Architecture of the University campus in terms of maximum energy efficiency

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Abstract. This article presents an analysis and overview of the main energy-efficient methods in the aspect of the campus planning structure in order to preserve the maximum comfort of students in various weather periods, as well as technologies for adapting campus buildings. The purpose of the work is to determine suitable methods for applying energy-efficient technologies in Siberia, and to present possible proposals for using these technologies in relation to the architectonic appearance of University campuses in Irkutsk.

Speaking about energy efficiency in terms of space-planning solutions and the architectural appearance of the campus, it should be noted that in regions with climate conditions with sharp temperature changes, in particular, and negative in general, it remains particularly acute, because finding a balance and universal solutions for these territories is still relevant. There are many positive examples and non-trivial solutions to this problem. However, in order to proceed to concrete examples, it is necessary to note the main difficulties and obstacles dictated by certain aspects of the climate area.

To include the aspect of temperature changes inside the main campus building and, accordingly, the outdoor space, which entails a number of related problems, from the smaller - the presence of the wardrobe for students and staff of the University, the existence of a double vestibule and larger - the inability to access the campus because of extremely uncomfortable high or low temperatures, as for access to the building must interact with the street. The above problems are elegantly solved by many campus planning structures. The first is the University of Waterloo [12] in Waterloo, Canada, where all the buildings on the campus permeate the transitions between buildings and exclude contact with the adverse environment to a minimum (figure 1). This example demonstrates the persistent pedestrian connectivity of the structure of the entire University and the interpenetrating layout, which again allows students to effectively move and communicate with various specialties and directions. The second is Qasim University [7], al-Qasim province, Saudi Arabia, where we observe the same principle, but under different climatic conditions and with a different centric layout from the previous example, in the core of which is the main building of the campus, with a large covered space inside and from it there are pedestrian crossings to other buildings-dormitories, laboratories, academic buildings (figure 2). From the point of view of compositional construction of space, the main guidelines and clear structure are clearly distinguished, which again increases the efficiency of navigation and sense of space. The third
example is the University of southern Denmark [10], which is dotted with transitions between buildings and sets a fairly solid structure, with all buildings of medium and low storeys (figure 3).

One of the minor problems was the entrance to the educational institution, which should be equipped with a vestibule - an air layer to preserve heat. So in the Harbin Institute of architecture in the entrance group is a number of dense vertical fabric canopies like curtains. This is one of the ways to adapt a building to harsh climatic conditions, if it was not designed with these in mind.

**Figure 1.** University of Waterloo, Canada [5]. The author analytics is N Krivchikov, 2020

**Figure 2.** Qasim campus structure, Saudi Arabia [5, 7]. The author analytics is N Krivchikov, 2020

Next, we can observe planning solutions that meet the challenges of wind loads and create a cascade for shelter. These include the University of Toronto Scarborough [11] and Novosibirsk State University [6]. In the first case, we observe a continuous main building that wraps around the forest and creates the same barrier against the wind (figure 4). Considering the building of the NSU, it is impossible not to note the isolation of the main building, where again the fact of wind protection of the internal space can be traced (figure 5). Thus, we can say that this type of location of the main building can create comfortable conditions of arrival both inside, due to the length or closed system, and outside, because even in winter, the recreational space remains protected from the wind.

The energy efficiency of campuses directly depends on the amount of energy that consumes and saves the entire ensemble of the campus, so it is important to use the most effective technologies for energy conservation and energy reproduction. These include the University of Queensland [9],

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Queensland, Australia. On its territory there are arrays of solar panels that perform not only the function of generating electricity, but also protection from precipitation, the scorching sun. (Figure 6) these panels do not look foreign and are rather a business card of an advanced University.

Figure 3. University of southern Denmark campus, Denmark [5]. The author analytics is N. Krivchikov, 2020

Figure 4. Analysis of the University of Toronto Scarborough campus, USA [5]. The author analytics is N. Krivchikov, 2020

Also, the use of solar panels can be observed on the territory of Stanford University, although there the panels were not integrated into civil buildings, but the array of panels located on the roof of a multi-level parking lot produces a fairly large amount of energy in relation to the California climate. This again indicates the interest of the world's leading universities in alternative energy sources and the prospects of this technology in terms of introducing students to such technologies. In addition to the roof of the Parking lot we can notice solar panels directly on the energy complex.

In addition, at the University of southern Denmark, one of the institutes was built using adaptive facade technology [4], in which the elements had a degree of freedom sufficient to change their position depending on weather conditions, thereby saving energy for cooling and heating the room. Having sensors and lights that analyze the current state of the environment allows the facade elements to change their position offline, and even if the panel is closed, the perforation on it helps natural insolation and
ventilation. The elements themselves are determined by the basic shape of the building and the interiors echo this idea. Also on the roof we can note the presence of solar panels, which again emphasizes the environmental friendliness of the building (figure 7).

Figure 5. Novosibirsk State University, Russia [5, 6]. The author analytics is N Krivchikov, 2020

Figure 6. University of Queensland, Australia [5, 9]. The author analytics is N Krivchikov, 2020

The complex of the biomedical laboratory complex in the center of Phoenix, Arizona, USA (figure 8) is also a striking example of the use of the facade [2]. The building's cladding consists of about 5,000 recycled copper panels, which emphasize the distinctive identity of the area and protect the interior from direct sunlight [8]. The layered system of facade panels consists of rigid insulation, five centimeters of air space and a waterproofing membrane. The integrative system allows light to penetrate into interior spaces and creates a unique architectural appearance of the building, which resembles a canyon in its shape. The design used sustainable features - led lighting and chilled beams in offices and laboratories. The building is a recipient of the LEED Silver certificate from the green building council of the United States.

The Aga Khan University [1], Pakistan (figure 9), is also an example of advanced technologies of the topic under consideration. Here we can observe a symbiosis of the above techniques, including elegant facades and transitions between buildings. The architectonic appearance of the University creates a huge number of shadow spaces that hide visitors. Natural materials create a natural and environmentally oriented environment [13].
In the winter of 2018, calculations were made in the framework of the competition “vanguard of science” among 1-2 courses, pedestrian activity on the campus of the Irkutsk national research technical University, the most active pedestrian routes were determined (figure 10).

Figure 7. University of southern Denmark, Kolding [10]

Figure 8. Phoenix biomedical campus, USA [2]

Figure 9. Aga Khan University, Pakistan [1]
In this regard, you can consider the option of comfortable organization of flows of students and employees from public stops, parks and dormitories of the University in the winter, suggesting transitions between buildings, following the example of the University of Waterloo. This will help to eliminate contact with an unfavorable environment to a minimum, and will allow you to organize a stable pedestrian connection of the structure of the entire University and the development of communication links between students and teachers of various specialties and directions.

Figure 10. The intensity of pedestrian traffic on the IRNITU campus, Russia for November-December 2018, was calculated by students of the ARB-18-2 group A Vlasova and V Belova. Supervisor and author of the drawing art.: lecturer Z F Nizamutdinova [3]
The conclusion is that advanced Universities interested in the development of their territories are implementing the most energy-efficient technologies, both in terms of the purely planning structure of the entire campus, and, in particular, space-planning solutions for individual buildings. This shows that architects are more conscious of their approach to the planning of future campuses and emphasizes that the environmental adaptation of buildings is a higher priority. Taking into account the disadvantages and advantages of using these technologies, it is proposed to develop a methodology for applying energy-efficient directions on the territory of Irkutsk University campuses.

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