METHODOLOGY TO ENHANCE THE PORTUGUESE THERMAL REGULATION ACCURACY FOR EXISTING BUILDINGS

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ABSTRACT

The goal of this study is to evaluate the accuracy of the Portuguese thermal regulation simplified methodology for existing buildings and to assess the influence of different parameters on the building final energy performance evaluation.

Simple “in-situ” measurement techniques were carried out to calibrate the input data in this methodology.

The results obtained with the simplified methodology, with and without the input data calibration, were compared with the results obtained with the detailed methodology and it was concluded that the “in-situ” calibration could contribute to improve the accuracy of the energy needs estimation and that the simplified methodology results are, in average, 11% higher than the detailed methodology.

INTRODUCTION

The European building stock is a critical area considering energy consumption and environmental pollution, as it consumes around 33% of the raw materials and final energy and around 50% of all the electricity. In addition, this sector is responsible for 10% of the particle emissions and 35% Carbon Dioxide emissions (Balaras et al, 2005).

In order to promote the sustainable development of the building sector and reduce its excessive energy consumption, the European Union introduced the Directive of the European Parliament and of the Council, of 16th December 2002, on the Energy Performance of Buildings – EPBD (European Commission, 2002).

With the entrance into force of the EPBD, which has as target the harmonization of all thermal regulations in the EU and the optimization of the buildings energy performance, all European countries are working hard to transpose this Directive into National laws.

In Portugal, the new thermal regulation was implemented in April 2006, but the energy certification process was put into practice in 3 steps:

- since July 2007 it is mandatory for all the new buildings above 1000m^2,
- since July 2008 it is mandatory for all new buildings;
- since 1st of January 2009 it is mandatory for all buildings (existing buildings are forced to be certified if they are sold or rented).

The transposition of the EPBD Directive into the Portuguese legislation resulted in two different regulations:

- RCCTE – Thermal Regulation for residential buildings (RCCTE, 2006);
- RSECE – Thermal Regulation for office buildings with HVAC systems (RSECE, 2006).

The full implementation of RCCTE can mean a great improvement on the energy efficiency of the Portuguese buildings, as, besides the localization, area, design, neighbourhood, etc., this will also become an important parameter to take into consideration when buying or renting a dwelling.

In addition, it means that the existing buildings must also meet the new energy requirements, although only if the owner executes a retrofit that costs more than 25% of the building market value.

However, it was necessary to introduce a new simplified calculation methodology for the existing buildings, in order to make possible cost-effective audits. In fact, this new methodology, introduced by the technical note NT-SCE-01 (ADENE, 2008), is a simplification of the methodology used for new buildings. The work presented here is the accuracy assessment of this methodology, applied to real case studies in order to guarantee its effectiveness and its real contribution to the energy performance enhancement of the Portuguese building stock.

In addition, two of the case studies were selected to perform a more extensive “in-situ” evaluation, in order to detect thermal bridges, obtain the infiltration rate and determine the exterior envelope “U-Values”.

THERMAL REGULATION - RCCTE

As main objective, RCCTE intends to limit the buildings primary energy needs and imposes minimal quality requirements for the building envelope. Additionally, there are also some ventilation requests in order to guarantee indoor air quality and reduce pathologies due to condensation.

Compared to the previous version, the main updates in this regulation are:

- New climatic zoning;
- New indoor comfort set points: Winter (20ºC); Summer (25ºC + 50% RH);
- Minimum air changes per hour: 0.6 h^{-1};
- Domestic Hot Water (DHW) reference consumption: 40 l per person and per day delivered at 60ºC;
- New requirements for thermal bridges;
- New Heating needs methodology assessment;
- New Cooling needs methodology assessment.

RCCTE Detailed Methodology

The RCCTE is a steady-state yearly calculation methodology and its goal is to estimate the residential buildings energy needs for heating, cooling and domestic hot water (DHW). The heating needs are obtained applying a degree-days method and the envelope heat balance for the heating season. The cooling needs are obtained applying the average difference between the interior-exterior temperature and the envelope heat balance during the cooling season. The DHW needs are obtained applying the average daily reference consumption and the annual number of days of DHW consumption.

This regulation defines reference values for the primary energy global needs (*Nt*) in order to limit the specific nominal primary energy annual global needs (*Ntc*). So, the *Ntc* value cannot be higher than the *Nt* value. The *Nt* and *Ntc* values are obtained using the following equations:

$$\mathrm{Nt} = 0{,}9.(0{,}01.\mathrm{Ni} + 0{,}01.\mathrm{Nv} + 0{,}15.\mathrm{Na})\ [\mathrm{kgep/m^2.y}]$$ (1)

Where:

- *Ni, Nv, Na* – heating, cooling and DHW reference needs, respectively [kgep/m^2.year].

$$\mathrm{Ntc}=0{,}1(\mathrm{Nic}/\eta\mathrm{i}).\mathrm{Fpui}+0{,}1(\mathrm{Nvc}/\eta\mathrm{v}).\mathrm{Fpuv}+\mathrm{Nac.Fpua}\ [\mathrm{kgep/m^2.y}]\ (2)$$

Where:

- ηi, ηv – heating and cooling system efficiencies, respectively;
- *Nic, Nvc, Nac* – heating, cooling and DHW specific needs, respectively [kgep/m^2.year][1];
- *Fpui, Fpuv, Fpua* – weighting factors for the heating, cooling and DHW needs, respectively.

[1] Kgep (Kilogram of Oil equivalent) is a primary energy unit that is updated every year by the Portuguese government and it is coupled to the yearly energy-mix

The heating needs are obtained applying the following equation:

$Nic=(Q_{ext}+Q_{lna}+Q_{pt}+Qv-Q_{gu})/Ap$ (kWh/m^2.year) (3)

$Q_{ext}=0.024.U.A_1.DD$ [kWh/year] (4)

$Q_{lna}=0.024.U.A_2.DD.\tau$ [kWh/year] (5)

$Q_{pt}=0.024.\Sigma_i\Psi_i.B_i.DD$ [kWh/year] (6)

$Q_v=0.024.(0{,}34.ACH.Ap.Pd).DD$ [kWh/year] (7)

$Q_{gu}=\eta[(q_i.M.A_p.0.72).(G_{south}.\Sigma_i(X_j.\Sigma_jA_e).M))]$ [kWh/year] (8)

Where:

- *U* – building exterior envelope thermal transmission coefficient [W/m^2.ºC];
- A_1 – building envelope in contact with the exterior [m^2];
- A_2 – building envelope in contact with non-heated spaces [m^2];
- τ – losses to non-heated spaces reduction coefficient [kWh/year];
- Ψ – linear heat flux transmission coefficient [W/m.ºC];
- *B* – floor or wall interior linear perimeter for envelope in contact with the soil or thermal bridge interior length [m];
- *ACH* – air changes per hour [h^{-1}];
- A_p – net floor area [m^2];
- p_d – floor to ceiling height [m];
- *DD* – Degrees-Day [ºC/day];
- q_i – internal gains [W/m^2];
- *M* – heating season duration [Months];
- G_{south} – average monthly solar energy that reaches a vertical surface south oriented [kWh/m^2.month];
- X_i –orientation coefficient for the different façade orientations;
- A_e – effective glazing solar radiation collector area for the different windows orientations;
- η – heat gains utilization factor.

The cooling needs are obtained applying the following equation:

$Niv = [(Q_1+Q_{gu}+Q_2+Q_3).(1-\eta)]/Ap$ (kWh/m^2.y) (9)

$Q_1=2.928.U.A_1.(\theta_m-25)+U.A_1[(\alpha.Ir)/25]$ [kWh/year] (10)

$Q_2=2.928.(0{,}34.ACH.Ap.Pd).(\theta_m-25)$ [kWh/year] (11)

$Q_3=2.928.(q_i.A_p)$ [kWh/year] (12)

Where:

- θ_m – average outdoor temperature in the cooling season [kWh/year];
- α – exterior envelope solar radiation absorption coefficient;

- Ir – solar radiation intensity for each orientation [W/m^2];

The DHW needs are obtained applying the following equation.

$Nac = [(0{,}081.M_{AQS}.n_d)/\eta_a - E_{solar} - E_{ren}]/Ap$ (kWh/m^2.y) (5)

Where:

- M_{AQS} – average daily reference consumption;
- ηd – annual number of days with DHW consumption;
- ηa – DHW system efficiency;
- E_{solar} – energy contribution from solar collectors;
- E_{ren} – energy contribution from other renewable sources.

Following this methodology, it is possible to obtain the energy label of the dwelling, by obtaining the ratio between the specific and reference primary energy needs (R), as shown in Figure 1.

RCCTE Simplified Methodology

The RCCTE existing buildings simplified methodology is, similar to the detailed one but with several simplifications for obtaining the required input data. Therefore, it is possible to reduce the time necessary to audit an existing building and thus make the certification process more affordable, without compromising the results obtained.

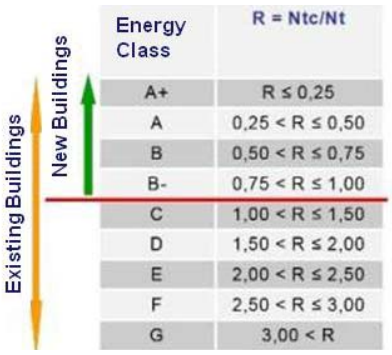

Figure 1 Dwelling energy class

The main simplification rules applied for the existing buildings are the following:

- Geometrical survey: ignore floor areas associated to recesses and projections with less than 1m; if the floor areas measurement accounts the partition walls, the total floor area should be reduced in 10%; ignore exterior doors area if they have less than 25% of glazed surface.
- Loss reduction coefficient (τ): in the calculation of heat losses due to elements in contact with not heated spaces, it should be admitted a value of τ for all non heated spaces that take the conventional value of 0.75;
- Thermal bridges and elements in contact with the ground: if the building constructive solution creates planar thermal bridges, it should be aggravated in 35% the exterior envelope “U-Value”; for the linear thermal bridges apply a conventional value of ψ=0.75 W/m.ºC;
- Mechanical Ventilation: apply an airflow of 100 m^3/h by each W.C, with a power consumption shown in Table 1;
- Shading Factor: the product of the shading factors due to overhangs, fins and surroundings can be considered Fs = 0,57 if there is no shading, Fs = 0,28 for regular shading and Fs = 0,17 for intense shading; considering the heating season and Fs = 0,50 if there is no shading, Fs = 0,28 for regular shading and Fs = 0,45 considering the cooling season;
- Thermal Inertia: instead of calculating the thermal mass of each building element there are a set of rules to consider the building inertia class (e.g. for strong thermal inertia it is required a floor and ceiling slab in concrete, stucco or gypsum finishing, etc);

With the shown simplifications applied, it is possible to obtain the energy needs in less time and with less complexity than the detailed building audits.

Table 1
Ventilation power consumption

AIRFLOW (m^3/h)	**POWER CONSUPTION** (W)
100	16
200	31
300	47
400	63

CASE STUDIES

In order to evaluate the performance of the simplified RCCTE methodology and the effect of the “in-situ” measurement of the exterior envelope “U-Value”, infiltrations rate and thermal bridges detection, there were selected 6 case studies in order to cover the most relevant building types: two detached single-family dwellings, one attached single-family dwelling and three multi-family dwellings.

Case Study 1 – Viseu

The case study 1 (CS1) is a multi-family dwelling, which is located in an urban area in Viseu. The building has six floors and the case study is on the second floor and has two bedrooms.

The construction system is an average Portuguese system from the 80’s based on a steel reinforced concrete pillars and beams structure, double pane brick masonry walls with insulation on the air gap and clear double glass with aluminium frame windows.

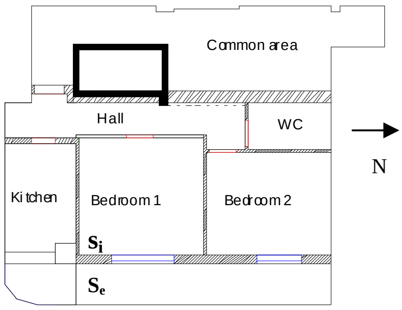

Figure 2 Viseu floor plans: S_i, S_e – positioning of interior and exterior heat flux sensor and thermocouples, respectively

The dwelling floor area is *Ap* = 52.36 m^2, with a floor to ceiling height- *Pd* = 2.52 m, located at an altitude of 450 m and at 100 km from the coastal line.

Case Study 2 – Quinta do Canelas

The case study 2 (CS2) is a detached single-family house, which is located in a rural area in Braga. The building, with two floors, is a single autonomous fraction and has four bedrooms.

The construction system is an average Portuguese system from the 80's based on a steel reinforced concrete pillars and beams structure, double pane brick masonry walls without insulation and clear single glass with wooden frame windows.

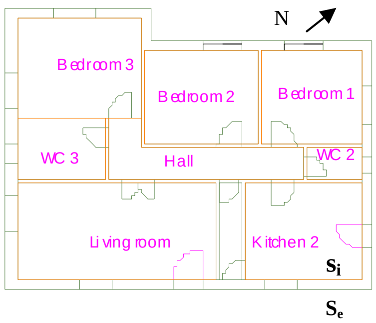

Figure 3 Quinta do Canelas floor plans; S_i, S_e – positioning of interior and exterior heat flux sensor and thermocouples, respectively

The dwelling floor area is *Ap* = 132.67 m^2, with a floor to ceiling height- *Pd* = 2.67 m, located at an altitude of 180 m and 65 km from the coastal line.

Case Study 3 – Felgueiras

The case study 3 (CS3) is an attached single-family dwelling, which is located in an urban area in Felgueiras. The building, with 2 floors, is a single autonomous fraction and has two bedrooms.

The construction system is based on a steel reinforced concrete pillars and beams structure, single pane light concrete masonry units (CMU) walls with external insulation and clear double glass with aluminium frame windows.

The dwelling floor area is *Ap* = 137.69 m^2, with a floor to ceiling height- *Pd* = 2.7 m, located at an altitude of 100 m and 50 km from the coastal line.

Case Study 4 – Aldeia de Leste

The case study 4 (CS4) is a detached single-family house, which is located in a rural area in Braga. The building, with one floor, is a single autonomous fraction and has two bedrooms.

The construction system is a typical Portuguese low-end system from the 80's based on a steel reinforced concrete pillars and beams structure, single pane concrete block walls (CMU) and clear single glass with aluminium frame windows.

The dwelling floor area is *Ap* = 54.42 m^2, with a floor to ceiling height - *Pd* = 2.44 m, located at an altitude of 89 m and 60 km from the coastal line.

Case Studies 5 and 6 – Bragança

The case studies 5 (CS5) and 6 (CS6) are on a multi-family building, which is located in an urban area of Bragança. The building has five floors, the case study 5 is on the first floor, and the case study 6 is on the second floor and both have two bedrooms.

The construction system is based on a steel reinforced concrete pillars and beams structure, double pane brick masonry walls with insulation on the air gap and clear double glass with aluminium frame windows.

The dwelling floor area is *Ap* = 54.42 m^2, with a floor to ceiling height- *Pd* = 2.44 m, located at an altitude of 89 m and 60 km from the coastal line.

In Table 2 and 3 there are summarized the main envelope characteristics from all the Case Studies:

Table 2
Case studies interior envelope and glazings characteristics

Case Study	Envelope in contact with non-heated spaces U - Value [W/m^2.ºC]			Glazings	
	Roof	Floor	Wall	U-Value [W/m2.ºC]	Shading Coefficient (g)
CS1	-	1.30	0.96	3.70	0.75
CS2	1.55	1.55	2.15	3.70	0.75
CS3	0.80	0.44	0.73	1.60	0.75
CS4	2.35	-	1.36	4.10	0.7
CS5	-	0.52	0.52	3.04	0.75
CS6	0.57	-	0.52	3.04	0.75

Table 3
Case studies exterior envelope and ground floor characteristics

Case Study	Exterior Envelope U - Value [W/m2.ºC]			ψ – Value [W/m.ºC]
	Roof	Floor	Wall	Ground Floor
CS1	-	1.40	0.63	-
CS2	-	-	0.96	2.00
CS3	0.56	0.47	0.61	2.00
CS4	-	-	1.74	2.50
CS5	-	0.56	0.47	-
CS6	0.59	-	0.47	-

ENERGY NEEDS ESTIMATION

The work carried out, as already mentioned, has two main objectives with different approaches:

- *Simplified RCCTE methodology assessment* – intend to validate the method accuracy by the application of both the detailed and simplified methodology to several case studies;
- *Input data calibration* – intends to verify if the implementation of the input data calibration, applying simple "in-situ" measurements, results in a benefit for the existing building certification process.

The selected case studies were chosen not only to be representative of different Portuguese typologies, but also to be representative of different envelope solutions conducting to different heat losses (shown in Table 4).

Table 4
Weight of different sorts of thermal losses

CASE STUDY	LOSSES ASSOCIATED TO			
	Exterior envelope	Interior envelope	Windows	Air changes
CS1	16%	**30%**	24%	**30%**
CS2	**41%**	33%	9%	17%
CS3	**38%**	21%	14%	27%
CS4	**57%**	28%	4%	11%
CS5	33%	7%	24%	**36%**
CS6	26%	3%	28%	**43%**

In the RCCTE methodology, the heat losses considered on the heating needs calculation are:

- *Losses associated to the exterior envelope* – walls, floors, roofs, walls and floors in contact with the ground and linear thermal bridges;
- *Losses associated to the interior envelope* – walls in contact with non-heated spaces or other buildings, floors in non heated spaces, interior roofs (in non heated spaces), windows in non heated spaces and thermal bridges (only in walls separating non-heated spaces with τ >0,7);
- *Losses associated to the exterior windows* – horizontal or vertical windows;
- *Losses associated to the air changes*– considering natural ventilation (due to infiltrations) or mechanical ventilation.

Simplified RCCTE methodology assessment

In this approach, it was applied the detailed and the simplified RCCTE methodology to the presented six case studies and obtained the following results:

Table 5
Case studies energy needs and class

CASE STUDY	METHOD	N_{IC}	N_{VC}	N_{AC}	N_{TC}	ENERGY CLASS
		[kWh/m2.year]				
CS1	Simplified	108.9	6.3	89.2	10.9	C
	Detailed	91.7	5.5	87.6	10.3	C
CS2	Simplified	211.0	2.1	56.7	11.0	**D**
	Detailed	177.8	0.7	57.6	10.1	C
CS3	Simplified	80.51	3.1	10.5	3.8	B-
	Detailed	75.1	3.7	10.6	3.7	B-
CS4	Simplified	336.9	2.0	82.9	11.0	C
	Detailed	322.6	0.8	84.3	10.7	C
CS5	Simplified	120.8	2.1	14.1	4.7	B
	Detailed	109.2	2.3	14.0	4.3	B
CS6	Simplified	98.6	3.3	14.2	4.1	B
	Detailed	86.6	3.8	14.1	3.8	B

When analyzing the intermediate results and the simplified parameters, it was concluded that if the losses reduction coefficient (τ) is not simplified, the results obtained with the two methods are very close, as shown in Table 6.

Table 6
Case studies energy needs and class with τ coefficient correction on the simplified approach

CASE STUDY	METHOD	N_{IC}	N_{VC}	N_{AC}	N_{TC}	ENERGY CLASS
		[kWh/m2.year]				
CS1	Simplified corrected	90.5	6.3	89.2	10.4	C
	Detailed	91.7	5.5	87.6	10.3	C
CS2	Simplified corrected	184.9	1.0	56.7	10.3	C
	Detailed	177.8	0.7	57.6	10.1	C
CS3	Simplified corrected	75.9	2.7	10.5	3.6	B-
	Detailed	75.1	3.7	10.6	3.7	B-
CS4	Simplified corrected	317.4	0.4	82.9	10.8	C
	Detailed	322.6	0.8	84.3	10.7	C
CS5	Simplified corrected	116.2	2.1	14.1	4.6	B
	Detailed	109.2	2.3	14.0	4.3	B
CS6	Simplified corrected	95.7	3.3	14.2	4.0	B
	Detailed	86.6	3.8	14.1	3.8	B

As the heating and DHW needs are the most preponderant parameters, in terms of energy consumption, and there are no simplifications for the DHW calculation, it was evaluated the heating needs differences between the simplified methodology (Test 1) or the corrected simplified methodology (Test 2) and the detailed methodology, in percentage and in absolute value, as presented in Table 7.

Table 7
Heating needs differences between the applied methodologies

CASE STUDY	TEST 1		TEST 2	
	Absolute [kWh/m^2.y]	Percentage	Absolute [kWh/m^2.y]	Percentage
CS1	12.1	12%	9.2	10%
CS2	11.6	10%	7.0	6%
CS3	14.3	4%	5.2	2%
CS4	5.4	7%	0.8	1%
CS5	33.2	16%	7.1	4%
CS6	17.2	16%	1.2	1%
Average	**15.6**	**11%**	**5.1**	**4%**

The simplified methodology always returns higher energy needs, in average 11% higher. However, if the parameter τ is not simplified it is possible to obtain only an average difference of 4%, what is a very good approximation, considering the time reduction due to the use of the simplifications.

Input data calibration

The second approach was to measure some "in-situ" relevant building parameters in order to verify their relevance considering the energy estimation using the detailed and the simplified methodologies.

The selected parameters are:

- *Thermal Bridges identification* – when there is no building plans it is very difficult to identify the thermal bridges. However, applying an infrared camera it is possible to identify the building structure and thermal bridges, as shown in Figures 5 and 6;
- *Exterior Envelope "U-Value"* – to obtain this parameter it was necessary to apply one heat flux meter, two thermocouples (to obtain the interior and exterior superficial temperature) and a data-logger to store the data (Silva et al, 2006). To calculate the "U-Value" it was used the ASTM sum technique (ASTM, 1999); In addition it was applied the infrared camera in order to set up the heat flux meter in a zone that can catch different parts of the masonry wall – bricks and mortar. In addition, the infrared camera was applied in order to guarantee the sensors were not under the influence of other building elements, e.g. thermal bridges, as shown in Figure 7. Since the heat-flux sensors are located on the envelope surface, the convective heat transfer applied for the U-Value calculation was the one presented in the RCCTE regulation[2].
- *Infiltrations rate* – for this parameter it was applied a blower-door and executed a pressurization and depressurization test in order to obtain the Air Changes per Hour (ACH) due to infiltrations.

The most relevant equipments applied in this study are presented in Figure 4.

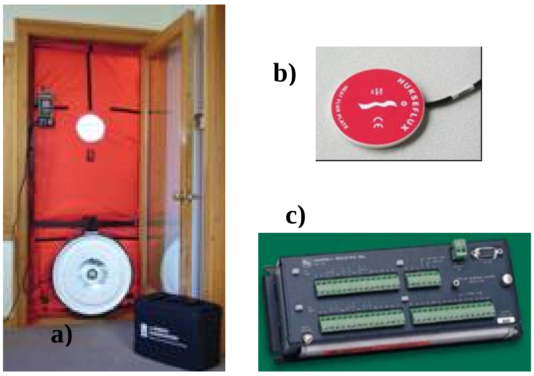

Figure 4 "in-situ" measurement equipment, a) blower-door, b) heat flux meter; c) data-logger

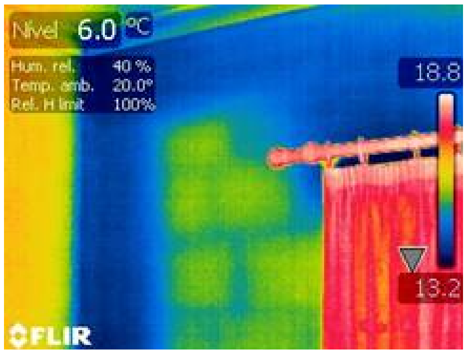

Figure 5 infrared picture – identification of thermal bridges (CS1)

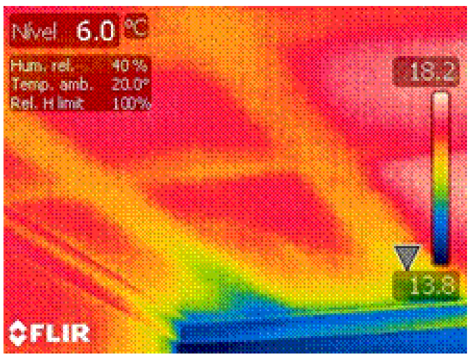

Figure 6 infrared picture – identification of roof structure (CS1)

[2] Exterior convective heat transfer resistance, he = 0.04 m^2.ºC/W; Interior convective heat transfer resistance, hi = 0.13 m^2.ºC/W;

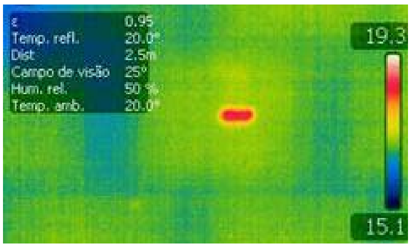

Figure 7 infrared picture – positioning the heat flux meter (CS1)

As it was not possible to execute the measurement campaign in all the case studies, there were selected two of them – CS1 (Viseu) and CS2 (Quinta do Canelas).

The thermal bridges were identified for both case studies and applied to both calculation methodologies. With the infrared camera it was possible to identify and measure the dimensions of beams, pillars, roller case boxes, and other elements that cause thermal bridges. For the “U-Values” and ACH of both case studies, there were obtained the values shown in Table 8, in order to adjust the values applied in both simplified and detailed RCCTE methodology.

Table 8
CS1 and CS2 exterior envelope “U-Value” and ACH

CASE STUDY	**U-VALUE** [W/m^2.ºC]		**ACH** [h^{-1}]	
	“in-situ”	RCCTE	“in-situ”	RCCTE
CS1	0.87	0.71	0.86	1.10
CS2	1.01	0.96	1.12	0.95

The differences obtained in terms of U-Value and ACH are more significant for the CS1 (18% for the U-value and 22% for the ACH)

The obtained higher differences in CS1 should be due to the lack of building plans for this case, thus the insulation thickness applied in RCCTE (3 cm) should not be correct, as a double pane brick masonry wall has a U = 0.87 W/m^2.ºC, so the exterior walls should only have 2cm of insulation.

Applying the measured parameters into the RCCTE detailed and simplified methodology there were obtained the following values:

Table 9
Case studies energy needs and class

CASE STUDY	**METHOD**	**N_{IC}**	**N_{VC}**	**N_{AC}**	**N_{TC}**	**ENERGY CLASS**
		[kWh/m2.year]				
CS1	Simplified calibrated	81.1	6.3	89.2	10.1	**B-**
	Detailed calibrated	83.7	6.9	87.6	10.0	**B-**
CS2	Simplified calibrated	189.2	1.0	56.7	10.4	C
	Detailed calibrated	182.7	0.6	57.6	10.5	C

Additionally, since the calibrated detailed methodology with the in-situ measured parameters is the one that gives more precise results, it was compared its heating needs, in percentage and absolute value, with:

- the simplified methodology (Test 3);
- the detailed methodology without in-situ measured parameters (Test 4);
- the corrected simplified methodology with the in-situ measured parameters (Test 5),

Table 10
Heating needs differences between the applied methodologies

CASE STUDY	**TEST 3**		**TEST 4**		**TEST 5**	
	Absolute [kWh/m^2.y]	%	Absolute [kWh/m^2.y]	%	Absolute [kWh/m^2.y]	%
CS1	28.3	13%	4.9	3%	6.5	3%
CS2	25.1	23%	8.0	9%	2.6	3%
Average	**26.7**	**18%**	**6.4**	**6%**	**4.5**	**3%**

Based on the results obtained, the simplified methodology shows, in average, significant differences when compared with the calibrated detailed methodology – Test 3 – (18%). However, if it is applied the simplified methodology correction, as previously shown, and the measured data – Test 5 – the average variation between both methods is insignificant (3%).

In addition, the differences obtained concerning the detailed methodology with and without the measured parameters (Test 4), are not as high as expected. Therefore, with a straightforward analysis it could be said that the measurement of “in-situ” parameter was not cost effective.

However, with a more detailed analysis, it was identified that the case study with higher differences between the measured and reference parameters (U-Value and ACH) was not the one that presented higher variations in Test 4.

This fact can be explained since the parameters corrections in CS1 are in opposite directions, this is, the “U-Value” correction lead to higher heating needs, however the ACH correction lead to less heating needs.

Supported by the obtained results, it is possible to verify that the measurement of the exterior envelope “U-Value”, infiltration rate and identification of thermal bridges will lead to more precise energy needs estimation and should be executed whenever it is possible.

CONCLUSION

With the results obtained in this paper, it was shown that the simplified RCCTE methodology produces acceptable results, compared with the detailed RCCTE methodology, and it is possible to achieve even better results if the losses reduction coefficient (τ) is not simplified.

Additionally, the “in-situ” measurement of the U-values, infiltration rate and thermal bridges identification should always be executed, especially if there are no reliable building plans and it is difficult to identify the composition of the building envelope.

However, this study will be continued in both approaches, this is, the assessment of the simplified RCCTE methodology and the implication of measuring “in-situ” the previously mentioned parameters. Thus, it will be possible to increase the database and have an even higher reliability on the results.

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