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Characterisation of representative building typologies for social housing projects in Brazil and its energy performance

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HIGHLIGHTS

- Characterisation of representative typologies built for social housing in Brazil.
- More recurrent building physics characteristics considered.
- Energy efficiency and thermal performance of Brazilian social housing analysed.
- Regulation for Energy Efficiency Labelling of Residential Buildings in Brazil used for analysis.

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ABSTRACT

In Brazil the housing deficit is around 5.5 million houses. To address this need, the government created a programme called “My house, My life”. The main subsidies of the programme are for families earning up to three times the minimum wage. In order to formulate strategies for more energy efficiency buildings, it is necessary to understand the thermal and energy performance of what is being built. This article defines representative projects for typologies being built in the Brazilian social housing sector through the analysis of 108 projects considering two groups of income levels and investigates the thermal and energy performance of the representative projects in relation to the Regulation for Energy Efficiency Labelling of Residential Buildings in Brazil for two bioclimatic zones. Five representative building models were defined. Considering the most common features found on the sample, the study suggests the importance of addresing energy efficiency measures on the sector since current building techniques for social housing shows a tendency towards a low performance in relation to the thermal and energy performance criteria of the Energy Labelling especially for lower income projects. This provides a basis for future policy and allows for more in depth studies within the sector.

1. Introduction

In Brazil 46.4% of primary energy is generated from renewable sources, mainly hydropower (13%), wood (9.5%) and sugar cane (19.1%) (Brazil, 2014). However, the situation is changing. The installed capacity of thermal generation in Brazil has increased by 41.2% between 2006 and 2010 due to an escalation in energy demand (Brazil EPE, 2013). The residential sector in Brazil accounts for 24.2% of the 48.5% of the total electric power consumption, which is attributed to the building sector (Brazil, 2014).

Brazil's housing deficit is estimated at 5.5 million homes, being approximately 83.5% urban (Brazil, 2011). 89.6 % of the deficit is among the population with income up to three times the minimum wage (Brazil, 2011) and Southeast and Northeast regions account for the majority of housing needs (Brazil Mincidades, 2012a).

1.1. Social housing plan "My House, My Life"

In 2009 the National Housing Plan (PlanHab) introduced a long-term plan for 2023 for the housing sector. This plan included the "My House, My Life" Programme (Programa Minha Casa, Minha Vida – PMCMV) to address the housing deficit. The Programme on its second phase has subsidies based on fixed values by family income Band. The first family income Band was up to R$ 1600.00 per month[1]; 2nd Band up to R$ 3275.00; and 3rd Band between R$ 3275.01 and R$ 5000.00 (Brazil, 2013a). The

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[1] 1 US$ = around R$ 2.70 in December 2014 and the minimum national wage in 2014 was R$724.00.

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Programme intends to subsidise home ownership for families in Band 1st and facilitate access conditions to property for families with income up to R$ 5000.00 (Brazil, 2015).

In the Programme, social housing projects for lower income families (1st Band) are mainly implemented through Housing Companies and State Agents, which, in most cases, are responsible for the projects and sometimes subcontract private companies to implement and/or design the projects, operating the municipal government in cooperation with the State or the Federal government. On the other hand, housing for people with higher incomes (2nd and 3rd Bands) are developed largely by private companies or entrepreneurs (UNEP, 2010). There are 34 Housing Companies and Financing Agents in 18 Brazilian States (ABC, 2013).

Among the projects prioritisation criteria for the Programme, especially for the 1st Band is the "lower cost of the housing units" as set out in Annex I[2] of "Portaria No. 465" of October 3rd 2011 (Brazil Mincidades, 2011). The minimum specifications (regarding unit area, windows dimensions, among others) required for the projects and the maximum value and subsidies of the units in 1st Band are determined by the housing typology according to the Programme strand and financing adopted (FAR, FDS or Public Offer) (Brazil Mincidades, 2012a). In relation to sustainability, for this Band, the programme only demands items such as individual metering of water and gas, and the mandatory use of solar heating is implemented mainly in detached and two storey houses projects of 36 m^2 and 39 m^2 financed by the FAR, and of 38 m^2 financed by the FDS. There are some differences in requirements that are mandatory for the building projects according to the Programme strands attended that affect thermal and energy performance, but it is observed that there are not significant differences regarding floor area, number of rooms or layout of the requirement projects within the diverse Programme strands.

The limited budget available for the significant number of houses to be built often results in low build quality and thermal performance, and the absence of energy efficiency measures (Bodach and Hamhaber, 2010) in particular for projects aimed at lower income families (Almeida et al., 2013; Linck et al., 2013; Silva et al., 2013; Curcio et al., 2013). Especially in this sector, the current situation of housing policy in the country tends to prioritise capital costs, without much consideration on the long term benefits and thermal performance.

For projects of Bands 2 and 3, rules are for more general guidelines with issues like accessibility, compliance with environmental preservation standards, municipal ordinances regarding the quality of building and participation of companies holding the SiAC[3] (Brazil Mincidades, 2012b). Resources from FGTS are mainly used in these Bands. Recently, criteria were defined for application of environmental and social guidelines for housing on the Programme financed with this resource (CAIXA, 2015). Measures recommended related to energy efficiency and eligible to be financed are renewable energy systems like solar water heating and micro-generation for electricity and white roofs for multifamily buildings, among others. Also, incentive could be given for national environmental certification process.

1.2. Building typologies as a basis for policy

Projects in Brazil should respond to the different climatic needs. NBR 15220-3 (ABNT, 2005a) divided the country in eight bioclimatic zones. Zone 1, includes climates in the southern part of the country with more necessities for heating; zones 2 and 3, especially in the south and southeast have similar requirements for summer and winter; zones 4, 5 and 6 have necessities for summer and winter strategies, but the differences between them is less pronounced than on the previous zones. Zones 7 and 8 mainly located on the north and northern part of the country, need only strategies for summer (CAIXA, 2010).

To encourage energy efficiency in buildings, Inmetro with the support of Procel Edifica launched in 2010, the Regulation for Energy Efficiency Labelling of Residential Buildings (RTQ-R) in Brazil as a voluntary scheme, for now on called here Energy Labelling. The aim is the identification of the energy efficiency level of residential buildings and houses, with levels ranging from A (most efficient) to E (least efficient) focusing on naturally ventilated buildings.

Considering the impact and growth of the social housing, it is critical to address this sector in order to achieve Brazil's government energy reduction targets. A characterization of the projects that are being built today, with the formulation of typologies and analysis of their thermal and energy performance, would help in forming the basis for effective policy in the housing industry.

Building typologies can be used to assess the energy performance of buildings. The International Energy Agency (IEA) defines two fundamental modelling methods to analyse aspects of energy use from buildings: bottom up and top-down method. The top-down modelling tends to be used to investigate interrelations between the energy sector and economy (Kavgic et al., 2010). In the bottom-up model are two approaches, one based on statistical and, other based on the physics of buildings which include consideration of samples of representative buildings (Shorrock and Dunster, 1997). Carlo and Toccolini (2005) argue that a representative building should be determined considering similar features representing characteristics of the sample.

Studies of the existing building stock are numerous (Balaras et al., 2007; Dall'O' et al., 2012; Nik, Sasic Kalagasidis 2013; Theodoridou, et al., 2011) but usually do not address building typologies of recent buildings with much detail.

In Brazil, some research has resulted in representative models of the residential sector. Tavares (2006) proposed a methodology for measuring the energy life cycle of Brazilian residential buildings, including five models as representative of the sector based on a top-down approach. However, floor areas assumed for the lower income models do not match the average areas that are delivered today within the PMCMV.

Schaefer and Ghisi (2012) developed a representative model of existing social housing in Florianópolis, south of Brazil to be used in computer simulations based on data from 10 buildings. Later, Schaefer et al. (2012) collected data from 30 homes resulting in two typologies models considering family income up to R$ 1600.00 and between R$ 1600.00 and R$ 5000.00. Data were processed with statistical methods through mean values, standard deviation and confidence interval considering the most recurrent features of the sample. These projects are a sample of existing social housing in Florianópolis, however, not necessarily what is being built in PMCMV. In particular, the model for lower income shows only one room, outside the requirements of the Programme.

Thus, the purpose of this paper is to define representative models of new projects currently being built in Brazilian social housing sector and to evaluate the thermal and energy performance of these projects against the Energy Labelling considering two Brazilian bioclimatic zones. This provides a basis for future policy and allows for a more in depth study of the impacts and benefits of incorporating energy efficiency measures within the sector.

2. Methods

To develop and evaluate representative projects of social housing being built through the PMCMV based on real data with

[2] Provides guidelines in the National Program of Urban Housing (PNHU) for projects in PMCMV with FAR resources for Band 1st.

[3] Certificate of Assessment System of Services and Works Compliance.