

## Theoretical Possibilities of Using Building Integrated Wind Turbines for Urban Energy Production

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**Abstract:** *The wind energy potential is being used more and more all over the world today. This is auspicious because renewable resource is used for energy production, thus avoiding carbon emissions in the environment that come from burning fossil fuels. Vast wind farms fields have been developed in areas with wind potential and more recently marine areas are used for the installation of high-capacity wind turbines. In addition to these concerns of high-power applications, the concept of building integrated wind turbine for energy production of reduced power but which can be used in urban consumption is proposed, thus contributing to obtaining the title of city with green energy buildings. In order to achieve this goal, the aspects of space that must be occupied by the wind power plants must be considered, but also by the aspect of the building in architectural terms for the appropriate framing in the respective area. Thus, both criteria must be met in order to carry out such projects in urban buildings, which offer them advantages over classic buildings in terms of the energy production aspect based on environmentally friendly renewable sources.*

**Keywords:** *Wind turbine at buildings, three-dimensional modelling, CFD*

### 1. Introduction

The growing need for energy worldwide has led to the increasing use of fossil fuels which as we know have meant huge emissions of greenhouse gases into the atmosphere, which affects the environment in terms of increasing annual temperature values, rising sea levels by the accelerated melting of glaciers, which represent irreversible changes for the moment. The solution to mitigate these extreme phenomena would be to reduce these emissions globally. This goal is an ideal that is imposed by most world countries with high emissions level. One of the solutions is represented by the production of energy from renewable sources, which have registered an advance in recent years globally. For this reason sources of solar energy, wind, tidal or waves force are aimed to obtain green energy with a low impact on the environment for production.

In terms of wind force, it should be noted that applications have increased based on the use of high-power horizontal axis turbines both on land and more recently at sea with higher powers.

In order to supplement the energy production at city level, attempts have been made to install wind turbines in urban buildings as a means of bringing production closer to final consumers.

### 2. Mounting solutions for wind turbines on urban buildings

Different solutions for wind turbines mounting on urban buildings are presented, which have the possibility to bring an energy input by using the existing space on the roof. These methods are representing a viable alternative for urban areas that identify themselves as high energy consumers using the space on the roof that is available.

Regarding the typology of wind turbines used, both horizontal and vertical axis models can be used, depending on the possibilities existing at the working point where the assembly is performed. The wind speed, the direction as well as the period of action are considered in order to choose the turbine constructive type that is indicated to be used.

Examples of installation and use of wind turbines on the rooftop of buildings are shown in Figure 1.



a) Hybrid vertical axis wind turbine



b) Darrieus wind turbine



c) Horizontal axis wind turbine

**Fig. 1.** Wind turbines mounted at rooftop of the buildings

In addition to the roof mounting of wind turbines, the process of including wind turbines in the building's own architecture is also used, thus forming an architectural model that also has the role of modern design that complements the energy aspect.

These architectural procedures represent modern trends in terms of building construction that bring an extra aesthetic and functional value to these buildings that attract attention through the state-of-the-art aspect (figure 2).



d) London Strata SE1 building



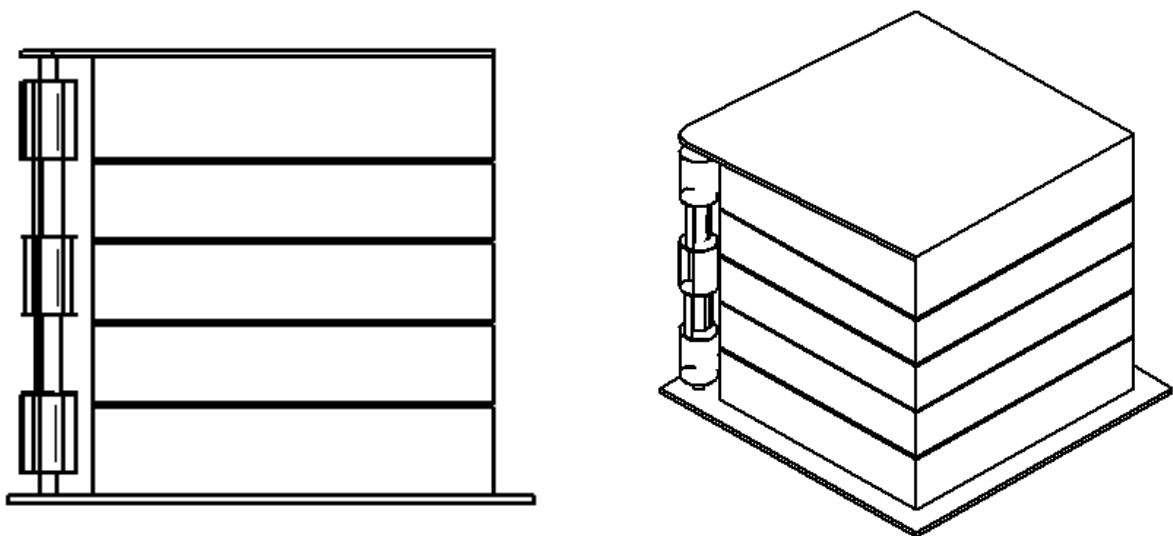
e) Bahrain world trade center

**Fig. 2.** Building integrated wind turbine

### 3. Vertical axis wind turbine model integrated at buildings

It is conceptually presented the process of installing wind turbines in urban buildings in order to produce energy and at the same time to be well integrated into the architecture of the building so as not to affect the appearance and aesthetics of the building.

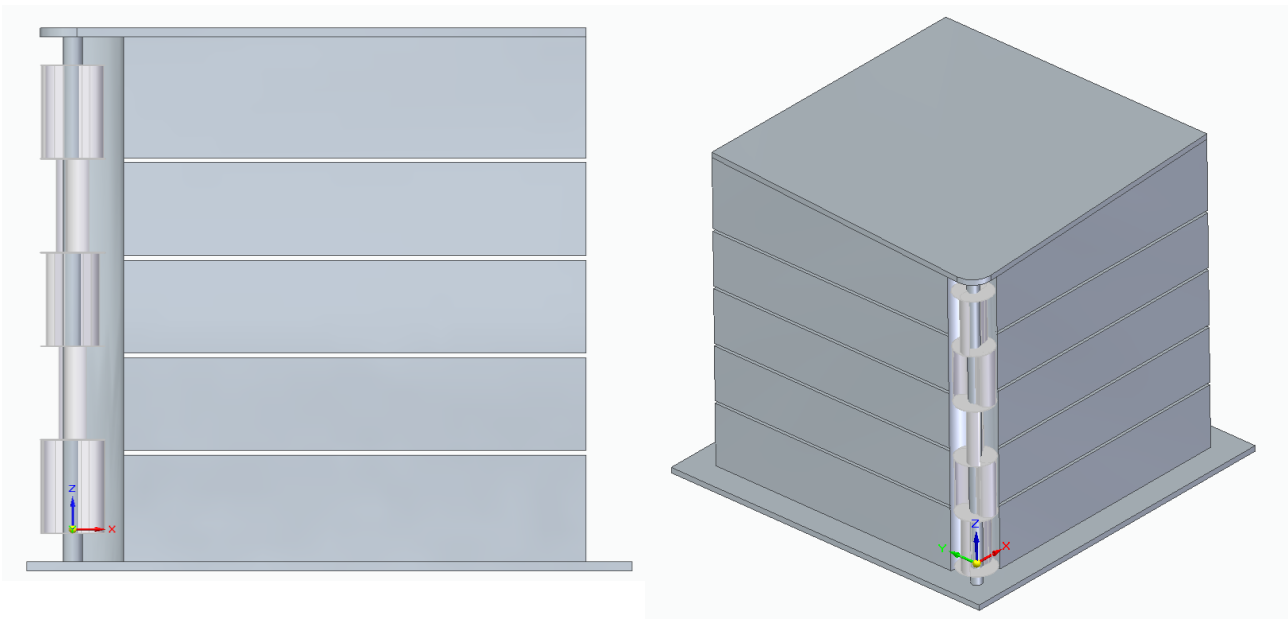
The methodology that follows this principle refers to the use of wind turbines with vertical axis that present extensive mounting possibilities adaptable to large lengths both vertically and horizontally. The wind turbines installation can be done both on the building corner side and also on the rooftop. The endowment type is made for buildings located in suitable positions related to the continuous wind action that can be used for installation of the turbines.

**Fig. 3.** Vertical axis wind turbine integrated on building corner concept

The mounting possibility of wind turbine system with vertical axis at the corner of a building is presented (figure 3). It represents a practical model for equipping buildings with wind power plants for energy production which can be applied to buildings located in areas with constant wind actions. This installation type of as well as the rotor typology proposed for installation also ensures an aspect that falls within the modern design norms increasing the architectural and aesthetic value of the respective building.

#### 4. Wind action on the building virtual model

Using the building 3D model (figure 4), an analysis of the air flow is performed to show the main air flow rate stream that have the property of driving the wind turbine rotor in motion.

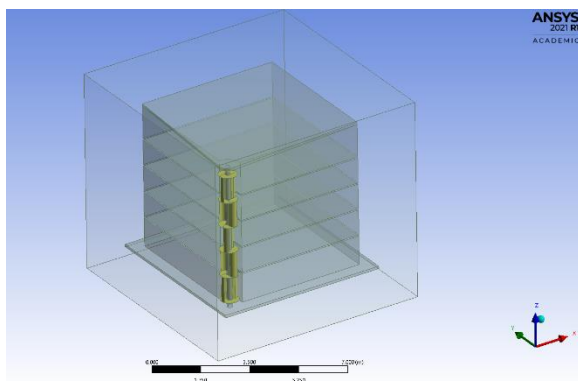


**Fig. 4.** Building with integrated wind turbine 3D model

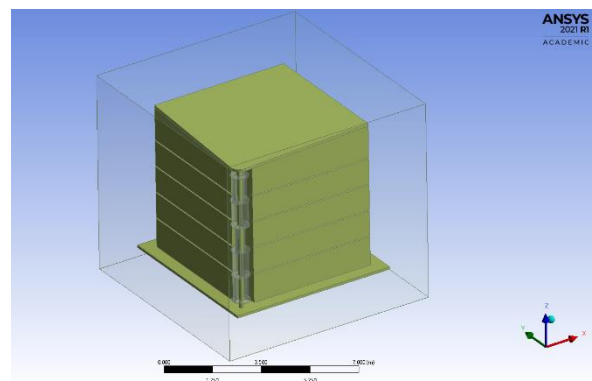
The airflow analysis is performed with the Ansys CFX program performing the numerical simulation of air circulation at the building level and the appearance of the potential for the turbine rotor to move based on the wind force.

The working fluid is represented by air at 25 degrees Celsius with the k-Epsilon turbulence option for the fluid region.

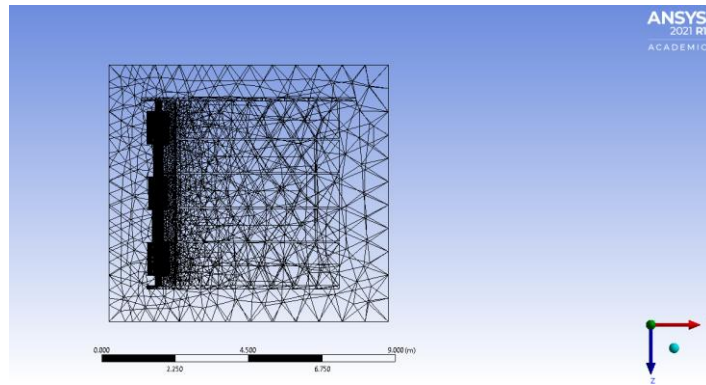
Figure 5 shows the main domains of the analysis on the imported virtual model.



a) Wind turbine rotating domain



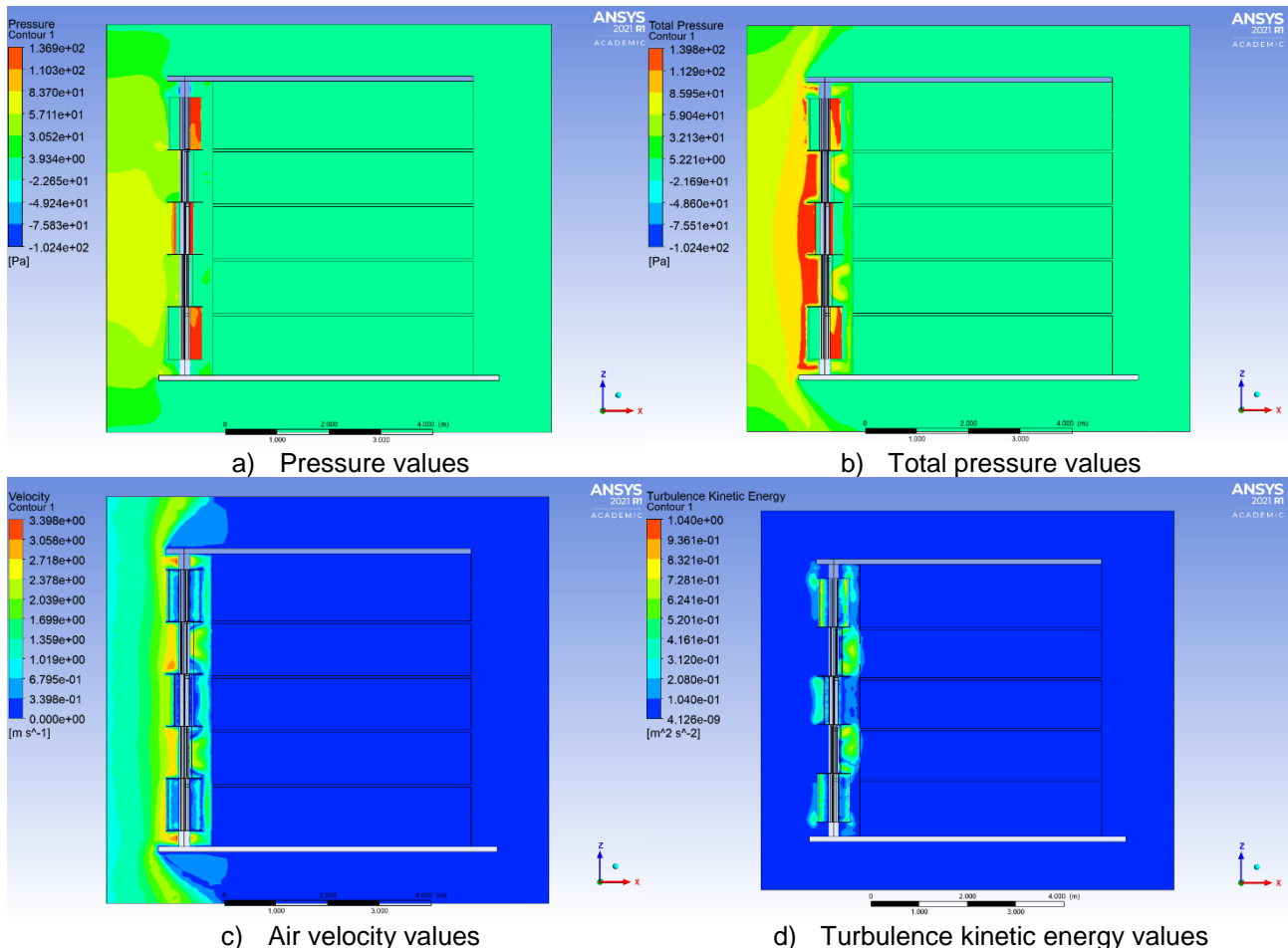
b) Building solid domain



c) Mesh domain

**Fig. 5.** Flow analysis principal domains

Using the methods of numerical analysis on the virtual building model with vertical axis wind turbine embedded, the energy potential can be predicted based on the wind force for different values of the air circulation velocities.



a) Pressure values

b) Total pressure values

c) Air velocity values

d) Turbulence kinetic energy values

**Fig. 6.** The obtained result values from air flow analysis

On the obtained results (figure 6), can be observed the main trajectory described by the air circulation at the building level acting directly on the building lateral wall but also on the turbine rotor which is positioned integrated on the building corner. For a better air circulation and an improved action of the rotor can be adopted a curved shape of the building facade that would direct the main air flow on the turbine rotor blades thus ensuring better results.

## 5. Conclusions

When it comes to producing the energy needed by growing human communities, all possibilities and alternatives needs to be adapted and redesigned in order to improve the atmospheric emissions level.

The energy sector needs to make major changes in the coming years for obtain encouraging results and this goal will be achieved if new technologies in the field of renewable energy production that are available and in unlimited quantities are developed and applied.

A solution to be applied is also the one proposed in this paper to achieve the endowment of buildings with wind turbines for energy harvesting in urban areas.

This mounting method can be accomplished for both new and old buildings and it should be noted that for new buildings it could become a task in the future, to ensure an energetic component of the building and to move to the level of energy independent building.

In addition, from the building architectural point of view, these facilities can be incorporated in the basic architecture of the building, thus achieving a combination and a harmonization of the aesthetic and functional aspect.

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