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P160

30-03-2010

Energy Performance of Buildings
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Information paper on EN 15459

Economic evaluation procedure for energy systems in buildings

Economic calculations provide a powerful incentive for undertaking energy conservation measures. The purpose of this information paper is to provide detailed information about Standard EN 15459. All of the procedural steps and relevant Articles in EN 15459 are listed to show the scope and the detail of the economic calculations that should be performed and the way in which the economic aspects, various costs and technical aspects should be considered. This standard presents a method for making economic calculations of the functioning of heating systems, using data from other systems that may influence the energy use of the heating system.
This method can be used, in full or in part, for the following purposes:

- to consider the economic feasibility of energy conservation options in buildings;
- to compare different solutions of energy saving options in buildings (e.g. plant types, fuels);
- to evaluate the economic performance of an overall design of the building (e.g. the trade-off between the energy needs and the energy efficiency of heating systems);
- to assess the effect of possible energy conservation measures on an existing heating system, by economic calculation of the cost of the energy use with and without the energy conservation measure.

1 > Scope of the standard

This standard provides a calculation method for the economics of heating systems and other systems that are involved in the energy use of the building. This standard applies to all types of buildings.

The fundamental principles and terminology involved are explained in this standard.

The main items used in the standard are:

- the definitions and structure of the types of costs which shall be taken into account for calculating of the economic efficiency of energy conservation options in buildings;
- the input data required to define the costs of the systems under consideration;
- the methods that are to be used for the calculations;

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- the way in which the results of the economic calculations are to be expressed;
- the informative annexes indicating default values for e.g. lifetime, repair costs, maintenance costs, etc., for use in the calculations.

This standard is applicable to calculations of the economic performance of energy conservation options in buildings (e.g. insulation, more efficient generators, distribution systems and lighting, renewable sources, combined heat and power).

2 > Principle of the method

2.1 Organisation of the costs

The approach of the calculation method is to take a global perspective (overall costs). However, depending on the objectives of the investor, the calculation method may be applied considering only certain cost items. For example, calculations of the costs of alternative solutions for heating systems may be performed considering only costs for the domestic hot water system and the space heating system.

Costs are separated into investment costs (including periodic replacement of components) and running costs.

The various types of costs are organised as shown in Figure 1.

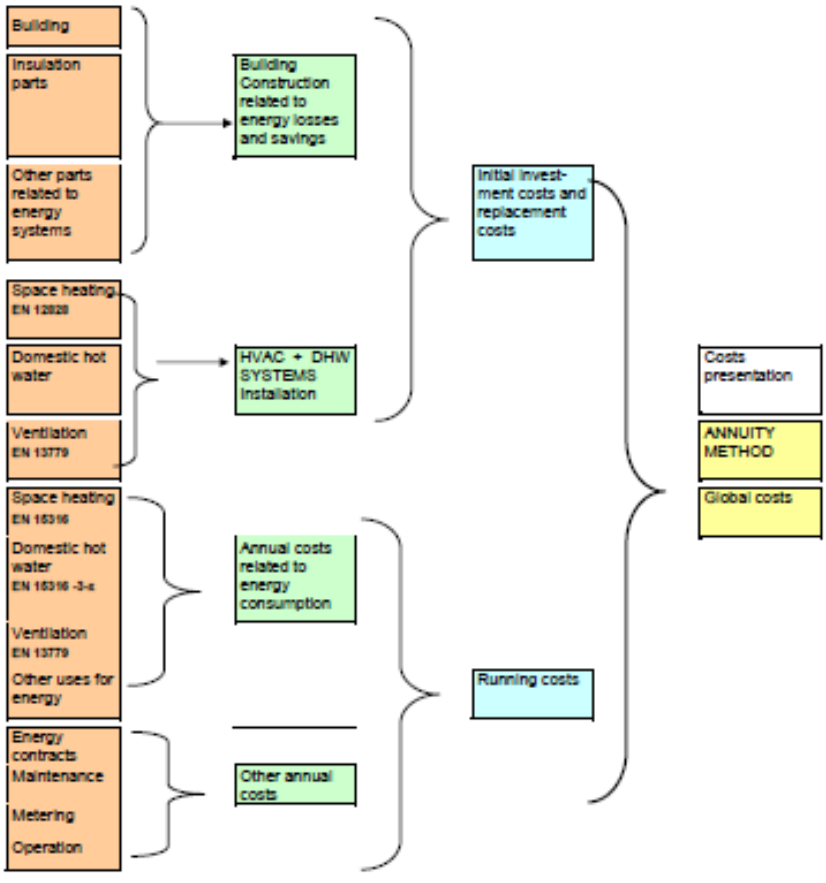


Figure 1 – Organisation of costs

The method is defined in Clause 5 of EN 15459.

2.2 Basic calculations

Clause 5.1 of EN 15459 concerns the calculation of the basic parameters:

- real interest rate
- discount rate
- present value factor
- annuity factor

2.2.1 Global cost

Principles of the calculation – Clause 5.2.1 of EN 15459

Calculation of global cost may be performed using a component or system approach, considering the initial investment C_I and – for every component of a system j – the annual costs for any year i (referred to the starting year) and the final value.

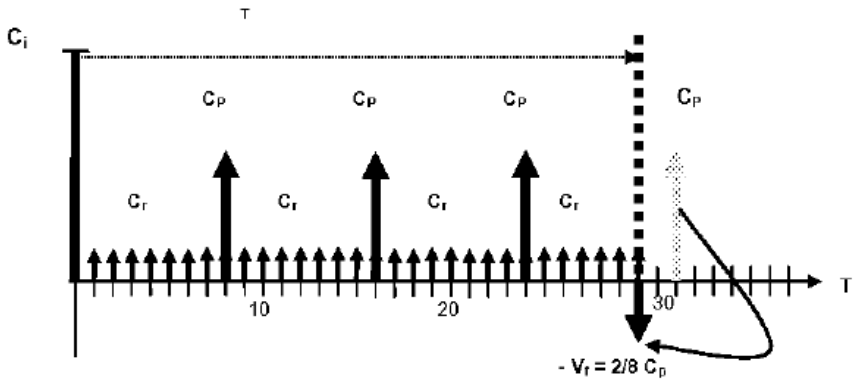
Global cost is a function of the duration of the calculation period τ.

The calculation may be performed either using detailed cost data on an annual basis or from the general economic data for every component.

Dynamic calculations take into account any annual variations in the discount rate or in the development of prices for any of the costs that contribute to the annual costs (e.g. energy costs, operational costs, periodic or replacement costs, maintenance costs and added costs).

Calculation of the final value – clause 5.2.2 of EN 15459

The final value $V_{f,\tau}(j)$ of a component is determined by straight-line depreciation of the initial investment until the end of the calculation period and referred to the beginning of the calculation period (Figure 2).



Key:
C_i initial investment costs
C_r running costs
C_p periodic costs
V_f final value
T calculation period

Figure 2 – Illustration of final value concept

If the calculation period τ exceeds the lifespan τ_n (j) of the component under consideration (j), the whole of the last replacement cost is taken into consideration in calculating the straight-line depreciation.

Total costs for replacement of component j during the calculation period considered (including initial investment), is the sum of:

- the initial investment V_0;
- the replacement costs (A'_0, A''_0, etc.): any time the lifespan of the component is reached, the component shall be replaced, the cost of which must take into account any expected increase (or decrease) in the price of such products and the discount rate.

Figure 3 illustrates an example of this principle, in which the calculation period ($\tau = T$) might be 30 years and the lifespan of the component ($\tau_n = T_n$) might be 12 years).

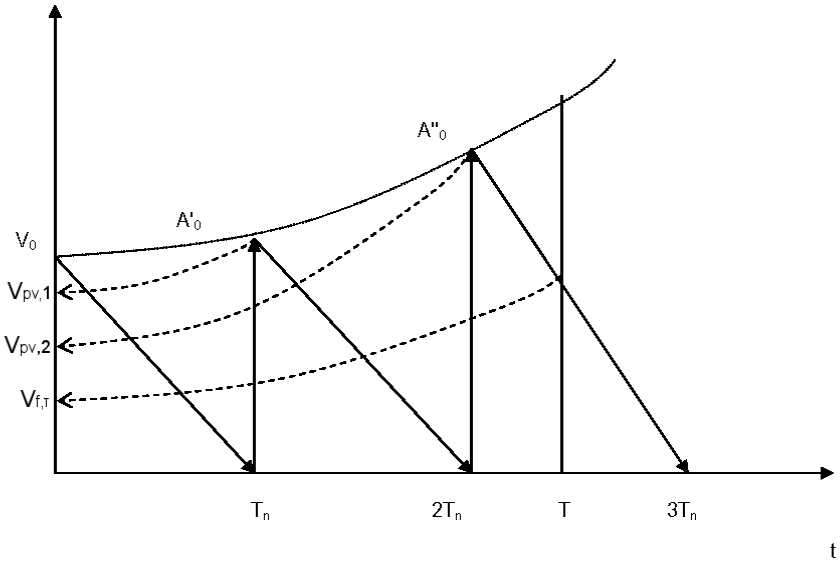


Figure 3 – Development of value during the calculation period

2.2.2 Annuity calculation

An alternative approach is to determine the annuity costs of the building. The annuity calculation method transforms any costs to an average annualized cost.

Whereas the global cost calculation method provides a value of the total costs throughout the calculation period τ, the annuity calculation uses the annuity factor a(n), to transform all costs to annual costs (Figure 4).

The calculations for the period τ considered are of the following three types:

- investment costs, related to the part of the building structure to be taken in account and any components and systems with a service life that is greater than or equal to the designed payback period of the building, are distributed evenly within the intended payback period of the building;
- periodic or replacement costs are distributed evenly over the years between the times that the cost is incurred;
- running costs expressed on an annual basis are by definition annual costs.

Dynamic calculations take into account any annual variations of the discount rate as well as annual variations in the development of prices for any of the costs considered (see 5.3.5 of EN 15459).

A simplified version of the calculation of annualized costs is available in the special case when the discount rate and annual costs are constant during the calculation period.

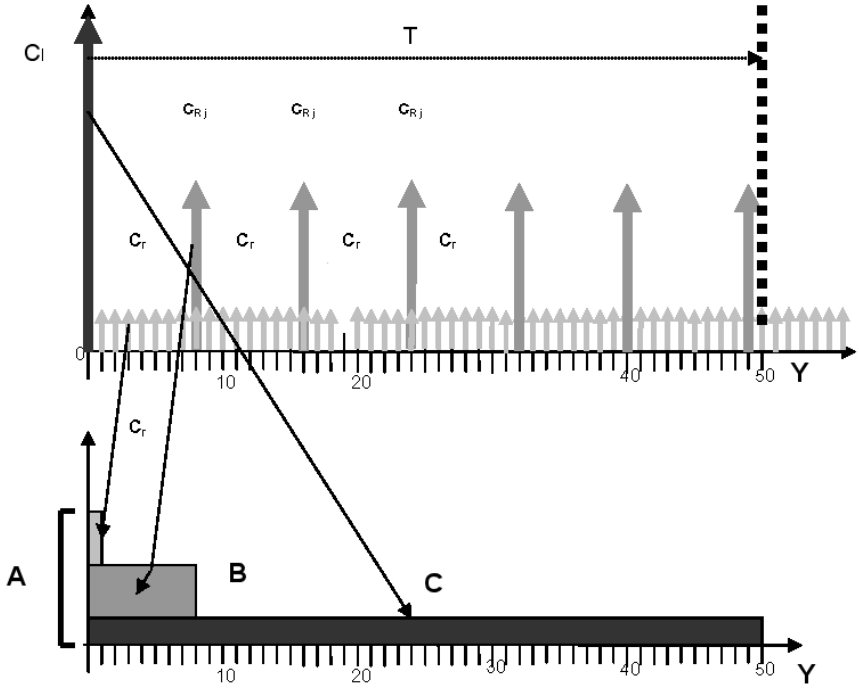


Figure 4 – Annuity cost presentation

Annuity calculation for unchanged component during the design payback period of the building – clause 5.3.2 of EN 15459

All initial costs of the components or part of the systems that remain unchanged during the intended payback period of the building are multiplied by the corresponding annuity factor $a(\tau_{\_Building})$.

Annuity calculation for replaced components – clause 5.3.3 EN 15459

The initial replacement costs shall be multiplied by the corresponding annuity factor depending on R_p (the rate at which the price of the products is expected to change) and the lifespan of the considered component (See Annex A of EN 15459).

Annuity calculation for running costs – clause 5.3.4 of EN 15459

Running costs include annual energy costs, operational costs, maintenance costs and any additional costs for installation and building.

Influence of price development for dynamic calculations – clause 5.3.5 of EN 15459

If annual costs are expected to change during the calculation period, these costs must be multiplied by the price dynamic factor $ß_x$ in order to determine the present value of the annual costs throughout the calculation period.

The price dynamic factor is a function of the inflation rate R_i, the market interest rate R and the rate R_x at which the relevant prices are expected to change.

3 > Description of the method step by step.

General

Figure 5 illustrates the different stages of the method, which are described in the following.

The process is consecutive.

Some of the data are for information only (environment of the project: country, location, local constraints, building use, noise…), but shall be documented in order to provide possibility for comparison between buildings or use of conventional costs ratio in the building construction (e.g. cost per area unit).

The parameters shall be chosen in accordance with those considered for the energy certification of the building.

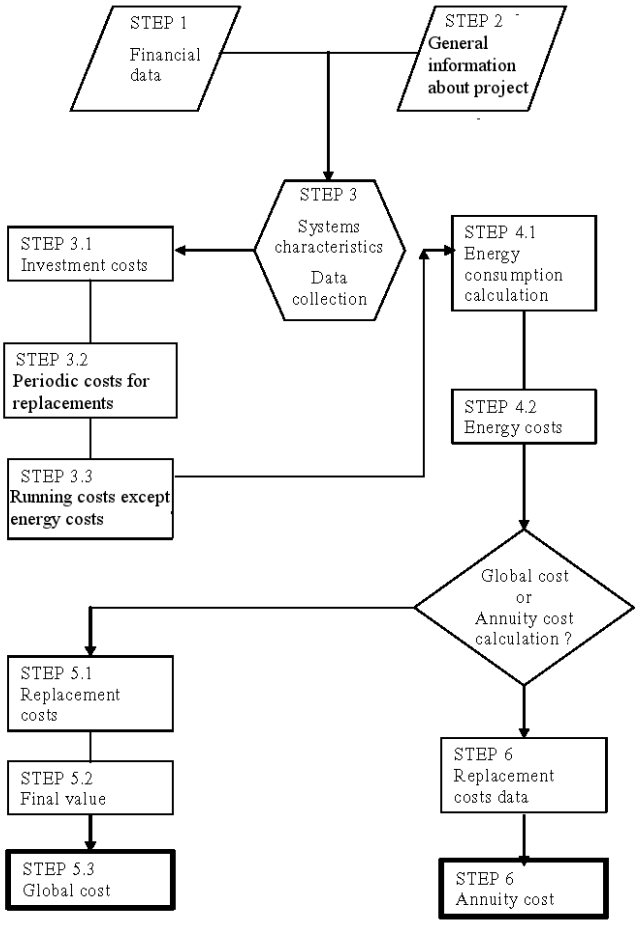


Figure 5 – Flowchart of the different stages of the method

STEP 1 - Financial data

Duration of the calculation – clause 6.2.1 of EN 15459

The time period considered in the calculation can be fixed according to the objectives of the calculation or be they may be specified by the owner of the building. The default value could be the expected lifetime of the building. But it may also be interesting to perform the calculation for a shorter calculation period, e.g. to evaluate the costs during the period of a mortgage.

The time period determines the number of years considered for the global cost calculation method. For the annuity calculation method, only the intended payback period of the building is relevant.

Financial rate – clause 6.2.2 of EN 15459

The inflation rate that is assumed should be calculated or estimated from available economical institute data as an average value over the calculation period.

The market interest rate is the average expected value of the interest rate over the calculation period.

Human operation costs – clause 6.2.3 of EN 15459

The rate of development of human operation costs refers to the costs for operational staff (usually the rate of development of human operation costs is higher than the inflation rate). The average expected value over the calculation period is to be applied.

Energy prices – clause 6.2.4 of EN 15459

As a first approximation, the rate of development of energy prices is considered equal to the inflation rate. This information can be obtained from energy utilities or from the economic analyses regularly provided by the European Commission or national energy forecasting organizations.

NOTE: Supplementary information on water supply costs can be useful in the calculation of annual costs.

STEP 2 - General information about the project

Identification of systems – clause 6.3.1 of EN 15459

In this step, the systems to be considered in the economic calculations are identified and project data necessary to perform the calculations are provided. Information is obtained from the design project and from the contractors.

Environment of the project – clause 6.3.2 of EN 15459

These data are intended for information only and are not used in the calculations. They identify the constraints that could define or influence the energy consumption and the choices between the alternative solutions that are being analysed:

- country or region;
- location of the building, e.g. city centre, urban zone;
- construction constraints on the external aspects of the building (roof, envelope);
- type of building (e.g. row house, detached house, co-housing, multi-story building);
- noise.

Meteorological and environmental data (not mandatory) – clause 6.3.3 of EN 15459

These data are given for information only.

Constraints/opportunities related to energy – clause 6.3.4 of EN 15459

Official energy requirements on building fabric and systems (these data are necessary in order to identify the constraints/opportunities for HVAC systems in relation to energy uses):

- forbidden fuels;
- orientation of the building;
- flue (possible or impossible);
- district heating (existing or nonexistent);
- difficulties related to fuel distribution;
- fuel gas network proximity;
- possible sources of renewable energy (e.g. solar collectors, fuel cells, natural ventilation, heat pump);

Identify customer's approach on comfort and occupancy.

STEP 3 - Systems characteristics

Data collection – clause 6.4.1 of EN 15459

Data concerning components and systems are collected and information about lifespan, maintenance and operation are obtained.

Annex A provides some default values for the most important components.

STEP 3.1 - Investment costs for systems related to energy – clause 6.4.2 of EN 15459

General

This step is applied to the systems identified at Step 2, which are related to energy and energy conservation.

Table 3 of EN 15459 provides examples of different applications of the calculation method.

Investment cost for building construction

This chapter identifies those parts of the structure that are related to energy efficiency or energy use (e.g. building fabrics, insulation, openings, glazing, doors, solar protection). The calculation may be performed with all of the building structure taken into account, but in this case, the influence of the energy system will be reduced.

The lists given in 6.4.2.2 to 6.4.2.8 are meant for information and the listed items need only be taken into account if they are relevant to the objective of the calculation. They include:

- Investment cost for building construction
- Space Heating
  - Generation and storage
  - Distribution
  - Emission
  - Control
- Domestic hot water
- Ventilation
- Space cooling
- Lighting
- Connection to energy supplies
- Other systems

STEP 3.2 - Periodic costs for replacements– clause 6.4.3 of EN 15459

In this step, timing and costs of the replacement of systems and components are obtained.

Some data about the service life of components are presented in Annex A of EN 15459.

STEP 3.3 – Running costs excluding energy costs – clause 6.4.4 EN 15459

1 Operational costs (excluding energy)

Operational costs represent the cost for energy operators of the building.

2 Maintenance and repairs

In this step the inspection and replacement of consumable items, or the annual contracts for cleaning and maintenance of components and systems, are to be considered.

As periodic inspection of energy systems for heating and air conditioning are mandatory, these verifications must be considered as part of the periodic maintenance operations (e.g. for boilers, chillers).

3 Added costs

Include insurance and taxes that are related to energy systems. For example, special taxes related to pollutants or energy use.

STEP 4 - Energy costs

General – clause 6.5.1 of EN 15459

Energy costs fall into two main categories:

- those directly related to energy use as recorded on meters or the total fuel consumption of the building. The method for determination of energy use must use data on the energy content of the fuel furnished by its provider;
- those fixed according to the quantity of energy subscribed with energy utilities or rental for the energy systems (e.g. gas tank, electricity transformation).

For district heating systems, special subscription conditions may apply. Environmental (or social) costs could also be introduced as a cost related to energy.

Energy sales (if relevant) are counted separately as negative costs.

STEP 4.1 - Calculation of energy use – clause 6.5.2 of EN 15459

Calculation should be performed according to standardised methods.
EN 15603 allows calculation of the energy use for the whole building. If the economic analysis concerns only some of the energy systems, then the energy consumption calculation must similarly only take these systems into account (i.e. EN 15316 series for space heating and domestic hot water systems)

Reference to the standards (or specific methods, if applicable) should be made when reporting the results of the analysis.

STEP 4.2 - Energy costs – clause 6.5.3 of EN 15459

Energy costs are determined by the tariff for the energy considered.
In some cases, energy costs can be calculated from the variable tariffs of the utility. These tariffs (mainly for electricity) may vary during the day and during specific periods of the year.

Renewable energy sources or energy sales (electricity or hot water) must be considered either as a financial income (as electricity from Photovoltaic cells can be sold directly on the electric grid) or as a way to reduce energy costs at the building level (e.g. solar collectors). The design of the system will determine which of these two possibilities apply.

STEP 5 - GLOBAL COST CALCULATION

Step 5.1 Calculation of replacement costs – clause 6.6.1 of EN 15459

Replacement costs throughout the calculation period are calculated from the timing and costs of any expected replacement of systems and components, as determined in Step 3.2.

The present value factor or discount rate is to be used to refer costs to the starting year.

Step 5.2 Calculation of final value – clause 6.6.2 of EN 15459

The final value at the end of the calculation period is determined by summing up the final value of all systems and components.

The final value of a specific system or component is calculated from the lifetime remaining at the end of the calculation period, assuming linear depreciation since its last replacement. The final value is determined as remaining lifetime divided by lifespan and multiplied by last replacement cost, referred to the starting year by the appropriate discount rate.

Figure 3 illustrates the calculation process for one unit (component or system).

Step 5.3 Calculation of global cost – clause 6.6.3 of EN 15459

The different types of cost (initial investment costs, periodic and replacement costs, running costs) and the final value are converted to global cost (referred to the starting year) by applying the appropriate present value factor (or discount rate).

The present value factor (or discount rate) may be different for different types of costs, due to different rates of price development for energy, human operation, products, maintenance and added costs.

The total global cost is determined by summing up the global costs of initial investment costs, periodic and replacement costs, annual costs and energy costs and subtracting the global cost of the final value.
Annex C of EN 15459 illustrates organization of the result data sheet.

STEP 6 - ANNUITY COST CALCULATION

Annuity cost calculation is performed for any component of part of the system according to 5.3.

For the annuity cost calculation, the calculation period is fixed and corresponds to the intended payback period of the building.
The total annualized cost is determined by summing up the annualized costs of systems and components (investment and replacements), the annual costs (operation costs, maintenance costs, added costs) and the energy costs (see Annex D of EN 15459).

The different types of costs are converted to annualized costs by applying the appropriate annuity factor (see the example in Annex E).

For systems and components with a lifespan greater than or equal to the intended payback period of the building, the annualized cost is determined from the initial investment cost and the annuity factor corresponding to the payback period.

For systems and components with a lifespan that is less than the calculation period, the annualized cost is determined from the replacement cost and the annuity factor corresponding to the service life.

Annual costs and energy costs are by definition annualized costs.

The annuity cost corresponds to the average annual cost at year 0.

Annexes A – E

Informative annexes provide useful and detailed information about the economic data on energy systems, systems descriptions, the organisation of data and results in the calculation sheets and provide some examples with detailed calculation steps.

4 > FAQ

Why is there a standard for the economic evaluation procedures for energy systems?

In the recast of the EPBD the Calculation of cost-optimal levels of minimum energy performance requirements is mandated in Article 5. The Commission will develop a comparative methodology and Member States will have to use it for comparison purposes only and shall report the results. The method will cover cost-critical criteria such as investment costs, operating / maintenance costs, and energy costs. An international standard makes this task easier for the Commission and will ensure that the procedure remains transparent.

What are costs taken into account in the economic calculations?

Costs include initial investments costs and annual costs. Annual costs include running costs and any periodic costs for the repair or replacement of components and systems.

Is the calculation limited to the heating systems?

More details are given for the heating systems (e.g. list of components), but the same methodology can be applied to other systems such as lighting and to the building itself.

What are the differences between the global cost method and the annuity cost method?

Global cost calculation is determined by the duration of the calculation period and the final value concept; they estimate the total cost incurred in the period considered. Annuity calculations transform all costs to annual costs by using annuity factors.

5 > References

1. EN 15459, Energy performance of buildings – Economic evaluation procedure for energy systems in buildings, November 2007
2. EN 15603, Energy performance of buildings – Overall energy use and definition of energy ratings, January 2008 *(Calculated energy rating part)*

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Associated partners:
HTA Luzern (CH), BRE (GB), Viessmann (DE), Roulet (CH), JRC IES (EC)
Link: www.iee-cense.eu

Original text language: English

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