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Two-Dimensional Model of Wind Flow on Buildings to Optimize the Implementation of Mini Wind Turbines in Urban Spaces

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1. Introduction

The way to sustainability as a new and essential paradigm of our society must lead to the search of energy consumption reduction and to increase the energy efficiency in our buildings, combined with the replacement of fossil fuels by renewable energies.

The most important criteria for the sitting of power plants is the location near to the raw material. Renewables open the door of distributed generation, because dispersed generation can be located wherever it is the precious source of energy.

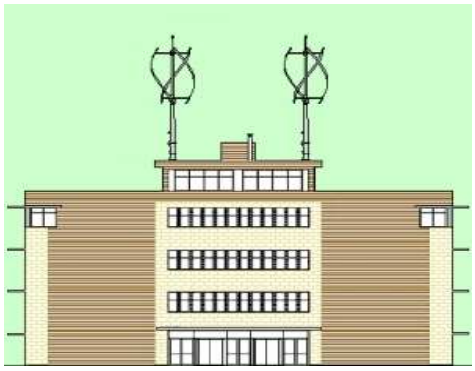
The roofs of the buildings present a very valuable source of renewable energy: wind. Similar to the study of the perfect location for wind generators in the natural environment, we need to have models for characterization of wind in the urban space to optimize the locations of the mini wind turbines in that space as well as the chose of the most appropriate type.

The scientific study of the implementation and optimization are the basis for a line of research developed by our group in recent years. Its most important results and main conclusions are presented in this paper.

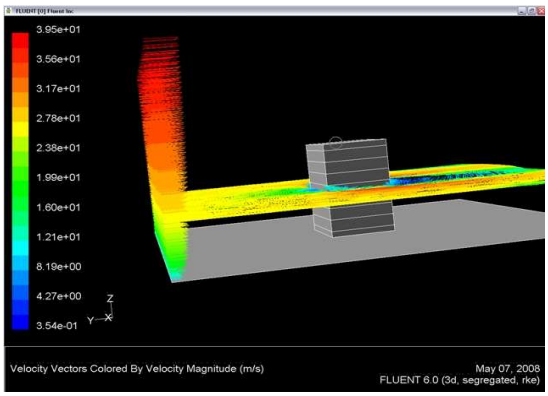
Keywords: Renewable Energy, Wind Power, Mini Wind Turbines, Sustainable Building, Urban Turbines.

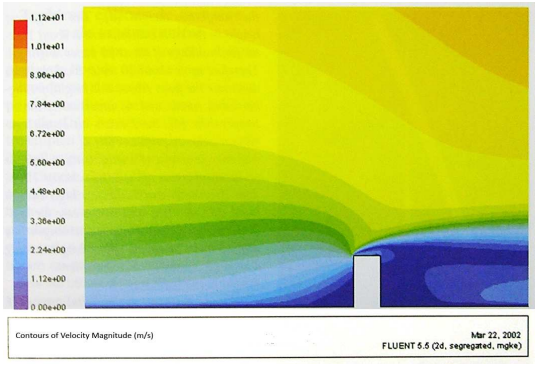
2. Description of two-dimensional model of wind flow on decks of buildings

The model is based both on simulations and on experimental data, which have been taken for years to validate the simulation models. This allows these models to be verified, validated, and extrapolated to other buildings. A series of simulations have been developed with the application FLUENT © (Computational Fluid Dynamics) for evaluation of CT, the increasing roof factor, and to validate its value.

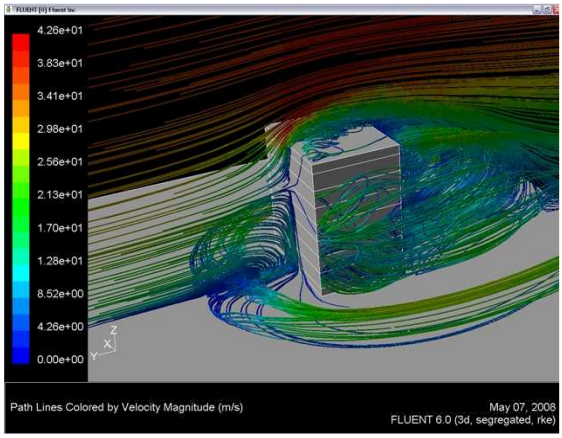


The following picture shows the modification of wind flow in the horizontal plane due to the presence of a building, in a simulation obtained with the mentioned application FLUENT ©.

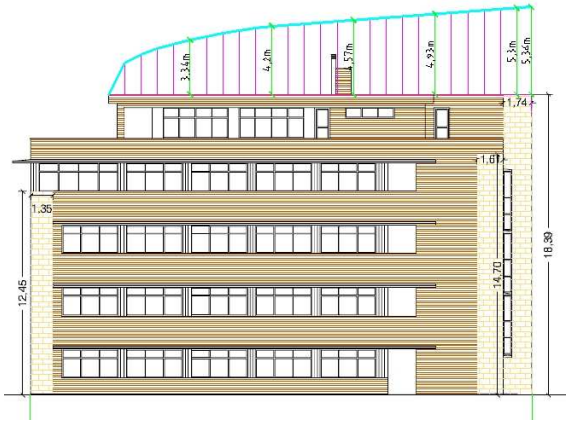




Next two images show, similarly to the previous one, the modification of the wind flow in a simulation obtained with FLUENT ©, but now in the vertical plane.



The wind flow separates at the edge of the roof of the building and forms a low speed separation bubble.



Outside the separation bubble, the wind speed increases. This increase is about 20% of the wind speed that corresponds to that height. The vector of wind velocity is not parallel to the roof but presents an angle with the horizontal plane, the separate-ion angle. As a result, the acceleration vector of wind forms an angle of separation to the roof or to the sides of the building, which depends on the size of the building and the wildness or rugged of their surroundings.

The following conclusions have been obtained from this line of research based on the obtained models. The separation angle is greater near the edge of the roof of the building and varies with wind speed. The higher the building (both in height and diameter or plant), the greater the separation angle reached, reaching even 90°. For low buildings that angle will be imperceptible. The more rugged is the area near the building the lower the angle of separation.

3. Optimizing the implementation of mini wind turbines in urban spaces

The wind turbines have to be placed always at a height above the separation bubble, in order to avoid the slow speeds as well as significant turbulences. Furthermore it is noteworthy that the wind turbines will benefit from an increase of 20% of air velocity compared with the wind at the same location if there was no effect of the building. That is, the urban space provides an extra increase of wind power, provided that the location of wind turbines is optimized.

4. Conclusions

The study of the two-dimensional model of wind flow for building decks allows the optimization of the implementation of mini wind turbines in the urban space.

Besides urban areas, due to the acceleration produced by the buildings on the wind speed, adds extra wind power increase, provided that the location of wind turbines is optimized.

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