POTENTIAL IMPACT OF USING BUILDING PERFORMANCE SIMULATION IN URBAN CENTRAL AREAS FOR ARCHITECTURE AND URBAN PLANNING DESIGN

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ABSTRACT

Architecture and urban planning practice is on the front line directly applying best-case evidence-based solutions to take the most of conserving and generating energy. The excessive and inevitable growth of cities derived in high rise building in most of urban central areas. High rise buildings bring together: possibilities of high density housing, daylighting access limitations in low floors apartments and issues related with the exploitation of solar irradiation for renewable energies purposes.

Today's powerful building simulation tools can be leveraged for energy modeling during early design phases and even to shape tomorrow's cities morphology. For further reductions in building energy consumption, energy simulations done during conceptual design has potential to impact long term energy use both in architecture and urban planning (Kamal et al, 2014). This paper reviews early conceptual high rise buildings design and their interaction with the immediate built environment looking at the consequences in terms of daylight availability and the potential of irradiation use for clean energy generation (IEA, 2006).

INTRODUCTION

Planning and Building Codes play a decisive role in regulating the development of urban environments. The regulations of urban planning and environmental management of urban land and other rights should guarantee citizens the right to natural light, as a basic human right (Bautista, G., 2012).

A case study of the city of San Miguel de Tucuman, in Northwest Argentina is presented. Particularly attention is paid to its central area which does not escape the global trend of massive densification often in detriment of its environmental quality.

Building simulation is a powerful tool which can be used at all steps of architectural design complementing and fostering innovations in the field of geometry (Gillcherist, R., 2010) (Mascaró, J.J.; 2010).

Its predictive capabilities have been reflected in many areas of architectural design and energy assessment of buildings and urban environments. (Ajmat, R. 2008).

This paper seeks to explore the potential energy savings and energy production due to solar radiation with the implementation of the current Urban Planning Code of Tucuman under different proposed scenarios.

For this study both the global environment and the local level of SMT were analyzed in the first stage from the legal and morphologically point of view.

That is why, knowing how and to what extent the building density of the city affects or diminishes the chances of capturing solar radiation, will allow better planning, as well as generating new appropriate policies for better land use.

SELECTING THE AREA OF ANALYSIS

A central area from San Miguel de Tucuman is studied as a test case to propose a methodology that can be applied to any area of it. This area of the city is considered representative in both ways: its urban morphology and from the point of view of real estate interests.

The Central Area of SMT has developed from its foundation framed in a 120 by 120 meters grid which, as time pass by, it has been growing in height- generating value - in denser areas from downtown area to the Great SMT.

\begin{figure}[h]
  \centering
  \includegraphics[width=\textwidth]{image1.png}
  \caption{URBAN MORPHOLOGY. Plot of grid urbanization. Clustering analysis condition: similar surface and morphology of blocks.}
  \end{figure}

The following variables were used to define the study area:

URBAN VARIABLES
- Blocks, shape (volume) and orientation.
- Streets, width.
- Distance between buildings and streets.
- Particular Urban Regulations for the area, feasibility of land uses according to activities.
- Trees, size and density (in this study this variable is not considered by the characteristics of the studied sector, where the trees do not have large scale – orange trees).

**BUILDING VARIABLES**
- Morphology, regular or irregular.
- Parceling, dimensions
- Different Urban Factors: LOF (Land Occupation Factor), FOL (Factor of land use), SVF (Sunlighting Volumetric Factor), SUF (Sunlighting Urban Factor), PEA (Potential Energetical Area), FF (Form Factor) (De Schiller, S.; 2002)

**SIMULATION AND EXPERIMENT**

The starting point of this methodology is the generation of geometries using appropriate software (Autocad and SketchUp) optimized to work modeling morphological and volumetric scenarios; then processing the incidence of radiation on the surfaces (Ecotect) and finally the post-processing of results with the aid of spreadsheets and graphic interface (Excel) for the presentation of data.

Based in the analysis of the urban layout of the central area with the frame that corresponds to the sectorization of the urban code, a study area is defined; it comprises blocks around San Martin’s Square.

Three scenarios were analyzed: Scenario 1: Current Situation. Scenario 2: Maximum building area by allotment with minimum height. Scenario 3:
Minimum allotment building area with maximum height.

The result of using a table where the dimensions of the ground are compared, and CUP constraints is constructed according to district regulations ends in an amount of allowed building area, which would be organized depending the expected scenario and will be arranged in the area taking the most in each way. This is done in order to push the boundaries of today scenario allowing the CUP with its benefits, virtues and defects.

At this point we can make the 3D digital model of the urban environment in which they will work.

A standardized orthogonal plot is constructed in order to simplify the representation. Thus the number of types of allotments is significantly reduced (eg. 52 allotments per block). So in this case we can reduce particular types from 52 to 10 different types per block. This simplification will automate the process of updating modifications for different scenarios. (Mesa, N.; 2010)

Once the base template is ready the procedure continues with the extrusion of volumes for each proposed scenario, considering its own characteristic.

Once geometries representative of each scenario are generated, the potential of solar radiation on the facades of the buildings is determined using a graph-based computational model based on hourly climate data.

**Figure 7 Scenario 1 Maximum building area by allotment with minimum height.**

**Figure 8 Scenario 2 Minimum allotment building area with maximum height.**

**Figure 9 Simplified orthogonal plots.**

**Figure 10 Scheme of the Simulation Process**

**Figure 11 Totals Solar Annual Irr. for Scenario 1**
It is also possible to qualitatively study the penetration of solar penetration into the courtyards (allowed by the CUP) through solar geometry.

It works on the basis of each of the proposed modeled scenarios, setting the model geo-location, hour, day and season. Different scenes are added in the same file. So with a single configuration it can turn on and off the various proposed scenarios and quickly compare them. Through a cutting plane we can see what happens with solar penetration inside the courtyards block by block and in every season.

Solar geometry study for June 21 courtyards and front cutting block.

Solar shading performance for different scenarios can be studied throughout the year or along a typical day on each season. Therefore the influence of height in the quality of the generated environment due to each building or a group of them towards urban spaces inside and out can easily be analyzed.
DISCUSSION AND RESULT ANALYSIS

The analysis of compact urban environments and its accessibility to solar energy is a challenging task either for urban planners as for architects when designing for a single plot. Therefore a simplified process which can ease the steps towards valuable conclusions linking morphology and size of future buildings is an asset. The results of this methodology show a variety of possibilities for the study of circumstances when relating the different possible scenarios with the solar irradiation. Scenarios 1 and 2 show how the development without restrictions in height and compactness affect the potential of using solar radiation for different purposes such as energy generation; furthermore it affects particularly the right to natural light as most of the surfaces of courtyards will receive low percentages of sun in winter being the case that San Miguel de Tucuman is not far from the tropic. It can be argued that this method uses simple tools for predictions in complex environments; however the process linking different tools in an automated sequence can be considered an interesting step forward for architects and urban planners. Furthermore, discussions about the future of urban codes which consider more in depth the potential of solar energy could be facilitated by this straightforward methodology.

CONCLUSION

A process of simulation of urban performance to analyze the consequences of the ongoing densification building industry in the central area of a city is proposed in this paper. The future consequences of the implementation of actual building codes if it continues in favor of property business benefits compromising sanitation and the right to natural light can be analyzed through this method. These first results of the application of a methodology to investigate the actual effects of the application of urban regulations allow:

- The analysis of the potential of clean energy production at urban level
- The evaluation of interventions at a general level (urban) or in a specific plot and their influence on the surrounding environment.
- To check the habitability of particular situations (courtyards in high rise buildings).

REFERENCES


IEA 2010 High rise refurbishment, the energy efficient upgrade of multistory residences in the EU. Paul Waide. IEA 2010.

