New technical solutions for energy efficient buildings

State of the Art Report

Energy efficient building design

Authors:
Heimo Staller, Angelika Tisch, IFZ
Oct. 2010
Background

In the building sector the highest energy saving potentials can be realized by energy efficient building design. The energy efficiency of buildings is significantly influenced by architectural design aspects, such as orientation, shape of the building structure, where the openings of windows are located, etc. Therefore in the Working Group “New technical solutions for energy efficient buildings” besides the presentation of single technical solutions (e.g. innovative HVAC-systems and renewable building materials) a focus is also on energy related design aspects. Especially in tendering procedures for architectural competitions public clients have to take strong notice on these energy related design aspects. On the following pages a short overview of the most important innovative design strategies for energy efficient building design is given.

Climate Design – Adaptation to climate conditions

Looking back in history we can see that building design, besides other factors (social aspects, availability of building materials, etc.) always was a result of the climatic conditions on the building site. Today the mainstream of modern architecture is neglecting these climatic conditions, compensating inefficient building design with enormous efforts concerning the energy supply for heating, cooling and lighting. To design energy efficient buildings (Low-Tec Buildings) architectural concepts have to integrate this old knowledge and develop new innovative design solutions based on climatic aspects.

Most important aspects with strong influence on the building design are outdoor temperature, solar radiation, humidity and wind.

In figure two an office building in Vienna with an innovative design solution based on climatic aspects is shown. The design of the south façade of the building is based on the climatic conditions of Vienna, enabling highest solar gains (reduction of space heating demand) in winter and avoiding solar inputs in summer (reduction of cooling demand). The south façade has a fanfold structure with 400 m² of PV-Elements for shading in summer, producing electrical energy all over the year.
General strategies for energy efficient buildings

In general there are following strategies for the design of energy efficient buildings:

- Minimization of losses
- Maximization of solar gains – Heating case
- Minimization of solar gains – Cooling case
- Minimization of electricity demand for artificial lighting

Depending on the degree of latitude strategies with stronger focus on gains or stronger focus on losses might more efficient, in general it can be stated that on most European sites a combination of all measures make sense.

Minimisation of losses - Compactness

In Europe transmission heat losses play an important role for the energy performance of buildings. Depending on the building type (housing, office, schools, etc.) transmission losses can have the highest ratio of all losses. Therefore the first design relevant measure should be the reduction of heating losses by minimization of the shape/volume ratio. Especially for an economical realization of passive houses or zero- and plus energy- houses compactness is of highest importance, as worse compactness means higher construction costs (improvement of u-values => more insulation materials => higher costs).
Maximisation of solar gains – Heating case

In the heating period a maximization of passive solar gains should be the main target to reduce the heating energy demand. Optimized interaction of orientation, size of windows and disposable thermal mass are the key elements. In figure four a school building in Vella, canton Grisons, Switzerland without technical heating system is shown, only using passive solar energy and mechanical ventilation with heat recovery for heating. Special design of windows and a special sunblind with reflector (reflecting sunlight to the ceilings) enables a maximization of solar energy gains for the classrooms. Massive floors, walls and special designed ceilings (ribbed concrete slabs with large surface area) are used for the storage of solar energy.

Minimisation of solar gains – Cooling case

Transparent building elements (windows)

Orientation and size of transparent building elements (windows) have important influence on the cooling demand. In central European climate pure south orientation is the best orientation for the reduction of the heating and the cooling energy demand. Intelligent shading elements with different orientation (e.g. south windows with horizontal elements, west and east windows with vertical elements) are further measures for the reduction of solar gains.
Natural cooling with passive night ventilation

In office buildings up to 2/3 of the total cooling load (around 200 – 250 Wh/m²/day) can be managed by passive cooling without mechanical energy. Night temperature in summer around 15°C, adequate thermal building mass and the possibility of natural stack ventilation (e.g. in atriums, see figure below) are requirements for this kind of cooling.

![Passive cooling](image)

Fig. 5 Passive cooling (without mechanical energy) through stack ventilation in the night, office building W.E.I.Z. II, Weiz, Austria, architects: A plus ZT GmbH Weiz [5]

Natural ventilation by wind-

For high rise buildings natural ventilation concepts by wind are innovative alternatives to conventional mechanical ventilation systems. The new office building of the European Central Bank in Frankfurt (architects: Coop Himmelb(l)au, energy concept: Univ. Prof. Brian Cody) will be the first office building using only natural ventilation. The design of the building is based on wind and ascending forces around and in the building.

![Natural ventilation](image)

Fig. 6 Natural ventilation concept by wind, Head European Central Bank, Frankfurt, Univ. Prof. Brian Cody and Coop Himmelb(l)au [6]
Minimisation of electricity demand for artificial lighting

Besides heating and cooling the energy demand for artificial lighting is of importance for the energetic performance of buildings. Buildings with huge overall width, like office buildings, tend to have substantial energy demand for artificial lighting. The development of innovative daylight concepts is the most important strategy to decrease the energy demand for lighting. Daylight concepts always have to be considered in combination with aspects for heating and cooling.

Active use of solar energy

Compared to other HVAC-systems active use of solar energy (thermal and photovoltaic solar collectors) on one hand has strong input on the design of the building and on the other hand the use of solar energy also has strong influence on the environmental performance of the building. The intensive use of solar energy requires a comprehensive integration of solar panels in the architectural design concept and influences the design of buildings strongly. Solar panels can be mounted on walls and roofs, whereas in urban context roofs offer better conditions (less shading by other buildings, free choice of declination enabling higher degrees of efficiency).
Fig. 8 Holistic approach: Solar panels (PV), passive night cooling and integrated day light concept, architectural competition Technology Centre Aspern, Vienna, architects: Treberspurg & partner and Frank & partner, Vienna [8]

References

[2] ENERGYbase, pos architekten schneider ZT KG, Vienna