How to calculate the energy efficiency of a building

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SUMMARY

The energy requirements of a building has become a crucial factor in determining its value and, therefore, in its commerciability, in its management and in its use.

The fabric of the Italian construction industry is characterized by the existence of a large number of buildings built during the economic boom (1960-1990), when the priorities were: building the greatest number of apartments in the shortest time possible given the high demand for housing due to the population shift from rural areas to urban areas.

Nowadays the energy crisis, the awareness that we have to limit our use of fossil fuels, require that we determine the energy requirements of existing buildings and design projects in order to cut energy consumption in both heating and cooling interior space.

To determine the energy requirements of a building, we have to perform a set of operations and controls consisting of a series of studies, calculations and drawings.

The profession of surveyors, in cooperation with UNI (*Ente nazionale italiano di unificazione*-Italian National Standards Body), has identified a best practice crucial for providing a professional service based on a standard of quality.

In fact, the proper performance of the service means that we can develop a classification for the building comparable to those provided by laws and regulation, which identifies the level of the building's "energy hunger".

In the often frequent case of buildings deemed to be of a "high" energy class (Italian law classifies buildings from "G-high energy consumption" to "A-low energy consumption"), we must develop a scenario for renovating the exterior casing and the systems so that the building, now with lower energy needs, may qualify for inclusion in a "low" energy class.

Compliance with the service quality requirements - encompassing the process, the expertise and the methods of evaluation – support the professional in providing service so that he can meet his client's needs and consider the interests of any third parties.

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Today, a European citizen consumes on average 50,000 kWh of energy per year. This is 500 times more than what that same citizen is capable of producing. Consequently, energy importation weighs heavily on the economy of the entire continent. Consider that 40% of this energy is consumed to run buildings.

Most of this energy is produced with the consumption of fossil fuels that, as we all know, are not on unlimited supply. Barring exceptional discoveries, in 10 years' time the demand will exceed availability.
Among other things, the production of energy by using fossil fuels implies the emission into the atmosphere of enormous quantities of CO_2, causing further bio-climatic disruption.

What is the European Union doing?
With the intent of implementing the Kyoto protocol (1997) and aware of the need to address such an important issue, the European Parliament has issued Directive no. 2002/91/EC on energy saving, by which it establishes that all member States must impose national laws and regulations towards its application so as to making it fully operational by 2005.

In order to achieve the '20-20-20' target (i.e. to reduce by the year 2020 the consumption of energy throughout Europe by at least 20% compared to the consumption levels recorded in 2008; to achieve that at least 20% of EU energy consumption come from renewable resources; to reduce global greenhouse gas emissions by at least 20% below 1990 levels) the European Parliament has issued another directive on energy efficiency, no. 2010/31/EU, proposing to Member States how to implement the provisions regarding the energy performance of buildings.

Directive 2010/31/EU must be implemented by Member States by 9 July 2012, at least as regards its parts that are substantial amendments to Directive 2002/91/EC.

What is Italy doing?
Italy has acknowledged the provisions contained in Directive 2002/91/EC (but has not yet acknowledged Directive 2010/31/EU) via various regulations of implementation[1], which, in

[1] Legislative Decree No. 192 of 19/08/2005 "Implementation of Directive 2002/91/EC on energy performance of buildings", Legislative Decree No. 311 of 29/12/2006 "Amendments and additions to Legislative Decree No. 192 of 19 August 2005", President's Decree No. 59 of 02/04/2009 "regulations for the implementation of Decree No. 192/2005", Ministerial Decree of 26/06/2009 "National guidelines for energy certification of buildings" and

addition to regulating the energy performances of new buildings or subject to building works or plant- engineering, provide the issue of an energy performance certificate (ACE) for each building sale or purchase.
One should also consider that energy is a competitive issue between the Italian State and the Regions. This means that the latter can impose laws and regulations that at local level modify the procedures for drafting the energy certification, with respect to the procedures imposed at national level. One must add to this that in several regions, in order to prepare the energy certification of a building unit it is not enough to be a professional registered with a specific Roll or Society for that profession because the regions require the attendance to special courses that often have final examinations, through which the professionals may acquire registration in specific registers of energy certifiers officially recognised by that specific region.

The energy certificate shows the building's classification with regard to its annual energy consumption, per square meter, expressed in kWh. The energy classes are 8 and range from G to A+, and are determined by evaluating the energy demand for winter heating (Epi) and energy requirements for sanitary water production (EPacs).
At present, the scale of reference of the global energy class is determined by a calculation "ad hoc" for each building, by means of a sum of two components

- Component related to the winter heating: the calculation refers to the form coefficient of the building (S / V = surface dispersing divided the heated volume) and to the Climate Zone in which it is located (hence the related "Degree Day").
- Component related to the hot water: the calculation is based on an algorithm that takes into account the "standard needs".

For the reasons mentioned above, so there are no fixed boundaries to divide the various classes.

How does one calculate the energy efficiency of a building?
The overall energy performance of a building is calculated via the definition of the global energy performance index (EPgl).
The global energy performance index takes into account various factors, including:

1. The consumption of primary energy for:
   a. Winter heating (EPI)
   b. Summer air-conditioning (Epe)
   c. Hot water production (EPacs)
   d. Artificial lighting (EPill); (not currently regulated)
2. The energy delivered and the auxiliary energy of the utility supply systems;
3. The systems for the own production or use of energy.

The standard methods for defining a building's energy performance are mainly two:

Legislative Decree No. 28 of 03/03/2011 "Implementation of Directive 2009/28/EC on the promotion of the use of energy from renewable resources".

1. "calculated design method", based on the evaluation of energy performance starting from the input data of the building's energy design as built and of the utility supply systems serving the building as implemented. This method is first choice for newly constructed buildings and for those completely overhauled, for the preparation of the energy classification certificate and for the technical report on the design's compliance with lower energy consumption provisions;
2. "calculation from standard or building survey method", based on the evaluation of the energy performance starting from the input data derived from on site surveys of the existing building. In this case, the approach can be:
   i. via surveys, even with instruments, of the building and/or utility supply systems performed according to the technical regulations of reference, laid down by the national, European and international regulatory bodies or, should these regulations be missing, by the technical and scientific literature;
   ii. via building construction analogy with other buildings and utility supply systems of the same age, integrated by national, regional or local databases or abacuses;
   iii. based on the main weather, type, geometry and system data.

These methods are applied using computation procedures pursuant to the regulations issued by the Italian National Unification Organization (UNI)[2], also with reference to average climatic data.

These documents are in line with the CEN regulations issued under Mandate M/343 in support of European Directive No. 2002/91/EC on the energy performance of buildings.

What is the impact of energy certification on building value?

Obviously, classification has its impact on building property values and therefore on market prices, since it highlight to prospective buyers the range of expenses required to maintain the building.

An indication, not based on scientific data but taken from the first market references coming in, the difference between a class A+ building and a G class building shows variations in unit price per square meter ranging up to € 500,00.

[2] UNI TS 11300 - Part 1 Calculation of a building's thermal energy requirements for summer air conditioning and winter heating;
UNI TS 11300 - Part 2 Calculation of the primary energy requirements and performance for winter heating and for the production of sanitary hot water;
UNI TS 11300 - Part 3 Calculation of the primary energy requirements and performance for summer air-conditioning;
UNI TS 11300 - Part 4 Use of renewable energy sources and of other energy production methods for winter heating and for the production of sanitary hot water (at public inquiry)

What is the reason for these differences?
Today, building energy classification is not yet adequately considered during the building survey phase. It is absolutely true, however, that the greater the use of kWh/m² in order to obtain "normal" habitability and comfort conditions, the greater the costs for running the building.

To this cost one must add the costs for maintenance, amortization, management, etc., which for the purposes of this paper can be considered essentially similar for all building classes.

The unit cost of one kWh differs according to the source of energy used. In the case of winter heating, the energy used is derived prevailingly from diesel fuel or gas, while electric energy is mainly used for air-conditioning in summer.
The average cost of one kWh, derived from the various energy sources available, generally speaking amounts to € 0,15, with the differences in management costs according to class.
Below is a table showing an example of differences in cost, for properties located in the same town, with similar geometric and technological features:

Class	EPgl Kwh/mq	Cost per kwh	**Cost of building energy menagement**	**Diff. W.r.t. class A+**
		euros	euros/mq	euros/mq
A+	25	0,15	3,75	---
A	30	0,15	4,50	1,25
B	50	0,15	7,50	3,75
C	70	0,15	10,50	6,75
D	90	0,15	13,50	9,75
E	120	0,15	18,00	14,25
F	160	0,15	24,00	20,25
G	>160	0,15	>24,00	>20,25

Having identified the greater unit cost for management, it is possible to calculate the corresponding lesser unit value of the building, based on the capitalisation of the difference in cost.

Indicatively, the capitalization rate, mediated between residential and office destinations, can be assumed to be 4%. This allows us to calculate the difference in terms of minor unit value of the buildings as shown in the following table:

Class	**Unit Capitalization**	**Diff. w.r.t. class A+**
		euro/mq
A+		

A	euros/mq 1,25 : 0,04 =	30,00
B	euros/mq 3,75 : 0,04 =	95,00
C	euros/mq 6,75 : 0,04 =	170,00
D	euros/mq 9,75: 0,04 =	245,00
E	euros/mq 14,25 : 0,04 =	355,00
F	euros/mq20,25 : 0,04 =	505,00
G	euros/mq >20,25 : 0,04 =	>505,00

which is perfectly in line with the first market references mentioned earlier.

What are the market's reactions?

Italy features a large number of buildings built during its economic boom (1960-1990) when the priority was to build as many apartments as possible in the shortest time possible.

The energy classification of a building contributes to its attractiveness and therefore its price, stimulating owners to act in favour of a decrease in energy consumption. The limitation of a building's energy consumption therefore has become a civic duty as well as an important element in defining its value.

Energy certification is becoming a tool for transforming the real estate market. It improves its transparency and efficiency because it provides prospective buyers with an objective definition of the energy performance of the building they are intending to buy and therefore of the relating expenses.
The certification is preparatory to the design of new highly performing buildings as well as to the renovation of existing ones.

In order to promote building construction actions aimed at curbing the energy consumption of existing buildings, the Italian government has issued regulations that provide for considerable tax discounts for owners, amounting to 55% of the cost for required works.

What are Italian Land Surveyors doing?

The *Consiglio Nazionale Geometri e Geometri Laureati* (National Council of Land Surveyors and Graduate Surveyors) has undersigned with UNI a convention for the joint preparation of a quality standard regarding the professional qualification of the professional category.
The quality standard consists of a general organization document and of a document containing the technical specifications relating to individual professional services concerning three macro-areas:
E. - building construction, town planning and the environment,
P. – cadastral surveys and expert surveys,
T. - topography, cartography and geodesy.

As regards macro-area E, the provisions apply to the correct performance of the professional service in defining a building's classification, to be likened to that envisaged by the regulations, that identifies a building's "energy demands".

In the rather frequent case of "high" energy classification buildings, one must plan towards the qualification or re-qualification (in the case of pre-existing buildings) of the building's shell and utility supply systems, so as to reduce the building's energy demands and therefore reclassify it in a "low" class.

How does one identify a building's qualification or re-qualification works for the purpose of lower energy consumption?

Having defined the calculation method, the professional can use the technical specification that lists the sequence of operations and checks to be performed when defining the thermal energy requirements of a building and for the consequential definition of any necessary re-qualification works.

The activities the land surveyor is called to perform can be summarized as follows:

- preliminary documented verification
- on site inspection
- description of room layout
- description of shell
- description of utility supply systems
- measurement of transmittances and of "free" energy supplies
- measurement of primary energy requirements
- calculation of utility supply system performance
- identification of energy class
- if required, planning of a qualification scenario of the shell and of the utility systems
- if required, identification of the resulting energy class.

In describing the shell and the utility supply systems, through the use of the modern technology available and especially of thermography applied to buildings, the land surveyor can elaborate a diagnosis of the building and highlight its critical points, such as thermal bridges, insufficient insulation of piping, or any other parameters, to be solved via precise improvement actions he or she proposes and aimed at substantially reducing the building's global energy consumption.
Only a trained and constantly updated professional is capable of supporting the final user in the complex and delicate activity of energy re-qualification of existing buildings.

To this regard, it should be noted that since 2009 it has become mandatory for all Italian land surveyors to attend courses towards the obtainment of minimal educational credits for pursuing the profession.

This innovation is proof of the Category's will to prepare to tackle the labour market with the necessary professional skill and with the awareness of the delicate social role it is called to play.

From these brief indications it is possible to infer how fundamental the role of the professional is, also and especially at the social level. Indeed, better design leads to:

- buildings with greater market value
- more healthy and comfortable living quarters
- lower building management costs
- less pollution.

In short: live and let live better.

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