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COMMISSION DELEGATED REGULATION (EU) No 244/2012

of 16 January 2012

supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements

(Text with EEA relevance)

(OJ L 81, 21.3.2012, p. 18)

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(Text with EEA relevance)

THE EUROPEAN COMMISSION,

Having regard to the Treaty on the Functioning of the European Union,

Having regard to Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings ([1]), and in particular Article 5(1) thereof,

Whereas:

(1) Directive 2010/31/EU requires the Commission to establish by means of a delegated act a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements.

(2) It is the responsibility of Member States to set minimum energy performance requirements for buildings and building elements. The requirements must be set with a view to achieving cost-optimal levels. It is up to the Member States to decide whether the national benchmark used as the final outcome of the cost-optimal calculations is the one calculated for a macroeconomic perspective (looking at the costs and benefits of energy efficiency investments for the society as a whole) or a strictly financial viewpoint (looking only at the investment itself). National minimum energy performance requirements should not be more than 15 % lower than the outcome of the cost-optimal results of the calculation taken as the national benchmark. The cost-optimal level shall lie within the range of performance levels where the cost-benefit analysis over the lifecycle is positive.

(3) Directive 2010/31/EU promotes the reduction of energy use in the built environment, but also emphasises that the building sector is a leading source of carbon dioxide emissions.

(4) Directive 2009/125/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for the setting of ecodesign requirements for energy-related products ([2]) provides for the establishment of minimum energy performance requirements for such products. When setting national requirements for technical building systems, Member States must take into account the implementing measures established under this Directive. The performances of construction products

([1]) OJ L 153, 18.6.2010, p. 13.
([2]) OJ L 285, 31.10.2009, p. 10.

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to be used for the calculations under this Regulation should be determined in accordance with the provisions of Regulation (EU) No 305/2011 of the European Parliament and of the Council of 9 March 2011 laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC ([1]).

(5) The objective of cost-effective or cost-optimal energy efficiency levels may, in certain circumstances, justify the setting by Member States of cost-effective or cost-optimal requirements for building elements that would in practice raise obstacles for some building design or technical options as well as stimulate the use of energy-related products with better energy performance.

(6) The steps that comprise the comparative methodology framework have been set out in Annex III to Directive 2010/31/EU and include the establishment of reference buildings, the definition of energy efficiency measures to be applied to these reference buildings, the assessment of the primary energy demand of these measures and the calculation of the costs (i.e. net present value) of these measures.

(7) The common framework for the calculation of the energy performance as established in Annex I to Directive 2010/31/EU applies also to the cost-optimal framework methodology for all its steps, in particular the step of the calculation of the energy performance of buildings and building elements.

(8) For the purpose of adapting the comparative methodology framework to national circumstances, Member States should determine the estimated economic lifecycle of a building and/or building element, the appropriate cost for energy carriers, products, systems, maintenance, operational and labour costs, primary energy conversion factors, and the energy price developments on this point to be assumed for fuels used in their national context for energy used in buildings, taking into account the information provided by the Commission. Member States should also establish the discount rate to be used in both macroeconomic and financial calculations after having undertaken a sensitivity analysis for at least two interest rates for each calculation.

(9) To ensure a common approach to the application of the comparative methodology framework by the Member States, it is appropriate for the Commission to establish the key framework conditions needed for net present value calculations such as the starting year for calculations, the cost categories to be considered and the calculation period to be used.

(10) Establishing a common calculation period does not conflict with Member States' right to fix the estimated economic lifecycle of buildings and/or building elements since the latter could both be longer or shorter than the calculation period fixed. The estimated economic lifecycle of a building or building element has only

([1]) OJ L 88, 4.4.2011, p. 5.

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limited influence on the calculation period since the latter is determined rather by the refurbishment cycle of a building, which is the period of time after which a building undergoes a major refurbishment.

(11) Cost calculations and projections with many assumptions and uncertainties, including for example energy price developments over time, are generally accompanied by a sensitivity analysis to evaluate the robustness of the key input parameters. For the purpose of the cost-optimal calculations, the sensitivity analysis should at least address the energy price developments and the discount rate; ideally the sensitivity analysis should also comprise future technology price developments as input for the review of the calculations.

(12) The comparative methodology framework should enable Member States to compare the results of the cost-optimal calculations with the minimum energy performance requirements in force and to use the result of the comparison to ensure that minimum energy performance requirements are set with a view to achieving cost-optimal levels. Member States should also consider setting minimum energy performance requirements at cost-optimal level for those building categories where so far no minimum energy performance requirements exist.

(13) The cost-optimal methodology is technologically neutral and does not favour one technological solution over another. It ensures a competition of measures/packages/variants over the estimated lifetime of a building or building element.

(14) The results of the calculations and the input data and assumptions used are to be reported to the Commission as stipulated in Article 5(2) of Directive 2010/31/EU. These reports should enable the Commission to assess and report on the progress made by Member States towards reaching cost-optimal levels of minimum energy performance requirements.

(15) To limit their administrative burden, it should be possible for Member States to reduce the number of calculations by establishing reference buildings that are representative of more than one building category, without affecting Member States' duty under Directive 2010/31/EU to set minimum energy performance requirements for certain building categories,

HAS ADOPTED THIS REGULATION:

Article 1

Subject matter and scope

In accordance with Article 5 of, and Annexes I and III to, Directive 2010/31/EU, this Regulation establishes a comparative methodology framework to be used by Member States for calculating cost-optimal levels of minimum energy performance requirements for new and existing buildings and building elements.

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The methodology framework specifies rules for comparing energy efficiency measures, measures incorporating renewable energy sources and packages and variants of such measures, based on the primary energy performance and the cost attributed to their implementation. It also lays down how to apply these rules to selected reference buildings with the aim of identifying cost-optimal levels of minimum energy performance requirements.

Article 2

Definitions

In addition to the definitions in Article 2 of Directive 2010/31/EU, the following definitions shall apply noting that for the calculation at macroeconomic level applicable charges and taxes are to be excluded:

(1) *Global cost* means the sum of the present value of the initial investment costs, sum of running costs, and replacement costs (referred to the starting year), as well as disposal costs if applicable. For the calculation at macroeconomic level, an additional cost category *costs of greenhouse gas emissions* is introduced;

(2) *Initial investment costs* mean all costs incurred up to the point when the building or the building element is delivered to the customer, ready to use. These costs include design, purchase of building elements, connection to suppliers, installation and commissioning processes;

(3) *Energy costs* mean annual costs and fixed and peak charges for energy including national taxes;

(4) *Operational costs* mean all costs linked to the operation of the building including annual costs for insurance, utility charges and other standing charges and taxes;

(5) *Maintenance costs* mean annual costs for measures for preserving and restoring the desired quality of the building or building element. This includes annual costs for inspection, cleaning, adjustments, repair and consumable items;

(6) *Running costs* mean annual maintenance costs, operational costs and energy costs;

(7) *Disposal costs* mean the costs for deconstruction at the end-of-life of a building or building element and include deconstruction, removal of building elements that have not yet come to the end of their lifetime, transport and recycling;

(8) *Annual cost* means the sum of running costs and periodic costs or replacement costs paid in a certain year;

(9) *Replacement cost* means a substitute investment for a building element, according to the estimated economic lifecycle during the calculation period;

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(10) *Cost of greenhouse gas emissions* means the monetary value of environmental damage caused by CO_2 emissions related to the energy consumption in buildings;

(11) *Reference building* means a hypothetical or real reference building that represents the typical building geometry and systems, typical energy performance for both building envelope and systems, typical functionality and typical cost structure in the Member State and is representative of climatic conditions and geographic location;

(12) *Discount rate* means a definite value for comparison of the value of money at different times expressed in real terms;

(13) *Discount factor* means a multiplicative number used to convert a cash flow occurring at a given point in time to its equivalent value at the starting point. It is derived from the discount rate;

(14) *Starting year* means the year on which any calculation is based and from which the calculation period is determined;

(15) *Calculation period* means the time period considered for the calculation usually expressed in years;

(16) *Residual value* of a building means the sum of the residual values of the building and building elements at the end of the calculation period;

(17) *Price development* means the development over time of prices for energy, products, building systems, services, labour, maintenance and other costs and can be different from the inflation rate;

(18) *Energy efficiency measure* means a change to a building resulting in a reduction of the building's primary energy need;

(19) *Package* means a set of energy efficiency measures and/or measures based on renewable energy sources applied to a reference building;

(20) *Variant* means the global result and description of a full set of measures/packages applied to a building that can be composed of a combination of measures on the building envelope, passive techniques, measures on building systems and/or measures based on renewable energy sources;

(21) *Subcategories of buildings* means categories of building types that are more disaggregated according to size, age, construction material, use pattern, climatic zone or other criteria than those established in Annex I(5) to Directive 2010/31/EU. It is for such subcategories that reference buildings are generally established;

(22) *Delivered energy* means energy, expressed per energy carrier, supplied to the technical building system through the system boundary, to satisfy the uses taken into account (heating, cooling, ventilation, domestic hot water, lighting, appliances, etc.) or to produce electricity;

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(23) *Energy needed for heating and cooling* means heat to be delivered to or extracted from a conditioned space to maintain intended temperature conditions during a given period of time;

(24) *Exported energy* means energy expressed per energy carrier delivered by the technical building system through the system boundary and used outside the system boundary;

(25) *Conditioned space* means space where certain ambient parameters such as temperature, humidity etc. are regulated by technical means such as heating and cooling etc.;

(26) *Energy from renewable sources* means energy from renewable non-fossil sources, namely wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases.

Article 3

Comparative methodology framework

1. When calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements, Member States shall apply the comparative methodology framework laid down in Annex I to this Regulation. The framework prescribes calculation of cost-optimal levels for both macroeconomic and financial viewpoints, but leaves it up to the Member States to determine which of these calculations is to become the national benchmark against which national minimum energy performance requirements will be assessed.

2. For the purpose of the calculations, Member States shall:

(a) take as a starting year for the calculation the year in which the calculation is being performed;

(b) use the calculation period in Annex I to this Regulation;

(c) use the cost categories in Annex I to this Regulation;

(d) use for carbon costing as a minimum lower bound the projected ETS carbon prices as given in Annex II.

3. Member States shall complement the comparative methodology framework by determining for the purpose of the calculations:

(a) the estimated economic lifecycle of a building and/or building element;

(b) the discount rate;

(c) the costs for energy carriers, products, systems, maintenance cost, operational costs and labour costs;

(d) the primary energy factors;

(e) the energy price developments to be assumed for all energy carriers taking into account the information in Annex II to this Regulation.

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4. Member States shall endeavour to calculate and adopt cost-optimal levels of minimum energy performance requirements in relation to those building categories where so far no specific minimum energy performance requirements exist.

5. Member States shall undertake an analysis to determine the sensitivity of the calculation outcomes to changes in the applied parameters, covering at least the impact of different energy price developments and the discount rates for the macroeconomic and financial calculations, ideally also other parameters which are expected to have a significant impact on the outcome of the calculations such as price developments for other than energy.

Article 4

Comparison of the calculated cost-optimal levels with current minimum energy performance requirements

1. Member States shall decide after having calculated the cost-optimal requirement levels both for a macroeconomic and for a financial perspective, which one is to become the national benchmark and report this decision to the Commission as part of the reporting mentioned pursuant to Article 6.

Member States shall compare the outcome of the calculation chosen as the national benchmark referred to in Article 3 with the current energy performance requirements for the relevant building category.

Member States shall use the result of this comparison to ensure that minimum energy performance requirements are set with a view to achieving cost-optimal levels in accordance with Article 4(1) of Directive 2010/31/EU. Member States are strongly recommended to link fiscal and financial incentives to compliance with the cost-optimal calculation outcome of the same reference building.

2. If a Member States has defined reference buildings in such a way that the result of the cost-optimal calculation is applicable to several building categories, they may use this result to ensure that minimum energy performance requirements are set with a view to achieving cost-optimal levels for all relevant building categories.

Article 5

Review of the cost-optimal calculations

1. Member States shall review their cost-optimal calculations in time for the review of their minimum energy performance requirements required by Article 4(1) of Directive 2010/31/EU. For the review, in particular the price developments for the input cost data has to be reviewed and if need be updated.

2. The results of this review shall be transmitted to the Commission in the report provided for by Article 6 of this Regulation.

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Article 6

Reporting

1. Member States shall report to the Commission all input data and assumptions used for the calculations and the results of those calculations. This report shall include the primary energy conversion factors applied, the results of the calculations at macroeconomic and financial level, the sensitivity analysis referred to in Article 3(5) of this Regulation and the assumed energy and carbon price developments

2. If the result of the comparison referred to in Article 4 of this Regulation shows that the minimum energy performance requirements in force are significantly less energy-efficient than cost-optimal levels of minimum energy performance requirements, the report shall include any justification for the difference. To the extent that the gap cannot be justified, the report shall be accompanied by a plan outlining appropriate steps to reduce the gap to a non-significant size by the next review. In this regard, the significantly less energy-efficient level of minimum energy performance requirements in force will be calculated as the difference between the average of all the minimum energy performance requirements in force and the average of all cost-optimal levels of the calculation used as the national benchmark of all reference buildings and building types used.

3. Member States can make use of the reporting template provided for in Annex III to this Regulation.

Article 7

Entry into force and application

1. This Regulation shall enter into force on the 20th day following its publication in the *Official Journal of the European Union.*

2. It shall apply from 9 January 2013 to buildings occupied by public authorities and from 9 July 2013 to other buildings except for Article 6(1) of this Regulation, which shall enter into force on 30 June 2012, in line with Directive 2010/31/EU EPBD Article 5(2), second paragraph.

This Regulation shall be binding in its entirety and directly applicable in all Member States.

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ANNEX I

Cost-optimal methodology framework

1. ESTABLISHMENT OF REFERENCE BUILDINGS

(1) Member States shall establish reference buildings for the following building categories:

1. single-family buildings;

2. apartment blocks and multifamily buildings;

3. office buildings.

(2) In addition to office buildings, Member States shall establish reference buildings for other non-residential building categories listed in Annex I paragraph (5)(d) to (i) to Directive 2010/31/EU for which specific energy performance requirements exist.

(3) If a Member State is able to demonstrate in the report referred to in Article 6 of this Regulation that an established reference building can be applicable to more than one building category, it may reduce the number of reference buildings used and with that the number of calculations. Member States shall justify this approach on the basis of an analysis showing that a reference building that is used to serve several building categories is representative of the building stock for all the categories covered.

(4) For each building category, at least one reference building shall be established for new buildings and at least two for existing buildings subject to major renovation. Reference buildings can be established on the basis of building subcategories (e.g. differentiated by size, age, cost structure, construction material, use pattern or climatic zone) that take into account the characteristics of the national building stock. Reference buildings and their characteristics shall correspond to the structure of current or planned energy performance requirements.

(5) Member States can make use of the reporting template provided in Annex III to report to the Commission the parameters considered in establishing the reference buildings. The underlying data set on the national building stock used for establishing the reference buildings should be communicated to the Commission as part of the report referred to in Article 6. In particular the choice of characteristics that underpin the establishment of reference buildings shall be justified.

(6) For existing buildings (both residential and non-residential), Member States shall apply at least one measure/package/variant representing a standard renovation necessary to maintain the building/building unit (without additional energy efficiency measures beyond legal requirements).

(7) For new buildings (both residential and non-residential), the currently applicable minimum energy performance requirements shall constitute the basic requirement to be met.

(8) Member States shall calculate cost-optimal levels also for minimum performance requirements for building elements installed in existing buildings or shall derive those from the calculations done at buildings level. When setting requirements for building elements installed in existing buildings, the cost-optimal requirements should to the extent possible take into account the interaction of that building element with the entire reference building and other building elements.

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(9) Member States shall endeavour to calculate and set cost-optimal requirements at the level of individual technical building systems for existing buildings or derive these from the calculations done at buildings level not only for heating, cooling, hot water, air-conditioning and ventilation (or a combination of such systems), but also for lighting systems for non-residential buildings.

2. IDENTIFICATION OF ENERGY EFFICIENCY MEASURES, MEASURES BASED ON RENEWABLE ENERGY SOURCES AND/OR PACKAGES AND VARIANTS OF SUCH MEASURES FOR EACH REFERENCE BUILDING

(1) Energy efficiency measures for both new and existing buildings shall be defined for all input parameters for the calculation that have a direct or indirect impact on the energy performance of the building, including for alternative high-efficiency systems such as district energy supply systems and the other alternatives listed in Article 6 of Directive 2010/31/EU.

(2) Measures may be bundled to packages of measures or variants. If certain measures are not suitable in a local, economic or climatic context, Member States should indicate this in their reporting to the Commission in accordance with Article 6 of this Regulation.

(3) Member States shall also identify measures/packages/variants using renewable energy for both new and existing buildings. Binding obligations laid down in the national application of Article 13 of Directive 2009/28/EC of the European Parliament and of the Council ([1]) shall be considered as one measure/package/variant to be applied in that Member State.

(4) Energy efficiency measures/packages/variants identified for the calculation of cost-optimal requirements shall include measures necessary to meet the currently applicable minimum energy performance requirements. If applicable, they shall also include measures/packages/variants necessary to meet the requirements of national support schemes. Member States shall also include measures/packages/variants necessary to meet the minimum energy performance requirements for nearly zero-energy buildings for new and possibly also existing buildings as defined by Article 9 of Directive 2010/31/EU.

(5) If a Member State can demonstrate, by submitting previous cost analyses as part of the reporting referred to in Article 6, that certain measures/packages/variants are far from cost-optimal, these may be excluded from the calculation. However, such measures/packages/variants should be revisited in the next review of the calculations.

(6) The selected energy efficiency measures and measures based on renewable energy sources, and packages/variants, shall be compatible with the basic requirements for construction works as listed in Annex I to Regulation (EU) No 305/2011 and specified by Member States. They shall also be compatible with air quality and indoor comfort levels according to CEN standard 15251 on indoor air quality or equivalent national standards. In cases where measures produce different comfort levels, this shall be made transparent in the calculations.

3. CALCULATION OF THE PRIMARY ENERGY DEMAND RESULTING FROM THE APPLICATION OF SUCH MEASURES AND PACKAGES OF MEASURES TO A REFERENCE BUILDING

(1) The energy performance is calculated in accordance with the common general framework provided in Annex I to Directive 2010/31/EU.

([1]) OJ L 140, 5.6.2009, p. 16.

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(2) Member States shall calculate the energy performance of measures/packages/variants by calculating, for the nationally defined floor area, first the energy needed for heating and cooling. Subsequently the delivered energy for space heating, cooling, ventilation, domestic hot water and lighting systems is calculated.

(3) Energy produced onsite shall be deducted from the primary energy demand and delivered energy.

(4) Member States shall calculate the resulting primary energy use using primary energy conversion factors established at national level. They shall report to the Commission the primary energy conversion factors in the reporting referred to in Article 6 of this Regulation.

(5) Member States shall use:

(a) either the relevant existing CEN standards for the calculation of energy performance;

(b) or an equivalent national calculation method provided that the latter is in accordance with Article 2(4) and Annex I to Directive 2010/31/EU.

(6) Energy performance results shall, for the purpose of the cost-optimal calculation, be expressed in square meters of useful floor area of a reference building and refer to primary energy demand.

4. CALCULATION OF THE GLOBAL COST IN TERMS OF NET PRESENT VALUE FOR EACH REFERENCE BUILDING

4.1. **Categories of costs**

Member States shall establish and describe the following separate cost categories to be used:

(a) *Initial investment costs*;

(b) *Running costs*. These include costs for periodic replacement of building elements and might include, if appropriate, the earnings from energy produced that Member States may take into account in the financial calculation;

(c) *Energy costs* shall reflect overall energy cost including energy price, capacity tariffs and grid tariffs;

(d) *Disposal costs* if appropriate.

For the calculation at macroeconomic level, Member States shall in addition establish the cost category:

(e) *Cost of greenhouse gas emissions*. These shall reflect the quantified, monetised and discounted operational costs of CO_2 resulting from the greenhouse gas emissions in tonnes of CO_2 equivalent over the calculation period.

4.2. **General principles for cost calculation**

(1) In projecting energy cost developments, Member States may use the energy price development forecasts in Annex II to this Regulation for oil, gas, coal and electricity, starting with the average absolute energy prices (expressed in euro) for these energy sources in the year of the calculation exercise.

Member States shall also establish national energy price development forecasts for other energy carriers used to a significant extent in their regional/local context and if appropriate also for peak load tariffs. They shall report the projected price trends and the current shares of the different energy carriers in building energy use to the Commission.

(2) The effect of (expected) future price developments for other than energy costs, replacement of building elements during the calculation period, and disposal costs where applicable, may also be included in the cost calculation. Price developments, including through innovation and adaptation of technologies, have to be taken into account when the calculations are reviewed and updated.

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(3) Cost data for cost categories (a) to (d) shall be market-based and shall be coherent as regards location and time. Costs should be expressed as real costs excluding inflation. Costs shall be assessed at country level.

(4) When determining the global cost of a measure/package/variant, the following may be omitted:

(a) costs that are the same for all assessed measures/packages/variants;

(b) costs related to building elements which have no influence on the energy performance of a building.

All other costs need to be fully taken into account for the calculation of global costs.

(5) The residual value shall be determined by a straight-line depreciation of the initial investment or replacement cost of a given building element until the end of the calculation period discounted to the beginning of the calculation period. The depreciation time is determined by the economic lifetime of a building or building element. Residual values of building elements may need to be corrected for the cost of removing them from the building at the end of the estimated economic lifecycle of the building.

(6) Disposal costs, if applicable, are to be discounted and can be subtracted to the final value. They might need to be first discounted back from the estimated economic lifetime to the end of the calculation period and in a second step discounted back to the beginning of the calculation period.

(7) At the end of the calculation period, the disposal costs (if applicable) or the residual value of the components and building elements are taken into account to determine the final costs over the estimated economic lifecycle of the building.

(8) Member States shall use a calculation period of 30 years for residential and public buildings, and a calculation period of 20 years for commercial, non-residential buildings.

(9) Member States are encouraged to use Annex A to EN 15459 on economical data for building elements when defining estimated economic lifetimes for those building elements. If other estimated economic lifetimes for building elements are established, these should be reported to the Commission as part of the reporting referred to in Article 6. Member States shall define at national level the estimated economic lifecycle of a building.

4.3. **Calculation of global costs for a financial calculation**

(1) When determining the global cost of a measure/package/variant for the financial calculation, the relevant prices to be taken into account are the prices paid by the customer including all applicable taxes including VAT and charges. Ideally also the subsidies available for different variants/packages/measures are to be included into the calculation, but Member States can choose to leave subsidies aside, ensuring however that in that case both subsidies and support schemes for technologies, but also possibly existing subsidies for energy prices are taken out.

(2) Global costs for buildings and building elements shall be calculated by summing the different types of costs and applying to these the discount rate by means of a discount factor so as to express them in terms of value in the starting year, plus the discounted residual value as follows:

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$$C_g(\tau) = C_I + \sum_j \left[\sum_{i=1}^{\tau} (C_{a,i}(j) \times R_d(i)) - V_{f,\tau}(j) \right]$$

where:

τ means the calculation period

$C_g(\tau)$ means global cost (referred to starting year τ_0) over the calculation period

C_I means initial investment costs for measure or set of measures j

$C_{a,I}$ (j) means annual cost during year i for measure or set of measures j

$V_{f,\tau}$ (j) means residual value of measure or set of measures j at the end of the calculation period (discounted to the starting year τ_0).

R_d (i) means discount factor for year i based on discount rate *r* to be calculated

as:

$$R_d(p) = \left(\frac{1}{1 + r/100} \right)^p$$

where p means the number of years from the starting period and r means the real discount rate.

(3) Member States shall determine the discount rate to be used in the financial calculation after having performed a sensitivity analysis on at least two different rates of their choice.

4.4. **Calculation of global costs for the macroeconomic calculation**

(1) When determining the global cost for the macroeconomic calculation of a measure/package/variant, the relevant prices to be taken into account are the prices excluding all applicable taxes, VAT, charges and subsidies.

(2) When determining the global cost at macroeconomic level of a measure/package/variant, in addition to the cost categories listed under 4.1, a new cost category cost of greenhouse gas emissions is to be included so that the adjusted global cost methodology reads as:

$$C_g(\tau) = C_I + \sum_j \left[\sum_{i=1}^{\tau} (C_{a,i}(j) R_d(i) + C_{c,i}(j)) - V_{f,\tau}(j) \right]$$

where

C c, i(j) means carbon cost for measure or set of measures j during year i.

(3) Member States shall calculate the cumulated carbon cost of measures/packages/variants over the calculation period by taking the sum of the annual greenhouse gas emissions multiplied by the expected prices per tonne CO_2 equivalent of greenhouse gas emission allowances in every year issued, using as a minimum lower bound initially at least EUR 20 per tonne of CO_2 equivalent until 2025, EUR 35 until 2030 and EUR 50 beyond 2030 in line with current Commission projected ETS carbon price scenarios (measured in real and constant prices EUR 2008, to be adapted to the calculation dates and methodology chosen). Updated scenarios shall be taken into account every time a review of the cost-optimal calculations is carried out.

(4) Member States shall determine the discount rate to be used in the macroeconomic calculation after having performed a sensitivity analysis on at least two different rates, one of which shall be 3 % expressed in real terms.

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5. UNDERTAKING A SENSITIVITY ANALYSIS FOR COST INPUT DATA INCLUDING ENERGY PRICES

The purpose of sensitivity analysis is to identify the most important parameters of a cost optimal calculation. Member States shall perform a sensitivity analysis on the discount rates using at least two discount rates each expressed in real terms for the macroeconomic calculation and two rates for the financial calculation. One of the discount rates to be used for the sensitivity analysis for the macroeconomic calculation shall be 3 % expressed in real terms. Member States shall perform a sensitivity analysis on the energy price development scenarios for all energy carriers used to a significant extent in buildings in their national context. It is recommended to extend the sensitivity analysis also to other crucial input data.

6. DERIVATION OF A COST-OPTIMAL LEVEL OF ENERGY PERFORMANCE FOR EACH REFERENCE BUILDING

(1) For each reference building, Member States shall compare the global cost results calculated for different energy efficiency measures and measures based on renewable energy sources and packages/variants of those measures.

(2) In cases where the outcome of the cost-optimal calculations gives the same global costs for different levels of energy performance, Member States are encouraged to use the requirements resulting in lower use of primary energy as the basis for comparison with the existing minimum energy performance requirements.

(3) Once a decision is taken on whether the macroeconomic or the financial calculation is to become the national benchmark, averages of the calculated cost-optimal energy performance levels for all the reference buildings used, taken together, shall be calculated in order to compare with the averages of the existing energy performance requirements for the same reference buildings. This is to allow the calculation of the gap between existing energy performance requirements and the calculated cost-optimal levels.

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ANNEX II

Information on estimated long-term energy price developments

For their calculations, Member States may take into account the estimated fuels and electricity price development trends as provided for by the European Commission on a biannually updated basis. These updates are available at the following website: http://ec.europa.eu/energy/observatory/trends_2030/index_en.htm

These trends may be extrapolated beyond 2030 until longer-term projections become available.

Information on estimated long-term carbon price developments

For their macroeconomic calculations, Member States are required to use as a minimum lower bound the projected ETS carbon prices in the Commission reference scenario up to 2050, assuming implementation of existing legislation, but not decarbonisation (first line of table below). The projections currently assume a price per tonne of EUR 20 until 2025, EUR 35 until 2030 and EUR 50 beyond 2030, measured in real and constant prices EUR 2008, to be adapted to the calculation dates and methodology chosen (see table below). Updated scenarios on the carbon prices as provided by the Commission shall be taken into account every time a review of the cost-optimal calculations is carried out.

Carbon price evolution	2020	2025	2030	2035	2040	2045	2050
Reference (frag. action, ref. fossil f. prices)	16,5	20	36	50	52	51	50
Effect. Techn. (glob. action, low fossil f. prices)	25	38	60	64	78	115	190
Effect. Techn. (frag. action, ref. fossil f. prices)	25	34	51	53	64	92	147

Source: Annex 7.10 to http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SEC:2011:0288:FIN:EN:PDF

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ANNEX III

Reporting template that Member States may use for reporting to the Commission pursuant to Article 5(2) of Directive 2010/31/EU and Article 6 of this Regulation

1. REFERENCE BUILDINGS

1.1. Report on the reference buildings for all building categories and how they are representative of the building stock by using Table 1 (existing buildings) and Table 2 (new buildings). Additional information may be added in an annex.

1.2. Give the definition of the floor area reference used in your country and how it is calculated.

1.3. Please list the selection criteria used to define each reference building (both new and existing): e.g. statistical analysis based on use, age, geometry, climate zones, cost structures, construction material, etc., introducing also the indoor and outdoor climatic conditions, and geographic location.

1.4. Please indicate whether your reference building is an example building, virtual building, etc.

1.5. Please indicate the underlying dataset for the national building stock

Table 1

Reference building for existing buildings (major refurbishment)

For existing buildings	Building geometry (1)	Shares of window area on the building envelope and windows with no solar access	Floor area m^2 as used in building code	Description of the building (2)	Description of the average building technology (3)	Average energy performance kWh/m^2, a (prior to investment)	Component level requirements (typical value)
(1) **Single family buildings and subcategories**							
Subcategory 1							
Subcategory 2 etc.							
(2) **Apartment blocks and multifamily buildings and subcategories**							
(3) **Office buildings and subcategories**							
(4) **Other non-residential building categories**							

(1) S/V (surface to volume), orientation, area of N/W/S/E facade.
(2) Construction material, typical air tightness (qualitative), use pattern (if appropriate), age (if appropriate).
(3) Technical building systems, U values of building elements, windows — area, U value, g value, shading, passive systems, etc.

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Table 2

Reference building for new buildings

For new buildings	Building geometry (1)	Shares of window area on the building envelope and windows with no solar access	Floor area m^2 as used in building code	Typical energy performance kWh/m^2, a	Component level requirements
(1) **Single family buildings and subcategories**					
Subcategory 1					
Subcategory 2 etc.					
(2) **Apartment blocks and multifamily buildings and subcategories**					
(3) **Office buildings and subcategories**					
(4) **Other non-residential building categories**					

(1) S/V, area of N/W/S/E facade. To note: the orientation of the building can already constitute an energy efficiency measure in itself in the case of new buildings.

Table 3

Example of a basic reporting table for energy performance relevant data

		Quantity	Unit	Description
Calculation	method and tool(s)			short description of the calculation method adopted (e.g. with reference to EN ISO 13790) and comment on the calculation tool(s) used
	Primary energy conversion factors			values of delivered to primary energy conversion factors (per energy carrier) used for the calculation
Climate condition	location			name of the city with indication of latitude and longitude
	heating degree-days		HDD	to be evaluated according to EN ISO 15927-6, specifying the period of calculation
	cooling degree-days		CDD	
	source of climatic dataset			provide references on climatic dataset used for the calculation
	terrain description			e.g. rural area, sub-urban, urban. Explain if the presence of nearby buildings has been considered or not
Building geometry	Length × Width × Height		m × m × m	related to the heated/conditioned air volume (EN 13790) and considering as 'length' the horizontal dimension of the façade south-oriented

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			Quantity	Unit	Description
	number of floors			—	
	S/V (surface-to-volume) ratio			m^2/m^3	
	ratio of window area over total building envelope area	South		%	
		East		%	
		North		%	
		West		%	
	orientation			°	azimuth angle of the South façade (deviation from the South direction of the 'South' oriented façade)
Internal gains	building utilisation				according to the building categories proposed in Annex 1 to Directive 2010/31/EU
	average thermal gain from occupants			W/m^2	
	specific electric power of the lighting system			W/m^2	total electric power of the complete lighting system of the conditioned rooms (all lamps + control equipment of the lighting system)
	specific electric power of electric equipment			W/m^2	
Building elements	average U-value of walls			W/m^2K	weighted U-value of all walls: U_wall = (U_wall_1 · A_wall_1 + U_wall_2 · A_wall_2 + … + U_wall_n · A_wall_n)/(A_wall_1 + A_wall_2 + … + A_wall_n); here are: U_wall_i = Uvalue of wall type i; A_wall_i = total surface of wall type i
	average U-value of roof			W/m^2K	similar to walls
	average U-value of basement			W/m^2K	similar to walls
	average U-value of windows			W/m^2K	similar as for walls; it should take into account the thermal bridge due to the frame and dividers (according to EN ISO 10077-1)
	thermal bridges	total length		m	
		average linear thermal transmittance		W/mK	
	thermal capacity per unit area	external walls		J/m^2K	to be evaluated according to EN ISO 13786
		internal walls		J/m^2K	
		slabs		J/m^2K	

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			Quantity	Unit	Description
	type of shading systems				e.g. solar blind, roll-up shutter, curtain, etc.
	average g-value of	glazing		—	total solar energy transmittance of glazing (for radiation perpendicular to the glazing), here: weighted value according to the area of different windows (to be evaluated according to EN 410)
		glazing + shading		—	total solar energy transmittance for glazing and an external solar protection device has to be evaluated according to EN 13363-1/-2
	Infiltration rate (air changes per hour)			1/h	e.g. calculated for a pressure difference inside/ outside of 50 Pa
Building systems	ventilation system	air changes per hour		1/h	
		heat recovery efficiency		%	
	efficiencies of heating system	generation		%	to be evaluated according to EN 15316-1, EN 15316-2-1, EN 15316-4-1, EN 15316-4-2, EN 15232, EN 14825, EN 14511
		distribution		%	
		emission		%	
		control		%	
	efficiencies of cooling system	generation		%	to be evaluated according to EN 14825, EN 15243, EN 14511, EN 15232
		distribution		%	
		emission		%	
		control		%	
	efficiencies of DHW system	generation		%	to be evaluated according to EN 15316-3-2, EN 15316-3-3
		distribution		%	
Building Setpoints and Schedules	temperature setpoint	winter		°C	indoor operative temperature
		summer		°C	
	humidity setpoint	winter		%	indoor relative humidity, if applicable: ‘Humidity has only a small effect on thermal sensation and perceived air quality in the rooms of sedentary occupancy’ (EN 15251)
		summer		%	
	operation schedules and controls	occupancy			provide comments or references (EN or national standards, etc.) on the schedules used for the calculation
		lighting			
		appliances			
		ventilation			
		heating system			
		cooling system			

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			Quantity	Unit	Description
Energy building need/use	(thermal) energy contribution of main passive strategies implemented	(1) …		kWh/a	e.g. solar greenhouse, natural ventilation, day-lighting, etc.
		(2) …		kWh/a	
		(3) …		kWh/a	
	energy need for heating			kWh/a	heat to be delivered to or extracted from a conditioned space to maintain the intended temperature conditions during a given period of time
	energy need for cooling			kWh/a	
	energy need for DHW			kWh/a	heat to be delivered to the needed amount of domestic hot water to raise its temperature from the cold network temperature to the prefixed delivery temperature at the delivery point
	energy need for other (humidification, dehumidification)			kWh/a	latent heat in the water vapour to be delivered to or extracted from a conditioned space by a technical building system to maintain a specified minimum or maximum humidity within the space (if applicable)
	energy use for ventilation			kWh/a	electrical energy input to the ventilation system for air transport and heat recovery (not including the energy input for preheating the air) and energy input to the humidification systems to satisfy the need for humidification
	energy use for internal lighting			kWh/a	electrical energy input to the lighting system and other appliances/systems
	energy use for other (appliances, external lighting, auxiliary systems, etc.)			kWh/a	
Energy generation at the building site	thermal energy from RES (e.g. thermal solar collectors)			kWh/a	energy from renewable sources (that are not depleted by extraction, such as solar energy, wind, water power, renewed biomass) or co-generation
	electrical energy generated in the building and used onsite			kWh/a	
	electrical energy generated in the building and exported to the market			kWh/a	
Energy consumption	delivered energy	electricity		kWh/a	energy, expressed per energy carrier, supplied to the technical building systems through the system boundary, to satisfy the uses taken into account (heating, cooling, ventilation, domestic hot water, lighting, appliances, etc.)
		fossil fuel		kWh/a	
		other (biomass, district heating/ cooling, etc.)		kWh/a	
	primary energy			kWh/a	energy that has not been subjected to any conversion or transformation process

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2. SELECTING VARIANTS/MEASURES/PACKAGES

2.1. Report in table format the characteristics of selected variants/measures/packages that are applied for the cost-optimal calculation. Please start with the most common technologies and solutions and then move towards the more innovative ones. If there is evidence from previous calculations that measures are far from being cost-optimal, no table has to be filled in but this should be reported separately to the Commission. The format below can be used, but please note that the examples listed are purely illustrative.

Table 4

Illustrative table for listing selected variants/measures

Each calculation should refer to the same comfort level. Pro forma each variant/package/measure should provide the acceptable comfort. If different comfort levels are taken into account, the base of the comparison will be lost.

Measure	Reference case	Variant 1	Variant 2	Etc. …
Roof insulation				
Wall insulation				
Windows	5,7 W/m^{2}K (description)	2,7 W/m^{2}K (description)	1,9 W/m^{2}K (description)	
Share of window area of total building envelope				
Building-related measures (thermal mass, etc.)				
Heating system				
DHW				
Ventilation system (incl. night ventilation)				
Space cooling system				
Measures based on RES				
Change of energy carrier				
Etc.				

The listing of measures is purely illustrative.

For the building envelope: in W/m^{2}K

For systems: efficiency

Several levels of improvements can be selected (for example: different thermal transmittance values for windows)

3. CALCULATION OF THE PRIMARY ENERGY DEMAND OF THE MEASURES

3.1. **Energy Performance Assessment**

3.1.1. Report the calculation procedure for the energy performance assessment that is applied to the reference building and the adopted measures/variants.

3.1.2. Give references to relevant legislation, regulation, standards and norms.

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3.1.3. Fill in the calculation period (20 or 30 years), the calculation interval (annual, monthly or daily) and the used climate data per reference building.

3.2. **Energy demand calculation**

3.2.1. Please report the results of the energy performance calculation for each measure/package/variant for each reference building differentiated to at least energy need for heating and cooling, energy use, delivered energy and primary energy demand.

Insert also the energy savings.

Table 5

Energy demand calculation output table

Please fill out one table for each reference building and building category, for all of the introduced measures.

Reference building										
Measure/ package/ variant of measures (as described in Table 4)	Energy need		Energy use					Delivered energy specified by source	Primary energy demand in kWh/m^2, a	Energy reduction in primary energy compared to the reference building
	for heating	for cooling	heating	cooling	ventilation	DHW	lighting			

Please fill out one table for each reference building.

Reporting can be limited to the most important measures/packages but it should be indicated how many calculations have been carried out in total. If there is evidence from previous calculations that measures are far from being cost-optimal, no table has to be filled in but this should be reported separately to the Commission.

3.2.2. Report the summary of primary energy conversion factors used in the country in a separate table.

3.2.3. Indicate the delivered energy per carrier in an additional table.

4. GLOBAL COST CALCULATION

4.1. Calculate the global cost for each variant/package/measure using the following tables, referring to low, medium or high (energy price) scenario. The cost calculation for the reference building shall be put at 100 %.

4.2. Report the source of the applied energy price development

4.3. Report the applied discount rate for the financial and the macroeconomic calculation and the result of the underlying sensitivity analysis on at least two different interest rates each.

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Table 6

Output data and global cost calculations

Please fill out the table for each reference building using it once for the macroeconomic and once for the financial calculation. Please insert the cost data in national currency.

Variant/ package/ measure as given in Table 5	Initial investment cost (referred to starting year)	Annual running cost			Calculation period (1) 20, 30 years	Cost of greenhouse gas emissions (only for the macroeconomic calculation)	Residual value	Discount rate (different rates for macroeconomic and financial calculation)	Estimated economic lifetime	Disposal cost (when applicable)	Global cost calculated
		Annual maintenance cost	Operational cost		Energy cost (2) by fuel with the medium energy price scenario						

(1) For residential and public buildings 30 years of calculation period shall be taken into account; for commercial, non-residential buildings at least 20 years.

(2) The effect of (expected) future price developments has to be taken into account if it is about replacement of components during the calculation period.

4.4. Please report your input parameters used for the calculation of the global cost (e.g. labour cost, cost of the technology, etc.)

4.5. Perform calculation on the sensitivity analysis for the main costs and for energy costs and the applied discount rate for both macroeconomic and financial calculation. For each variation of cost use a separate table like the Table above.

4.6. Please indicate the assumed cost of greenhouse gas emissions for the macroeconomic calculations.

5. COST-OPTIMAL LEVEL FOR REFERENCE BUILDINGS

5.1. Report the economic optimal energy performance level in primary energy (kWh/m^2 year or, if a system level approach is followed, in the relevant unit, e.g. U value) for each case in relation to the reference buildings indicating whether it is the cost-optimal levels calculated at macroeconomic or at financial level.

6. COMPARISON

6.1. If the difference is significant, please indicate the reason that justifies the gap and also a plan with the appropriate steps to reduce the difference if the gap cannot be justified (fully).

Table 7

Comparison table for both new and existing buildings

Reference building	Cost-optimal range/level (from-to) kWh/m^2, a (for a component approach in the relevant unit)	Current requirements for reference buildings kWh/m^2, a	Gap

Justification of the gap:
Plan to reduce the non-justifiable gap: