Application of LEED green rating systems in infrastructure of airport complexes

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Abstract. The main trends in the development of airport complexes in the international transport system include growing eco-movement and measures to reduce harmful emissions and greening their infrastructure. There are modern green rating systems for certification of green buildings and constructive objects, which equally impose requirements on the transport system. Along with them, there is an Airport Carbon Accreditation Program focused only on airport complexes. It contains 6 levels and aims to minimize the negative impact of airport complexes, reducing the carbon footprint. This factor, according to scientists, is the root cause of global climate change. In addition to reducing emissions, measures are being taken to switch to renewable energy sources. This is very important because the energy and water consumption of this infrastructure is high.

1 Introduction

This study analyzes the use of green technologies for transport infrastructure, in particular for the airport complex. The main purpose of this study is to study modern green rating systems of transport infrastructure and the effects that this has brought to the examples of modern airports.

Residential and industrial buildings built in accordance with the standards of green construction provide a comfortable and safe human life and reduce the negative impact on the environment through the use of renewable energy sources [1-4]. In addition to the structures themselves, the modern green rating systems also include the greening of transport infrastructure. After all, only by approaching the problem of the carbon footprint comprehensively, its solution is possible [5, 6].

Aviation mode of transport is advanced, its main advantage is speed. To date, the delivery of cargo or passengers on modern comfortable airliners even to the most remote point in the world takes about a day. However, the possibility of saving time has a downside, a negative
Harmful emissions from the activities of airports account for about 2% of carbon dioxide, but this figure is finite and with an actively growing passenger traffic in the next 10-15 years, it may double\[7\]. In addition, the airport infrastructure has a large energy and water consumption, equal to the needs of tens of thousands of households, while leaving a large amount of garbage. Despite all of the above negative influences, aviation communication has long been a part of work and life, and it is impossible to refuse such convenience. In this regard, more and more attention has recently been paid to monitoring, reducing the harmful impact of airports on the environment and restoring the natural balance of the territory.

Green rating of buildings and structures for compliance with environmental friendliness and energy efficiency is carried out according to the well-known standards, such as BREEAM (England), LEED (USA), DGNB (Germany)\[8\]. They are also applicable to the design of airport terminals. In 2009, the Airports Council International (ACI) adopted the Airport Carbon Accreditation Program, aimed at protecting the environment by reducing the negative impact of airports and leading to zero carbon dioxide emissions\[9\]. At the moment, this is the only program that focuses on the greening of airports. It is a structure consisting of six stages of transition to the neutral impact of airports on the natural environment:

1. Mapping — measurement of the carbon footprint;
2. Reduction — improvement of infrastructure and reduction of negative impact;
3. Optimisation — measurement of uncontrolled emissions and taking measures to reduce them;
4. Neutrality — “compensation” for the remaining carbon dioxide emissions that could not be reduced at the first stages, that is, to provide funds to projects that are focused on reducing carbon dioxide emissions;
5. Transformation — drawing up a long-term strategy for managing and minimizing harmful emissions;
6. Transition — fulfillment of all accreditation requirements, compensation of residual carbon emissions due to internationally recognized compensations.

In 2015, the Member States of the United Nations Council of the United Nations adopted 17 Global Goals (SDGs) until 2030, aimed at improving the quality of life in economic, social and environmental parameters. These goals do not relate directly to airports, but create a context within which further strategies are formed to improve the environmental situation, including for transport infrastructure. Also in 2015, the Paris Agreement on the Prevention of Climate Change by Reducing Carbon Emissions was adopted. And in 2016, the international system of compensation and reduction of carbon emissions (CORSA) was adopted, which determines the procedure and possibilities of compensation for the negative impact of airports on the environment. Thus, all this marked the first steps towards a low-carbon world.

2 Methods

The study used a review-analytical method of investigating the problem.
the airport infrastructure bears a greater negative "load" on the environment than the operation of aircraft.

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Figure 1. The influence of the functional elements of the airport on the biosphere.

In 2006, Boston Logan Terminal A became the first airport terminal in the world to receive a LEED certificate. The airport is equipped with 20 wind turbines that compensate for about 3% of the building's energy needs. A heat-reflecting roof is also installed, water pipes with low water consumption, and the runway is made of environmentally friendly asphalt. All these design features allow you to reduce operating costs. Thus, more than 75% of the waste from the demolition of the former terminal and the construction of a new one was reused or recycled. More than 10% of construction materials were produced from recycled materials. Also, during the construction, measures were taken to reduce indoor air pollution.

In 2019, solar energy systems including 15,000 solar panels were installed in Terminal 2 at Dubai's largest airport. This project is part of Shams Dubai, a system for connecting alternative energy to buildings in the Emirate. Energy saving is carried out due to the generation of 7,483,500 kWh of energy by these panels. The number of carbon dioxide emissions also decreased by 3243 metric tons.
A waterfall has been made in the green garden of the airport, which is not only a design solution, but also performs a practical function. Pumping rainwater, the stream cools the air under the dome of the building, and the collected water goes to the needs of the airport. Equipment with skylights for natural lighting reduces the need for electric lighting during the day. Also, there is a large number of green spaces, gardens and vertical garden - a green wall with a height of 15 m at the airport.

3 Results and Discussion

There are several airports in North America that were certified in the LEED program. These include San Francisco International Airport, Chicago O'Hare International Airport, Port Authority of New York and New Jersey, Los Angeles Airport and Columbus International Airport. San Diego International Airport was the first in the world to be certified LEED Platinum for its high level of energy efficiency and environmental frequency of the project. The LEED system is not applicable to the entire airline complex, but only to some of its buildings, however, this does not reduce its significance for projects, and the examples given earlier confirmed that the reduction of the carbon footprint is significant.

Figure 2 shows the level of certification of these airports and their facilities. So, 29% of the structures are at the initial level, they are only registered. 14% of airports received a low-level certificate, 31% a silver-level certificate, 23% a gold-level certificate, and the smallest share falls on a platinum-level certification - 3% of airports.

![LEED certification of the world's airport complexes](image)

**Figure 2.** LEED certification of the world's airport complexes.
4 Conclusions

In conclusion, it is worth adding that progressive airports are characterized by development as a system comparable to the city. Therefore, it becomes important to implement the same principles of sustainable development that we strive for the cities. Various methods are used to significantly reduce harmful emissions into the environment and reduce the cost of operating the airport. Special materials are being developed: low-carbon concrete, wood, biofuels.

During the construction of the Indira Gandhi International Airport in India, secondary raw materials were used to a greater extent. The introduction of solar panels is carried out by many airports around the world, for example, Denver Airport has a total solar generation capacity of about 10 megawatts, Helsinki, YVR, etc. Transport for movement on the platform and for communication with the city is changing to electric cars or running on biofuels. At the airport in the Galapagos Islands, electricity generation is fully covered by the use of windmills and photovoltaic panels. Reducing the carbon footprint is possible only with an integrated approach to the problem: from the use of renewable energy sources to breeding bees near the airport. Air hubs manage to reduce the level of controlled CO2 emissions by 20-40%. For instance, at the Brussels airport they were reduced by 34%, and in Oslo by 35%. Compensations for residual emissions are also applied.

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