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WIND TECHNOLOGIEST IN BUILDING CONSTRUCTION – PROBLEMS AND SOLUTIONS

TECHNOLOGIE WIATROWE W BUDOWNICTWIE – PROBLEMY I ROZWIĄZANIA

Abstract

The energy efficiency of a building has become a superior objective in the processes of design and construction. Rapid development of the wind power industry and the related technologies enables us to use wind systems in modern construction projects. The innovative nature of these solutions however, give rise to various cumbersome issues. They are mostly related to the structure of the building, its influence on the natural environment and interactions between the structure and the wind system on the use of the building. The solution often depends on interdisciplinary cooperation, which begins at the stage of design and construction of the wind turbines. This cooperation is also essential during the selection of wind power devices, designing the building and the construction process itself. As a result, increasingly efficient wind systems are implemented.

Keywords: renewable energy sources, wind turbines, energy-saving buildings

Streszczenie

Energooszczędność obiektu budowlanego staje się dziś nadrzędnym celem w procesie projektowania i wykonawstwa. Gwałtowny rozwój energetyki wiatrowej i związanych z nią technologii umożliwia zastosowanie systemów wiatrowych we współczesnym budownictwie. Innowacyjność tych rozwiązań pociąga jednak za sobą wiele problematycznych kwestii. Najczęściej związanych z konstrukcją budynku, wpływem na środowisko naturalne, oddziaływaniami pomiędzy obiektem, a instalacją wiatrową oraz z użytkowaniem budynku. Ich rozstrzygnięcie często zależy od współpracy interdyscyplinarnej zaczynającej się już na etapie projektowania i wykonawstwa turbin wiatrowych. Współpraca ta staje się nieodzowna również w trakcie doboru urządzeń wiatrowych i projektowania obiektu budowlanego oraz samej budowy. Wynikiem takiego współdziałania staje się wdrażanie coraz to sprawniejszych systemów wiatrowych.

Słowa kluczowe: odnawialne źródła energii, turbiny wiatrowe, budynki energooszczędne

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1. Introduction

The issue of energy-efficient architecture, passive houses and use of renewable energy is undertaken more frequently. We develop building technologies whose main aim is to get energy from renewable resources. Recently one could observe the phenomenon of rapid development of the wind power industry and related technologies for use in construction. The wind turbines which generate energy for buildings are more modern. Owing to such thriving development, we have at the present a wide range of wind turbines which may be adapted to a particular building and working conditions. However, the variety of available devices result in many problems with their usage or installation.

2. The most common problems of wind architecture

There are numerous problems related to the issue of wind technologies in construction. Three main groups may be distinguished here:

influence on the building – related to oscillations which occur when the turbine moves. The greatest oscillations are generated by large-size turbines. This phenomenon extorts the necessity of using appropriate connections between turbines and the building, which could prevent oscillations or decrease the ones which occur. These turbines also limit the use of facade materials. One should not use moving facades which could easily come into resonance with the turbine and could be damaged after a certain time.

influence on the natural environment – to which the so-called syndrome of wind turbines belongs. It is a syndrome of complaints which are not proved scientifically (such as disorder and aggravation of sleep, headache, tinnitus, dizziness etc.), which may purportedly occur in case of persons who live around wind farms and disappear spontaneously when they move away. The notion was created by Nina Pierpoint, PhD. She describes the influence of wind turbines on the condition of human health with the following statement: “noise or low-frequency oscillations cheat the system of balance of the organism thus it thinks that it is in movement¹”. Nina Pierpoint’s research begins the debate on the health of people who reside in the area where wind turbines are located. Despite the fact that scientific and technical circles criticised Pierpoint’s research (the disease which she claims to result is not proven scientifically), it seems necessary to conduct multilateral interdisciplinary studies into this problem.

Other negative results of the influence of wind turbines on human health include excessive exposure to infrasound (0–20 Hz) and low-frequency noise (20–500 Hz), which may lead to vibroacoustic disease.

Another important aspect of the influence on the natural environment is also the influence of wind turbines on animals, including birds and bats. There is a possibility of fatal collision with turbines as well as negative influence on nesting sites.

¹ N. Pierpoint, *Wind Turbine Syndrome: A Report on a Natural Experiment*, Santa Fe 2009, p. 294.

Analyses of the effects of the operation of wind turbines on human health, which have been conducted so far, as well as their influence on the environment, are insufficient, which makes it necessary to conduct further research in this scope.

structural problems – resulting from the installation of large-size turbines, structure of the building with which they are connected and the layout of the installation in the case of dynamic architecture.

A part of the above problems were solved, which improved particular turbine systems. Some of them are still being designed and their completion depends on whether the current problems are solved.

3. Examples of solutions

The following buildings are examples of certain technologies currently used for the purpose of obtaining energy for particular buildings and concepts of dynamic architecture with the main aim of getting wind energy by means of the entire volume of the building. Their designers faced many complications at the stage of design and construction.

They were mostly connected with excessive loads which resulted from the size of turbines being part of the given building. One example is the Razor skyscraper in London, which was designed by the Atkins workroom.

There are three turbines on the top of the skyscraper which are a part of the facade and which are to deliver 8% of the energy demand of the building. The building is significantly higher than the surrounding structures, which allows for a complete utilisation of wind speeds reaching up to 56 km/h in this area and height. It was assumed that the turbines would produce up to 50 MWh of energy per year. Each of them has 5 vanes, rather than 3 as the most popular ones, which is to significantly reduce noise generated in the process. It is very important because the building is located in a dense urban area. Not only the construction processes of the skyscraper was challenging but especially the design of its foundations.



III. 1. The Razor in London [3]

The designers of the Bahrain World Trade Centre in Manama, also coped with the problem of oscillations caused by the operation of large-size wind turbines. The BWTC is a complex of 50 storey twin skyscrapers with a view overlooking the Persian Gulf. There are three wind turbines between two triangular top tapered towers. Each of them has a diameter of 29 meters and in full operation they may deliver 11–15% of the towers' energy requirement. Two skyscrapers resembling sails and creating with their form a funnel, use their shape to increase the flow of wind which drives the turbines. The shape of the building also levels the speed of wind (winds closer to the territory are weaker which could cause uneven use of the turbines). The important issue in the construction of the BWTC was the problem of linking the turbines with the building. A large team of specialists working on the projects for many months perfected the structure of the turbines as well as the bridges hanging between the towers to which the turbines were fixed. Regular rotation of the turbines could cause the bridges to oscillate, which would weaken the structure and could lead to damage of the building. The problem was resolved among others, by proper shaping of the bridges. The BWTC is undoubtedly a milestone in the field of environmentally friendly architecture and the attempts of linking it with the technologies of generating wind energy. It was one of first such completed projects and became an inspiration for architects and constructors from all over the world.



III. 2. Bahrain World Trade Centre in Manama [4]

The producer of the Architectural Wind turbine, Aero Vironment, coped with the negative influence on the environment as a threat to animals. The company responds to the needs of the urban wind power industry. The turbines are small, silent and do not need any towers. Moreover, they may be installed in clusters. They were provided with screens which prevent birds from colliding with the rotors. The system is designated for installation on the top of the buildings and to use their aerodynamics in order to utilise wind power as fully as possible. Turbines operate even at low windspeeds, which guarantees the possibility of generating significant amounts of clean energy. They are able to operate separately or in cooperation with other technologies of renewable energy (for example solar thermal collectors). Architectural Wind turbines are available in various sizes ranging from 6 kW, measuring 1.2 m × 1.2 m



Ill. 3. Architectural Wind turbines by AeroVironment [5]

and 200 kg in mass. These turbines have a negligible influence on the structure of existing buildings and comprise an attractive architectural detail.

The so-called dynamic architecture belongs to the newest concepts of wind architecture. These are mostly tower blocks whose main goal is to obtain electric energy from wind and they are (for the most part) turbines themselves. Dynamic architecture introduces three leading innovations to the skyscraper of the traditional type, which are: variable shape, clean energy production and energy self-sufficiency. Buildings designed according to this trend are to ‘follow’ the sun taking advantage of its light as much as possible and move together with the wind converting its power into electricity. These assumptions are to cause modern architecture to be more efficient and environmentally friendly.



Ill. 4. David Fisher's Rotating Tower [4]

David Fisher, who is an Italian-Israeli architect, presents a totally new dimension of wind architecture. In his projects he implements two concepts: a prefabrication, which assumes the wide use of finished components in construction and Dynamic Architecture, which means introducing time as the fourth dimension to the architecture. The Rotating Tower in Dubai, which is to be its own wind plant, is one of his recent projects. There will be separate turbines with vertical rotational axis extorting the rotation of the entire floor between particular storeys of the 420-metre skyscraper. Each floor is to rotate with a maximum speed of 6 m/min or make one full rotation in 90 minutes. The central axis of the building will be an immovable concrete core, on which previously installed and prefabricated components of particular modules composing floors will be 'hoisted'. Horizontal turbines placed between the floors are to be almost invisible. They will be made of carbon and their shape and modern technology of workmanship are to provide the solution for acoustic problems.

Communicating the matter of centrifugal force arising in the building, which operates in such a way, as well as laying out and operating sanitary and electrical installations, are interesting problems with which designers have to wrestle.

4. Conclusions

Difficulties resulting from the introduction of new technologies are an inevitable element of development and their solution and implementation of increasingly more efficient systems, provides and drives progress. It refers in particular to complex systems, to which one may include wind technologies in the construction process. They require interdisciplinary cooperation beginning at the stage of design, which enables skilful synchronisation of turbines with the building and its territory as well as a solution to the created problems. Such cooperation results in the implementation of more efficient wind systems.

These conclusions concern turbines integrated into the building structure as well as autonomous structures related with other energy sources and wind farms.

References

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