Reduction of Energy Use or Improvement of Efficiency

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Abstract

The article deals with the concept of "Passivhaus" (PH) in relation to the inside environment and compares PH and the concept of bioclimatic design. Bioclimatic design is an integral part of eco-building oriented interventions in the built environment. The main numerically expressed goal of the PH is reduction of heating energy use to less than 15 kWh/m^2.year. To reach this goal at least triple glazing is mandatory. This consequentially reduces daylighting illumination level in the building. The basic philosophy of daylighting and the first step in design is that the room is provided with it in the worst case, i.e. maximizing daylighting. [1] In second phase interventions connected with the control of intensity or glare must be taken into the account. Cutting off direct contact with the external environment is viewed as the collateral damage in one-sided energy conservation activities. But the concept of alienating people from the natural environment is according to many studies harmful to health and consequentially to the productivity. The external environment is not by definition hostile to human beings; on the contrary it can have stimulative effects on body and mind. Daylight provides quality lighting, stimulates sense of sight and is important communication mode between the internal and external space. The constant change of light improves concentration and responsiveness. The same holds true for acoustic environment and aural perception and sense of smell. The bioclimatic concept is based on simultaneous adaptation to the external conditions and internal needs and requirements. Closer the building is able to follow these two profiles and the better is the communication between them, the more efficient it is. The adaptive model of the built environment system represents the dynamic structure which performs in real time conditions. Such design and usage philosophy enables optimal exploitation of natural resources and rational adaptation of living patterns. The objective of the above described interventions in the framework of bioclimatic design is healthy living and working environment with the lowest possible energy use and not the lowest energy use based on the physiological minima. In the opinion of World Health Organisation (WHO) it is possible that up to 30% of new and renovated buildings is linked with Sick building syndrome (SBS), most of them with bad quality of inside air. The main causes are transport of air through the systems for heating, cooling and air-conditioning (HVAC), emission of gases from some building materials, volatile organic compounds (VOC), moulds and inappropriate disposal of light industrial chemicals from premises or inappropriate cleaning and filtering of outside air.

1. Introduction

"Every man, wherever he goes, is encompassed by a cloud of comforting convictions, which move with him like flies on a summer day." Bertrand Russell (1872–1970), British philosopher and mathematician.*Sceptical Essays* "Dreams and Facts" (1928).

Latterly we are witnesses of apparently incomprehensible development of events conected with world's climate conditions. It looks like that the consequences of climate change trends are changed conditions in living and working environment and influence on the health of faunae and florae. Part of this system are also human beings. Unbalanced exploitation of material and energy caused these changes.

Care for sustainable development is explicitly defined as important strategic task of EU and her member states. It must find its place in development orientation of all sectors including construction sector. The PH is declared today as so called sustainable construction in the embrace of politically popular expression sustainable development. Being put in force in Rio Declaration on Environment and Development sustainable construction means complete balance of economic, social, environmental and health development points of view. The economy and partly environmental components are stressed in the contemporary PH while the social and health view are intentionally or unintentionally forgotten. Considering studies which scientifically prove negative influences of diminished daylight, insufficient ventilation based on physiological minima with planed large amount of expected non-satisfied occupants, we can define passive houses as distinctly non-sustainable.

"Non-sustainable are all human activities which have negative influence on the environment, health and life of people and can not be performed in the future. If it is estimated that human activity is non-sustainable in the future it must be sustained and can not be executed." [2]. An essential necessity for future sustainable society is a low environmental impact. The answer to this problem is given in various requirements for all kinds of reductions. The reductions raise questions whether something is possible at all or what to do. The basic philosophy here is inadmissibility and inhibition, both with negative connotation. Can we change the negative spiral into a positive one towards a sustainable society? How can we develop a sustainable design to achieve a positive spiral on the basis of permissibility? [3].

“Pasivhaus standard” movement become in recent times some sort of religious movement. [4]. In religions rational explanation does not exist. People simply believe in something. If somebody believes in something it is extremely difficult to convince him in opposite. PH prophets and some owners assert that living in the PH is very comfortable. There are several explanations to such opinions. One and the most acceptable one is cheating. If it is not warm enough in the bathroom you switch on electric heater. Another one is that consequences of sick building syndrome are not acute yet and residents are not aware of the problems. The third one is that if somebody really believes in something this overrun the system of physiologic sensors. Unfortunately there is another explanation that people which found out that they made a mistake which costs a lot of money are not prepared to admit this. If you bay a lousy mobile phone you throw it away, if you built a problematic house it is difficult to confess this to yourself let alone to the others.

Connection with the environment is the mechanism which enables people to react to the changes. If there is a change, for instance in the air, and something impact organism, is this organism if it is permanently exposed to changes in the air, prepared for the change and can adequately react. But if this organism is adopted to the conditions with unchangeable properties i.e. temperature, relative humidity, “washed” air, maybe even the same kind of bacteria and it changes its adopted environment with another environment, or the system with the artificial environment breaks down, than everything can go wrong. Human beings need the exposure to changeable, dynamic systems.

According to Selkowitz [5] from Environmental Energy Technologies Division, Lawrence Berkeley lab, there is an interesting relation between the yearly energy costs for an employed

person per m^2 which is 20 USD and expense for an employed person per m^2 which is 2000 USD. Even a small improvement of productivity or reduction of absence owing to illness is much more cost efficient as energy saving which is expressed either in lower or higher temperatures and daylight illuminaion disturbances. Bryan [6] presented the case where a 0.5% higher productivity covers all expenses for heating and a 6.6% higher productivity covers all expenses for the whole building

„Cardiovascular health requires periodic exercises when human body is exposed frequently to considerable physical discomfort. The current explanation and focus of sick building syndrome is the need to provide higher fresh air flows. This is done in face of the evidence that occupants desire naturally ventilated buildings and more direct control of their environment with operable windows and easy to use daylighting.« [7] Parts of holidays activities are connected to thermal discomfort: skiing at low temperatures and roasting on sun in summer. While people expose themselves to the thermal discomfort, which does not happen accidentally or from some masochistic motives, some experts think that it is exigent to assure in buildings, in living and working environment such temperatures which diminish the percentage of thermal discomfort.

The insufficiency of daylighting has influence on onset of depression. [8]. The prise of depression in Europe (EU 28) was 42.000.000.000 €/a, direct costs in health system, 76.000.000.000 €/a indirect costs in economy, all together 118 milliards per year, 253 € per inhabitant, 1% of GDP.

Incorrect air ventilation due to increased thermal insulation and air infiltration tightness as well as thermal bridges in the building structures are the origin of condensation of water and microbial growth, and a faster deterioration of building material. The European Construction Technology Platform has estimated the savings in b€/year for EU-15 which could result from a more comfortable and healthy indoor environment: reduced Allergies and asthma (based on a reduction of 8 to 25% of medical costs), 3-6, reduced Sick building Syndrome symptoms (based on 20-50% reduction and 2% productivity improvement, 15-54, increased productivity by comfort related improvements (based on 0.5-5% increase in worker performance), 30-240. [9].

As explained above any game with energy conservation through increased U-values for windows, which is one of the main trump cards of PH, results in decrease of daylight penetration in the room and causes harmful consequences.

2. Communication and Bioclimatic Design

2.1. Concept

The architectonic artefact is the interface between the natural environment and the human built environment, adjusted to the people's needs considering both their life and work. The basic condition of the functioning of ecological systems is rationality and equilibrium of their parts and complexes. This measure is valid also for the socio-ecological system, their parts being built environment and man.

Location conditions are formed by the geomorphologic structure, more or less unchangeable, but influenced by negative impacts coming from the built environment, by climatic conditions, changeable and unpredictable, but in certain sense harmonic, and by behaviour patterns and peoples life habits, which depend on location and social and economic status as the result of creativity and are as such changeable but mostly non harmonic. These differences can be the starting point for the design as strategic planning on the building and location levels.

If the users' demands and the conditions in the natural environment are different and changing, then the response of the building to these demands and conditions has to be dynamic and changeable, too. The temporal function of these activities is irregular with its stopping points in metastable state, when their charges are filled or emptied in unpredictable cycles. These charges represent the power which must be used as a generator for design decisions. An efficient profit of power charges can not be achieved with motionless design solutions. Bioclimatic design concept is in contradiction to some contemporary ideas based on rational use of energy, like European Passivhaus model, where the main goal is reduction of heating energy use. To reach this goal triple glazing, air tightness and heat exchangers are needed. This consequently reduces daylighting illumination level and air quality in the building. Cutting off the direct contact with the external environment is viewed as collateral damage. But the concept of alienating people from the natural environment is according to many studies harmful to health and consequently to productivity. The external environment is not by definition hostile to human beings; on the contrary it can have stimulative effects on body and mind. Daylight provides quality lighting, stimulates sense of sight and is important communication path between the internal and external space. The constant change of light improves concentration and responsiveness. The same is true for acoustic environment as well as aural perception and sense of smell.

The great unifying theme at the conclusion of the 20th century, the 10th megatrend, is the triumph of the individual. Naitsbit & Auberdene [10] emphasised that this new era of the individual is happening simultaneously with the new era of globalization. Global transparency reveals qualities of the individual and these qualities must be rewarded. In our case of designing living and working environment, qualities must be rewarded not only with minimal requirements, based on manipulative rationalisation, but also with maximal possible demands taking into account health, comfort and pleasure. The adaptive model of the built environment system represents a dynamic structure which performs in real time conditions. Such design and use of philosophy enables optimal exploitation of natural resources, rational adaptation of living patterns, and it is essentially the result of hundreds of years of processes of development of human living environment. The objective of the above described interventions in the framework of bioclimatic design is healthy living and working environment with stimulating performance oriented environment with the lowest possible energy use and not the lowest energy use based on the physiological minima.

Efficiency is the performance goal of groups of influential parameters, represented by comfortable living conditions, higher quality of life and intelligent systems. They are lying in the space which is defined by cultural and physiological characteristics and demands on the one side, and by technology level and necessary energy supply together with all positive and negative impacts on the natural environment on the other side. The basic characteristic of the system oriented into the efficiency is its duality.It provides higher quality of life and the lowest impact of artefacts on the environment. High technology can help to harmonise the diversity of influences and conditions if it is oriented into the efficiency. Flexibility of use, being in the past a function of place and time, also becomes a function of the technical capability of appliances. It is typical for all interlaced activities that they are moving out of elastic bounds of possibilities of the natural environment. It is practically impossible to avoid these pejorative influences at the contemporary technology level.

2.2. Cases

PH has central system for air exchange with central thermal recuperator. The air must be brought through canals with different geometry, even with dimensions in cross section of 2x20 cm, in each room in the building and than remove it from rooms again through the exchanger. These canals are

one of the main generators of SBS. In the air there is an enormous number of different particles, organic and inorganic, with different dimensions. There is no commercial filter available which could collect all of them. Vendors of PHs like to stress that their houses have filter which removes all undesired substances from air. Actually this is a piece of luck because is such case we could be provided with the air which could be compared with drinking of destilled water. The particles in the air are [11] particulate or gaseous, organic or inorganic, visible or invisible, submicroscopic, microscopic or macroscopic, toxic or harmless. They are in the form of dust, fumes and smokes, mists and fogs, and vapours and gases, with different dimensions, from 0,1 μm and 0,3 μm to 100 μm, the span of living particles, for instance viruses from 0,005 to 0.1 μm, bacteria 0.4 to 5 μm, fungus spores 10-30 μm and pollen from 10-100 μm, as far as almighty filters are concerned. These particles can be deposited on surfaces of canals and in connection with the condensed water serve as substrata for microbial growth. Anti-electrostatic and bactericide treatment of canals is advertised as solution for the above mentioned problems, irrespective of the known consequences of antifouling treatment of boats on see flora and fauna.

PH "standard" is used as the basis for treated interventions in EuroSun 2008 Conference contributions without taking into the account the consequences of influences of thermal insulation measures in glazing on daylight. Haasel et.alt. [12] are claiming high ratio of daylight use "which enables a significant reduction of electricity demand for artificial lighting" on one side, while energy concept described among other measures order to reduce total energy consumption of the building an increase in air tightness first to n_{50} = 1.5 ach (from n_{50} = 4.29 ach) and second to n_{50} = 1 ach (from n_{50} = 1.5 ach), and reduction of windows area to WFR = 0.131 (from WFR = 0.1745). Selkel et. alt. [13] declared "high indoor comfort for the office building user« without presenting data on thermal and visual transparency of glazing system. In the last case PH standard requirements were a burden in otherwise interesting design concept. The level of misunderstanding PH "standard" is leading sometimes to absurd reactions as for instance in the case of Brotas et. alt. [14], where authors proposed to use PH "standard" both for heating and cooling (Heating criterion: The useful energy demand for space heating does not exceed 15 kWh per m² net habitable floor area per annum. Cooling criterion: The useful, sensible energy demand for space cooling does not exceed 15 kWh per m² net habitable floor area per annum) in the Portuguese climatic conditions!

In the special issue of Energy and Buildings collected papers summarising the work of this of this IEA research Task, Reinhart and Selkowitz describe how in 2002, a paper in Science [15] identified a previously unknown direct connection between the eye and the circadian pacemaker within the brain that drives daily wake–sleep cycles. They suggest that "*This emerging research field could establish new requirements for lighting buildings that are based on non-visual effects of light on humans. Such requirements might at times be higher than the minimum visual requirements that are currently stipulated in norms. Satisfying these new needs could become both an environmental burden, if met through electric lighting, or an opportunity, if satisfied through an increased use of daylight.*"

To compare thermal and light balance of a building a comparative study of 27 accidentally selected buildings was performed [16]. The variation of energy consumption for heating was compared to the changes in the illumination level for Ug = 1.1 W/m^{2}K and 0.6 W/m^{2}K. Because of the improvement of thermal insulation of windows from 1.4 to 0.6 W/m^{2}K 27 buildings average energy use for heating Eav-eq was reduced by 15 % but at the same time the share of daylight illumination Qn/Au was reduced by 25 %. In two cases, there was 0.7–1.5 % reduction for heating

and 29 % decrease of daylight illumination. In the worst case, there was 13 % reduction for heating and more than 60 % decrease of daylight illumination. [Figure 1].

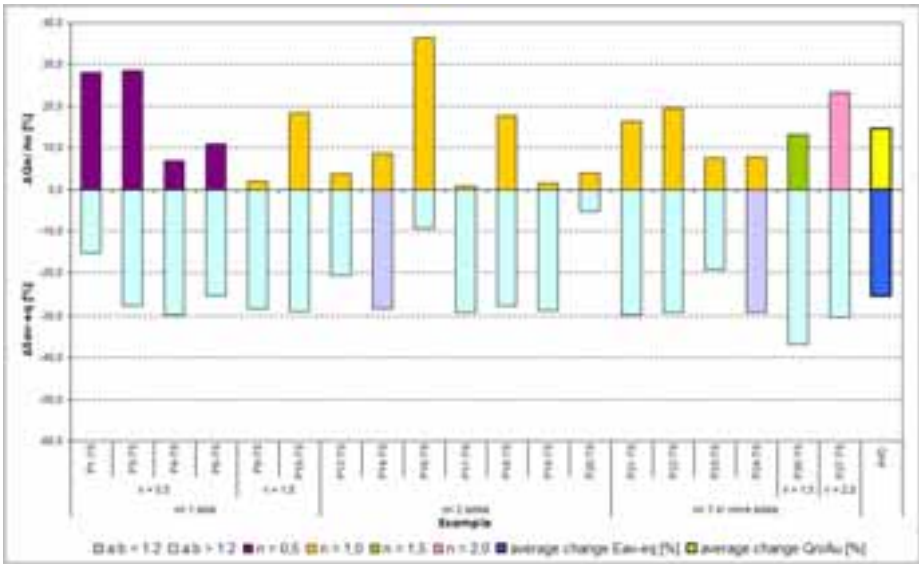

Figure 1. Comparison of heating energy reduction (+ %) and consecutive daylight reduction (- %) between windows with U = 1.4 W/m2K and g = 0,65 and windows with U = 0,6 W/m2K and g = 0,5 in 27 coincidentally selected buildings.

The influence of double and triple glazing on specific annual energy use for heating and daylighting, was studied also on sample building [17]. Two cases with the dimensions of openings 14 % (Fig. 10) and 46 % (Fig. 11) of floor area were compared for clear and dirty glass (80 %) and perpendicular incidence angle (80 %). The double glazing with the U-value of the opaque part 0.15 W/m2K and air change n = 1, consists in: glass optifloat clear 4 mm + argon 15 mm + glass optitherm S3 4 mm, U = 1.12, g = 61 %, TV = 76 %, and the triple glazing: glass optitherm SN 4 mm + argon 12 mm + glass optifloat clear 4 mm + argon 12 mm + optitherm SN 4 mm, U = 0.74, TV = 66 %, g = 50 %. For the studied types of glazing, Pilkington Spectrum v02.01.01 application (standards EN 410, EN 673/12898) and for energy consumption computer program TOST (standard ISO 13790) were used.

It must be emphasised that the data presented in the technical documentation material are valid for normal (90°) incidence and clear glass. The factor for the reduced transmittance in an urban environment is because of angle of incidence 0.8 and for influence of dirt also 0.8. The specific energy use for heating was in the case of the smallest permitted window, according to Slovenian regulation, opening with double glazing 68.33 kWh/m2a and in case of triple glazing 67.80 kWh/m2a respectively. Practically for the same quantity of needed energy in both cases, the only result of the replacement of double with triple glazing was that average level of daylighting was diminished by 13–15 % with all the related consequences. In the case with the largest window opening the specific energy consumption for heating was for double-glazing 59 kWh/m2a and by triple glazing 55 kWh/m2a i.e. reduction of 7 %. However, at the same time annual average daylight illumination was reduced by 14 % in ideal conditions presented by glass producers with clean glass and incidence angle of solar radiation of 90°. In real time conditions, where factors of dirtiness on glass and incidence angle of solar radiation were taken into the account daylight illumination is reduced by 38 %. There is an increase of average illumination of 72 % when the smallest allowed opening, 14 % of floor area is exchanged with the biggest possible, 42 % of floor area.

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In the publication Innovative Passivhausprojekte [xx], there are 11 cases of passive houses presented. There are 11 cases with triple glazing and in 1 case there is aditional glazing with 4 glasses. The following information on Ug (glazing) W/m^2K and g (%) are given for triple glazing: in 4 cases with U_g 0.5 W/m^2K and with g values from 48-52%, in 1 case U_g 0.53 W/m^2K and g value from 36-47%, in 4 cases U_g 0.6 W/m^2K with g values from 50-52%, in 2 cases U_g 0.7 W/m^2K with g values from 49-52% and in 1 case with four glasses U_g 0.53 W/m^2K and g value from 49-52%. There are also data on U_W (window) but they are not relevant as far as daylighting is concerned. These data can be compared with data on glasing characteristics for different configurations and applied materials, glases, coatings, fillings from Pilkington Company website. The result of calculation with Pilkington Spectrum^{TM} computer aplication for the configuration Optitherm^{TM} S3 4 mm, argon (90%) 12 mm, Optifloat^{TM} Clear 4 mm, argon (90%) 12 mm, Optitherm^{TM} S3 4 mm are U 0.7 W/m^2K, τ_V 71% and g 50%. We can observe that only in one case theoretical values from the producer are the same as data published in the above mentioned publication. Compared with calculated data all g values published in Innovative Passivhausprojekte publication are higher. The most interesting is the case with 4 glasses with U_g value, 0.53 W/m^2K and g value 36-47% which is not acceptable even by declared PH standard.

In a 2000 multiple building study of 39 schools in Sweden, Smedje and Norback [19] identify a 69% reduction in the 2-year incidence of asthma among students in schools that received a new displacement ventilation system with increased fresh air supply rates, as compared to students in schools that did not receive a new ventilation system. [3]. Health benefits of access to nature by different authors quoted in case of use of natural ventilation 46-67% fewer SBS symptoms, 15-33% few mucosal and nasal symptoms, 52% fewer migraines, 17% fewer doctor visits, 35% fewer hospital stays, 17% fewer colds, 31% fewer circulation problems and 37% less cough. [20]

3. Conclusion

Our primeval conceptions on shelter are threatened when excluding system is used in the design of living environment and where the goal - hidden or unhidden - is maximal restriction of communications of thermal and light flows, of visual and sonic communications in order to reduce thermal energy use. Architectonic active spaces and constructional functional zones are more than a sum of physical parts, they are interconnected and dependent whole.

The interventions in the reduction of window's U value have no sense at the momentary technology level of glazing because the amount of transferred daylight is disproportionally reduced in comparison with the reduction of energy for the heating. This holds true even more if we take into the consideration collateral consequences on health and productivity.
If the system gets stuck in the stable state a lot of energy is needed to move it into another state. This is the most energy wasteful system. This is the reason why stable, non-dynamic systems could not stand changes. Today a typical example of stable, stationary system concept is a "passive house" concept.

The use of calculation of single parts of interactions between the inner and the outer environment as the only criteria in the process of building design can have absurd influence on architecture and is unacceptable. The envelope as an interface must enable positive communications between these two. It can not be a closed box whose purpose is prevention of any kind of communication but active system, regulator of changes between the natural and artificial environment, changes which are unavoidable, desirable, encouraging and numerous. Besides health and comfort, pleasure can represent a value related to the harmonious development of the individuals in the framework of sustainable development. We know what we want, we can try to find out what we must do, and be prepared how to do it when technology will be available. The biggest danger for inteligent house is to use "market" oil price, which is anything but a real market price, as a comparative value for decisions. What is needed: better system for protecting and encouraging fledgling ideas and transforming theory into practice.

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