VARIOUS APPROACHES TO THE EVALUATION OF THE ENERGY PERFORMANCE OF BUILDINGS IN ITALY – SOME RESULTS OF CALCULATION PROCEDURES APPLICATION ON RESIDENTIAL BUILDINGS

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Summary

In Italy there are some difficulties comparing the energy performance classification obtained by the analysis of similar buildings located in the different regions, related for example to the climatic conditions in the different regions. Besides, some Regions developed their own calculation models, on the basis of national and international standards. An attempt to compare the simulation results of different regional and national methodologies has been developed in the present work.

Keywords: EPBD, Energy performance, national procedures, calculation methods, energy certification

1 The energy certification in Italy

1.1 The national situation

The EPBD acknowledgement in Italy is coming; in fact the Italian government has promulgated some laws (the last one in April, 2009, [1]) and guidelines (in June, 2009, [2]) in the field of energy performance of building, even if there is not yet a law to define clearly the accredited experts (EPBD, Art. 10).

The national energy certification is based on EPBD and calculations are made in accordance with EN Standards developed under EU mandate M343.

Following the indications of the EN ISO 13790 standard, for the assessment of the energy performance to produce the energy performance certificate, a protocol has been defined at national level to specify the type of sources of information and the conditions when they may be applied instead of the full required input.

In fact, the Italian Standardization Organization UNI has published the national technical specification UNI TS 11300 [3] which is the national reference in the application

of EN Standards. The UNI TS 11300 includes 4 parts: Part 1, on the evaluation of energy needs for space heating and cooling, Part 2 on the evaluation of primary energy needs and of system efficiencies for space heating and domestic hot water production, Part 3 on the evaluation of primary energy and system efficiencies for space cooling and Part 4 (not yet published) on renewable energy.

The national laws assume that the calculations must be performed following the UNI TS 11300 standard and indicate that the global index EP_{gl} must be used for the characterisation of the energy performance of buildings, as considered in the EPBD:

$$EP_{gl} = EP_i + EP_{acs} + EP_e + EP_{ill} \quad (1)$$

where:

- EP_i is primary energy referred to energy use for space heating (winter season);
- EP_{acs} is primary energy referred to domestic hot water;
- Ep_e is primary energy referred to energy use for space cooling (summer season);
- EP_{ill} is referred to lighting.

All these indices have to be compared with the corresponding limit values prescribed by national law, depending on climatic conditions and on the ratio between the building thermal envelope area and volume (**Tab.1**).

To determine the classification of buildings the EP_{gl} indicated in (1) should be used, but at the present time, except for Lombardy region, the calculations consider only heating and domestic hot water primary energy ($EP_{gl} = EP_i + EP_{acs}$).

Tab. 1 Limits for the primary energy of buildings in the Italian law valid from 2010 [3]

S/V	**Climatic zone and Degree Days**									
	A	B		C		D		E		F
	≤ 600	> 601	≤ 900	> 901	≤ 1400	> 1401	≤ 2100	> 2101	≤ 3000	> 3000
	Residential Buildings [kWh/m^{2}year]									
≤ 0.2	8.5	8.5	12.8	12.8	21.3	21.3	34	34	46.8	46.8
≥ 0.9	36	36	48	48	68	68	88	88	116	116
	Other buildings [kWh/m^{3}year]									
≤ 0.2	2	2	3.6	3.6	6	6	9.6	9.6	12.7	12.7
≥ 0.9	8.2	8.2	12.8	12.8	17.3	17.3	22.5	22.5	31	31

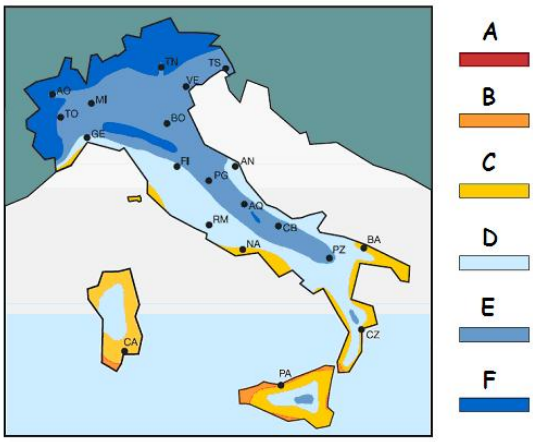

Fig. 1 Climatic zones (A-F) referred to Degree Days values in Tab.1

1.2 The regional situation

In Italy, Regions can define their own laws in the field of energy saving. In this approach, some Regions have promoted local laws, others apply national rules. Regional methodologies take into account local climate, building construction typical typologies, and consider local conditions for the existing building stock. Moreover they can assume different energy classification scales from each other.

In **Tab.2** the regional situation is shown. The Regions that have adopted regional certification acted before the recent national dispositions available from 2009. Some other Regions didn't implement their own methodologies but decide to adopt the national dispositions. Other Regions have assumed directly environmental sustainability procedures which consider also energy certification calculations. At present time there is no obligation to apply these criteria if no financial contribution is requested.

Tab. 2 Regional situation

Region	Certification Regional	Sustainability	Certification National
Abruzzo			x
Basilicata			x
Calabria			x
Campania			x
Emilia Romagna	x		
Friuli Venezia Giulia		x	
Lazio			x
Liguria	x		
Lombardia	x		
Marche		x	
Molise			x
Piemonte	x		
Puglia		x	x
Sardegna			x
Sicilia			x
Toscana			x
Provincia Bolzano	x		
Provincia Trento	x		
Umbria		x	x
Valle d'Aosta			x
Veneto			

2 Some calculations

The analyses were based on the example reported in EN 12831:2006, with some more defined details. It deals with a residential building insulated in the inside and with a condensing boiler as heat generation system (**Fig.2**).

The heating system characteristics are resumed in **Tab.3**. The calculations were performed with different software: two of them based on Regional methodologies, one reference software recognised by national Guidelines and one commercial software validated by the national organism CTI (the Italian Thermo-Technical Committee, a body

federated to UNI, whose scope is to carry out standardisation activities in the thermo-technical sectors).

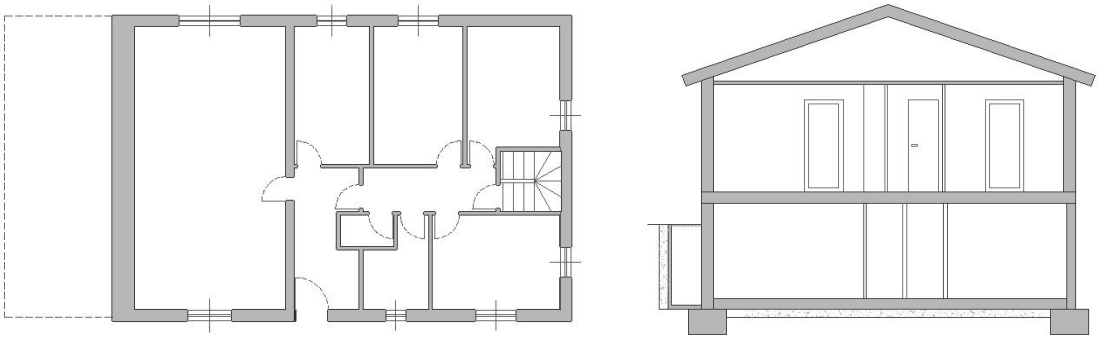

Fig. 2 Plan and section of the building

Tab. 3 Characteristics of the heating system

Generator nominal power	23 kW
Stand-by heat losses	0,10%
Generator thermal loss at full load	10%
Generator envelope thermal losses	1,12%
Electric power for combustion air fan	203 W
Electric power of primary pump	34 W
Efficiency at nominal power output of the generator	104,00%

All of them adopted monthly quasi-steady-state calculation method. The last one allows making more precise calculation of some parameters, instead of using tabulated values. Some features of the software considered for the analyses, depending on the possibilities allowed by national and international standards (UNI TS 11300 and UNI EN ISO 13790), are summarized in **Tab.4**.

- CELESTE – following the Liguria methodology for the energy performance of buildings calculations;
- CENED+ – regional software valid in Lombardia to make the calculations described in the regional dispositions following the EPBD indications;
- DOCET – National tool considered by the national guidelines on the energy certification of buildings (2009), valid for existing residential buildings up to 3000 m^2;
- TerMus by ACCA Software – "validated" commercial software that allows to perform all the calculations considered in the UNI TS 11300 standard for new and existing buildings (design and standard energy ratings as indicated in EN 15217).

Note: commercial software for the energy certification need official "validation" by law that declare their conformity to the national UNI TS 11300 standard procedures.
The software Docet considers some approximations that sometime are not clearly indicated. The summarisation in the table is therefore an interpretation on the basis of the input data and the corresponding results and could not precisely correspond to the real situation.

Referring to the same case study, different climatic conditions were considered: the reference locations assumed have been Milano, Genova and Brallo di Pregola, a little village in Lombardia Region on the top of the Apennini between Genoa and Pavia, facing

on one side the Pianura Padana at 80.9 km (on a straight line) from Milano, 50.5 km from Pavia and 47.9 km from Piacenza and 45.9 km far from Genova (**Fig.3**).

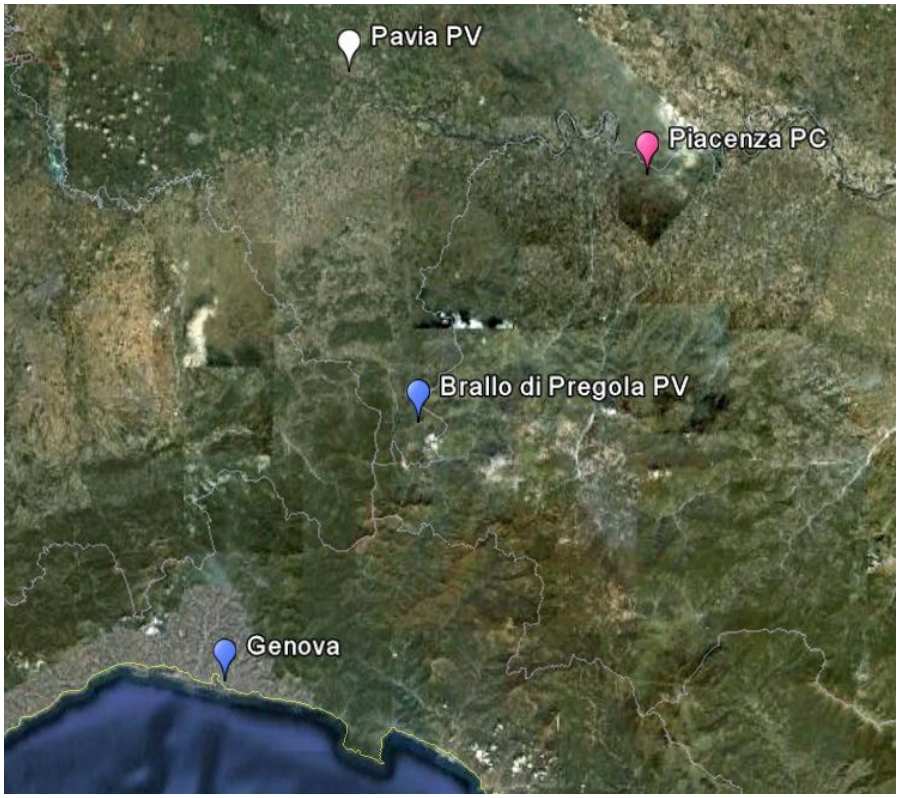

Fig. 3 Localisation of Brallo in comparison with Genova – Piacenza - Pavia

Tab. 4 Characteristics of the software utilised for the analyses

Tools that allow to make energy certification analyses at regional or national level	Shading reduction factor	Solar heat gains	Extra heat transfer by thermal radiation to the sky	Heat transmission coefficient	Thermal bridges	Generator thermal loss	Distribution, emission, contr4ol sub-system losses	
CELESTE	**D**	**D**	**D**	**D**	**T**	**S**	**T**	**S:** simplified
CENED+	**S**	**D**	**T**	**D**	**D**	**T**	**T**	**T**: tabulated
DOCET	**NC**	**S**	**NC**	**S**	**NC**	**S**	**T**	**D**: detailed
TerMus - sempl.	**D**	**D**	**D**	**D**	**D**	**S**	**T**	**NC**: not considered
TerMus - B1 or B2	**D**	**D**	**D**	**D**	**D**	**T**	**T**	

The simulations show the following results. In the plot, **Fig.4,** the calculations of the primary energy (EPH) and the energy needs for space heating (ETH) performed with the four software are compared considering the climatic conditions of Milano. The reference results are considered the ones obtained with Cened+ that represents the official regional tool. Three different results are showed for TerMus commercial software, which allows to assume three different hypotheses on the heating system performances, all of them in

accordance with national standard procedures. TerMus is officially recognised as one of the tested commercial tools that calculate the values corresponding to the national procedures. The maximum difference between the various results is about 5.5%. The influence of the energy needs on the primary energy varies from 78% to 85%, depending on the calculation methods.

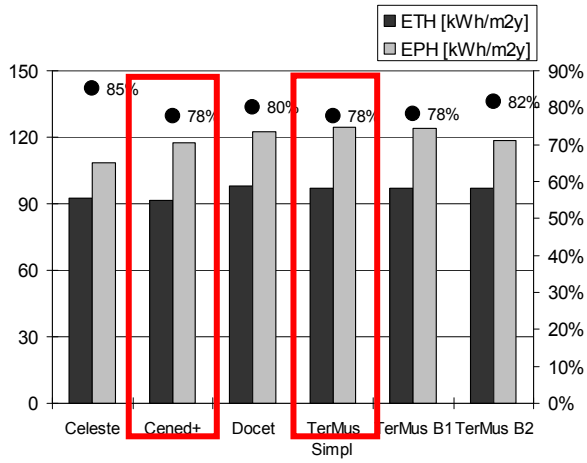

Fig. 4 Energy performance indexes calculated for Milano

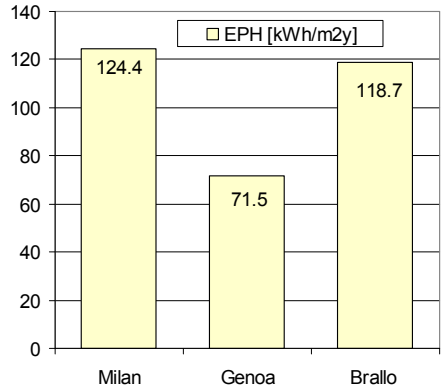

Fig. 5 Climatic data influence

In **Fig. 5**, a comparison among EPH values for Genova, Milano and Brallo di Pregola are shown. The climatic conditions of two main towns, Genova (close to the Mediterranean sea, 1435 Degree Days), and Milano (in the Pianura Padana, 2404 Degree Days), 130 km far from each other, give significantly different results in terms of energy performance of the same building. The Degree Days represent an indication related to the demand for energy needed to heat a building.

In the same plot the results for Brallo di Pregola (3772 Degree Days) are considered. This little village was considered as an emblematic example of the problems that can be attributed either to the fragmentation of calculation methods, or to the simplifications allowed by the standards, or to the lack of information available in the current standard documents (that should be revised taking into account the need of their application also in particular contexts).

Regarding the climatic data required for energy certificate calculations, the Italian Regions have an internal subdivision in "province", each one with its capital town. A “provincia” is an administrative division of intermediate level between municipality and Region: several provinces form a Region. Now there are 109 provinces in Italy, but the UNI 10349 Standard collects the monthly mean climatic data of 101 capitals (the ones existing in the 90th). So, there are no information about 8 capitals. The problem is that all the procedures for the energy certification calculations require monthly mean climatic data (temperature, vapour pressure, irradiance) of the province capitals. For the other towns and villages the temperatures are corrected taking into account the location above the mean sea level and considering as reference the closer province capital located on the same side of the mountains or hills, so the reference provincia capital doesn’t necessarily correspond to the admistrative provincia in which the considered town is located. On the contrary irradiance is corrected taking into account the altitude on the mean sea level and the two closest province capitals located on the same side of the hills / mountains.

For Brallo, which is in Lombardia, the regional software CENED+ has to be utilised. This tool makes the calculations considering the closest province capital of the Lombardia Region (Pavia), even if other province capital, located in the neighbouring region, is closer (Piacenza, in the continental region, far from the sea and therefore climatically more adequate, and Genoa, the closest one and therefore the correct one to be considered). In the UNI 10349, the national standard on the climatic data for heating and cooling calculations, the province capital closest (straight line) to the considered town, on the same geographic side is indicated as the reference location. The altitude difference will be taken into account by a correction formula, but only for the monthly mean temperature determination. Irradiance instead is calculated as the monthly mean value weighted on the latitude, on the basis of the data of the two closest province capital on the same geographic side

Nationally verified software adopts the correct values indicated by UNI 10349, independently from the region in which the town is located.

In **Tab.5** the monthly mean temperatures for Brallo di Pregola, calculated on the basis of the climatic conditions of Genoa or Pavia demonstrate the high difference in the input data that will determine significant differences in the results.

Tab. 5 Monthly mean temperatures of Brallo di Pregola

October	November	December	January	February	March	April	May	June	July	August	September
Commercial software (ref. Genoa)											
12.44	8.24	4.64	3.24	4.24	6.94	10.04	13.14	17.24	19.84	19.94	17.64
Cened+ (ref. Pavia)											
8.39	2.19	-2.61	-4.41	-1.71	3.49	7.99	12.19	16.39	18.59	17.79	14.39

If the Liguria tool CELESTE could be utilised in this case, it would allow to consider two province capitals, even if, at present, there is no indication on the correct order to input data and it is not clearly defined which province capital is used for the correction of the climatic data rather than for the other calculations (the first or the second one in the input mask). In any case in **Tab.6** some "variations" more or less applicable are shown.

Tab. 6 Primary Energy EPH [kWh/m^{2}year] referred to different couple of climatic reference data

Località di riferimento	**Cened +**	**Celeste**	**TerMus**
Pavia-Pavia	192.71	176.88	
Pavia-Genova		176.99	
Genova-Pavia		115.05	
Genova-Genova		112.58	
Genova-Piacenza		113.68	118.7
Piacenza-Genova		174.26	
Piacenza-Piacenza		175.54	
Piacenza-Pavia		181.45	
Pavia-Piacenza		180.78	

The comparison among the results of Celeste, Cened+ and Termus (Simpl.) gives significant differences. In the first column the values of Cened+ consider, as reference, only the Pavia climatic data, as the tool doesn't allow any other choice. In the second column the results obtained using Celeste show the various possible combinations and the variability in the results. The most adequate combination (Genova-Piacenza), to obtain

reasonable results (as it is supposed) is the one highlighted. In correspondence, the value calculated with TerMus are considered, as it takes really the closest province couple, for the climatic data calculation.

3 Observations on the results and conclusions

Some considerations can be made on the results of calculations. The UNI TS 11300 standard, as the EN ISO 13790, allows different approaches and levels of simplification in the calculation of some parameters and therefore, following some of them, the commercial tool TerMus was utilised in three different configurations. The other software considered in the analyses allow lower variability in the choices and therefore the results can be affected by larger approximation.

Starting from the same input data, but changing their meaning to follow the various hypotheses, different calculation methods were considered with TerMus. The results are indicated as TerMus Simpl. (simplified method, reference for the energy certification procedures), TerMus B1 (option if declared system efficiency values are available) and TerMus B2 (considering effective system efficiency values). They are slightly different each other, leading to a more or less evident difference in the energy certification results.

The absence of the obligatory use of a national methodology leads to multiple evaluations based on different regional assumptions, even if based on the same national criteria, represented by the contents of the UNI TS 11300 standard. Some Regions have provided to make available their own software, realised on the basis of the regional methodology for the energy certification of buildings.

In this paper only some aspects were highlighted, as the particularities that lead to obtain different results of the performance indexes are more and more. The confusion is high, but there is a great effort by all the involved parts, to obtain the correct results that can be utilised for further investigations and can lead to decide next steps towards energy saving.

At present, the situation is not too clear, but in the close future the continue application, the possible corrections of the standards, some details clarification, the revision of the methodologies and the tools will lead to a better understanding of the problems and to an easier application of the international dispositions.

The national experience should be compared with the others, in Europe, to help all the countries to follow the aims of the European Directive towards a relevant reduction of energy consumption and emissions.

References

[1] Decree of the President of the Republic 2 April 2009, n. 59

[2] Ministerial Decree 26 June 2009 – National Guidelines on the Energy certification of buildings

[3] UNI/TS 11300-1 Energy performance of buildings - Part 1: Evaluation of energy needs for space heating and cooling, 2008