Variation in the Irradiance on Facades According to Solar Access at Neighbourhood Level in Winter, Santiago. A Rationale for Public Policy in the Urban Planning

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Abstract. Next COP25 will be held in Santiago city in 2019 and its slogan is “Time for Action” so the urban planning has something relevant to say. Given that cities and renewable energy are explicit thematic lines in the conference the current paper focus on that. Link between cities and solar energy affects stakeholders such as the real estate agents and community so they are both concerns of the public policy. Real estate agent needs to be aware of a technical matter that affects resident lives at the neighbourhood scale. To address climate change two approaches has been declared by IPCC: mitigation and adaptation measures. The former focus on reduction of CO₂ in which building sector plays a fundamental role in this task. Solar energy is a source of clean energy for heating and lighting the buildings. Therefore, it might be protected from solar obstruction coming from building surrounding. The purpose of the study is to discuss and old concept as solar access in a new context real states development giving some quantitative and qualitative assessments on facades under and none solar obstructions. Methodology consists of daily monitoring of insolation on building facades besides of modelling and simulation in Ñuñoa neighbourhood in Santiago in winter. Results reveal that a significant reduction of intensity in radiation is observed in those circumstances. Obstruction and no obstruction are the scenes analysed to compare irradiation on buildings facades. In addition, a qualitative analysis is made based on residents perceptions. Urbanism normative about shadows cast are also analysed to set out current limitations and possibilities to improve the legal instrument in the future. Conclusions state that a new focus is recommended for the public policy: think in surrounding energy effects rather than the building alone if mitigation measures want to be applied for sustainable urban planning.

1. Introduction

Next COP 25 will be held in Santiago city in 2019 which literally means the cooperation between parts from all over the world to deal with climate change. In fact, countries should negotiate actions plans to reduce CO₂ emissions to the atmosphere for preventing the increase of global warming up to 1.5ºC. [1] (COP, 2019). Both cities and renewable energy are explicit thematic lines for the conference in which urban planning has something relevant to say. Link between cities and solar energy affects stakeholders such as the real estate agents and community so they are both concerns of the public policy. Real estate agent needs to be aware of technical matter that affects resident lives at the neighbourhood scale. To address climate change two approaches has been declared by IPCC: mitigation and adaptation measures [2]. The former focus on reduction of CO₂ in which building sector plays a fundamental role in this task.
Solar passive energy is a source of clean energy for heating, cooling and lighting the buildings. Therefore, it might be protected from solar obstruction coming from building surrounding. Trend of construct smart building for energy efficiency and increase of electric consumption for residential use suggest need for demand-side management policy (DSM) [3,4]. A discussion of an old concept as solar access [5,6] is brought again in a new context; high-rise real states development spread quantitative and qualitative data.

High-rise real estate densities is a growing trend at the metropolitan pericenter in the Great Santiago on the last five years [7] [1] (INE, 2019). Ñuñoa district represents one of the process of demographic growing and building stock reaching a peak in 2016. Figure 1. Cities are changing according to urban regulations of the planning instruments as Plan Regulador and investment of the real estate in the urban renewal process. The real estate agents capture favourable market conditions and analyse urbanism normative through the study of the buildings regulations allowed on site. As a result, a maximum profit on each allotment is obtained according to shadows cast studies on neighbour site according to the General Ordinance precepts (Ordenanza General de Urbanismo y Construcciones) (OGUC). [8] [2]

In brief, the Chilean regulations (OGUC) about shadows (Art. 2.6.11) declares that isolated building might increase its building coefficient if they keep shadows of the projected volume under the shadows cast by a “theoretical buildings”. This last hypothetically applies the maximum overall building regulations on-site.

That change was incorporated into the urban planning regulations in the year 2003 whose initial spirit was morphological and sunny [9] [3] (DDU, 2018). It is an advance, though some authors found that shadows legal article orders a sun angles correspond to the equinox, a mild season period, instead of the winter solstice, the most unfavourable due to low temperature and high heating needs [10] [4] (Cárdenas & Uribe, 2012). In fact, the highest energy demand in Chile occurs in the month of July, winter in the southern hemisphere [11] [5] (MINVU,2017).

The shadow cast is longer in winter solstice than in the equinox then it is greater the area of solar obstruction in neighbourhood properties, a factor should be considered by the urban planning instruments. A substantive change is required to facilitate the use of solar energy, clean and renewable, for passive and active systems, reduction of heating and lighting costs in neighbours, and to encourage the use of living spaces due to their thermal conditions. In one word, to ensure solar access to buildings and public spaces as a new matter of public policy.

In Chilean public energy policy, several initiatives have already developed by the Ministry of Energy ME; Ministry of Housing and Urbanism (MINVU), and Ministry of Transport and Telecommunications (MTT). The thematic proposals of the Ministry of Energy (ME) are mainly the use of energy systems, technological innovations in matters of Non-Conventional Renewable Energies ERNC, diversifying the energy matrix and decarbonising [12] [6]. The MINVU is mainly oriented to the implementation of EE Energy Efficiency measures applied to the architectural spaces, sustainable construction systems, and building certifications [5][2] (NTM, 2014). MTT has recently been committed to electromobility to reduce atmospheric pollution from fossil fuels of public traffic [6].

There are significant advances, but there is still a missing point: the relevance of solar access in high-rise building from real estate densities in the city. Theoretical trends are also oriented to the city zero-carbon or neutral carbon, and last years a relationship between the urban fabric typologies and energy use has been studied in developed countries [13] [7]. A path of resilience for the polluted city and high energy demand are precisely the use of solar energy in the housing or flat.

LSE Cities is an international centre at the London School for Economics and Political Science and the European Institute for Energy research EIFER states that fill the gap between an established discourses about heat-energy-demand on building typologies to the neighbourhood level which has far been overlooked [14] [8].

The purposes of the paper is to show variation in the irradiance on facades under solar obstructions and no obstruction at all in a growing trend developed by the real estate located in the Ñuñoa neighbourhood. A rationale for public policy in urban planning is looked for changes in the building regulations.
2. Materials and methods

Design methods consider usual restrictions of energy software that estimate values as solar incidence on facades based on theoretical algorithm. In fact real atmospheric conditions such as air pollution, water vapour or heat which comes from the city might change those assumptions because of turbidity and local climate [15][16]. Then two approaches were used to deal with changes: theory and empirical fieldwork. In the former modelling and simulations were used to build urban morphology of case study located in Ñuñoa district. In the latter monitoring were used to measure solar incidence on solar facades: East, North and South.

Winter season starts the 21st June to 21st September in the southern hemisphere and June month was considered for simulations and monitoring purposes in order to compare solar values in the same periods to get an adjustment coefficient for future urban planning.

Many tools and models for climate-sensitive planning have been developed since the last 20 years which include a wide range of the built-up environment from simple geometric analyses to more complex ones. Issues such as shadows, thermal, radiation, biometeorology and wind are some features of them (Janicke, 2018).

Tools for modelling and simulations was ECOTECT software for solar analysis which deliver energy value (Wh/m²). It is chosen because it is a simple tool widely used by architects in past projects. Visualization is a relevant outcome for communications to actors in urban development whether real estate agents, civil servant or the community. Figure 2 shows allotment in the urban fabric and a typical path of the sun across the sky vault to communicate basics concepts of shadows along the day in June for isolated small house. Though the scene might dramatically change if other tall buildings are built on its side. One of the consequences is the loss of direct solar radiation and sunlight at the neighbourhood level.
Instruments for measurements on site were Kipp & Zonen Pyranometer SP Lite2 Silicon for global solar radiation and a Kipp & Zonen weatherproof LogBox SE Data Logger. The instruments were previously calibrated with Apogee pyranometers situated on the Campus. Three radiometer were set on each side of a weatherproof white box oriented to the East, North, and West. The height of instruments was 1.5m above the roof of the Campus building at the university as Figure 3 shows. This site is located in the centre of Santiago city to capture real atmospheric conditions in winter times. Usually, solar stations are located at the airport outside the city or meteorological station located in unique sites which are not representative of the urban microclimate.

Residents are one of the key stakeholders then a survey was another instrument applied to the case study of Nuñoa. A total amount of 26 houses were affected by shadows cast and selected one voluntary person living in some of them. A survey of 13 people was carried out to get the perception of the residents living in the housing affected by shadows cast from high rise buildings at the neighbourhood level. A set of questions categorized in four general issues were made for residents: urban renewal, high-rise building, solar renewable energy and willingness to pay. A Likert scale was used to identify which features was more relevant for neighbourhood and how the people feel about that. Five range punctuation were used as follow: very good, good, neutral, bad, very bad.
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3. Results and discussion

Figure 4 shows the modelling and simulation of solar energy on buildings in a classical garden city morphology characterised by low height neighbourhood extent to one or two-floor maximum within front garden and backyard. Residential towers erected along the traffic corridor reaches 26 floors on-site according to the new regulations of the Master Plan called Plan Regulador de Ñuñoa. They are located in northern of the block then a large shadow fall above houses behind them. Irradiance value (W/m²) were normalised to energy values (kWh/m²) to get the same unit for comparison purposes between modelling and monitoring. North facades values under shadow cast fall a half roughly compares to other houses having no solar obstruction at all. Then the urban facades of the block according to north orientation is a relevant issue for urban planning policy to save solar access of people.

Figure 3. Kipp & Zonen pyranometer for global solar radiation above the roof at University Campus

Figure 4. Modelling and simulation of solar radiation incident on facades (horizontal and vertical)
Figure 5 shows measurements of daily irradiance curves on June (winter month) when solstice (21st) occurred in the southern hemisphere and maximum mean values reach 450 (W/m²) on the north facades while (350 W/m²) and (190W/m²) in the west and east facades respectively. It is interesting to note that in the afternoon there are more irradiance than in the morning which might be explained because of the cloud or semi-clear sky in winter. Comparison of theoretical and empirical values point out higher values in energy software simulation than in on-site measurements which is important to bear in mind for urban planning and façade design as well.

![Irradiance on facades (W/m²)](image)

Figure 5. Daily irradiance measurements on facade in Santiago, June 2015

Figure 6 shows the results of the survey for people. Firstly, advantages or disadvantages of living close to a new residential towers were asked in relation to traffic, safety, urban facilities, solar obstruction, visual and lighting obstruction, social renewal, added value and overload infrastructure. It is observed that only one is perceived as a positive attribute: the urban facilities improve neighbourhood (1.77). Others have negative perceptions as traffic (4,15) the worse of them followed by visual and lighting obstruction (3,85). The percentage of the people who identify a positive attribute was 23% and 77% a negative one.

Secondly, people identify effects of high-rise building on their houses such as solar obstructions, visual and lighting obstruction, loss of privacy, and noise perception. The highest negative perceptions were solar obstructions (3,85) and visual and lighting obstruction (3,85) followed by loss of privacy (3,08) and lastly noise perception (2,00).

Thirdly, the relevance and feasibility of using solar renewable energy point out the maximum value at neighbourhood level (4,85) while at the owned house quite less (4,64) and lowest value for solar PV installation (2,08). Fourthly, willingness to pay for a location far from real estate development reaches 92% of the survey people and they will pay 31% more of the current value of its property if solar access is guaranteed.

Up to date urbanism, normative is required to deal with solar energy issues from the build of the city in terms of public space and urban facades. Solar access for south neighbour residents is a missing concept in the current Chilean regulations although people realised of its effects in the quality of the urban environment. The real estate agents have an enormous debt to the city and people because of that but it needs a strong State not only to develop new instruments of territorial planning (IPT) but to supervise and to enforce the new law for compensation measures.
4. Conclusions and future actions

Variations of irradiance on facades has been accomplished by quantitative and qualitative method to check solar access at neighbourhood level. Quantitative assessment used software modelling and monitoring on Santiago city while qualitative assessment used to survey for people. In the former, a little difference was found between theoretical and empirical values which tend to be bigger in modelling cases. Information to bear in mind for future action plans. In the latter people assess in positive and negative ways some attributes derived from urban renewal although they are quite a criticism for real estate development, particularly high-rise building close to their houses. Compensation from the private investment might be considered in the new Chilean Law named “Ley de Aportes” in which civil works or funds should be given for streets or public space.

Solar access was one of the underlying concepts for residents due to environmental effects on the quality of life, daily and season, such as solar obstructions, visual and lighting obstruction. Real estate development is perceived as a thread for living and renewable energy. A relevant issue for energy public policy in urban planning. Currently, there is an urbanism normative related to shadows but it focuses on private investment (a single building) rather than the public space (street or garden). Both should be considered because of the public interest and the needs for private investment as well to build the city. Seasonal estimation of shadows is a relevant issue because the Chilean regulations consider equinox rather than winter in which shadows are longer than equinox. Current COP 25 to hold in Santiago, Chile is a great opportunity to discuss future action plans to change vision and to get compromise for the urbanism pro-solar energy.

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