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Energy Eficiency of Social Housing Existing Buildings – A Portuguese Case Study

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ABSTRACT

The European energy performance building regulations, Directive 2002/91/EC - Energy Performance of Buildings Directive (EPBD) of the European Parliament and Council, require that new buildings present minimum standards of energy efficiency. Accordingly the Portuguese regulations require that new buildings comply with minimum requirements on the energy performance and must have an energy performance certification through witch an energy efficiency label is attributed to the housing. It also require that existing buildings must have an efficiency energy label when submitted to a commercial transaction or to a deep rehabilitation. To achieve this goal the study of energy performance of existing buildings must be done. As many essentials elements to determine the U-factor and other thermal parameters are unknown, Portugal developed a simplified methodology to achieve the thermal performance of existing buildings. The aim of this paper is to present the study of the energy performance of a set of social dwellings that were constructed during the decade of 80, constructed before the former building thermal comfort specifications came into force. During the study the referred methodology was applied and conclusions of the energy efficiency label obtained were put out as the encountered difficulties. The study also compares the results obtained by the simplified methodology and by the detailed methodology that is required by Portuguese building thermal comfort specifications.

Keywords: Energy efficiency; social housing; sustainable construction.

1.INTRODUCTION

The Directive 2002/91/EC - Energy Performance of Buildings Directive (EPBD) of the European Parliament and Council on energy efficiency of buildings was adopted, on 16th December 2002 and came into force on 4th January 2003 [EPBD, 2002]. The EPBD is considered a very important legislative component of energy efficiency activities of the European Union designed to meet the Kyoto commitment and respond to issues raised in the Green Paper on energy supply security [CGP, 2000].

The EU Action Plan for Energy Efficiency identifies energy efficiency in the building sector as a top priority. The EPBD has a key role for realising the potential savings in the building sector, which is estimated at 28% and which in turn can reduce the total EU final energy use by around 11% [APEE, 2006]. In Portugal the EPBD along with related directives came into force in April 2006.

The Portuguese regulations require that new buildings comply with minimum requirements on energy performance and must have an energy performance certification through which an energy efficiency label is attributed to the housing (Figure 1).

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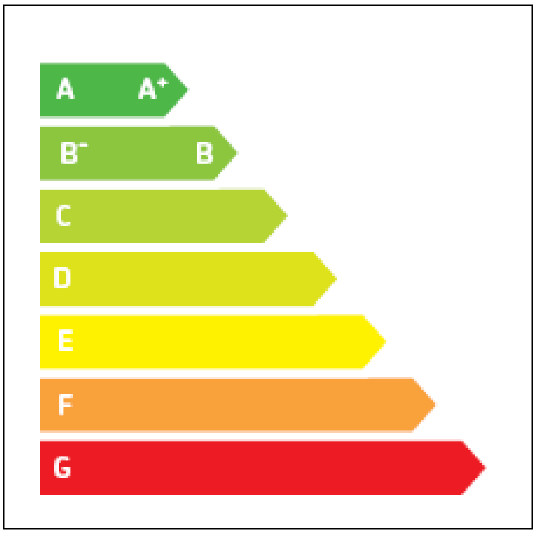

Figure 1. Energy efficiency label

A building service life is normally expected to be at least 50 years. An energy-efficient design can lead to considerable savings over its lifetime. Apart from reducing fuel and electricity bills, an energy efficient design can provide higher interior thermal comfort for occupants while being less vulnerable to the increase of energy costs. An energy-efficient design has to be planned from the beginning of the design phase until the end of the construction. It is extremely important to develop a study in the architectural phase of the project, to achieve a correct building orientation, the window and shaded zone projection and high thermal performance of the envelope. Although some efficient energy measures may be implemented after the construction, this is often harder and more expensive.

Higher levels of envelope insulation than those required in the thermal building regulations are in many situations economically justifiable. Solutions with well distributed insulation for the whole building envelope (exterior envelope walls, roof and floors) are more sustainable than in cases for which there is a high level of insulation for exterior envelope walls and for other elements lack of insulation, for example, no roof insulation [SEI, 2006].

On the 1st of January of 2009 came into force the last phase of the implementation of the Energy Certification System [SCE, 2006] in Portugal. Accordingly it is also required that existing buildings must have an efficiency energy label when submitted to a commercial transaction (when rented or sold) or to a deep rehabilitation. A technical note was published to support the energy certification of existing buildings [NT-SCE-01, 2008]. This note introduces a simplified methodology to obtain the energy performance of a building based in the detailed methodology defined in the legal requirement DL 80/2006 [RCCTE, 2006]. That simplified methodology permit to apply simplified criteria in several aspects [NT-SCE-01, 2008]:

- dimensional measures;
- heat lost through the envelope;
- constructive solutions identification and characterisation;
- mechanical ventilation;
- solar gains through window glazing;
- thermal inertia class;
- solar collectors systems;
- heating and cooling system;
- hot water heating device systems.

The aim of this methodology is the improvement of the energy performance of the existing buildings. In spite of this it does not lead to an envelope insulation improvement or upgrading, but to the inclusion of efficient energy systems (heating and cooling systems, hot water heating device systems, mechanical ventilation systems). The energy certification must implement the thermal comfort thinking but also the opportunity to solve hygrothermal defects, achieving higher construction durability.

The aim of this paper is to present the study of the energy performance of a set of social dwellings that were constructed during the decade of 80, constructed before the former building thermal comfort specifications came into force. The study compares the results obtained by the simplified methodology and by the detailed methodology that is required by Portuguese building thermal comfort specifications.

2. ENERGY EFFICIENCY

To achieve sustainable construction several strategies have been implemented along the years and some aspects are considered during the buildings' design phase:

- building geometric forms;
- facades building orientation;
- construction solutions of the envelope;
- natural environmental respect;
- use of natural resources (energy, water, land) as productive resources.

The perspective of the world population to achieve the 10 000 millions in 2050 year will cause a severe environmental impact, that seems to be 8 times superior than the actual one. So it is fundamental to implement in the construction the principles of the 4 R's [Lauria, 2007]:

- Reuse – give priority to the reuse of a building in spite of its demolition;
- Recycle – to use a great percentage of recycle construction materials diminishing the energy consumption necessary to their production;
- Reduce – reduce the consumption of new materials and the waste production, rehabilitating the existing buildings;
- Rehabilitate – decide to the rehabilitation of the existing buildings in spite of their demolition.

Despite new buildings are constructed under the specifications of the actual Building Thermal Performance Regulation [EPBD, 2002; RCCTE, 2006] it is possible to improve the energy efficiency of the existent buildings. Their rehabilitation is essential because their reuse will produce a lower environmental impact when implementing energy efficient solutions. The new legal specifications establish that new and existing buildings must have an energy efficiency label that demonstrates:

- which is the building energy performance level (9 levels from A+ to G, and the legal specifications establish that to new buildings the label must be from A+ to B- and to the existing buildings it can be one from A+ to G);

- the CO_2 emissions;

- the nominal energy needs: heating energy needs, cooling energy needs, hot water energy heating needs;

- the energy performance and air quality improvement proposals;

- the new energy performance class (if the proposals are implemented);

- the composition of the construction elements (walls, pavements, roofs, thermal bridges, glazed surfaces, heating and cooling systems, renewable energy systems, hot water energy systems (not renewable), ventilation systems.

The energy efficiency label has the aim to assure that the former owner of the building took place the necessary measures to get lower energy consumption and that the users can reduce and control their own energy consumption. This paper presents the results of the energy efficiency classification of a social residential apartment block, constructed in the city of Aveiro in the centre of Portugal.

3. CASE STUDY

This case study is part of a research work developed within a master thesis titled “Energy efficiency of a set of social housing and improvement solutions” as well of the PhD thesis titled Social Housing Maintenance Condition - Evaluation index and methodology to be obtained [Rodrigues, 2008].

3.1. Case Study Characterisation

The set of buildings studied is constituted by social housing apartments blocks constructed and rented by Aveiro local city council. The constructive typologies are similar to all the buildings (Figure 2).

Figure 2. Principal and posterior facade of one of the building blocks

This set of social housing are inside the urban zone, and has 443 apartments with 4 housing storeys including the ground level. Each building has one or more blocks (each block corresponds to one building entrance) and a regular plant. These buildings were constructed before 1990, the year of the publication of the former thermal building specifications. Accordingly they do not have any thermal insulation system. In spite of this the lateral walls have an exterior insulation system located above the level of the first storey, placed years after the construction of the buildings. Below this level the walls have a ceramic cover around the building. The ground floor is elevated 65 cm from the soil and the cavity below the pavement of the ground floor has low ventilation. The laundry facade is strongly ventilated.

3.2. Energy Efficiency

It was carried out an energy analysis from one ground floor dwelling that has been identified with a disadvantageous solar orientation: lateral façade oriented to North and the principal facade oriented to West (Figure 3).

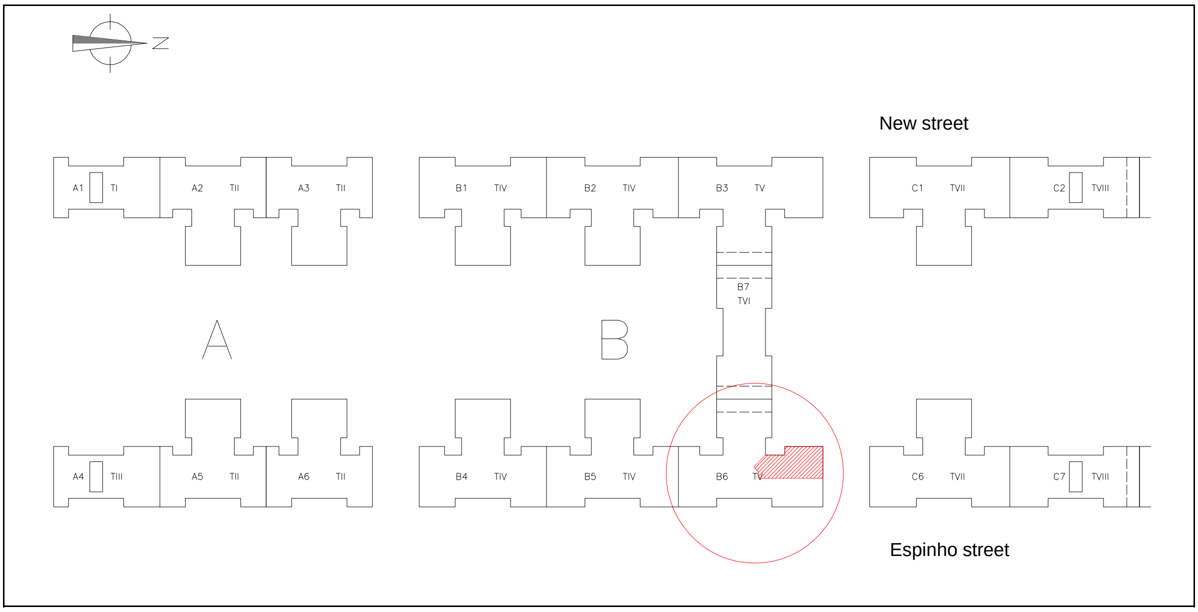

Figure 3. Location of the studied apartment block

The dwelling envelope and plant is represented in Figure 4. Figure 5 contains the construction solutions details of the different elements of the envelope.

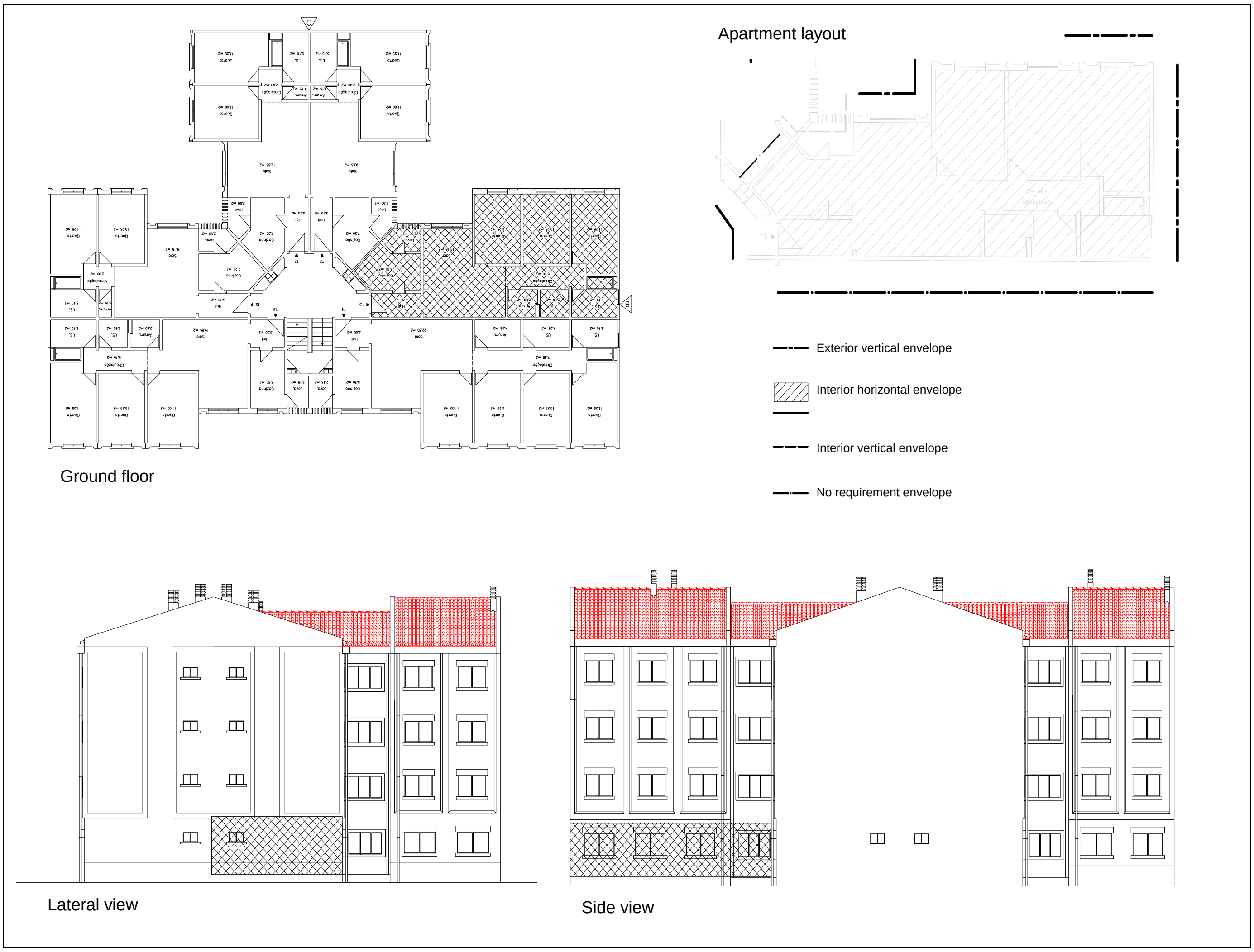

Figure 4. Plant and envelop of the dwelling

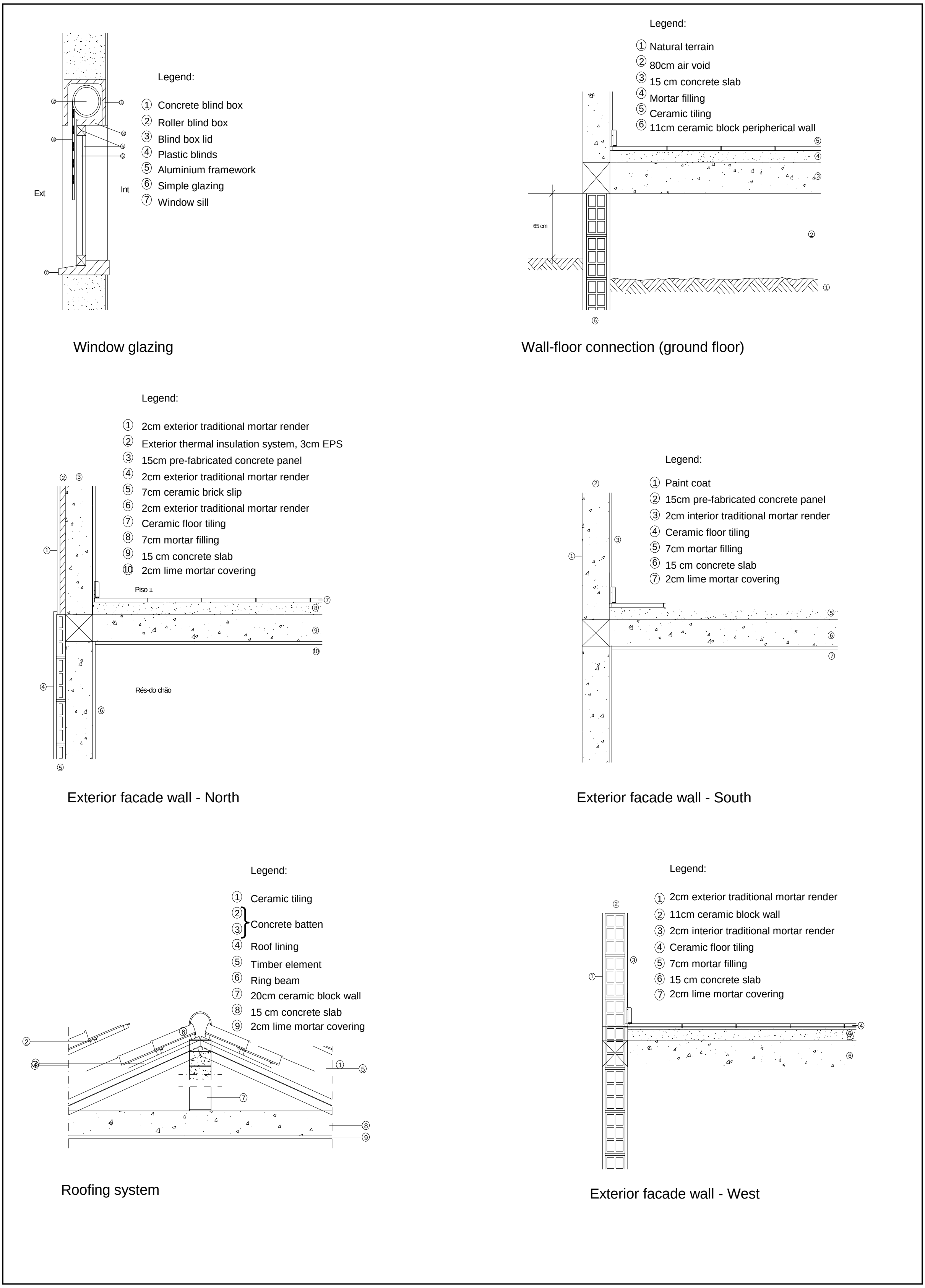

Figure 5. Details of the envelope constructive solutions.

To obtain the housing energy efficiency label was applied the detailed method established in the Building Thermal Performance Regulation [RCCTE, 2006] and the simplified method indicated in the technical note

[NT-SCE-01, 2008]. According to the Portuguese Building Thermal Performance Regulation [RCCTE, 2007] the building is within the climate zone I1 (Winter 1) and V1N (Summer 1 North), with low climate requirements. Which one of these zones have the design data indicated in Table 1.

Table1. Climatic Data

Winter climate zone	I1	Summer climate zone	V1N
Number of heating degrees-days (DG) (ºC.days)	1390	Design external temperature (ºC)	29
Heating season duration (months)	6	Thermal amplitude (ºC)	9

The apartment studied has 79.70 m² of area and 2.70 m of interior height. The thermal energy analysis demonstrated that the constructive solutions of the envelope do not comply with the minimum values required by the regulations as well whith the maximum values allowed by the regulations to the heating energy needs (N_{ic}), the cooling energy needs (N_{vc}), the heating energy needs of domestic hot water and the global primary energy needs (expressed in petroleum kilograms equivalent).

In the application of the simplified methodology the thermal linear bridges were measured considering twice the linear measure of the exterior envelope as well as the interior envelope with characteristics of exterior. The ψ-value (linear thermal coefficient) was considered equal to 0.75 W/m².ºC. The thermal linear bridges of the frameworks and of the corner between two exterior walls were not considered.

No others simplifications permitted by the technical note have been done because it was possible to obtain all the measurements, the U-value of all the constructive elements and the solar factor (g⊥) of the glazing areas. These could not be possible in other situations of existing buildings in consequence of the inexistence of project elements and details of the construction solutions executed.

The results obtained by the simplified and by the detailed methodology do not show great differences and the dwelling obtained in both a C energy label. A difference of 6% was registered between the results obtained as depicted in Table 2.

Table 2. Building energy calculation results

	N_{ic}	N_i	N_{vc}	N_v	N_{ac}	N_a	N_{tc}	N_t	R
DA	118.31	59.41	1.00	15.00	76.70	59.35	10.04	8.69	1.16
SA	141.80	64.55	1.00	16.00	76.70	59.35	10.72	8.74	1.23

DA: Detailed assessment; SA: Simplified assessment; Ventilation tax: 0.90; R=N_{tc} / N_t

In spite of the same energy class (C) having been obtained the difference between the values of R can support the option by the detail method.

The simulations effectuated showed that a better energy class can easy be achieved by the introduction of thermal solar systems. The bad thermal insulation conditions of the envelope could be maintained and the introduction of solar systems will permit to get a better energy performance classification without solving the indoor hydrothermal problems of the apartments. This solution does not perform a sustainable improvement considering the bad interior hydrothermal conditions. By the other hand the results depicted in Table 2 demonstrate that in the Winter season is required a great energy consumption (99% and 119% above to the maximum values allowed by the regulations - N_i) to achieve the comfort interior temperature (20º C). So in the existing buildings it would be very important to require a minimum quality of the envelope thermal requirements accordingly with the regulations [RCCTE, 2006], to achieve a higher internal comfort with lower consumption of energy.

4. CONCLUSIONS

From the application of the detailed methodology to the case study some aspects must be taken into account:

- in the existing buildings there are more difficulties to determine de U-value depending on the existence of a project and the knowing of the constructive solutions implemented;
- when possible technicians must choose the detailed methodology in spite of the simplified one, because this one can conduct to a lower energy class;
- the improvement measures that are indicated must assure their constructability;
- the energy analysis of existing buildings take to the introduction of thermal solar systems with the aim to get a higher energy class (label) without improve

the thermal characteristics of the envelope neither consider the energy sustainability;

- it would be very important to oblige in the existing buildings, that do not comply with the minimum thermal requirements, the improvement of the envelope thermal characteristics' through the verification of a maximum percentage of the limit values of the energy needs (N_{ic}, N_{vc}), relatively to the maximum required values (N_i, N_v).

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