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Contents

A REVIEW OF BUILDING ENERGY REGULATION, CLASIFICATION AND CERTIFICATION SCHEMES

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Abstract: Energy certification schemes for buildings emerged in the early 1990s as an essential method for improving energy efficiency, minimising energy consumption and enabling greater transparency with regards to the use of energy in buildings. However, from the beginning their definition and implementation process were diffuse and, occasionally, have confused building sector stakeholders. A multiplicity of terms and concepts such as energy performance, energy efficiency, energy ratings, benchmarking, etc., have emerged with sometimes overlapping meanings. This has frequently led to misleading interpretations by regulatory bodies, energy agencies and final consumers.

This paper analyses the origin and the historic development of energy certification schemes in buildings along with the definition and scope of a building energy certificate and critical aspects of its implementation. Embodied energy calculations and life cycle analysis are pointed out as key elements in building energy assessment and should be included in energy regulation and certification schemes in order to effectively lead the building sector towards sustainability.

Key words: energy certification, energy rating, energy benchmarking, embodied energy, building life cycle

1. INSTRUCTIONS

World energy crises, such as the 1979 oil shortage caused by the Iranian revolution or the drastic increase in the price of oil in the early 1990s due to the first Gulf War, raise governmental concerns over the supply energy and access to worldwide energy resources. European nations, highly dependent on energy resources from politically unstable areas, were particularly affected. At the same time, the global contribution from the energy consumption of buildings was steadily increasing, to around 20–40% in developed countries and exceeding the other major sectors, industry and transportation [1].

It was under such circumstances that a new concept relating to energy efficiency in buildings emerged in the early 1990s as an essential method of reducing energy use and CO_2 emissions: energy certification for buildings.

An overall objective of energy policy in buildings is to save energy consumption without compromising comfort, health and productivity levels.

This paper provides an overview energy certification in buildings with focuses on four critical issues: (1) the definition and scope of energy certification schemes, (2) building energy classification and (benchmarking and rating concepts) (3) the implementation of energy certificates in buildings (4) methodology to obtain a life cycle building energy rating, etc.

2. INSTRUMENTS FOR BUILDING ENERGY ASSESSMENT

Building energy assessment, extended to its design, construction, and useful life, allows for a proper quantification of the building's energy implications, and hence provides the basis for appropriate planning in the sector. Given the high relative weight of the sector in the country's energy balance, the very limited penetration of energy assessment tools in it and its high inertia to incorporate changes, there is a clear need to develop normative and mechanisms that structure the application of energy assessment in the building sector.
The two main mechanisms to articulate the participation of energy assessment in the building sector are *energy regulation* and *energy certification*. [3].

2.1. Energy regulation

The objective of energy regulation should be to establish and limit the upper bound for the building energy consumption. Energy regulation, that has a normative character, establishes the minimum, and often the only, building energy assessment tools that will be introduced in the sector. Therefore, it has a high responsibility in the internalization of energy assessment. The success of building energy regulation in effectively controlling the energy consumption in the sector will be to a great extent associated to the adopted energy performance indicator and to the promoted energy assessment tools.
Since there are no other mechanism, energy regulation lays down the foundation for the energy consumption in the building sector, and hence, should allow for a clear quantification of its implications both at national and at consumer level.

2.2. Energy certification

The main objective of energy certification is to promote higher energy performance standards than the regulated ones. In order to acomlish this, energy certification must provide a clear and detailed information about the building's energy performance, and thus enable straight comparison between different buildings. As well as with energy regulation, the indicators implemented in the energy certification will condition its capability to reach the pretended objective. The indicator implemented in the energy regulation should be included among the indicators provided by the energy certification in order to clearly situate the certification on the reference regulated level of energy performance. The most important elements for the success of energy certification are the energy assessment methods upon which energy certification is based, as well as their transparency.
Energy certification scheme that is well implemented must enable and promote a clear quantification of design concepts with potential for building energy consumption reduction, such as bioclimatic architecture, passive solar heating, passive cooling, passive ventilation, integration of renewable energies, always guaranteeing some given comfort levels. This is the only way to stimulate the market introduction of all these recommended design strategies from an energy point of view, but with a quality guaranty that avoids their discredit.
When there is a good energy certification scheme, with a compulsory character and a demand for short period actualization, it enables quantifying the actual energy state of the building sector, and monitoring its evolution in time, as well as promoting and evaluating the energy efficiency measures introduced in it. A proper energy certification scheme gives an added value to the building and allows the assignment of economic incentives to drive the building sector towards sustainability.

2.3.Building energy analysis

A building represents a very complex energy system, especially when it allows a high degree of interaction with its surrounding environment (bioclimatic architecture, solar passive design) with the aim of improving its energy performances. Therefore, given the high relevance of the building sector in the energy consumption, the introduction of rigorous energy analysis tools, capable to appropriately assessing the operational energy implications of different design options, should be promoted. Since this sector has no tradition in energy analysis, the role of the normative (compulsory regulation and certification schemes) is of utmost relevance to reach an effective introduction of energy analysis tools in the building sector. Important energy analysis tools in the building sector are EnergyPlus, Energy10, HOMER, HOT2 XP, DOE-2, AEPS System Planning, COMSOL, DesignBuilder etc.[13]

To appropriately assess building operational energy requirements, and especially those designs with a higher energy saving potential, the use of a complete and detailed dynamic energy simulation tool is required. The proper use of such an energy tool requires a considerable degree of qualification and training, and therefore requires additional resources, both for the building design team as well as for the administration that should control the regulation and certification schemes.

The energy regulation and certification schemes should always include the goal to achieve a real internalization of energy analysis in the building sector, since the building energy operational demand will always constitute an intrinsic contribution in all buildings. Other energy contributions may be more dependent on higher structures like urbanization, social organization, and technology development, which may change with time and that are often not accessible by a single building design (they are more a part of the urbanization certification sphere than to that of the individual building).

3. DEFINITION AND SCOPE OF BUILDING ENERGY CERTIFICATION

The term “building energy certification” has been used inconsistentlz and without precise definition from the very beginning. In the European Council Directive 93/76/CEE [8] to limit carbon dioxide emissions by improving energy efficiency, energy certification is presented as one of the cornerstones for achieving energy efficiency in buildings. This certification ‘‘shall consist of a description of their energy characteristics, must provide information for prospective users concerning a building’s energy efficiency’’ and besides that, ‘‘may also include options for the improvement of these energy characteristics’’.

The Directive 2002/91/EC [9] on the energy performance of buildings was introduced almost ten years later by the EU as a new regulatory instrument. This Directive contained also the requirement for a building energy performance certificate as ‘‘a certificate recognised by the Member State which includes the energy performance of a building calculated according to a methodology . .’’.

This second approach to an energy certification definition perpetuated two unresolved issues: how to define and how to measure building energy efficiency. It also introduced a new term energy performance that was related to building energy use. From such perspective European energy performance indicators (EPI) and American energy-intensity indicators or energy use intensities,are equivalent since both are ratios of energy use input to energy service output (site energy per square meter, CO_2 emissions per home, etc.).

The new European standard EN 15217 [10] is an attempt to describe methods for expressing energy efficiency and certification of buildings. Energy Performance Certificates are redefined within the development of a certification scheme (Fig. 1) which must contain at least:

• An overall energy performance index (EPI) stated in terms of energy consumption, carbon dioxide emissions or energy cost, per unit of conditioned area in order to make the comparison between buildings possible.

• An overall minimum efficiency requirement to be established by the legislation as a limit of the energy performance index (EPI_{MAX}). The standard recommends its correlation with other parameters (such as climate and building type) or a self-reference method.

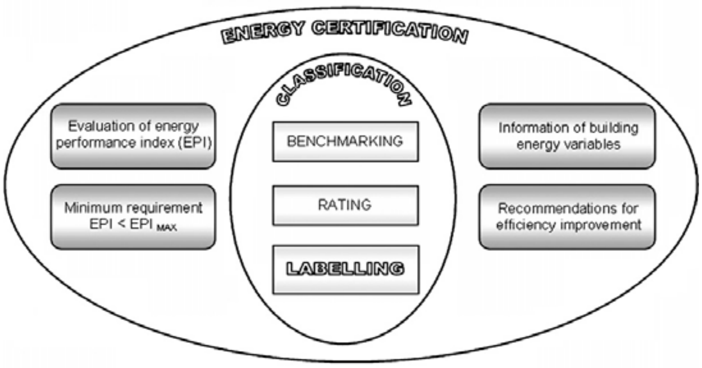

Fig. 1. Scope of the new European building energy certification scheme. [2]

• A label based in the A–G bands to achieve a suitable grading of buildings. The most important issue is the definition of the scale that should make reference, at least, to the building energy regulations, the existing building stock and the zero-energy building.
• Energy consumption by the main building components, such us building envelope and services, together with recommendations of energy efficiency measures for building owners' consideration.
The area covered by the certification thus includes not only to the energy performance of the building but also a minimum requirement and label or class that allows users to compare and assess prospective buildings. Besides other information, the certificate must contain, a classification of the building energy efficiency based on an energy label.

4. BUILDING ENERGY CLASSIFICATION

The term building energy classification encompasses any procedure that allows the determination of the quality of a building (in terms of energy use) in comparison with others. This section attempts to clarify the concepts of benchmarking and rating in the context of building energy classification.

4.1.Benchmarking process

The term building energy benchmarking started to be used in the 1990s, to denote the comparison of energy use in buildings of similar characteristics.
It consists of a comparison of the EPI of a building with a sample of similar buildings. It is also important, an governments should consider benchmarking in the early conception, development and implementation of energy efficiency policies within the building sector.
There are four phases in the benchmarking process [2]. First, it is necessary to hold or develop a database with information on the energy performance of a significant number of buildings. This information should be categorised, at least, by building type and size. Second is gathering the relevant information for the evaluation of the EPI for the actual building. Third, a comparative analysis of the building energy performance against the samples held in the database gives a quantification of the quality of the building in terms of energy use. Finally, energy efficiency measures that are feasible from both technical and economical perspectives should be recommended (Fig. 2).

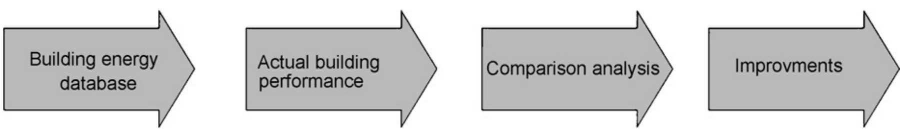

Fig. 2. Building energy benchmarking process. [2]

The energy consumption of the actual building can be predicted via a computer-simulation-method or measured on site. Through energy simulation detailed information and a wide variety of outputs could be obtained, however, it may require a great number of inputs, skilled users and a significant amount of time to gather and input the necessary data. This can make the process expensive. Energy use of new and existing buildings may be obtained at different levels of accuracy and cost.

There are always discrepancies between predicted and measured energy use. Some sources of error are natural uncertainties like the differences between real weather and typical simulation climate data. Others, like the use of default data for internal loads may be reduced by adjusting the building model to the existing building real conditions.

Occupant behaviour also has great influence of on energy performance. Large variations in energy use, even for the same climate and building type could be the result of the variables that are strongly dependent on the occupants or owner such as: number of people and activity, thermostat setpoints, equipment usage, natural ventilation, hot water demand, etc.

Gathering energy information to populate a database with a representative sample of the building stock is both expensive and technically complex. These are the reasons why only a few nations have undertaken this task to date. Most often information is collected on site from building owners, tenants, facility managers, etc.

Another way to generate a database is the application of building energy simulation to a variety of building types for a range of energy parameters (parametric benchmarking). In order to form a valid database it is critical to carefully select building types and calculate methods. One more constraint is the need to customise building envelopes and HVAC sizing for each climate and system type. An advantage is the possibility of covering a wide range of building energy consumption characteristics with a suitable selection and variation of the energy parameters. Additionally, energy simulation provides a wider range of energy outputs for future comparisons.

Finally, any benchmarking program that combines the use of measured energy consumption for actual buildings with a database based on simulation must be calibrated to ensure the comparative analysis is consistent. Currently, most benchmarking programs are based on measured energy use of existing buildings.

A subset of comparable buildings could be obtained by filtering the database against similarity parameters. This is called the comparison scenario. Energy intensity frequency distribution curves for that scenario enables determination of a percentile ranking, percentage of buildings with better (or worse) energy performance.

4.2.Energy rating

‘‘Rating’’ is perhaps the most confusing term within this framework, especially in non-English-speaking nations, as it is indistinctly used to refer to the building energy classification (the rating system), its application (the action of rating) and its final result (the rating figure).

Generally, the expression energy rating system may be used as a synonym of energy classification, that is, a method for assessing energy quality.

Energy rating within the framework of Directive 2002/91 means evaluation of the building energy performance. In the standard EN 15603 [11], CEN[1]proposes two types of ratings: (1) calculated ratings, based on computer calculations to predict energy used by a building for HVAC systems, domestic hot water and lighting and (2) measured (or operational) ratings, based on real metering on-site. Calculated ratings are subdivided into standard (also called asset) and tailored ratings. The asset ratings use the calculation procedure within standard usage patterns and climatic conditions not to depend on occupant behaviour, actual weather and indoor conditions, and are designed to rate the building and not the occupant. Asset ratings can be shaped to buildings during the design process (as designed), new buildings (as built) or to existing buildings.

[1] CEN-European Committee for Standardization

Energy efficiency certification schemes for new buildings are usually implemented by asset ratings. Both calculated and measured ratings can be applied for the existing buildings. The measured ratings are preferred to reduce energy performance discrepancies and limit consumer risk due to uneconomic retrofit investment or credibility problems if stakeholders conclude that energy rating system are less accurate than expected.
As recommended by CEN, a building energy certification scheme for existing buildings should be implemented by the use of operational ratings with reference values (benchmarks) taken from the building stock in order to establish the classification system. Similarly, for new buildings, an asset rating should be used in comparison with the references values set by the regulation, the building stock and the zero energy building.

4.3.Life cycle building energy rating

Life cycle energy analysis of buildings has been researched even before decades. The importance of including life-cycle issues within building regulations has also been high-lighted. Some authors have emphasised the need for a new methodology to be developed. They demonstrated with some very-low energy case study buildings that a reduction of energy use in operation does not always imply a reduction of life cycle energy use.

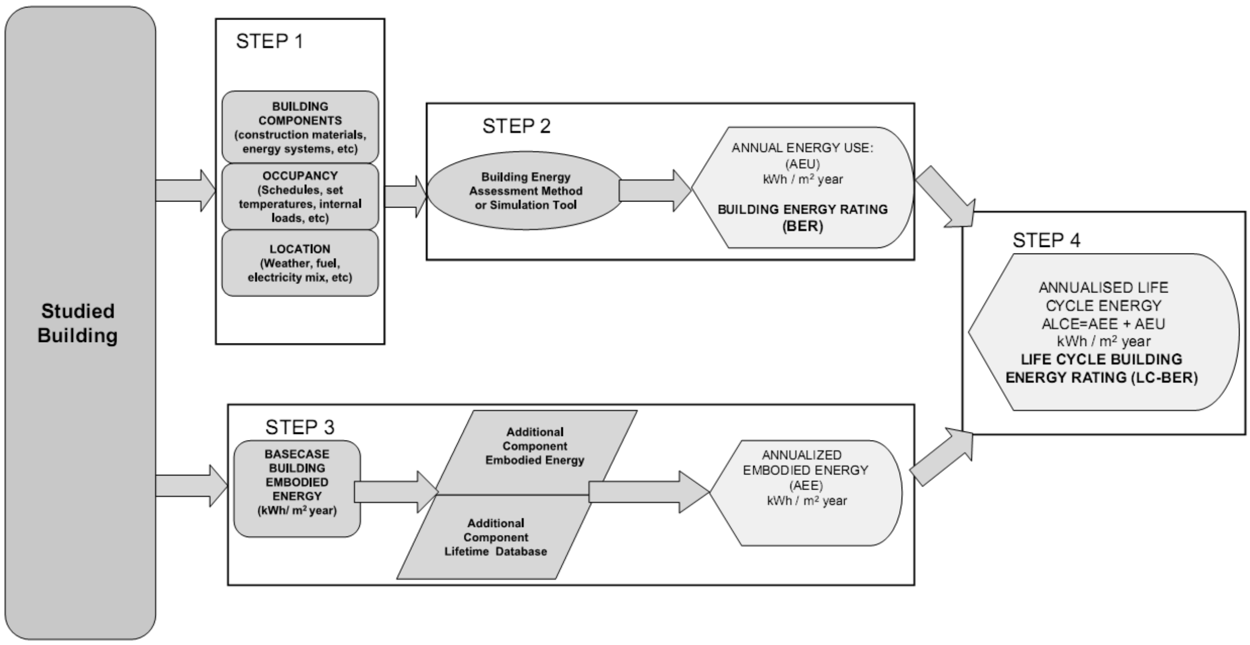

Fig. 3. Diagram of the proposed methodology to obtain a life cycle building energy rating (LC-BER). [5]

An extension of assessment methods and ratings into a life-cycle building energy rating (LC-BER) is proposed, by a simplified accounting method for embodied energy data of building compo- nents and systems, and presenting all in a common indicator in kWh of primary energy per square meter of building area per year currently used and widely understood measure. The process is illustrated in Fig. 3.
Step 1 is building information gathering. Information about building type and size, envelope characteristics, heating, cooling, ventilation and hot water systems and controls, lighting, etc. needs to be collected. These data can be obtained from building plans and specifications for new buildings, complemented by surveying of existing buildings. In this first step other factors such as indoor design temperatures, occupancy schedules and internal gains also need to be specified. They can be based on standardised data for specific building types. The input of location specific data such as weather, or data related to the properties of the fuels used and electricity mix, can also be based on standardised data defined within the BER methodology.

In Step 2, a calculation or simulation tool uses all the gathered data to calculate the annual energy use (AEU), and presents the results as an indicator, for example kWh of primary energy per square meter per year. After that the calculated result is compared to a benchmark energy performance scale (see Fig. 4) and a label awarded, for example on an A to G scale. Figure 4. is the result of research of the Irish house. The Irish house is selected from an example in the Irish Building Regulations Technical Guidance Document L (Minister for the Environment Heritage and Local Government, 2007).

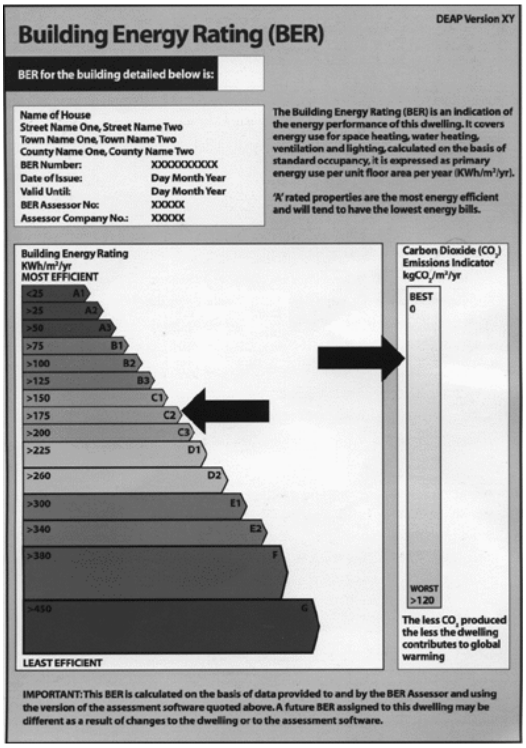

Fig.4. Irish domestic BER (Sustainable Energy Authority Ireland, 2010b- http://www.energyratingplus.ie/aboutus.php#compliance)

Before arriving at an LC-BER label two additional steps will be required, including embodied energy to provide a life cycle perspective. The embodied energy of a building is therefore the total energy required to construct it – that is to win the raw materials, process and manufacture them as necessary, transport them to site and put them together. It is the energy that has "gone in with the bricks" and which cannot be recovered during the lifetime of the building, no matter how efficiently it operates. Complexity of the data collection and calculations has always presented the biggest obstacle for the inclusion of embodied energy within building performance assessment methods.
A full inventory and details of 'cradle to grave' processes of all components and systems identified in Step 1 would be needed to extract embodied energy data accurately. This task is beyond the viability of building energy assessment and rating methods as they currently exist, a characteristic for success of which should be easy implementation and a relatively low cost.
The simplified approach proposed here is to facilitate the inclusion of embodied energy using a reference building as a base case, approached in line with the way some building regulations deal with compliance of energy requirements. The embodied energy data for a reference building of specific characteristics and size can be gathered in most countries based on economic data for different activity sectors complemented with statistical energy usage data, in what is called an input–output embodied energy analysis.
In Step 3 of the proposed model the embodied energy of 'additional components' of the reference building, such as additional insulation of the building envelope, or renewable energy systems, is accounted for in more detail using embodied energy data for each component. As the reference building embodied energy is calculated with typical materials and construction methods based on the input-output analysis , there could be cases where particular buildings do not compare directly to this reference typical building, as might be the case of buildings using, for example, low embodied energy cement or renewable materials. In such cases, the embodied energy of the reference building could be fine-tuned with input from inventory embodied energy analysis of the particular differential components.

For Step 3 a national or regional database would need to be included with embodied energy values of 'base-case' buildings and of different components and materials, togetherwith their service life, allowing the expression of embodied energy in terms of kWh primary energy per year or their 'annualized embodied energy' (AEE).

The last Step 4 of the proposed LC-BER represents the direct addition of results of AEU from Step 2 and AEE from Step 3, both expressed in the indicated terms of kWh of primary energy per year, allowing its comparison with a benchmark and the labeling of the results.

5. IMPLEMENTATION OF CERTIFICATES IN BUILDINGS

In the development of an energy certification scheme for new buildings some questions should arise:

- What should be calculated in order to assess building energy efficiency, how should the limit for energy efficiency be set, to what should the building energy efficiency be compared?

First step to take within the energy certificate implementation is the definition of energy performance indices. Some research [6] propose multiple indices to consider simultaneously energy use, environmental impact and indoor air quality, though energy use per unit of area and year is almost the standard EPI for buildings. Even for this simple EPI, one must decide the magnitude for energy use (delivered energy, primary energy, CO_2 emissions or energy cost) and choose energy services (lighting, hot water, HVAC, cooking, refrigeration, etc.) to be accounted for.
Building regulations should answer this question setting the minimum overall requirement for the energy performance index. There are two different approaches: fixed and customized limits. Energy efficiency of different building types is not comparable in terms of the energy performance index, since they provide different services. Parameters for achieving discrimination could be building type, climate, building shape, energy source and ventilation rates. Therefore, in the fixed limit option, the threshold value is dependent upon the parameters whose impact is to be reduced or neutralized.
A customised limit may be obtained by the self-reference (also called notional building) approach, where EPIr is set by a reference building having at least same location, geometry and pattern of use but different envelope and systems.
The next step in the implementation process is the definition of the comparison scenario. A subset of comparable buildings must be obtained by filtering the database against similarity parameters in relation to the object for comparison. Alternatively, when there are no buildings to be compared to, the solution is the self-reference approach where the actual building is compared with a reference building derived from the actual building according to rules laid down in the energy code.
The difference between the standards and calculation tool languages might be a source of problems. The rules to model the reference building must be written in the calculation tool terminology while regulations use a normative language. Thus, certification and energy code developers must have experience in both fields to assure the consistency and effectiveness of the certification scheme.

- How should energy performance be calculated?

Basically, there are two different approaches for the prediction of energy performance of buildings: simplified and detailed simulation methods. The implementation of the methodology requires the development of a computer based tool. When choosing the method issues such as accuracy, scope, reproducibility, complexity, sensitivity to energy parameters and user skills should be considered because they have a great impact on final users, professional associations, manufacturers, software developers, policy makers and other stakeholders. Thus, credibility and success of the certification scheme are strongly dependent on the second step of building energy certification implementation: development of an energy calculation tool.

- What energy efficiency improvements should be recommended?

Building energy certification schemes should produce a list of recommended measures to encourage building designers, owners, operators and users to improve the energy performance of their buildings.

For new buildings at design stage, engineers should work in parallel with architects to adjust design parameters to reduce energy consumption. Energy analyst knowledge and experience are necessary to suggest those measures of greater impact on savings. Intelligent tools capable to automatically explore different options and even to select an optimum are part of the coming future, meanwhile a results based analysis tool to guide the user in the improvement process could be of great help.

- What information should the energy certificate include?

Obviously, building energy certification final report must include at least the energy label and the EPI. In order to assess what other information should be of energy information according to its final use: (1) administrative data such as building address, date, certifier name, etc. are necessary to identify both building and certifier, (2) energy variables to be controlled and inspected (glass shading coefficient, boiler efficiency, etc.) by competent bodies and (3) information gathered by the energy agencies to populate their building database (building type, total area, conditioned area, HVAC system type, energy sources, etc.).

6. CONCLUSIONS

In this paper provided an overview of the general conditions for the building energy regulation and certification schemes to be effective in controlling and limiting the energy consumption of the building sector.
One of the key points in building regulation and certification schemes is the indicator implemented to assess the building energy performance.
Building energy tools with capabilities to effectively model the energy implications of different design and operational strategies are nowadays available. The internalization of the building operation energy analysis should be favoured by the energy regulation and certification schemes in order to rationally assess the energy saving options and promote the introduction of the most efficient design and operating strategies.
Embodied energy considerations and live cycle analysis should be included in energy regulation and certification schemes in order to effectively lead the building sector towards sustainability.
The implementation of the new European building energy certification scheme is a complex task facing some critical issues: definition of the energy performance index, development of an energy performance calculation tool, setting a threshold value for the performance index, definition of the comparison scenario, identification of potential energy efficiency measures and gathering energy information in the certification process.
The words energy rating should only be used for the assessment of the energy performance, both for new and existing buildings, in standard or actual conditions. Energy benchmarking tools provide a comparative appraisal of the energy performance of an existing building within a comparison scenario.
The success of building energy certification schemes will almost certainly depend on: (1) the ability to obtain better labels cost-effectively, (2) the credibility achieved by real energy savings and (3) the degree of commitment to the global environmental crisis of the building sector stakeholders.

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REFERENCES

[1] L. Pé rez-Lombard, et al., A review on buildings energy consumption information, Energy and Buildings 40 (3) (2008) 394–398

[2] Luis Pe ´ rez-Lombard a, Jose ´ Ortiz b, Rocı ´o Gonza ´ lez a, Ismael R. Maestre c, A review of benchmarking, rating and labelling concepts within the framework of building energy certification schemes, Energy and Buildings 41 (2009) 272–278

[3] Xavier Garcı ´a Casals, Analysis of building energy regulation and certification in Europe: Their role, limitations and differences, Energy and Buildings 38 (2006) 381–392

[4] Patxi Hernandez a, Paul Kenny b, Fromnet energy to zero energy buildings: Defining life cycle zero energy buildings, Energy and Buildings 42 (2010) 815–821

[5] Patxi Hernandez a,b,n, Paul Kenny c, Development of a methodology for life cycle building energy ratings, Energy Policy 39 (2011) 3779–3788

[6] C.-A. Roulet, et al., ORME: a multicriteria rating methodology for buildings, Building and Environment 37 (6) (2002) 579–586.

[7] Keith J. Moss, Energy Management in Buildings by Taylor & Francis, New York, 2006

[8] Council Directive 93/76/CEE of 13 September 1993 to limit carbon dioxide emissions by improving energy efficiency (SAVE).

[9] Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings.

[10] EN 15217, Energy performance of buildings—methods for expressing energy performance and for energy certification of buildings, 2007.

[11] EN 15603, Energy performance of buildings—overall energy use and definition of ratings, 2008.

[12] Arkesteijn, K., Dijk, D.V., 2010. Energy performance certification for new and existing buildings. Information Paper 156. CENSE European Project. www.iee-cense.eu.

[13] web site: http://apps1.eere.energy.gov/buildings/tools_directory, retrieved august 2011.