CEN Standards for Implementing the European Directive on Energy Performance of Buildings

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ABSTRACT: The Energy Performance of Buildings Directive (EPBD) requires EU member states to establish a methodology for calculating the energy performance of buildings within a framework that includes the effect of active and passive solar systems as well as other characteristics of buildings and their installed energy systems. Member states must also implement regulations based on this methodology, aimed at reducing the energy use of buildings by promoting both energy saving measures and a wider use of renewable energy sources. To facilitate the implementation of the Directive the European Community mandated the CEN to draft a series of standards that provide methods to assess (by measurement or calculation) the energy performance of buildings, including existing buildings and those in the design stage, ways to express energy performance requirements, and a certification procedure. This paper describes the global methodology proposed for building energy certification and presents the content of the main standards.

Keywords: energy, buildings, standards

1 INTRODUCTION

Directive 2002/91/EC[1] on the energy performance of buildings (EPBD) requires several different measures to achieve prudent and rational use of energy resources and to reduce the environmental impact of energy use in buildings.

This is to be accomplished by increased energy efficiency in both new and existing buildings. One tool will be the application by Member States of minimum requirements on the energy performance of new buildings and large existing buildings that are subject to major renovation (EPBD Articles 4, 5 and 6). Other tools will be energy certification of buildings (Article 7) and inspection of boilers and air-conditioning systems (Articles 8 and 9).

A basic requirement for measures in Articles 4, 5, 6 and 7 is the existence of a general framework for a methodology of calculation of the total energy performance of buildings, as set out in Article 3 and the Annex to the Directive.

This paper describes the most important European standards (ENs) that are intended to support the EPBD by providing the calculation methods and associated material to obtain the overall energy performance of a building.

2 THE STANDARDS AND THE EPBD

A total of 30 European standards (EN) and 24 international (EN ISO) standards are being revised or drafted to help European countries implementing the EPBD. These standards and their interrelationship are presented in a so-called "Umbrella Document"[2].

The four main components set out in the Directive relate to:

- calculation methodology;
- minimum energy performance requirements;
- energy performance certificate;
- inspections of boilers and air-conditioning.

The latter issue, which is not addressed in this paper, is handled in three standards

- prEN 15378: Boiler inspections
- prEN 15240: Air-conditioning inspections
- prEN 15239: Ventilation system inspections

The calculation methodology follows the framework set out in the EPBD Annex. Many of the standards deal with specific aspects of the calculation (e.g. fabric losses, air changes, lighting needs, system performance). All these aspects are drawn together in two standards

- prEN ISO 13790[3]: Building energy needs for heating and cooling (based on a balance of heat losses and heat gains).
- prEN 15203/15315[4]: Energy use for heating, cooling, ventilation systems, hot water and lighting, inclusive of system losses and auxiliary energy; and definition of energy ratings in terms of primary energy, CO_2 emissions, energy cost or other terms according to national energy policy.

The ways of expressing energy performance (for the energy certificate) and requirements (for regulations) as well as the content and format of energy performance certificates are handled in prEN 15217[5].

The main goal of these standards is to facilitate Member States‘ implementation of the Directive. In

consequence they do not prescribe a single definition of energy rating or the expression of energy performance, but rather give a limited number of options. Similarly the items on inspections offer various levels of inspection.

The Technical Committees of CEN that are involved in the preparation of the standards comprise:

- CEN/TC 89 Thermal performance of buildings and building components;
- CEN/TC 156 Ventilation for buildings;
- CEN/TC 169 Light and lighting;
- CEN/TC 228 Heating systems in buildings;
- CEN/TC 247 Building automation, controls and building management.

The process is being overseen by CEN/BT WG 173, Energy performance of buildings project group, which coordinates the work and ensures that standards prepared in different committees interface with each other in a suitable way.

3 OUTLINE OF THE STANDARDS

This describes the role of the standards that can be used for EPBD implementation.

3.1 Standards concerned with overall energy use in buildings

These standards provide a link between delivered energy and the energy performance indicators for buildings. Since a building generally uses more than one energyware[1] (e.g. gas and electricity), the different energy sources are collected per energyware. The overall energy rating is based on a weighted sum of delivered energywares. The weightings can be related to, for instance, primary energy or CO_2 emissions, to provide the end result of the calculation of energy performance (Article 3 of the Directive).

prEN 15217[5] sets out ways of expressing the energy performance in a certificate, and ways of expressing requirements on energy performance.

prEN 15203/15315[4] defines the uses of energy to be taken into account and provides methods to assess energy performance ratings for new and existing buildings.

3.2 Standards concerned with the calculation of delivered energy

The standards in this section provide the link between a building's energy needs and delivered energy for space heating and cooling as well as the energy requirements for ventilation, hot water and lighting. Different uses of energy are calculated separately:

Space heating – prEN 15316-1, the parts of prEN 15316-2 (depending on the type of heating system), including losses and control aspects, and prEN 15377 for embedded systems. The input to the calculation is the result from prEN ISO 13790.

Space cooling – prEN 15243, including losses and control aspects, and energy for humidification and dehumidification if applicable. The input to the calculation is the result from prEN ISO 13790.

Domestic hot water – the parts of prEN 15316-3, which include both the specification of domestic hot water requirements for different types of building, and the calculation of the energy needed to provide it.

Lighting – prEN 15193-1, based on installed lighting power and annualised usage according to building type, occupancy and lighting controls.

Ventilation – prEN 15241, energy needed to supply and extract air, based on installed fan power and controls, including energy for humidification and dehumidification if applicable.

Integrated building automation and controls – prEN 15232, takes into account additional energy optimisation based on interdisciplinary control functions and applications for space heating, ventilation, cooling, domestic hot water and lighting.

All of these standards take into account renewable energy sources where appropriate.

3.3 Standards concerned with calculation of building energy needs for heating and cooling

prEN ISO 13790 defines two routes to the calculation of the net energy for heating and cooling:

1. Simplified methods based on monthly or hourly calculations and simplified description of the building (in terms of element U-values, etc). The inputs to these calculations are obtained using the standards listed in 3.4.
2. Detailed numerical calculations. The detailed calculation procedure is not specified in the standard. prEN 15265 provides criteria that should be followed together with tests for the validation of computer software (although the tests cover only simple cases and do not include systems).

The choice of calculation method to be applied is to be made at national level. This will typically depend on the use of a building (residential, office, etc.), its complexity and/or systems, and the application (e.g. regulatory requirements, energy certification, new buildings, existing buildings).

The rules for the use of different calculation methods ensure compatibility and consistency between them. The standard provides, for instance, common rules for the boundary conditions and physical input data irrespective of the chosen calculation approach.

The calculations take account of control aspects that affect the heat gains and losses of the building, such as control of internal temperature, ventilation and solar protection.

[1] An energyware is a tradable commodity used mainly to produce mechanical work or heat, or to operate chemical or physical processes (ISO 13600).

3.4 Supporting standards

These standards provide the input data for the calculation of a building's energy needs.

3.4.1 Thermal performance of building components

The overall transmission heat loss coefficient is obtained by EN ISO 13789, which refers to other standards for the calculation of U-values. The standards for U-values fall into two groups:

- simplified methods (prEN ISO 6946, prEN ISO 13370, prEN ISO 10077-1, prEN 13947), which can be used for components within the scope of those standards; and
- detailed methods (prEN ISO 10211, EN ISO 10077-2), which can be used as an alternative, or for cases for which there is not an applicable simplified method.

The U-value of components, including windows and doors, can alternatively be established by measurement according to test methods cited in an applicable product standard.

Thermal bridges (at junctions between elements, etc) are covered in prEN ISO 10211 and prEN ISO 14683. Also included are methods for obtaining thermal values of building materials (prEN ISO 10456).

3.4.2 Ventilation and air infiltration

prEN 15242 provides methods for calculation of air flow rates to enable the calculation of heat losses due to air exchange. prEN 13779 covers mechanically ventilated buildings (including those with air conditioning).

3.4.3 Overheating and solar protection

There are standards for estimating internal temperatures without air-conditioning (EN ISO 13791 and EN ISO 13792), and for calculating the effect of solar protection devices (EN 13363). These calculations can be used to determine whether there is a need to consider air conditioning.

3.4.4 Indoor conditions and external climate

prEN 15251 addresses indoor conditions (temperature, humidity, air change rate) and specifications for the calculation and presentation of climatic data are given in prEN ISO 15927. prEN ISO 15927 does not contain actual climatic data, but rather a specification for such data, so that data in conformance with this standard are determined and established on a consistent basis and in a uniform format.

3.4.5 Definitions and terminology

EN ISO 7345, EN ISO 9288, EN ISO 9251 and EN 12792 contain definitions of terms and quantities used by other standards.

3.5 Standards concerned with monitoring and verification of energy performance

These standards include the determination of air leakage rates and infra-red thermography, which can be used in the verification of the energy performance of buildings.

Also included are standards on inspection of heating systems and air conditioning systems, which relate to Articles 8 and 9 of the Directive.

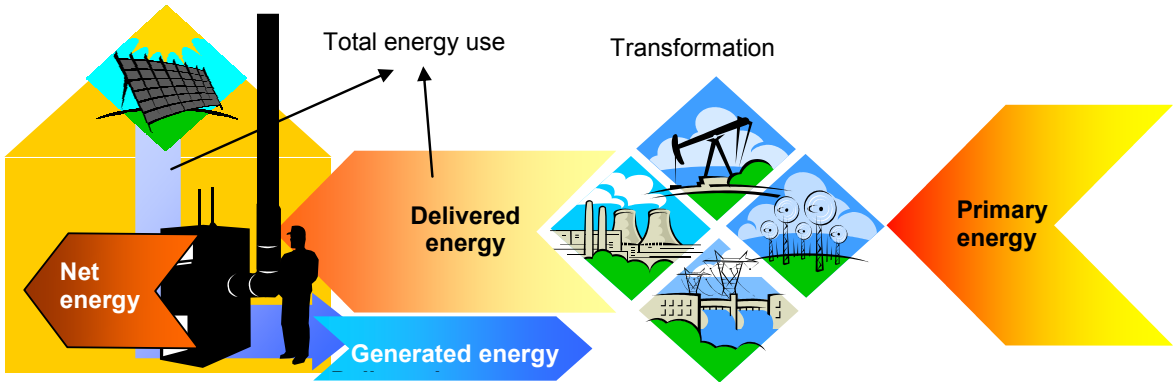

Figure 1: Energy flows to and from building: the primary energy vectors are transformed and transported to be delivered to the building in a useable form. In the building, the delivered energy is transformed into used energy, losses and possibly exported energy. The building may also have its own energy production from renewable energy sources.

4 CALCULATION METHODOLOGY

The calculation methodology is used to determine the net use of energywares by the building, quantities that are needed for energy certificates. This methodology addresses all energy flows shown in **Figure 1**.

The calculation is performed from building needs to primary energy.

The calculation is based on the characteristics of a building and its installed equipment. It is structured in three levels (**Figure 2**):

1. calculation of the building's energy needs for heating and cooling, together with that for ventilation, domestic hot water and lighting;
2. calculation of the building's delivered energy;
3. calculation of the overall energy performance indicators (primary energy, CO2 emissions, etc.).

4.1 Building net energy for heating and cooling

The building net energy for heating and cooling is calculated using standards mentioned in 3.3. This part of the calculation considers only the building properties and not those of the heating/cooling system. It results in the energy needs of the building (energy to be emitted by heat emitters, or energy to be extracted from the conditioned space, in order to maintain the specified internal temperature). In most buildings, the largest amount of energy is used for heating and cooling. prEN ISO 13790 provides methods to calculate the amount of heat needed by the building in winter, taking account of heat loss, internal heat gains and passive solar gains, and the amount of heat to be extracted from the building in summer, taking account of all heat sources and sinks present in the building. It allows for different levels of complexity:

- simplified hourly calculation;
- simplified monthly calculation;
- detailed calculations;

which can be chosen according to relevant criteria such as new or existing buildings or type and/or complexity of the building and its services. The calculations are based on boundary conditions specified for indoor climate (prEN 15251) and external climate. The simplified calculation methods are fully specified in the prEN ISO 13790. The detailed calculation methods are not fully specified in prEN ISO 13790, but any implementation needs to be validated according to the criteria in prEN 15265.

To perform this calculation data for indoor climate requirements, internal heat gains, building properties and outdoor climatic conditions are needed, and these are obtained using standards. prEN ISO 13790 includes guidance for partitioning a complex building into separate zones for the purposes of the calculation.

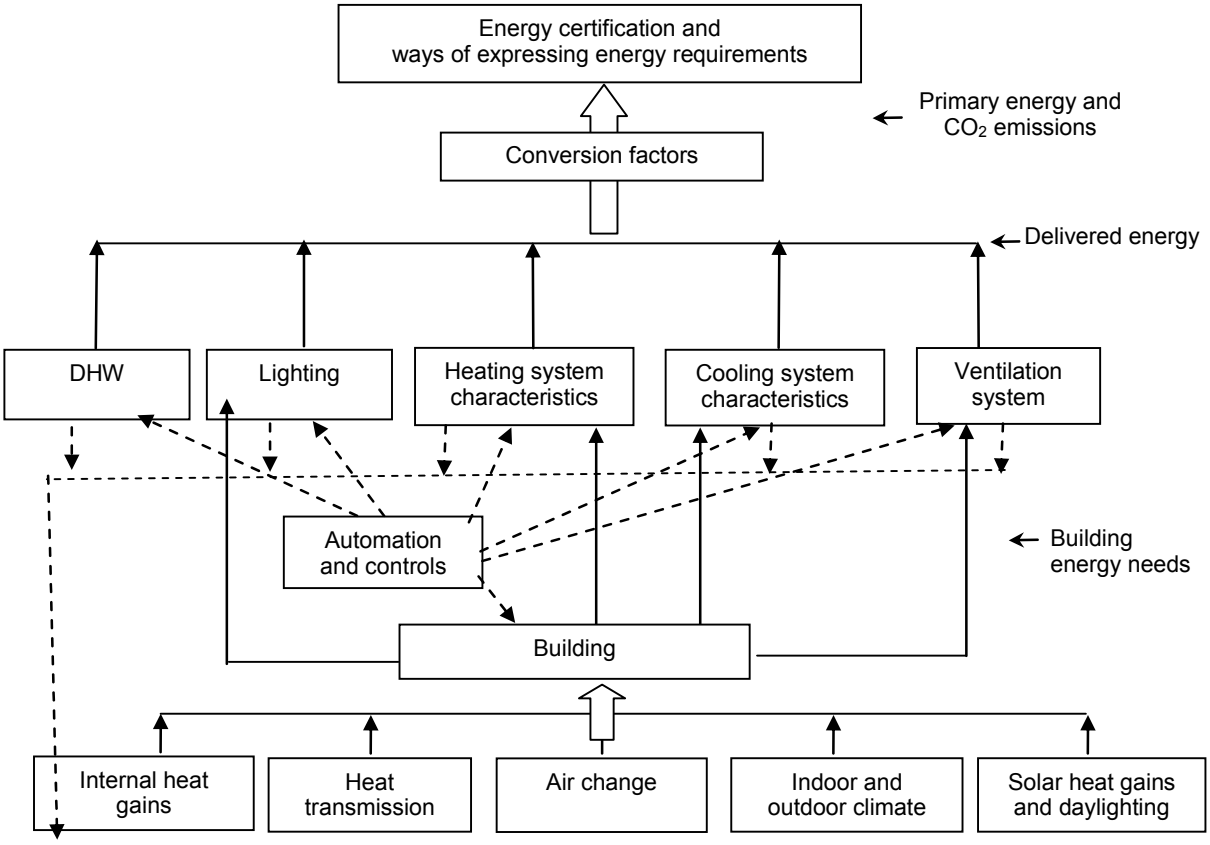

Figure 2: Energy flows and their links. The bottom row indicates the input data, comprising the building characteristics, its usage and climatic parameters. Recovered losses from systems contribute to the heat gains.

4.2 Delivered energy

The characteristics of the heating, cooling, domestic hot water and lighting systems, inclusive of controls and building automation, are taken into account to calculate the delivered energy, using standards listed in 3.2. Energy used for different purposes and delivered by different energywares is recorded separately. The calculations take account of heat emis-

sion, distribution, storage and generation and include the auxiliary energy needed for fans, pumps etc.

There is an interlinkage between Steps 4.1 and 4.2 because some of the system losses count as gains for the building part of the calculation. When these gains cannot be predicted without first knowing the heating and cooling needs, Steps 4.1 and 4.2 are performed twice. In the first calculation the gains from systems are omitted in the calculation of the net energy, in the second calculation they are included.

5 ENERGY RATINGS

Expression of the energy performance of buildings is needed:

- to enable the establishment of regulations regarding energy performance of buildings;
- to provide a means for defining energy ratings for buildings and deliver certificates;
- to encourage governments, building designers, owners, operators and users to improve the energy performance of buildings.

Energy certification of buildings requires a method that is applicable to both new and existing buildings and treats them in an equivalent way. Therefore, a methodology to obtain equivalent results from different sets of data is proposed. A methodology to estimate "missing" data (as can be the case with existing buildings) and to calculate a "standard" energy use for space heating and cooling, ventilation, domestic hot water and lighting is also provided.

prEN 15203/15315[2] defines the uses of energy to be taken into account and provides methods to calculate energy performance ratings for new and existing buildings. It also provides a methodology to improve confidence in the building calculation model by comparison with actual energy consumption and to assess the energy effectiveness of possible improvements.

Basically two types of energy ratings are proposed:

- a calculated energy rating using the methodology described in 1 and data obtained from building drawings or collected in a site survey, and
- a measured energy rating obtained from the actual energy consumption.

A standard calculated energy rating (the asset rating) is proposed for labelling. It is an energy rating calculated for standard conditions of occupancy, climate, environment, and use.

A measured rating (the operational rating) is proposed based on metered energy consumption. The metered energy consumption includes energy uses for all purposes and in actual conditions. The asset rating is calculated under standard conditions and includes, according to EPBD, only heating, cooling, hot water and ventilation. Lighting is included for most buildings but may be omitted for dwellings. Therefore, measured and asset ratings cannot be compared.

Measured and calculated ratings could be compared only if the calculation includes lighting and other energy uses (e.g. electrical equipment, **Figure 3**), and if it is calculated under the actual conditions for climate, occupancy, environment and use. Such a comparison allows improving the quality of input data used for the calculation, and thus increasing confidence in the model used for calculation, which is then validated. The validated model can be used not only for calculating the asset rating, but also for predicting the effect of retrofit scenarios.

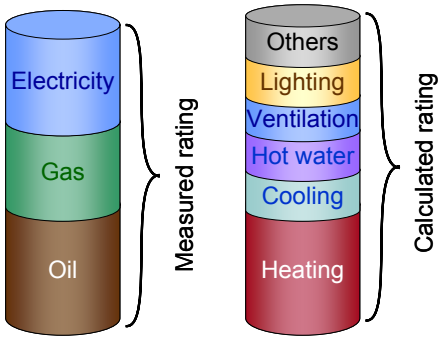

Figure 3: The two types of energy ratings proposed in prEN 15203/15315.

The result of energy rating is a list of amounts of net delivered energywares, and a single value should be used for the certificate. Amounts of fuels (litres, cubic metres, tonnes, etc.) are converted into energy units using gross calorific values. Since kilowatt-hours of delivered electricity, wood, coal, gas or oil are not equivalent, energy ratings are expressed as a weighted sum of all used amounts of energywares. The weights used for this sum are either primary energy factors or CO_2 production coefficients. Cost or factors related to national energy policy can also be used.

6 EXPRESSING THE ENERGY PERFORMANCE

As described in chapter 5 the ratings for the purposes of certification, determined according to prEN 15203/15315 are:

- asset energy rating, based on calculated energy use under standardised occupancy conditions;
- operational energy rating, based on metered energy.

These energy ratings are used in prEN 15217, together with building dimensions and possibly other parameters such as climate, use, etc., to express the energy performance of a building.

prEN 15217 defines the global energy performance indicator as one of the energy ratings divided by the conditioned floor area of the building.

[2] This number is provisional. The draft merges two documents prepared by CEN/TC89 (prEN 15203) and CEN/TC228 (prEN 15315)

The energy requirement for the design of new buildings or renovation of existing buildings is that the energy performance indicator shall be smaller than a limit expressed as a function of variables such as building use, shape factor, climatic parameter, etc. This function is defined at national or local level.

The standard also proposes two types of scales to compare the energy performance indicators of buildings: a continuous scale and classes.

The continuous scale is simply a graduated scale defined by best practice (e.g. zero energy building) at one end and the worst case at the other end. A specific building finds its place on this scale according to its energy performance indicator.

It also proposes a class system, in which buildings are sorted into seven classes A to G (**Figure 4**). The best buildings are in class A, buildings with energy performances in line with standards in classes A or B, buildings better than the building stock average in classes C or D, and other buildings in classes E to G, depending on their performance with respect to the building stock average for the same type of buildings.

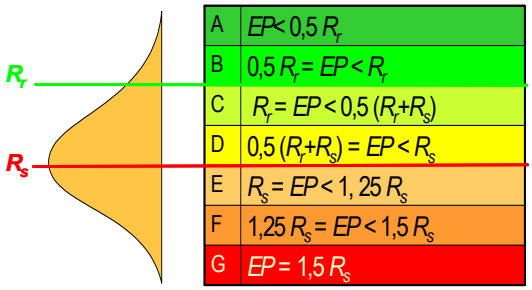

Figure 4: Proposal for sorting buildings given in prEN 15217. For each building type, the thresholds between classes are based on the average energy rating of the existing building stock, R_s, and on the national limit for new buildings, R_r. Like in other energy certification schemes, each class corresponds to a colour from green (A) to red (G).

prEN 15217 also defines:

- Procedures to define reference values and benchmarks
- Ways to design energy certification schemes. This last part is mainly a guideline enabling the member states to select the approach best suited to their needs.

7 CONCLUSION AND PERSPECTIVES

All drafts passed the public enquiry and are now under revision to take account of the many comments received. The preparation of these European standards has benefited from the contributions of many experts from several countries, and therefore should present more advantages and fewer defaults than any local document. The standards could be of great help to governments in charge of applying the building energy performance directive.

It is now up to the national policy makers to choose among the possibilities offered the option that best suits them for each type of building. Decisions to be taken at this level are, for each type (or use) of building:

- Measured or calculated rating?
- Primary energy factor, CO_2 coefficient, or other weights for aggregating the delivered energy-wares?
- Continuous scale or classes for the certificate?
- How to define the reference values?

They should also define the standard conditions for calculations and provide default values for climate, occupancy, use, etc.

The draft standards were submitted to public enquiry. They found a general agreement but, from the received replies, it was very clear that a uniform methodology and a common certificate cannot be adopted by all CEN members. Even buildings dimensions, including the floor area are defined in a different way in different countries!

Therefore, the standards offer a limited number of options that are compatible, in the sense that the energy performance expressed in one way can be translated into another way and be compared between countries.

8 ACKNOWLEDGEMENT

The tremendous work performed by experts from five CEN technical committees to present final draft standards in less than two years should be acknowledged. This development work is performed within the framework of Mandate M/343 from EC to CEN.

9 REFERENCES

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