A research methodology of wind energy integration in architecture

Sara MOTA CARMO,

Faculty of Architecture, University of Lisbon, School, Lisbon, Portugal

Saramota.carmo@gmail.com

ORCID: Prpf.Dra.Filipa Roseta

FCT member FCT: J815554S8XDW

Abstract

The wind in architecture is a natural resource under developed, being oftentimes unmindful in its potential by not being taken advantages of, neither in ventilation or energy production.

Therefore, this paper focuses on the research methodology applied on a PhD thesis, which aims to contribute to wind energy integration in architecture.

The PhD research is combining several varieties of mechanic systems that are considered necessary to be controlled to produce valid conclusions in the matter of integrated wind energy in architecture. The several variables of mechanic systems are according to the demands of the architectural comfort and the process to generate wind energy, that sometimes can seem opposite, as forward will be explained.

In order to approximate the findings of the PhD as possible as the veracity, the research methodology will be divided in four phases, combining theoretical and practice to end with the developing of a scale mode tested in a natural environment.

The outcome of the paper contributes to the knowledge to research methodologies that aims to integrate wind energy in architecture, regarding applying a renewable energy on buildings to contribute to a sustainable climate and economic system.

Keywords: wind-energy in architecture; research methodology; wind energy integrated on buildings;

1. Context

The climate change is a recurrent subject on the news in our days. The fact is that the catastrophes are constantly increasing and the consequences are getting dangerous for communities. Scientists are alerting about the costs of not breaking the climate change and the predictions are disastrous for our future.

The main cause pointed out as held responsible for the alteration that is being felt are greenhouse gases, that started being associated in 1896, for the Swedish scientist Arrhenius, relating the levels of carbon dioxide with the global warming.

There are several entities that are embracing the cause and are creating alerts and motivations to stop the global degradation. European Union is one of the entities that is concerned about the problem and in 1972 published the first policies in favour of our climate. The directive defended the need of preserve, protect and enrich the quality of the urban environment. More upgrades were provided in favour of our earth protection and the biggest step forward was the Kyoto protocol, in 1998, signed by 65 countries around the world. In a concrete way the goal reduced greenhouse gases by 5.2%, from 2008 to 2012.

However, successive settings were made till now and in 2015, the Paris agreement was published, in the 21 United Nations Convention. Signed by 195 countries, the agreement establishes the bonder of the increasing temperature in 1,5ºC, to decrease the risk and the rise of climate changes.

Although a big loss was noticed in 2017, with the exit of the USA, one of the major countries responsible for greenhouse gases, estimated at 14% of global production, the Paris agreement is still a reality that keeps the hope for a stabilized climate.

Diverse updates since 2015 were made and the current targets are decreasing greenhouse gases by 50% till 2030. To reach the goal some of the advices and supports of UE are directed to replace fossil energy consumption to renewable energy created from natural and sustainable resources.

For some countries like Portugal with good climate conditions to produce sustainable energy will be a good opportunity to contribute to slow down climate change besides creating autonomy and a sustainable economy because they will be producing energy independence. Being a good way to step out of energy market inflation, dominated by the petrol produced countries.

1.1. Architecture context

The building sector is considered by EU as one of the major energy consumers, being responsible for 40% of the global energy consumption. In order slow down that consumption, the EU lay out the concept of Nearly Zero Energy Building (NZEB), consisting on buildings designed with the intention of consuming the lowest energy as possible over strategies of construction and materials that keep the gains and lost energy balanced during all seasons. The concept of NZEB also preserved that the supply of small amounts of energy required, must by provided by renewable energies integrated on the building itself.

According to the NZEB concept, diverse renewable energies must be integrated on buildings at the same time to guarantee the energy supplied in different climate conditions.

However, some renewable energy are being integrated on buildings but not in equal equity. For example on the market, there are wide amounts of solar panels available for heating water or to generate energy. Making easy the option of its installation and utilization but unfortunately, we cannot say the same about other renewable energies depending on different natural resources apart of the sun.

Partly because of the shortage of different systems available on the market to collect renewable energy from different resource.

Valuing the natural resources available in Portugal, for example, we can say there are a few more options besides the sun, like the wind for example.

Our country is distinguished by having predicted winds by north quadrant, from an average intensity of 12m/s per year. An interesting value to have a good wind energy production, according to the systems available on the market.

The wind is a clear resource; prolific and sustainable without date to finish and because of its particularities is a value that must be incorporate into building design.

2. Wind energy in architecture

The first building with wind energy that is known is the windmill, built in century V.bC. In the following years, the wind in architecture was still being used until the industrial revolution, where electric engines replaced windmills.

In some way, after the industrial revolution, the wind turbines were still developed and during the Second World War, they were very useful to produce energy in battlegrounds.

In 2008, the first wind turbine in buildings was built, in the Bahrain world trade centre building. After that, more examples were built but the problems associated to the wind energy in buildings stopped the integration of wind energy in architecture.

The case studies show problems in:

- No integration;
- Inefficient energy producer;
- Strong noise associated;
- Vibration and overweight in the building frae;
- Big structure associated;
- Limited area to place the wind energy;

Nowadays few more systems of wind energy in architecture were associated but they were very little developed.

Fig. 1: Three windmill exemples

3. Objectives

As a principal objective the aim of this paper is to share the methodology applied in a PhD in the field of wind energy integrated in architecture, to reinforce the use of wind energy on buildings, Defending the values to use a

natural resource as a way to stop climate changes and as a sustainable economy.

The purpose of the PhD is to create knowledge, in the design of a building skin, as a wind energy producer balancing the comfort needs and function of a building skin. In that point and through the research made in the 1ºphase of the PhD the principal comfort points identified to ensure a well-being feeling in the experience of visiting an architectural object are[1]:

1. The noise created at the surrounding.

2. The in-permeability created to the sunlight.

3. The vibrations and the over weight to the building frame;

4. The anti-esthetic design solution.

5. The prejudicial air current created at the surrounding building.

Proceeding with the objectives, the methodology explaining on this paper will help provide the necessary tools to answer the matter above, combined with the goal of producing energy through the wind.

To understand the proportions between the different needs of the building a harmonic structure will be created for testing different solutions for a future application in the real building skin.

The testing will be direct to measure the coefficients of variables for a logical comparison and quantification of the real energy gain according to the intensity of wind in an urban environment.

4. Methodology

As Understanding architecture as an adaptive process of society, the methodology focus on building as a labour practice, in order to give some answers to the needs of actuality.

In order to research about the integration of wind energy in architecture and to develop the necessary phases of the PhD methodology, the first lectures about the subject of wind energy on building selected four categories to be studied deeply for the successful research.

Taking into account the specific bibliography of each category, the methods applied were based on some authors' methodology. After analysing the methods applied and the contributions for the goal of this PhD, the schedule and the specific methodology was created.

This methodology is combining theory and practice and is conducted in four phases,

The first phase consists in research bibliography and tools from the field of wind energy in buildings.

The theory research is based on different cases, such as The bahrain world trade centre, The strata tower, The pearl river tower, The Oklahoma medical research foundation, among others, comparing them on the matter of producing energy and keeping the necessary comfort intrinsic to building skins.

The second phase is the knowledge application learnt on the previous phase. It is known that in 2008, the first building with three wind energy turbines, designed between the two towers of the building, was built. After that, a few more buildings integrated some turbines too, but it is also known that in the following years the buildings with wind turbines were no longer designed, due to the disadvantage

associated with turbines in urban environment (explained in point 2 of the present paper).

According to the unsuccessful event of wind turbines in urban environment, the second phase of the PhD research is based on the piezoelectric system.

The system will be designed on different types of building skins using three-dimensional models produced by Rhino/Grassopher software.

The piezoelectric system is applied by understanding the natural flow of wind turbulence in the urban environment.

The association between the piezoelectric work and the movement created by urban wind will be the skin design focus of this research phase.

The third phase will use Rhino/Grassopher software plasticity and multifunctionality to compare the different skin solutions created in the previous phase, based on energy created and building skin comfort required.

The analysis of the comfort requirements will be in terms of noise, in permeability to sunlight, vibrations in the building frame, anti- esthetic design and air current created in the surrounding building.

Based on the results obtained, two or three three-dimensional models will be selected to be produced in the real environment.

The tests on the real scale production will test the process applied on the Rhino/Grassopher software and will confirm the veracity of the findings.

The fourth and last phase is the process of research validation according to the results obtained on the test in real environment. The results will be compared with wind energy systems for urban environment available on the market.

The PhD investigation will be accompanied by disseminations according to the results obtained during the whole process. The schedule for publications is one per year and one or two presentations in conferences and workshops.

5. Conclusions

Through the description of the methodology based on theory and practice analysis, the intention of the PhD is to take conclusions regarding the building skin design, analysing the best combination between wind energy produced and comfort inherent in buildings, such as pleasant noise, natural ventilation, natural lighting and acceptable vibration.

The intention of this paper is to share information regarding the development of the PhD project as a research related with wind energy in buildings. The publication pretends to contribute to the opening of the subject to a broader public and also to the enrichment of disciplinary knowledge of wind energy integrated in architecture.

Bibliographical References

Bosnjakovic, Mladen, From Wind Power Buildings Integration;

Kishore, R.A, Priya, S Piezoeletric wind turbine;

Wind Power (2012), European wind energy association;

Marques da Silva, Fernando (2013), Ventilação Natural Ação do Vento, LNEC

Mertens, Sander, Wind Energy in the Built Environment Concentrator Effects of Buildings;

United Nations Climate Change Conference,(2018), COP24 KATOWICE 2018;

Hogan, D.J (2016) From População e meio ambiente: a emergência de um novo campo de estudos;

Sousa, Hipólito (2016) From Fachadas de edifícios: LIDEL

ScienceDirect, (2017), Embodied Energy and Nearly Zero Energy Building: A Review in Residential Buildings;

Fernandes, Rita (2014), A Energia Eólica em Portugal, Faculdade de direito da Universidade Católica Portuguesa.

TV Lawson, Wind Effects on Building, volume 1&2

[1] The skin buildings are integrated in the main field of facades that in this research are mainly focus on double facade.