EUROPEAN COMMISSION

Draft

COMMISSION STAFF WORKING PAPER

Guidelines

Accompanying the document

Commission Delegated Regulation of …

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

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1. OBJECTIVES AND SCOPE

In accordance with Article 5 and Annex III of Directive 2010/31/EU, the Commission delegated Regulation of ….. supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings (recast) by establishing a comparative methodology framework for calculating cost optimal levels of minimum energy performance requirements for buildings and building elements (hereinafter called "the 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. The methodology specifies how to compare energy efficiency measures, measures incorporating renewable energy sources and packages of such measures in relation to their energy performance and the cost attributed to their implementation and how to apply these to selected reference buildings with the aim of identifying cost optimal levels.

Annex III of Directive 2010/31/EU requires the Commission to provide guidelines to accompany the comparative methodology framework with the aim to enable the Member States to undertake the necessary steps.

This document constitutes the guidelines as intended by Annex III of Directive 2010/31/EU. While these guidelines are not legally binding, they provide relevant additional information to the Member States and reflect accepted principles for the cost calculations required in the context of the Regulation. As such, the guidelines are intended only for facilitating the application of the Regulation and do not provide any "interpretation" of its content. It is the text of the Regulation which is legally binding and which is directly applicable in the Member States.

To facilitate its use by the Member States, the present guidance document closely follows the structure of the methodology framework as laid down in Annex I of the Regulation.

The guidelines will –contrary to the legal decision on the framework methodology itself - be reviewed periodically as experience with the Regulation's application both by the Member States and the Commission grows.

2. DEFINITIONS

Some of the definitions used in Article 2 of the Regulation benefit from further clarification.

For the purposes of the definition of *global costs*, the cost of land is excluded. However, if a MS wishes to do so, the initial investment costs, and hence also the global costs, could take into account the cost of the useful floor area that is needed to install a certain measure and with this introduce a ranking of measures according to the space they occupy.

As part of the definition of *global costs*, a Member State may choose to introduce carbon pricing into the calculation and attribute the resulting discounted expected carbon costs to different variants by using a standard price per ton of (avoided CO_2) for EU Emission Allowances and multiplying that price by the calculated CO_2 emissions per year. It has to be noted that the cost of carbon might in some national regimes already be included in the energy taxes and double counting should be avoided.

The method for calculating the *useful floor area* is to be defined at national level. It should be clearly reported to the Commission.

For the purpose of the cost optimum evaluation, the non-renewable part of *primary energy* is considered. The corresponding primary energy factors are to be set at national level, taking into account Annex II of Directive 2006/32/EC. It has to be noted that this does not contradict the definition of *primary energy* given in the Regulation - for overall building performance, both the non-renewable part and the total quantity of primary energy related to building operation should be reported.

Energy efficiency measures can be a single measure or constitute a package of measures. In its ultimate form a package of measures will constitute a variant of a building (= a full set of measures/packages needed for the energy efficient supply of a building and including measures on the building envelope, passive techniques, measures on building systems and/or measures using renewable energy sources).

Energy costs include all cost for energy use covered by Directive 2010/31/EU associated with all typical uses in a building. Energy used for appliances is not included, although Member States are free to include also these in their national application of the Regulation.

3. Establishment of reference buildings

In accordance with Annex III of Directive 2010/31/EU and Annex I(1) of the Regulation, Member States are required to define reference buildings for the purpose of the cost optimal methodology.

The main purpose of a reference building is to represent **the typical and average** building stock in a certain Member State, since it is impossible to calculate the cost optimal situation for every individual building. Hence, the reference building has to reflect as well as possible the actual national building stock made for the methodology to deliver accurate and representative calculation results.

It is recommended that reference buildings established in one of the two following ways:

I. Selection of a real example representing the most typical building in a specific category (type of use with reference occupancy pattern, floor area, compactness of the building expressed as a envelope area/volume factor, building envelope structure with corresponding U-value, technical services systems and energy carriers together with their share on energy use).

II. Creation of a "virtual building" which for each relevant parameter (see I) includes the most commonly used materials and systems.

The choice between these options (I and II) should be made on the basis of expert enquiries, statistical data availability, etc. The choice can be different for different building categories. Member States should report how the building category reference case was chosen.

For this purpose, Member States can makes use of table 1 and 2 of the reporting template annexed to the Regulation, which includes a basic list of elements that can be used to describe the reference buildings and building categories.

Member States are free to use and adjust already existing catalogues and databases of reference buildings for the purpose of the cost optimal calculations. Moreover, work carried out under the Intelligent Energy Europe programme can be used as input, in particular as regards:

- **TABULA** – Typology approach for building stock energy assessment: http://www.building-typology.eu/tabula/download.html

- **ASIEPI Project** – A set of reference buildings for energy performance calculation studies: http://www.asiepi.eu/wp2-benchmarking/reports.html[1]

The Regulation asks Member States to identify at least one reference building for new buildings and at least two for existing buildings subject to major renovation for each of the following categories: Single family buildings, apartment blocks/multi-family buildings and office buildings. In compliance with their obligation under Directive 2010/31/EU Annex I on the energy performance calculation and the obligatory use of the building classifications as listed, Member States can then establish reference buildings (again one for new built, two for existing) for office buildings in a way that these can also be used for the calculation of cost optimal requirements for other non-residential building categories. Alternatively, they can define reference buildings for the other non-residential categories in a way that one reference building represents two or more categories. Member States can finally also decide to establish reference buildings (again one for new built, two for existing) for every category of non-residential buildings separately, at least for those for which minimum energy performance requirements are in place.

As a general rule of thumb it can be assumed that the building stock will be reflected more realistically with a higher number of reference buildings and subcategories, but there is obviously a trade off between administrative burdens resulting from the calculation exercise versus the representativeness of the building stock. If the building stock is diverse more reference buildings will probably be required.

The approach taken towards establishing reference buildings for new and existing buildings is basically the same, with the exception that for existing buildings the description of the reference building provides a full qualitative description of the typical building and of the typical building systems installed. When it comes to new buildings, the reference building establishes only the basic building geometry, typical functionality and typical cost structure in the Member State, geographic location and indoor and outdoor climatic conditions.

In accordance with Annex III of Directive 2010/31/EU and Annex I(1) of the Regulation, Member States are not obliged to establish sub-categories, but only to establish reference buildings.

However, dividing a building category into sub-categories can be an intermediate step in determining the most representative reference buildings. Different building stocks require different characteristics. In one country, the differentiation based on construction materials might be most appropriate, in another country the age of the building. It will be important for the report to the Commission to indicate clearly why the chosen criteria guarantee a realistic picture of the building stock. With regard to the existing building stock, the importance of the *average* characteristics is underlined.

[1] **Note:** The ASIEPI project only defines the buildings' geometry and would not be sufficient for the purposes of the calculation.

The following remarks can be made on criteria for sub-categorisation:

Age	This criterion might make sense in a country where so far the existing building stock has not been tackled in refurbishment efforts and hence the original age of the building still constitutes a good proxy for the energetic performance of the building. In countries where the building stock has already to a large extent been renovated, the age groups have become too diverse to be captured simply by age.
Size	Size categories are interesting insofar as they can represent subcategories for both energy and cost related characteristics.
Climate conditions	In several Member States, national requirements distinguish between different climate zones or regions of the country. It is recommended that if this is the case the reference buildings should be representative for the specific climate zones or regions and that the energy consumption of the reference buildings should be calculated for each climate zone. It is recommended that climate conditions be described and used in accordance with EN ISO 15927- “Hygrothermal performance of buildings - Calculation and presentation of climatic data” applied as a country average or per climate zone, in case this distinction is made in the national building regulation. Heating degree days are available from EUROSTAT. It is recommended that when appropriate, cooling degree days are also included (specifying the base temperature and time step used for the calculation).
Orientation and shading	Depending on the geometries of the building and size and distribution/orientation of window surface, the orientation of a building as well as shading (from nearby buildings or trees) can have a significant influence on the energy demand of a building. It is however difficult to derive an "average" situation from this. It might make sense to define a "likely" situation for a building situated in the countryside and a likely situation for one in an urban setting if this critirion is considered in the national minimum requirements. The typical location of the reference building(s) should be reflected also in the impacts of orientation, solar gains, shading, demand for artificial lighting, etc.
Construction products in load carrying and other structures	Construction products in the envelope contribute to the thermal performance and have an impact on the energy demand of a building. For example, a high building mass can reduce the energy demand for cooling in summer. It is probable that a distinction needs to be made between different kinds of buildings in the definition of reference buildings (e.g. massive buildings and light-weight constructions) if reasonable shares of both are found in a specific country.

4. IDENTIFICATION OF ENERGY EFFICIENCY MEASURES, MEASURES BASED ON RENEWABLE ENERGY SOURCES OR PACKAGES OF SUCH MEASURES FOR EACH REFERENCE BUILDING

In accordance with Annex III of 2010/31/EU and Annex I(2) of the Regulation, Member States must define energy efficiency measures to be applied to the established reference buildings.

In accordance with Annex I(2), paragraph 3 of the Regulation, Member States must also include measures based on renewable energy sources into the calculation exercise.

It should be noted that measures acting on one system can affect the energy performance of another system. For example, the insulation level of the envelope affects the capacity and dimensions of the building systems. This interaction between different measures has to be addressed when defining packages/variants.

It is therefore recommended that measures are combined in packages of measures and/or variants, since meaningful combinations of measures can create synergy effects that lead to better results (regarding costs and energy performance) than single measures. Within a package of measures, efficiency measures that are cost effective may allow the inclusion of other measures that are not yet cost effective, but which could add substantially to primary energy usage and CO_2 savings associated with the total building concept –provided that the overall package still provides more benefits than costs over the lifetime of the building or building element.

The more packages assessed (and variation of the measures included in the assessed package), the more accurate the calculated optimum of the achievable performance will be.

To describe each building variant, the input needed is information on energy performance. Table 3 of the reporting template annexed to the Regulation provides an overview of the basic set of technical parameters necessary to perform an energy performance calculation.

It is recommended that when Member States fix their national calculation methodology, the order of appearance of the defined measures/packages/variants does not predetermine the outcome. Thus Member States should avoid establishing rules whereby a measure on the building envelope is always applied first and only then a measure on a building system is allowed.

4.1. Possible energy efficiency measures and measures based on renewable energy sources (and their packages and variants) to be taken into account

Many measures could be considered as a starting point for establishing measures/packages/variants for the calculation exercise. The list provided below is not comprehensive, nor can it be assumed that all measures will be equally appropriate in different national and climatic contexts. The list aims only to provide an indication of the possible measures to be considered.

Measures using renewable energy must also be considered. These measures will be necessary in due course to meet the nearly zero-energy requirements as established by Article 9 of Directive 2010/31/EU, and may already be cost optimal solutions before then.

<u>Building structure:</u>

– Total wall construction of new buildings or additional insulation system of existing walls [2] – Total roof construction of new buildings or additional insulation system of existing roofs. All parts of slab subjected to insulation system of new buildings or additional insulation system of existing slabs. – All parts of ground floor construction and foundation different from construction of reference building's or additional insulation system of existing floor-construction. – Increased thermal inertia with usage of exposed massive building materials at the interior space of buildings (for some climate situations only) – Better framing of doors and windows – Better sun shading (fixed or movable, operated manually or automatically) – Better air tightness (maximum air tightness corresponding to the state of technique) – Building orientation and solar exposition(can constitute a measure for new buildings only) – Change of share transparent/opaque surfaces (glazed area to facade area ratio optimization) – Openings for night ventilation (cross or stack ventilation)
<u>Systems:</u>
– Installation or improvement of heating system (based on fossil or renewable energy, with condensing boiler, heat pumps etc) at all sites – Monitoring and metering devices for temperature control of space and water temperature – Installation or improvement of hot water supply system (based on fossil or renewable energy). – Installation or improvement of ventilation (mechanical with heat recovery, natural, balanced mechanical, extraction). – Installation or improvement of active or hybrid cooling system (e.g. ground heat exchanger, chiller). – Improvement of utilization from daylighting – Active lighting system – Installation or improvement of PV systems – Change of energy carrier for a system – Change of pumps and fans

[2] Usually the thickness of insulation is varied stepwise and gradually. There would usually be a maximum applicable thickness per component. The corresponding U-value level required and recommended in national legislation/national technical standard should be considered. Insulation can be applied inside internally or externally or at both sides at various positions within the walls (care should be taken for risk of interstitial or surface condensation).

– Insulation of pipes – Direct water heaters or indirect water storage heated by different carriers, can be combined with solar thermal – Solar heating (and cooling) installations (of different sizes) – Intensive night ventilation (for non-residential buildings with massive structures and for some climate situations only) – Micro CHP with different carriers – Important: Renewable energy produced nearby (e.g. through combined heat and power, district heating and district cooling) can be taken into account only when the production of energy and consumption of a specific building are linked strongly to each other.
Established variants:
– Existing variants such as national Eco-labels and other established low energy or nearly zero energy buildings as defined at national level, as well as private variants such as passive house.

It is important to underline that existing variants should not be taken for granted as the only cost optimal solution. Also reviews should allow for new technological solutions and their price development to be taken into account.

4.2. Methods for reducing combinations and thus calculations

One of the main challenges of the calculation methodology is to ensure that on the one hand all measures with a possible impact on the primary or final energy use of a building are considered, whilst on the other hand the calculation exercise remains manageable and proportionate. Applying several variants on several reference buildings can quickly result in thousands of calculations. The number of variants calculated and applied to each reference building should certainly not be lower than 10 packages/variants plus the reference case.

Several techniques can be used in order to limit the number of calculations. One is to design the database of energy efficiency measures as a matrix of measures which rules out mutually exclusive technologies so that the number of calculations is minimised. For example, a heat pump for space heating does not have to be assessed in combination with a high efficiency boiler for space heating as the options are mutually exclusive and do not complement each other. The possible energy efficiency measures and measures based on renewable energy sources (and packages/variants thereof) can be presented in a matrix and unfeasible combinations eliminated.

Usually the most representative technologies in a given country for a given reference building would be listed first. Proven variants on the overall energy performance level should be considered here as a solution package fulfilling the expected target –e.g. passive house level expressed in a set of criteria to be fulfilled, including primary energy from non-renewable sources.

Stochastic methods for energy performance calculation can be used effectively for presenting the effects of particular measures and their combinations. From that, a limited number of combinations of most promising measures can be derived.

4.3. Indoor air quality and other comfort-related issues

As stipulated in Annex I(2) paragraph 5 of the Regulation, the measures used for the calculation exercise must be comfort compatible and in line with existing EU and national requirements. Also, the cost optimal calculation exercise has to be designed in such a way that differences in air quality and comfort are made transparent. In case of a serious violation of indoor air quality or other aspects, a measure might also be excluded from the national methodology.

Concerning indoor air quality, a minimum air exchange rate is usually set. The rate of ventilation set can depend on, and vary with, the type of ventilation (natural extraction or balanced ventilation).

Regarding the level of summer comfort it might be advisable, in particular for a southern climate, to deliberately take into account passive cooling that can be obtained by a proper building design. The calculation methodology would then be designed in such a way that it includes for every measure/package/variant the risk of overheating and of a need for an active cooling system.

5. Calculation of the primary energy demand resulting from the application of measures and packages of measures to a reference building

The objective of the calculation procedure is to determine the annual overall energy use in terms of primary energy, which includes energy use for heating, cooling, ventilation, hot water and lighting. According to Directive 2010/31/EU definitions, electricity for household appliances and plug loads may be included, but this is not mandatory.

It is recommended that Member States use CEN standards for energy performance calculations. CEN technical report TR 15615 (Umbrella Document) gives the general relationship between the EPBD Directive and the European energy standards. Moreover, standard EN 15603:2008 provides the overall scheme for energy calculation and the following definitions:

Energy-performance related definition as used in EN 15603:2008:

- **Energy source**: source from which useful energy can be extracted or recovered either directly or by means of a conversion or transformation process.
- **Energy carrier**: substance or phenomenon that can be used to produce mechanical work or heat or to operate chemical or physical processes.
- **System boundary**: boundary that includes within it all areas associated with the building (both inside and outside the building) where energy is consumed or produced.
- **Energy need for heating or cooling**: 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 domestic hot water**: 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 use for space heating or cooling or domestic hot water**: energy input to the heating, cooling or hot water system to satisfy the energy need for heating, cooling or hot water respectively.

- **Energy use for ventilation**: electrical energy input to the ventilation system for air transport and heat recovery (not including the energy input for preheating the air).

- **Energy use for lighting**: electrical energy input to the lighting system.

- **Renewable energy**: energy from sources that are not depleted by extraction, such as solar energy (thermal and photovoltaic), wind, water power, renewed biomass.

- **Delivered energy**: 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.).

- **Exported energy**: energy, expressed per energy carrier, delivered by the technical building systems through the system boundary and used outside the system boundary.

- **Primary energy**: energy that has not been subjected to any conversion or transformation process.

Under Annex I(3) paragraph 1 of the Regulation, the calculation of energy performance involves first the calculation of final energy needs for heating and cooling, then of the final energy needs for all energy uses, and thirdly of the the primary energy use. That means that the calculation direction goes from the needs to the source (i.e. from the building's energy needs to the primary energy). Electrical systems (such as lighting, ventilation, auxiliary) and thermal systems (heating, cooling, domestic hot water) are considered separately inside the building's boundaries. On-site energy production using locally available renewable energy sources is not considered part of delivered energy. Delivered energy inckudes e.g. electric energy drawn from the grid, gas from the grid, oil or pellets (all with their respective primary energy conversion factors) transported to the building for feeding the heating system.

It is recommended that the energy performance calculation is done as follows:

Calculation of energy performance from net energy needs to primary energy use:

1. Calculation of the building (thermal) **net thermal energy needs** to fulfil the user's requirements. The energy need in winter is calculated as energy losses via the envelope and ventilation minus the internal gains (from appliances, lighting systems and occupancy) as well as "natural" energy gains (passive solar heating, passive cooling, natural ventilation, etc.);

2. Subtraction from (1) of the **thermal energy from RES** generated and used on-site (e.g. from solar collectors);

3. Calculation of the **energy uses** for each end-use (space heating and cooling, hot water, lighting, ventilation) and for each energy carrier (electricity, fuel) taking into account the characteristics (seasonal efficiencies) of generation, distribution, emission and control systems;

4. Subtraction from electricity use of the **electricity from RES**, generated and used on-site (e.g. from PV panels);

5. Calculation of the **delivered energy** for each energy carrier as sum of energy uses (not covered by RES);

6. Calculation of the **primary energy** associated to the delivered energy, using national conversion factors;

7. Calculation of primary energy associated with **energy exported to the market** (e.g. generated by RES or co-generators on-site);

8. Calculation of **(net) primary energy** as the difference between the two previous calculated amounts: (6) - (7).

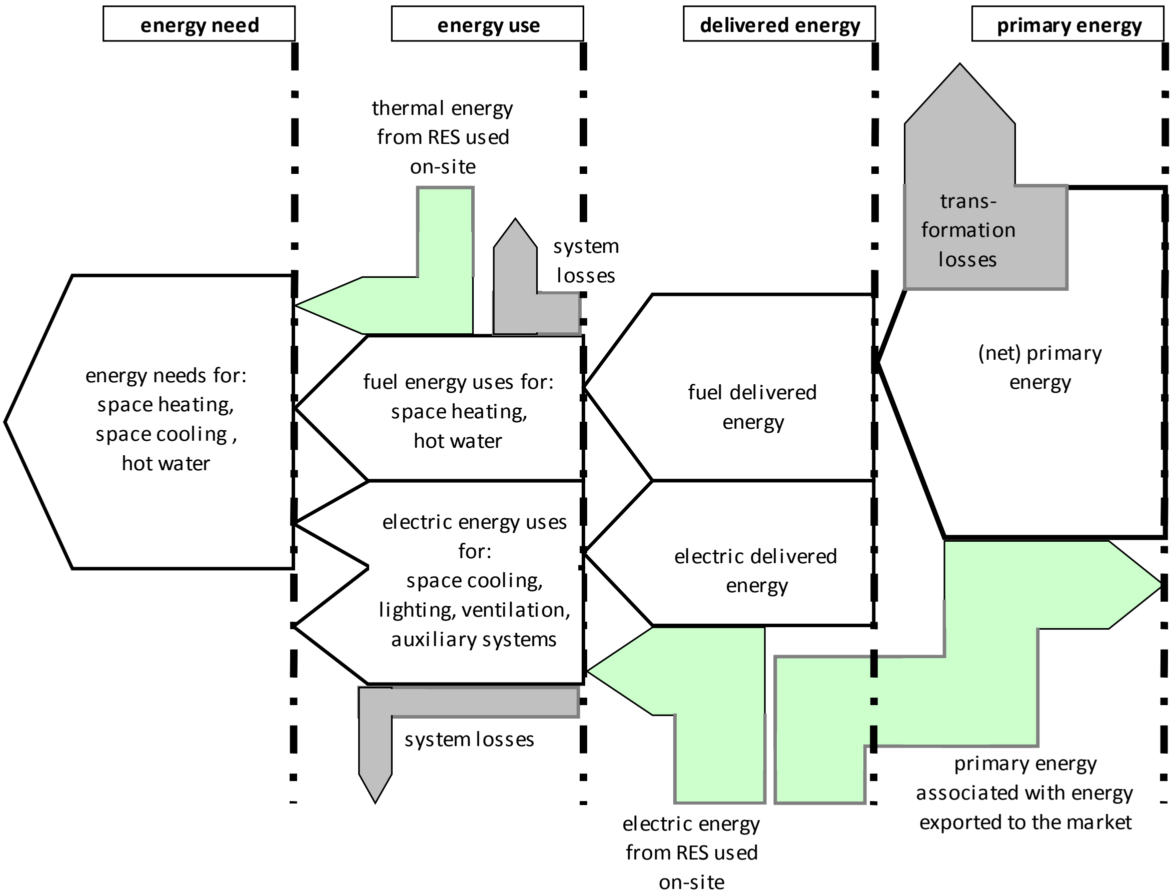

Figure 1 - Schematic illustration of the calculation scheme.

In order to reach reliable results it is recommended to:
• Clearly define the calculation methodology, also in relation to national laws and regulations;

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- Clearly define the boundaries for the system established for the energy performance assessment;
- Perform the calculations by dividing the year into a number of calculation steps (e.g. months, hours, etc.): performing the calculations for each step using step-dependent values and summing the energy consumption for all the steps over the year.
- Estimate the energy need for hot water following the approach in EN 15316-3-1:2007.
- Estimate the energy use for lighting with the quick method proposed by the standard EN 15193:2007 or more detailed calculation methods.
- Use standard EN 15241:2007 as the reference for calculating the energy use for ventilation.
- Take into account, where relevant, the impact of integrated controls, combining the control of several systems, in accordance with standard EN 15232.

In respect of the energy needs for heating and cooling, the energy balance of the building and its systems is the basis of the procedure. According to standard EN ISO 13790, the main calculation procedure consists of the following steps:

- choice of type of calculation method;
- definition of boundaries and thermal zones of the building;
- definition of internal conditions and external input data (weather);
- calculation of the energy need for each time step and zone;
- subtraction of recovered system losses from energy needs;
- consideration of interactions between zones and/or systems.

For the first and the last steps, a choice of different methods is suggested in the CEN standards. It includes:

- 3 different calculation methods:
    - a fully prescribed monthly quasi-steady-state calculation method;
    - a fully prescribed simple hourly dynamic calculation method;
    - calculation procedures for detailed (e.g. hourly) dynamic simulation methods.
- 2 different ways of dealing with interactions between a building and its systems:
    - holistic approach (the effect of all heat gains associated with building and its technical building systems are considered in the calculation of the energy needs for heating and cooling);

- simplified approach (recovered system heat losses, obtained by multiplying recoverable thermal system losses by a fixed conventional recovery factor, are directly subtracted from the thermal loss of each technical building system considered).

For the purpose of the cost-optimal calculation, in order to reach reliable results, it is recommended:

- to perform the calculations using a dynamic method;
- to define boundary conditions and reference use patterns in conformity with the calculation procedures, unified for all series of calculation for a particular reference building;
- to provide the source of the weather data used;
- to define thermal comfort in terms of indoor operative temperature (e.g. 20°C in winter and 26°C in summer) and targets, expressed for all series of calculation for a particular reference building.

Moreover it is suggested:

- to consider the interactions between a building and its systems using the holistic approach;
- to verify with dynamic simulations the impact of day-lighting strategies (using natural light);
- to show the electric energy use for appliances.

For calculating energy use for space heating, hot water and space cooling, as well the energy generation (thermal and electrical) from RES it is necessary to characterise the seasonal efficiencies of plants or use dynamic simulation. The following CEN standards can be used as reference:

- Space heating: EN 15316-1, EN 15316-2-1, EN 15316-4-1, EN 15316-4-2;
- Hot water: EN 15316-3-2, EN 15316-3-3;
- Conditioning systems: EN 15243;
- Thermal energy from RES: EN 15316-4-3;
- Electric energy from RES: EN 15316-4-6;
- Co-generation system: EN 15316-4-4;
- District heating and large volume systems: EN 15316-4-5;
- Biomass combustion systems: EN 15316-4-7.

In order to calculate primary energy the most recent national conversion factors should be used, also taking into account Annex II of Directive 2006/32/EC[3].

***Calculation example*:**

Consider an office building located in Brussels with the following annual energy needs:

- 20 kWh/(m² a) for space heating;
- 5 kWh/(m² a) for hot water;
- 35 kWh/(m² a) for space cooling;

and with the following annual energy uses:

- 7 kWh/(m² a) electricity for ventilation;
- 10 kWh/(m² a) electricity for lighting.

The building has a gas boiler for heating (space heating and hot water) with total seasonal efficiency of 80%. In summer, a mechanical cooling plant is used: the seasonal efficiency of the entire cooling plant (generation, distribution, emission, control) is 175%. Installed solar collectors provide thermal energy for hot water of 3 kWh/(m² a) and a solar PV system provides 15 kWh/(m² a), of which 6 are utilized in the building and 9 are exported to the grid. For electricity a delivered/primary conversion factor of 0,4 is assumed (primary/delivered = 2,5).

Energy calculation results:

- fuel energy use for space heating is 25 kWh/(m² a): 20/0,80;
- fuel energy use for hot water is 2,5 kWh/(m² a): (5 - 3)/0,80;
- electric energy use for space cooling results in 20 kWh/(m² a): 35/1,75;
- delivered fuel energy is 27,5 kWh/(m² a): 25 + 2,5;
- delivered electric energy is 31 kWh/(m² a): 7 + 10 + 20 - 6;
- primary energy is 105 kWh/(m² a): 27,5 + (31/0,4);
- primary energy associated with energy exported to the market is 22,5 kWh/(m² a): 9/0,4;
- net primary energy is 82.5 kWh/(m² a): 105 – 22,5.

[3] The ESD Directive was recently recasted by the Commission and a proposal presented on 22 June 1011 (COM 2011(370) final. The conversion factors are to be found in Annex IV.

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

In accordance with Annex III of Directive 2010/31/EU and Annex I (4) of the Regulation, the cost optimal framework methodology is based on the net present value (global costs) methodology.

The calculation of global cost considers the initial investment, the annual costs for every year and the final value as well as disposal costs if appropriate, all with reference to the starting year. Global cost calculations result in a net present value of costs incurred during a defined calculation period taking into account the residual values of equipment with longer lifetimes. Projections for energy costs and interest rates can be limited to the calculation period.

The advantage of the global cost method is that it allows the useof a uniform calculation period (with long lasting equipment taken into account via its residual value) – as opposed to the annuity method – and that it can be drawn on activities on life cycle costing (LCC) which also make use of net present value calculations.

The term 'global costs' is taken from standard EN 15459, but it corresponds to what generally in the literature is called life cycle cost analysis in the literature.

It should be noted that the global cost methodology does not include costs other than energy (e.g. water costs) as it follows the scope of Directive 2010/31/EU).

6.1. The concept of cost optimality

In line with Directive 2010/31/EU, Member States are required to establish cost optimal levels of minimum energy performance requirements. The methodology is addressed to national authorities, not to investors. In reality, there will be a multitude of cost optimal levels for different investors depending on the individual building and the investor's own perspective and expectations of what constitute acceptable investment conditions. It is therefore important to underline that the cost optimal levels identified will not necessarily be cost optimal for every single building/investor combination. However, with a solid approach for determining the reference buildings Member States can ensure that the requirements in place are appropriate for the majority of buildings.

While the specific situation of rented buildings with the split benefits issue should be kept in mind, it is not desirable to have different requirements for buildings depending on whether these are rented out or not, as the status of the occupant is independent of the building which is the focus of the calculation.

Besides the fact that various and possibly numerous individual perspectives and investment expectations exist, there is also the question of scope of costs and benefits that are taken into account. Does one only consider the immediate benefits that affect the investor themself, or does one also look at other indirect costs and benefits that are triggered by an energy efficiency investment?

The Regulation reflects Annex III of Directive 2010/31/EU that seems to indicate a methodology based on the prices, costs and benefits perceived by the investor in the building. (For example, the Annex mentions "*earnings of energy produced*" rather than overall "*CO_2 reduction*" and lists several cost categories usually associated with a micro level investment valuation approach, but not macro level costs for CO_2 abatement).

For such an approach, Member States need to ensure that the input data used includes:

- All applicable subsidies and incentives
- All applicable taxes (VAT and others)
- Prices as paid by the end consumer

To note: VAT might be excluded fully from all cost categories of the global cost calculation simplifying the calculation, if in that Member State no VAT-based subsidies and supporting measures exist. A country that already has or intends to put in place VAT-based support measures should include VAT as an element in all cost categories so as to be able to feed the support measures into the equation.

Since the purpose of the calculation exercise is to prepare and inform the setting of generally applicable minimum energy performance requirements, it would seem logical that the scope goes beyond a single building or construction project and encompasses a broader public good perspective where the investment in energy efficiency and its associated costs and benefits are assessed against policy alternatives. Such a broader investment perspective aligns also relatively well with primary energy as the 'currency' of energy performance, whereas a purely private investment perspective can be aligned with either primary energy or delivered energy as the currency of energy performance.

In practice it will however not in any case be possible to capture all societal direct and indirect benefits, as some are intangible, non quantifiable or cannot be monetised. However, some external benefits and costs have recognised quantification and costing approaches that allow capturing these. This is in particular true for the costs of reduced CO_2 emissions that can be taken into account by calculating the price per ton of avoided CO_2. The methodology established in the Regulation would allow Member States to include as an additional cost category the cost of avoided CO^2 emissions, aligning their approach with those Member States that already have CO_2 taxation in place that intends to achieve a similar objective (cost internalisation).

To note: Several Member States have established a national methodology that tries to identify the cost optimal level both from a public good perspective, but also from the perspective of the investor who needs to get back the costs of the investments through benefits over the investment's lifetime (either through energy savings or rental income). Establishing both levels of cost optimality allows policy makers to identify any gap that persists between what is cost optimal for one investor and what would be cost optimal for the overall society. This information could then be used to inform decisions on financial and other support schemes. Member States can choose to calculate cost optimality for both viewpoints, but are under the Regulation not obliged to do so.

In such a calculation the methodology would need to be adjusted for a calculation of the cost optimal level from a public good perspective where subsidies and taxes would have to be excluded from the calculation and prices and costs would have to be defined differently, no longer as end consumer prices.

6.2. The discount rate

In order to make the discount rate applicable, usually a discount factor will have to be derived from it to be used in the global cost calculation.

$R_d(i)$, the discount factor for year i based on discount rate *r*, can be calculated as:

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

where

p is the number of years from the starting period;

R_r is the real discount rate; and

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

It is for Member States to decide on the discount rate to be used. A higher discount rate – typically higher than 4% and possibly differentiated for non-residential and residential buildings - will reflect a purely commercial, short term approach to the valuation of investments. A lower rate – typically ranging from 2-4% excluding inflation - will more closely reflect the benefits that energy efficiency investments bring to building occupants over the whole of an investment's lifetime.

It is to be noted that as an effect of the financial calculation principle the amount of global costs is higher when lower discount rates are applied, since future costs (mainly energy costs) are discounted at a lower rate, leading to a higher present value of the global costs.

Member States are requested to perform a sensitivity analysis using different discount rates

6.3. Cost categorisation

Under Annex I(4) of the Regulation, Member States are required to use the following basic cost categories: initial investment costs, running costs (including energy costs and periodic replacement) and, if appropriate, disposal costs.

Due to their importance in the given context, energy costs are listed as a separate cost category although usually they are seen as part of the operational cost. Furthermore, replacement cost is not seen as part of maintenance cost - as is sometimes the case in other cost structures - but as a separate cost category.

This cost categorisation for the calculation of cost optimal levels of minimum requirements is based on standard EN 15459. It differs slightly from cost categorisation systems usually used for life cycle cost assessment (compare standard ISO 15686-5:2008 on Buildings and constructed assets - Service-life planning - Part 5 Life-cycle costing). The following illustration summarises the cost categories to be applied.

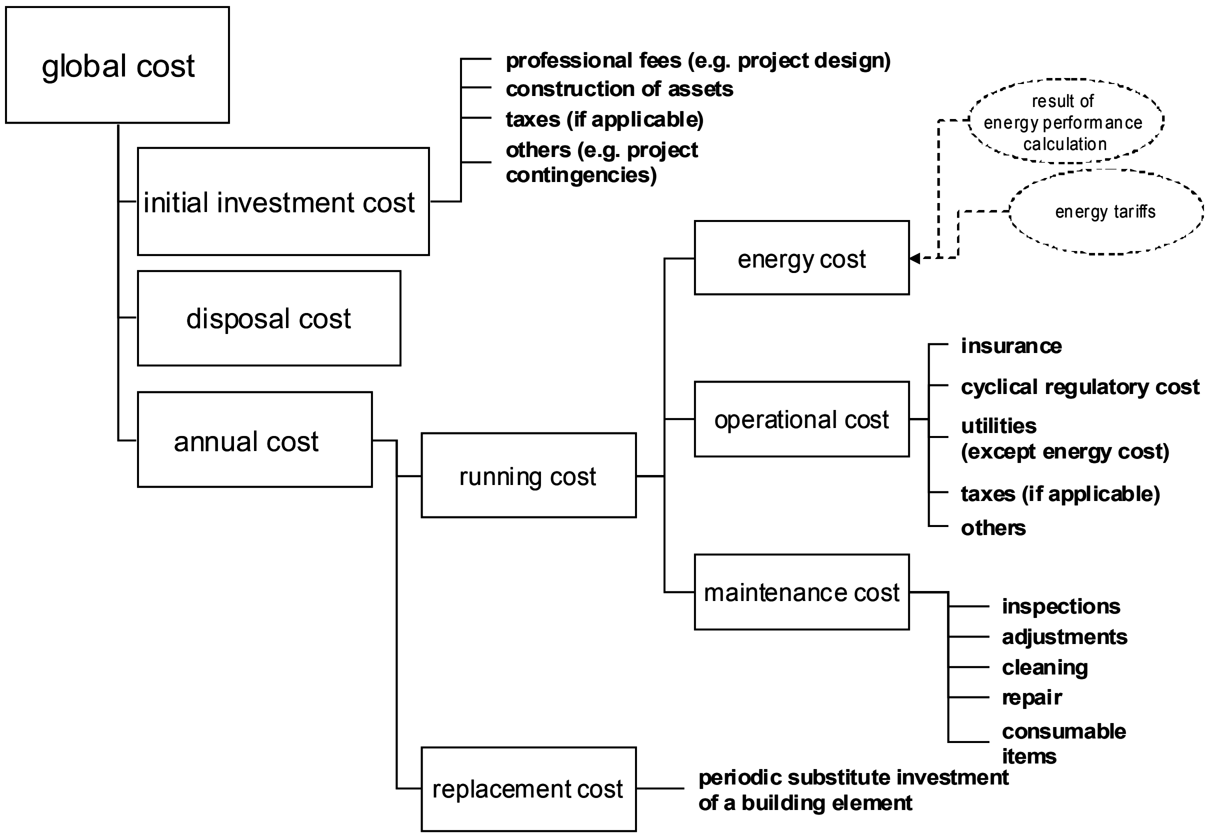


Figure 2: Cost categorisation according to the Framework Methodology

In general, it is to be emphasised that the enumeration of cost categories given in the Regulation is comprehensive. Nevertheless, if other cost categories are important in the context of the calculation of cost optimal levels of minimum requirements (such as the costs of CO_2 emissions) , they can also be taken into account.

It has to be noted that the cost of the capital needed to finance energy efficiency investments is not included as a separate category in the Regulation as this is generally already reflected in the discount rate.

Energy costs are based on consumption, size of the building, current rates and price predictions. Energy costs are directly connected to the result of the energy performance calculation. This means energy costs depend on the *system* characteristics of the building. Most other cost items such as investment cost, maintenance cost, replacement cost etc. are largely allocated to *specific building elements*. Therefore global cost has to be calculated with buildings sufficiently disaggregated into separate building elements, so that differences in measures/packages/variants are reflected in the result of the global cost calculation.

Non-fuel related operation and maintenance costs are often more difficult to estimate than other expenditures since operating schedules vary from building to building. There is great variation even among buildings of the same category. Some data gathering and screening might therefore be needed in order to determine a reasonable average cost per square meter for certain categories and subcategories.

The Regulation prescribes in principle a **full cost approach** for new construction as well as for major refurbishment. This means that for each assessed measure/package/variant of the reference building the full cost of construction (or major renovation) and the subsequent use of the building should be calculated. But since the focus of the exercise is the comparison of measures/packages/variants (and not the assessment of total costs for the investor and user of the building), the following cost items may be omitted in the calculation:

- Costs related to building elements which do not have an influence on the energy performance of the building, for example: cost for floor covering; cost for wall painting, etc. (if the energy performance calculation does not reveal any differences in this respect);

- Costs that are the same for all measures/packages/variants assessed for a certain reference building (even if the related building elements have or could have an influence on the energy performance of the building). Since these cost items do not make a difference in the comparison of the measures/packages/variants, it is not required to take them into account. Examples could be:

  - For new construction: Earthworks and foundation, cost for staircases, cost for lifts, etc. - if these cost elements are the same for all measures/packages/variants assessed;

  - For major renovation: cost for scaffolding, demolition cost etc. - once again under the precondition that no difference in these cost items can be expected for the measures/packages/variants assessed.

It has to be noted that the Regulation does not allow for the so-called additional cost calculation approach[4]. For the calculation of the cost optimality of minimum energy performance requirements the additional cost calculation approach is not suitable for the following reasons:

- The characteristics of the standard building have an impact on the results of the assessment of cost optimality;

- The additional cost calculation approach can not reflect fully the scope of assessed measures/packages/variants: Many energy efficiency measures are to be seen as an integral part of the building design. This is particularly true for measures that are related to “passive cooling” approaches, such as: the choice of share of window area and the placement of window areas according to the orientation of the building, the activation of thermal mass, the bundle of measures related to night cooling etc. The additional cost calculation approach has difficulties in displaying inter-linkages between certain building characteristics, e.g. the choice of a certain type of façade requires certain static preconditions; thermo-active building systems for heating and cooling require a certain level of net energy demand etc. Trying to allow for all these potential inter-linkages in an additional cost calculation approach would make the approach confusing and non-transparent;

- The additional cost calculation approach requires a detailed cost attribution between costs that are attributed to the standard renovation and costs that are associated with the additional energy efficiency. This separation is sometimes not very easy to make.

4 An additional cost calculation approach starts from a standard building (e.g. a building that is in line with the actual minimum requirements) and starting from that, additional measures (e.g. a better insulation, shading, a ventilation system with heat recovery etc.) are added. The cost comparison is made based on additional investment cost and differences in running cost.

6.4. Gathering of cost data

The Regulation states that cost data must be market-based (e.g. obtained by market analysis) and coherent as regards location and time. This means that cost data need to be gathered from one of the following sources:

- Evaluation of recent construction projects;
- Analysis of standard offers of construction companies (not necessarily related to implemented construction projects);
- Use of existing cost databases which have been derived from market-based data gathering.

It is important that the cost data sources reflect the disaggregation level which is required to compare different measures/packages/variants for a given reference building. Therefore, so-called "top-down" benchmark databases such as BKI (2010)[5] or OSCAR (John Lang Lasalle 2009)[6], which are commonly used for the rough estimate of investment and operating cost of buildings, can not be used for the purpose of cost-optimal calculations because their data are not sufficiently related to the energy performance of the building. Their disaggregation level is too low to be able to derive cost differentiations of different measures/packages/variants.

6.5. Basic listing of elements of costs to be taken into account for calculating initial investment costs of buildings and building elements

The listing below is by no means comprehensive or topical and is intended purely as an indication of elements to be taken into account:

For the building envelope	
Insulation of building envelope: • Insulation products • Additional products for application of the insulation to the building envelope (mechanical fixings, adhesive etc.) • Design costs • Installation costs of insulation (including water vapour barriers, weather membranes, measures to ensure air-tightness and measures to reduce the effects of thermal bridges) • Energy-related costs of other	Windows and doors: • Glazing and/or glazing enhancement • Frame • Gaskets and sealants • Installation costs The technical systems, products and components are described for example in various standards under CEN/TC 33 - Doors, windows, shutters, building hardware and curtain walling and CEN/TC 89 (see above).

5 Baukosteninformationszentrum Deutscher Architekten (BKI): Statistische Kostenkennwerte für Gebäude, 2010, www.baukosten.de.

6 John Lang Lassalle: Büronebenkostenanalyse OSCAR 2008, Berlin, 2009. Can be ordered from www.joneslanglasalle.de

building materials, if applicable • Other building related measures with impact on thermal performance. This can include e.g. external shading devices, solar control systems, and passive systems not covered elsewhere. The technical products and systems are described for example in various standards under CEN/TC 88 - Thermal insulating materials and products and CEN/TC 89 – Thermal performance of buildings and building components.	
For building systems	
Space heating: • Generation and storage equipment (boiler, storage tank heat generation controls) • Distribution (circulator, circuit valves, distribution controls) • Emitters (radiators, ceiling floor heating, fan coils, emission controls) • Design costs • Installation costs The technical systems are described for example in various standards under CEN/TC 228 - Heating systems in buildings and CEN/TC 57 - Central heating boilers, e g EN 15316-2-1 CEN/TC 247, EN 12098, EN 15500, EN 215, EN 15232 For reference comfort conditions, EN15251 "Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics" or equivalent should be taken into account.	Domestic hot water: • Generation and storage (including solar thermal systems, boiler, storage tank, heat generation controls) • Distribution (circulator, circuit valves/mixing valves, distribution controls) • Emitters (tab valves, floor heating, emission controls) • Design costs • Installation (including insulation of the system and pipes) The technical systems are described for example in various standards under CEN/TC 228 - Heating systems in buildings, CEN/TC 57 - Central heating boilers and CEN/TC 48 - Domestic gas-fired water heaters.
Ventilation systems: Concerning investments, the costs of mechanical ventilation systems are to be	Cooling: As a comfortable indoor temperature needs to be ensured, passive or active cooling

assessed. Possibilities for natural ventilation are covered with the definition of reference buildings. Investment costs should include: • Heat generation and recovery equipment (heat exchanger, pre-heater, heat recovery unit, heat generation controls) • Distribution (fans, circulators, valves, filters, distribution controls) • Emitters (ducts, outlet services, emission controls) • Design costs • Installation costs The technical systems are described for example in various standards under CEN/TC 156 - Ventilation for buildings.EN15251 or equivalent should be taken into account for reference comfort conditions and requirement for ventilation.	measures or a combination of both (supplying remaining cooling demand) need to be taken into account, depending on the specific climate conditions. In this category, the costs of active cooling systems are referred to. Passive cooling measures are either covered with the choice of reference buildings (e.g. building mass) covered in category "thermal insulation" (e.g. insulation of roofs to reduce cooling demands) or category "Other building related measures with impact on thermal performance" (e.g. external shading). Investment costs of active cooling systems include: • Generation and storage equipment (generator, heat pump, storage tank, heat generation controls) • Distribution (circulator, circuit valves, distribution controls) • Emitters (ceiling/floor/beams; fan cols, emission controls) • Design cost • Installation The technical systems are described for example in various standards under CEN/TC 113 - Heat pumps and air conditioning units. EN15251 should be taken into account for reference comfort conditions.
Lighting Concerning investments, active systems for artificial lighting or applications to increase use of daylight are to be assessed. Measures that refer to the design and geometry of the building envelope (size and position of windows) are being covered with the choice of the reference buildings. Investment costs should include: • Type of light sources and luminaires • Associated control systems • Applications to increase use of	Building automation and control Investment costs should include: • Building management systems which introduce supervising functions (separate system controls are accounted for within the specific system) • Technical intelligence, central controller • Controls (generation, distribution, emitters, circulators) • Actuators (generation, distribution,

daylight • Installation EN 12464 "Light and lighting - lighting of workplaces - Part 1 indoor work places" should be taken into account for reference comfort conditions and requirement levels. The energy requirements for lighting systems are described in EN 15193.	emitters) • Communication (wires, transmitters) • Design costs • Installation and programming costs The technical systems are described for example in various standards under CEN/TC 247 - Building Automation, Controls and Building Management
Connection to energy supplies (grid or storage) Investment costs should include: – Costs for first connection to the energy network (e.g. district heat, PV-system) – Storage tanks for combustion fuels – Necessary related installations	**Decentralised energy supply systems based on energy from renewable sources** Investments costs should include: - Generation - Distribution - Control devices - Installation

6.6. Calculation of periodic replacement cost

Besides initial investment costs and running costs, periodic replacement costs are the third cost driver. Whereas smaller repair work and consumables are usually subsumed under maintenance cost, periodic replacement refers to the substitution of a whole building element, which is necessary for ageing reasons, and is therefore treated as a separate cost category.

The point in time of periodic replacement is dependent on the lifetime of the building element or component. At the end of the lifetime a replacement has to be foreseen in the global cost calculation.

> *Example:* The cost of a heat recovery unit with an estimated economic lifetime of 15 years has to be calculated twice in the global cost calculation with a calculation period of 30 years: once in the beginning as initial investment cost and again as replacement cost after 15 years.

To note: It is up to Member States to determine the estimate economic lifetime of building elements and components as well as the entire building, but they may wish to use the guidance given in standard EN 15459 (for energy systems in buildings) and other standards. In any case the lifetime for the building elements used for the calculation must be plausible. e In general the replacement cost will be the same as the initial investment cost (in real terms!). For specific cases, however, where major price developments may be expected over the next 10-15 years, the Regulation allows for adaptations of the level of replacement cost.

Example: Replacement cost for photovoltaic systems will presumably be lower (for the same performance) than the initial investment cost.

6.7. Calculation period versus estimated lifecycle

The use of a calculation period as part of a net present value approach does not impede Member States' choice of estimated economic lifecycles for building and building element. The estimated lifecycle can either be longer or shorter than the calculation period.

If a reference building category for existing buildings were to be established in a way that made the reference building's remaining lifecycle smaller than the calculation period, the maximum remaining lifetime could in this case become the calculation period.

In fact, the technical lifespan of building elements has only limited influence on the calculation period. The calculation period is, rather, determined by the so-called refurbishment cycle of a building, which is the period of time after which a building undergoes a major refurbishment, including an improvement of the building as a whole and an adaptation to changed user requirements (in contrast to simple replacement). The reasons for major refurbishment are usually diverse, with ageing of important building elements (e.g. façade) being just one of them. Refurbishment cycles differ widely between building types (which is why different calculation periods are set for residential/public and non residential/commercial buildings) and Member States, but are almost never below 20 years.

Figure 3 illustrates the approach for a building element which has a longer lifetime than the calculation period (e.g. the façade or the bearing structure of the building). With an assumed lifespan of 40 years and a straight-line depreciation, the residual value after 30 years (end of the calculation period) is 25% of the initial investment cost. Of course, this value has to be discounted to the beginning of the calculation period.

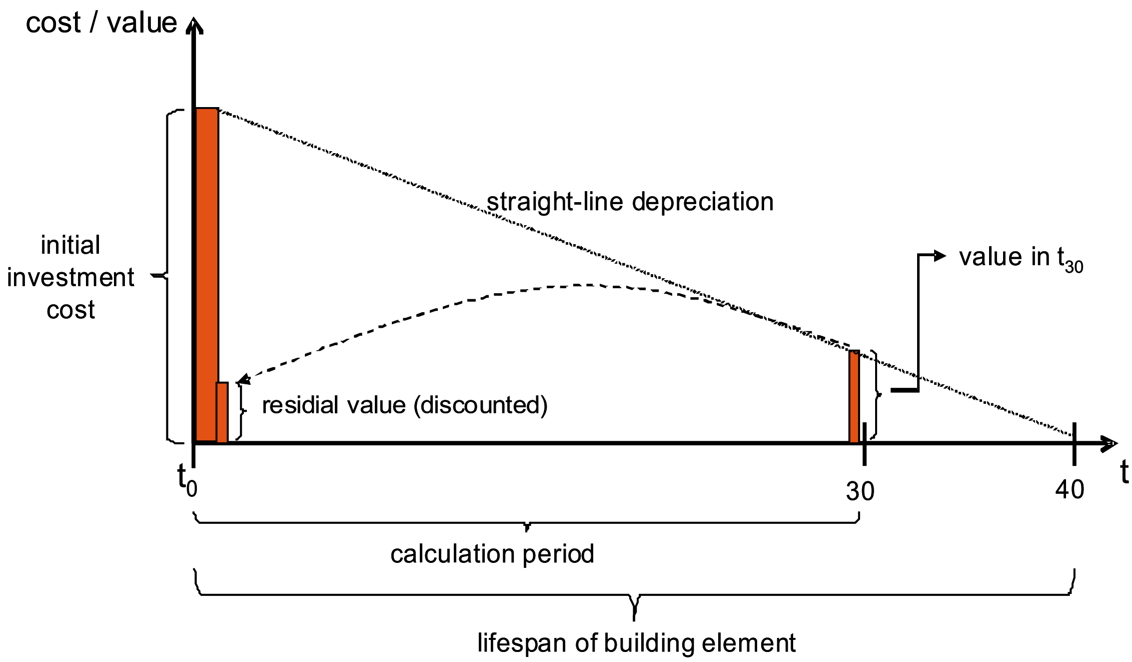


Figure 3 Calculation of the residual value of a building element which has a longer lifetime than the calculation period

Figure 4 shows how the residual value has to be calculated for a building element which has a shorter lifespan than the calculation period (e.g. heating boiler). With an assumed lifespan of 20 years the element has to be replaced after that period of time. Since the element has been renewed a new depreciation period starts. In this case after 30 years (end of the calculation period) the residual value of the element is 50% of the replacement cost. Once again this value has to be discounted to the beginning of the calculation period.

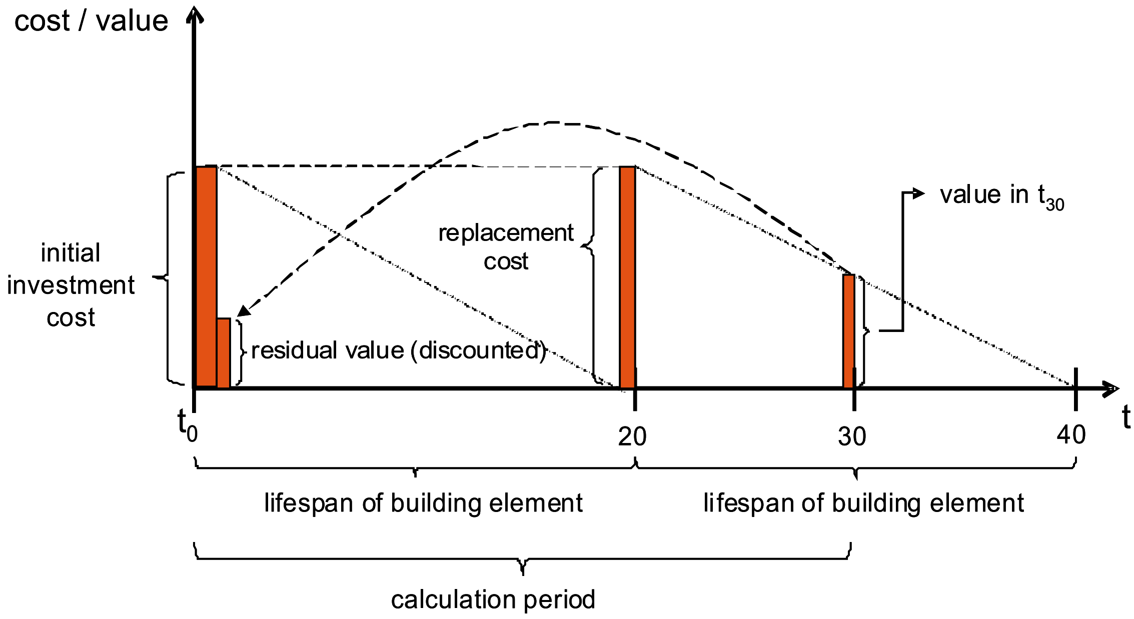


Figure 4 Calculation of the residual value of a building element which has a shorter lifetime than the calculation period

6.8. Starting year for the calculation

The regulation requires that Member States use as a starting point for the calculation the year in which the calculation is being carried out. The main purpose of this is to ensure that the current price and cost levels are reflected when the cost optimality of various measures/packages/variants is identified - to the extent that that data is already available. It is however possible for MS to base the calculation on the starting year (year of calculation, say for the first exercise 2012), but use as a reference for the minimum energy performance requirement requirements that are already established and foreseen for the near future, for example those that would become applicable in 2013.

6.9. Calculation of residual value

The Regulation requires the inclusion of the residual value in the global cost calculation. The residual value of the building at the end of the calculation period is the sum of residual values of all building elements. The residual value of a certain building element is dependent on the initial investment cost, the depreciation period (which reflects the lifetime of this building element) and if appropriate any costs for removing a building element.

6.10. Cost development over time

Except for energy cost and replacement cost, the Regulation does not include other real term cost increases or decreases. This means that for the other cost categories - i.e. operational cost and maintenance cost - price development is assumed to be equal to the overall inflation rate.

With respect to the development of cost for energy carriers over time, Annex II of the Regulation provides information that Member States can use for their calculations, but Member States are also free to use other forecasts. Based on this and other information sources, Member States need to develop their own scenarios for cost development over time. Energy cost developments are to be assumed for all energy carriers used to a significant extent in a Member State and might include for example bio energy in all its aggregations, LPG, district heating and cooling.

It is important to note that scenarios for different fuel sources have to be in a plausible correlation. Also, the electricity price trends for a Member State should be plausibly correlated with overall trends, i.e. with the trends for the main underlying fuels used at national level for producing electricity.

Price developments might also be assumed, if appropriate, for peak load tariffs.

6.11. Calculation of replacement costs

For replacement cost there is the possibility to adapt the initial investment cost - which serves as basis for the fixing of replacement cost - for selected building elements if major technological development is expected for the up-coming years. For example: the replacement cost for a photovoltaic plant can be assumed to be lower then the initial investment cost since major cost reduction is expected due to technological progress. The same might be true for other renewable energy technologies or for building automation systems

6.12. Treatment of taxation, subsidies and feed-in tariffs in the cost calculation

The general rule of the Regulation is that existing taxation and subsidy schemes that support the use of energy efficient technologies and of renewable energy sources should be taken into account in the global cost calculation. This refers in particular to:

- Energy and/or CO_2 taxation of energy carriers;
- Investment subsidies for (or depending on) the use of energy efficient technologies and of renewable energy sources;
- Regulated minimum feed-in tariffs for electricity produced from renewable energy sources.

6.13. Inclusion of earnings from energy production

If a Member State wishes to include in the calculation the earnings from renewable energy produced (as indicated in Annex III of Directive 2010/31/EU "where applicable"), it should endeavour to include all subsidies (both for electricity and thermal, also both for renewable energy and energy efficiency). If, for example, only a feed in tariff for produced electricity were considered in the equation, other subsidies and support schemes and the technologies benefiting from these would be disadvantaged and the results would imply an inherent bias in favour of the subsidies considered. In particular a bias towards electricity production at the expense of reduced demand for heating and cooling should be avoided.

6.14. Calculation of disposal costs

According to the Regulation the inclusion of disposal cost in the global cost calculation is not a requirement. Member States may include disposal costs if they think they are relevant and if they are able to make plausible estimates of their amount. Disposal costs need to be discounted back to the end of the calculation period.

In principle there are two places where disposal costs can be taken into account in the global cost calculation:

- The usual place is to take into account the end-of-life cost of the building, i.e. the cost for demolition and disposal of material including decommissioning cost (see standard ISO 15686 for a more precise definition of end-of-life cost items). The influence of the end-of-life cost depends on two factors: the absolute amount of cost and - even more important - the point in time when they are assumed to occur. In this context it is important to note that end-of-life costs do not occur at the end of calculation period but at the end of the lifetime of the building. Therefore an estimate of the lifetime of the building as a whole (and not of single building elements) is required. This may depend on the type of construction on the one hand (e.g. prefabricated houses versus solid construction) and on the type of use on the other hand (e.g. retail properties usually have shorter lifetimes than residential buildings). Member States are free to choose building lifetimes, but the lifetimes used should show plausible relationships when comparing different building categories.

- A second place where disposal cost may be introduced is in connection with replacement cost, since the dismantling or demolition of the old building element creates some cost. This cost is usually not included when fixing the replacement cost at the same level as the initial investment (no cost increase/decrease in real terms). Therefore the addition of some extra disposal costs related to replacement activities seems to be plausible and may be included in the global cost calculation.

The major challenge with respect to the consideration of disposal costs is the acquisition of reliable and market-based cost data. Usually disposal costs in the construction sector are only taken into account through a proxy based on the cubic capacity of the building, differentiated - in some cases - by construction type.

To note: If the assumed lifetime of the building goes beyond 50 to 60 years, the influence of disposal costs on the final result will be marginal due to discounting.

7. Derivation of a cost optimal level of energy performance for each reference building

7.1. Identification of cost optimal range

Based on the calculations of primary energy usage (step 3) and global costs (step 4) associated with the different measures/packages/variants (step 2) assessed for the defined reference buildings (step 1), graphs can be drawn per reference building that describe primary energy usage (x-axis: kWh primary energy/(m² useful floor area and year)) and global costs (y-axis: EURO/m² useful floor area) of the different solutions. From the number of measures/packages/variants assessed, a specific cost curve (= lower border of the area marked by the data points of the different variants) can be developed.

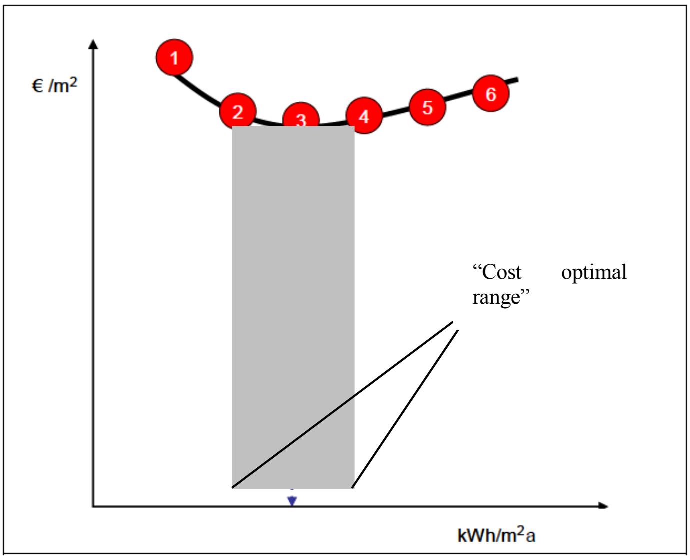


Figure 5: Different variants within the graph and position of the cost optimal range[7]

The combination of packages with the lowest cost is the lowest point of the curve (in the illustration above, package "3"). Its position on the x-axis automatically gives the cost optimal level of minimum energy performance requirements. As stipulated in Annex I(5) paragraph 2 of the Regulation, if packages have the same or very similar costs, the package with the lower primary energy use (= left border of the cost optimal range) should if possible guide the definition of the cost optimum level.

To note: Even with similar results it should be recalled that the upfront investment costs might differ even if the energy performance is similar and more incentives might therefore be needed.

For building elements, cost optimal levels are assessed by fixing all parameters (option 1: starting from the variant that has been identified as cost optimal; option 2: starting from different variants and using an average of the resulting values) and varying the performance of a specific component. Graphs can then be developed to show the performance (x-axis, e.g. in W/(m²K) for components like the roof of a building) and global costs (y-axis, in EURO/m² useful floor area). The building element properties with the lowest cost will provide the cost optimal level. If different building element properties have the same or very similar costs, the building element property with the lower primary energy use (= left border of the cost optimal range) should guide the definition of the cost optimum level (the fact that higher upfront investment needs occur should not be forgotten).

It is important to note that performance requirements for boilers and other installed appliances and equipment are set under the framework of the Ecodesign Directive.

7.2. Comparison with current requirements on Member State level

The current requirements on Member State level need to be compared to the calculated cost optimal level. Therefore the current regulations need to be applied to the reference building, leading to a calculation of the primary energy consumption of the building according to the rules set out in step 3.

[7] Source: Boermans, Bettgenhäuser et al., 2011: Cost optimal building performance requirements - Calculation methodology for reporting on national energy performance requirements on the basis of cost optimality within the framework of the EPBD, Eceee.

In a second step, the difference between the current level and the identified cost optimal level is calculated according to the following equation:

Identification of the gap:

Gap% (reference building level) = (cost optimal level [kWh/m²a] – current minimum performance requirements [kWh/m²a]) / cost optimal level [kWh/m²a]) x 100%

For building elements, the gap is calculated according to the following equation:

Gap% (for building elements) = (cost optimal level [unit of performance indicator[8]] – current minimum performance requirements [unit of performance indicator]) / cost optimal level [unit of performance indicator]) x 100%

8. Sensitivity analysis

The Regulation requires some sensitivity analyses to be undertaken by the Member States. The minimum requirement is a sensitivity analysis covering low, medium and high price scenarios for all energy carriers, plus two scenarios for the discount rate. Member States have to determine the most appropriate scenario once the sensitivity assessment is performed. This is the one to be fed into the result for the cost optimal calculation.

Besides undertaking a sensitivity analysis for these two key parameters, Member States are free to conduct additional sensitivity analyses particularly for the main cost drivers as identified in the calculation such as the initial investment cost of major building elements or costs related to the maintenance and replacement of energy systems in buildings.

9. Estimated long term energy price developments

The energy price development trends provided in Annex II of the Regulation give information about the estimated long-term price developments for oil, gas and coal, as well as electricity. Member States must take this information into account when determining the costs for energy carriers for the purpose of their cost-optimal calculations.

The information provided in Annex II of the Regulation is taken from energy trend scenarios developed with the PRIMES model (a modelling system that simulates a market equilibrium solution for energy supply and demand in the EU 27 and its Member States). The European Commission publishes bi-annual updates of these trends and the latest version can be found on: http://ec.europa.eu/energy/observatory/trends_2030/index_en.htm.

The latest update[9] implies a 2.8 % annual increase in gas prices, a 2.8 % annual increase in oil prices and a 2 % annual increase in coal prices. These trends may be extrapolated beyond 2030 until more long-term projections become available.

These projections are based on a relatively high oil price environment compared with previous projections and are similar to reference projections from other sources. The baseline price assumptions for the EU27 are the result of world energy modelling (using the

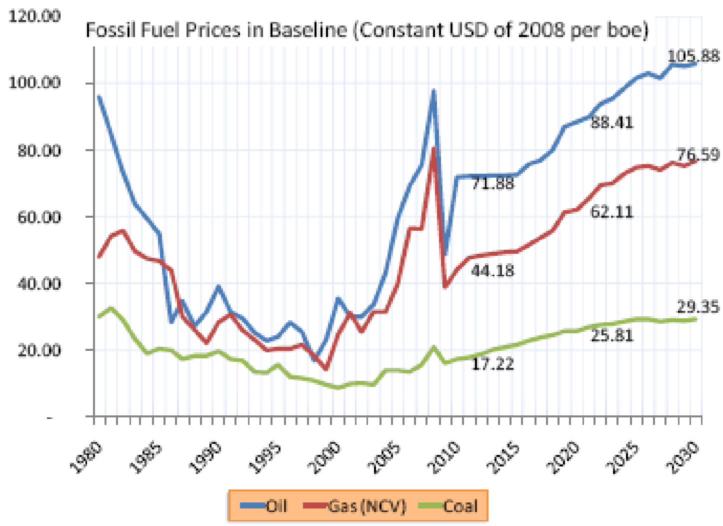
8 E.g. U-value of a roof [W/m²K]

9 Source: EU Energy Trends to 2030; update 2009. European Union, 2010 http://ec.europa.eu/energy/observatory/trends_2030/doc/trends_to_2030_update_2009.pdf

PROMETHEUS stochastic world energy model) that derives price trajectories for oil, gas and coal under a conventional wisdom view of the development of the world energy system.

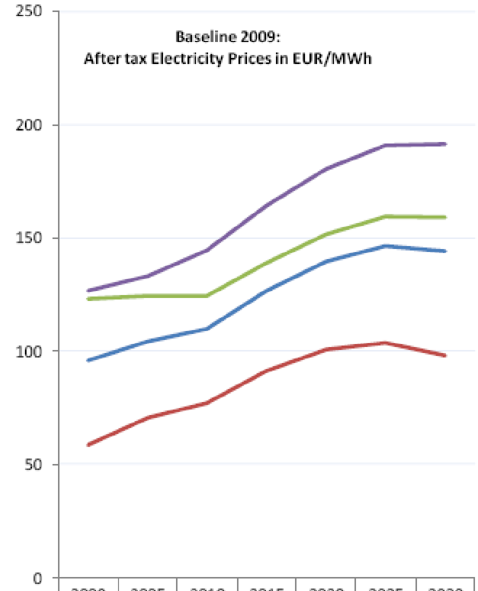
International fuel prices are projected to grow over the projection period with oil prices reaching 88$'08/bbl (73 €'08/bbl) in 2020 and 106$'08/bbl (91 €'08/bbl) in 2030. Gas prices follow a trajectory similar to oil prices reaching 62$'08/boe (51 €'08/boe) in 2020 and 77$'08/boe (66 €'08/boe) in 2030 while coal prices increase during the economic recovery period to reach almost 26$'08/boe (21 €'08/boe) in 2020 but then stabilize at 29$'08/boe (25 €'08/boe) in 2030.2

The Figure below shows the development of fossil fuel prices in the Baseline scenario. It shows a constant increase of prices, but the ratio between the prices is expected to stay relatively constant in future projections.



Regarding electricity, the projected changes in the EU27 power sector will have significant impacts on energy costs and electricity prices. Total cumulative investment expenditure for power generation in the period 2006-2030 is projected to reach 1.1 trillion €'08 with electricity prices increasing substantially both relative to present levels and in comparison to the 2007 Baseline. Auction payments and increasing fuel prices and higher capital costs (for renewable energy and CCS) are among the factors explaining the electricity price rise.

The average price of electricity, net of auction payments, increases to 108.4€/MWh in 2020 and 112.1€/MWh in 2030 (in real terms, i.e. in money of 2005), a consistent rise compared to current values due to higher capital and O&M costs, and higher fuel and variable costs. The auction payments account for 9.4% of the average pre-tax electricity price.



	2000	2005	2010	2015	2020	2025	2030
Average	96	104	110	127	140	146	144
Industry	59	71	77	92	101	104	98
Services	123	124	124	139	152	159	159
Households	127	133	144	164	180	191	192

It is recommended that for residential buildings the households price predictions are used, whereas for non-residential buildings the commercial prices might be more appropriate.

Member States can also develop the assumed energy prices for the calculation period from current cost levels, as for example provided by EUROSTAT. The information from EUROSTAT differentiates prices for domestic and industrial use, depending on delivered volume. Accordingly, different price levels need to be taken into account for the reference buildings described in chapter 3.

Other energy carriers can be coupled to these assumed developments (e.g. natural gas being linked to the oil price) or can be derived from other national or international forecasts. As the prices of many energy carriers are subject to a strong national, regional or even local influence, such as biomass, district heating and geothermal, these forecasts should take into account expected longer-term political as well as economic developments. For example, regarding district heating, possible effects from necessary changes in the infrastructure (size of district heating systems, energy delivered per m of grid etc.) should be taken into account.

On heating oil:

Heating oil is a low viscosity, flammable liquid used in building furnaces and boilers. As a distillate product of crude oil, the price of heating oil is intrinsically linked with the crude oil price. Moreover, other factors, such as supply and demand, seasonal influences, the dollar-Euro exchange rate and logistical costs, influence the price of heating oil.

Example: Estimates from the United Kingdom[10] indicate that heating oil price is around a quarter above the Brent crude price but this will be different in different Member States.

The efficiency of electricity production depends on the types of primary fuels consumed and the specific equipment that is used. These characteristics are unique to specific power plants

10 See http://heating-oil.blogs-uk.co.uk/

and differ across Member States. For example, some countries have a higher percentage of hydroelectric power, while others consume greater quantities of coal or use significant amounts of nuclear energy. Member States will have to adopt conversion factors to convert the electricity used in the reference buildings into primary energy.