Vol. 10, No 1/2021, 135-144

DOI: 10.17512/bozpe.2021.1.14

Construction of optimized energy potential
Budownictwo o zoptymalizowanym potencjale energetycznym

ISSN 2299-8535 e-ISSN 2544-963X

New generation of fencing structures – dynamic / adaptive facades. Prospects of the use in Russia

Alexander Spiridonov[1] (*orcid id: 0000-0003-1097-1604*)
Igor Shubin[1] (*orcid id: 0000-0001-9178-8646*)
Roman Gerashchenko[1] (*orcid id: 0000-0001-7301-2959*)
[1] Research Institute for Building Physics under Russian Academy of Architecture and Construction Science

Abstract: Based on a review and analyses of new technology and solutions in modern facade structures, a classification of a new generation of facades has been carried out. There are five main classes of facade: "Bioclimatic" (or "green"); "Energy"; "Light concentrators"; "Scenic" (or "architectural"); and "Dynamic" (or "adaptive"). Their distinctive features are given in the article. The most common examples of facades from various classes are considered. An assessment was made on the prospects for using the new generation facades in Russia.

Keywords: bioclimatic facades, energy facades, light concentrators, stage facades, dynamic facades, energy saving, microclimate parameters

Please, quote this article as follows:

Spiridonov A., Shubin I., Gerashchenko R., New generation of fencing structures – dynamic / adaptive facades. Prospects for the use in Russia, BoZPE, Vol. 10, No 1/2021, 135-144, DOI: 10.17512/bozpe.2021.1.14

Introduction

Windows are often called "the eyes of houses", and the facades of buildings can be defined as "the face of the city". Unfortunately, since the 1960s – an era characterised by the mass construction of houses (Khrushchevka) – the Soviet people have had to put up with being surrounded by mostly gray, identical panel buildings. Frankly, even today – despite some exceptions – the Russian urban landscape is rather monotonous and dull. Psychologist argue that these gray and ultimately uninteresting buildings have a negative effect on the population – depriving them of initiative and hope.

Of course, the main function of the facades (external walling and envelopes) of buildings is protection from adverse climatic conditions. And the overwhelming majority of the fences used in our country perform this function.

However, the explosive development of building and related technologies has led to the emergence of a very large number of new facade solutions that were not previously available. Modern architects use facades for the creative display of rhythm, balance, proportion and experiments. It has become easier for them to ensure a balance between technology and aesthetics in their projects. Of course, it is necessary to take into account the engineering role of the facade (thermal protection and energy saving, natural lighting, ventilation, and sound insulation), but sometimes, following a beautiful design, this can be forgotten.

Due to the huge variety of already existing facade projects in many countries, we decided to introduce a classification of them, based on the main function embedded in the solution (as a rule, there are several such identified functions).

Below are the five main classes of modern non-traditional facades:

1. "Bioclimatic" (or "green") facades, in which the main idea is to protect the environment (use of plants (http://www.earthtimes.org), protection of buildings from smog (https://www.archilovers.com), biogas production (http://www.morethangreen.es), rainwater use (https://khyatirajani.wordpress.com), etc.);
2. "Energy" facades, in which the main function is to collect additional energy to ensure the operation of the building (photovoltaic panels of various modifications (https://inhabitat.com; http://architime.ru/specarch/top_10_smart_house/smart_houses.htm; https://ru.wikipedia.org; https://museudoamanha.org; http://materiability.com; https://aasarchitecture.com), the use of wind generators (https://inhabitat.com; http://architime.ru/specarch/top_10_smart_house/smart_houses.htm), the use of passive geothermal installations (https://aasarchitecture.com) and much more);
3. Facades, which we called "light concentrators or hubs", where the main function is the maximum and rational use of day lighting thanks to various modern and innovative technical solutions (http://architime.ru/specarch/top_10_shopping_center/shopping_center.htm; https://archi.ru/projects/world/660/nacionalnaya-biblioteka-chekhii; https://varlamov.ru/379642.html; https://novate.ru/blogs/240911/18848/; https://nosviatores.com/institut-arabskogo-mira-institut-du-monde-arabe/; https://www.sahmri.org/);
4. "Scenic" (or "architectural") facades that are more intended to revitalize the urban environment through various optical or other solutions (http://www.crous-toulouse.fr/logement/olympe-de-gouges/; https://architime.ru/specarch/charles_sowers_studios/windswept_installation.htm; http://charlessowers.com/wave-wall; http://architime.ru/specarch/rob_ley/eskenazi_hospital.htm; https://iart.ch/en/-/die-kinetische-fassade-des-megafaces-pavillons-olympische; http://www.architime.ru/specarch/urban_art_projects_studio/brisbane_airport_parking.htm);
5. "Dynamic" (or "adaptive") facades, in which, by changing the appearance of the facade, the issues of microclimate regulation in the building's premises are resolved (light conditions, local or general air conditioning and natural ventila-

tion, many other tasks) (https://aasarchitecture.com; https://arttravelblog.ru/dostoprimechatelnosti/bashni-bliznecy-al-baxar-v-abu-dabi-oae.html; https://www.archdaily.com/335620/rmit-design-hub-sean-godsell; https://www.masterstudies.ru; https://www.pinterest.ru; https://www.archdaily.com/89270/kiefer-technic-showroom-ernst-giselbrecht-partner; https://www.archdaily.com/256766/flashback-signal-box-herzog-de-meuron; http://architime.ru/specarch/paul_rudolph/intiland_tower.htm; http://architime.ru/specarch/henning_larsen_architects/sdu_campus_kolding.htm; https://architime.ru/specarch/white_void/flare.htm).

In this article we will give one or two examples of buildings, the facades of which we attributed to classes 1-4, and we will focus in more detail on “dynamic” facades.

1. Bioclimatic facades

The most impressive to the passer-by is a vertical garden, made in accordance with the scheme developed by Patrick Blanc (https://www.verticalgardenpatrickblanc.com/). The garden consists of 3 main parts – a metal frame, PVC sheet with a thickness of 1 cm and a layer of artificial rot/felt using polyamide.
The frame with the PVC mounted is installed on the wall with some medium, which provides additional heat and sound insulation for the premises. Artificial felt is fastened to the PVC. Its high capillarity ensures an even distribution of water. Plants are planted on this felt layer in the form of seeds, cuttings or pre-grown bushes – about thirty plants per square meter. Surface watering and fertilizing is automated. The weight of a vertical garden, including the plants and metal frame, is less than 30 kg per square meter. Thus, the vertical garden can be implemented on any wall, without restrictions on the size or height.

Of course, such an exotic example (Fig. 1) is unlikely to be widely used due to our climatic conditions, exceptions would be the Crimea and the Krasnodar Region. But in the southern regions of Europe such buildings are appearing more and more.

Fig. 1. Vertical garden (Spain, Madrid) (http://www.earthtimes.org)

A much more interesting solution for Russian megalopolises, characterized by high air pollution, is a special facade that absorbs a significant amount of harmful impurities in the air (https://www.archilovers.com).

Prosolve370e panels, designed by the German company Elegant Embellishments, and based on the Alcoa technology created in 2011, were mounted on the building of the Torre de Especialidades Hospital (Mexico City) (Fig. 2). The material contains titanium dioxide, which effectively purifies the air from toxins and other harmful substances.

Fig. 2. Hospital building Torre de Especialidades (Mexico City) (https://www.archilovers.com)

2. Energy facades

Buildings with such facades are becoming more common with the further development of technology and increased efficiency of photovoltaic modules. Though this a topic that should probably be reviewed in a separate article, we will give one (perhaps, somewhat shocking) example – the Kunsthaus Museum of Contemporary Art (Fig. 3) in the city of Graz (Austria) (https://ru.wikipedia.org).

Fig. 3. Kunsthaus Museum of Contemporary Art (Graz, Austria) (https://ru.wikipedia.org)

The foundation of the building is a reinforced concrete structure, and the outer shell is made of acrylic panels with built-in photovoltaic elements, which allow the production of enough energy to operate the museum. Of course, a strange sight to see in the center of the old city, many tourists and, more importantly, residents seem to like the building.

3. Light hubs (concentrators)

After a break in the late 1980s and 1990s, buildings began to appear in which the architects attempted to take advantage of natural light. This was due to both the energy saved by utilizing natural light and the positive effect on the person. Among the many examples of buildings, the authors have chosen to present the newly built Art Museum of Ordos (Fig. 4) (https://novate.ru/blogs/240911/18848/).

The surface of the building consists of polished and curving metal louver panels that help the Ordos Museum to resist the harsh desert climate and frequent sandstorms. The natural light penetrates through the glass roof and spreads through the building using reflective walls, and the blinds provide natural ventilation.

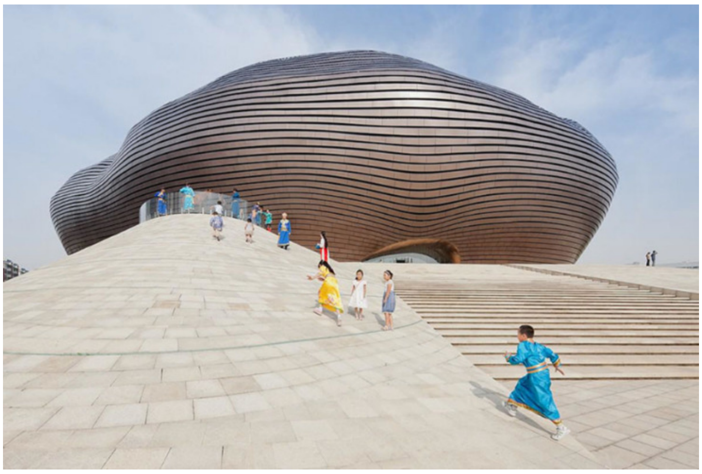

Fig. 4. Art Museum of Ordos (China) (https://novate.ru/blogs/240911/18848/)

4. "Stage" ("architectural") facades

Such facades are used for various reasons; to diversify the urban environment, to report information, and, in the opinion of the authors, just as a "tongue in cheek" design. It is also used in fairly unexciting urban spaces. For example, the authors have chosen the building of Eskenazi Hospital (Indianapolis, USA) (http://archi time.ru/specarch/rob_ley/eskenazi_hospital.htm).

An original approach based on an optical effect was used in this building: the illusion that the façade is moving (when in fact it is fixed) is created as pedestrians and cars pass by the building. To achieve the desired effect, panels of different sizes were used, each set at a certain angle. The selected color scheme was fairly simple: one side of the panels was painted in golden yellow, and the other in dark blue. But thanks to the angles of inclination of the surfaces and the reflection of light, an illusion of various shades is created, which makes the spectrum of colors much more diverse (Fig. 5).

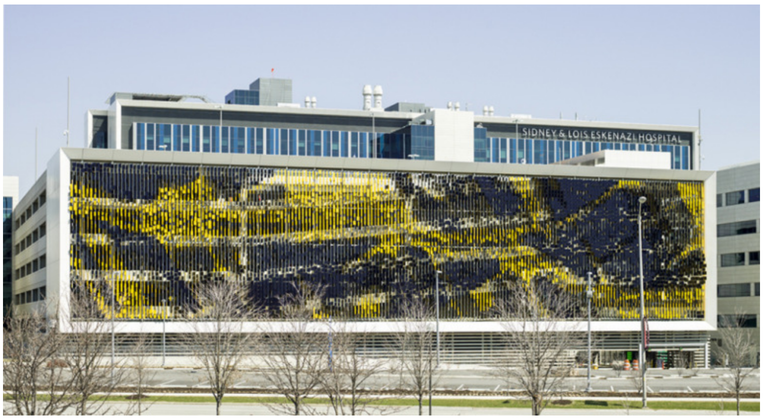

Fig. 5. The Building of Eskenazi Hospital (Indianapolis, USA) (http://architime.ru/specarch/rob_ley/eskenazi_hospital.htm)

5. “Dynamic” (“adaptive”) facades

The authors would like to now focus more on this façade type, since it shows the greatest need and possibility in the near future to move from the ideology of “protecting the premises from environmental exposure” to the ideology of “using indoor environment”. Fortunately, there is a vast wealth of projects and structures available to choose from. Some of which are listed below.

“The Gate Residence” project (https://aasarchitecture.com) (Egypt) shows the utilization of a lot of new products. In particular, “wind catchers”, vertically positioned devices that distribute airflow in the desired direction; passive geothermal installations for cooling and/or heating the building; innovative solar photovoltaic cells that can convert solar radiation into electricity (these are installed in place of ordinary glass); water-heating glass-metal pipes powered by solar energy; vertical wind turbines; vertical gardens. All of which looks very impressive (Fig. 6).

Built in 2014, the SDU Campus Kolding building (Kolding, Denmark) (http://architime.ru/specarch/henning_larsen_architects/sdu_campus_kolding.htm) is one of the most prominent examples of dynamic facades (Fig. 7).

Around 1600 triangular perforated steel blinds are installed on the facade, in order to regulate the flow of natural light into the premises, depending on its intensity. The entire system is equipped with sensors that continuously measure the ambient light and temperatures in the rooms and control the blinds with the help of small motors. When the shutters are closed, they lie flush along the facade.

In the half-open state, they break the plane of the wall, giving the building additional expressiveness. Thus, the Kolding campus building is equipped with a sun protection system that adapts to specific climatic conditions.

Fig. 6. “The Gate Residence” Project (https://aasarchitecture.com) (Egypt)

Fig. 7. SDU Campus Kolding building (Kolding, Denmark)
(http://architime.ru/specarch/henning_larsen_architects/sdu_campus_kolding.htm)

The Kiefer Technic exhibition hall is located in Steiermark (Austria) (https://www.archdaily.com/89270/kiefer-technic-showroom-ernst-giselbrecht-partner) (Fig. 8).

The dynamic facade is operated using electronic controls inside the building, which can individually control each of the 54 motors powering the facade. This is a simple system that does not include any type of regulation based on the sensor readings of climatic conditions, but responds only to input data from people in the building. The facade itself functions as a shading device, but also gives users the ability to control the angle of the panel and the amount of light transmitted into the interior.

Fig. 8. The Kiefer Technic Building (Steiermark, Austria)
(https://www.archdaily.com/89270/kiefer-technic-showroom-ernst-giselbrecht-partner)

During the design and construction of the Al Bahr Towers in the UAE (https://arttravelblog.ru/dostoprimechatelnosti/bashni-bliznecy-al-baxar-v-abu-dabi-oae.html) (Fig. 9), the goal was set to create, regardless of the extreme heat conditions, a comfortable indoor microclimate without the consumption of large amounts of power.

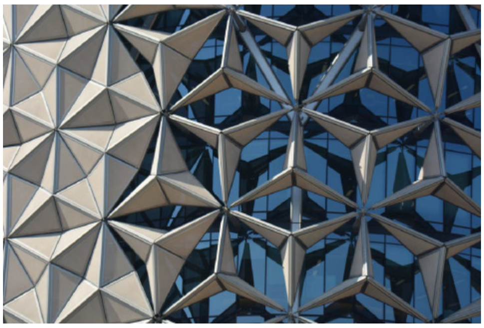

Fig. 9. Fragment of the facade of the Al Bahr Tower in the UAE
(https://arttravelblog.ru/dostoprimechatelnosti/bashni-bliznecy-al-baxar-v-abu-dabi-oae.html)

As a solution, moving gratings were created. The kinetic elements are designed in such a way that they change their position depending on the time of day and the movement of the sun. This grid construction creates the effect of a double shell that envelops the building. The gigantic shielding facade consists of more than 1000 mobile elements and mirrors exactly the facade of the Jean Nouvel Institute of Arabic Culture (https://nosviatores.com/institut-arabskogo-mira-institut-du-monde-arabe/).

Strings of movable panels regulate the climate of office premises, and, at the same time, form geometric shapes that give the building additional artistic expression. As a prototype of the design, traditional Arabic Mashrabiya openwork lattices were used, letting in the light but not allowing the air to get too hot inside the room. The facades of the RMIT design school building (Melbourne, Australia) (https://www.archdaily.com/335620/rmit-design-hub-sean-godsell) are made of thousands of small sandblasted glass circles, each of which is attached to the central bar (Fig. 10). Depending on the humidity and temperature inside the building, these rods automatically rotate to facilitate (or block) the flow of air through the facade.

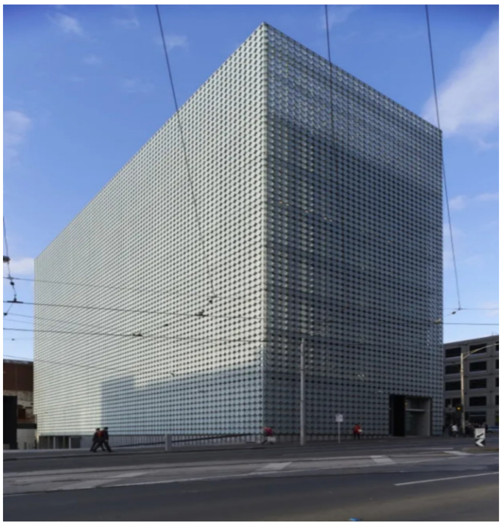

Fig. 10. The RMIT Design School Building (Melbourne, Australia) (https://www.archdaily.com/335620/rmit-design-hub-sean-godsell)

Currently, there are a lot of new technical solutions for building envelopes being developed, which in the coming years, will be put to use "on facades": the kinetic membrane "FLARE" (http://architime.ru/specarch/paul_rudolph/intiland_tower.htm), thermo-bimetallic louvered grilles (https://www.masterstudies.ru), the Saber membrane, which works as an air conditioner with zero energy consumption (https://www.pinterest.ru), and many more. In fact, when it comes to traditionally conservative construction, we live in an era when not only the appearance of buildings is changing dramatically, but also the ideological approaches to their operation and the maintenance of their indoor climatic parameters.

Conclusions

Of course, the cost of such facades is higher (sometimes significantly more so) than standard facades. And some will never pay themselves off by the energy savings and other innovations incorporated in their design (the authors of "stage" facades did not set themselves such a goal). Their main function is the creation of a comfortable and interesting environment and the full-scale testing of technological innovations.

In Russia, the appearance of new buildings (even typical buildings) is also changing for the better, but, unfortunately, it is based – for the most part – on already long thought out and repeatedly worked out solutions at home and abroad. There is a lack of highly skilled architects, engineers, and designers working in

Russia. Visually, you can notice many new buildings but there are practically no "pioneering" technological solutions.

This is connected, in the authors' opinion, with the notion that sits in the back of all our minds – "the payback period of capital expenditures". For most of the examples above, this is far longer than the expectations of the investors. Consequently, the authors are very sceptical about whether truly breakthrough technologies in construction and a new generation of facades is really a possibility in Russia.

Of course, there are new ideas always being developed among the Russian scientific community, however, so far, few have reach practical implementation.

This is a situation in which the authors sincerely hope will change in the future.

Bibliography

http://www.earthtimes.org
https://www.archilovers.com
http://www.morethangreen.es
https://khyatirajani.wordpress.com
https://inhabitat.com
http://architime.ru/specarch/top_10_smart_house/smart_houses.htm
https://ru.wikipedia.org
https://museudoamanha.org
http://materiability.com
https://aasarchitecture.com
http://architime.ru/specarch/top_10_shopping_center/shopping_center.htm
https://archi.ru/projects/world/660/nacionalnaya-biblioteka-chekhii
https://varlamov.ru/379642.html
https://novate.ru/blogs/240911/18848/
https://nosviatores.com/institut-arabskogo-mira-institut-du-monde-arabe/
https://www.sahmri.org/
http://www.crous-toulouse.fr/logement/olympe-de-gouges/
https://architime.ru/specarch/charles_sowers_studios/windswept_installation.htm
http://charlessowers.com/wave-wall
http://architime.ru/specarch/rob_ley/eskenazi_hospital.htm
https://iart.ch/en/-/die-kinetische-fassade-des-megafaces-pavillons-olympische
http://www.architime.ru/specarch/urban_art_projects_studio/brisbane_airport_parking.htm
https://arttravelblog.ru/dostoprimechatelnosti/bashni-bliznecy-al-baxar-v-abu-dabi-oae.html
https://www.archdaily.com/335620/rmit-design-hub-sean-godsell
https://www.masterstudies.ru
https://www.pinterest.ru
https://www.archdaily.com/89270/kiefer-technic-showroom-ernst-giselbrecht-partner
https://www.archdaily.com/256766/flashback-signal-box-herzog-de-meuron
http://architime.ru/specarch/paul_rudolph/intiland_tower.htm
http://architime.ru/specarch/henning_larsen_architects/sdu_campus_kolding.htm
https://architime.ru/specarch/white_void/flare.htm
https://www.verticalgardenpatrickblanc.com/