. With increasing fees, however, water use has been reduced to close to 100 litres per day and capita. It is unlikely to go much beyond that without special measures.

Further conservation of water can be achieved in several ways. One is the reuse of so-called grey water (from shower, washing etc) for toilets. Another is the collection of rain water. Installations for water re-circulation within a household or multi-family house are available commercially.

Water use is normally not a problem in the Baltic Sea region except for in the southern parts, in Poland and Germany, where water conservation is sometimes important. It may also be worth while reducing water use in situations where isolated houses in the countryside have limited access to water.

Waste and Nutrient Flows

Organic waste includes toilet waste and compostable organic waste. Toilet waste in conventional systems leaves the house as sewage. However it is also possible to do this differently, on the basis of either an individual household, a multi-family house or a neighbourhood.

Urine may thus be collected separately using a urine separating toilet. The urine contains most of the nutrients in toilet waste and if taken care of directly reduces the load on a wastewater treatment considerably. Urine can be collected in a large container and may be used yearly for gardening or by nearby farmers to fertilise agricultural fields. The rest of the toilet waste may be also taken care of locally e.g. in composting toilets. However this is less common. If urine is going to be collected separately it best to consider already when the house is constructed.

Composting of garden and food waste is increasingly common and has a very long tradition, as it was normal in older times. Because of the EU waste directives the proper collection and treatment of organic waste will be required. On a municipal level, organic waste may also be used for the production of biogas.

Separation of other forms of solid waste does not require special arrangements of the building itself, only that proper waste management is observed.

Ventilation

Ventilation is the system in the house which influences the indoor climate more than any of the other systems. It is also the system that most often leads to complaints. Thus designing a well-functioning ventilation system is crucial. A good ventilating system should provide a good indoor climate, about 20°C and some 50% humidity, generate no sound (especially no infrasound), and have low emissions of pollutants, especially particulates.

We do not ventilate our houses because of our need for oxygen. Houses do not have oxygen deficiencies. Nor do they have a noticeable excess of carbon dioxide. In fact we ventilate to get rid of surplus heat, surplus humidity, some chemical emissions and body odours. Some of these needs can be addressed by other means than ventilation. Proper management of heat, e.g. low energy lamps and better stoves, lead to less extra heat, proper management of showers to less extra humidity, and more green plants improve the indoor climate.

Some of these problems are typical only of offices, schools etc. Heat removal is thus necessary for such buildings. Work places typically exchange the entire indoor air volume once per hour and this is thus a very considerable mass flow, consuming much energy if not taken care of properly.

The preferred ventilation system is today self-ventilation, which is a wind-driven air exchange. To make this work well, regulation of self-ventilation is needed. In particular it is important to take proper care of the heat content of the air leaving the buildings and thus make the house energy efficient. Wind-supported ventilation uses the minute differences in pressure that is produced by the wind forces. Tightly insulated buildings with rather high ceilings or even sometimes connections between two or more storeys support self-ventilation.

The indoor climate in properly designed and maintained buildings with self-ventilation may be very pleasant. It offers the living standard that we would like to see in future ecological living.

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Internet Resources

SmartLIFE – Sustainable Growth Solutions

http://www.smartlife-project.net

Tiles and Bricks of Europe (TBE) – Stay with Clay

http://www.staywithclay.com/default-en.asp

House of design, Hällefors

http://www.hellefors.se/formenshus/engelsk/default.htm

U.S. Department of Energy – Energy and Environmental Guidelines for Construction

http://www.eere.energy.gov/buildings/info/design/construction.html

Healthy Building Network – Market Transformation

http://www.healthybuilding.net/market_transformation.html

Building For Health Materials Center

http://www.buildingforhealth.com/

Beddington Zero Energy Development (BedZED)

http://www.bedzed.org.uk

Kreditanstalt für Wiederaufbau (KfW) – The Credit Institution for Reconstruction in Berlin

http://www.kfw.de

Ekologibyggarna

http://www.ekologibyggarna.se

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