IV

*(Notices)*

# NOTICES FROM EUROPEAN UNION INSTITUTIONS, BODIES, OFFICES AND AGENCIES

# EUROPEAN COMMISSION

## Guidelines accompanying 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

(2012/C 115/01)

**TABLE OF CONTENTS**

## 1. **OBJECTIVES AND SCOPE**

In accordance with Article 5 of, and Annex III to, Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings ([1]), the Commission Delegated Regulation (EU) No 244/2012 ([2]) supplements 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 (hereinafter 'the Regulation').

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 of minimum energy performance requirements. Annex III to Directive 2010/31/EU requires the Commission to provide guidelines to accompany the comparative methodology framework with the aim of enabling the Member States to take the necessary steps.

This document constitutes the guidelines as intended by Annex III to 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 for facilitating the application of the Regulation. It is the text of the Regulation which is legally binding and which is directly applicable in the Member States.

For ease of use by the Member States, this document closely follows the structure of the methodology framework as laid down in Annex I to the Regulation. The guidelines will – unlike the Regulation itself – be reviewed periodically as experience is gained with the application of the methodology framework, both by the Member States and by the Commission.

## 2. **DEFINITIONS**

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

For the purposes of the definition of *global costs*, the cost of land is excluded. However, if a Member State so wishes, 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, thus introducing a ranking of measures according to the space they occupy.

*Primary energy* for a building is the energy used to produce the energy delivered to the building. It is calculated from the delivered and exported amounts of energy carriers, using primary energy conversion factors. Primary energy includes non-renewable energy and renewable energy. If both are taken into account it can be called total primary energy.

(1) OJ L 153, 18.6.2010, p. 13.
(2) OJ L 81, 21.3.2012, p. 18.

As part of the definition of *global costs*, a Member State may choose to introduce other external costs (such as environmental or health costs) besides carbon pricing into the calculation of the macroeconomic cost optimum.

For the purpose of the calculation of *annual costs*, the methodology as presented by the Commission does **not** include a specific category to cover the cost of capital as it was considered to be captured already by the discount rate. If a Member State wants to specifically capture the payments that occur over the entire calculation period, Member States could for example include capital costs within the category of annual costs as to ensure that they are also discounted.

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-optimal evaluation, the non-renewable part of *primary energy* is considered. It has to be noted that this does not contradict the definition of *primary energy* given in the Directive — for overall building performance, both the non-renewable part and the total quantity of primary energy related to building operation should be reported. The corresponding primary energy (conversion) factors are to be set at national level, taking into account Annex II to Directive 2006/32/EC. ([1])

*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 costs for energy uses as covered by Directive 2010/31/EU associated with all typical uses in a building. Energy used for appliances (and their cost) is therefore 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 to Directive 2010/31/EU and Annex I(1) to 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 buildings established ought to reflect as accurately as possible the actual national building stock so that the methodology can deliver representative calculation results.

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

(1) 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 of energy use).

(2) Creation of a 'virtual building' which, for each relevant parameter (see 1) includes the most commonly used materials and systems.

The choice between these options should be made on the basis of expert enquiries, statistical data availability, etc. It is possible to use different approaches for different building categories. Member States should report how the building category reference case was chosen (see also point 1.4 of reporting template as given in Annex III to the Regulation).

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:

— **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 ([2])

([1]) Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services and repealing Council Directive 93/76/EEC (OJ L 114, 27.4.2006, p. 64).

([2]) The ASIEPI project only defines the buildings' geometry and would not be sufficient for the purposes of the calculation.

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;

— Office buildings; and

— The other non-residential categories listed in Annex I(5) to Directive 2010/31/EU for which specific minimum performance requirements exist.

The Regulation gives Member States a choice to either:

— 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; or

— Define reference buildings for the other non-residential categories in a way that one reference building represents two or more categories. In this way a reduction of necessary calculations and hence administrative burden can be achieved. It might even be possible to derive all reference buildings of the non-residential sector from a basic reference building for offices.

That means that if a Member State defines office buildings in a way that these reference buildings could be applicable to all other non-residential building categories that Member State would need to define 9 reference buildings in total. If not, the number of reference buildings would obviously be higher.

**To note**: In accordance with Annex III to Directive 2010/31/EU and Annex I(1) to the Regulation, Member States are *not* obliged to establish subcategories, but only to establish reference buildings. However, dividing a building category into subcategories can be an intermediate step in determining the most representative reference buildings.

Different building stocks might require different categorisation. In one country, differentiation based on construction materials might be most appropriate, while in another country this may be 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.

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

| | |
|---|---|
| *Age* | This criterion might make sense in a country where so far the existing building stock has not undergone refurbishment and hence the original age of the building still constitutes a good proxy for the energy 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.<br><br>It is recommended that if this is the case the reference buildings should be representative of the specific climate zones or regions and that the energy consumption of the reference buildings should be calculated for each climate zone.<br><br>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, if this distinction is made in the national building regulation. Heating degree days are available from EUROSTAT. It is recommended that where appropriate, cooling degree days should also be 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 surfaces, the orientation of a building as well as shading (from nearby buildings or trees) can have a significant influence on energy demand. 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 criterion is considered in the national minimum requirements.<br><br>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 or full glass façade vs. partly glass facade) if reasonable shares of both are found in a specific country. |
| *Heritage protected buildings* | Member States who have not excluded heritage protected buildings (Article 4(2) of Directive 2010/31/EU) might wish to establish subcategories that reflect the characteristics of typically protected buildings. |

As a general rule 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 the administrative burden resulting from the calculation exercise and 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.

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

In accordance with Annex III to Directive 2010/31/EU and Annex I(2) to the Regulation, Member States must define energy efficiency measures to be applied to the established reference buildings. Measures that are submitted to the calculation will have to cover the technologies listed under Article 6 of Directive 2010/31/EU and repeated under Article 7 (last paragraph), namely decentralised supply, cogeneration, district heating and cooling and heat pumps. In accordance with paragraph 3 of Annex I(2) to the Regulation, Member States must also include measures based on renewable energy sources in the calculation exercise. It should be noted that RES-based solutions might not solely linked be to achieving the nearly zero energy target.

Moreover, 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 be 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. Variants are defined for the purpose of the delegated act as a "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".

Whilst it might therefore be difficult to exactly draw the line between a package of measures and a variant, it is clear that the variant refers to complete sets of solutions needed to fulfil existing high performance buildings etc. Variants to be considered can include well-established concepts that are used to construct e.g. a certified Eco-labelled building, a Passive house, a 3-litre house or any other set of measures that has been established to achieve very high energy efficiency. It should however be noted that the purpose of the cost optimal methodology is to ensure a fair competition between different technologies and is not confined to calculating the global cost of already established and proven packages/variants.

Within a package/variant 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/variants are used (and variations of the measures included in the assessed package), the more accurate the calculated optimum of the achievable performance will be.

The determination of the finally selected packages/variants will probably be an iterative process in which a first calculation of selected packages/variants reveals the need to add further packages to allow finding out where exactly sudden "jumps" in global costs occur and why these occur. Hence it might be necessary to define an additional package to find out which technology is responsible for the higher global cost.

To describe each package/variant, information on energy performance is needed. 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 should not predetermine the outcome. Thus Member States should try to avoid establishing rules whereby a measure on the building envelope is always applied first and only then is a measure on a building system 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.

Against the background of Article 9 of Directive 2010/31/EU and its definition of a nearly zero-energy building, which covers both energy efficiency and also renewable energy sources, it will be necessary to also consider measures based on renewable energy sources for the calculation exercise. These measures will in particular be necessary in future 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.

The list below aims only to provide an indication of the possible measures to be considered.

Building structure:

— Total wall construction of new buildings or additional insulation system of existing walls [1].

— 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 (being different from the reference building's construction) or additional insulation system of existing floor construction.

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

— 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 and films applied to windows).

— Better air tightness (maximum air tightness corresponding to the state of technology).

— Building orientation and solar exposure (can constitute a measure for new buildings only).

— Change of share transparent/opaque surfaces (glazed area to facade area ratio optimisation).

— Openings for night ventilation (cross or stack ventilation).

Systems:

— 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 utilisation from daylighting.

— Active lighting system.

— Installation or improvement of PV systems.

— Change of energy carrier for a system.

— Change of pumps and fans.

— 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.

— Alternative systems such as the ones listed in Article 6 of 2010/31/EU including decentralised supply systems, district heating and cooling cogeneration, etc.

Established variants:

— Existing packages/variants such as national Eco-labels and other established low-energy or nearly zero-energy buildings such as e.g. passive house.

It is important to underline that existing variants should not be taken for granted as the only cost-optimal solution even if they have been cost-efficient or even cost optimal so far.

### 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 to several reference buildings can quickly result in thousands of calculations. However, test runs performed for the Commission did reveal that the number calculated and applied to each reference building should certainly **not be lower than 10 packages/variants** plus the reference case.

Various techniques can be used 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, 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 paragraph 6 of Annex I(2) to the Regulation, the measures used for the calculation exercise must meet the basic requirements for construction products (Regulation (EU) No 305/2011) and for indoor air comfort 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 calculation exercise and requirement setting.

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. The main reference for this is Annex I to Directive 2010/31/EU which applies fully also to the cost-optimal framework methodology.

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 their 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. (definition different from the one used in Directive 2010/31/EU).

— **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) to the Regulation, the calculation of energy performance involves first the calculation of final energy needs for heating and cooling, then the final energy needs for all energy uses, and thirdly the primary energy use. That means that the 'direction' of the calculation is 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.

For the purpose of the cost optimal methodology, on-site energy production using locally available renewable energy sources is not considered part of delivered energy which implies a need for modification of the proposed system boundary in EN 15603:2008.

Under the cost optimal methodology, the modified system boundary allows expressing all energy uses with a single primary energy indicator. As a result, the RES-based active technologies enter into direct competition with demand-side solutions, which is in line with the purpose and intention of the cost optimal calculation to identify the solution that represents the least global costs without discriminating against or favouring a certain technology.

This would lead to a situation where certain RES-based measures show better cost efficiency than some energy demand reduction measures, whilst the general picture should still be that measures reducing energy demand will be more cost effective than measures adding RES-based supply. Thus, the overall spirit of the EPBD (i.e. reduce energy use first) would not be compromised and the nearly zero-energy definition (i.e. a building with a very high energy performance and the nearly zero or very low amount of energy still needed to be covered to a large extent by renewables) is complied with.

If a Member State would want to clearly avoid the risk that active RES installations replace energy demand reduction measures, the calculation of cost optimality could be done in steps gradually expanding the system boundary to the four levels given in Figure 1 below: energy need, energy use, delivered energy and primary energy. With this, it will become clear how each measure/package of measures contributes to the buildings energy supply in terms of costs and energy.

Delivered energy includes 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 buildings technical system.

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

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

(1) Calculation of the building's **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) ([1]);

(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 with the delivered energy, using national conversion factors;

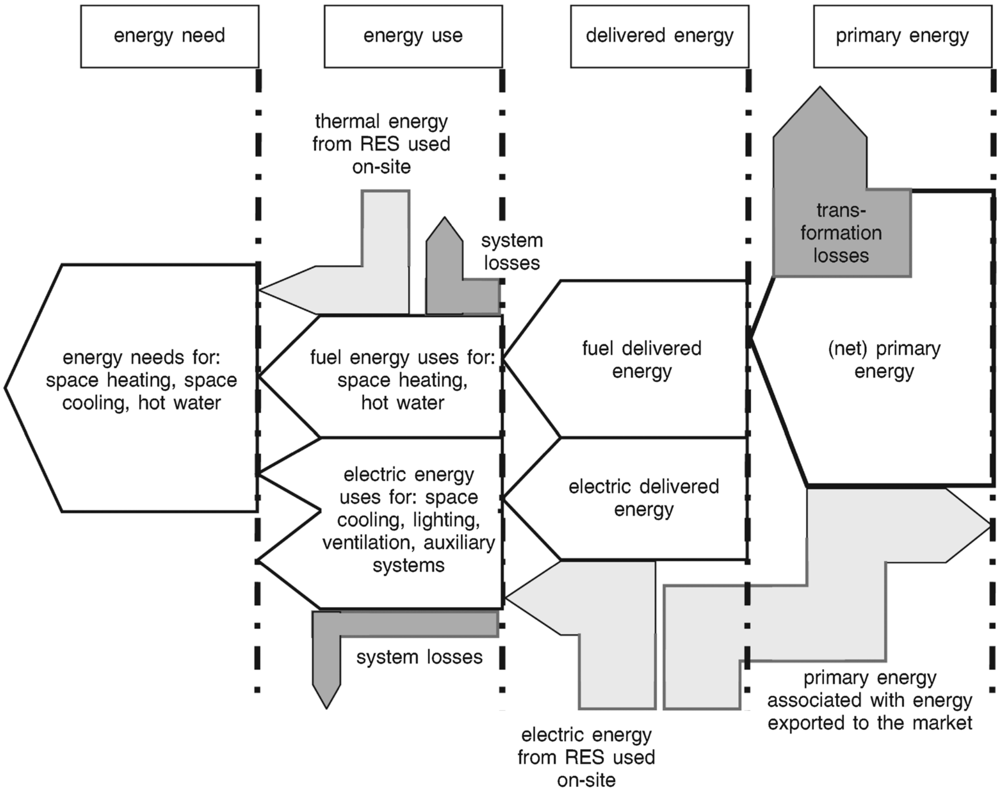
(7) Calculation of primary energy associated with **energy exported to the market** (e.g. generated by RES or co-generators on-site);

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

([1]) Please note that soon a methodology on the accounting of energy from heat pumps will be made available by the Commission under the framework of Directive 2009/28/EC of the European Parliament and of the Council (OJ L 140, 5.6.2009, p. 16).

*Figure 1*

**Schematic illustration of the calculation scheme**




**In order to achieve reliable results it is recommended to:**

— Clearly define the calculation methodology, also in relation to national laws and regulations;

— 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, namely:

— Three 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.

— Two different ways of dealing with interactions between a building and its systems:

  — Holistic approach (the effect of all heat gains associated with a 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, to achieve reliable results it is recommended to:

— Perform the calculations using a dynamic method;

— Define boundary conditions and reference use patterns in conformity with the calculation procedures, unified for all series of calculation for a particular reference building;

— Provide the source of the weather data used;

— 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;

— Verify with dynamic simulations the impact of day-lighting strategies (using natural light);

— Show the electric energy use for appliances.

For calculating **energy use** for space heating, hot water and space cooling, as well as the energy generation (thermal and electrical) from RES, it is necessary to characterise the seasonal efficiencies of systems or to 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.

District heating and cooling and decentralised energy supply can be dealt with in a similar fashion as can electricity supplied from outside the system boundary, which would hence be attributed a specific primary energy factor. The establishment of these primary energy factors are outside the scope of the present cost optimal guidance document and would have to be determined separately.

To calculate **primary energy**, the most recent national conversion factors should be used, also taking into account Annex II to Directive 2006/32/EC ([1]). These will have to be reported to the Commission as part of the reporting referred to in Article 5 of Directive 2010/31/EU and Article 6 of the Regulation.

**Calculation example:**

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

— 20 kWh/($m^2$ a) for space heating;

— 5 kWh/($m^2$ a) for hot water;

— 35 kWh/($m^2$ a) for space cooling;

and with the following annual energy uses:

— 7 kWh/($m^2$ a) electricity for ventilation;

— 10 kWh/($m^2$ a) electricity for lighting.

The building has a gas boiler for heating (space heating and hot water) with a total seasonal efficiency of 80 %. In summer, a mechanical cooling system is used: the seasonal efficiency of the entire cooling system (generation, distribution, emission, control) is 175 %. Installed solar collectors provide thermal energy for hot water of 3 kWh/($m^2$ a) and a solar PV system provides 15 kWh/($m^2$ a), of which 6 are utilised 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/($m^2$ a): 20/0,80;

— fuel energy use for hot water is 2,5 kWh/($m^2$ a): (5 - 3)/0,80;

— electric energy use for space cooling results in 20 kWh/($m^2$ a): 35/1,75;

— delivered fuel energy is 27,5 kWh/($m^2$ a): 25 + 2,5;

— delivered electric energy is 31 kWh/($m^2$ a): 7 + 10 + 20 - 6;

— primary energy is 105 kWh/($m^2$ a): 27,5 + (31/0,4);

— primary energy associated with energy exported to the market is 22,5 kWh/($m^2$ a): 9/0,4;

— net primary energy is 82,5 kWh/($m^2$ a): 105 – 22,5.

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

In accordance with Annex III to Directive 2010/31/EU and Annex I(4) to 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 sum of annual costs for every year and the final value as well as disposal costs if appropriate, all with reference to the starting year. For the calculation of the macroeconomic cost optimum, the category of global costs is to be expanded by a new category, the cost of greenhouse gas emissions defined as the monetary value of environmental damage caused by $CO_2$ emissions related to the energy consumption in a building.

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.

([1]) A proposal for a revised ESD Directive was presented by the Commission on 22 June 2011 (COM 2011(370) final. The conversion factors are to be found in Annex IV to the proposal.

The advantage of the global cost method is that it allows the use of 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 make use of lifecycle costing (LCC) which is also based on net present value calculations.

The term ‘global costs’ is taken from standard EN 15459 and corresponds to what generally in the literature is called 'lifecycle cost analysis'.

It should be noted that the global cost methodology as prescribed in the Regulation does not include costs other than energy (e.g. water costs) as it follows the scope of Directive 2010/31/EU. The global cost concept is also not fully in line with a complete life cycle assessment (LCA) that would take into account all environmental impacts throughout the lifecycle including so-called 'grey' energy. Member States are however free to extend the methodology towards full life cycle costing and might consider for this purpose also EN ISO 14040, 14044 and 14025.

### 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) and the cost optimal level is not calculated for each case, but for developing generally applicable regulations at national level. 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 to determining the reference buildings, Member States can ensure that the requirements in place are appropriate for the majority of buildings.

Whilst one should keep in mind the specific situation of rented buildings, for example regarding the split incentives problem or situations where the rent is fixed and cannot be increased beyond a certain limit (e.g. for social policy reasons), 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.

However, there might be certain groups of investors who will not be able to take full advantage from a full cost optimal investment. This issue, often called the 'owner-tenant dilemma', will need to be addressed by Member States as part of wider energy efficiency and social policy objectives and not within the cost optimal methodology. The calculation exercise can however provide Member States’ authorities with the information on the financial gap that exists for certain investor groups and hence can inform policies. For example, the difference between the cost optimum at macroeconomic level and the cost optimum at financial level might give hints regarding the necessary funding and financial support that might still be needed to make energy efficiency investments economically interesting for the investor.

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 costs and benefits of the investment decision (i.e. financial perspective), or does one also look at other indirect costs and benefits (often called externalities) that are triggered by an energy efficiency investment and that apply to other market actors than the investor (macroeconomic perspective)? Both of these perspectives have a specific rationale and inform on different issues.

The purpose of the calculation exercise at macroeconomic level is to prepare and inform the setting of generally applicable minimum energy performance requirements, and encompass a broader public good perspective where the investment in energy efficiency and its associated costs and benefits are assessed against policy alternatives and where externalities are factored in. As such, the investment into energy efficiency in buildings is compared against other policy measures that reduce energy use, energy dependency and $CO_2$ emissions. 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.

However, in practice it will not be possible to capture all societal direct and indirect benefits, as some are intangible or non-quantifiable, or cannot be monetised. Nevertheless, some external benefits and costs have recognised quantification and costing approaches that allow them to be captured.

On the other hand, the microeconomic perspective will show the limitations to the investor when e.g. stricter energy efficiency requirements might be desirable from a societal point of view, but are not cost effective for the investor.

The Regulation requires Member States to calculate cost optimality once at macroeconomic level (excluding all applicable taxes (such as VAT), and all applicable subsidies and incentives, but including carbon costs) and once at financial level (taking into account prices as paid by the end consumer including taxes and if applicable subsidies, but excluding the additional greenhouse gas abatement costs).

**To note:** Once both calculations are performed, it is up to the Member States to decide which of the calculations is to be used as the national cost optimal benchmark.

As for the calculation of the cost optimum at macroeconomic level, the Regulation requires the consideration of greenhouse gas emissions costs by taking the sum of the annual greenhouse gas emissions multiplied by the expected prices per ton $CO_2$ equivalent of greenhouse gas emission allowances issued in every year, using initially as a minimum lower bound at least 20 Euro per ton of $CO_2$ equivalent until 2025, 35 Euro until 2030 and 50 Euro beyond 2030 in line with current Commission projected ETS carbon price scenarios measured in real and constant prices for 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. Member States are free to assume higher carbon costs than these minimum levels, such as the one suggested 0,03-0,04 Euro per kg provided in Directive 2009/33/EC ([1]), Annex, Table 2.

Finally, Member States are free to expand the category of costs greenhouse gas emissions from capturing only $CO_2$ emissions to covering a wider range of environmental pollutants again in line with Directive 2009/33/EC Annex Table 2 as given below:

The present value of the minimum environmental costs per unit of emissions to be used in calculations of the environmental costs:

| $NO_x$ | NMHC | PM |
|---|---|---|
| 0,0044 EUR/g | 0,001 EUR/g | 0,087 EUR/g |

It has to be noted that, for the financial perspective calculation, the inclusion of available support schemes (along with taxes and all available subsidies) would usually be required to reflect the real financial situation. However, given that such schemes often change quickly it is also possible for a Member State to calculate without subsidies for a private investor point of view.

Moreover at financial level, the calculation may be simplified by fully excluding VAT from all cost categories of the global cost calculation, if in that Member State no VAT-based subsidies and support measures exist. A Member State 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 include the support measures into the calculation.

### 6.2. **Cost categorisation**

Under Annex I(4) to the Regulation, Member States are required to use the following basic cost categories: Initial investment costs, running costs (including energy costs and periodic replacement costs) and, if appropriate, disposal costs. In addition, the cost of greenhouse gas emissions is included for the calculation at macroeconomic level.

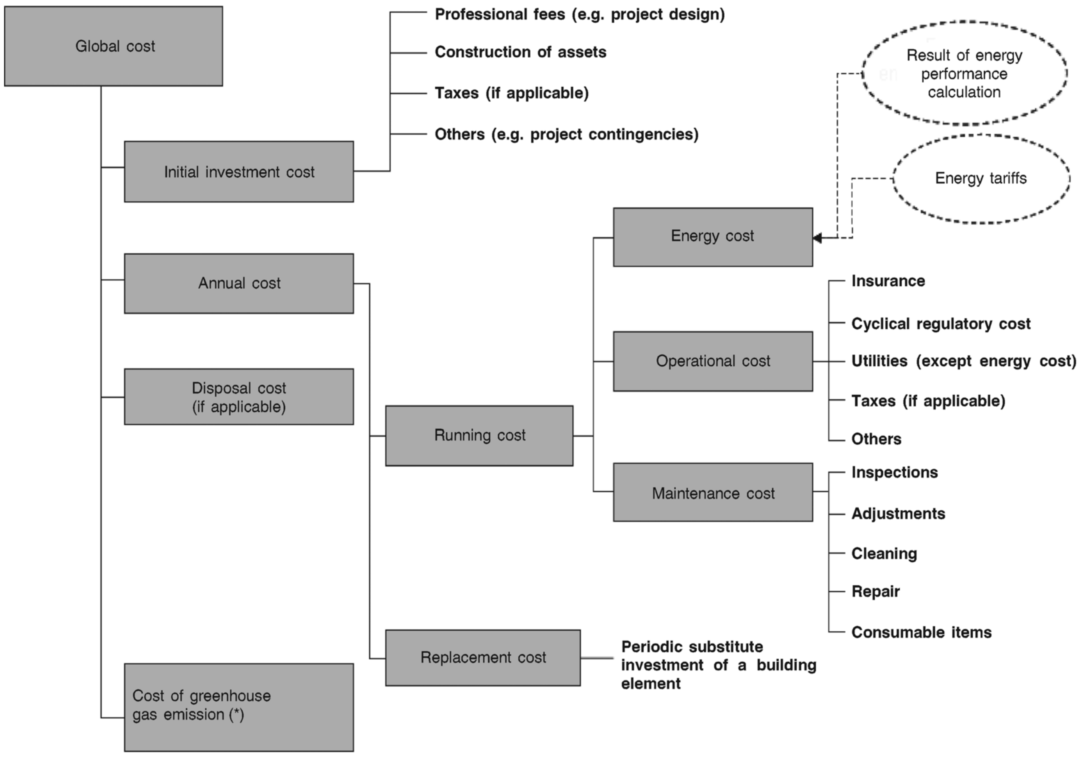
Due to their importance in the given context, energy costs are listed as a separate cost category although usually they are seen as part of the operational cost. Furthermore, replacement cost is not seen as part of maintenance cost (as is sometimes the case in other cost structures) but as a separate 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 lifecycle cost assessment (compare standard ISO 15686-5:2008 on Buildings and constructed assets - Service-life planning - Part 5 Lifecycle costing). The following illustration summarises the cost categories to be applied.

([1]) Directive 2009/33/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of clean and energy-efficient road transport vehicles (OJ L 120, 15.5.2009, p. 5).

*Figure 2*

**Cost categorisation according to the framework methodology**




(*) For calculation at macroeconomic level only

It has to be stressed that the enumeration of cost categories given in the Regulation is comprehensive. Nevertheless, if other cost categories are considered important in the context of the calculation of cost-optimal levels of minimum requirements (such as costs related to other environmental pollutants), they can also be taken into account (for more details, please see Chapter 6.1.).

Moreover, the cost of the capital needed to finance energy efficiency investments is not included as a separate category in the Regulation. However, Member States may include it, for example within the category of annual costs to ensure that they are also discounted.

Energy costs are based on consumption, size of the building, current rates and price predictions, and are directly linked to the result of the energy performance calculation. This means that 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 costs have 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 operational and maintenance costs are often more difficult to estimate than other expenditures since operating schedules vary from building to building. There is a great variation even among buildings of the same category. Some data gathering and screening might therefore be needed 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 applied to a reference building, the full cost of construction (or major renovation) and the subsequent use of the building should be calculated. However, since the focus of the exercise is the comparison of measures/packages/variants (and not the assessment of total costs for the investor and building user), the following cost items may be omitted from the calculation:

— Costs related to building elements which do not have an influence on the energy performance of the building, for example: cost of floor covering, cost of 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 of staircases, cost of lifts, etc. – if these cost elements are the same for all measures/packages/variants assessed;

  — For major renovation: cost of scaffolding, demolition cost, etc. – once again under the precondition that no differences 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 ([1]). For calculating 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 cannot 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 package of measures related to night cooling, etc. The additional cost calculation approach makes it difficult to show 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 calculation confusing and non-transparent;

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

6.3. **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 for the investment costs, running costs, energy costs and if applicable disposal costs. 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 ([2]) or OSCAR ([3]), which are commonly used for rough estimates of the investment and operating cost of buildings, cannot 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.

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

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

([3]) Jones Lang LaSalle: Büronebenkostenanalyse OSCAR 2008, Berlin, 2009. Can be ordered from www.joneslanglasalle.de.

### 6.4. **The discount rate**

The discount rate is expressed in real terms, hence excluding inflation.

The discount rate used in the macroeconomic and financial calculation is to be established by the Member State after performing a sensitivity analysis on at least two rates for each calculation. The sensitivity analysis for the macroeconomic calculation shall use one rate of 4 % expressed in real terms. This is in line with the current Commission's 2009 Impact Assessment guidelines, which suggests 4 % as societal discount rate [1].

A higher discount rate – typically higher than 4 % excluding inflation 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 % to 4 % excluding inflation – will more closely reflect the benefits that energy efficiency investments bring to building occupants over the entire investment's lifetime. The discount rate will be different from Member State to Member State as it reflects to a certain extent not only policy priorities (for the macroeconomic calculation), but also different financing environments and mortgage conditions.

To make the discount rate applicable, usually a discount factor will have to be derived that can 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:

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

Where;

p is the number of years from the starting period; and

r is the real discount rate.

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.

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

The listing below is not necessarily comprehensive or up-to-date and is intended purely as an indication of elements to be taken into account:

| *For the building envelope* | |
|---|---|
| **Insulation of building envelope:**<br><br>— Insulation products<br><br>— Additional products for application of the insulation to the building envelope (mechanical fixings, adhesive, etc.)<br><br>— Design costs<br><br>— Installation costs of insulation (including water vapour barriers, weather membranes, measures to ensure air-tightness and measures to reduce the effects of thermal bridges)<br><br>— Energy-related costs of other building materials, if applicable | **Windows and doors:**<br><br>— Glazing and/or glazing enhancement<br><br>— Frame<br><br>— Gaskets and sealants<br><br>— Installation costs<br><br>The technical systems, products and building elements 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). |

[1] http://ec.europa.eu/governance/impact/commission_guidelines/docs/ia_guidelines_annexes_en.pdf. The US Department of Energy Federal Energy Management Program 2010 edition of energy price indices and discount factors for performing life-cycle cost analysis which suggests 3 %. http://www1.eere.energy.gov/femp/pdfs/ashb10.pdf.

| | |
|---|---|
| — 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.<br><br>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 elements. | |
| ***For building systems*** | |
| **Space heating:**<br><br>— Generation and storage equipment (boiler, storage tank heat generation controls)<br><br>— Distribution (circulator, circuit valves, distribution controls)<br><br>— Emitters (radiators, ceiling floor heating, fan coils, emission controls)<br><br>— Design costs<br><br>— Installation costs<br><br>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<br><br>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:**<br><br>— Generation and storage (including solar thermal systems, boiler, storage tank, heat generation controls)<br><br>— Distribution (circulator, circuit valves/mixing valves, distribution controls)<br><br>— Emitters (tap valves, floor heating, emission controls)<br><br>— Design costs<br><br>— Installation (including insulation of the system and pipes)<br><br>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:**<br><br>Concerning investments, the costs of mechanical ventilation systems are to be assessed. Possibilities for natural ventilation are covered with the definition of reference buildings.<br><br>Investment costs should include:<br><br>— Heat generation and recovery equipment (heat exchanger, pre-heater, heat recovery unit, heat generation controls)<br><br>— Distribution (fans, circulators, valves, filters, distribution controls)<br><br>— Emitters (ducts, outlets, emission controls)<br><br>— Design costs<br><br>— Installation costs | **Cooling:**<br><br>As a comfortable indoor temperature needs to be ensured, passive or active cooling 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) or covered in the category 'thermal insulation' (e.g. insulation of roofs to reduce cooling demand) or the category 'Other building-related measures with impact on thermal performance' (e.g. external shading). Investment costs of active cooling systems include: |

| | |
|---|---|
| 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 requirements for ventilation. | — Generation and storage equipment (generator, heat pump, storage tank, heat generation controls)<br>— Distribution (circulator, circuit valves, distribution controls)<br>— Emitters (ceiling/floor/beams; fan coils, emission controls)<br>— Design cost<br>— Installation<br>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:**<br>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:<br>— Type of light sources and luminaires<br>— Associated control systems<br>— Applications to increase use of daylight<br>— Installation<br>EN 12464 'Light and lighting - lighting of work-places - 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. | **Building automation and control:**<br>Investment costs should include:<br>— Building management systems which introduce supervising functions (separate system controls are accounted for within the specific system)<br>— Technical intelligence, central controller<br>— Controls (generation, distribution, emitters, circulators)<br>— Actuators (generation, distribution, emitters)<br>— Communication (wires, transmitters)<br>— Design costs<br>— Installation and programming costs<br>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):**<br>Investment costs should include:<br>— Costs for first connection to the energy network (e.g. district heat, PV-system)<br>— Storage tanks for combustion fuels<br>— Necessary related installations | **Decentralised energy supply systems based on energy from renewable sources:**<br>Investment costs should include:<br>— Generation<br>— Distribution<br>— Control devices<br>— 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 costs, periodic replacement refers to the necessary substitution of a whole building element as a result of ageing, and is therefore treated as a separate cost category.

The point in time of periodic replacement depends on the lifetime of the building element. At the end of that lifetime a replacement has to be provided for 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 at the beginning as initial investment cost and again as replacement cost after 15 years.

It is up to Member States to determine the estimated economic lifetime of building elements 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 of the building elements used for the calculation must be plausible. In general the replacement cost will be the same as the initial investment cost (in real terms!). However, where major price developments may be expected over the next 10-15 years, the Regulation allows and also encourages the adaptation of the level of replacement cost to take into account the expected price developments when technologies ripen.

## 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 buildings and building elements. 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 the reference building's remaining lifecycle is shorter 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 major refurbishment, including improvement of the building as a whole and 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 in the delegated act) 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. 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**

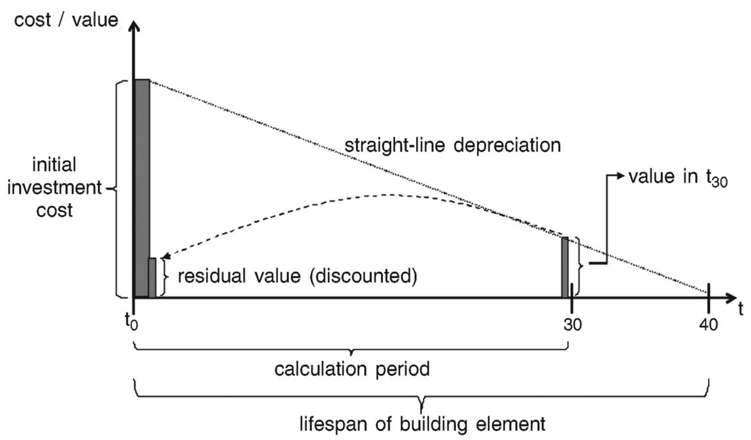
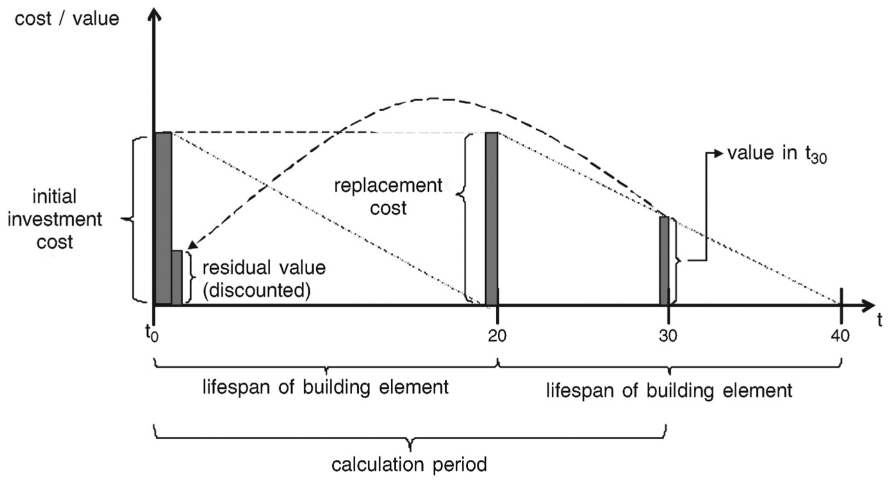



*Figure 4* shows how the residual value has to be calculated for a building element which has a shorter lifespan than the calculation period (e.g. heating boiler). With an assumed lifespan of 20 years the element has to be replaced after that period of time. Once the element has been renewed a new depreciation 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 such data are already available). However, it is possible for Member States to base the calculation on the starting year (year of calculation, say 2012 for the first exercise), but use as a reference for the minimum energy performance requirement those 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 including the residual value in the global cost calculation. The residual value of a 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 any 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.

Experiences have shown that prices of new technologies can quickly decrease when the market takes them up, as was the case with new and more efficient boilers or double glazing. Given that most investments occur only at year 1, future decreases in technology prices will not have a huge impact on the cost calculations. Nevertheless, it will be very important to consider such price decreases during a review and update of the input data for the next calculation exercise. Member States might also include an innovation or adaptation factor into their calculation that ensures that the dynamic evolution of costs over time is taken into account.

With respect to the development of costs for energy carriers and carbon costs over time, Annex II to the Regulation provides information that Member States can use for their calculations, although Member States are 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 have 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 costs there is the possibility of adapting the initial investment cost (which serves as a basis for fixing the replacement cost) for selected building elements if major technological development is expected during the upcoming years.

*Example*: The replacement cost for a photovoltaic system can be assumed to be lower than the initial investment cost since major cost reduction is expected due to technological progress. The same might be true for other RES technologies, building automation, new generation boilers, etc.

### 6.12. **Calculation of energy cost**

Energy costs shall reflect both the cost of necessary capacity and necessary energy. Moreover, if possible, energy costs should be based on a weighted average of the basic (variable cost) and peak load (normally fixed cost) tariffs paid by the final customer including all costs, taxes and profit margins of the supplier. All energy uses covered by Annex I to Directive 2010/31/EU are to be considered.

### 6.13. **Treatment of taxation, subsidies and feed-in tariffs in the cost calculation**

Inclusion of all applicable taxes (VAT and others), support schemes and incentives is necessary for the calculation of the cost optimum at financial level, while they are not considered for the calculation at macroeconomic level. This refers in particular but not exclusively 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 energy produced from renewable energy sources.

Whereas the Regulation obliges Member States to consider the taxes paid by customers for the financial level cost calculation, it allows Member States to exclude subsidies and incentives, since these might change very quickly. Therefore, the applicable incentives and subsidies cannot be taken into account for the entire period the cost optimal calculation is supposed to be the national benchmark. Moreover, reviewing the benchmarks every time a change in subsidies or incentives occurs will also not be possible. To avoid a perpetuation of the subsidy scheme that is currently in force, a Member State might find it helpful to also calculate the real private costs without subsidies to identify the difference and thus steer future subsidy policies.

When Member States leave out subsidies from the calculation at financial level, they should ensure that not only subsidies and support schemes for technologies, but also possibly existing subsidies for energy prices are taken out.

### 6.14. **Inclusion of earnings from energy production**

If a Member State wishes to include in the calculation the earnings from renewable energy produced "where applicable" (as per Annex III to Directive 2010/31/EU), it should endeavour to include *all* available subsidies and support schemes (for both electricity and thermal, and also 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.

Earnings from energy produced might be deducted from the category of annual costs. The option to include earnings from energy produced would naturally result in the inclusion of all other taxes, fees and subsidies in order to complete the financial perspective for which it is best suited.

### 6.15. **Calculation of disposal costs**

According to the Regulation the inclusion of disposal costs 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:

— Firstly, and most commonly, through 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 costs and – even more importantly – 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 the 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 house versus solid construction) and on the type of use on the other (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.

— Secondly, disposal costs may be introduced in connection with replacement costs, since the dismantling or demolition of an 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 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 an approximation based on the volume of the building, differentiated (in some cases) by construction type.

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

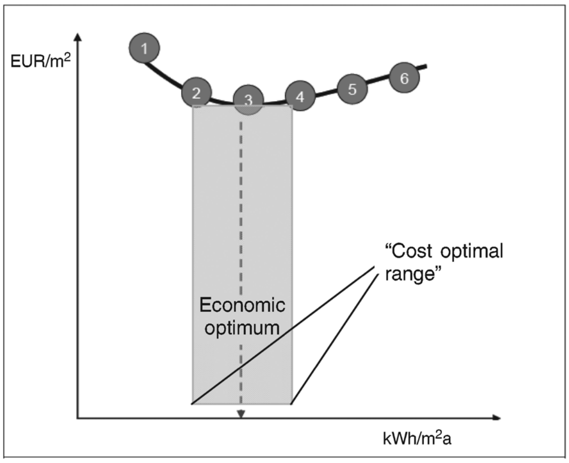
## 7. DERIVATION OF A COST-OPTIMAL LEVEL OF ENERGY PERFORMANCE FOR EACH REFERENCE BUILDING

### 7.1. **Identification of the cost-optimal range**

Based on the calculations of primary energy use (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 use (x-axis: kWh primary energy/($m^2$ useful floor area and year)) and global costs (y-axis: EURO/$m^2$ 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** ([1])




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 paragraph 2 of Annex I(6) to 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 borne in mind that the necessary investment needs 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 building element. Graphs can then be developed to show the performance (x-axis, e.g. in $W/(m^2K)$ for building elements like the roof of a building) and global costs (y-axis, in $EURO/m^2$ 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 be taken into account).

It is important to note that minimum performance requirements for boilers and other installed appliances and equipment are being set under the framework of the Ecodesign Directive ([2]).

7.2. **Comparison with current requirements at Member State level**

The current requirements at 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.

In a second step, the difference between the current level and the identified cost-optimal level is calculated according to equation in the box below.

([1]) *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.

([2]) 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 (OJ L 285, 31.10.2009, p. 10.)

**Identification of the gap**

Gap % (reference building level) = (cost-optimal level [kWh/m$^2$a] – current minimum performance requirements [kWh/m$^2$a]) / cost-optimal level [kWh/m$^2$a]) 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 (1)] – current minimum performance requirements [unit of performance indicator]) / cost-optimal level [unit of performance indicator]) x 100 %

The difference between the calculated cost-optimal levels of minimum performance requirements and those in force should be calculated as the difference **between the average of all** the minimum energy performance requirements in force and the average of all the calculated cost optimal levels resulting from the variants applied to all the comparable reference buildings and building types used. It is up to the Member State to introduce a weighing factor representing the relative importance of one reference building (and its requirement) in a MS over another. However, such approach should be made transparent in the reporting to the Commission.

In line with recital 14 of Directive 2010/31/EU, a significant discrepancy between the outcome of the cost optimal cost calculation and the minimum requirements currently in force in a Member State exist if the latter are 15 % lower than the cost-optimum.

## 8. SENSITIVITY ANALYSIS

Sensitivity analysis is standard practice in ex-ante assessments when outcomes depend on assumptions on key parameters of which the future development can have a significant impact on the final result.

The Regulation therefore requires some sensitivity analyses to be undertaken by the Member States. The Regulation requires Member States to perform at least a sensitivity analysis on different price scenarios for all energy carriers of relevance in a national context, plus at least two scenarios each for the discount rates to be used for the macroeconomic and financial cost optimum calculations.

For the sensitivity analysis on the discount rate for the macroeconomic calculation, one of the discount rates shall be set at 3 % expressed in real terms (2). Member States have to determine the most appropriate discount rate for each calculation once the sensitivity assessment is performed. This is the one to be used for the cost-optimal calculation.

Member States are encouraged to perform such analysis also on other input factors such as the projected trends in future investment costs for building technologies and building elements or on any other input factor that is deemed to have significant influence on the result (e.g. primary energy factors, etc.).

Although it is true that a future price development will not impact on the upfront investment costs occurring at the start of the calculation period, the assessment on how the market uptake of technologies might influence their price level is very useful information for policy makers. In any event, such technology price developments are crucial for informing the review of the cost optimal calculations.

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 to 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.

(1) E.g. U-value of a roof [W/m$^2$K]

(2) This rate is used in the Commission's Impact Assessment Guidelines of 2009 and broadly corresponds to the average real yield on longer-term government debt in the EU over a period since the early 1980s.

The information provided in Annex II to 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 biannual 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 (1) 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 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 USD'08/bbl (73 EUR'08/bbl) in 2020 and 106 USD'08/bbl (91 EUR'08/bbl) in 2030. Gas prices follow a trajectory similar to oil prices, reaching 62 USD'08/boe (51 EUR'08/boe) in 2020 and 77 USD'08/boe (66 EUR'08/boe) in 2030, while coal prices increase during the economic recovery period to reach almost 26 USD'08/boe (21 EUR'08/boe) in 2020 but then stabilise at 29 USD'08/boe (25 EUR'08/boe) in 2030.

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 EUR'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 EUR/MWh in 2020 and 112,1 EUR/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.

*Table*

**Estimated long-term after-tax electricity price developments in EUR/MWh (baseline 2009)**

| | 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.

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

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 stemming from necessary changes in the infrastructure (size of district heating systems, energy delivered per m of grid, etc.) should be taken into account.

**Heating oil:**

Heating oil is a low viscosity, flammable liquid used in building furnaces and boilers. Being a distillate product of crude oil, its price 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 ([1]) indicate that the heating oil price is around a quarter above the Brent crude price but this will be different in other 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 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 their reference buildings into primary energy.

([1]) See http://heating-oil.blogs-uk.co.uk/