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Initial Research Analysis of Solar Energy Procedure for use of Solar Energy in Buildings Residential Valuation

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Abstract

The process of technological innovation in order to save energy and to meet the building project encourages the search for new sources of energy from the beginning of the development process. For this research was proposed to investigate the thermal comfort and their contribution to improving the well being of the building users, from three case studies developed regions in the states of São Paulo, Rio de Janeiro and Roraima located in Brazil. The methodological approach relied on the assessment of buildings comfort conditions based on the data collection methodology developed by Moraes (2004), the influence of the thermal performance of the building standard, NBR 15575-1, and the feeling of comfort human heat, Fanger (1972) in buildings. The research analyzed techniques and design procedures to evaluate the solar insolation conditions, shading, air and renovation of the original building floors in contact with the ground during the summer and winter period. A new residential project procedure was proposed based on thermal performance technology of residential buildings to encourage the use of solar energy. When comparing residential project procedures, ie the condition of human thermal comfort feeling of existing work and later reformed it was the influence of solar technology in residential design. So this article is a reflection on the ways and means by which the projects of buildings organize the search for high-quality design solutions that get the feeling of thermal comfort of the building user.

Keywords – technological innovation; thermal comfort; regions; solar energy; climate

1. Introduction, Objective and methodological approach

It was proposed for investigating research from three studies of Brazilian case, such as local climatic conditions can influence the environmental performance of the building and thermal comfort feeling of its residents. The methodological approach adopted is objective and subjective physical measurement, explained in detail by Moraes (2004), is summarized below. As the case study took place in three distant regions the first stage of the study corresponded to the establishment of a theoretical reference, comprising the fundamental methodological elements that characterize the collection of data and the actual thermal behavior. This guided the activities of the following steps Table 1.

Table 1: Data collection of subjective and objective physical measures (Moraes, 2004)

Survey of climatological variables of external and internal environment		Thermal perception of the building user through evaluation questionnaire
External	Internal	Questionnaire
Weather station	Registration internal climate data through "data logger" and "sensors"	based on Fanger method (1972) refers feel of human thermal comfort and Givoni (1968) is based on the thermal performance of the building

Survey of climatological variables of the external environment

- Local weather

The climate of the three regions of Brazil are the city of Araraquara, SP being at a distance of 270 kilometers from São Paulo Capital. It is located at 21°47'40" south latitude and 48°10'32" west longitude at an altitude of 664 meters. The weather during summer maximum temperature of 30 °, 18 ° minimum temperature relative humidity 78%, 12% solar radiation. And the climate during winter maximum temperature 28 °, 12 ° minimum temperature, relative humidity (dry season). The city of Boa Vista, Roraima located at 76 meters altitude, latitude 2 ° 49'10" North and Longitude 60 ° 40'17" West. In summer the climate during summer maximum temperature 32 °, minimum temperature 22 ° relative humidity 63%, average solar radiation 11% and may increase up to 22%. And winter weather during the winter maximum temperature 32 °, 20 ° minimum temperature relative humidity, solar radiation decreases 30%. The city of Rio de Janeiro, Brazil is located at 22 ° 54'10" south latitude and 43 ° 12'28" west longitude at an altitude of 2 meters. The weather during summer maximum temperature of 30 °, 25 ° minimum temperature relative humidity 78%, 14% solar radiation and the climate during winter maximum temperature 32 °, minimum 18 ° temperature, relative humidity. Table 2 - 6 summarizes the methodological elements of the external environment that make reference to the typical day of autumn, winter spring and summer.

Table 2: 25/10/16

	Temperature max and min	**Air velocity**	**Air humidity**
Boa Vista – RR	25° e 32°	NE 22 km/h	58%
Araraquara – SP	20° e 29°	N 10 km/h	80%
Niterói – RJ	26° e 35°	NNO 6,25/h	80%

Table 3: 2015 - UVI max predicted

	Autumn March 23	**Winter June 21**	**Spring September 23**	**Summer December 21**
Boa Vista – RR	13.5	10.2	11.4	10.2
Rio Janeiro – RJ	10.3	4.8	9.8	13.2
São Paulo - SP	10	4.8	10	13.5

Table 4: 2015 - mm / rain

	Autumn March 23	**Winter June 21**	**Spring September 23**	**Summer December 21**
Rio Janeiro – RJ	109mm	62mm	90mm	129mm
São Paulo - SP	103mm	46mm	117mm	173mm
Recife - PE	307mm	329mm	79mm	312mm

Table 5: 2015 - minimum temperatures

	Autumn	**Winter**	**Spring**	**Summer**
Rio Janeiro – RJ	22°	18°	20°	23°
São Paulo - SP	16°	12°	15,25°	18°
Recife - PE	22°	21°	21°	° a °

Table 6: 2015 - maximum temperatures

	Autumn March 23	**Winter June 21**	**Spring September 23**	**Summer December 21**
Rio Janeiro – RJ	28°	25,5°	26°	29,5°
São Paulo - SP	25°	22,5°	24,5°	27,5°
Recife - PE	29,5°	28°	29°	° a °

Survey of climatological variables of the internal environment

The internal data record occurred through "data logger" and sensors to monitor the temperature [T (° C)], humidity [UR (%)] and air velocity [Var (m / s)] and atmospheric pressure P (atm). Physical measurements of the internal monitoring were obtained by the following equipment: 1) datalogger, 2) Thermo par type T; 3) Psychrometer, 4) hot wire anemometer and 5) globe thermometer.

Thermal perception of the building user through evaluation questionnaire

The questions asked to the residents of the homes, illustrates the need to provide the full team early on and keep it throughout the process. It was found that each step of the process is characterized by iterative cycles in which the alternatives are formulated, tested and reformulated to meet the best solution. So the questions put to the residents of the homes are based on the feeling of thermal comfort, used in studies of Fanger (1972) and evaluation of the building Givoni (1968) and post-occupation Orstein (1992), with adaptations, prepared a questionnaire through simple language interpretation for the evaluation of the environments in this study, which was divided into three parts: 1) profile of residents: age, sex, height, weight, nationality, scholarly, current year, description of clothing; 2) thermal conditions: temperature, preferably for the period, description of physiological sensations, disease and 3) discomfort factors: perception and preference as to the movement of air (air speed), and environmental cooling, evaluation of thermal comfort as well as preferred location of the used rooms.

Evaluation thermal performance of the building

The evaluation thermal performance of the building will be based on the NBR 15575-1 establishes basic requirements of life and the guarantee of the main systems that make up the buildings. In 2008 there was the first publication of ISO 15575-1 by ABNT, Brazilian Association of Technical Standards, being revised in the years 2010, 2012 and 2013. The standard started to be used on February 19, 2013 with validity from July 19 the same year. The standard sets NBR 15575-1 (ABNT, 2013) determines that the thermal performance of the building should be evaluated for the performance conditions in winter and summer. As analysis criterion is based on the maximum and minimum temperature environments with prolonged stay as dorms or living room to assess the conditions of her are critical thermal point of view. It was observed the lack of some important information to calculate the solar irradiation in which the building is exposed, like the kind of sky and a typical day date project, which depending on configuration may or may not facilitate the approval of a construction system.

Choice of built projects

The projects of national buildings were chosen according to the facts of a) interviews with the owner of the buildings; b) a proposal for reform have been initiated to increase the environmental comfort of the residents of the buildings to reduce energy consumption and c) seek construction project solutions with technologies aimed at improving the environment.

Interviews with owners of buildings occurred in all stages of data collection, proposals for reform and construction of the new design stage. The investigation sought to rescue the history of each cultural process in the region, highlighting the main problems, the positive and the results achieved for the environmental performance targets of the building with thermal comfort solutions for residents.

The following steps were conducted as another stage of preparation for data collection:

Through the development of a protocol for data collection, in which the following types of evidence were identified: a) methodological elements from the environment climatological and questionnaire; b) Performance Goals of the thermal environment of the building and c) design solutions. Were prepared also the following instruments that constituted the research database I) registration forms and analysis of evidence; II) guide chips for interviews; and III) assessment questionnaire design process management.

Data collection was performed through interviews and project documents studies, between 2014 and 2015, in order to investigate the occurrence of evidence at each stage and the relationships between them. Were investigated the following a) architect author of the project; b) designer structures; c) air conditioning designer; d) designer energy simulation; e) technical lighting designer; f) thermal and acoustic comfort consultant; g) researcher at the consulting team in eco-efficiency and h) frames consultant.

Data analysis aimed to position the case studies in relation to the theoretical framework; and discussed the design aspects of the buildings, from the most significant experiences, difficulties and positive points noted.

The aim of this paper is to present the main results related to the following of this research: a) documentation of studies of buildings in three different climate regions divided into Brazilian states; b) thermal comfort; c) thermal performance of the building; d) technological innovation applied to energy savings; f) passive technology evaluation according to the insolation, shading, air renewal and the floor of the original building in contact with soil; g) use of solar energy in residential buildings and h) the importance of checking the life cycle for operation and maintenance costs of the building.

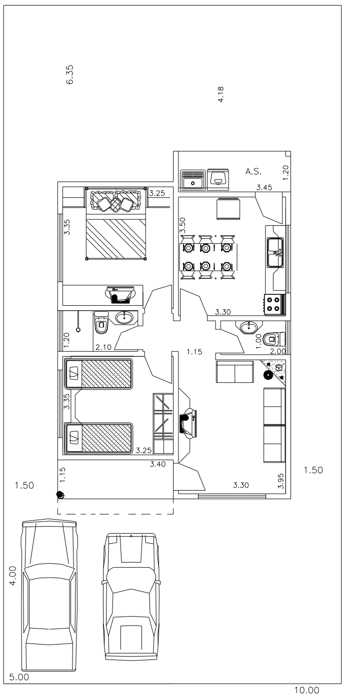
Features of the project from unifamiliar edification

The characteristics of the single-family buildings are described in Table 7.

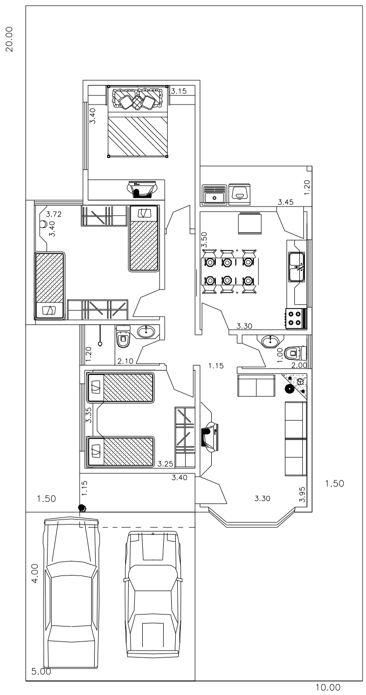
Table 7: Characteristics of buildings

Edification	City _State	Population (n°)	Building area (m²)
Casa 1	Araraquara, SP	3	87
Casa 2	Boa Vista, RO	3	67
Casa 3	Rio de Janeiro, RJ	3	140

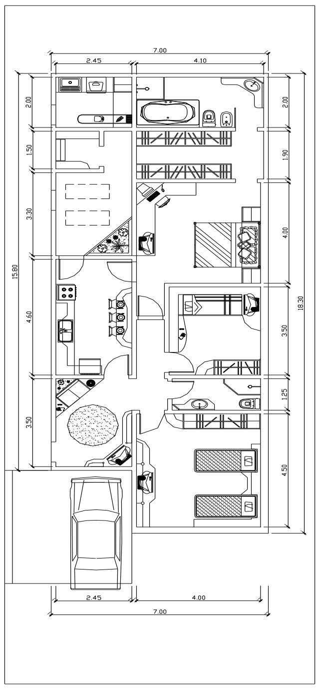
The material used in the construction of the buildings are made up of ceramic tile, aluminum gutter, armed slab of ceramic blocks. The walls are common brick built on the site, with thickness of 15 and 25cm. The size of the opening for ventilation and lighting ranges from 25% to 20%. The floor plan of the building are shown in Figures 1a,b,c.



1a
Figura 1a Araraquara,SP



1b
Figura 1b Boa Vista, RO



1c
Figura 1c Rio de Janeiro, R

2. Discussion

Today due to the brazilian energy crisis and the search for quality of the building and the questioning of the population related to high energy costs is one of the national priorities due to various additions over a year in monthly consumption rate with an increase of 50% over 2015. As there is also the question about the aesthetic development of buildings with damage to the environmental comfort. The questioning by the building user to construction refers the question "The building is aesthetically beautiful but and environmental comfort as can be achieved by reducing energy consumption."

Reducing energy consumption can take place through two types of solar energy technology in homes and the solar panels and solar water heater both can be applied and / or integrated in the building and connected to the grid. Through photovoltaic solar panels with solar cell / photovoltaics, use the photovoltaic effect to absorb energy from the sun and causing the electrical current to flow between the two layers with opposite charges Already the water heating by solar energy is composed of collectors / solar panels and thermal reservoir, "bolier" and these collector plates are responsible for the absorption of solar radiation. These technologies are essential to transform a building or residence at zero energy.

Solar panels can be used on roofs and facades and aesthetic models, or even replace sun protection. However, due to the urban planning of cities should be considered some building design particularities where the work is located. This is because to maintain the energy efficiency of photovoltaic equipment must be properly installed by the builder during deployment in work because the envelope of the building, and shadows of equipment can reduce your ability. According Givoni (1998), through urban policies and urban design, can interfere with the climate of a given location, providing thermal comfort inside and outside of buildings and thus reduce the energy demand for artificial air conditioning." The costs of photovoltaic panels are reducing but to transform the building zero energy (EEZ) requires certain design requirements to capture enough energy for the consumption of the building. Through a planning prior consumption, the type of adaptive system, working in conjunction with renewable energy sources in the project. But users of the buildings have resistance to this type of equipment due to the high cost of implementation, not checking the return of the equipment installation may be repaid by reducing the rates of the buildings energy consumption over the years, so do not one thinks of the long-term benefit. A successful example of the use of solar energy in Brazil is the Environment Agency Energy, headquarters of companies in the Enel Group in Niterói (RJ). Where is the solar pannels on the parking lot. Who reaches the mark of 50 MW of solar power generation in one year of operation. Parking (Figure 4) allows accommodate 20 cars being built in an area of 260m2 with 175 solar panels installed in an area. The volume is enough to power about 25 houses simultaneously with an average consumption of 200 kWh / month. The solar power generation avoids emission of 6.2 tons of CO_2 in the atmosphere, I would calculate the average per month, corresponding to six cars that run 17 kilometers a day representing a saving of 60 million liters of water consumption used if generated by hydropower. Allowing self-consumption and the surplus sharing generated with the electrical system, according to Resolution 482 of the National Electricity Agency, Aneel. (Procel, Info 27/01/16).

Figure 4. Solar Parking Enel

3. Results

Residents evaluated the single-family building in relation to aspects of sunlight, shading, air renewal and the original building floor. The materials used for the construction of building formed the basis to verify the feeling of comfort during the winter and the summer period. Table 8.

Table 8: Materials used in the construction of the building in Brazilian cities

	Araraquara-SP	Rio de Janeiro-RJ	Roraima - RO
Insolation	Heat gains due - double brick clay wall; - Clay Tile; - wholesale trailer - Ceiling height 3.2 meters.	Heat gains due - Bahia simple brick wall; - Clay Tile; - fine trailer; - Right foot reduced h = 2.8 meters.	Heat gains due - simple brick concrete block wall; - Clay Tile; - fine trailer; - Right foot reduced h = 2.8 meters.
Shadowing	Sun Protector - Solar Brise; - arborization.	Sun Protector - blinds; - awnings, - curtains.	Sun Protector - blinds, - pergolas, - curtains
Air renewal	Natural ventilation and artificial - Air-conditioned dormitory; - Fans all rooms	Natural ventilation and artificial - Air-conditioned dormitory; - Fans all rooms	Natural ventilation and artificial - Air-conditioned dormitory and living room; - Fans kitchen, living room.
Floor of the building	- Cold floor and taco	- Cold floor	- Cold floor

The feeling of thermal comfort according to the natural and artificial ventilation during the summer and winter occurred according to Table 9.

Table 9: Comfort Feeling

Ventilation Type	Natural ventilation	Artificial ventilation	Unconditioned
Period	Summer	Summer	Winter
Araraquara-SP	Warm	Neutral	Slightly cold
Rio de Janeiro-RJ	Hot	Slightly warm	Cold
Roraima (RO)	Hot	Neutral	Neutral

Obs. Residents of the city of Boa Vista use air conditioning throughout the year because the winter maximum temperature 32 ° C, minimum temperature 20 ° C

The reform had as proposed building project to reduce energy consumption in order to minimize its energy demand. The sequence of photovoltaic panels were applied to the envelope of the building to generate the energy needed to achieve an annual energy balance reduced from previous years. The application of photovoltaic in building coverage allows absorb large amount of solar radiation during the day.

It was found that the largest expenditures are air conditioning and lighting. The old lamps were replaced by lamps with technology "led". The LED is a corresponding LED (or Light Emitting Diode). It features a well reduced size compared to other lamps and the LED has a brightness good rate.

The installation of windows with larger openings are used to increase airflow into and out of the building. The exchange of walls plaster increases the thickness to 3 cm (Araraquara), 4cm (Rio de Janeiro) and 5cm (Boa Vista) using textures and colors of pastel shades reduce heat load gains given the standard of thermal performance adopted . The air conditioners were replaced by modern equipment that have reduced energy consumption. Surrounding the building trees were planted, grass and gardens to mitigate the temperature, in the case of the building located in Rio de Janeiro to reduce air pollution.

As for the management of the building, it can be observed that a multidisciplinary homebuilder staff can bring meaningful solutions to reduce the cost of reform and propose alternative strategies to reduce energy consumption in air conditioning and installation of equipment in the building using manpower qualified and trained to install the materials.

The use of NBR 15575-1 (ABNT 2013) show that the building of the road conditions in contact with the soil favor the thermal performance of residence. Note to get the best results it is important to use appropriate floors and thermal insulation used in your installation.

4. Conclusions

An important contribution of this research occurs is due to the building design process with research, with the characteristics of the buildings and the common problems faced by residents of different climatic regions. But it is observed that require different building design solutions prioritizing adaptation of the residence to the weather.

In this first stage of the research is concluded that the comparative analysis between the three processes, including the strengths and difficulties, which reinforces the validity of lessons learned and discussed as a reference for future projects. In the three case studies, particular resident's presence was found to find innovative technology to reduce the cost of energy. In this sense it includes the use of photovoltaic plates to reduce the power consumption. Local climatic characteristics were essential to direct the design guidelines for future reform with the computer simulations for energy reduction as a priority to positive results since the beginning of preparation of the reform project to its executive project ending with good use after occupation the building. The lessons learned suggest that information to the owner on how to reform the building to reduce energy consumption is crucial since the beginning of the project and knowledge of the various design possibilities can not implemented with cost planning and making possible range of more aggressive targets on environmental performance.

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