ANALYSIS OF WIND FLOW IN BUILT UP AREAS AND POSSIBLE UTILISATION OF BUILDINGS IN TERMS OF PLACING SMALL WIND EQUIPMENTS

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ABSTRACT

The aim of the paper is to analyse parameters of wind flow in built up areas. Aerodynamics of buildings deals with the theory of air flow around buildings. We explore and explain the adverse flow conditions, ways to positively affect the action of wind on buildings, structures and their surroundings. Concentrated urban area creates a very difficult turban complex, which increases the relief of air blasts of wind turbulence. The intention of this work is to obtain information on wind flow, its effects on buildings and how to make a proper use of energy -alternative clean source. We also focus on an analysis of usability of residential buildings in terms of placing small wind equipment on residential buildings. Subjects to review are the factors affecting the suitability of residential buildings for the location of small wind equipment and consequently the choice of the most efficient method of placing small wind equipment on residential building. Another indispensable factor is the term of the environmental impact of small wind equipment on the human and nature.

Keywords: wind energy, wind equipment, building aerodynamics

INTRODUCTION

Wind power as a renewable energy can be used to produce electricity even in built up areas. Currently, in Slovakia and in the world there are large numbers of residential buildings of various shapes and sizes that are suitable as the possibility of placing wind devices. There are several ways to use residential houses for the location of small wind installations, which are described in more detail in this work.

The idea of using residential buildings for the construction of wind energy is real and in the Slovak Republic. The work describes the current state of the use of residential buildings for small wind installations as well as existing small wind facilities suitable for integration in the building. Likewise also it draws attention to the existing legislation in force to wind energy and its use.

AERODYNAMICS AND INFLUENCE OF FLOW BY BUILDINGS

Aerodynamics deals with and explains how adverse flow conditions arise and how we can positively affect the action of wind on the design, building and its surroundings. Building aerodynamics deals with the theory of air flow around buildings. [2]

Architectural aerodynamics focuses on obtaining detailed information about the shape of the velocity profile and turbulence characteristics. Constantly changing nature of atmospheric conditions and the large variability in geometry shape of buildings and files, creating a huge variability in the effects of wind. Reliable correlations, as well as basic theoretical justification for the wind, obtained after years of intense research models and terrain. Significantly shorter as research local instantaneous wind pressure on the surface of the building envelope in which the value fluctuation component of the speed is many times greater than the values of mean geostrophic wind. Differential pressure stemming therefrom are then determining variable for the penetration of water and air infiltration materials and constructions building envelope. Problems caused by wind flow fields in urban areas – urban centers of influence and mechanical effects of wind on the pedestrian areas, are in terms of a scientific approach to solving the wind, the youngest area. [2]

By studying the wind as one of the components of the environment around buildings, it is only possible on the basis of studies of buildings aerodynamics, meteorology and human factors. When designing urban units, as well as the buildings themselves and their surroundings will ensure that the conditions of the environment and in terms of the effects of wind. While studying physics problems of the effects of wind on buildings and structures requiring a study of aerodynamics building complex building physics, building climatology and the human factor in the creation of artificial environment, the architects familiar with the theory in the design of details, components and systems building and make their positive use to influence and flow-induced loads of wind [2].

In addressing both studies are necessary knowledge in aerodynamics of buildings, which deals with the theory of air flow around buildings. It explains how adverse conditions arise that flow. Using his methods of examination, classifies and shows the way how to conditions caused by a blow to the construction, building and surroundings positively influence. Development of architectural aerodynamics focuses on obtaining detailed information about the shape of the velocity profile and turbulence characteristics. Constantly changing atmospheric conditions and the large variability in the geometry of the shape of the building, creating a huge variability in the effects of wind. [2], [4], [7], [9]

THE METHOD OF LOCATING SMALL WIND INSTALLATIONS ON RESIDENTIAL BUILDINGS

Structurally integrated wind turbines in buildings or on buildings associated with designing and building specially adapted for the use of wind energy. The greater the scope of the design, the greater is the impact on the environment and the surroundings of the building itself. These projects thus become a major challenge in designing and constructing since they must fulfill all the needs and requirements of owners and people living in them. By utilizing built apartment building, in which the construction is foreseen with the location of wind energy, his suitability must be examined and assessed. But it is not just a question of numbers, size, nature and location of the turbines, the calculation of the annual profit and provided their life. By integrating these dynamic rotating machines for new buildings we can influence decisions on the location and orientation of buildings, size and curvature of the facade construction, use of materials, construction methods, and so on [1]

The design process of construction of a residential building absorbs a lot of time architects and also requires more financial resources. In addition, it is desirable to deal with as well as other aspects of the proposal have an impact on energy consumption (eg. Insulation, ventilation, water circulation, solar shading, use of material, etc.) [4], [9]

Wind turbines on the roof of a residential building or next to the apartment building will operate at higher speeds. The area near the building will be about 20% higher speed than the wind speed away from the building. In this method, the location of the wind turbine may be a device type HAWT and VAWT. There are several options for such a placement of wind turbines. [8], [1], [5], [6]

Positioning on the roof of the building with the peripheral edge (Method A)

This method uses the location of the particular advantage of better quality wind, located in the larger height. These winds have higher kinetic energy and are less turbulent. The integration of this method placements to natural wind speed of about 10%.

Features:

- the height of the building role in so far as to avoid local turbulence, the skirt formed by sharp opposing sides provide air flow incident to the turbine without the effects of the vertical component of the wind speed.
- Given that, there is a separated flow of air at the edge of the flat roof of about 45 ° to each other it is necessary to place the device at a higher mast in order to avoid direct contact with the turbulent flow in the recirculation zone.
- Such location of wind energy is suitable for both types of devices. The use of type VAWT device has the advantage that it can more effectively capture the wind energy in changing the wind direction in the range of 360 °. HAWT type devices are also capable of the rotation, but are not as effective in terms of changes in wind direction.
- Since it is necessary to place the device on a tall mast, then there will be an increase in vibration when the torque to be transmitted to the roof structure, and also can not avoid a greater impact strobe shield.
- Sound accompanied by the operation of the device can be eliminated by soundproofing the facades of buildings

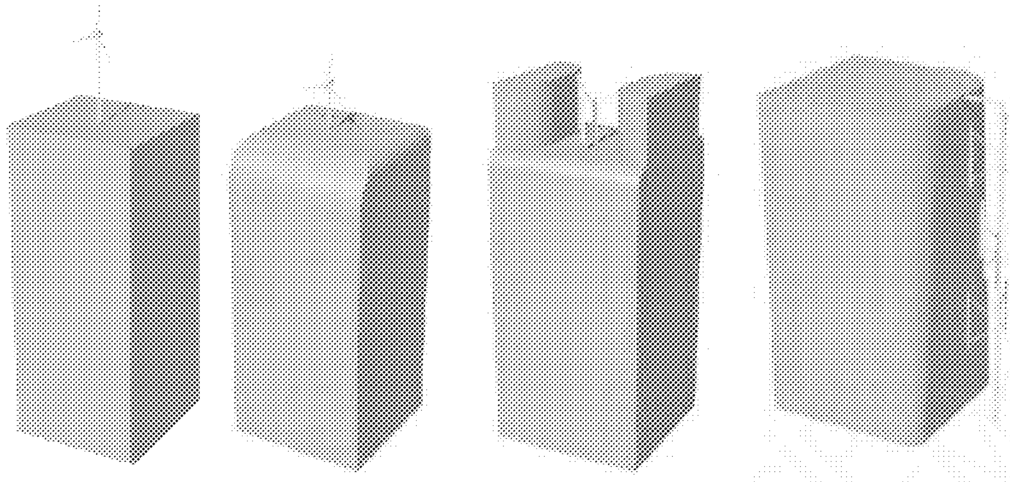

Fig. 1 Location of wind facilities on the building or at side [1]

Positioning on the roof of the building with a rounded peripheral edge (Method B)

The method utilizes placing a higher quality of wind in elevated places and improve speed by about 15%. This percentage increase is due to the rounded peripheral edges of the roof of the building. Rounded top windward front facade of the building means that the height of the building may be less than sharp at the peripheral edges of the roof.

Features:

- Extension of the curved front of the building affects the speed as well as its aerodynamic shape allows for better airflow façade towards wind energy. The cost of construction of such a curvature can be compensated by increasing the value of the building and also it will help to improve her appearance.
- Improve airflow rounded the windward side also causes a smaller angle boundary layer, allowing location of wind facilities on a low mast. Lower mast will be less vibrations transmitted to the building structure, as well as strobe effect of twisting the device will have a much smaller impact on its surroundings as it was in the process A.

Positioning device on the roof and rounded the windward side between two concentrators (Method C)

This method placement is used in locations where wind flow is bi-directional, and enhances the wind speed of about 20%.

Features

- The space which is formed by the wind concentrator can be used to place a wind device. Concentrator, and the windward side of the building are the top rounded, to ensure better air-flow wrap.
- Because this method uses the location in bidirectional wind, more suitable devices are the type VAWT. HAWT type devices could be when turning the gondolas come

into contact with the concentrator and damaged. One solution could be to use active pitching of blades in order to exploit the wind force from both sides. Machinery may be placed on a high mast, as the windward side is rounded.

- The concentrator can be used as noise insulation and also masks the stroboscopic effect.
- As well as in Method B, and the building may not be too high in order to achieve the same wind speed as in building roofs with sharp edges.

Wind location device at the side of the building with curved sides (method D)

In this case, the integration of the device on its side facades of the building, which has a rounded edge toward the device. It is believed the same conditions that the device will be more effective than free-standing unit and total energy increase of about 50-60%.

Features:

- The lack of space for the rotation and the ability to capture the wind from both sides for shaping the way of the position-type VAWT.
- The adjacent wall of the building to the turbine should be a solid, acoustically and thermally insulated, not glazed, to avoid an accident in a rapture disappearance of any part of the wind machine.
- Turbines should be safe and of good quality, with good access for maintenance. It should also be ensured around the unit, as it is also accessible from the ground.
- To use the whole of the building is the possibility of integrating several wind energy in line.

Location of wind energy in the building square concentrator (Method E)

The method of placement is similar to Method D except that the concentrator surrounds the turbine from all sides. If the wind speed is the same in all directions, and results in an improved flow of the wind by approximately 25%, of the freestanding equivalent. Although this option requires a loss of usable area of the building due to construction of the concentrator, there are several examples of large, tall buildings which have such space, whether in terms of aesthetics or serve to reduce wind load. In this case, it can be used to place the device of the wind.

Features:

- This form of integration of wind energy is inclined to buildings with narrow profile to the concentrator is able to capture more air.
- For the method the location is appropriate device-type VAWT, since the surface is a square and the area of the concentrator.
- Size of the hole depends on the available technology and wind energy should be tailor made to avoid additional costs.

- Internal façade hole should not form the glass surfaces, but heat and sound insulated surface, protecting the comfort of people occupying a dwelling house.
- Access to the device must be well thought out and safe for a fast access time of failure.

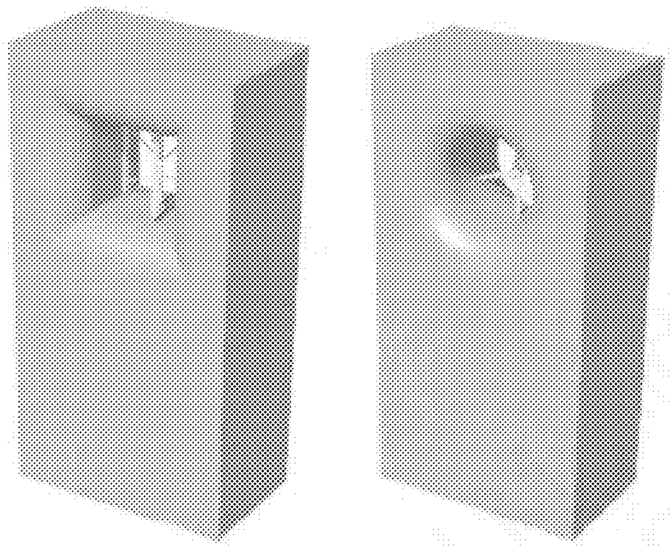

Fig. 2 Location of wind installations into buildings [1]

Location of wind energy into a circular concentrator in the building (method F)

Location is similar to Type E except that it has a square shape of the air concentrator, but circular. In this process, the type of equipment used HAWT. The increase in energy is approximately 35%.

Features:

- Size concentrator should be coordinated with the available technology to avoid costly design and aftertreatment.
- If, for equipment type HAWT used active pitching of the turbine blades, it can use wind energy on both sides, which ensures efficient performance.
- The cost of a round concentrator is higher than for a square concentrator but aesthetically it is preferably used, and the area required for the construction is less.
- A major drawback of concentrator built into the building is that bulky, which could be used as a useful living space.
- Emissions, noise and vibrations caused by the operation of the device must be thoroughly removed using insulation around the perimeter of the concentrator.
- Bird protection grid can be placed on both sides of the concentrator, thus avoiding penetration and contact with the turbine blades.

Location of wind energy between buildings with curved sides towards the device (method G)

Is a group of two buildings, which serve as feeders of air to the device. In this method, the location of bringing about greater efficiency by about 10% more than in stand-alone buildings (method D)

Features:

- Orientation, shape and spacing of buildings are key variables turbine output. Orientation of the building must be in accordance with the direction of the wind in order to ensure the most effective distribution of air flow to the unit. The rounded shape allows smooth passage of air to the device. Distance buildings will be essential to achieve the right timing and alignment currents of both buildings to the device.
- More appropriate equipment for this method of locating the corresponding type VAWT. As mentioned above, these types of devices are more efficient with regard to the capture of wind.
- Adjacent spaces should be insulated thermally and acoustically in order to avoid disturbing problem during running of the device.
- Surrounding areas nearby must be fenced and secured to avoid injury. Bird protection network can be used to avoid crossing between buildings.

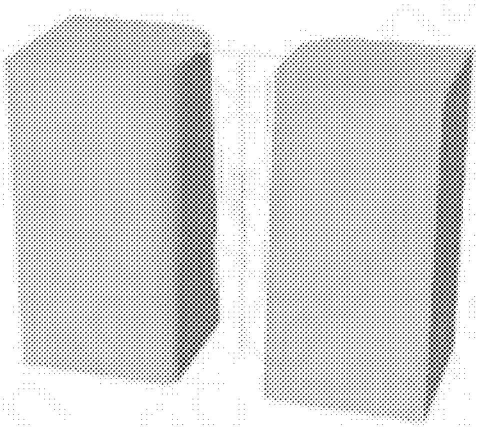

Fig. 3 Location of wind installations between buildings [1]

CONCLUSION

Placing small wind installations on residential buildings does not present yet in the Slovak Republic sufficiently comprehensive in all aspects of sophisticated area. Small wind turbines on the market today are not generally designed for low wind speed and location in an unstable turbulent urban environment. The same is true for structures and buildings that are not designed for dynamic positioning devices and dynamic loads. Some of the proposed projects have failed due to noise emissions, high turbulence or vibration. For this reason, more and more manufacturers trying to promote the market and strive for and development of small wind turbines in design, mechanical noise reduction and safety.

As a courtesy by the state of wind energy can be considered a project called Green households. Householders may apply for contributions to the installation of equipment for renewable energy from European and national sources. The project will help owners of houses and apartment buildings to cover 30-50% of the cost of modern facilities which are classified and wind turbines with an output of 10 kW.

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