Estratto da:

ISBN: 978-0-947649-40-1

Conference Themes

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2. human aspects of the indoor environment
3. building services
4. commissioning and operation
5. energy capture and conversion
6. advances in applications
7. validation and calibration
8. software issues
9. simulation in design practice
10. regulation/code compliance
11. application day case studies

The organising committee would like to thank all of those who took part in BS2009 and made it such a success!

Regards,

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ASSET RATING: DISAGREEMENT BETWEEN THE RESULTS OBTAINED FROM SOFTWARE FOR ENERGY CERTIFICATION

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ABSTRACT

The general practice for establishing the consumption in *asset ratings* of a building consists of entrusting the energy analysis of the shell of a building to calculating software.

The building is the subject of an extremely complicated analysis, and there are many variables at stake, is it more correct to aim for a simplification of the problem, in the knowledge that behind every analytical formula there is the possibility of an evaluation error, or is it better to aim for calculation models that are more and more detailed in an attempt to succeed in predicting the real energy behaviour of the building ?

Depending on the objective that has been set, it is a good idea to identify the tool best adapted to reaching it: it is not correct to use simplified calculation methods for every analysis, but not correct to apply dynamic simulation models unconditionally either.

This article shows the different predictive results of energy performance implemented on a sample building and obtained using different software and methods of calculation.

KEYWORDS

Asset rating, Energy Certification, Energy performance of building.

INTRODUCTION

The building energy certification has to purpose to let the users or the planners know the objective energy characteristics of the building-plant set and compare them with the ones from an energy efficient construction thus pinpointing the eventual elements which will be possible to improve. Therefore the energy certification, as defined by the Directive 2002/91/CE [1] in the Legislative Decree 192/2005 [2], includes the energy diagnosis.

The energy diagnosis serves to reveal: the overall conditions of the building-plant set, those elements that are not as efficient and on which it is possible to intervene, and the eventual savings with respect to the initial conditions in order to estimate the cost for an intervention.

This last factor finds its greater application when testing already existing buildings.
Before the introduction of the UNI/TS 11300 [3], two methods were basically used to assess building energy performance:

- *asset rating*, that is an energy performance evaluation through a calculation procedure carried out under standard conditions.
- *operational rating*, that is an energy performance evaluation through the collection of the actual building consumption data.

One of the many commercially available programs present on the market nowadays is almost required to calculate *Asset rating*.

The Primary Energy Requirement or *building energy performance* is the amount of actual or expected energy consumption needed to satisfy the several requirements of a building working under standard conditions [4]. Such amount is assessed through one or more indices calculated by considering the building characteristics, its relative plants and the climate characteristics of the area. It has been pointed out that the term 'calculated' to estimate real consumption from energy bills (defined as FEP_{OP}) is not adequate to represent the objective characteristics of the building-plant set since such a result is strongly biased by users' behavior and seasonal events.

The real evaluation –based on real consumption, is defined by the European normative: *operational rating*.

Instead the building primary energy requirement evaluated through the specific normative (FEP_{as}) provides an objective description of the building-plant set since it refers to standardized climate and working conditions. It consists in the calculation applicable to the Energy Certification (*asset rating*) [5]. Such a requirement must match to the real one where the users' behaviours and the seasonal trends match the standardized ones envisioned by the norms [6]. Instead the real consumption data are obtained by introducing the parameters for the actual building usage and climate trends in the evaluation reference scheme. This applies to the energy diagnosis defined as *tailored rating* [7]. In particular the conventional reference values for calculation purposes are defined as:

- Set-point inside temperatures;
- air exchanges;
- length of the heating and cooling periods;
- working regime of the thermal system;
- inside heat sources.

SIMULATION PROGRAMS

There are many programs on the market for energy certification and energy performance evaluation on buildings. It could be said there are too many.

Besides offering a vast choice to professionals, it has also emerged that many of them give different results even if used on the same project–a problem for a program generating data that has legal and commercial value [8].

Such programs often use algorithms based on different methodologies although they are often derived from law directives.

This study compares the results obtainable through 7 different estimation programs for energy performance on buildings representative of the range of the available estimation codes.

As a further test, the results were also compared against the results from the dynamic simulation program TRNSYS® of the Solar Energy Laboratory, University of Wisconsin [9].

The results from such a program, already validated by the international scientific community, can be exploited as a term of comparison to evaluate the differences relative to the data obtained through the tested programs.

The test programs–grouped according to the calculation methods claimed by the producer software houses, were identified by the letters A-G and are reported in the table below:

Table 1.
Simulation programs

Program	Calculation Method
A	
B	Normative EN 832
C	
D	Simplified
E	
F	Normative UNI from Law Decree 192/2005
G	
TRNSYS®	Dynamic Simulation

METODOLOGY

The evaluation of the results from several programs requires that the input data be unequivocally identical. A model of a simple family house was set up for this purpose.

It consisted of two apartments (two-family house) that were mirror-images to each others, with a flat roof and a floor directly on the ground.

The sample building was set up in such a way to reduce most of the building geometrical and physical complexity and plan specifications to allow a sure comparison based on the same data thus avoiding misunderstandings.

Furthermore, to emphasize the differences among the possible results from the various programs and, above all, to understand both their individual performances and their functioning, it was decided to singularly evaluate the two identical and mirror apartments which obviously had different sides exposed to outside exchange.

Figure 1 below shows the plan of the two floors and a building cross section.

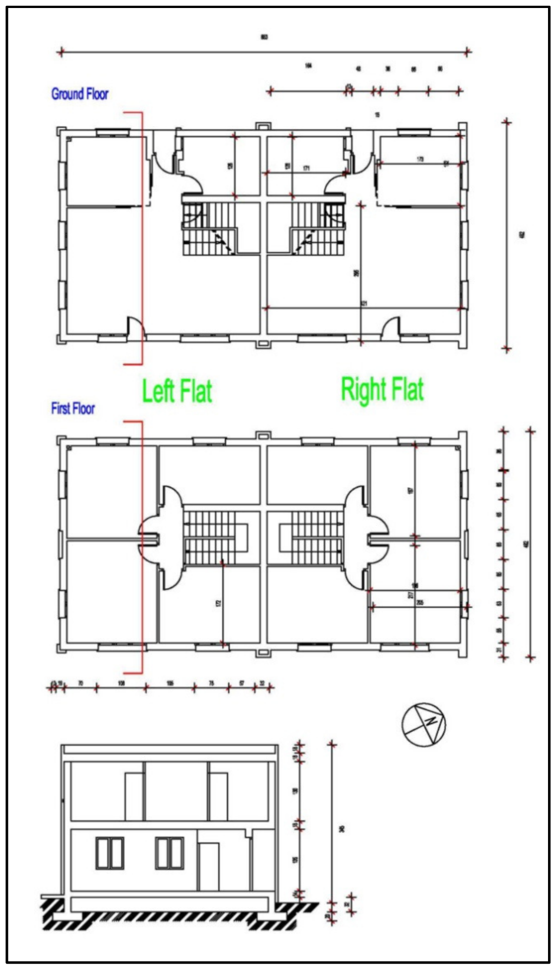

Figure 1. Plan and cross section of the building.

The following tables 2 and 3 show the building geometrical and thermophysical characteristics of the construction elements used as input data to evaluate the energy performances while table 4 show the heating system characteristics hypothesized for the simulation with the different powers for the different areas taken in consideration.

The input data satisfied the input requirements of every tested program in such a way to reduce, in each of the programs, the error margin produced by the greater or smaller amount of information on the building fed to the editing procedure.

Table 2
Building sizes

Geometrical characteristics of the construction	
Total outside height	7 m
Inside height	2.7 m
Base surface of the whole construction	28*12 m
Base surface for each apartment	14*12 m
Total side surface	588 m^2
Total dispersion surface	1 092 m^2
Gross volume of the whole building	2 469 m^3
S/V Ratio	0.478 m^{-1}

Table 3
Characteristics of the construction elements

Thermophysical characteristics of the building		
Element	**Tipology**	**Transmittance (U) W/m²K**
Perimetrical walls	Heavy structure with insulation and interspace	0.25
Floor	Ventilated	0.33
Roof	Laterocemento with insulation on the extradox	0.20
Glass	Low emissivity double glazing with argon 4-16-4	1.40
Frames	thermal cut and wind proof PVC	2.00
Other factors		**Values**
Orthogonal sun factor of glass surfaces (g_{ort})		0.62
Frame surface and glass surface ratio (S_{tel}/S_{tot})		0.34

Table 4
Plant Characteristics

Characteristics of the plants			
Ventilation	Ventilation system	Absent	
	Hourly air exchanges	0.3 vol/h	
Heating system	Heat generator	Standard	
	Terminals	Radiation plates	
	Nominal generator power (P_{ns})	Brescia	20 kW
		Rome	12 kW
		Palermo	10 kW
Inside temperature	20 °C		
Hot water	Not considered		

Climate Factors

The climate of the area where the construction is built consists in an ulterior factor determining energy performance.

The building was evaluated with climate data from three different Italian areas each representing different winter weather conditions [10]:

- Brescia (lat. 45° 32'; long. 10° 12', altitude 149 m., degree-days 2 410);
- Rome (lat. 41° 53'; long. 12° 28', altitude 20 m., degree-days 1 415);
- Palermo (lat. 38° 07'; long. 13° 21', altitude 14 m., degree-days 751).

The daily average temperature of the air in winter time for each or the three cities taken in consideration and to the heat-on periods set by the present Italian Law [11,12] are reported in the diagram of figure 2.

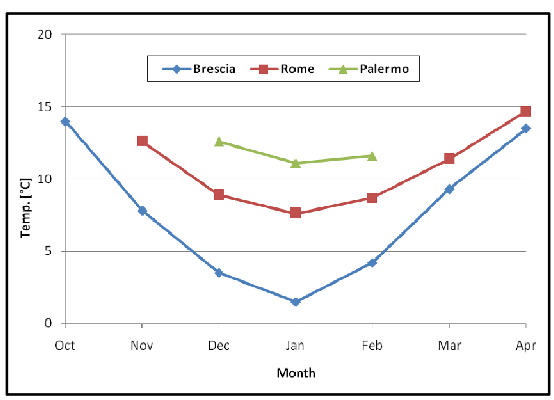

Figure 2: trend of the daily average temperatures for the three cities taken in consideration.

Performance Evaluations

Transmission and ventilation dispersion, inside sources, sun source, the usage factor the for free heat sources and the energy requirement for the building were the values that needed to be found.

The plants required calculation for emission, regulation, distribution and production performance and for the primary energy requirement for the winter acclimatization of the building.

RESULTS

The data inferable from the calculation results from each of the 8 programs and for the two apartments were grouped in:

- Heat losses (transmission + ventilation);
- Free sources (internal gains + solar gains);
- Specific energy requirement of the building (PE_H) [13].

The latter–defined as the building energy performance index, is given by (1) that follows:

$$PE_H = \frac{Q_H}{A_U \cdot 1000} \qquad (1)$$

where Q_H is the building energy requirement referred to the whole heating season defined by (2) as

$$Q_H = (Q_L) - A_U\,(Q_G) \qquad (2)$$

Where

Q is the total exchanged energy (transmission + ventilation);

Q_G is the energy due to the free sources;

A_U is the usage factor of the energy free sources.

The simulation results on each of the climate data for the three cities taken in consideration are reported below.

Specifically Tables 5 – 7 show the results for the dispersions and the free sources as well as the specific energy requirements for the two living units, respectively calculated with the climate data in the cities of Brescia Rome and Palermo.

Figures 3 – 8 show the comparison graphs for each of the two apartments both for dispersions and the free sources as well as the actual index of the building energy performance that is the specific energy requirement. In the latter figures it is possible to appreciate the differences (broken line) from the reference values, calculated through the dynamic simulation software TRNSYS®16, considered representative of the actual energy behaviour.

Table 5
Simulation results obtained with the climate data from the city of Brescia.

Flat	Left			Right		
Software	Loss	Gain	PE_H		Loss	Gain
	kWh/y		kWh/m^2 y		kWh/y	
A	11 466	30 716	78.6	81.2	10 221	32 708
B	5 660	32 266	138.6	144.3	4 901	34 169
C	12 426	26 880	60	66.1	11 299	29 145
D	7 354	23 338	67.2	81.3	6 965	24 780
E	9 768	26 972	72	77	8 091	29 876
F	10 964	22 370	60	65	9 640	25 641
G	9 992	30 364	88.5	91.1	8 871	31 987
TRNSYS®	8 436	28 408	92.4	99.2	8 143	32 087

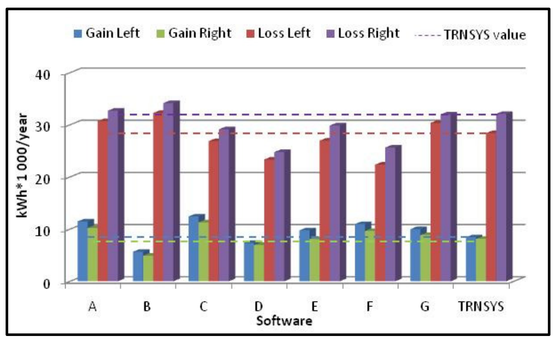

Figure 3 Dispersions and free sources for the two living units calculated with the climate data from the city of Brescia.

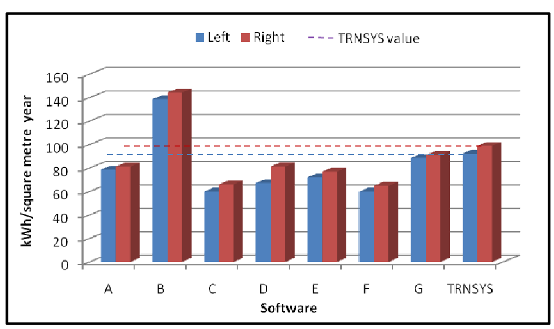

Figure 4 Specific energy requirement (PE_H) for the two living units calculated with the climate data from the city of Brescia.

Table 6
Simulation results obtained with the climate data from the city of Rome.

Flat	Left			Right		
Software	Loss	Gain	PE_H		Loss	Gain
	kWh/y		kWh/m^2 y		kWh/y	
A	10 218	19 026	34.08	36.01	9 811	22 017
B	5 538	19 952	74.28	77.19	5 001	21 101
C	10 210	16 402	26.52	27.33	9 076	18 040
D	7 780	14 818	32.28	35.11	6 971	15 819
E	8 666	15 996	26.4	27.4	7 964	16 831
F	10 198	16 020	30	32	9 152	17 008
G	10 340	19 230	48.12	49.99	9 665	20 161
TRNSYS®	7 782	12 346	31.2	33.71	6 901	13 987

Table 7
Simulation results obtained with the climate data from the city of Palermo.

Flat	Left			Right		
Software	Loss	Gain	PE_H		Loss	Gain
	kWh/y		kWh/m^2 y		kWh/y	
A	7 560	11 024	15.12	16.17	7 001	12 121
B	4 202	11 600	39	41	3 987	11 217
C	7 796	9 670	9.12	9.99	7 129	9 877
D	5 888	9 028	14.4	15.4	5 040	9 145
E	7 080	10 646	15.6	16.1	6 871	11 001
F	8 412	10 420	14.4	15.3	8 069	11 119
G	7 398	12 024	26.88	27.91	7 076	12 987
TRNSYS®	5 700	6 976	19.2	20.2	5 181	7 121

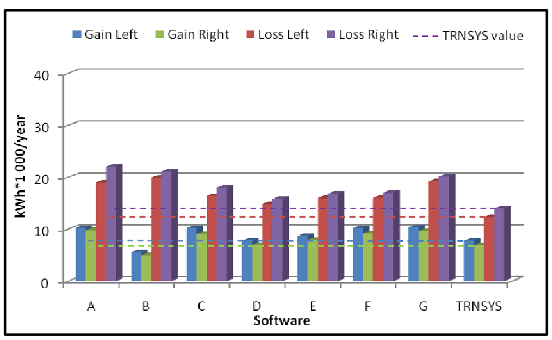

Figure 5 Dispersions and free sourcesy for the two living units calculated with the climate data from the city of Rome.

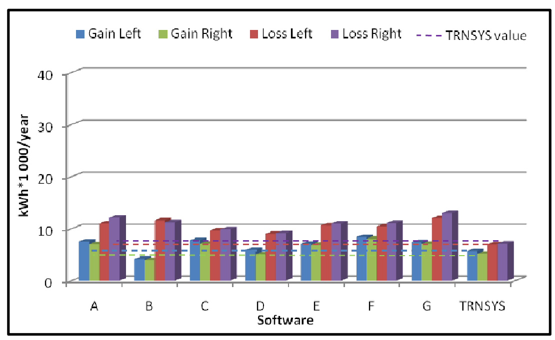

Figure 7 Dispersions and free sources for the two living units calculated with the climate data from the city of Palermo.

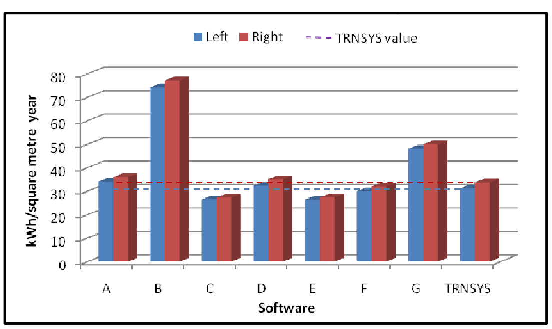

Figure 6 Specific energy requirement (PE_H) for the two living units calculated with the climate data from the city of Rome.

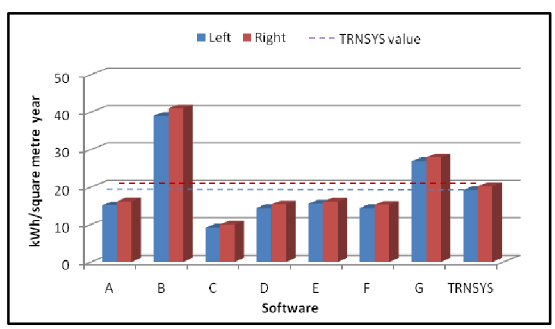

Figure 8 Specific energy requirement (PE_H) for the two living units calculated with the climate data from the city of Palermo.

CONCLUSIONS

The simulation values immediately show the large difference among the results obtained by repeating the test with different programs. The apartment on the right though identical to the one on the left, coherently to the worse exposition of a side to the north, gave poorer performance values. All programs fulfilled this expectation. However the obtained data revealed that several programs tended to underestimate the free sources contribution, especially in those climate contexts that would allow remarkable and positive solar supply to the winter energy balance.

The output values of the performance index that is the specific energy requirement, of several programs appear illogical and incoherent–almost with no correlation to free sources and dispersions.

The graphs in figures 9 – 11 present the error bars with respect to the simulation by the program TRNSYS® 16. The error bars graphically represent the potential error interval relative to each data index in the same series. Obviously their length depends on the amount of uncertainty associated to the value [14].

The performance index data presented differences of 40% in between the various programs and with respect to the reference one. According to these data, each energy certification–produced by each of the programs studied here, would place the same building under a different energy class.

Figure 12 reports the distribution of the classes according to the SACERT subdivision [15] for each of the six simulations carried out with each program.

The latter analysis brings out that most of the results from the different programs are more coherent and closer together when calculations are carried out with climate data that reduce the building eating requirement.

However the doubt on the reliability of these tools remains, in spite of the fact that they are inspired by the same technical norms and applied to the same building, they put out different results.

The European Directive 2002/91/CE on energy certification points out the importance of having simple test tools giving univocal and repeatable results; this test grossly unfulfilled this Directive. At the moment most of the programs tested in this study are being updated to properly meet the requirement changes introduced by the new legislation.

A detailed revision of the calculation codes is to be hoped for in order to assure accurate and reliable building energy evaluations.

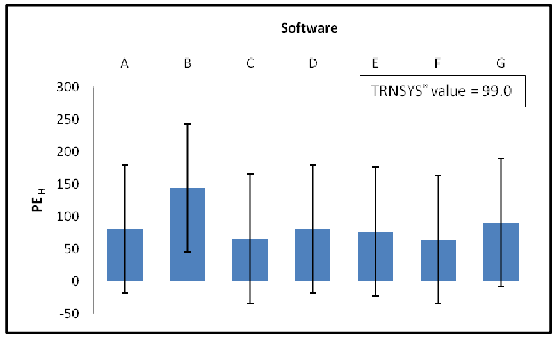

Figure 9 The Specific energy requirement value (PE_H) with its relative error bar for the right apartment – Brescia.

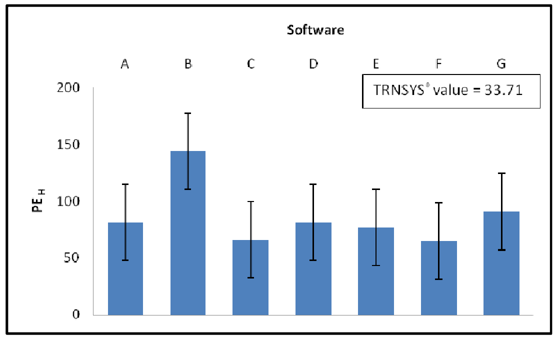

Figure 10 The Specific energy requirement value (PE_H) with its relative error bar for the right apartment – Rome.

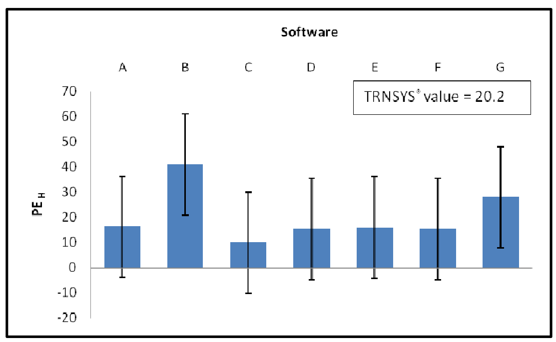

Figure11 The Specific energy requirement value (PE_H) with its relative error bar for the right apartment – Palermo.

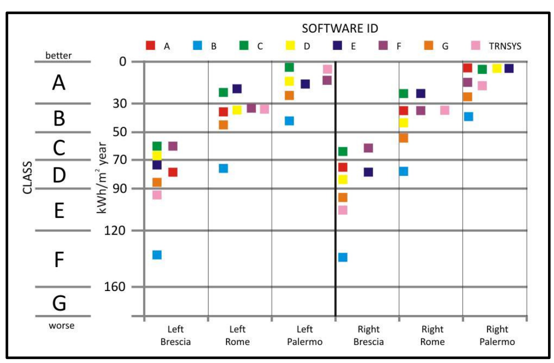

Figure12 Energy performance classes determined by each of the programs for every simulations.

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