Implementing the cost-optimal methodology in EU countries – lessons learned from case studies

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The recast Energy Performance of Buildings Directive (EPBD, 2010/31/EU) requires Member States to introduce minimum energy performance requirements for buildings, building elements and technical building systems and set these requirements based on a cost-optimal methodology. However, the relevant regulation and guidelines developed by European Commission provide Member States with a very large degree of flexibility on how to implement the cost-optimal methodology at national level. The report presents the findings of the latest study (BPIE, 2013) carried out by Buildings Performance Institute Europe providing practical examples of cost-optimal calculations in EU countries. The study serves as additional guidance to Member States on the cost-optimality process and on how to use the methodology relating to nearly Zero-Energy Buildings (nZEB) requirement and long-term climate goals.

Introduction to EPBD Cost-Optimality

According to EPBD recast, Member States (MS) must set minimum energy performance requirements for buildings and building elements with a view to achieving cost-optimal levels. As "cost-optimal" level is defined the energy performance level which leads to the lowest cost during the estimated economic lifecycle. The cost-optimal methodology introduces - for the very first time - the prerequisite to consider the global lifetime costs of buildings to shape their future energy performance requirements. Thus, the evaluation of buildings' requirements will not anymore be related only to the investment costs, but will additionally take into account the operational, maintenance, disposal and energy saving costs of buildings.

The relevant legal document providing the frame is the EU Commission's *Cost-Optimal Delegated Regulation* (EC, 2012a). To support MS, this regulation is accompanied by *Guidelines* (EC, 2012b) outlining how to apply the framework to calculate the cost-optimal performance level. MS must report their level of energy requirements to the Commission at regular intervals of maximum five years, with the first report due by March 21, 2013, one year after Regulation's announcement.

Aims and methods of the study

Despite the general framework and guidelines provided by European Commission, a very large degree of flexibility has been given to MS regarding the selection of

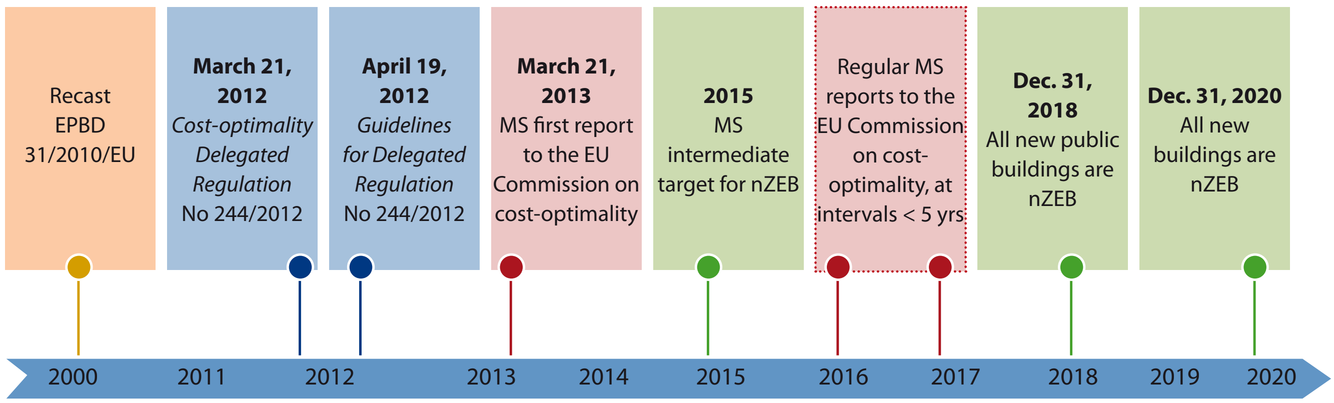


Figure 1. Implementation timeline for cost-optimality and nearly Zero-Energy Buildings' requirements of EPBD.

input data and the necessary assumptions for the cost-optimal calculation. Therefore, the BPIE study (BPIE, 2013) aims to provide additional guidance by delivering calculation examples for new residential buildings in Austria, Germany and Poland. Implications of using different values for key factors of the calculation (discount rates, simulation variants/packages, costs, energy prices) are also highlighted. Moreover, the study presents the advantage of considering ambitious packages of measures towards nearly zero-energy levels and to evaluate the carbon emissions in the light of long-term climate goals.

The cost-optimal calculations for the three countries considered in this study were elaborated by a group of local experts with a strong expertise in the field of energy efficiency and cost-optimality.

The calculations followed the steps indicated by the *Cost-Optimal Regulation* (EC, 2012a). Consequently, all three cost-optimal calculations were based on several common assumptions, while different national contexts and actual approaches were applied where relevant. The calculations were performed for both financial and societal/macro-economic perspectives, as required by the *Cost-Optimal Regulation* (EC, 2012a).

The cost-optimal evaluations were done only for new residential buildings, i.e. for single-family buildings (SFH) and/or multi-family buildings (MFH).

The calculations were implemented for packages of measures that comprise the actual buildings' standards as reference and several improved thermal performance and several heating & ventilation variants, including renewable energy options. Among the calculated packages of measures, there were some very ambitious ones towards nZEB levels.

Links with nearly-Zero Energy Buildings and long-term climate targets

According to EPBD, from 2020 onwards new buildings that will be constructed within EU have to be at 'nearly zero-energy' levels. At the same time, the *Cost-Optimal Regulation* (EC, 2012a) for adapting the energy performance requirements in the MS building codes will have to be applied from 2013. Therefore, it is recommended to use the cost-optimality methodology for new buildings, in order to identify and address the further implications of implementing requirements for nearly zero-energy buildings.

More specifically, the implementation of cost-optimality nowadays can offer an early evaluation of the existing gaps to be filled-in over the following years. By evaluating packages of insulation and heating variants leading towards nZEB levels, it will be possible to spot three types of potential gaps that have to be filled by 2020:

- Financial gap, i.e. the actual cost difference between cost-optimal and nZEB levels;
- Energy performance gap, i.e. the difference between primary energy at cost-optimal and nZEB levels;
- Environmental gap, i.e. the difference between associated CO_2 emissions to primary energy at cost-optimal and nZEB levels, the latter aiming also to nearly zero-carbon emissions (or < 3kg $CO_2/m^2/yr$), as it was suggested in a previous BPIE study (BPIE, 2011).

Cost-Optimal calculations for Austria and Germany

The cost-optimal calculations implemented under the scope of this study were focused on Austria, Germany and Poland. However, this paper presents indicatively only the results for Austria and Germany.

Table 1. Overview of parameters used for the sensitivity analysis for Austria.

Parameter	Value for basic calculation	Value for sensitivity analysis
Sens1: Cost of environmental damage	0 EUR/t CO_2	Carbon price according to recommended values by the C-O Regulation Annex II
Sens2: Energy price development	2.8 % p.a.	4 % p.a.
Sens3: Discount rate	3.0 % p.a.	1.0 % p.a.
Sens4: Discount rate and energy price development	3.0 % p.a. 2.8 % p.a.	1.0 % p.a. 4.0 % p.a.
Sens5: Investment cost		Reduction of difference costs between variants (due to regional cost differential)
Macro1: Macroeconomic-perspective 1	Discount rate 3.0% p.a. Energy price 2.8% p.a. VAT included No subsidies 0 EUR/t CO_2	Discount rate 1.0% p.a. Energy price 2.8% p.a. No tax No subsidies Carbon price according to recommended values by the C-O Regulation Annex II
Macro2: Macroeconomic-perspective 2	Discount rate 3.0% p.a. Energy price 2.8% p.a. VAT included No subsidies 0 EUR/t CO_2	Discount rate 1.0% p.a. Energy price 2.8% p.a. No tax No subsidies Carbon price according to recommended values by the C-O Regulation Annex II
Macro3: Macroeconomic-perspective 3	Discount rate 3.0% p.a. Energy price 2.8% p.a. VAT included No subsidies 0 EUR/t CO_2	Discount rate 1.0% p.a. Energy price 4.0% p.a. No tax No subsidies Carbon price according to recommended values by the C-O Regulation Annex II

The cost-optimal calculation for **Austria** was done for a newly constructed multi-family residential building. Altogether, 50 different technical variants were defined, with differentiations in thermal quality of the building envelope, window area, heat supply and ventilation systems. In addition, a series of sensitivity analyses was conducted in order to check the reliability and stability of the results of the baseline scenario. With the sensitivity analysis the impact of important framework conditions, such as the discount rate or the energy price development, was tested.

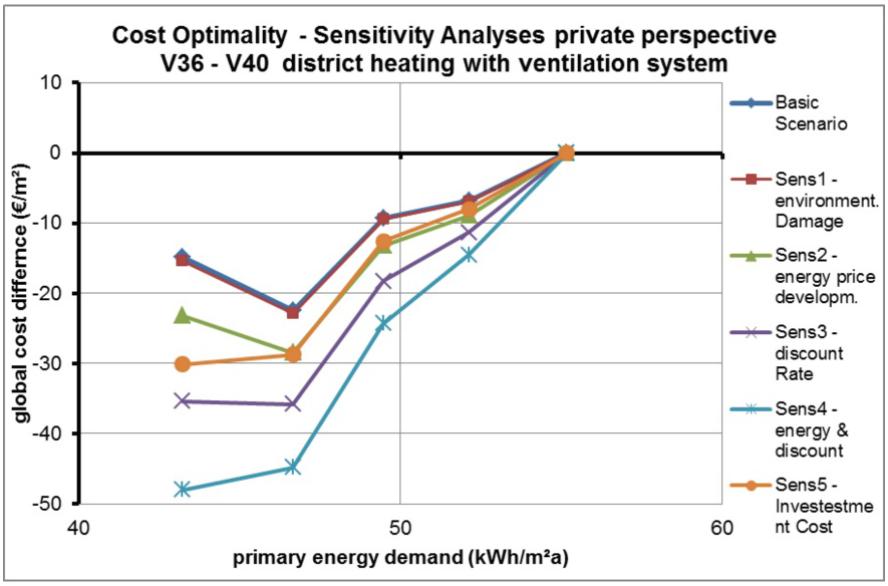
Table 1 summarises the variants considered in the sensitivity analysis for Austria.

Figure 2 shows an example of the results for the variants with district heating and ventilation systems.

The top diagram (**Figure 2**) presents the results regarding the private investor's perspective (financial calculation) (basic scenario compared to Sens1 to Sens5), while the figure on the bottom presents the results related to the macro-economic perspective (Macro1 to Macro3).

In short, the results showed that the influence of the tested input parameters was almost insignificant, mainly concerning the form of the cost curve and remarkable shifts of the cost optimum. It should be stressed that the cost curves are still very shallow. From the influence factors tested (and considering the assumptions taken), the most important factor seems to be the discount rate (Sens4); however, the assumed cost differences related to different qualities are also important (Sens5). The sensitivity analyses related to the macroeconomic perspective (Macro1 to Macro3), with a combination of low discount rate, exclusion of VAT and inclusion of CO_2-cost, show an improvement of the cost curve, mainly regarding the most efficient solutions – i.e. the variants with the lowest primary energy demand and lowest CO_2-emissions.

Overall, the implementation of the cost-optimal calculations for Austria -which are thoroughly presented on the relevant case study report (BPIE & e7, 2013) - proved that the actual building requirements are very close to the cost-optimal levels for new MFH. However, a tightening of the current building code of 15%-22% will be required when considering other heating methods (including solar heating) than district heating, which was considered in the reference case.



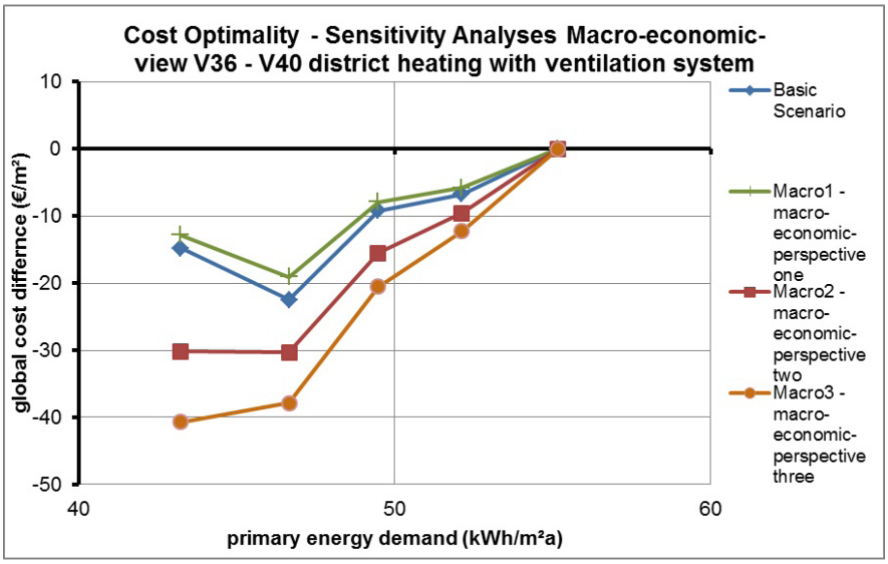


Figure 2. Results of the sensitivity analyses for the variants with district heating and ventilation system.

Moreover, the cost-optimal calculations for Austria included several packages of measures at very low-energy levels, with primary energy demand between 30-50 kWh/m²/yr. Compared to typical rent levels in multi-family houses (7-10 €/m² on average) and the levels of operating cost (0.50-1.50 €/m² except energy), the global cost differences between actual building requirement standards and those close to nZEB levels do not exceed 0.15 €/m² and many of the highly efficient variants are closer to the cost-optimum. Among the packages of measures at low-energy levels, some have significantly low CO_2 emissions or even negative CO_2 balance due to the overcapacity of renewable energy generation.

For **Germany**, cost-optimal calculations were done both for single-family and multi-family buildings. In total, 72 different packages of measures were used, including several thermal insulation and heat supply variants. A sensitivity analysis was performed on exemplary discount rates and energy price development scenarios.

Table 2. Important findings and recommendation for the cost-optimality calculation.

Reference Buildings	• Have to be **representative of the existing building stock** and **new buildings** in each country; • With simple geometries; • **Reproducible** in practice;
Selection of packages of measures	• Number of calculated packages have to be **at least 10** in addition to the reference case, which reflects actual regulations; • **Very ambitious packages** of measures should also be considered to provide an estimation of the financial and environmental implications of upcoming **nZEB** requirements;
Methodology and framework conditions	• Calculation based on **primary energy**; • Harmonized with the **European Standards**; • **Accurate conversion factors** and periodically updated;
Costs of materials, work and equipment	• Lack of accurate information of the costs in MS; • Scarce and not consistently collected data; • **Databases should be developed** and open to periodical scrutiny of main stakeholders;
Discount rates and energy prices development	• The energy prices development as well the relation with discount rate influence the global costs calculation and may slightly shift the cost-optimal point

A sample of the results of cost-optimal calculations at financial perspective is presented on **Figure 3**.

The calculation results are summarised in the followings:

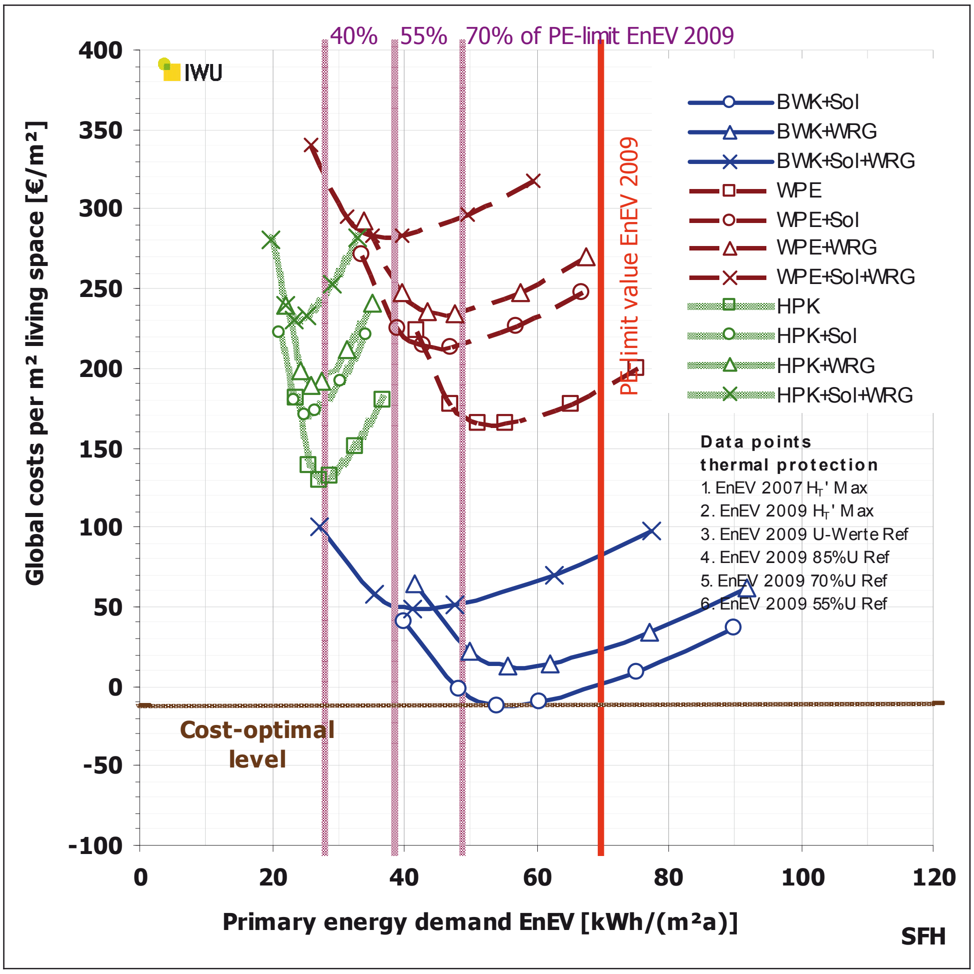
- The cost-optimal level for both SFH and MFH is represented by a package composed by thermal insulation standard with U-values at 85% of the EnEV 2009 for reference building, combined with a condensing boiler and with solar heating system (4th data point of the curve – BWK+Sol / primary demand approx. 53-54 kWh/m²yr).
- Packages based on combinations of thermal insulation measures with wood pellet boilers (curves with green colour) or electric heat pumps (curves with brown colour) have nearly comparable global costs for both SFH and MFH. The global costs are nevertheless higher than those of packages including condensing boilers (curves with blue colour), but the primary energy demand values are lower, especially for heat supply systems with wood pellet boilers. The global cost differences are more significant for the SFH than in the MFH (due to lower investment costs per sq. meter for wood pellet boilers and electric heat pumps in the MFH).
- The current minimum energy performance requirements of EnEV 2009 for new buildings (vertical red line in the graph) do not yet achieve the cost-optimal levels. Compared to EnEV 2009, the cost-optimal levels lead to decreases of the global costs by about 12 €/m² (SFH) and 8 €/m² (MFH).
- On the whole, the extensive implementation of cost-optimal calculations in Germany -which can be found on the relevant case study report (BPIE & IWU, 2013) -proved that a tightening of current building requirements of approximately 25% is possible. German government has already adopted a plan to achieve this tightening in two steps, each by 12.5%.

Furthermore, for Germany, it has been assumed that the future nZEB definition will be close to the German national standard for energy in buildings, 'KfW Effizienzhaus 40'(kfW, 2012), which is the most ambitious level of the federal grant programme for new buildings. Compared to typical construction costs for new buildings in Germany (1300 €/m²), the additional global costs range between 2 and 8 % for the packages of measures towards nZEB. The CO_2 emissions associated to these packages of measures are in the range of 4.2 to 9.5 kg/m²/yr for both SFH and MFH.

Recommendations and conclusions

Finally, **Table 2** summarizes important findings and recommendations concerning the main implementation steps of the calculation and the selection of the most influential factors.

Overall, cost-optimal methodology causes a paradigm shift in building assessment methods: from considering only the investment costs to assessing the lifetime costs of a building. Cost-optimal methodology may be used as an opportunity to timely evaluate and facilitate the upcoming introduction of nZEB in EU as well as



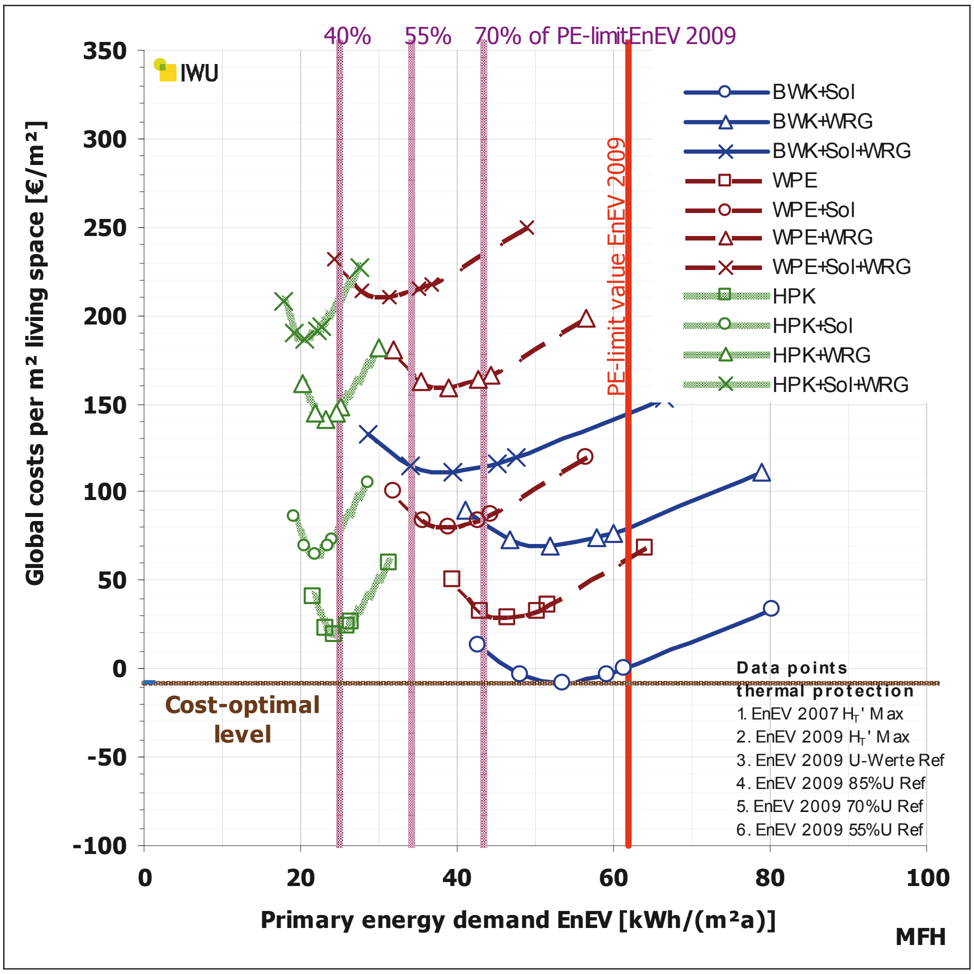


Figure 3. Global costs for SFH and MFH for all heat supply systems (baseline scenario, medium energy price development).

to increase consistency between buildings policies and long-term climate goals. However, all these potential benefits may be endangered by a poor implementation of cost-optimality among MS. To avoid this, there is a need for more guidance, best practices exchange between MS representatives and experts and awareness rising among stakeholders and citizens concerning the benefits of having ambitious buildings policies and regulations.

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