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Wind building design

M, Martínez, A. Pulido, J. Romero, N. Angulo and C. Roca

Department of Electrical Engineering
Universidad de Las Palmas de Gran Canaria
Campus Universitario de Tafira – Edif. Ingenierías, 35017 Las Palmas (Spain)
Phone/Fax number:+0034 928 451987, e-mail: apulido@die.ulpgc.es, mmartinez@die.ulpgc.es

Abstract. The Canary Islands are one of the best places in Spain in wind resource, but with a limited land area 7529 km2, a high rate of population (2,103.992 people in January 2009), a high degree of protected land 42.2% of the territory, very deep waters, and a huge dependence on foreign petroleum for 99% of energy consumed. We have to look for urban wind energy as an opportunity to extract energy without occupying valuable and scarce land, using own resource and diversifying the energy basket. We will study different existing buildings designs and will make our own proposals in order to assess, for which we will use specific software.

Key words

Wind energy, building design, integrate

1. Introduction

One of the technologies more profitable today is the wind turbines. Distributed generation offers a lot of advantages. In the case of wind energy on buildings that produce no environmental impact compared to the option of a wind farm.

Usually mills on buildings are less than 100 kW or having an area of less than 200 m2 rotor, small wind turbine. The close countries of Spain have specific legislation for small wind, not in Spain, but it is hoped that soon that changes.

On the other hand from 2019 the buildings to be built in Europe should be self-sufficient energy and emit zero CO2. UK has a plan "Low Carbon Buildings", in which aims to generate between 30% and 40% of the country's electricity by 2050 through distributed microgeneration installations in buildings.

As we will see, a gradual integration of generation facilities in urban and industrial areas. The purpose of this paper is to analyze basically several envelopes for these future buildings emulate hill effect, concentrated lines of force in order to increase wind energy production. Software has been used and has been tested with various designs to determine the most optimal from the point of view of generation.

It should be noted also that in Spain there are about 7 MW of small wind power installed by the 11,500 MW of conventional wind. Almost all small wind is concentrated in rural applications.

The noise and vibration problems have kept away from buildings this technology, especially in residential areas. For both issues there are technical solutions easier since the beginning of the project, that in existing building.

2. Integration of wind turbines on buildings

Like all issues, the integration of wind turbines on buildings has many advantages and disadvantages that are listed briefly below. Just wanted to mention two, would change the face of our cities and save the destruction a lot of natural landscapes.

Arguments for Integrated Wind Turbines

• Economic: demand reduction and energy sales
• Alternative to more and more expensive energy sources (oil, gas, electricity)
• Show environmental consciousness
• Get a certificate to stand out of the mass
• Upwind generated by buildings facades increases wind velocities
• Buildings are reaching into high velocity layers, and with that no wind turbine tower is needed
• The structure can be used to encase turbines to enhance their performance, hide them visually and at the same time make them safer
• Aerodynamic building structure can direct and concentrate wind towards the turbine
• Long transmission lines for energy transportation, linked to significant losses, can be cancelled out
• Preserving natural areas of the strong impact of wind farms

Arguments against Integrated Wind Turbines

• Wind turbines for electricity production are depending on the wind and are therefore not reliable/ always available

• New surrounding buildings are changing the local wind conditions and must be part of the project as well

• Noise and vibrations close to buildings clash with the desire of more comfort

• Wind velocities in cities are lower and more turbulent than on rural sites

• Expensive volume where people could live in is used by implementing turbines

• The turbines designed for urban integration are often not as effective as those used in wind farms

Fig. 1.- Wind energy city

3. State of the art

A lot of examples of wind turbines in design of urban structures exist. It is a challenging mission to put it into reality though. Most of the designs never made their way from the drawing board to construction site. But the vision is the first step to mission. Integrated wind turbines are most reasonable for high rises, since their height reaches into high wind velocity layers. We saw facts about high rises, some design examples, a green buildings certificate in Europe and America will be introduced.

All designs provide for these considerations

- The wind increases with height, so normally are towers or skyscraper

- Turbulence harmful vibrations in the turbines and decrease its production, so building has soft shapes

- Wind turbines produce noise and vibration nuisance, normally are office building, no residential

- The power produced is proportional to the catchment area. In some cases seeking more aesthetics and the publicity, that energy savings

So we can admire some famous designs in the next pictures:

Fig. 2.- Bahrain World Trade Centre. Manama, Bahabrain

Fig. 3. - Tower Burj Al Taqa. Riyadh, Dubai

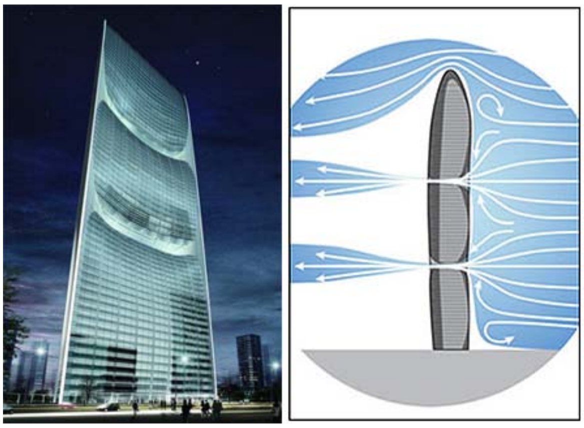

Fig. 4.- Peral River Toser. Guangzhou, China

Fig. 5.- Strata Castel house. London, UK

Fig. 6.- Cor Wall. Miami, USA

4. Virtual wind 3D software

Virtual wind 3D is a software modelling and 3D visualization of wind flow. It permits to predict and understand wind behaviour in certain situations; rural, suburban and urban places. It works connected as a Plugin to Google SketchUp 7, so you can export the models in design to the program and run within the simulator, which generates estimates as wind, according to the previous direction and speed, affects the environment and the model designed.
Because of this, we can say that it is relatively simple modelling of the building relate to subsequent treatment in the Virtual wind.

5. Model Desing

5.1. Model number one

Building designed with aerodynamic shape similar to a drop, as the hill effect, the wind rise along the incline surface.
And we will use the higher magnitude in the air speed on the flat surface of the semicircular area of the building through the installation of small-wind turbines bayed on the market. We have considered office use, where the area is sloping dark glass, like windows, a material with low roughness.

Fig. 7. Model 1

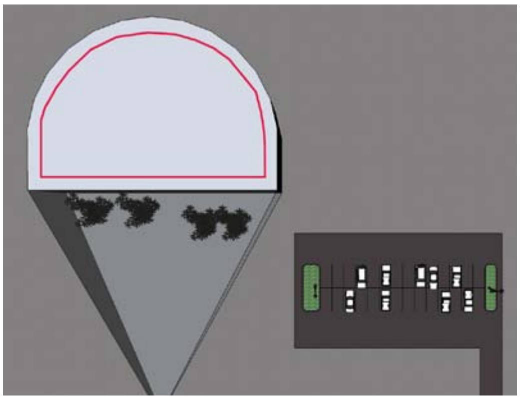

Fig. 8. Model 1

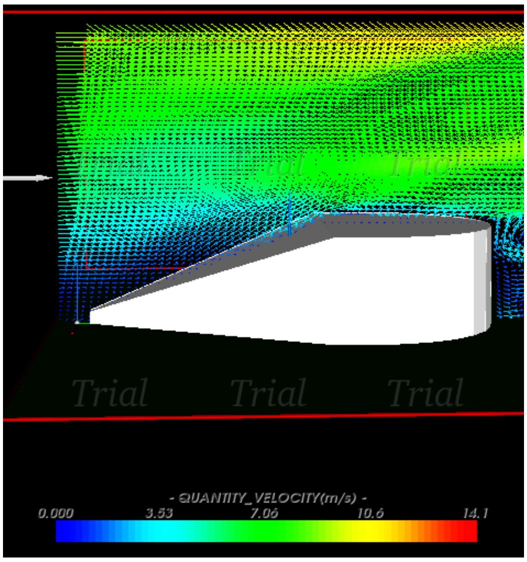

Fig. 9. Model 1. Simulation

With this model the wind speed doubles, but we can´t forget, that the energy produced is proportional to the cube of speed.

5.2. Model number two

It has built a structure like a nozzle on the roof, which directs and accelerates the air, if we introduce the wind turbines in, also serve to mitigate the noise.

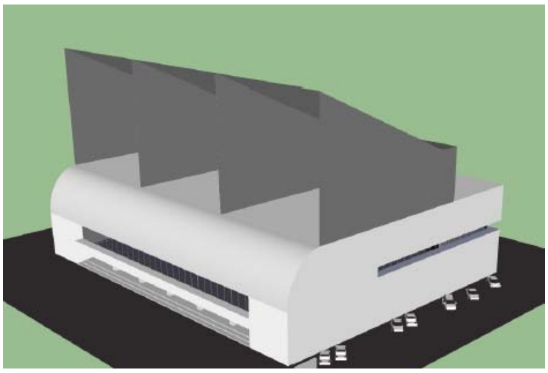

Fig. 10 Model 2

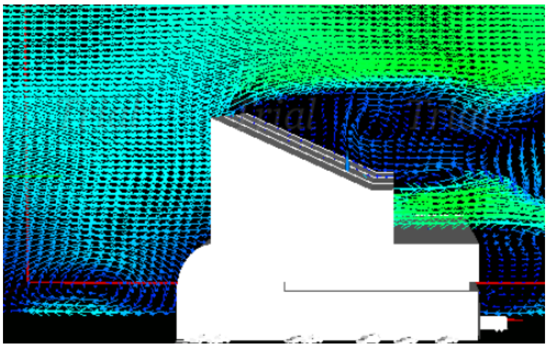

Fig. 11 Model 2. Simulation

With this model the wind speed doubles too. We expected more from this model, but the pressure at the outlet diverts airflow in the input.

5.3. Model number three

It´s a combined of three buildings when trying to channel and increase the speed of the wind. Consisting of 2 towers with elliptical base, arranged in such a way to channel the wind, we place between a building, as in model 1, which generates the hill effect.

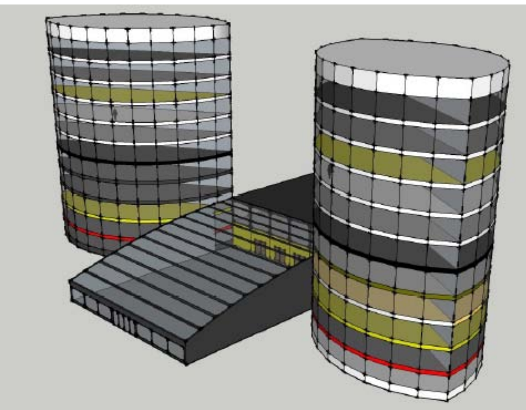

Fig. 12 Model 3

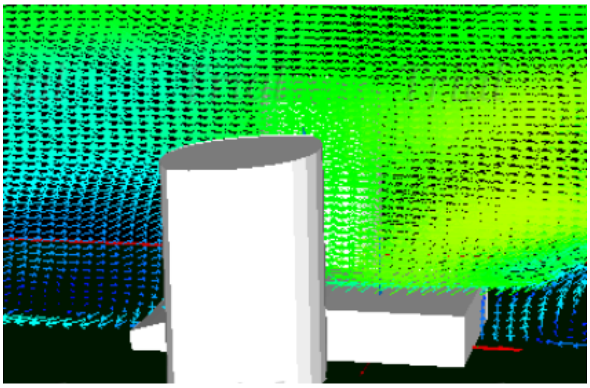

Fig. 13 Model 3. Simulation

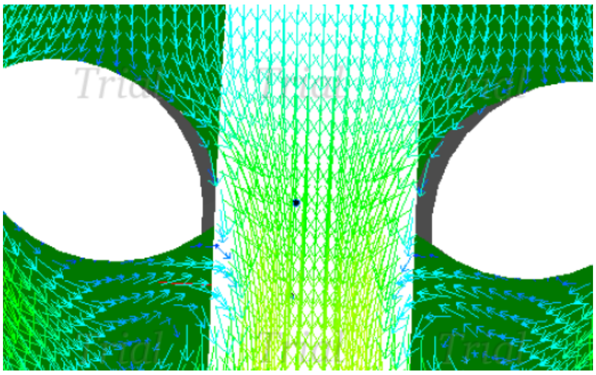

Fig. 14 Model 3. Simulation

In this case the wind speed triples, as expected because the air is concentrated in the vertical and horizontal without narrow output

5.4. Model number four

A smaller building, like a normal house. It is a structure supported on two bearing walls, the house of elliptical profile separated about 10 m above the ground, so that the wind is redirected into the space below, as if it were a wing, and into the headspace . Wind turbines will be available up and down.

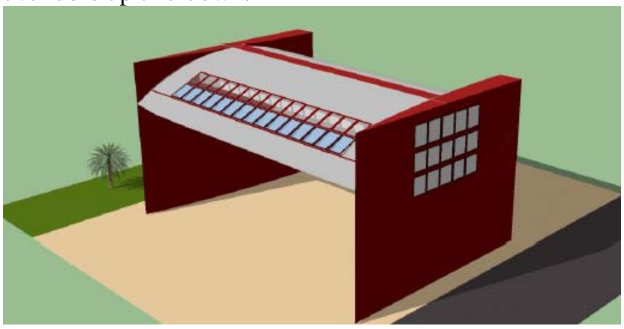

Fig. 15 Model 4

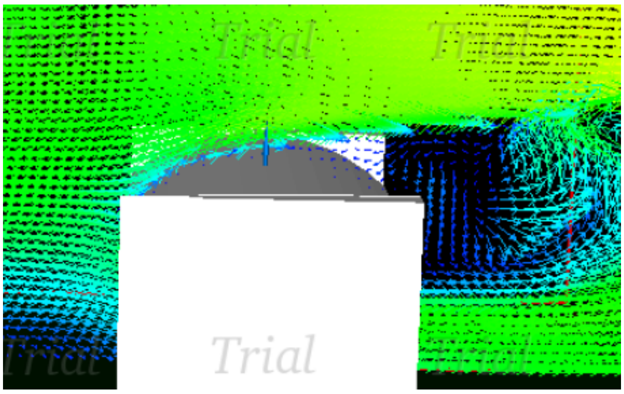

Fig. 16 Model 4. Simulation

With this model the wind speed doubles too.

6. Turbulence considerations

Existing buildings usually have angular shape (cubic), so it cause strong turbulences, we can find two solutions:

- increase the high of wind tower, so it will be out of turbulence zone
- reform the roof to make it more aerodynamic, using a low cost deflector on the ledge

In any case, turbulence aren´t good for wind use. The correct this a priori design phase or remodelling in existing buildings would allow better use of them for this purpose.

Urban planning in areas of new construction could include a section rather than on maximizing consisted urban farm use. Playing with permitted heights and volumes. Thus the developments will be adapted towards harnessing wind up.

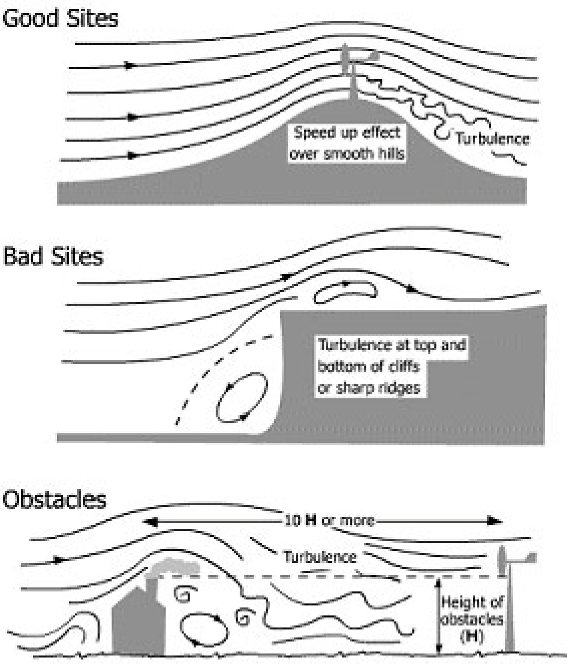

Fig. 17. Turbulences

This Amner in the following case the turbines are out of turbulence zone, it saves lifespan of equipment.

Fig. 18. Conventional logging

7. Conclusions

Buildings should not be designed for maximum wind energy production.

In other hand, must carry a complete energy study. Which provides for the use of natural light, heat losses in winter and summer, hot water production and finally the generation of electricity.

In existing designs, we find very inefficient wind turbines, having very little catchment area.

They aren´t commercial units that will be very expensive.

The building structure must consider the stress and vibration of the turbine, also should improve the noise insulation.

The proposed buildings have a high ratio of external surface to volume they contain. This results in over investment cost and thermal losses by the walls.

Existing buildings with a cubic shape produce large turbulence in the upper part by the edges.

A low cost solution is simply, to soften the finish of the top in a conventional building. In this way, it will be not necessary elevated the turbines to save the turbulences, and at the same time accelerate the speed of the air. It´s not necessary strange shapes buildings.

Fig. 19 curved roof

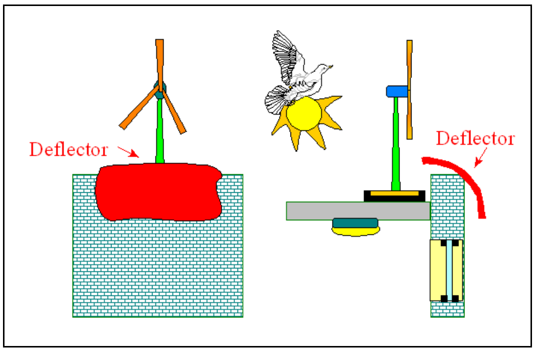

Fig. 20 Deflector on the roof

The deflector may be an architectural element to cover the entire facade or a single element that only affect near each wind turbine.
Solutions should be sought to vibration bench floating elements that dissipate or channel them separately from the rest of the structure.
So, if we look for implement and produce real zero CO_2 cities require a study from the beginning. The solutions must permit use of commercial turbines; maintain the cubic shape of building, maximizing the use of land respect to the enclosed volume.
Anyway, we have compared four designs using different shapes, all of them increased wind speed, doubling or even tripling the value of air speed to that height. The electricity production increases exponentially.
This solution is not the best even those sites with highly variable wind direction

References

[1] Mendler S; Odell W; The HOK Guidebook to Sustainable Design; John Wiley & Son, Inc., 2000
[2]A G Dutton, JA Halliday, MJ Blanch. The feasibility of building Mounted/integrated wind turbines
[3]Matsusima T, Takagi S, Muroyama S; Characteristics of a highly efficient propeller type small wind turbine with a diffuser; Renewable Energy 31, 2006