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ANALYSIS OF ENERGY-EFFICIENT STRUCTURES

A recent study [1] of the potential of passive solar energy as a fuel reveals that the equivalent of 13% of the primary energy used in houses and non-domestic buildings in the European Community is already provided by solar energy. Positive action to increase the adoption of solar design principles in the building sector could increase this amount by more than 50%, by 2010.

The energy consumed in buildings in Europe for heating, cooling, lighting and appliances, constitutes Europe's primary energy consumption. Thus the potential for energy saving and the consequent reduction of the environmental impact of energy use, is significant for Europe. It has been the policy of the Commission of the European Communities over period of 15 years, to reduce Europe's consumption of primary energy. The reasons behind the effort to reduce consumption of primary energy are three-fold:

- a political reason: to reduce Europe's dependence on imported oil
- an economic reason: to lighten the financial burden on the Member States particularly in view of rising oil prices
- an environmental reason: to reduce the pollution of our environment

One of the instruments to pursue this policy is financial support for research and development on energy. Information on the performance of low energy buildings in Europe was collected and published in carefully designed brochures together with architectural and constructional details as well as occupant response. All the buildings in the mentioned brochures have been occupied for the appropriate function, the reactions of the users are recorded and the energy performance has been monitored. [2]

The aim of the project is to study the design of energy-efficient buildings, mainly the impact of the design to the architectural appearance of structures using the low energy design features. I would like to bring the attitude of ecological thinking concerning an ecological building into the public of Slovakia. In fact, Slovakian architecture has a small knowledge in energy-efficient building and people are mostly not informed well enough about energy-efficient hauses`s principles.

The other reason, why there is so little interest in energy-efficient houses in Slovakia, is that the first financial impact concerning a low energy demand building is quite high. It means that if an investor is interested in energy-efficient design and is keen on building or renovating, using a low energy design features, his investment will be much higher than in general way of building. The investment will return in the amount of money representing the saved energy. But it takes some time, generally several years, to repay the low energy design technology. Slovak economic is not strong enough to allow the government to support Slovakian investors in their effort to build ecological structures as it is in CEC countries. Financial support makes the repaying period shorter and encourages the investors to built ecologically.

In my opinion, the main reason of low interest in ecological living is that most people do not even think about the opportunity to live in the energy-efficient house, since the enlightenment concerning ecological building in Slovakia is quite poor.

My effort will aim at architectural analysis of the energy-efficient houses of the world and in Slovakia. I would like to study the architectural impact of these houses on their occupants and find a way of possible comparison of the situation in Austria and Slovakia. Slovakian architecture did not produce a complex energy-efficient structure that would offer permanent housing. There are some family houses that integrate low energy features, but still, there is not a complex system that would understand the demands of energy-efficient housing. The location of Austria within Europe, outstanding architectural works, high quality of energy-efficient structures and the neighbouring location allows to study the low-energy design features in real conditions. The energy-efficient structures are designed to cooperate with their occupants. If the low energy design misses the

understanding of the occupants, it does not work to its maximum efficiency. The occupants should be introduced the way of operating the systems so that they live in mutual coexistence with the house. Occupants of energy-efficient houses in Austria can objectively refer to survey that will be introduced in energy-efficient houses in Vienna, to obtain a response of their occupants to the living conditions in low-energy designed structures. The aim is to go through the energy-efficient projects in Slovakia, to asses the low energy design features of these projects and their impact on the architectural appearance. I would like to find the way of possible direction of energy -efficient building in Slovakia and point out the architectural features of energy-efficient structures, their influence on architectural appearance in newly built structures and in renovations.

How do architects present passive solar design?

Passive solar buildings are designed to collect energy, from the sun to provide heating and lighting within the buildings, and to reject solar energy when it can lead to overheating. All buildings collect some solar energy, unless they are completely shaded, and the task of a solar designer is to increase the useful heating and lighting whilst minimizing the risk of overheating.

Large south-facing windows increase direct solar heating with unobstructed access to the sun, particularly to the low winter, spring and autumn sun. By locating the main living rooms on the south side, maximum use will be made of the solar gains. The mass in the walls and floors of a building absorb a certain amount of solar heat both reducing overheating when the sun is shining and providing a store of heat when the sun goes down. [2]

By increasing the solar gain in a building, the use of fossil fuel for heating and lighting is reduced, and by reducing overheating, the use of active cooling systems is reduced or even eliminated. Comfort may also be increased, particularly where full heating is not supplied and where air conditioning is not available.

Thus passive solar design is part of the climate respecting, or bioclimatic movement in architecture, sharing the goals of reducing the consumption of fossil fuels and consequent pollution.

The aim of the designer is to use solar energy to provide heating and lighting within the buildings whilst minimizing the risk of overheating. Designer's effort is to keep the solar gains within the structure and use them to their maximum. None of the solar gains should be wasted. A very detailed planning is needed to design an energy-efficient structure to maximize its function.

Starting point – site and climate

These are very important features that influence the solar design, passive or active.

Climate gives us global conditions that we have to count on - localization on the Earth surface – sea side / mid-continental position / latitude – all this features influence the annual average temperature and the fluctuation between maximum and minimum temperature, the amount of degree days plays an important role concerning the solar gain.

Microclimate is defined by local conditions – unobstructed south facing hillside offers a direct solar gain that is the main aspect of solar design structures. House situated on south facing slope is sheltered from the north against possible harsh north winds. The dense trees on the north side of the house act in the same way. Orientation to the cardinal points considering the site plays decisive role in the solar design.

The architect has the power to adjust the energy-efficient structure to existing conditions of the site. The art of the architectural work is to site the object as a sculpture in a gallery of living environment. Each artificial impact to environment should act in conjunction with natural forces and not in opposition to them. The design of the energy-efficient structures thus creates shelter for human being trying not to obstruct the environment. The aesthetic impact of low energy demand structures is in architect's hands. There are many ways how to support the site conditions and create a suitable building.

Aspects important in energy-efficient design

- In the point of view of saving energy, the most important aspect of architectural proposal is the geometry of the building. The lowest energy consumption offers the shape of cylinder. Shapes with the highest energy consumption are thin and tall objects (towers) and long board-like objects. The best solar gains have objects of cube shape or a cylinder.

• the solar gains through vertical windows have only a small influence on energy consumption; therefore the main factor in low energy design should be the geometry of the building.
• Second very important aspect is the amount of glass surfaces within the facades of the objects. It is important to find a correlation between the window area and the surface of the object considering the orientation to cardinal points.
• The third aspect concerns the density of buildings. The energy consumption in a family house in comparison to block of flats is much higher. Although this is a question of the living comfort, it is an aspect we should count on.
• We should also take in mind the layout of the buildings. Rooms should be proposed in mutual continuity and thus to be divided into several zones.
• Very important is the prevailing wind direction. Architect has an opportunity to make use of the wind, so that it helps to ventilate the houses. Main aspects considering wind are the height of the building and its direction.

The geometry of the structure, its proportions, use of glass on facades and use of thermal-proof mass, sunspaces and shading devices are architectural features playing important role in the appearance of the energy-efficient structure.

Planning

- flexibility and unconventional thinking are required when designing energy efficient house. Architect Strong, the designer of the house "IMPACT 2000" that was the first photovoltaic house in US built in fully integrated manner says: "Although solar passive or active houses can be of any architectural style, they tend to be contemporary. You need a lot of design flexibility and contemporary design allows that freedom". Strong's architects and engineers worked as a team on all aspects of the design, including the interior spaces and the mechanical system. This is a major departure from standard practice. The quality of this approach is evident in the house architecture, as well as in its performance. [2] Our architectural standard approach is to fix the design and then the subcontractors fit the system.

- energy-efficient design is suitable for any type of building. Family houses, housing developments, apartment blocs, housing estates, administrations, factories, and public buildings – all these architectural types can profit from solar design, passive or active.

- the implementation of low energy design features into any of these types is very important. Presentation of energy-efficient design makes people think ecologically. It teaches people to behave ecologically, to save our environment. The financial impact of this design in housing and public buildings should be supported. For example, people cannot pay the energy-efficient design of schools. The investment will return as lower energy consumption and ecological environment. The low energy design features are very suitable for public buildings, since they are very distinctive in architectural appearance and they present the attitude of people to live ecologically in health environment. Low energy design of schools teaches the students to save nature and shows, that the fossil fuels are not the only way of energy gain. Most of low energy design features play very important role in esthetic and architectural appearance of buildings. They have very strong architectural impact. They are visible at first sight, which attracts people's attention. It is important, that the low energy design is not just an architectural jewel of the buildings, but that it plays very important role in ecological education. The operating of energy design systems should be accessible to all people so that they have the feeling of participation on ecological way of living.

Appearance

- solar design offers a designer many distinctive architectural features, which make the structure impressive. Large glass surfaces used on south facing facades offer free field to designer`s creativity. Together with integration of photovoltaic modules, air-heating collectors or collectors for water heating and shading devices, a boundless flexibility of architectural creativity offers a great diverseness in energy-efficient design appearance. Usage of thermal mass, transparent insulation, light and heavy constructions and sunspaces to maintain even temperatures within the structure are very important points that in mutual coincidence with all features of energy-efficient design form the harmony of an architectural esthetic. The

great variety in use of materials and the way of their presenting is distinctive both in exterior and interior design.

Auxilliary heating system

- because we are talking about energy-efficient structures, the central heating system is not inevitable. The house is designed to gain as much heat as possible from solar sources and of course consequently to keep the heat within the house with maximum usage. The solar gain is obtained thanks to the large south windows or sunspaces. The rest of the heat can be produced by geothermal heat pump. In some cases the electric auxiliary heating system is used. To obtain good air circulation the convective loop of warm air has to be provided. Heating and keeping the heat within the house has great influences on the house design.

Operating modes and control

- it is important that users of solar buildings understand something about the design if the potential solar gains are to be used and not wasted. Often the house occupants fail to understand the solar system and so waste available solar gains. Sometimes they simply do not control the solar and heating systems, which leads to unsatisfactory usage of solar design and the solar gain is wasted. The more complex systems they are the more they suffer from not understanding of their operating by the occupants. Whether this is the failure on behalf of the designers to inform the users adequately, or the failure of the users to adapt to the design, is open to argument.

Monitoring and user response

- it is important to draw conclusions for future energy-efficient projects and the only way to learn the successes as well as the faults is to monitor the buildings that have been already built. The energy-efficient project needs a lot of detailed work to be done. But at the end, when the struc-ture works well and the occupants are satisfied, the obstruction of the environment was minimized.

Conclusion

Using solar energy to provide heating in buildings and designing to reduce overheating by passive features is a strategy that will only work if users are happy with the design. Occupant surveys [2] show that users generally feel positive about the buildings from the point of view of comfort and appearance. Passive solar buildings are seen as being light and airy. Although lack of privacy in houses due to large south-facing windows can be a problem. Also low lighting levels in northern rooms with small windows are unsatisfactory. Sunspaces are in general liked by users and are mostly well used as additional living space. Passive solar buildings offer an opportunity of using glass and light to achieve a distinctive appearance and this can be used to advantage.

Successful energy-efficient architecture has not only to combine solar heating and auxiliary heating, day lighting and passive cooling, production of hot water and electricity but has to create good external layouts and appearances together with pleasant internal arrangements. This is the challenge for the designer.

NOTES

/1/ Passive Solar Energy as a Fuel 1990 – 2010` is a report from the CEC available from DG XIII, Luxembourg under nr EUR - 13094

/2/ Commission of the European Communities.: Solar Architecture in Europe Design, Performance and Evaluation The studies were produced under the guidance of Theo C Steemers, CEC DGXII. Dorset: Prism Press, 1991, ISBN 1 85327 073 3

/3/ A Fine Homebuilding.: Energy-Efficient Houses, A photovoltaic test House Analysis of the house written by Charles Wardell Newtown: The Taunton Press, 1993