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ACCURACY OF THE PORTUGUESE EPBD IMPLEMENTED THERMAL PERFORMANCE CALCULATION PROCEDURES - RCCTE

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ABSTRACT

The driving force of the thermal regulations revision in the European Union (EU) was the European Energy Performance of Buildings Directive – EPBD (European Commission, 2003). The main objectives of the EPBD are the harmonization of all thermal regulations in the EU and the optimization of buildings energy performance, taking into account the climatic conditions, interior comfort conditions of the occupants and economic viability, for both new and existing buildings.

In order to be efficient and effective, the thermal regulations must accurately estimate the energy performance of buildings and so, the building certification will allow comparisons of the results obtained in the different climates to be more meaningful. Having this fact in mind the Portuguese calculation methodology will be put side by side with a dynamic simulation for the energy performance estimation.

This study was based on the heating and cooling needs estimation of single houses and dwellings, for the three major Portuguese thermal regions, using the simplified calculation models established in the Portuguese thermal regulation and the results obtained with a dynamic simulation tool.

INTRODUCTION

One of the main challenges that nowadays humankind has to face is the climatic changes and environmental depletion. It is known that these challenges are closely related to the energy consumption. In the 15 European Union, there are about 164 million buildings, responsible for 40% of the final energy demand and 1/3 of the greenhouse gas emissions. Therefore, in order to promote the reduction of energy consumption, it is fundamental to apply sustainable development principles in the construction sector (Tzikopoulos et al, 2005; Eyckmans and Cornillie, 2002).

However, one of the measures with a larger impact in building energy consumptions is the implementation of more restrictive thermal regulations. The new Portuguese thermal regulation – Regulation of the Characteristics of the Thermal Behaviour of Buildings (RCCTE) – increases the minimal requirements, promote the use of renewable energy and support the use of certified materials.

If the thermal regulation uses a methodology that can, effectively, estimate the energy performance of buildings, the implementation of the RCCTE can result in buildings that are more efficient and thus less energy consumers.

The objectives of this work are improving the confidence on the RCCTE calculation methodology, EPBD based regulation, by comparison with a dynamic simulation tool – eQuest.

The Portuguese thermal regulation issue an energy performance certificate and assign an energy label to a building, that classifies the buildings on an energy efficiency scale. This energy label allows the prospective buyer or tenant to compare the buildings energy quality and select the most efficient.

Thus, the thermal regulations must correctly foresee the energy performance of buildings and so, the building certification will allow comparisons of the results obtained in the different climates to be more meaningful.

The goal of this paper is to assess and compare the energy needs of different buildings types for three major Portuguese thermal regions, using the steady-state calculation methodology established in the Portuguese thermal regulation and the results obtained from a dynamic simulation tool, in order to verify the accuracy of the RCCTE calculation methodology.

Then, there were selected three buildings, of different types (single detached house, single attached house and two dwellings belonging to a multifamily building with a commercial area on the ground floor) in order to estimate their heating and cooling needs in three Portuguese thermal regions. In addition, the heating and cooling needs were also obtained by means of a dynamic simulation tool – eQuest – in each climate (Bragança, Faro, Lisboa and Porto) so it is possible to evaluate the performance of the RCCTE calculation methodology.

BUILDING AND CONSTRUCTION SOLUTIONS DESCRIPTION

To perform this study there were selected three buildings, a single detached house (D), a single attached house (A) and a multifamily building with a commercial area on the ground floor, where two dwellings were analysed (1º AD – first floor and 2ºAD – second floor).

Building Description

Single Detached House

The single detached house is a ground floor house, North oriented, that has two bedrooms, one kitchen, one bathroom and one dining and living room.

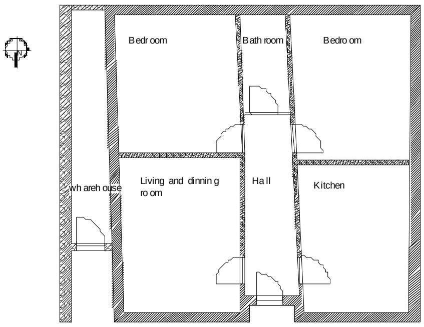

Figure 1 Schematic plan of the ground floor of the single-family detached building studied

Single Attached House

The single attached house is a two-storey house, North oriented, that has one garage, one kitchen one bathroom and one dining and living room on the ground floor and two bedrooms, one office and two bathrooms on the second floor (Figure 2).

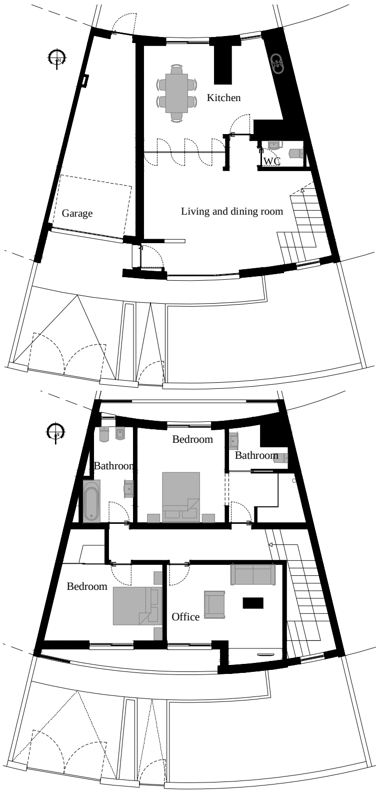

Figure 2 Schematic plan of the 1st and 2nd floor of the single family attached building studied

Multifamily building dwellings

The two dwellings studied belong to a five-storey multifamily building, NE oriented, with a basement (parking), a commercial area on the ground floor and the remaining three floors have four dwellings, each.

The studied dwellings (highlighted on Figure 3) have one kitchen, two bathrooms, two bedrooms, one dining and living room. The first dwelling (1ºAD) studied is on the first floor (over the commercial area) and the second one (2ºAD) is on the second floor.

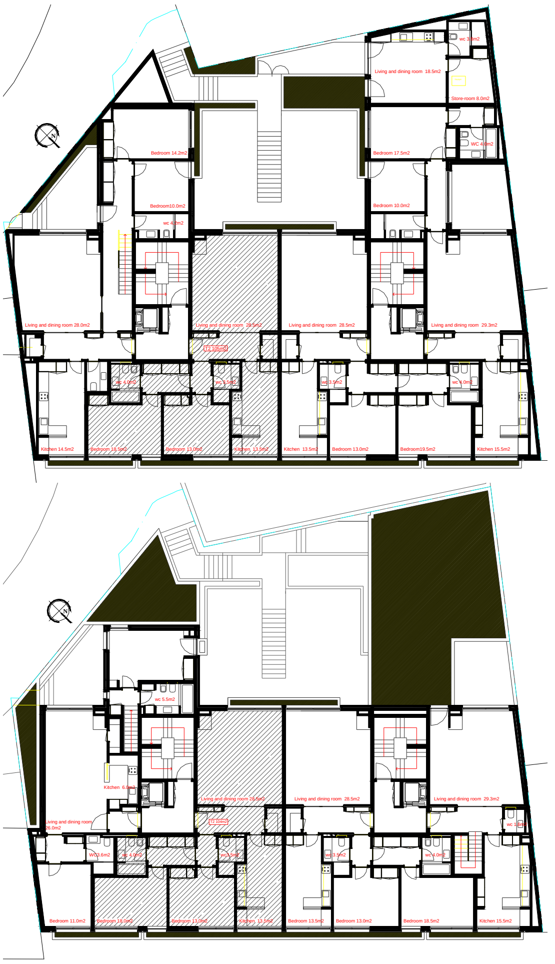

Figure 3 Schematic plan of the 1st and 2nd floor of the multifamily building studied

All the buildings have heavy thermal inertia. The most important building characteristics are shown on Table 1.

Table 1

Studied building characteristics

BUILDING TYPE		N	AP (m^2)	PD (m)	V (m^3)	FF	VENTILATION TYPE	ACH (h^{-1})
Single House	D	2	54.4	2.4	130.6	0,87	Natural	1.05
	A	3	137.7	2.7	371.8	0.59	Mechanical	0.69
Dwelling	1ºAD	2	90.3	2.5	225.8	0.24	Mechanical	0.89
	2ºAD	2	89.8	2.5	224.5	0.29	Mechanical	0.89

N - Number of bedrooms; Ap – Net Floor Area; Pd - Floor to ceiling height; V – Volume; FF - Shape Factor; ACH - Number of air changes per hour

Construction Solutions

The construction solutions of the studied buildings are presented below (Table 2 and Figure 4).

The single detached house exterior walls are single pane hollow concrete block (25 cm) without thermal insulation. The windows have aluminium frames, with single pane clear glazing (4mm) and metallic roller blades. The roof and the floor in contact with the ground are concrete slabs with 30 cm.

Table 2
Construction solutions of the studied buildings

ELEMENT	U [W/m^{2}ºC]
Single Detached House	
External walls	1.74
Windows	4.10
Wall separating the autonomous fraction and the warehouse	1.56
Roof and the floor	2.35
Single Attached House	
External walls	0.50
Walls separating the autonomous fraction and the garage	0.61
Windows	1.60
Roof	0.80
Floor	0.47
Floors separating the autonomous fraction and the garage	0.44
Multifamily building dwellings	
External walls	0.47
Wall separating dwellings and the common circulation zones	0.45
Wall separating the dwellings from the elevator shaft	0.73
Windows	3.04
Roof	0.59
Floors	0.52

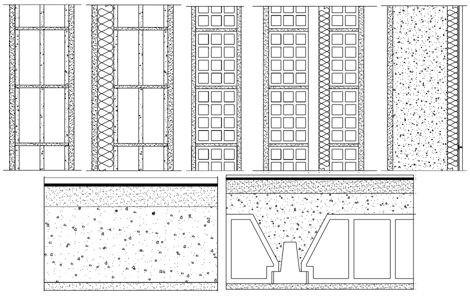

Figure 4 Vertical cross-section of the construction solutions of the buildings walls and floors

The single attached house exterior walls are single pane hollow concrete block walls (25cm) and 5cm of expanded extruded polystyrene placed by the exterior.

The roof and the floors are pre-stressed concrete slabs, with "T" beams and 25cm hollow pots, with 3cm of expanded extruded polystyrene and a 4cm regularization layer.

The windows have aluminium frames with thermal break, with double pane clear glazing (4+12+8mm) and metallic roller blades.

The multifamily building dwellings exterior walls are double pane hollow brick (15 + 11cm) with 4cm of expanded extruded polystyrene placed on a 6cm air cavity.

The roof and floors are pre-stressed concrete slabs with "T" beams and 28cm hollow pots, with 4cm of expanded extruded polystyrene and a 6cm regularization layer.

The windows have aluminium frames, with double pane clear glazing (5+8+5 mm) and metallic venetian blinds on the outside.

ESTIMATION METHODS

To predict a building thermal behaviour there are two possible approaches: using a steady-state methodology or tool, as RCCTE methodology, that has better repeatability, but is not able to capture system complexities; using dynamic simulation tools, that are more flexible, but more expensive in time and effort.

Portuguese thermal regulation - RCCTE

The Portuguese thermal regulation focuses on residential buildings and service building without HVAC systems. The objectives of this regulation are: Guarantee that the heating and cooling requirements for thermal comfort, the ventilation requirements for air quality and the hot water requirements are satisfied without an excessive energy consumption; Minimize the pathologies in the construction elements due to condensation.

This regulation defines reference values for the heating needs (N_{ic}) and cooling needs (N_{vc}). The Nic and Nvc are obtained using the equations 1 and 2.

Where: $\boldsymbol{A_p}$ is the useful floor area; ***GD*** is the heating degree-day; ***U*** is the thermal transmittance (U-value, *e* - for elements of the external envelope and *i* – for elements of the internal envelope); $\boldsymbol{A_e}$ is the area of the elements of the external envelope; $\boldsymbol{A_i}$ is the area of the elements of the internal envelope; $\boldsymbol{\tau}$ is the coefficient of reduction of the thermal losses to non-heated spaces; $\boldsymbol{\Psi_s}$ is the linear thermal transmittance of the elements in contact with the soil; $\boldsymbol{B_s}$ is the length of the elements in contact with the soil; $\boldsymbol{\Psi_j}$ is the linear thermal transmittance of the linear thermal bridge; $\boldsymbol{B_j}$ is the length of linear thermal bridges; $\boldsymbol{R_{ph}}$

$$N_{ic} = \frac{0{,}024.GD.(U.A_e + U.A_i.\ \tau + \sum \Psi B_s + \sum \Psi B_j + (0{,}34 * Rph + Ap * Pd) - \eta_H (qi.M.Ap\,0{,}720 + G_{Sul} \sum_j [X_j \sum_n A_{snj}].M)}{A_p} \quad (1)$$

$$N_{vc} = \frac{(1\text{-}\eta_C).\left[\left[2{,}928\ U.A.(\theta_m - \theta_i) + U.A.(\frac{\alpha.Ir}{h_e})\right] + \sum_j \left[Ir_j \sum_n A_{snj}\right] + \left[2{,}928\,(0{,}34.Rph.Ap\,Pd)\right] + 2{,}928\,qi.Ap\right]}{A_p} \quad (2)$$

are the hourly air flow rate; P_d is the floor to ceiling height; η_H is the dimensionless gain utilisation factor; η_C is the dimensionless utilisation factor for heat losses; qi are the internal heat gains (due to the occupants, illumination and equipments - 4 W/m^2 for residential buildings); M is the duration of heating period; G_{Sul} is the average mensal value of the solar energy falling on a vertical surface south oriented of a unitary area during the heating season; X_j is the orientation factor; A_{snj} is the effective collecting area of the solar radiation (n – surface; j – orientation); θ_m is the average external air temperature for the cooling season; θ_i is the internal air temperature; α is the coefficient of absorption of solar radiation of the outside surface of the element; I_r is the average Intensity of the total solar energy falling on the surfaces, per orientation, for all the cooling season; h_e is the external thermal superficial conductance of the envelope element (25 W/m^2.ºC).

Dynamic Simulation Tool - eQuest

Computer-based simulation is accepted by many studies as a tool for evaluating the buildings energy consumption (Waltz, 2000; Al-Homoud, 2001, Zhu, 2006).

The eQUEST (The Quick Energy Simulation Tool) software was used to develop the energy model and calculate energy consumption, using detailed hourly simulations on a yearly basis.

eQuest is a free commercial software tool, developed as part of the Saving by Design incentive program offered by California utilities. Also, it complies with the accuracy requirements imposed by the ASHRAE standard 140-2004 (based on IEA's BESTEST criteria) (California Energy Commission, 2007).

eQUEST is an hourly building energy simulation tool, and uses the DOE-2.2 calculation engine. DOE-2 is a widely used and accepted building energy analysis program that can predict the energy use and cost for all types of buildings (Ziai, 2006).

eQuest is an easy to use building energy use analysis tool that combine a building creation wizard, an energy efficiency measure wizard and a graphical results display module with an enhanced DOE-2.2-derived building energy use simulation program (Crawley, 2005, Hirsch, 2005).

Within eQuest, DOE-2.2 performs an hourly simulation of the building design for a one-year period. It calculates heating or cooling loads for each hour of the year, based on the factors such as: walls, windows, glass, people, equipment loads, and ventilation.

SIMULATIONS

This study, following the Portuguese building energy performance calculation methodology, Regulation of the Characteristics of the Thermal Behaviour of Buildings (RCCTE) and using eQuest was performed using the climatic data, the internal heat gains and the hourly airflow rate presented on the Portuguese thermal regulation.

To demonstrate the building compliance with the regulation, the national database of hourly annual typical climates for every municipality in Portugal must be used to eliminate any uncertainties derived from the use of different climatic data sets. So these database was also used in the simulation with eQuest, to be possible to compare the results (even thought this database does not have the wind velocity and direction that can be important in a dynamic simulation).

Te heating and cooling needs were calculated, using RCCTE methodology and eQuest, with standard occupancy data, standard climate and standard environment provided at national level.

Portuguese thermal regulation - RCCTE

The Portuguese regulation calculation model was applied in order to obtain the energy needs of the presented case studies, in four locations covering the major part of the Portuguese continental area, the most populated areas and different climates:

Bragança – B (41º78'N, 6º70'W);
Faro – F (37º04'N, 7º93'W);
Lisboa – L (38º73'N, 9º11'W);
Porto – P (41º16'N, 8º62'W);

The cities location is shown on Figure 5 and the climatic data are shown in Table 3. The I3 and V3 climatic zones have the most unfavourable climatic conditions.

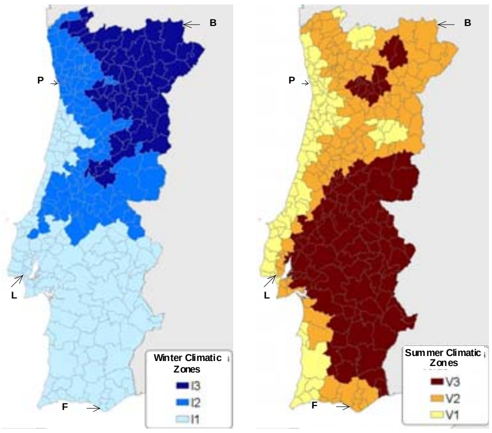

Figure 5 Portuguese Climatic Zones and Municipalities under analysis

Table 3
Climatic data for the different cities according to RCCTE

Municipality	Winter Climatic Zone	GD (ºC.days)	Heating period (months)	G_{South} (kWh/m^2.month)	Summer Climatic Zone	Θ_{ATM} (ºC)
Bragança	I3	2850	8.0	90	V2	19
Faro	I1	1060	4.3	108	V2	23
Lisboa	I1	1190	5.3	108	V2	23
Porto	I2	1610	6.7	93	V1	19

GD - Heating degree-days (20ºC); G_{South} - Average Solar energy in a south oriented vertical surface (winter season); θ_{atm} - Average Exterior Air Temperature in the Cooling Season

Bragança has cold winters and hot, dry summers. Porto has mild and humid winters and summers. Lisboa and Faro have warm winters and summers.

According to the Portuguese thermal regulation, the analysis was performed with the following input data:

- Heating setpoint: 20ºC;
- Cooling setpoint: 25ºC.

RESULTS

RCCTE

The Specific Nominal Heating Needs (Nic) and the Specific Nominal Cooling Needs (Nvc) are presented in Table 4, for the three studied buildings located in the four cities.

Lisboa and Faro, that belong to the same winter and summer zone (I1 V2S) but have different heating periods and heating degree-days, have similar specific nominal heating needs (10% differences) and the same specific nominal cooling needs.

Table 4
Heating (Nic) and cooling (Nvc) needs from RCCTE

MUNICIPALITY	NIC	NVC
	[kWh/m^2.year]	
Detached Building		
Porto	286.7	0.7
Lisboa	209.5	11.4
Faro	188.4	11.4
Bragança	523.6	0.8
Attached Building		
Porto	61.9	3.6
Lisboa	42.9	12.9
Faro	40.1	12.9
Bragança	126.1	3.7
Multifamily Building		
Porto 1ºAD	48.6	2.1
Porto 2ºAD	39.5	3.5
Lisboa 1ºAD	33.1	11.3
Lisboa 2ºAD	26.4	14.9
Faro 1ºAD	31.3	11.3
Faro 2ºAD	25.3	14.9
Bragança 1ºAD	102.7	2.3
Bragança 2ºAD	86.6	3.8

Nic - Specific Nominal Heating Needs; Nvc - Specific Nominal Cooling Needs;

The heating needs for the buildings in Bragança (I3), that have more unfavourable winter climatic conditions and longer heating period, are more than 60% higher than the specific nominal heating needs of the same building located in Lisboa (Table 4).

Dynamic simulation tool – eQuest

The three selected buildings were also evaluated applying the dynamic simulation tool eQuest. For that, the building models were created (Figures 6 to 9), but also it was necessary to calibrate them using the RCCTE data:

- *Weather data* – a climatic file using the information presented in the RCCTE database (from the tool SOLTERM) was generated;
- *Internal loads* – the occupancy, lighting and equipment loads were obtained based on the RCCTE data.

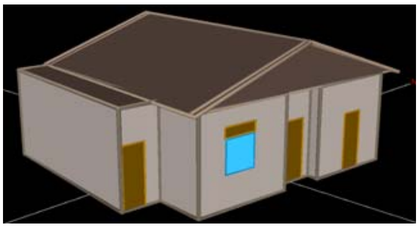

Figure 6 Detached Building model

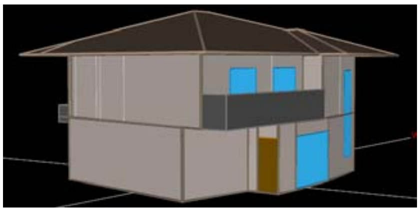

Figure 7 Attached Building model

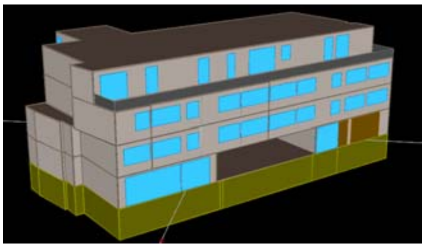

Figure 8 Multifamily Building model- front

The results of the different types of buildings using the eQuest are presented in Table 5.

Table 5
Heating and cooling needs using eQuest

MUNICIPALITY	HEATING NEEDS	COOLING NEEDS
	[kWh/m^2.year]	
Detached Building		
Porto	289.5	0.1
Lisboa	216.6	9.9
Faro	204.2	17.4
Bragança	323.2	0.35
Attached Building		
Porto	67.8	1.6
Lisboa	45	6.75
Faro	36.9	9.32
Bragança	87.5	3.9
Multifamily Building		
Porto 1ºAD	54.4	3.5
Porto 2ºAD	48.6	3.6
Lisboa 1ºAD	36.9	11.7
Lisboa 2ºAD	33.4	10.7
Faro 1ºAD	28.6	15.8
Faro 2ºAD	26.4	13.8
Bragança 1ºAD	72.8	7.3
Bragança 2ºAD	64.4	6.9

For the detached house Lisboa and Faro have similar heating needs (6% differences), but 43% differences in the cooling needs (Table 5).

The variations in the heating needs, for Lisboa and Bragança are of about 33% for the detached building and of about 50% for the attached building and multifamily dwellings.

The differences between Bragança and Porto are about 10% for the detached building and of 25% for the other 2 building types.

The cooling needs are almost thirty times higher in Lisboa than in Bragança, for the detached building, that is not insulated and two times higher for the attached building and for the dwellings.

As the cooling needs are low, the variations between the different climatic zones are high in percentage, but not significant in absolute values, due to their low weight on the Portuguese annual energy needs.

RCCTE Vs Dynamic simulation tool – eQuest

The Case studies heating and colling needs obtanied by both estimation methods – RCCTE and eQuest – were put side by side and are presented in Table 6.

Table 6
Differences for the Heating and Cooling needs for the different climatic zones using eQuest and RCCTE

MUNICIPALITY	**DIFFERENCES**			
	Heating		**Cooling**	
Detached Building				
	[%]	**Absolute** [kWh/m^2.y]	**[%]**	**Absolute** [kWh/m^2.y]
Porto	1.0	- 2.8	85.7	+ 0.6
Lisboa	3.3	- 7.1	13.2	+ 1.5
Faro	7.7	- 15.8	34.5	- 6.0
Bragança	38.3	+ 200.4	56.3	+ 0.5
Attached Building				
Porto	8.6	- 5.9	55.6	+ 2.0
Lisboa	4.7	- 2.1	47.7	+ 6.2
Faro	12.2	+ 4.9	27.8	+ 3.6
Bragança	30.6	+ 38.6	5.1	- 0.2
Multifamily Building				
Porto 1ºAD	10.7	- 40.0	5.9	- 2.0
Porto 2ºAD	18.7	- 2.8	2.1	- 6.2
Lisboa 1ºAD	10.3	- 3.4	5.8	- 1.4
Lisboa 2ºAD	21.0	- 28.2	7.0	- 4.2
Faro 1ºAD	8.6	+ 28.5	2.7	- 4.5
Faro 2ºAD	4.2	- 7.4	1.1	+ 1.1
Bragança 1ºAD	29.2	+ 68.5	30.0	- 5.0
Bragança 2ºAD	25.7	+ 44.9	22.3	- 3.1

- RCCTE underestimates the energy needs; + RCCTE overestimates the energy needs;

For Porto, Lisboa and Faro the differences in the heating needs are less than 10%, but for Bragança (I3 climatic zone) the differences are of 38% for the detached building, that is non-insulated, 31% for the attached building and of about 26% and 29% for the multifamily dwellings.

The relative differences in the cooling needs are higher for the detached building in Porto, due to the higher heat exanges, as this building is non-insulated, has a higher shape factor and is naturaly ventilated.

The heating needs for Bragança (I3) using the RCCTE methodology are always significativelly higher than the ones predicted using eQuest, even though the climatic file used in the dynamic symulation with eQuest is based on the climatic data applied to calculate the climatic data used in the RCCTE.

Therefore, the RCCTE climatic data and climatic file were analyzed regarding the heating degree-days, GD (base on 20ºC), and the average solar energy reaching a south oriented vertical surface in the winter season, G_{south}, were calculated and the folowing differences were detected:

	GD (ºC.days)	Gsouth (kwh/m^2.month)
Climatic data from RCCTE:	2850	90
Climatic file used in eQuest:	2518	94

Thus the heating and cooling needs, for the detached building located in Bragança, were also estimated using the RCCTE methodology, however with the degrees-day (GD) and the average solar energy in a South oriented vertical surface (Gsouth) calculated from the climatic file generate from the hourly annual typical climates applied in eQuest.

Also, to verify that the diferences were not due to a climatic file error, a simulation using the Bragança weather file from the EnergyPlus web site was performed. The results are presented in Table 7.

In addition an analysis for two other cities, both also belonging to the I3 Climatic Zone (Vila Real and Guarda), located on the north and center part of Portugal (Figure 9), was performed. The results are, as well, shown in Table 7.

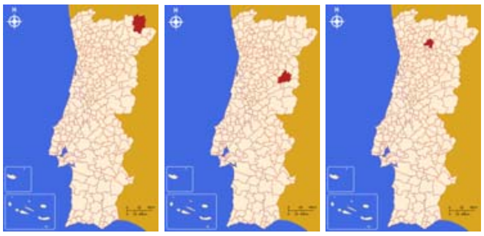

Figure 9 Bragança, Guarda and Vila Real location

Table 7 shows that the difference between the heating needs, using RCCTE and eQuest, will slightly decrease (from 38% to 30%) after adjusting the RCCTE climatic data, for the Bragança detached building.

The weather file created to be used with eQuest was confirmed to be error free, since the heating and cooling needs calculated using eQuest with the RCCTE climatic file and using the EnergyPlus weather file, are similar (differences of 12%) as Table 7 shows. This difference is only due to the fact that the RCCTE climatic data do not include information about the wind velocity and direction.

Table 7
Heating and Cooling needs for the different climatic zones using eQuest and RCCTE, for the detached building

MUNICIPALITY	**HEATING NEEDS**		**COOLING NEEDS**		**DIFFERENCES (%)**	
	RCCTE	**EQUEST**	**RCCTE**	**EQUEST**		
	[kWh/m^2.year]				Heating	Cooling
Bragança (RCCTE climatic data)	523.6	323.2	0.8	0.35	38	56
Bragança (GD from eQuest climatic file)	458.5	323.2	0.8	0.35	30	56
Bragança (EPlus weather file)	523.6	367.8	0.8	1.15	30	30
Vila Real	490.6	296.8	1.1	0.6	40	45
Guarda	455.4	344.0	0.7	0.15	24	79

The difference on the heating needs is of 30% when compared to the values obtained for Bragança with RCCTE, using the adjusted GD and Gsouth, and eQuest using the EnergyPlus site weather file.

The differences between the three cities belonging to I3 climatic zone are also similar, 38 and 40% for Bragança and Vila Real, respectively, both located on the north part of Portugal (Figure 9), and 24% for Guarda located on the centre part of Portugal.

This differences are due to the climatic data variations and on the fact that Vila Real heating period lasts for 7 months (2660ºC.days, 90kwh/m^2.month) and in Guarda is 8 months long (2500ºC.days, 90kwh/m^2.month), as in Bragança.

The difference on the heating needs for Bragança and Vila Real are of 6% using the RCCTE methodology and 8% using eQuest. The differences between Bragança - Guarda and Vila Real - Guarda are of about 13% and 7%, using RCCTE, and 6% and 14% using eQuest, respectively.

The cooling needs ablsolute differences is less than 1 kWh/m^2.year, for all the municipalities belonging to I3 climatic zone.

Thus, the large differences on the heating needs between RCCTE and eQuest are not due to an model error but due to the fact that RCCTE is a simplyfied methodology, which is not able to include the daily and seasonal differences of temperature and solar radiation.

The percentual differences on the cooling needs are higher than on the heating needs, due to the simplyfied global heat balance methodology that is the base of the RCCTE. This methodology is neither sensitive to the daily and seasonal temperature (uses an average exterior air temperature in the cooling season) and solar radiation variations, neither to the effect of the thermal inertia to the building behaviour.

Table 8 shows the global energy needs for the three types of buildings and for the four municipalities analyzed and also for the detached building located in Vila Real and Guarda.

Table 8
Global energy needs for the different climatic zones using eQuest and RCCTE,

MUNICIPALITY	**RCCTE**	**EQUEST**	**DIFFERENCES**	
	[kWh/m^2.year]		**[%]**	**Absolute** [kWh/m^2.year]
Detached Building				
Porto	287.4	289.6	1	- 2
Lisboa	220.9	226.5	2	- 6
Faro	199.8	221.6	10	- 22
Bragança	524.4	323.6	38	+ 201
Vila Real	491.7	297.85	39	+ 194
Guarda	456.1	344.7	24	+ 111
Attached Building				
Porto	65.5	69.4	6	- 4
Lisboa	55.8	51.8	7	+ 4
Faro	53.0	44.5	13	+ 7
Bragança	129.8	91.4	30	+ 38
Multifamily Building				
Porto 1ºAD	50.7	57.9	12	- 7
Porto 2ºAD	43.0	52.2	18	- 9
Lisboa 1ºAD	44.4	48.6	9	- 4
Lisboa 2ºAD	41.3	44.1	6	- 3
Faro 1ºAD	42.6	44.4	4	- 2
Faro 2ºAD	40.2	40.2	0	0
Bragança 1ºAD	105.0	80.1	24	+ 25
Bragança 2ºAD	90.4	71.3	21	+ 19

- RCCTE underestimates the global energy needs; + RCCTE overestimates the global energy needs;

As Table 8 shows, the differences in the global energy needs are less than 20% for I1 and I2 climatic zones (maximum 22 kWh/m^2.year for the detached, non-insulated building in Faro).

For I3 climatic Zone the variation is higher, 20% to almost 40% in Bragança and Vila Real, especially for the less insulated buidings.

Thus, it was observed an average variation between the total needs otained by the RCCTE and eQuest methodologies by city of:

- Porto (Zone I2, V1) – 9%;
- Lisboa (Zone I1, V2) – 6%;
- Faro (Zone I1, V2) – 7%;
- Bragança (Zone I3, V2) – 28%;
- Vila Real (Zone I3, V2) – 40%;
- Guarda (Zone I3, V1) – 25%.

However, the Vila Real and Guarda average total needs variation analysis is not as significant as for the other cities, since they only include the detached building case study.

CONCLUSIONS

The objective of this study was to evaluate the precision of the Portuguese thermal regulation calculation methodology. Therefore, the RCCTE, heating and cooling needs estimation methodologies were put side by side with the ones calculated with the dynamic simulation tool eQuest.

As the RCCTE methodology is a steady-state method, it was expected to find differences between the results obtained with the two methodologies.

From this evaluation it can be said that there are significant differences for the buildings heating needs for the I3 Portuguese climatic zone calculated using the RCCTE calculation methodology and using the dynamic simulation tool, especialy for buildings with less or no insulation.

For the I2 and I1 climatic zones there is a good adjustment for the heating needs using the RCCTE methodology and eQuest.

The small differences detected between the two methodologies, in terms of heating needs, for I1 and I2 climatic zones is a good indication, as these climatic zones cover most part of Portugal and the heating needs are the most important in Portugal.

The detected differences in the cooling needs are percentually higher than in the heating needs, however the absolute differences are not significant.

When analyzing the global energy needs the variation is small, except for I3 climatic zone and the detached non-insulated building in Faro.

The differences between cities belonging to the same climatic zone are similar when using RCCTE method and eQuest.

The RCCTE calculation methodology presents good results for the I1 and I2 Portuguese climatic zones, since the differences in the heating and cooling needs obtained using the RCCTE methodology and eQuest are small. This method just appears to have a higher difficulty in estimate accurately the heating needs for buildings in the Portuguese I3 climatic zone.

This analysis shows that the RCCTE methodology, even being useful to compare the buildings qualitatively and to compare buildings in diferent locations, using the energy label, is not adequate to predict the building energy performance in detail. However, the prediction of the buildings performance is not the RCCTE purpose, for that the Portuguese legislation indicates a simplified dynamic simulation method (STE-RSECE), or the use of dynamic simulation tools (Esp-r, EnergyPlus, VisualDoe, eQuest, or any other commercial software tool that comply with ASHRAE standard 140-2004).

The RCCTE methology is aimed to verify the complience of the building with the thermal regulation, to issue an energy performance certificate and to assign an energy label to a building, that classifies it on an energy efficiency scale.

This study shows that the RCCTE methodology is a accurate tool to compare the thermal behaviour of buildings. Thus, the building certification will allow that the comparisons of the certified building stock of different climatic regions of the country can be meaningful.

Moreover, as the prospective building buyer or tenant will prefer a building with a better energy label, the market will force the improvement of the energy performance of buildings.

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