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COMMISSION NOTICE

Guidelines accompanying Commission Delegated Regulation (EU) 2025/2273 to facilitate the application of the revised methodology framework for calculating cost-optimal levels

(Text with EEA relevance)

(C/2025/6439)

Contents

1. OBJECTIVES AND SCOPE

In accordance with Article 6 of and Annex VII to Directive (EU) 2024/1275 of the European Parliament and of the Council ([1]), Commission Delegated Regulation (EU) 2025/2273 ([2]) supplements that Directive establishing and revising a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements.

The methodology set out in Commission Delegated Regulation (EU) 2025/2273 specifies how to compare energy efficiency measures, measures incorporating renewable energy sources and packages of such measures in relation to their energy and emission performance and the cost attributed to their implementation. It also sets out how to apply those measures and packages to selected reference buildings with the aim of identifying cost-optimal levels of minimum energy performance requirements.

Annex VII to Directive (EU) 2024/1275 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 referred to in Annex VII to Directive (EU) 2024/1275. While these guidelines are not legally binding, they provide relevant additional information to the Member States and reflect accepted principles for the cost calculations set out in the context of Delegated Regulation (EU) 2025/2273. As such, the guidelines are intended to facilitate the application of that Delegated Regulation. It is the text of Delegated Regulation (EU) 2025/2273 which is legally binding and which is directly applicable in the Member States.

For ease of use, these guidelines closely follow the structure of the methodology framework as laid down in Annex I to Delegated Regulation (EU) 2025/2273. These guidelines may 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 Delegated Regulation (EU) 2025/2273 might benefit from further explanation.

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 include the cost of the useful floor area that is needed to install a certain measure, thus ranking measures according to the space they occupy.

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

The method for calculating the reference floor area (defined in Article 2(52) of Directive (EU) 2024/1275) is to be defined at national level. It should be clearly reported to the Commission.

For the cost-optimal evaluation, the total primary energy is considered as the main metric (including its non-renewable and renewable parts). Primary energy for a building is the energy used to produce the energy delivered to the building. It is calculated from the amounts of delivered and exported energy carriers, using total primary energy conversion factors. The corresponding primary energy (conversion) factors are to be set at national level.

Measures may be individual measures or constitute a package of measures. In its ultimate form a package of measures will constitute a variant of a building (that is to say, 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).

([1]) Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast) (OJ L, 2024/1275, 8.5.2024, ELI: http://data.europa.eu/eli/dir/2024/1275/oj).

([2]) Commission Delegated Regulation (EU) 2025/2273 of 30 June 2025 supplementing Directive (EU) 2024/1275 of the European Parliament and of the Council as regards the establishment of a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements (OJ L, 2025/2273, 06.11.2025, ELI: http://data.europa.eu/eli/reg_del/2025/2273/oj).

Energy costs include all costs for energy uses as covered by Directive (EU) 2024/1275 associated with all typical uses in a building. Energy used for appliances (and their cost) therefore does not have to be included, although Member States are free to include it in their national application of Delegated Regulation (EU) 2025/2273.

3. **ESTABLISHMENT OF REFERENCE BUILDINGS**

In accordance with Annex VII to Directive (EU) 2024/1275 and Annex I to Delegated Regulation (EU) 2025/2273, Member States are required to define reference buildings for the cost-optimal methodology.

The main purpose of a reference building concept 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 the actual national building stock as accurately as possible 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 an envelope area/volume factor, building envelope structure with corresponding thermal transmittance (U-value), technical building systems and energy carriers together with their share of energy use);

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

The choice between those options should be made based on 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 section 1, point 4 of the reporting template in Annex III to Delegated Regulation (EU) 2025/2273).

It is up to each Member State to define the best way to categorise its building stock for the cost-optimal calculations for both renovation and new construction. Member States can refer to the previous cost-optimal report for the definition of the reference buildings, bearing in mind that some of them might need to be updated to properly take into consideration the evolution of the building stock [3].

Member States are free to use and adapt existing catalogues and databases of reference buildings for the cost-optimal calculations. Moreover, work carried out under the Intelligent Energy Europe, Horizon 2020, and Horizon Europe programmes can be used as input, in particular:

— **the EU Building Stock Observatory Database** – Providing information on reference building materials and thermal performance of building elements across Member States: https://building-stock-observatory.energy.ec.europa.eu/database/;

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

Pursuant to Delegated Regulation (EU) 2025/2273 Member States are 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:

(1) single-family buildings;

(2) apartment blocks/multi-family buildings;

(3) office buildings; and

(4) the other non-residential categories listed in Annex I, point 6, to Directive (EU) 2024/1275 for which specific minimum performance requirements exist.

(3) Further information on how Member States identified reference buildings and performed cost-optimal calculations can be found in: Zangheri, P., D'Agostino, D., Armani, R., Maduta, C., Bertoldi, P., Progress in the Cost-Optimal Methodology Implementation in Europe: Datasets Insights and Perspectives in Member States, Data, 2023, *8*(6), 100, 10.3390/data8060100; Zangheri, P., D'Agostino, D., Armani, R., Bertoldi, P., Review of the cost-optimal methodology implementation in Member States in compliance with the Energy Performance of Building Directive. Buildings 2022, 12, 1482, 10.3390/buildings12091482.

Delegated Regulation (EU) 2025/2273 gives Member States a choice to either:

— establish reference buildings (again one for new builds, two for existing buildings) 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. This would reduce the number of calculations and hence the administrative burden can be achieved. It might even be possible to derive all reference buildings for 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 they can be applied to all other non-residential building categories, that Member State would need to define nine reference buildings in total. Under Annex I, section 1, point 3, to Delegated Regulation (EU) 2025/2273 this approach must be justified with an analysis showing that a reference building that is used to serve several building categories is representative of the building stock for all the categories covered. If another approach is taken, the number of reference buildings would obviously be higher.

NB In accordance with Annex VII to Directive (EU) 2024/1275 and Annex I, section 1, to Delegated Regulation (EU) 2025/2273, Member States are not obliged to establish subcategories, but only to establish reference buildings. However, dividing a building category into subcategories may be an intermediate step in determining the most representative reference buildings.

Different building stock might require different categorisation. In one Member State, differentiation based on construction materials might be most appropriate, while in another country the age of the building may be more appropriate. It will be important to indicate clearly in the report to the Commission 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 only a limited share of the existing building stock has 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. It is recommended that, if this is the case, the reference buildings should be representative of the specific climate zones or regions and the energy consumption of the reference buildings should be calculated for each climate zone. It is recommended that climate conditions be described and used in accordance with EN ISO 15927 'Hygrothermal performance of buildings - Calculation and presentation of climatic data' applied as a country average or per climate zone, if this distinction is made in the national building regulation. Heating and cooling degree days are available from Eurostat. It is recommended that cooling degree days are also included where appropriate (specifying the base temperature and time step used for the calculation).

Location, orientation and shading	Depending on the geometries of the building and the size and distribution/ orientation of windows, 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. The typical location of the reference building(s) should also be reflected in the impacts of orientation, solar gains, shading, demand for artificial lighting, envelope airtightness, etc. In addition, the choice of technical building systems and the corresponding costs may differ significantly between rural areas and urban areas, and the cost-optimal methodology may help treat these situations separately.
Construction products for the building envelope, load carrying structures	Construction products in the building envelope contribute to the thermal performance of a building and have an impact on its energy demand . 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 building in the definition of reference buildings (for example, buildings with high thermal mass versus lightweight constructions, full glass façade versus partial glass façade, framed structures versus load-bearing wall/panel structures) if reasonable shares of both are found in a specific country.
Main equipment for heating	The type of energy system used and the energy source could also be a criterion for defining reference buildings in certain situations.
Heritage protected buildings	Member States that wish to adapt minimum energy performance requirements to heritage protected buildings (Article 5(2) of Directive (EU) 2024/1275) might 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 work and the representativeness of the building stock. If the building stock is diverse, more reference buildings will probably be required.

The approach 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. For new buildings, the reference building establishes only the basic building geometry, typical functionality and typical cost structure in the Member State, the geographical location and the indoor and outdoor climatic conditions. This should be reflected in the information reported in the relevant tables of the template set out in Annex III to Delegated Regulation (EU) 2025/2273 (Tables 3-5).

Flexibility is left to Member States on the information to be included in the reporting template [4] and on the way they report the results of calculations, as long as all relevant information is communicated. Annex III, section 1, to Delegated Regulation (EU) 2025/2273 on reference buildings, provides indications in this regard.

(4) For example, if only natural ventilation is considered in a reference building, the cells referring to ventilation systems performance can be removed or left blank in Table 3. The same applies to Table 5, where results of measures/packages/variants are reported.

Different approaches can be used depending how Member States set the calculation for new buildings. For example, in some cases, the reference buildings for new buildings in different sub-categories are differentiated only based on the heating systems, while the geometry and building envelope characteristics do not change (for example because of a prior assessment, which reduced the number of variants). In such cases, Table 3 can contain information on the geometry and building envelope only once, while the results of the different heating systems could be reported in the same table in different columns (as suggested in section 1, point 9 of Annex III to Delegated Regulation (EU) 2025/2273). If the reference building also varies in terms of building envelope characteristics, it could be useful to adopt a similar approach in Table 3. In these cases, those differences in reference buildings are not considered as measures/packages/variants, so they can be reported in Table 3 of Annex III to Delegated Regulation (EU) 2025/2273. Any additional measures/packages/variants can be reported under Tables 4 and 5 of that Annex.

Another possible approach could be to report the characteristics of a reference building for new buildings with the existing requirements in force in Table 3 of Annex III to Delegated Regulation (EU) 2025/2273 and to start from there to set the measures/packages/variants to be reported under Tables 4 and 5 of that Annex.

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 VII to Directive (EU) 2024/1275 and Annex I, point 2, to Delegated Regulation (EU) 2025/2273, Member States are to define energy efficiency measures to be applied to the established reference buildings. In accordance with section 3, point 2 of Annex I to Delegated Regulation (EU) 2025/2273, Member States should also include measures based on renewable energy sources in the calculations, also in line with the objectives and requirements set pursuant to other Directives (for example Directive (EU) 2018/2001 of the European Parliament and of the Council ([5])). Those measures may cover the technologies mentioned under recital 22 of Directive (EU) 2024/1275, such as solar thermal, geothermal, solar photovoltaics, heat pumps, hydroelectric power and biomass, but also renewable energy provided by renewable energy communities, efficient district heating and cooling, and energy from other carbon-free sources.

Moreover, measures involving one building element (meaning a technical building system or an element of the building envelope, as defined in Article 2(17) the Directive (EU) 2024/1275) can affect the energy performance of another building element. For example, the insulation level of the envelope affects the capacity and dimensions of the building systems. This interaction between different measures should be addressed when setting packages/variants.

It is therefore recommended that measures be combined into packages of measures and/or variants, since meaningful combinations of measures can create synergy effects that lead to better results than individual measures (in terms of global costs and energy performance). Variants are defined in Article 2(21) of Delegated Regulation (EU) 2025/2273.

Whilst it might therefore be difficult to draw an exact line between a package of measures and a variant, it is clear that the variant refers to a complete set of solutions needed to fulfil existing high performance buildings standards, etc. Variants could include well-established concepts that are used to construct for example a certified Eco-labelled building or Passive House, or any other set of measures that has been established to achieve very high energy efficiency. However, it should be noted that the purpose of the cost-optimal methodology is to ensure 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, cost-effective efficiency measures may be accompanied by other measures that are not yet cost-effective, but which could add substantially to primary energy and emission savings associated with the total building concept. The overall package must still provide more benefits than costs over the lifetime of the building or building element.

([5]) Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (OJ L 328, 21.12.2018, p. 82, ELI: http://data.europa.eu/eli/dir/2018/2001/oj).

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

The determination of the finally selected packages/variants will probably be an iterative process in which an initial calculation of selected packages/variants reveals the need to add further packages to find out where exactly sudden 'jumps' in global costs occur and why. 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 Delegated Regulation (EU) 2025/2273 (Annex III) provides an overview of the basic set of technical parameters necessary to perform an energy performance calculation. It is important to underline that Table 3 refers only to the reference building calculation, therefore, as mentioned in Chapter 3 of these guidelines, not all the parameters in Table 3 need to be reported for the assessed measures/packages/variants. Table 5 is where the synthetic reporting of measures/packages/variants takes place. As mentioned in Annex III to Delegated Regulation (EU) 2025/2273, reporting can be limited to the most important measures/packages, but the total number of iterations carried out should be indicated.

When Member States set their national calculation methodology, it is recommended that they ensure that the order of measures/packages/variants does 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 after that 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 considered**

Many measures could be considered as a starting point for establishing measures/packages/ variants for the calculations. 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 11 of Directive (EU) 2024/1275 and its definition of a zero-emission building ('ZEB'), it will also be necessary to consider measures based on renewable energy sources in the calculations. A ZEB is not to cause any on-site direct carbon emissions from fossil fuels and its operational greenhouse gas ('GHG') emissions is to comply with a maximum threshold established at Member State level. That is to be reflected in the cost-optimal calculations, specifically when identifying the measures for new buildings. For example, the installation of a fossil fuel boiler cannot be considered in the cost-optimal calculation for new ZEBs, not being compliant with the requirements set in Article 11 of that Directive.

Furthermore, introducing life-cycle GWP consideration will also encourage building and product requirements also based on sustainability and circularity principles, although the GWP calculation is not mandatory in the cost-optimal calculation. In line with Article 7(5), Member States are to publish and notify to the Commission, by 1 January 2027, a roadmap detailing the introduction of limit values on the total cumulative life-cycle GWP of all new buildings and set targets for new buildings from 2030, considering a progressive downward trend. This might have an influence on the way reference buildings for new buildings and consequent measures/packages/variants are identified in the cost-optimal calculation. In other words, the reference buildings and consequent measures/packages/variants should ideally be consistent with the level of ambition of the limit values and targets of the life-cycle GWP.

New requirements will need to be reflected in the technology packages and measures assessed in the cost-optimal calculations, for example in terms of solar energy deployment (Article 10 of Directive (EU) 2024/1275) and indoor environmental quality (entailing both indoor winter and summer thermal comfort ([6]) and indoor air quality).

([6]) For example, the issues of overheating need to be carefully considered when evaluating technology packages and setting requirements. Some building regulations may be designed to keep heat inside and cold outside. However, considering the increasingly warmer climate, some new elements may need to be introduced. This also links with the requirement for the comparative methodology framework to enables the consideration of outdoor climate conditions and their future changes according to best available climate projections, including heat and cold waves.

The consideration of prefabricated solutions and off-site construction methods could be addressed when defining the packages and, if considered, should be carefully reflected in the evaluation of the relevant cost categories.

The following list aims to provide an indication of possible measures that can be considered.

Building envelope and structure:

— Total wall construction of new buildings or additional insulation of existing walls (7).

— Total roof construction of new buildings or additional insulation of existing roofs.

— All parts of slabs subjected to insulation in new buildings or additional insulation 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.

— Increased thermal inertia with use of building materials with high thermal mass in the interior space of buildings.

— Increased energy performance of doors and windows (better framing of doors and windows, lower U-value through for example, double or triple glazing with low-emissivity layers, etc.).

— Better sun shading to mitigate the risk of overheating in summer (fixed or movable, manually operated or automatic, films applied to windows).

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

— Building orientation and solar exposure (for new buildings only).

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

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

Systems:

— Installation of heating systems (for example, based on renewable energy generation, such as heat pumps, solar thermal, bioenergy, or district heating and cooling systems).

— Improvement of heating systems (also to enable operation at lower temperature levels).

— Installation of low-temperature heat distribution systems.

— Monitoring and metering devices for temperature control of space and water temperature.

— Installation or improvement of hot water supply system.

— Installation or improvement of ventilation (mechanical with heat recovery, natural, balanced mechanical, extraction, enthalpy heat-exchangers).

— Installation or improvement of active or hybrid cooling system (for example, ground heat exchanger, chiller).

(7) 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 required and recommended in national legislation and 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 to reduce the risk of interstitial or surface condensation). Attention should be paid to minimising thermal bridges.

— Efficient lighting system.

— Automatic lighting controls (for example, suitably zoned, providing occupancy detection, daylight sensing).

— Installation of energy storage systems.

— Installation or improvement of photovoltaic (PV) systems, also in combination with energy storage systems and control systems to maximise on-site use of generated electricity and demand-side flexibility.

— Change of energy carrier for a system.

— Change of pumps and fans.

— Insulation of pipes.

— Building automation and control systems (BACS).

— Direct water heaters or indirect water storage heated by different carriers, can be combined with solar thermal.

— Solar heating (and cooling) installations.

— Intensive night ventilation (for non-residential buildings with heavy structures and for specific climate situations).

— Micro combined heat and power (CHP) with different carriers.

— Important: Renewable energy produced nearby (for example through CHP, district heating and district cooling) can be considered only when there is a strong link between the production of energy and a specific building's energy consumptions.

Established variants:

— Existing packages/variants such as national eco-labels and other established low-energy buildings such as the passive house.

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 and, where relevant, its emission performance, are considered, whilst on the other hand the calculation process 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 showed that the number of packages/variants calculated and applied to each reference building should certainly not be lower than 10 plus the reference case (before packages/variants are applied).

Various techniques can be used to limit the number of calculations, including those availing of the support of digital tools and artificial intelligence. 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 district heating system 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 as a set of criteria to be fulfilled, including total primary energy from renewable and non-renewable sources and the emission performance.

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

4.3 Indoor environmental quality and other comfort-related issues

As laid down in section 2, point 6 of Annex I, to Delegated Regulation (EU) 2025/2273, the measures used for the calculations are to meet the basic requirements for construction products laid down in Regulation (EU) 2024/3110 of the European Parliament and of the Council ([8]) and for indoor environmental quality ('IEQ'), as defined in Article 2(66) of Directive (EU) 2024/1275. Also, the cost-optimal calculation process should be designed in such a way that differences in indoor environmental quality (temperature, humidity, ventilation rate and presence of contaminants) are made transparent. A measure might also be excluded from the national calculation and requirement setting, if it has a serious detrimental impact on indoor environmental quality or other aspects.

With regards to indoor air quality, for example, 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) and in addition needs to reflect the requirements set in Article 5(1), Article 7(6) and Article 8(3) of Directive (EU) 2024/1275.

With the rise of global temperatures, measures to reduce indoor temperatures by design (for example, adjusting the orientation of façades to reduce direct sunlight, using external shading, and using natural ventilation) will become increasingly important. Those elements have a significant effect on indoor conditions and therefore on indoor environmental quality. Regarding the level of summer comfort, it is advisable, in particular for a southern climate, but not exclusively, to deliberately take into account passive cooling that can be obtained by proper building design. The calculation methodology would then be designed in such a way that it includes the risk of overheating and the possible need for an active cooling system for every measure/package/variant. Advice for the selection, implementation, commissioning, and operation of passive and active cooling systems with regard to maintaining comfort and energy efficiency are provided by IEA EBC Annex 80 ([9]) and REHVA ([10]), for example.

Delegated Regulation (EU) 2025/2273 provides in Annex II reference to data on the heating degree days ('HDD') and cooling degree days ('CDD'), published yearly by Eurostat ([11]) and to the HDD and CDD future projections drawn up by the Commission, which Member States may use in their calculations to take into account outdoor climate conditions and their future changes according to best available climate projections, including heat and cold waves. Other relevant sources may also be used. Member States have flexibility on whether to include climate data projections in their calculations and how to do it ([12]). A sensitivity analysis may be used to assess the effects of the inclusion of future climate changes into the calculation.

The Commission's guidance on technical building systems, indoor environmental quality and inspections ([13]) includes information on how to define a heat wave and how to address extreme climate events in the design phase of a building and provides indicators for passive survivability against heat waves and extreme outdoor air pollution events. The thermal comfort indicators can be used during the design to optimise the building using passive measures (such as solar shading, cross-ventilation, and filtration). However, if limits are not met during design, the building may not have the passive ability to withstand an extreme event and may require active measures against extreme outdoor conditions(for example active cooling systems, fans, and air cleaning). Those considerations may also be taken into account to identify the measures/packages to assess in the cost-optimal calculations in order to ensure the required IEQ levels.

([8]) Regulation (EU) 2024/3110 of the European Parliament and of the Council of 27 November 2024 laying down harmonised rules for the marketing of construction products and repealing Regulation (EU) No 305/2011 (OJ L, 2024/3110, 18.12.2024, ELI: http://data.europa.eu/eli/reg/2024/3110/oj).
([9]) International Energy Agency. Resilient Cooling of Buildings Technology Profiles Report (Annex 80). Energy in Buildings and Communities Technology Collaboration Programme, May 2024.
([10]) Resilient Cooling Design Guidelines, REHVA.
([11]) https://ec.europa.eu/eurostat/databrowser/view/nrg_chdd_a/default/table?lang=en&category=nrg.nrg_chdd.
([12]) For example, projected data may be averaged on the basis of the estimated lifetime of the buildings analysed or of a forward-looking period of shorter duration.
([13]) Annex 10 to Commission Notice providing guidance on new and substantially modified provisions of the recast Energy Performance of Buildings Directive (EU) 2024/1275 (OJ C, C/2025/6438, 18.12.2025, ELI: http://data.europa.eu/eli/C/2025/6438/oj).

5. CALCULATION OF THE TOTAL PRIMARY ENERGY USE AND EMISSION PERFORMANCE 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 total primary energy, which includes energy use for heating, cooling, ventilation, hot water and lighting. The main reference for this is Annex I to Directive (EU) 2024/1275, which also applies fully to the cost-optimal framework methodology. Member States can also refer to the guidance on the energy performance calculation methodology, including on the calculation of transparent building elements ([14]).

It is recommended that Member States use the key European standards on the energy performance of buildings, namely (EN) ISO 52000-1, (EN) ISO 52003-1, (EN) ISO 52010-1, (EN) ISO 52016-1, (EN) ISO 52018-1, (EN) ISO 52120-1, EN 16798-1 and EN 17423 or superseding documents.

These guidelines use the following terms and definitions:

Energy-performance related definitions as used in (EN) ISO 52000-1:

— **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 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.

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

— **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.) or to produce the exported energy.

— **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. Primary energy includes non-renewable energy and renewable energy. If both are taken into account, it can be called total primary energy.

— **CO_2 emission factor:** for a given energy carrier, quantity of CO_2 emitted to the atmosphere per unit of delivered energy. The CO_2 emission coefficient can also include the equivalent emissions of other greenhouse gases (for example, methane).

([14]) Annex 10 to Commission Notice providing guidance on new and substantially modified provisions of the recast Energy Performance of Buildings Directive (EU) 2024/1275 (OJ C, C/2025/6438, 18.12.2025, ELI: http://data.europa.eu/eli/C/2025/6438/oj).

Under section 3 of Annex I to Delegated Regulation (EU) 2025/2273, 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 total primary energy use. That means that the 'direction' of the calculation is from the needs to the source (that is to say, from the building's energy needs to the total 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. Finally, the emission performance is calculated.

On-site energy production using locally available renewable energy sources (such as ambient heat, geothermal heat, solar thermal, photovoltaic, etc.) ([15]) displaces delivered energy from the grid, which would otherwise be used instead, and reduces the impact of the building on the energy grid. Annex I to Delegated Regulation (EU) 2025/2273, in section 3, point 3, provides that renewable energy produced on site and self-used for services related to the energy performance of buildings ('EPB services', in line with Article 2(56) of Directive (EU) 2024/1275) is not to be accounted in the primary energy use calculation. To do this, in the calculation of primary energy use, the primary energy factor of on-site renewable energy sources can be multiplied with a factor of value equal to 0. This approach is in line with the guidance on Annex I to Directive (EU) 2024/1275 ([16]). This enables the benefits of using renewable energy onsite to be represented both for the individual building and for the building as part of the larger energy system. For ambient heat, this also recognises that this is free and not harmful primary energy use, and that any inefficiencies in this context are captured in the primary energy needed to operate the heat pump.

Under the cost optimal methodology, this approach also allows all energy uses to be expressed with a single total 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 lowest global costs without discriminating against or favouring a certain technology.

If a Member State wants to clearly avoid the risk that active renewables-based installations (such as the installation of a PV system) replace energy demand reduction measures (such as the improvement of the building envelope or the installation of more efficient technical building systems) in line with the 'energy efficiency first' principle, the calculation of cost optimality could be done in steps gradually expanding the system boundary: energy need, delivered energy and total primary energy. With this, it will become clear how each measure/package of measures contributes to the building's energy supply in terms of costs and energy.

The renewable energy exported to the grid can be deducted from total primary energy use, in accordance with Annex I to Directive (EU) 2024/1275. When deducting the energy exported to the grid from total primary energy use, it is recommended to consider it with a maximum primary energy factor ('PEF') of 1, and preferably a PEF that reflects grid distribution losses (for example, 0.95 or 0.90). The use of the same primary energy factor for the electricity grid overestimates the energy exported to the grid by the building and results in unequal treatment.

On-site generation offers benefits, even when the energy generated is not self-used for EPB services. The cost-optimal methodology should allow for the consideration of such benefits. Therefore, energy consumed in the building premises for other on-site uses (including appliances, miscellaneous and ancillary loads, or electro-mobility recharging points) may be considered in the calculation of total primary energy, as detailed in the guidance on Annex I to Directive (EU) 2024/1275. For the purposes of the calculation, energy generated on site and used for non-EPBD uses can be accounted as if it had been exported, although Member States may apply a primary energy factor or weighting factor that reflects the lack of grid distribution losses (that is to say, a PEF of 1 instead of a PEF of 0.90 used for exporting electricity). Energy generated on site and used for non-EPBD uses could also be considered to realistically determine the share of on-site renewables (for example, PV production) that is actually available for self-use and to have a more realistic share of the exported energy. The energy cost saving (see section 6.12 of these guidelines) in terms of reduction of the electricity delivered from the grid for other on-site uses can also be considered in the economic benefits of the (fully considered) investment in the on-site renewable generation system (for example, PV system).

([15]) On-site renewable energy production can be ambient heat for heat pumps, energy from solar-thermal and solar photovoltaic, or other solutions (e.g. energy from wind or micro-hydro turbines installed on site, although these solutions are quite rare). Note that the energy from on-site generators based on bioenergy is a secondary energy carrier, since the primary energy carrier (e.g. solid biomass, biogases or biofuels) is supplied from outside building premises.

([16]) Annex 10 to Commission Notice providing guidance on new and substantially modified provisions of the recast Energy Performance of Buildings Directive (EU) 2024/1275 (OJ C, C/2025/6438, 18.12.2025, ELI: http://data.europa.eu/eli/C/2025/6438/oj).

To realistically determine on-site renewable generation, including share of self-consumption and exported energy, Delegated Regulation (EU) 2025/2273 requires either sub-hourly, hourly or monthly modelling (the latter adjusted for example through considering monthly correction factors). Hourly or sub-hourly calculation intervals are seen as the preferred option due to greater accuracy; however, if a monthly calculation methodology is in place, it is necessary to adjust it to reflect the dynamic effects that occur in hourly calculations (for example through monthly calibration factors which are the results of hourly reference calculations).

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 (for example, months, hours); perform the calculations for each step using step-dependent values and add up the energy consumption for all the steps over the year;

— estimate the energy need for domestic hot water following the approach in EN 12831-3:2017;

— estimate the energy use for lighting with the quick method proposed by standard EN 15193-1:2017+A1:2021 or more detailed calculation methods, (if applicable);

— use standard EN 16798-5-1+2:2017 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 52120.

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 52016-1, the main calculation procedure consists of the following steps:

(1) choice of type of calculation method;

(2) definition of boundaries and thermal zones of the building;

(3) definition of internal conditions and external input data (weather);

(4) calculation of the energy need for each time step and zone;

(5) subtraction of recovered system losses from energy needs;

(6) consideration of interactions between zones and/or systems.

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

(1) a fully prescribed monthly quasi-steady-state calculation method;

(2) a fully prescribed simple hourly dynamic calculation method.

For the scope of the cost-optimal calculation, to achieve reliable results it is recommended to:

— perform the calculations using a dynamic method or an hourly dynamic calculation 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 and use future climate data projections;

— define thermal comfort in terms of indoor operative temperature (for example 20 °C in winter and 26 °C in summer), humidity levels, and minimum air exchange rate as well as targets, expressed for all series of calculation for a particular reference building.

The following suggestions may also be followed:

— 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 other on-site uses such as appliances, plug loads and, if applicable, electric vehicle (EV) charging, especially in connection with on-site renewable energy generation and consider the related benefits;

— show the energy produced on-site, both for self-use and exported energy (including stored);

— consider the benefits of bi-directional charging and grid flexibility (if applicable).

To calculate the energy use for space heating, hot water and space cooling, as well as the energy generation (thermal and electrical) from renewable energy sources, 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;

— conditioning systems: EN 16798-9+13+14;

— thermal energy from RES: EN 15316-4-3;

— co-generation system: EN 15316-4-4;

— district heating and large volume systems: EN 15316-4-5.

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 PEFs is outside the scope of these guidelines and would have to be determined separately.

To calculate renewable and non-renewable primary energy, the most recent national conversion factors should be used. Conversion factors should be forward-looking, in line with point (2) of Annex I to Directive (EU) 2024/1275.

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 domestic 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 is connected to a district heating system (for space heating and hot water) with a total seasonal efficiency of 95 %. In summer, a mechanical cooling system is used: the seasonal efficiency of the entire cooling system (generation, distribution, emission, control) is 250 %. 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 kWh/(m^2 a) are utilised in the building for EPB services and 9 kWh/(m^2 a) are exported to the grid. A total primary energy factor of 1.8 is assumed for grid electricity, 1.0 for exported electricity, and 1.1 for district heating. Next to this CO_2 emission factors of 220 g/kWh for district heat and 180 g/kWh for electricity are assumed.

When on-site self-used PV is considered in the delivered energy, for the purpose of the primary energy calculation, the primary energy factor should be multiplied by a correction factor of 0, so that k x PEF = 0.

Example of energy calculation results:

— energy use for space heating is 21 kWh/(m^2 a): 20/0.95;

— energy use for domestic hot water from on-site solar thermal is 3 kWh/(m^2 a);

— energy use for domestic hot water from district heating is 2.1 kWh/(m^2 a): (5 - 3)/0.95;

— electric energy use for space cooling is 14 kWh/(m^2 a): 35/2.5;

— delivered district heating energy is 23.1 kWh/(m^2 a): 21 + 2.1;

— delivered electricity from the grid is 25 kWh/(m^2 a): 7 + 10 + 14 - 6;

— electricity from on-site PV used on-site is 6 kWh/(m^2 a);

— total primary energy (without exported energy) is 70.4 kWh/(m^2 a): 23.1 × 1.1 + 3 × (1 × 0) + 25 × 1.8 + 6 × (1 × 0);

— primary energy associated with energy exported to the grid is 8.1 kWh/(m^2 a): 9 × 0.9;

— net total primary energy (with exported energy) is 62.3 kWh/(m^2 a): 70.4 – 8.1;

— GHG emission performance is 7.96 kg/(m^2 a): 23.1 × 220 + (25-9) × 180.

Example including other on-site uses:

the solar PV system provides 15 kWh/(m^2 a), of which 10 kWh/(m^2 a) is utilised in the building (6 for EPB services and 4 for other on-site uses) and 5 kWh/(m^2 a) is exported to the grid.

— primary energy associated with energy exported to the grid is 4.5 kWh/(m^2 a): 5 × 0.9;

— net total primary energy is 61.9 kWh/(m^2 a): 70.4 – 4 – 4.5.

Forward-looking primary energy and weighting factors should be taken into account in the calculations to properly consider these trajectories in energy systems, in line with national energy and climate plans (NECPs) ([17]). Consistently, forward-looking GHG emission factors are recommended. Member States have flexibility on how to reflect the forward-looking aspect of such factors or the relationship with NECPs. The factors should be appropriately defined on the basis of the calculation period, for example averaged by taking into account the situation at the initial year of the calculation and the expected progress throughout the lifetime of the building ([18]).

([17]) This is also in line with Annex I to the Directive (EU) 2024/1275, which requires that the calculation of primary energy be based on regularly updated and forward-looking primary energy factors or weighting factors per energy carrier. Further information on these factors is provided in Annex 12 to Commission Notice providing guidance on new and substantially modified provisions of the recast Energy Performance of Buildings Directive (EU) 2024/1275 (OJ C, C/2025/6438, 18.12.2025, ELI: http://data.europa.eu/eli/C/2025/6438/oj).

([18]) This is also in line with Annex I to Directive (EU) 2024/1275, which requires that the calculation of primary energy be based on regularly updated and forward-looking primary energy factors or weighting factors per energy carrier. Further information on these factors is provided in Annex 12 to Commission Notice providing guidance on new and substantially modified provisions of Directive (EU) 2024/1275 (OJ C, C/2025/6438, 18.12.2025, ELI: http://data.europa.eu/eli/C/2025/6438/oj).

Member States may decide how to apply these elements, for example:

— Member States may decide to apply a value for PEF considering a 5-year forecast in line with the NECP. This value would allow for the consideration of short- and medium-term changes in the value of different PEFs, that is relevant for the choice of systems in use.

— Member States may decide to apply a value for PEF considering longer-term forecasts (e.g. 20 years) in line with the NECP ([19]). This value could be useful to take into consideration long-term changes in the value of different PEFs over the lifetime of the building. Averaging (e.g. arithmetical or weighted average) is strongly recommended in these cases avoiding to consider implicitly the contribution of buildings sector to long-term reduction of the energy demand and related GHG emissions.

A sensitivity analysis may also be used to assess the effects of different options and identify the most relevant approach.

5.1 Accounting for the whole life-cycle Global Warming Potential ('GWP')

Pursuant to Article 6(2) of Directive (EU) 2024/1275, Member States may take into account the life-cycle GWP when calculating the cost-optimal levels of minimum energy performance requirements. To that end, they may use a calculation methodology in accordance with the Union framework that will be set out in the delegated act (to be adopted by 31 December 2025) pursuant to Article 7(3) of Directive (EU) 2024/1275, designed for the purpose of calculating the GWP of new buildings. To calculate the life-cycle GWP in relation to existing buildings undergoing renovation, Member States are free to adapt the methodology as necessary or to use their own calculation method, according to the relevant standards.

For new buildings, referring to the Union framework is highly recommended, but possible adaptations may be needed. For example, since the focus of the exercise is the comparison of measures/packages/variants (and not the assessment of the whole life cycle GWP of the reference building), elements that are the same for all measures/packages/variants assessed for a certain reference building can be omitted in the GWP calculation (earthworks and foundation, cost of staircases, cost of lifts, etc.). This is in line with the considerations in section 6.2 of these guidelines.

Total primary energy is to remain the main indicator for the identification of the cost-optimal levels of minimum energy performance requirements. The scope of the cost-optimal calculation, indeed, is to prioritise the measures that support the best energy performance with the lowest global costs for the individual investor (financial perspective) and for the society (macroeconomic perspective). However, if Member States opt to consider the life-cycle GWP for the calculation of the cost-optimal levels, the emission performance over the building life cycle of different measures/packages/variants also becomes relevant, for example to identify additional requirements addressing the whole life-cycle performance of a building and/or to identify the cost-optimal levels ([20]).

In order to maintain a manageable number of measures/packages/variants and to keep the recommended focus on energy performance, Member States may select only the options that fall into the cost-optimal range (see, e.g., Figure 4) and start from these to perform additional optional life-cycle GWP calculation. Additional parameters that do not strictly affect the operational energy and emission performance of the building, but that on the other hand have an impact on the whole life-cycle GWP of a building (e.g. type and quantity of material used for achieving the identified cost-optimal level, origin of materials, resources used for their production and disposal, recycling and reusing possibilities, etc.) can be assessed. The results of this additional step might help set additional requirements also in terms of life-cycle GWP, expressed as $kgCO_2eq/(m^2)$, and further rank the solutions identified in the cost-optimal range.

([19]) Weighted averages are expected in these cases, as simply applying the PEF expected at the last year of the calculation bears the risk to distort results and disregard the evolution in the first years.

([20]) As mentioned in section 4.1 of these guidelines, Member States may consider the life-cycle GWP for the calculation of the cost-optimal levels for the purpose of ensuring the consistency, especially with Article 7(2) and 7(5) of Directive (EU) 2024/1275.

In the **macroeconomic calculation**, it is also possible to consider whole life-cycle carbon costs in the global costs equation: the equation refers to operational emissions, but if a Member State opts to take into account the life-cycle GWP for calculating the cost-optimal levels, the cost of greenhouse gas emissions may be expanded to include it. In this case, Member States may need further work to identify the costs to monetise the whole life-cycle emissions but may use the same costs that they used to monetise the operational emissions. The differences between the global cost calculation period in the cost-optimal (at least 20 and 30 years) versus the GWP calculation period (set to 50 years) would need to be carefully considered in this monetisation. In the **financial calculation**, for example, eventual subsidies for buildings and building elements with low embodied emissions can be accounted in addition.

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

In accordance with Annex VII to Directive (EU) 2024/1275 and Annex I, section 4 to Delegated Regulation (EU) 2025/2273, the cost-optimal framework methodology is based on the net present value (global costs) methodology.

The calculation of global costs considers the initial investment, the sum of annual costs for each year, the final value and, if appropriate, disposal costs, all with reference to the starting year.

For the calculation of the macroeconomic cost optimum, the category of global costs also includes a category for the cost of GHG emissions defined as the monetary value of environmental damage caused by CO_2 emissions related to the energy consumption in a building. In addition, the cost of environmental and health externalities of energy use reflects the quantified, monetised and discounted operational costs of other environmental pollutants related to energy use (namely, fine particulate matter $PM_{2.5}$ and nitrogen oxides NOx). Even if a Member States does not use the macro-economic calculation to set the cost-optimal levels, its broader perspective provides important information that can be used for setting additional requirements (for example, in terms of emission performance) and wider policy objectives.

Global cost calculations result in a net present value of costs incurred during a set calculation period, taking into account the residual values of equipment with longer lifetimes. Projections for energy costs and interest rates can be limited to the calculation period.

The advantage of the global cost method is that it allows the use of a uniform calculation period (with long-lasting equipment taken into account via its residual value) – unlike 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 15459-1:2017 and corresponds to what generally in the literature is called 'lifecycle cost analysis'.

The global cost methodology as prescribed in Delegated Regulation (EU) 2025/2273 does not include costs other than energy (for example water costs) as it follows the scope of Directive (EU) 2024/1275. 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. However, Member States are free to extend the methodology towards full life-cycle costing (LCC) and might also consider for this purpose EN ISO 14040, 14044 and 14025 as well as specific norms for LCC in buildings: EN 15459 and ISO 15686-5.

6.1 The concept of cost optimality

In accordance with Directive (EU) 2024/1275, 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 most 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 (for example, 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 of 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 process can however provide Member State authorities with 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 attractive to 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. The purpose of the calculations at macroeconomic level is to prepare and inform the setting of generally applicable minimum energy performance requirements. They 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 ([21]) are factored in. Such a broader investment perspective also aligns relatively well with total primary energy as the 'currency' of energy performance (with additional important information that could be added with the calculation of emission performance), whereas a purely private investment perspective can be aligned with either total primary energy or delivered energy.

However, in practice it will not be possible to capture all direct and indirect impacts of energy efficiency measures and measures based on renewable energy sources, as some are intangible or non-quantifiable, or cannot be monetised. Nevertheless, a significant share of these impacts have recognised quantification and costing approaches that allow for them to be captured. For example, Member States are free to consider additional multiple benefits of energy efficiency measures and measures based on renewable energy sources in their cost-optimal calculations, including, for example, in terms of private and public health costs of energy efficiency measures, impacts on gross domestic product (GDP). In order to estimate some of these multiple benefits, a simplified methodology is described in section 6.16 of these guidelines including default datasets, an annotated example, and literature references. Member States are free to use their own methodology to monetise multiple benefits, provided that all assumptions and sources for the evaluation are clearly indicated. A detailed list of bibliographical sources and references is given in sub-section 6.16.3 to support Member States that opt to consider other multiple benefits of energy efficiency measures and measures based on renewable energy sources in the cost-optimal calculations.

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

Delegated Regulation (EU) 2025/2273 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 environmental and health externalities) and once at financial level (accounting for prices as paid by the end consumer including taxes and if applicable subsidies, taking into account the cost of greenhouse gas allowances as part of energy costs in line with the new emission trading system for emissions from fuel combustion in buildings and excluding the additional greenhouse gas abatement costs, as counted at macroeconomic level in line with the existing emission trading scheme).

Possible double-counting issues that might occur in the macroeconomic calculation could be addressed in the definition of carbon costs, based on national energy price structure.

([21]) For the cost-optimal calculations, externalities are only considered at macroeconomic level, as they are defined as costs or benefits that are caused by one party but financially incurred or received by another.

NB 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.

For the financial perspective calculation, the inclusion of available support schemes (along with taxes and all available subsidies) would usually be required and recommended 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 no VAT-based subsidies and support measures exist in that Member State. 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.

A steady and predictable financing framework at Member State level is highly recommended. The first national building renovation plans, introduced in Article 3 of Directive (EU) 2024/1275, will be submitted by Member States to the Commission by the end of 2026 and will contribute with relevant information on the implemented and planned policies and measures in a Member State as well as on the investment needs, the budgetary sources and the administrative resources to ensure the renovation of the national stock of residential and non-residential buildings, both public and private, into a highly energy-efficient and decarbonised building stock by 2050.

6.1.1 *Additional consideration on the macroeconomic calculations and externalities*

Under Delegated Regulation (EU) 2025/2273, the calculation of the cost optimum at macroeconomic level requires the consideration of greenhouse gas emissions costs by multiplying the sum of the annual GHG emissions by the expected prices per ton CO_2 equivalent of GHG emission allowances issued in every year, taking into consideration costs in line with the recommended ETS carbon price trajectories provided by the Commission for national projections ([22]) to be adapted to the calculation dates and methodology chosen. Updated recommendations should be taken into account every time the cost optimal calculation is reviewed, but their adoption remains voluntary.

Additionally, Member States are to expand the macroeconomic calculation of global costs to consider health and environmental externalities of energy use. To do this, they should consider the monetised impacts of the operational emissions of air pollutants related to energy use in buildings and, specifically, at least fine particulate matter ($PM_{2.5}$) and nitrogen oxides (NOx). Member States may also include in the calculation other air pollutants listed in Article 1 of Directive (EU) 2016/2284 of the European Parliament and of the Council ([23]): sulphur dioxide (SO_2), non-methane volatile organic compounds (NMVOC), ammonia (NH_3) ([24]). It is important to note that not all energy uses are linked with the direct or indirect emission of $PM_{2.5}$ or NOx. $PM_{2.5}$ is most significantly more relevant for solid fuel boilers based on bioenergy and fossil fuels than for liquid; NOx for liquid and gaseous fuel-burning heating equipment, for which NOx emission is more relevant. Energy generation (including district heating) also has an indirect impact that needs to be taken into

([22]) Regulation (EU) 2018/1999 of the European Parliament and of the Council of 11 December 2018 on the Governance of the Energy Union and Climate Action, amending Regulations (EC) No 663/2009 and (EC) No 715/2009 of the European Parliament and of the Council, Directives 94/22/EC, 98/70/EC, 2009/31/EC, 2009/73/EC, 2010/31/EU, 2012/27/EU and 2013/30/EU of the European Parliament and of the Council, Council Directives 2009/119/EC and (EU) 2015/652 and repealing Regulation (EU) No 525/2013 of the European Parliament and of the Council (OJ L 328, 21.12.2018, p. 1, ELI: http://data.europa.eu/eli/reg/2018/1999/oj).

([23]) Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants, amending Directive 2003/35/EC and repealing Directive 2001/81/EC (OJ L 344, 17.12.2016, p. 1, ELI: http://data.europa.eu/eli/dir/2016/2284/oj). That directive sets national emission reduction commitments for each Member State for the period 2020 to 2029 and more ambitious ones as of 2030, targeting air pollutants that are responsible for significant negative impacts on human health and the environment. The Clean Air Programme established a target to reduce the health impacts of air pollution by half by 2030 compared to 2005.

([24]) NH_3 pollution is mostly linked with the agricultural sector and, therefore, it is not identified as relevant for the cost-optimal calculation, which mainly addresses the building sector, its energy demand and emission performance.

consideration. The consideration of $PM_{2.5}$ allows the health and environmental impacts of combustion, for example, of fossil fuels and bioenergy [25] to be considered in the global cost calculation. Bioenergy use accounts for around 50% of the emissions of fine particulate matter ($PM_{2.5}$) across the EU and, being $PM_{2.5}$ the main driver of the health effects of air pollution, is of primary concern for air quality policy [26].

For the calculation of the above-mentioned externalities, reference values in terms of pollutant emission for different energy sources (g/kWh of fuel) can be found in the EMEP/EEA air pollutant emission inventory guidebook [27] and the related emission factor database. Further product-specific information for the calculations can be found in connection to ecodesign:

— Commission Regulation (EU) No 813/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for space heaters and combination heaters [28];

— Commission Regulation (EU) No 814/2013 of 2 August 2013 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for water heaters and hot water storage tanks [29];

— Commission Regulation (EU) 2015/1185 of 24 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel local space heaters [30];

— Commission Regulation (EU) 2015/1189 of 28 April 2015 implementing Directive 2009/125/EC of the European Parliament and of the Council with regard to ecodesign requirements for solid fuel boilers [31];

— and accompanying guidelines: https://energy-efficient-products.ec.europa.eu/document/download/ce43bba7-70a1-4d6f-8c69-5e146ec7973c_en?filename=guidelinesspacewaterheaters_final.pdf.

For example, Regulation (EU) 2015/1189 sets space heating emission requirements in terms of $PM_{2.5}$ and NOx for biomass and fossil fuel boilers. Such information is also displayed in the data sheet of such products.

The emission inventories reported every year in February and the emission projections reported every two years, in accordance with Article 10(2) of Directive (EU) 2016/2284, can be used for country-specific pollutant emissions from different energy sources. The comparison of the projected emissions with the reduction commitments for 2020-2029 and 2030 onwards could be used to identify the relevance of including in the calculation of environmental externalities any of the non-mandatory pollutants as well as to determine future developments. For example, sulfur dioxide (SO_2) pollution is primarily caused by the burning of fossil fuels that contain sulfur, such as coal, petroleum oil, and diesel. If coal is a significant contributor to energy supply sector of a country, it may be relevant to include its impact in the estimation of health externalities.

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(25) While not a requirement under the EPBD, the amount of operational GHG emissions coming from bioenergy can inform on what harvesting needs and associated Land Use, Land Use Change and Forestry emissions this would entail. "[*In the land use, land-use change, and forestry (LULUCF) sector] carbon removals have and continue to decline at a worrying speed in recent years. This negative trend is, to a large degree, due to a decrease in forest-related removals, mainly as a consequence of an increase in harvesting […] Climate change itself is having an increasing impact too. […]. There are many indications that, because of climate change, the future robustness of EU forest removals is far from guaranteed*." (European Commission. (2024). Climate Action Progress Report 2024. https://climate.ec.europa.eu/document/download/7bd19c68-b179-4f3f-af75-4e309ec0646f_en?filename=CAPR-report2024-web.pdf).

(26) European Commission: Directorate-General for Environment, Increasing policy coherence between bioenergy and clean air policies and measures – Final project report, Publications Office of the European Union, 2024, https://data.europa.eu/doi/10.2779/94296. The study also proposes a simplified metric for the calculation of the operational $PM_{2.5}$ emissions from buildings, based on the EMEP/EEA air pollutant emission inventory guidebook.

(27) The 2023 edition EMEP/EEA air pollutant emission inventory guidebook, with link to the Emission Factor Data Viewer, is available at the link https://www.eea.europa.eu//publications/emep-eea-guidebook-2023.

(28) OJ L 239, 6.9.2013, p. 136, ELI: http://data.europa.eu/eli/reg/2013/813/oj.

(29) OJ L 239, 6.9.2013, p. 162, ELI: http://data.europa.eu/eli/reg/2013/814/oj.

(30) OJ L 193, 21.7.2015, p. 1, ELI: https://eur-lex.europa.eu/eli/reg/2015/1185/oj.

(31) OJ L 193, 21.7.2015, p. 100, ELI: http://data.europa.eu/eli/reg/2015/1189/oj.

For that calculation, the recommended costs, expressed in EUR per unit of pollutant emission, are made available by the Commission and will be updated where new data are available. Specifically, the costs of pollutant emissions are monetised, for the transport sector, by taking into account impacts on health, on crop and biodiversity loss as well as material damage ([32]).

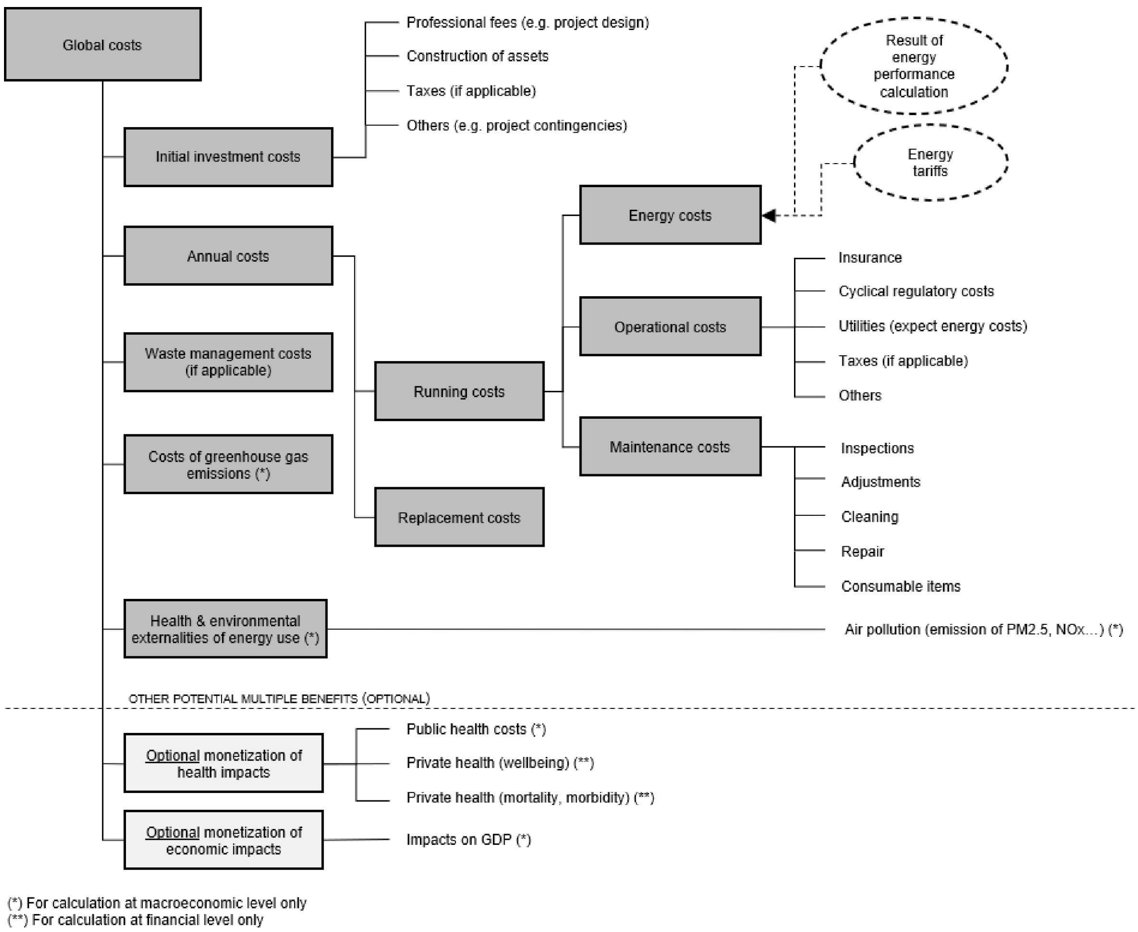
6.2 Cost categorisation

Under Annex I, section 4, point 1 to Delegated Regulation (EU) 2025/2273, Member States are required to use the following basic cost categories: initial investment costs, annual costs (including energy costs and periodic replacement costs) and, if appropriate, waste management costs. Also, the costs of greenhouse gas emissions and of other relevant environmental pollutants (under health and environmental externalities of energy use) are 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 energy performance requirements is based on standard EN 15459-1:2017. The following illustration summarises the cost categories to be applied.

Figure 1

Cost categorisation according to the framework methodology



([32]) European Commission: Directorate-General for Mobility and Transport, Essen, H., Fiorello, D., El Beyrouty, K., Bieler, C. et al., Handbook on the external costs of transport – Version 2019 – 1.1, Publications Office, 2020, https://data.europa.eu/doi/10.2832/51388. This publication also provides costs to monetise CO_2 emission damage.

The enumeration of cost categories given in Delegated Regulation (EU) 2025/2273 is comprehensive. Nevertheless, if other cost categories are considered important for the calculation of cost-optimal levels of minimum energy performance requirements, they can also be taken into account. Moreover, the cost of the capital needed to finance energy efficiency investments is not included as a separate category in that Delegated 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, or replacement cost, 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 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.

Delegated Regulation (EU) 2025/2273 prescribes in principle a full cost approach for new construction as well as for major renovation. This means that for each assessed measure/package/variant applied to a reference building, the full cost of construction (or major renovation) and 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:

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

(2) 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, they do not have to be taken 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.

Delegated Regulation (EU) 2025/2273 does not allow for the so-called ‘additional cost’ calculation approach ([33]). 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;

— the approach cannot fully reflect 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. The additional cost calculation approach makes it difficult to show interlinkages between certain building

([33]) An additional cost calculation approach starts from a standard building (for example, in line with current minimum requirements) to which additional measures are added (for example, better insulation, shading, ventilation system with heat recovery). The cost comparison is based on additional investment costs and differences in running costs.

characteristics, for example, 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. Trying to allow for all these potential interlinkages 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 additional energy efficiency measures. This separation is sometimes not very easy to make.

6.3 **Gathering of cost data**

Delegated Regulation (EU) 2025/2273 states that cost data is to be market-based (for example, obtained by market analysis) and coherent as regards location and time for the investment costs, running costs, energy costs and if applicable waste management 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 required to compare different measures/packages/variants for a given reference building. Therefore, 'top-down' benchmark databases such as BKI ([34]) or SIRADOS ([35]), which are commonly used for rough estimates of the investment and operating cost of buildings, cannot be used for the cost-optimal calculations because their data are not sufficiently related to the energy performance of the building. Their disaggregation level is too low to be able to derive cost differentiations of different measures/packages/variants.

6.4 **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 is to use a rate of 3 % expressed in real terms, and lower rates (from 0% to 3% excluding inflation) should also be considered. This is in line with the current Commission's impact assessment tool that suggests 3 % as societal discount rate.

A higher discount rate – higher than 3 % excluding inflation and possibly differentiated for non-residential and residential buildings – will reflect a purely commercial, short-term approach to the valuation of investments, which is not encouraged. A lower rate – typically ranging from 0 % to 3 % excluding inflation – will more closely reflect the benefits that energy efficiency investments bring to building occupants over the entire investment's lifetime ([36]). Assessing lower-than-average discount rates for energy efficiency measures and measures based on renewable energy sources when performing sensitivity analyses is therefore recommended.

The discount rate will be different among Member States as it reflects to a certain extent not only policy priorities (for the macroeconomic calculation), but also different financing environments and mortgage conditions.

([34]) Baukosteninformationszentrum Deutscher Architekten (BKI): Statistische Kostenkennwerte für Gebäude.
([35]) SIRADOS Baudaten, 2024, www.sirados.de.
([36]) A 2024 study of the Buildings Performance Institute Europe (BPIE) highlights that lower discount rates *'not only emphasise the importance of multiple building renovation benefits but also support building renovation projects and encourage deep renovation'.* BPIE (2024). *From cost savings to societal gains: rethinking the cost-optimal methodology.* Available at: https://www.bpie.eu/publication/from-cost-savings-to-societal-gains-rethinking-the-cost-optimal-methodology/.

To make the discount rate applicable, usually a discount factor will have to be derived that can be used in the global cost calculation. Rd(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.

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 list of cost elements to be taken into account for calculating initial investment costs of buildings and building elements

The list 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	
Thermal insulation of building envelope: — insulation products — additional products for application of the insulation to the building envelope (mechanical fixings, adhesive, etc.) — design costs — installation costs of insulation (including water vapour barriers, weather membranes, measures to ensure airtightness and measures to reduce the effects of thermal bridges) — energy-related costs of other building materials, if applicable — other building-related measures with impact on thermal performance, for example, external shading devices, solar control systems, and passive systems not covered elsewhere. The technical products and systems are described for example in various standards under CEN/TC 88 – Thermal insulating materials and products and CEN/TC 89 – Thermal performance of buildings and building elements.	**Windows and doors:** — glazing and/or glazing enhancement — frame — gaskets and sealants — installation costs — 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 – Thermal performance of buildings and building elements.

For building systems	
Space heating: — generation and storage equipment (boiler, storage tank, heat generation controls) — distribution (circulator, circuit valves, distribution controls) — emitters (radiators, ceiling floor heating, fan coils, emission controls) — design costs — installation costs	**Domestic hot water:** — generation and storage (including solar thermal systems, boiler, storage tank, heat generation controls) — distribution (circulator, circuit valves/mixing valves, distribution controls) — emitters (tap valves, floor heating, emission controls) — design costs — installation costs (including insulation of the system and pipes)

The technical systems are described for example in various standards under CEN/TC 228 - Heating systems in buildings and CEN/TC 57 - Central heating boilers. For reference comfort conditions, EN 16798-1:2019 'Energy performance of buildings. Ventilation for buildings. 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.	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: The investment costs of mechanical ventilation systems are to be assessed. Possibilities for natural ventilation are covered with the definition of reference buildings. Investment costs should include: — heat generation and recovery equipment (heat exchanger, pre-heater, heat recovery unit, heat generation controls) — distribution (fans, circulators, valves, filters, distribution controls) — emitters (ducts, outlets, emission controls) — design — installation — monitoring and control devices for measuring and regulating indoor air quality The technical systems are described for example in various standards under CEN/TC 156 - Ventilation for buildings. EN 16798-1:2019 or equivalent should be taken into account for reference comfort conditions and requirements for ventilation.	**Cooling:** 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. This category covers the costs of active cooling systems. Passive cooling measures are either covered with the choice of reference buildings (for example, building mass) or covered in the category 'thermal insulation' (for example, insulation of roofs to reduce cooling demand) or the category 'Other building-related measures with impact on thermal performance' (for example external shading). Investment costs of active cooling systems include: — generation and storage equipment (generator, heat pump, storage tank, heat generation controls) — distribution (circulator, circuit valves, distribution controls) — emitters (ceiling/floor/beams; fan coils, emission controls) — design — installation — monitoring and control devices for automated solar shading devices The technical systems are described for example in various standards under CEN/TC 113 - Heat pumps and air conditioning units. EN 16798 should be taken into account for reference comfort conditions.
Lighting: Investments costs of 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 covered with the choice of the reference building. Investment costs should include: — type of light sources and luminaires — associated control systems — applications to increase use of daylight — installation	**Building automation and control:** Investment costs should include: — building management systems which introduce supervising functions (separate system controls are accounted for within the specific system) — technical intelligence, central controller — controls (generation, distribution, emitters, circulators) — actuators (generation, distribution, emitters) — communication (wires, transmitters) — design

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.	— installation and programming — Control system for on-site RES generation (for example, PV) and self-use (incl. EV-charging), battery storage and export to the grid The technical systems are described for example in various standards under CEN/TC 247 – Controls for mechanical building services.
Connection to energy supplies (grid or storage): Investment costs should include: — first connection to the energy network (for example, district heat, PV-system) — storage tanks for combustion fuels — necessary related installations — thermal and electric storage	**Decentralised energy supply systems based on energy from renewable sources:** Investment costs should include: — generation — distribution — storage — charging infrastructure (for example, for EVs) — control devices — installation

6.6 Calculation of periodic replacement cost

Besides initial investment costs and running costs, periodic replacement costs are the third cost driver. Whereas smaller repair work and consumables are usually subsumed under maintenance 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 an initial investment cost and again as a 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 15459-1:2017 (for energy systems in buildings) and other standards. In any case, the lifetime of the building elements used for the calculation should be plausible. In general, the replacement cost will be approximately the same as the initial investment cost (in real terms). However, where major price developments may be expected over the next 10-15 years (for example, due to 'economy of scale' effects), Delegated Regulation (EU) 2025/2273 allows and also encourages the adaptation of the 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 were 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 renovation cycle of a building, which is the period of time after which a building undergoes major renovation, including improvement of the building as a whole and adaptation to changed user requirements (in contrast to simple replacement). The reasons for major renovation are usually diverse, with ageing of important building elements (for example, façade) being just one of them. Renovation cycles differ widely between Member States and building types (which is why different minimum calculation periods are set for residential/public and non-residential/commercial buildings in the Delegated Regulation (EU) 2025/2273) but are almost never below 20 years.

Figure 2 illustrates the approach for a building element which has a longer lifetime than the calculation period (for example, 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 2

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

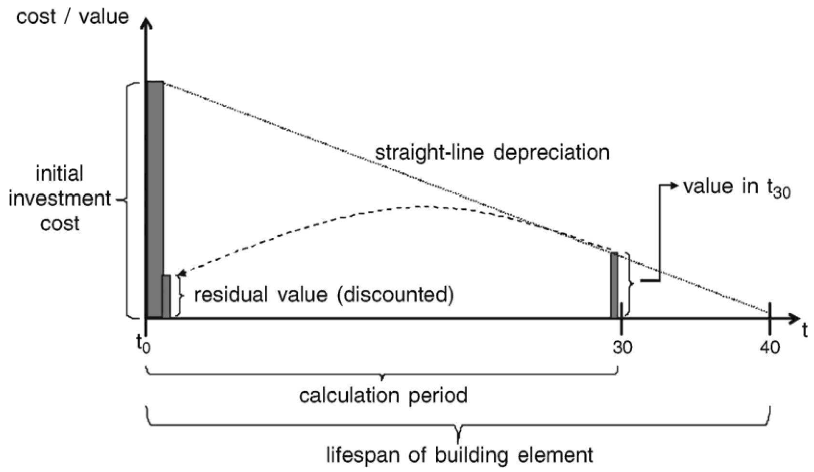
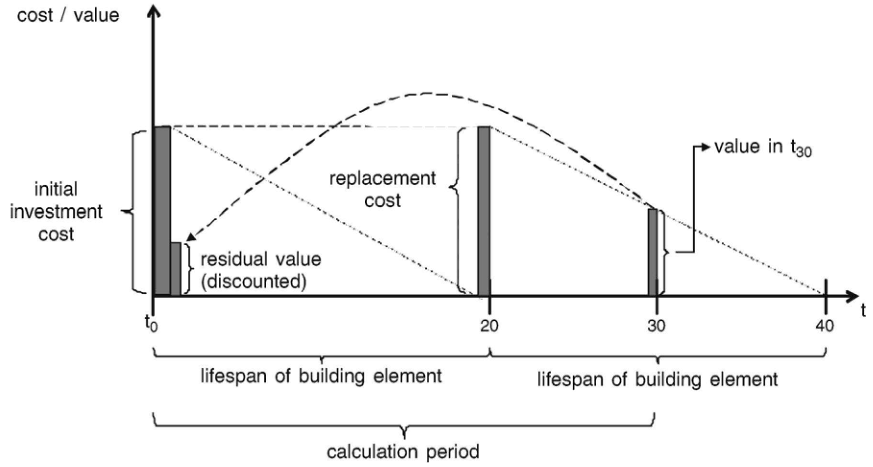


Figure 3 shows how the residual value has to be calculated for a building element with a lifespan shorter than the calculation period (for example, heating boiler). With an assumed lifespan of 20 years the element has to be replaced after that period of time. Once the element has been renewed a new depreciation 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 3

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

Pursuant to Delegated Regulation (EU) 2025/2273 Member States are to use the year in which the calculation is carried out as a starting point for the calculation. The main purpose of this is to ensure that the current price and cost levels are reflected in the cost-optimal calculation of measures/packages/variants (where such data are available). However, it is possible for Member States to base the calculation on the year of calculation (say 2027 for the first exercise), but use as a reference for the minimum energy performance requirement those requirements that are already established and will come into effect in the near future, for example those that would apply from 2028.

6.9 Calculation of residual value

Pursuant to Delegated Regulation (EU) 2025/2273 the residual value is to be included 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 the building element) and, if appropriate, any costs for its removal.

6.10 Cost development over time

Except for energy cost and replacement cost, Delegated Regulation (EU) 2025/2273 does not include any other real term cost increases or decreases. That means that for the other cost categories (that is to say, operational cost and maintenance cost) price development is assumed to be equal to the overall inflation rate.

Experience has shown that the price of new technology can quickly decrease when the market takes it up. 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 set of calculations. Member States might also include an innovation or adaptation factor into their calculation that ensures that the dynamic development of costs over time is taken into account. In Annex II to Delegated Regulation (EU) 2025/2273, the Commission provides reference to technology cost assumptions, elaborated as part of the EU Reference Scenario, one of the Commission's key analysis tools in the areas of energy, transport and climate action. The aim is to provide useful information, which Member States are free to use for their assessments.

With respect to the development of costs for energy carriers and carbon costs over time, Annex II to Delegated Regulation (EU) 2025/2273 provides information that Member States can use for their calculations, although they are free to use other official 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, bioenergy, district heating and cooling, and electricity.

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, that is to say, 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 or time-variable tariffs. This will gain increasing importance in an increasingly decarbonised energy sector with a growing share of renewables.

6.11 Calculation of replacement costs

For replacement costs it is possible to adapt the initial investment cost (which serves as a basis for fixing the replacement cost) for selected building elements if major technological development is expected in the upcoming years.

6.12 Calculation of energy costs

Energy costs should reflect the cost of both 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. This should include all costs, taxes and profit margins of the supplier. All energy uses covered by Article 2(56) and Annex I to Directive (EU) 2024/1275 are to be considered.

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

The calculation of the cost optimum at financial level needs to include all applicable taxes (VAT and others), support schemes and incentives. These 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 renewable energy sources;

— regulated minimum feed-in tariffs for energy produced from renewable energy sources.

Whereas Delegated Regulation (EU) 2025/2273 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 for which 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 a subsidy scheme in force, Member States might find it helpful to also calculate the real private costs without subsidies. This will enable them to identify the difference and thus steer future subsidy policies, particularly with regard to certain groups for which financial gaps might be identified through the calculation exercise, such as vulnerable households, people affected by energy poverty and people living in social housing. Member States are encouraged to link fiscal and financial incentives to compliance with the cost-optimal calculation outcome of the same reference building.

When Member States leave out subsidies from the calculation at financial level, they should ensure that this includes not only subsidies and support schemes for products and technologies, but also any subsidies for energy prices.

Governmental price interventions in emergency situations may result in distorted energy prices, artificially reducing the benefits of energy savings. Member States should ensure correction of the existing energy prices to consider not only short-term energy price projections (for example to consider the effect of energy price mechanisms), but also the long-term costs of supplying renewable energy, such as grid expansions, energy storage, reserve capacity and other investments needed for the energy transition at a system level. This is especially important given that the expected duration of energy efficiency benefits will most likely be longer than the foreseen duration of the energy price protection measures.

6.14 **Inclusion of earnings from energy production**

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

If on-site production of renewable energy is relevant, it is recommended to include the entire investment costs and all of the revenues from feeding the surplus electricity into the grid. In this way a fair balancing of costs and benefits is applied. Revenues from selling electricity to the grid should only be considered if the electricity is delivered and for as long as earnings are expected. For example, in the event of peaks of production in summertime, which will become increasingly relevant in the future, PV-systems might not be allowed to feed in all the electricity they produce, therefore only the effective feed-in should be considered here. Caps to exported energy may also be considered to reflect this potential issue. Packages combining on-site renewables with measures reducing the energy demand and electrification solutions as well as solutions such as storage and demand-side flexibility should also be evaluated in this context. Additionally, the difference in prices between the fed-in electricity and the electricity delivered to the building should be carefully considered in the calculation.

When a Member State includes in the calculation the earnings from energy produced on-site, where applicable, 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. In particular, a bias towards electricity production at the expense of reduced demand for heating and cooling should be avoided.

6.15 **Calculation of waste management costs**

Pursuant to Delegated Regulation (EU) 2025/2273, waste management costs are to be included in the global cost calculation, where applicable. Member States may include waste management costs if they think they are relevant and if they are able to make plausible estimates of their amount. Waste management 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, that is to say, the cost for dismantling, re-use, recycling, 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 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 is required of the lifetime of the building as a whole (and not of single building elements). This may depend on the type of construction (for example prefabricated house versus solid construction) and on the type of use (for example 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, waste management 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 setting the replacement cost at the same level as the initial investment (no cost increase/decrease in real terms). Therefore, some extra costs related to replacement activities may be included in the global cost calculation.

The major challenge with respect to the consideration of waste management costs is obtaining reliable and market-based cost data. Usually, those 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.

NB If the assumed lifetime of the building exceeds 50 to 60 years, the influence of waste management costs on the final result will be marginal due to discounting.

6.16 **Multiple benefits**

In addition to the health and environmental externalities, described in section 6.1.1 of these guidelines, energy performance improvements in buildings have a range of positive effects other than direct energy and cost savings, also known as multiple benefits (including, for example, improved indoor climate, energy system enhancements, increased property value, etc.). Recognising and incorporating these benefits into the cost-optimal methodology can enhance the economic viability of energy efficiency measures ([37]). However, it is important to highlight that Member States are not required to consider these multiple benefits in their cost-optimal calculations, but are welcome to consider them, where sufficient data and resources are available.

Multiple benefits, appropriately quantified, might affect both microeconomic and macroeconomic level calculations.

([37]) A 2024 study from the BPIE discusses some of these multiple benefits (improved energy security, productivity gains, alleviating energy poverty, benefits for the grid) and introduces some potential quantification and monetisation approaches. BPIE (2024). *From cost savings to societal gains: rethinking the cost-optimal methodology*. Available at: https://www.bpie.eu/publication/from-cost-savings-to-societal-gains-rethinking-the-cost-optimal-methodology/

6.16.1 *Simplified methodology for the monetisation of some health and economic impacts of energy efficiency measures*

A simplified methodology for the accounting of **private and public health impacts** and **economic impacts** – that is to say, in terms of effects on gross domestic product (GDP) – of energy efficiency measures is here presented for Member States consideration in their cost-optimal calculations ([38]). Default data for Member States are also provided in case no country specific data are available.

In the framework of this simplified methodology, micro or private impacts are those associated with the actual use and value of a building. They are reflected in the dimension of private health (referring to mortality, morbidity, and wellbeing). Macro or societal impacts, on the other hand, are those linked to society as a whole. They are reflected by the category of public health. Economic impact in terms of GDP is considered at macroeconomic level only. Example for this category are actions that trigger increased economic activity: on the one hand, the positive effects of the production and construction activities linked to manufacturing or installing a certain product or system; on the other hand, the added societal value of individuals having less sick days, which needs to be differentiated from public health costs on macro level (for example, health treatment costs).

The methodology is based on scientific research data. However, there are limitations to the approach regarding its applicability for individual buildings. As implied by the methodology that provides a ranges of default data per floor area (m^2), it is only applicable to typical reference buildings with an average floor area. In order to avoid overestimating the impact of externalities, Member States could introduce a cap for large residential buildings (characterised by a significantly larger floor area than a typical reference building), based on typical constructions parameters. Especially for non-residential buildings such as offices, partial occupancy and absence at night-time and weekends need to be considered, as there are no users inside the building during that time.

Country-specific and individual data might deviate significantly from the default data , as – due to limited data availability – these are defined as average EU-level assumptions across Member States and building types.

Member States are free to use their own methodology to monetise health impacts, provided that all assumptions and sources for the evaluation are clearly indicated. Member States can also decide to add impacts other than the ones referred to for their calculations. A detailed list of bibliographical sources and references used as basis for the default data are provided to support these efforts, in sub-section 6.16.3.

The following table provides **default data for the monetisation** ([39]) of health and economic impacts. It differentiates by private and public domain and gives lower boundary and upper boundary datapoints in €/m^2y. The values are derived from recent studies and literature in order to show the bandwidth and sensitivity of available quantifications and monetisation methods (for example, the bandwidth for wellbeing ranging from 0.5-2.7 €/m^2y is significantly higher than for public health ranging from 1.0–1.8 €/m^2y). The methodology is designed to use the upper boundary impact, which is reduced then by further assumptions and factors during the calculation process (for this, refer also to the examples elaborated later in the sub-section 6.16.2).

Table 1

Default data for health and economic impacts

	Dimension	Calculation perspective	Lower bound	Upper bound
$C_{a, HL}$ (*)	Public health costs	Macro-economic	1.0 €/m^2y	**1.8 €/m^2y**

([38]) Instead of benefits, in this case, the methodology talks about "impacts": this means that health and economic impacts are always added in the global cost calculation, rather than being subtracted as "benefits". As this latter approach requires the definition of a reference (which is if at all only useful for renovations, but not for new buildings), the proposal is to include the impacts against a "zero" reference.

([39]) Sources for the upper-bound and lower-bound values in Table 1 derive from: European Commission. (2016). The Macroeconomic and Other Benefits of Energy Efficiency, available at: The Macroeconomic and Other Benefits of Energy Efficiency - European Commission. Copenhagen Economics. (2012). Multiple benefits of investing in energy efficient renovation of buildings Multiple benefits of EE renovations in buildings - Full report and appendix.pdf. Mzavanadze, N. (2018). Final Report: quantifying energy poverty-related health impacts of energy efficiency, D5.4 (final report) from COMBI.

	Dimension	Calculation perspective	Lower bound	Upper bound
	Private health (wellbeing)	Micro/Financial	0.5 €/m²y	**2.7 €/m²y**
	Private health (mortality, morbidity)	Micro/Financial	2.6 €/m²y	**5.6 €/m²y**
$C_{a, EC}$ (*)	Economic (GDP)	Macro-economic	0.2 €/m²y	**0.4€/m²y**

(*) to be added in the global cost equations at section 4, points 3 and 4 of Delegated Regulation (EU) 2025/2273

While Table 1 above refers to the general bandwidths for each dimension, the next step is to relate the impact of individual measures/packages/variants to the dimensions. This is done using the indications for **impact quantification** from Table 2. In order to quantify the impacts of all relevant measures (rows) on the different impact categories (columns), the measures are packaged in five clusters, respectively grouping measures impacting:

— the energy efficiency of the building envelope;

— the energy efficiency of technical building systems;

— the installation or improvement of a ventilation system;

— the introduction of renewable energy for heating and cooling;

— lighting.

General remark: All percentages below are based on findings from an extensive literature review. Examples are provided for the applicability of the percentages, but individual assumptions have to be made in each context. Member States have flexibility to identify those measures that they deem relevant to the calculation of health impacts, starting from the indication of this document.

The **energy efficiency of the building envelope** cluster comprises all measures that improve the quality of insulation and reduce the thermal conductivity and transmittance of opaque building envelope components like facade, roof, top floor ceiling, or cellar ceiling. In addition, the quality of transparent building elements (windows and roof windows) is also considered here. Maximum values (high reduction potential) in Table 2 (such as 30 % impact for public health or 60 % for economic) correspond to a new building or a renovation level to zero-emission building (ZEB) level as future-proof standard. In the case of a staged renovation or the replacement of individual components only, smaller factors should be considered, for example reflecting the percentage of components replaced compared to the whole envelope. For example, typical U-values for new buildings western European countries (but not only these countries) are in the range of 0.12–0.15 W/(m²K) for opaque building elements like façades or roofs and below 1.0 W/(m²K) for windows. For renovations, the values are typically slightly higher. These differ per Member State, hence no specific values are referenced here.

The **energy efficiency of technical building system**s cluster summarises all relevant measures that increase the efficiency of technical building systems for heating, cooling, hot water, or auxiliary energy (for example, fans, pumps). Examples could be the installation of new heating systems or distribution pumps or the replacement of an old inefficient boiler with a new more efficient one. While the energy efficiency of the system has a very limited impact on public health and on mortality and morbidity (mainly through improved outdoor air quality), the private wellbeing domain is affected to a higher degree. More efficient, reliable and stable heating systems can improve the wellbeing of the occupants significantly. Therefore, the bandwidth goes up to 30 % of impact – which would, for example, correspond to the replacement of a very old, decentralised oil, gas or coal boiler that cannot ensure constant indoor temperatures with a modern heat pump system including the installation of appropriate low-temperature heat distribution and control systems.

The **ventilation system** cluster includes all measures that primarily improve the ventilation rate of a building/building unit, in order to avoid mould and damp and improve indoor environmental quality. Efficiency improvements due to more efficient ventilation fans or the implementation of a heat recovery system should be accounted for in the technical building system energy efficiency package. Indoor air quality has medium to low impact on the wellbeing domain according to literature, but a medium effect on public health costs. The highest impact, however, exists in relation to morbidity and mortality (private health) and economic impact. Many studies show that many respiratory diseases can be prevented by avoiding mould and damp in buildings. In addition, ventilation systems ensure the proper levels of clean air (filtration of pollutants), given that an airtight envelope will reduce the natural air renewal rate. Installing ventilation systems in new or renovated buildings will have maximum impact if an appropriate ventilation rate (air exchange rate) can be reached. For residential buildings, this rate is typically defined between 0.2–1.0 air exchanges per hour (1/h), dependent on the individual rooms and usage profiles. Some rooms (such as bathrooms and kitchens) can have a higher ideal air exchange rate than other rooms but are also occupied for less time. For non-residential buildings, the air exchange rate can be significantly higher (for example, up to 20 1/h for laboratories, hospitals, or workshops).

All measures that increase the renewable energy share for technical building systems (for EPB services) should be considered under the **renewable heating/cooling systems** cluster. A typical example would be the installation of a heat pump. Maximum impact would be achieved by replacing a very old, decentralised oil, gas or coal boiler that cannot ensure constant indoor temperatures with a modern heat pump system including the installation of appropriate low-temperature heat distribution systems. Using renewable electricity for heating and hot water lowers the outdoor emissions of the building and therefore has a small impact on public health, private health (mortality, morbidity) and the economy. Individual wellbeing, however, could be improved more significantly when using renewable energy sources, as residents enjoy better living conditions compared to a pre-renovation situation, where old equipment is not able to ensure constant indoor temperatures. The possible overlaps with the cluster on energy efficiency of technical building systems should be considered here: wellbeing in this context is also related to a heating system that is supplying constant temperatures and, possibly, to a heat distribution system that is replaced/adapted to ensure low-temperature distribution, which typically provides higher comfort levels.

The **lighting** cluster considers all lighting-related measures improving the energy efficiency (such as replacement of fluorescent lighting with LED lighting) and the illuminance. Appropriate lighting conditions are essential to avoid damage to eyesight and mental illness. Therefore, impact is reported in the domains of private health and public health (for example, in form of higher spendings for medical/health treatments and health insurance). The maximum impact would be observed when replacing old compact fluorescent lighting (CFL) with low illuminance levels in a workplace with modern LED lighting that provides the desired level of illuminance.

For each dimension, Table 2 gives a default bandwidth for the impact range per package. These ranges are derived from a literature review within the technical background study on the review of the cost-optimal calculation methodology.

Table 2

Multiple impacts quantification (default ranges for reduction potential per cluster)

Relevant measures (cluster)	Public health costs	Private health (wellbeing)	Private health (mortality, morbidity)	Economic (GDP)
Energy efficiency of the building envelope	medium-low 10-30%	medium-low 10-30%	medium-low 15-35%	medium 30-60%
Relevant energy efficiency of technical building systems	low 5-10%	medium-low 10-30%	low 5-10%	low 5-10%
Ventilation system	medium 30-40%	medium-low 15-35%	high-medium 30-60%	high 40-60%

Relevant measures (cluster)	Public health costs	Private health (wellbeing)	Private health (mortality, morbidity)	Economic (GDP)
Relevant renewable heating/ cooling systems	low 5-10%	medium-low 10-20%	low 5-10%	low 5-10%
Lighting, where applicable	medium 30-40%	-	low 5-10%	-

Quantifying the impact according to Table 2 is a step where country- and building-specific considerations are expected to come into play. The experts conducting the calculations are invited to assign weights within the ranges in Table 2 to the relevant identified measures and packages of measures, based on their knowledge of the reference building and local specificities. It is important to mention, for example, that not all measures improving energy efficiency of technical building systems always have an impact on health. This is true in absolute terms, but also in relation to the reference building characteristics.

If all or most measures of a package are implemented, the impact reduction potential per package should be determined at the upper end of the bandwidth, while for individual measures or measures with little impact the lower end of the bandwidth should be assumed. The final quantification is up to the Member State, but the default ranges of Table 2 provides indication of what recent studies and literature conclude.

After having assumed all reduction potential (percentages), this needs to be added up to obtain the overall reduction potential per dimension (public health, wellbeing, mortality and morbidity, and GDP). However, the assumption on the overall reduction potential is capped at 95 % of the impact, as the remaining 5 % is assumed as default, even for very highly efficient buildings with a high energy performance (for example, zero-emission buildings).

That calculation has a lower impact in terms of global costs (and hence greater benefits are expected), when packages combining multiple measures are considered rather than when individual measures are considered separately. Slight differences in terms of indoor environmental quality among the analysed packages could also be captured in this calculation.

In the first step of the assessment, a **starting point for the calculation** needs to be defined as reference for the individual renovation activity or new building standard. One simple way of setting the reference is by determining the overall energy performance of the building assessed between the very worst-performing building in the stock (that is to say, equal to 100 % of multiple impacts) and a future-proof zero-emission building (equal to 5 % of multiple impacts). That way, the individual reduction potential that can be addressed by applying measures is set. As this simple approach does not take into account any individual characteristics of the buildings (for example, whether a ventilation system is included before renovation or not), a more detailed approach could be taken that considers the individual components before renovation (or for the standard new building) according to Table 2, analogue to the assessment of the impact quantification.

In order to give some specific guidance and show the application of the methodology, the following section provides some practical examples.

6.16.2 *Steps of the simplified methodology and applied example*

To monetise the health and economic impacts and calculate $C_{a,HL}$ and $C_{a,EC}$ for the equation of global costs referred to in Annex I, section 4, points 3 and 4 of Delegated Regulation (EU) 2025/2273, two separate methodologies are defined for renovation and new buildings.

For **renovation**, the first step (**A**) is the setting of the 'starting point' as a reference against which the impact of renovation is benchmarked.

The status of the existing building is therefore determined (sub-step **A.1**) by ranking the not yet renovated reference building in the national building stock between the very worst-performing buildings (where 100 % of the multiple impacts would be considered as the starting point) and the best case for an existing building, which typically would be a zero-emission building (where only 5 % of the multiple impacts would be considered).

The ranking could be based on a simple approach using the energy performance level or EPC class of the building, which does not account for all relevant characteristics of a buildings (such as, a ventilation system, which can significantly affect multiple impact calculation). An alternative approach could be based on the quantification of multiple impacts according to Table 2 (step B in this example). Once the starting point percentage is determined, it needs to be applied to the upper-bound value from Table 1 for each category (sub-step **A.2**). The outcome defines the starting point for the renovation and is the basis for reducing multiple impacts/externalities by renovation measures.

A. **Evaluation of the 'starting point': status of the existing building chosen as reference**

A.1. Ranking of reference building (non-renovated) between very worst-performing building (considering 100% of multiple impacts) and a building with 5% of multiple impacts (that is to say, close to a zero-emission building)

A.2. Application of the percentage to the maximum value of all multiple impacts (upper bandwidth), as listed in Table 1

A.3. Define outcome as 100% of multiple impacts for the reference building (see example below) as starting point for the renovation

Example: If the reference building ranking, based on 'distance' from worst-performing building and zero-emission building references, is 90%, this means that the upper-bound values from Table 1 are multiplied by 90% and added up. Overall, the multiple impacts add up to 9.4 €/(m^{2}y) for the not yet renovated building as a starting point for renovation.

— Public health costs	90% × 1.8 = 1.6 €/(m^{2}y)
— Health (wellbeing)	90% × 2.7 = 2.5 €/(m^{2}y)
— Health (mortality, morbidity)	90% × 5.6 = 5.0 €/(m^{2}y)
— Economic (GDP)	90% × 0.4 = 0.3 €/(m^{2}y)
= total impact before renovation	= 9.4 €/(m^{2}y)

In the next step (**B**), the **impact of the renovation measures** is determined. To do this, the renovation measures considered for renovation need to be identified (sub-step **B.1**). After that, the weighting percentages for each of the four impact categories need to be assigned according to Table 2 (sub-step **B.2**). For this step, the default data in the tables and the explanations provided in this section can help to identify the appropriate assumptions for the specific reference building in the national and local context. The next step is establishing the overall reduction potential for the renovation measure (sub-set **B.3**). This step consists of multiplying of the aggregated percentages of step B.2 by the starting point of step A. It allows for the calculation of the potential savings related to the measures compared to the reference building, which is a relevant information for Member States to have. Based on the individual reduction potentials per domain, the multiple impacts after renovation can be determined at the same level of detail (sub-step **B.4**).

B. **Evaluations of the impacts of the identified renovation measures**

B.1. Identifying the renovation measures considered

B.2. Assigning of the weighting percentages for each of the multiple impact categories (Table 2)

B.3 Establishing the reduction potential of the renovation for the multiple impacts

B.4 Calculating the multiple impacts remaining after renovation

Example: if the selected measures are 'energy efficiency of the building envelope' and 'ventilation system', this could mean that, for public health the impact of the specific measure is ranked in the middle of the category with 20 %, while for ventilation it is ranked on the lower side with 25 %. Overall, public health impacts can be reduced by 45 %. The same exercise needs to be done for private health and economic impacts.

— Public health costs	20% + 25% = 45%
— Health (wellbeing)	25% + 45% = 70%
— Health (mortality, morbidity)	40% + 50% = 90%
— Economic (GDP)	20% + 35% = 55%

For example, the 45% from step B.2 for the public health domain is multiplied by the starting point for public health from step A, which is 1.6 €/(m^2y). The same exercise needs to be done for private health and economic impacts. Overall, a total reduction potential of 7.2 €/(m^2y) can be determined for the individual renovation package.

— Public health costs	45% × 1.6 = 0.7 €/(m^2y)
— Health (wellbeing)	70% × 2.5 = 1.7 €/(m^2y)
— Health (mortality, morbidity)	90% × 5.0 = 4.5 €/(m^2y)
— Economic (GDP)	55% × 0.3 = 0.2 €/(m^2y)
= total reduction potential of renovation	= 7.2 €/(m^2y)

The public health costs before renovation are 1.6 €/(m^2y). The renovation reduces them by 0.7 €/(m^2y), which leads to remaining costs of 0.9 €/(m^2y). The same exercise needs to be done for private health costs and economics. Overall, the remaining multiple impacts after renovation amount to 2.3 €/(m^2y).

— Public Health costs	1.6 – 0.7 = 0.9 €/(m^2y)
— Health (wellbeing)	2.5 – 1.7 = 0.8 €/(m^2y)
— Health (mortality, morbidity)	5.0 – 4.5 = 0.5 €/(m^2y)
— Economic (GDP)	0.3 – 0.2 = 0.1 €/(m^2y)
= remaining impacts after renovation	= 2.3 €/(m^2y)

The final step is assigning the multiple impacts of renovation measures to micro and macro levels, starting the from information in Table 1. The public health and economic domains are under the macroeconomic level, while private health (wellbeing, mortality, morbidity) is assigned to the financial level as follows (step **C**).

C. **Assigning the multiple impacts of renovation measures to financial and macroeconomic levels**

Example:

Macroeconomic calculation:	$C_{a, HL}$ = 0.9 €/(m^2y);
	$C_{a, EC}$ = 0.1 €/(m^2y);
Financial calculation:	$C_{a, HL}$ = 0.8 + 0.5 = 1.3 €/(m^2y).

6.16.3 *Additional data sources for multiple benefits*

The box below gives an overview of the underlying studies and literature on the monetisation of multiple benefits, including health and economic impacts, which have been evaluated for the default data in Table 1 and Table 2. As the default data are presented only as Union average, Member States could use the data sources further research on individual country data.

The box below mentions a non-exhaustive list of sources for possible national datasets, including a list of additional information. However, the reported data may require some form of manipulation before they can be used in the cost-optimal calculation (for example, breaking down the data into appropriate units). In addition, the presentation of those default data does not necessarily guarantee accuracy or applicability, as some of the listed sources may only be useful in specific cases. The data may however be used as reference.

Please note, all the sources listed in the box below are discussed in the technical background study on the review of the cost-optimal calculation methodology.

Co-benefits of energy related building renovation – Demonstration of their impact on the assessment of energy related building renovation (Annex 56) (Ferreira et al., 2017): Presents findings from the International Energy Agency (IEA) Energy in Buildings and Communities (EBC) Programme Annex 56 on the identification of co-benefits related to building renovation. Monetised values for GDP are provided, including one-off and permanent annual benefits.

COMBI D2.7: Final quantification report (Thema & Rasch, 2018): Provides aggregated impacts and results for each Member State for various benefits such as avoided GHG emissions and air pollution, GDP, employment, public budget, avoided mortality, health impacts in disability-adjusted life years (DALYs), gain in active days.

COMBI D3.4: Quantifying air pollution impacts of energy efficiency (Mzavanadze, 2018) : Documents impact of air pollution on health.

COMBI D5.4: Final report: quantifying energy poverty-related health impacts of energy efficiency (Mzavanadze, 2018): Reports quantified and monetised values for various health benefits per Member State. Specifically of interest are the monetised values of avoided premature mortality due to reduced exposure to indoor cold and avoided morbidity due to reduced exposure to indoor dampness per Member State, where available. Value of a statistical life (VSL) and value of a life year (VOLY) are provided for each Member State, as well as excess cold weather mortality reduction potential values related to housing quality and retrofit depths.

COMBI D5.4a: Final report: Quantification of productivity impacts (Chatterjee & Ürge-Vorsatz, 2018): Various productivity and health impact results are presented per Member State (Figures 7-12, Tables 11-12).

COMBI D6.4: Macro-economy impacts of energy efficiency (Naess-Schmidt, et al., 2018): Specifies quantification and monetisation results for GDP, employment and public budget impacts per Member State.

Multiple Impacts Calculation Tool (MICAT) ([40]): Online tool enabling the analysis of multiple impacts of energy efficiency across different sectors and Member States. The user specifies various parameters, such as the time frame, and identifies building-related improvements (for example, building envelope improvements). Quantified and monetised values are then calculated for various social, environmental, and economic impacts.

Untapping multiple benefits: hidden values in environmental and building policies (Shnapp et al., 2020): Quantified and monetised values are provided for various multiple benefits (thermal comfort, lighting, indoor air quality, noise, reduction of air pollution, GHG impacts, employment effects, GDP, public budget, health and wellbeing, and productivity), which are summarised from other prominent studies (for example, COMBI).

Multiple benefits of energy renovations of the Swedish building stock (Copenhagen Economics, 2016): Provides results for calculated benefits, including health, CO_2, economic activity, and public budget impacts relevant in the Swedish context.

([40]) https://micatool.eu/seed-micat-project-en/index.php.

Alleviating Fuel Poverty in the EU (BPIE, 2014): Examples and case studies include estimates on health, wellbeing, employment and GHG reduction impacts that could be used as reference on case-by-case basis.

Poor indoor climate, its impact on child health, and the wider societal costs (RAND, 2019): The study uses data on housing deficiencies from the EU-SILC database and the Global Burden of Disease database to estimate children's exposure and related health implications of various housing deficiencies. The burden of disease from indoor damp exposure is also quantified. Finally, monetised values for cumulative and average economic gains associated with the reduction of children's exposure to damp and mould and GDP effects of improving ventilation rates are provided. All values are provided per Member State.

The Macroeconomic and Other Benefits of Energy Efficiency (European Commission, 2016): GDP, employment impacts, public budgets, building asset value, health impacts and environmental impacts are addressed. Estimates for the various impacts based on the scenarios are reported for the whole EU and in many cases, also per Member State.

Multiple benefits of investing in energy efficiency renovation of buildings (Copenhagen Economics, 2012): Employment, public finances, GDP, and health impact results are presented based on a low and high energy efficiency scenario, which correspond to investment costs, and are generally reported at EU level.

Poor indoor climate: its impact on health and life satisfaction, as well as its wider socio-economic costs (RAND, 2022): Data from the EU-SILC database and from the World Health Organisation is used to quantify and monetise values related to the impact of noise, light, air quality, and thermal comfort. Specifically, healthcare costs attributable to living in damp or dark housing conditions are provided as well as monetised values for wellbeing losses (individual and aggregated) associated with indoor climate risks. All values are reported per Member State and for the whole EU.

Building 4 People: Quantifying the benefits of energy renovation investments in schools, offices and hospitals (Kockat et al., 2018): Details the health, wellbeing, and productivity impacts of indoor environmental quality as it relates to schools, offices, and hospitals, including quantified values.

Healthy and Efficiency Retrofitted Buildings (HERB) tool ([41]): Excel-based modelling tool for estimating environmental, socio-economic, and health benefits of building retrofits, which can be used to produce quantitative estimates for multiple benefits of investing in building retrofits.

Integrated seismic and energy renovation of buildings ([42]): Guidance and data covering i) the review of renovation technologies, ii) a methodology to assess the benefit of combined renovation throughout the life cycle, iii) regional impact analysis integrating energy performance, seismic risk and socioeconomic aspects, iv) impact of renovation scenarios, v) review of implementing measures and good practices. The analysis covers residential buildings at NUTS-3 level in all EU Member States.

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

7.1 The concept of cost optimality

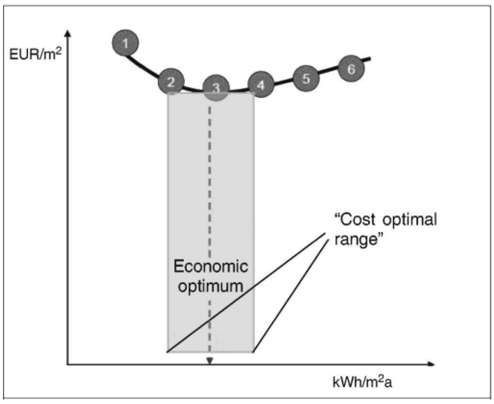
Based on the calculations of primary energy use (step 3 of the cost-optimal methodology framework detailed in Annex I to Delegated Regulation (EU) 2025/2273) and global costs (step 4) associated with the different measures/packages/variants (step 2) assessed for the defined reference buildings (step 1), graphs can be drawn per reference building that describe total primary energy use (x-axis: kWh primary energy/(m^2 reference floor area and year)) and global costs (y-axis: EUR/m^2 reference floor area) of the different solutions.

([41]) https://www.c40knowledgehub.org/s/article/Healthy-and-Efficient-Retrofitted-Buildings-Tool-HERB?language=en_US.
([42]) https://publications.jrc.ec.europa.eu/repository/handle/JRC132940 and https://buildings-renovation-makerspace.jrc.ec.europa.eu.

From the number of measures/packages/variants assessed, a specific cost curve can be developed (shown by the lower border of the area marked by the data points of the different variants).

Figure 4

Cost categorisation according to the framework methodology ([43])



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.

In the same way, graphs can also be drawn for emission performance (x-axis: kg CO_2-emissions/(m^2 reference floor area and year)) and global costs (y-axis: EUR/m^2 reference floor area), to supplement considerations in terms of total primary energy. Such a graph may be used to introduce further requirements in terms of operational emissions that Member States might want to introduce to complement primary energy considerations (e.g. to exclude solutions resulting in the cost-optimal range of the total primary energy graph, but with significantly higher operational GHG emissions than the other solutions pertaining to that range).

As stipulated in section 6 of Annex I, point 2 of Delegated Regulation (EU) 2025/2273, if packages have the same or very similar costs, the package with the lower primary energy use (left of the cost-optimal range) should if possible guide the definition of the cost-optimum level.

NB 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 drawn up show the performance (x-axis, for example, in W/(m^2K) for building elements like the roof of a building) and global costs (y-axis, in EUR/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 (the left border of the cost-optimal range) should guide the definition of the cost-optimal level (possible higher upfront investment needs should be taken into account).

([43]) 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.

It is important to note that minimum performance requirements for boilers and other installed appliances and equipment are being set under Regulation (EU) 2024/1781 of the European Parliament and of the Council ([44]) and existing measures adopted pursuant to Directive 2009/125/EC of the European Parliament and of the Council ([45]).

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 for the total primary energy. Therefore, the current regulations need to be applied to the reference building, leading to a calculation of the total primary energy consumption of the building according to the rules set out in step 3 of the calculation methodology framework in Annex I to Delegated Regulation (EU) 2025/2273.

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

Identification of the gap

Gap % (reference building level) = (current minimum performance requirements [kWh/m^{2}a] – cost-optimal level [kWh/m^{2}a]) / cost-optimal level [kWh/m^{2}a]) × 100 %

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

Gap % (for building elements) = (current minimum performance requirements [unit of performance indicator ([46])] – cost-optimal level [unit of performance indicator]) / cost-optimal level [unit of performance indicator]) × 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 weighting factor representing the relative importance of one reference building (and its requirements) in a Member State over another. However, such an approach should be made transparent in the reporting to the Commission.

In line with recital 18 of Directive (EU) 2024/1275, a significant discrepancy between the outcome of the cost-optimal calculation and the minimum requirements currently in force in a Member State exists if the latter are at least 15 % less efficient than the cost-optimum. For example, the current minimum performance requirement is 120 kWh/m^{2}y and the cost-optimal level identified is 100 kWh/m^{2}y. In this instance, the gap is 20%, so higher than 15%, which means that the minimum energy performance requirement in force needs to be adjusted. Vice versa, if the current minimum performance requirement is 100 kWh/m^{2}y and the cost-optimal level identified is 120 kWh/m^{2}y, the gap is negative, so no changes are required.

Article 6(3) of Directive (EU) 2024/1275 states that if minimum energy performance requirements in force in a Member State are less energy-efficient than cost-optimal levels of minimum energy performance requirements by more than 15 %, the Member State concerned is to adjust the minimum energy performance requirements in place within 24 months of the results of that comparison becoming available. This coincides with the delivery date of the cost-optimal report to the Commission.

([44]) Regulation (EU) 2024/1781 of the European Parliament and of the Council of 13 June 2024 establishing a framework for the setting of ecodesign requirements for sustainable products, amending Directive (EU) 2020/1828 and Regulation (EU) 2023/1542 and repealing Directive 2009/125/EC (OJ L, 2024/1781, 28.6.2024, ELI: http://data.europa.eu/eli/reg/2024/1781/oj).

([45]) 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 (recast) (OJ L 285, 31.10.2009, p. 10, ELI: http://data.europa.eu/eli/dir/2009/125/oj).

([46]) For example, U-value of the roof (W/m^{2}K).

8. SENSITIVITY ANALYSIS

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

Therefore, pursuant to Delegated Regulation (EU) 2025/2273 sensitivity analyses are to be undertaken by the Member States. Member States are 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-optimal calculations.

For the sensitivity analysis on the discount rate for the macroeconomic calculation, one of the discount rates is to be set at 3 % ([47]) expressed in real terms. Lower rates (0-3 %) are recommended to support building renovation projects and encourage deep renovation. Member States have to determine the most appropriate discount rate for each calculation once the sensitivity analysis is performed. That discount rate is the one to be used for the 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 any other input factor deemed to have significant influence on the result (for example, primary energy factors, future changes in climate conditions).

Although it is true that future price development will not affect the upfront investment costs that occur at the start of the calculation period, the assessment of 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.

([47]) This rate is recommended in the Commission's Impact Assessment Tool (Better Regulation Toolbox 2023, Tool #64, Discount Factors) for social discount rates, allowing economists to place a present value on the future costs and benefits of projects that are intended to provide a societal benefit.