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## ARCHITECTURAL ANSWER FOR GLOBAL CLIMATIC CHANGES

**Summary.** Basic directions of development of modern architecture are looked through. They are architecture on water, sun architecture and architecture of large interior spaces in the context of global rise in temperature of climate and increase of receipt of sun radiation.

**Keywords:** modern architecture, climatic changes

## ARCHITEKTONICZNA ODPOWIEDŹ NA GLOBALNE ZMIANY KLIMATYCZNE

**Streszczenie.** Artykuł zawiera przegląd podstawowych kierunów rozwoju współczesnej architektury. Przedstawione są obiekty na wodzie, tzw. architektury słońca oraz architektura dużych wewnętrznych przestrzeni, w kontekście globalnego wzrostu temperatury i promieniowania słonecznego.

**Słowa kluczowe:** architektura współczesna, zmiany klimatyczne

### 1. Introduction

#### *Raising of problem*

One of the functions of architecture is protection of a man from discomfort able and harmful influences of external environment. Therefore, together with global climatic changes must change architecture as shell between internal and external space. Now it is important to develop the forecasts of directions of development of architecture in reply to the basic consequences of changes of climate.

#### *Purpose of the article*

Generalization of basic lines of separator model of development of modern architecture is on the basis of extrapolation of consequences of modern climatic changes on the near future and medium-term prospect.

*Analysis of climatic changes and their consequences*

The sun heats the Earth by the visible spectrum of radiation, and the Earth, in same queue, heated, selects thermal rays, which can not penetrate through the layer of carbon dioxide and disperse in an universe (as it was always) – so we look after a permanent rise in temperature of climate of land, which presently arrives at  $0,7^{\circ}\text{C}$ , and in according to the forecasts of scientists, for next 50 years this rise in temperature can attain  $5^{\circ}\text{C}$ ! More than century ago a Swedish scientist and Nobel laureate, Svante Arrhenius (1859–1927), reported back, that humanity, burning hydrocarbon, supersaturated an atmosphere carbonic acid which unavoidable early or late will result in a global rise in temperature of the planet, and farther to the ecocatastrophe.

Today, burning oxygen, and throwing out in the atmosphere of the Earth the unbelievable amount of carbonic acid we move this balance, set by millenniums, which results in contamination of atmosphere, worsening of quality of air, destruction of ozone sphere in the atmosphere of the Earth.

Usually content of oxygen prevails carbonic acid considerably, so in 2005 there was about 21% oxygen and carbon dioxide 0,0379% in an atmosphere, but these numbers lately change quickly. Hydrocarbon (coal and oil), especially at uneffective incineration selects carbon dioxide, which accumulates in the upper layers of atmosphere of the Earth and creates there warm spread layer which is main reason of the so-called hotbed effect.

For fight against these negative processes in 1997 in Kioto the representatives of 141 states of the world met to take part in the congress and came to the general idea as to limitation of extrass in 15 atmosphere, which causes a general rise in temperature. In the signed protocol (law), they obliged 39 basic industrial states to shorten extrass carbonate and 5 other gases on 5,2% relatively to the level of 1990. The states with a transitional economy must shorten extrass even to the level of 1990.

Nowadays rise in temperature of climate is objective reality, which is investigated many respected international organizations and fixed in international documents and established at numerous conferences and symposiums of different levels in Kioto, Venice, Copenhagen and others (pic. 1).

The basic consequences of global rise in temperature of climate are following:

1. Melting glaciers on mountain ranges and north and south poles of the Earth, which causes getting up of level of the world ocean and diminishing of area of land;
2. Increase of receipt of sun radiation on a terrene, which has consequences as a change of limits of climatic areas, increase of duration of period of vegetation of plants and reduction of the heated season, which in same queue extends possibilities of the use of sun heat for conditioning (heating or cooling) of apartments on a base exhausting of traditional block fuels;

3. Increase of certain discomfort and even aggressiveness of environment to the man, which shows up in more frequent origin of the extreme weather phenomena (tornados, storms, considerable fallouts, contrasting changes of temperature and humidity), also passing of greater amounts of hard ultraviolet on a terrene through diminishing of thickness of ozone layer.

**Basic hypothesis** of development of architecture in the context of global climatic changes consists of three perspective directions of answer to the ecological calls of XXI century:

1. architecture of houses on water,
2. sun energysaved architecture,
3. atrium architecture of large interior spaces.

## 2. Architecture of houses on water

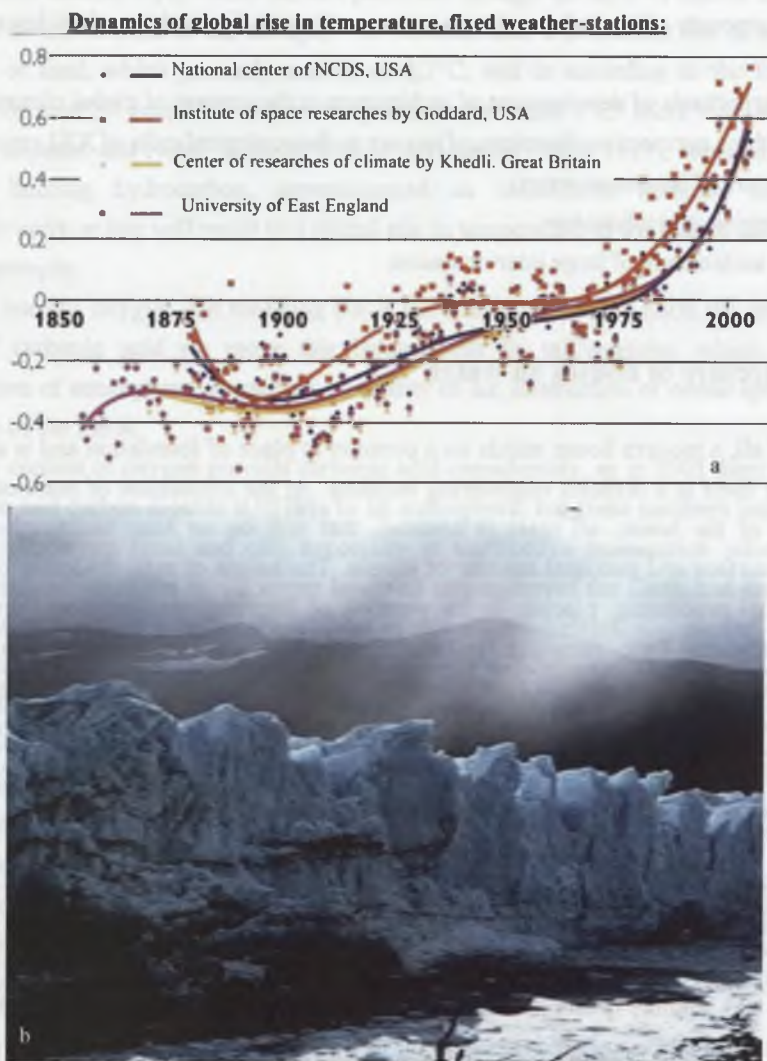
First of all, a modern house stands on a pontoon in place of foundation and is a ship. The pontoon, in itself is a difficult engineering building. At the calculation of pontoon as future foundation of the house, all mass is counted, that will be on him: building, equipment, furnitures, surface and maximal amount of people. The height of side, thickness of plates of steel, internal processing, placing in the pontoon of engineering equipment depend on it. These parameters form firmness, reliability and longevity of the foundation of the architectural object, and also his form and tectonics. It is related to that, the designers must expect sizes, sailing, firmness, unsinking, different and heel, and the engineering calculations of the designers are aimed at that even at the large moving of mass from one edge of building to other, users will not feel discomfort and will restrain positive emotions.

Houses on water as to comfort do not yield by nothing to landed buildings, but at the correct equipment they excel the last. Specifically the index of humidity in a house on waters, identical with a house which is on the land in 50 meters from water, thus, it is worthless to afraid, that from a location on water microclimate of architectural environment will become worse, and it is possible to attain comfort by the modern systems of ventilation and materials. Advantages of life on water are large enough: in winter it is possible there is skating rink and fishing, and in summer there are remarkable landscapes, a made fast cutter, a beach on a terrace and again fishing.

The sizes of the house are limited only to superficiality and breadthways, it is related to sailing, in fact your house will stand on water, and how much it is higher and narrower, than it is less proof. But our designers will give you an advice and everything will be counted, so that you will be never troubled and will not doubt in reliability of life on water. His legally administrative advantage consists in absence of necessity to take the land out. To build a house on water it is only needed to lease some off-shore territory – in all a few meters.



Water is free of charge. However, it is better when a house on water will be energy autonomous and independent of engineering communications.



Pic. 1. Dynamics of global rise in temperature according to international supervisions (1850–2010).

A danger of intensive deglaciation and getting up of the level of the world ocean on the Earth  
 Fot. 1. Dynamika wzrostu globalnej temperatury zgodnie z międzynarodowymi raportami (1850–2010). Niebezpieczeństwo intensywnego topnienia i wzrostu poziomu oceanów na Ziemi

So far such building in Ukraine in general and in Kyiv in particular only collects turns (pic. 2). For a year, possibly anymore, five houses are hand over for rent. In Europe floating houses occupy greater part of embankments in Holland, Italy, Spain, France, Monaco.

Modern architect-futurologists actively develop the projects of architectural objects on water. They are floating theaters, hotels, housing groups and the whole cities. The projects of

technologies of building on water and creation of power generators are developed with the use of difference of salinity and temperature on different depths, and also sea waves. This problem is especially actual for the developed countries of Europe, Asia, America, with large megapolities, located on the coasts of the rivers and seas.

The best example of architecture on water is project suggestion of Belgian architect Vincent Callebaut, which offered his solution of the problem of habitation in the conditions of future ecological crisis (pic. 3). After the forecasts of IGEC (the intergovernmental group of evolution of climate), the level of the ocean must rise from 20 to 90 cm during XXI century with a critical mark 50 cm (against 10 cm in XX century).



Pic. 2. Architecture of floating houses: habitation (a, b), hotels (c, d), offices (e), restaurants (f), on the Dniper near and in the boards of Kyiv has a traditional Interpretation of the form, which reminds a ship or a house which is erected on the land and put on a pontoon

Fot. 2. Architektura pływających budynków: mieszkalne (a, b), hotele (c, d), biura (e), restauracje (f), na Dnieprze w pobliżu Kijowa i jego granicach posiada tradycyjne formy przypominające statek lub dom wzniesiony na lądzie i umieszczony na pontonie

Architect Vincent Callebaut offered a surprising project, which would serve as luxurious future retreat for 50 000 inhabitants, which take refuge from water, the level of which rose in consequence of the global rise in temperature, for the decision of this problem.



Pic. 3. A floating ecopolis of the XXI century is for climatic refuges in the conditions of global rise in temperature: the general view of submarine and upperworks, and also group of ecopolices near the urbanized coast city-amphibian for 50 000 inhabitants of the Belgian architect Vincent Callebaut

Fot. 3. Pływające ekopolis XXI wieku jest klimatyczną enklawą w warunkach globalnego wzrostu temperatury, widok części podwodnej i nawodnej a także grupa obiektów w pobliżu zurbanizowanego wybrzeża, w formie miasta-amfibii dla 50 000 mieszkańców – według belgijskiego architekta Vincenta Callebaut



He trusts that the world will take refuge desparately after devastations from climatic changes and will hope that his city-amphibian will serve as a luxurious decision. It is a pity only, that, nowadays, the amount of people is approached to 7 milliard and this luxurious future refuge will be accessible only for 50 000 inhabitants (simply for rich people).

### 3. The sun energyconservated and ecological houses

Architecture of sun houses answers three basic systems of the use of sun energy: passive, active and integral or combined.

The passive system differs an advantageous orientation, functional zoning, large windows and massive non-load-bearing constructions, by the glass volume of winter garden, for the accumulation of sun heat.

The active planetary system traditionally consists of a collector of energy, an accumulator, a heat exchanger and communications with a pump. The basic economic problem of the active system is a possible combination of its elements with the protection of houses. For the last few years the tendency of transformation of houses was set in the planetary systems with the constructions of double-duty: a roof-collector, a wall as a communicator, a foundation as an accumulator. Modern sun houses are laid with zero and even with positive power balance, in this tendency, created in Europe (pic. 4).

The integral planetary system combines advantages of the set higher systems and gives the special lines of sun modeling: a developed south slope of a roof and facade, an extended form of a plan for architecture. However, sun energy through its spraying is not simple and cheap in its use, that is why considerable attention it is followed to spare energy-saving of houses. The problem of sun architecture helps to decide nature. Bionic analogies were actively use and used in many projects. In particular, city Masdar (Masdar City), or in-arabic "source ", it is counted on building for Abu-Dhabi (UAE) in 2007–2023. The author of the ecological city Norman Foster (Norman Foster&Partners). The general area of the future city is 7 km<sup>2</sup>, estimate cost of the building is 22 milliard of dollars. Roofs and covers of squares of the city is like flowers and leaves of plants, which will collect sun energy for the necessities of people (pic. 5).

In the prospect sun houses will transform into bionic objects, which like nature flexibly react on changes of receipt of sun radiation in the cycle of a day, a season, a year.

The architectural project of the building, as an inalienable component, includes measures of the economy of energy:

1. compactness of the form of the building (the most compact form of the building is a hemisphere, his part of surface, in relation to a volume (in relation to a hemicube) makes only 81%, then a cylinder goes – 92%, a pyramid – 98%, hemicube – 100% and finally a cube – 105%);

2. the orientation of the building; the location of windows (most windows and transparent parts of walls or roof must be turned to a sun, it is impossible here to forget about the summer protection from the sun);
3. the zoning of the building (division on hotter – dwellings, and colder are auxiliary or buffer areas);
4. the creation of massive walls which accumulate and give heat in the middle of the building and others like that.

Beginning from the middle of 1970's the most European countries increased the rationed sizes from the heatcover of constructions in 2–3,5 times. Now this process proceeds: requirements to heat-insulation materials rise constantly, by the norms of heatpenetrability become harder for separate built constructions and buildings on the whole. In this connection in Ukraine from the 1<sup>st</sup> of October, 1996 amendments were brought into an action to SBN from a build heating engineering, which increased the normative values of resistance of heat transfer of external non-load-bearing constructions substantially, as for the new building so at the reconstruction and the major repair.

Choosing build materials, it is needed to turn large attention on charges energies, necessary for the production of these materials (for example, if energy on the production of heat-insulation materials, their transporting, and treatment on the building ground exceeds energy which we will economize using these materials in the building, then such building will not be ecological, even if it needs no heating in general!).

So, calculating the power utility of materials, it is followed to consider not only by their coefficient of the heatpenetrability but also on charges of energy, necessary for converting of natural raw material into the concrete element of building, in accordance with time of his use in building and economy of energy due to his use at this time, and also energy on utilization of this built element. Except of it, it is necessary to choose such materials, which at production, building, using and utilization, do not throw out in an environment harmful for a man toxic gases, solvents, radiation (radon radiation) and others like that.

It is followed to take into account durring planning of an engineering equipment of the building: possibility of use of the energy that is recommenced; the choice of the ecological systems of heating and fuel; distributing and adjusting of radiators or radiative warmly planes; heating of water; possibility of the use of energy due to recuperation of air and water; it also should check the chosen system of heating for its accordance to the architectural planning of the building and its use.

Use of sun energy is based on the use of photo-electric panels and bionic analogies with flowers and their flexible adaptation to conditions of illumination. The center of the city will be closed by large flowers with mobile petals, which will cover point-of-sale areas and the area of rest. Huge umbrellas – „flowers of sunflowers” protect an architectural environment from sunrays, collect sun energy and use it during the day and the night.





Pic. 4. A receipt of sun radiation on the surfaces of the house and examples of structural elements of the system of sun collectors of a vacuum type (a–d). Modern sun houses are built in Europe on the territory of Germany, Poland, Ukraine (e–h), including the pilot object the „Sun house with a zero balance of energy” by J. Szefer near the city of Opole

Fot. 4. Wykorzystanie promieniowania słonecznego na powierzchni budynku i przykłady elementów konstrukcyjnych systemu kolektorów słonecznych do typu próżniowego (a–d). Nowoczesne słoneczne domy są budowane w Europie: na terenie Niemiec, Polski, Ukrainy (e–h), w tym pilotażowy obiekt „dom słońca o zerowym bilansie energii” J. Szefer niedaleko Opola



Pic. 5. The sun architecture in the City of Masdar (Abu-Dhabi, UAE), a project was executed: architectural bureau of Norman Foster&Partners and LAVA – Laboratory of Visionary Architecture

Fot. 5. Słoneczna architektura w centrum Masdar (Abu-Dhabi, Zjednoczone Emiraty Arabskie), projekt został wykonany przez biuro architektoniczne Norman Foster&Partners oraz biuro LAVA – *Laboratory of Visionary Architecture*



#### 4. Atrium architecture of large interior spaces

Three creative conceptions architecture of atrium spaces were set in which carry in itself considerable volume planning possibilities, potential of composition and emotional expressiveness and considerably promote aesthetically beautiful qualities of an object:

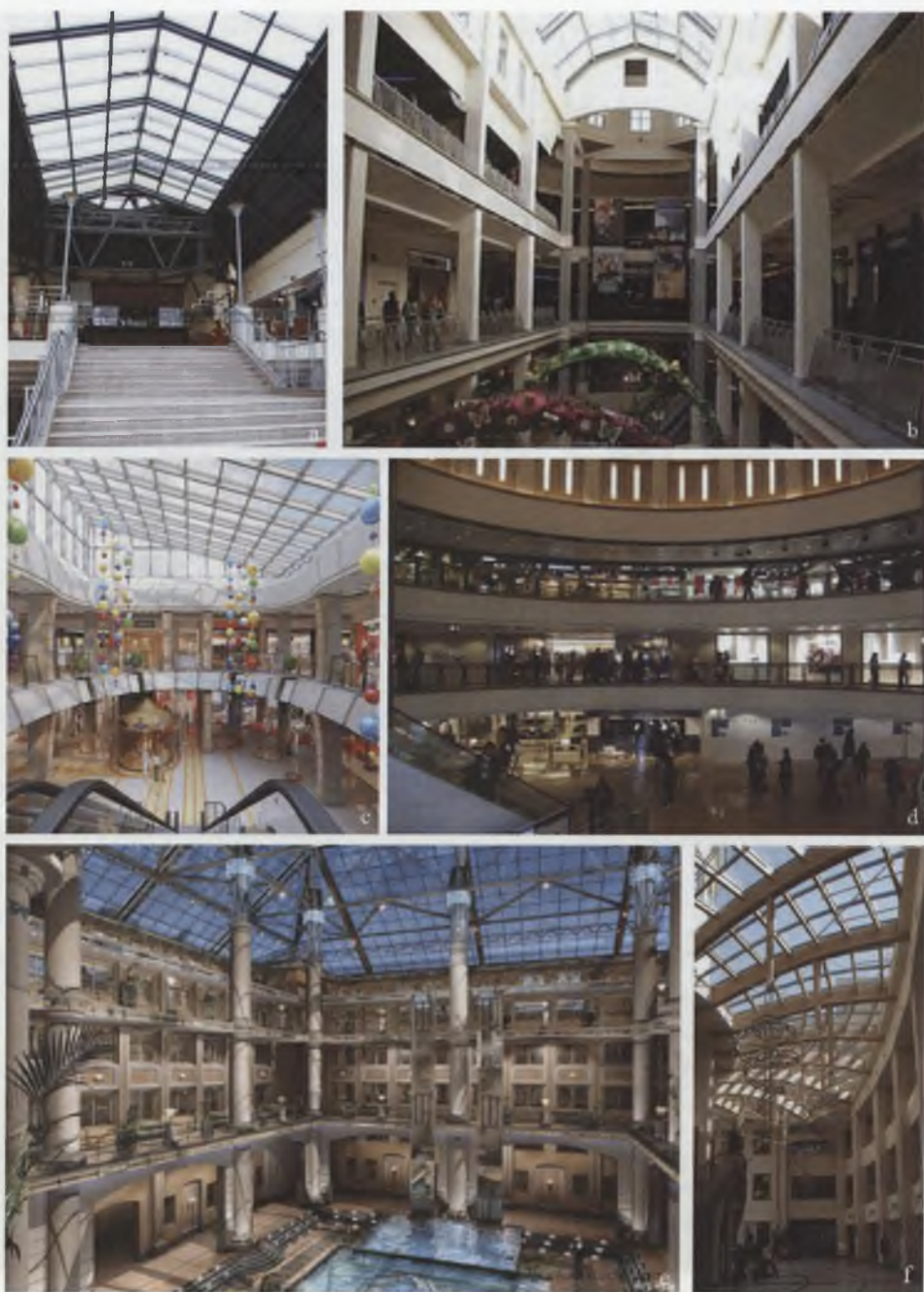
1. So-called open-space which link (planningly and by sight) internal space of public houses with external.
2. The closed space, unlike other types of large space, plays the role of the centre of volume-spaced composition and is the knot of all internal-volumed human communicative streams, by the area of rest and communication.
3. Judicial space is designed with a calculation on continuous motion of streams of visitors and draws together the decision of internal space of public buildings and complexes with the suburn city environment.

The analysis of international experience shows that an architectural reception serves functional and microclimatic purposes, promoting comfort, visiting or business activity, in public complexes. „Large spaces” which promote the level of not only comfort of environment of public buildings considerably but also emotional and aesthetically beautiful expressiveness of their interiors, indeed give them democratic and humanism contents.

Atrium architecture of „large spaces” is caused to living by the concrete problems of change of climate and development of the modern city. First of all it is the problem of stimulation of the traditional city way of life which is especially observed in buildings of modern streets-arcades. The climatic and ecological problems of architecture become sharper, it is possible to consider an answer for it, mainly buildings of K.I. Rosha and G. Dinkelov. And, finally, the problem of increasing of commercial efficiency of large complexes in the central districts of the city, that especial model of the example of „entertaining architecture” of G. Portman. At the same time each of the considered buildings concentrates in itself all adopted problems and aspires to their decision. So, architecture of G. Portman is characterized with entertaining lines and the attempt of creation of ecological oases.

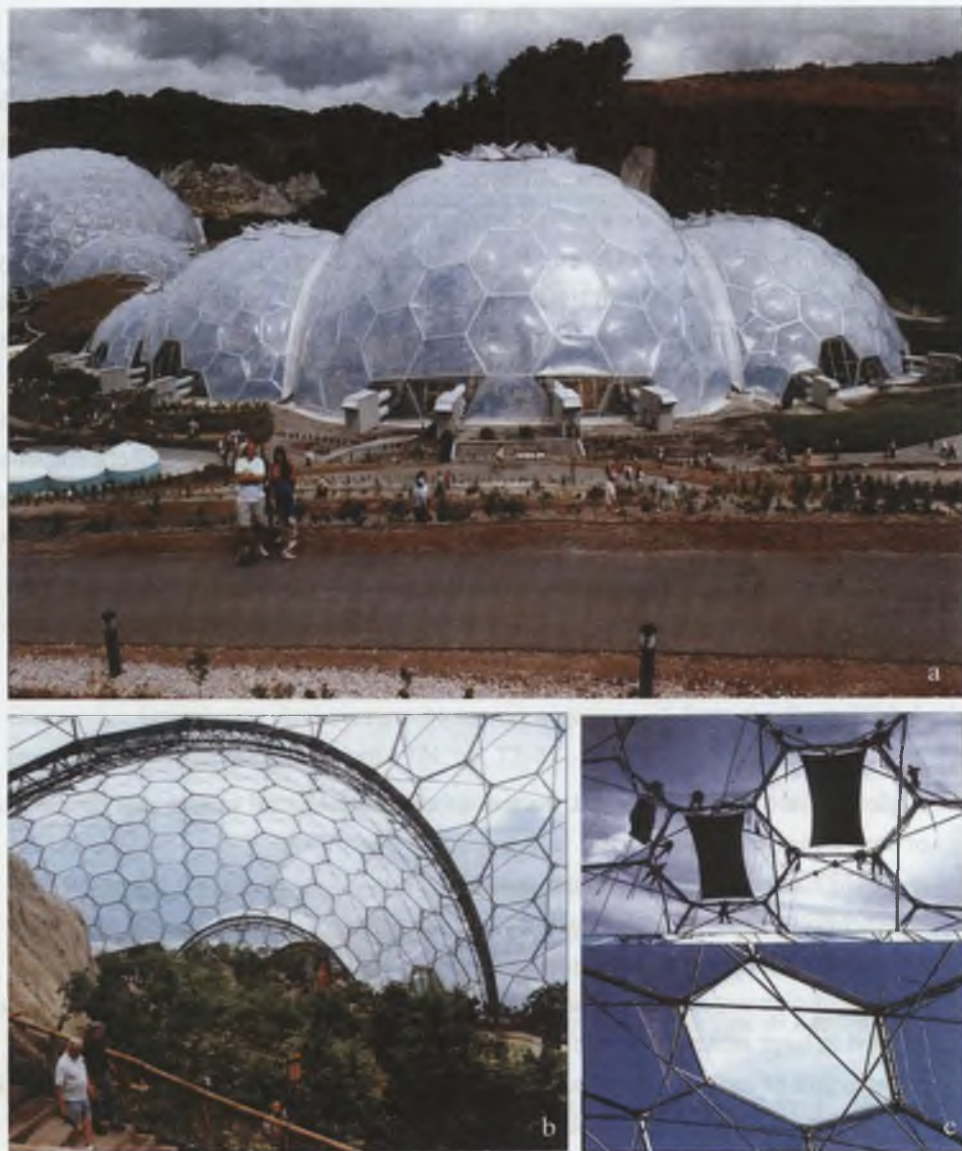
On the basis of above said it is obviously, that in the searches of working out this problems architects speak to architectural experience, which selected the basic types of spatial decisions, which strike by their actuality. A fundamental type is a hothouse and derivatives from it opened spaces outside as exhibition pavilions, winter gardens; the „closed spaces” are such as hotels, stations, libraries, museums of the XIX century of architecture of the so-called „victorian epoch”; „judicial spaces” as arcades, covered markets of the past century. These types exist in our days too. Insoway, museums (museum – the typological innovation of the XIX century) and libraries (such, as libraries of architect A. Labrust, and inheritance to them) were built with a skylight through a glass roof. This reception was forgotten afterwards. Today K. Rosh and G. Dinckelov offer such solution in the annex to underground





Pic. 6. Atrium architecture of large interior spaces of point-of-sale arcades and internal yards in Europe and Asia (a–d), entrance halls and oasis of public objects is an university in Russia and the center of rest with a pool at Hong Kong (e–f)

Fot. 6. Architektura atrium – dużych wewnętrznych przestrzeni galerii handlowych i wewnętrznych dziedzińców w Europie i Azji (a–d), hole wejściowe i oaze obiektów publicznych mają uczelnie w Rosji i centra rekreacyjne z basenem w Hongkongu (e–f)



Pic. 7. Winter garden – climatethrone, near the city of Cornvel in England, (2001 year). It is the place of crater of the pit of mining of caolin by the opened method (after materials of „Świat aluminium”, nr 2/24 (2002), s. 60–63; General vision (a); A transparent dome has a length, width and height according:  $240 \times 110 \times 55$  m. Metallic framework is filled special light transparent, easy and elastic plastic. In some cellular areas the elements of sun protection and ventilation are foreseen (b, c)

Fot. 7. Ogród zimowy – klimatron, w pobliżu miasta Cornvel w Anglii (2001 rok). Jest to miejsce zagłębienia po kopalni odkrywkowej kaolinu (na podstawie „Świat aluminium”, nr 2/24 (2002), s. 60–63; widok ogólny (a); przezroczyste kopuły mają wymiary:  $240 \times 110 \times 55$  m. Metalowa struktura nośna jest wypełniona specjalnym przepuszczającym światło, dogodnym i elastycznym tworzywem sztucznym. W niektórych panelach są przewidziane elementy ochrony przeciwsłonecznej i wentylacja (b, c)



Passage of Museum in New York (1973–1973), E.M. Pey – in the East corps of the national gallery in Washington (in 1978). In building of libraries of 1970's a tendency of returning to the decisions of the XIX century is observed. So the library hall of the college in Uelsli (the USA, architects Perri, Dick, Steel and Rodghers) was created with application of glass hothouse roof. Presently the railway stations are not built with landing-stages with a glass roof. However, all they are used frequently for building of air terminals (an air terminal in Western Berlin architects are Gerkan, Kargo, Nikhel's, in 1975). At the same time lately in the XIX century the new unknown types of houses appear from the point of application of a glassroof. So, for example, child's hospital in Philadelphia (architects Kharbeson, Khyu, Livingstoun, Larsen, Amenta) is built with the large opened glass yard.

For the last years multifunction complexes, are characterized where the hothouse principle is used at the same way. An acquaintance with modern buildings allows to select point-of-sale arcades and internal yards; entrance halls of public objects, oases of entertaining centers, aquaparks and health complexes (pic. 6, a–e). The prototype of large interior spaces with bright transparent coverings are framework constructions covered tapes by the type of „climatethrones”.

## 5. Conclusions

1. A global rise in temperature and changes of climate cause the necessity of development of architecture into directions:
  - a. – architecture of houses on water,
  - b. – architecture of sun, ecological houses,
  - c. – atrium architecture of large interior spaces.
2. Architecture on water does not have attachment to the concrete place of building and can be used in large settlements and for the necessities of ecological refugees.
3. Architecture of sun, ecological houses develops in the direction of energy noninteraction and zero and positive energy balance.
4. Atrium architecture of large interior spaces has tendencies to planning of closed, open and judicial space which execute the function of defence of people from discomfort naturall climatic changes.

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