CEN-CE training on EN 15459 on economic evaluation procedures

The CEN-CE project introduces a training and certification of experts on several EPB standards. One of them is EN 15459-1:2017 for economic evaluation procedures. The main aim of this standard is support for designers, building owners and managers in the decision making process on energy related investment and finding the cost optimal solution. The CEN-CE training provides the overview of the methodology, basic principles and gives recommendations for practical use of this standard with caution for risk mitigation by consideration of different scenarios for most influencing input parameters.

Keywords: economic evaluation, global cost, payback period, EPB Standards, energy performance of building

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EN 15459 as a tool for economic evaluation for energy related investments

EN 15459-1:2017 provides a method for economic evaluation procedures for building, building components and energy systems. The aim of this standard is the support for the decision taking on technologies applied in building construction and renovation process and help to find the cost optimal solution by aggregation of present and future costs in two main indicators described in this standard that are:

- global costs
- payback period of investment.

Global costs are the sum of the present value of the initial investment costs, annual running costs and replacement costs referred to the starting year as well as disposal costs if applicable. If the lifespan of the last replacement cost exceeds the end of calculation period, the final value of a component at the end of calculation period is determined and referred to the beginning of the calculation period. The global costs approach allows to find the optimal option from comparison of unlimited number of solutions.

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Payback period is the time when the investment costs are balanced with the monetary savings occurring. The payback period is used to compare the cost efficiency of investment against the reference case. Usually the solution under consideration is compared to a reference situation that can be situation before investment in case of renovation or the minimum requirements in case of new building construction. EN 15459-1:2017 provides calculation for the discounted payback period.

The potential applications of the methods described in the EN 15459-1 are:

- evaluation of economic performance of an overall design of the building,
- evaluation of economic feasibility of specific energy related investment,
- comparison of energy saving options and finding the cost efficient and cost optimal solutions.

An important part of this standard is the informative data for components provided in Annex D referenced also by the Commission delegated regulation (EU) No. 244/2012 supplementing EPPBD for calculating **cost-optimal levels** of minimum energy performance requirements for buildings and building elements. EN 15459-1 after revision in 2017 is in line with this Regulation in terms, definitions and calculation methodology and therefore this training could also support the cost optimal level of energy performance calculation by national authorities.

The informative data for components provided in Annex D and referenced in Regulation No. 244/2012 are:

- the life span of components in years (Min – Max),
- annual maintenance cost (% of initial investment),
- disposal cost (% of initial investment).

Connection with other EPB standards is based on delivered energy per energy carrier calculated according to Overarching standard EN ISO 52000-1 that is input for energy costs calculation. For finding the cost optimal solution also link with the primary energy calculated according to EN ISO 52000-1 is recommended.

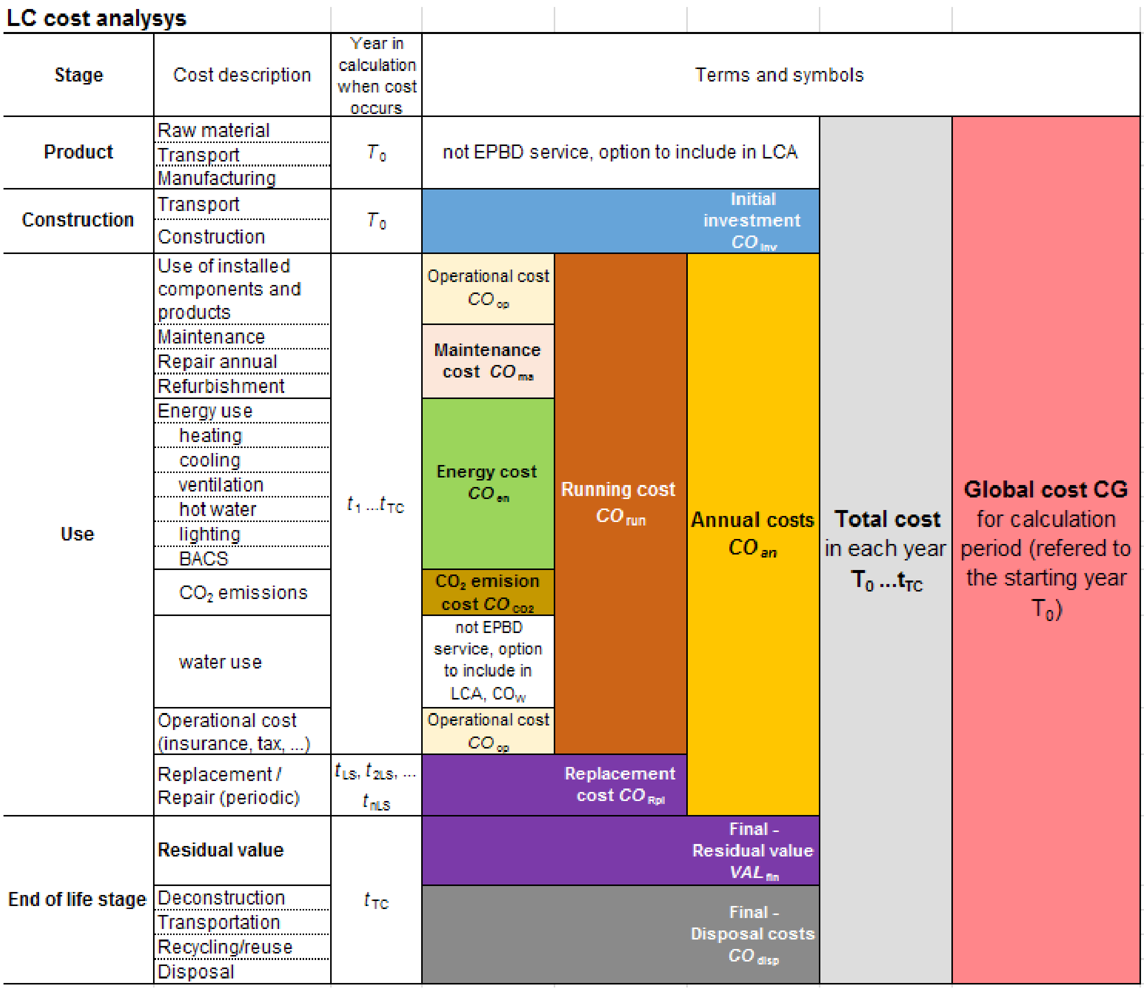


Figure 1. The structure of costs considered for economic evaluation of energy related investment.

The CEN-CE training materials

The CEN-CE teaching materials on EN 15459 are focused on presentation and understanding of:

- the structure of data considered in economic calculation;
- required inputs;
- calculation method (formulas);
- resulting outputs;
- recommendation for interpretation of results, reporting and use in design practice.

The specific of this standard is wide variety of level of detail and uncertainty of some inputs as it presents an aggregation of present and future costs over a long calculation period (20 – 50 years). Therefore, the reporting and interpretation of the results needs special attention. Sensitivity analysis on most important inputs and consideration of different scenarios for future development is recommended in CEN-CE training for practical use of this standard and failure risk mitigation.

The structure of the costs considered in calculation are detailed in **Figure 1**. They are in line with the Commission delegated regulation (EU) No. 244/2012 for calculating **cost-optimal levels** of minimum energy performance requirements.

The flowcharts help to understand the calculation steps (**Figure 2**) and the spreadsheet allows the demonstration of calculation and influence of different input parameters.

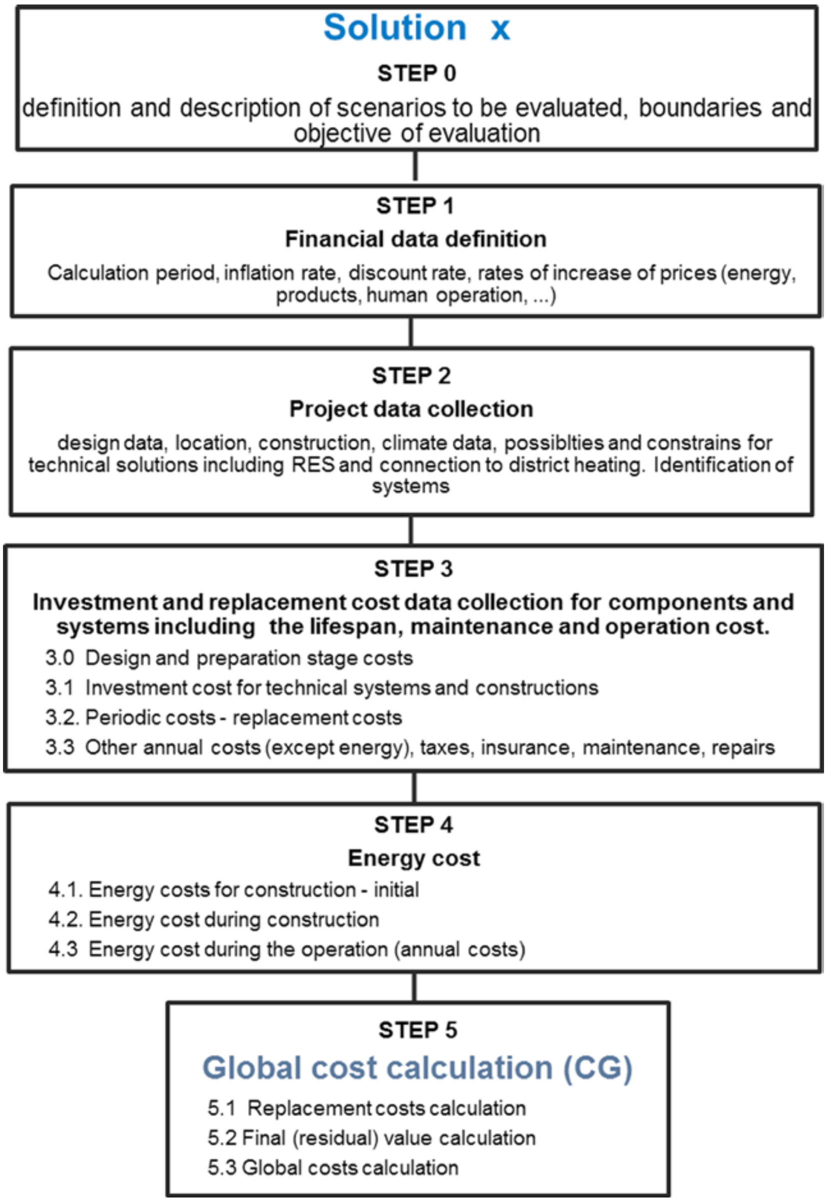


Figure 2. Example of flowchart for calculation of global costs.

Example of definition and presentation of input data in spreadsheet is shown in **Figure 3** and of output in **Figure 4**.

Input parameters, scenarios and boundaries

All input data shall be consistent and shall be based on local conditions at the time of the analysis. Some optional informative default values and options can be presented in National Annex A if it exits or default inputs for CEN option can be find in Annex B to standard.

The description of scenarios (solutions) under consideration with the boundaries specification is needed before input data collection. The **scenarios** have to be defined and described by:

- the time (duration) of calculation (whole life cycle, economic lifespan);
- physical limits (whole building, part of the building, only building system);
- costs considered (overall costs, only selected specific cost items for specific systems or products);
- financial data (discount rate, inflation)
- evolution of prices (energy, products, services, human operation)
- scenarios for maintenance and replacement cost

Sensitivity on most influencing parameters

Economical results are closely related to the project under consideration. The NZEB are costly and the potential solutions to achieve NZEB should be carefully evaluated. The sensitivity of results increases depending on the complexity and number of parameters taken into account in calculation and it may be difficult to come to the conclusion.

Part of CEN-CE training is focused on the sensitivity analysis for the most influencing input parameters with important uncertainty. The CEN–CE certified expert

Initial investment and periodic cost (replacement, substitute investment that is necessary for age reasons according to their lifespan)

Variant 1 Current stage Var 0 Average thermal insulation, condensing boiler

Description	Building envelope - specific information data										
		Walls		Roof		Floor, basement ceilings		Internal partitions		Windows	Total (envelope) €
Lifespan (years) LS =	LS =	30	LS =	20	LS =	30	LS =	20	LS =	20	
Price evolution rate RAT_{pr} =	RAT_{pr} =	1.0%	RAT_{pr} =	0.0%	RAT_{pr} =	0.0%	RAT_{pr} =	0.0%	RAT_{pr} =	0.0%	
Maintenance cost (rate from investment) RAT_{ma} =	RAT_{ma} =	1.0%	RAT_{ma} =	1.0%	RAT_{ma} =	1.0%	RAT_{ma} =	1.0%	RAT_{ma} =	1.0%	
Disposal cost (rate from investment) RAT_{disp} =	RAT_{disp} =	1.0%	RAT_{disp} =	1.0%	AT_{disp} =	1.0%	RAT_{disp} =	1.0%	RAT_{disp} =	1.0%	
Initial investment cost CO_{inv}	CO_{inv} =	**7 000**	CO_{inv} =	**4 800**	CO_{inv}	**5 000**	CO_{inv} =	**0**	CO_{inv} =	**1 700**	**18 500**

Figure 3. Example of input data in spreadsheet.

Presentation of results

	B	C	D	G	H	I
3	**Solution 1**			**Solution 2**		
4	Average thermal insulation, condensing boiler		**Var 0**	Thermal insulation (CO level), condensing boiler		**Var 1**
5	Reference floor area A_{ref}=	105.00	m^2	Reference floor area A_{ref}=	105.00	m^2
6	Calculation period t_{TC}	50	years	Calculation period t_{TC}	50	years
7	Discount rate RAT_{disc}	3%		Discount rate RAT_{disc}	3%	
8	Macro / micro economic (with / without CO2)	**macro**		Macro / micro economic (with / without CO2)	**macro**	
9	Energy (gas, electricity) price evolution =	2.0%		Energy (gas, electricity) price evolution =	2.0%	
11	Primary energy PE (with export)	**232**	$kWh/(m^2.a)$	Primary energy PE (with export)	**158**	$kWh/(m^2.a)$
12	Global costs *CG*	**143 907**	€	Global costs *CG*	**128 716**	€
13	Unitary Global Cost	**27.4**	€/m^2	Unitary Global Cost	**24.5**	€/m^2
15	**Results**	Solution 1		**Results**	Solution 2	
16	$CO_{INIT\ Initial}$ Investment	21 800	**8%**	$CO_{INIT\ Initial}$ Investment	28 200	**12%**
17	CO_{per} Periodic, replacement investment	28 134	**10%**	CO_{per} Periodic, replacement investment	34 209	**14%**
18	CO_{ma} Maintenance cost	12 550	**4%**	CO_{ma} Maintenance cost	15 500	**6%**
19	**CO_{op} Operation (insurance, tax, servicies)**	10 900	**4%**	**CO_{op} Operation (insurance, tax, servicies)**	14 100	**6%**
20	CO_{en} Energy cost (subtracted income from export)	187 510	**67%**	CO_{en} Energy cost (subtracted income from export)	133 476	**56%**
21	CO_{CO2} External GHG Cost	19 451	**7%**	CO_{CO2} External GHG Cost	13 199	**6%**
22	CO_W water use cost (optional - not EPBD	0	**0%**	CO_W water use cost (optional - not EPBD	0	**0%**
23	COdisp Disposal cost	687	**0%**	COdisp Disposal cost	851	**0%**
24	Sum of costs for calculation period	281 032		Sum of costs for calculation period	239 535	
25	Sum of earnings from exported energy	0		Sum of earnings from exported energy	0	
26		5 621	€/year		4 791	€/year

Interface_1 | Interface_2 | Method_input_1 | Method_input_2 | Method_calculation_1 | Method_calculation_2 | Method_output | **Output_interface**

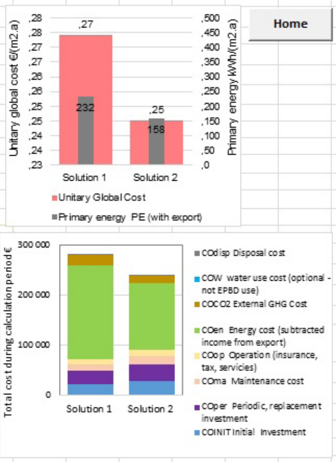


Figure 4. Example of method output presentation in spreadsheet for economic evaluation for two options.

should be aware about the dependency of the results on a good estimation of all input parameters used in calculation with regards to their future developments (e.g. the prices evolution).

The different scenarios consideration is recommended to be calculated and presented as the results. This will allow the risk mitigation of uncertainty of input data e.g. by consideration of the most-likely, optimistic and pessimistic scenario. The most influencing parameters and choices in economical evaluation to be considered are:

- the discount rate (lower highlights benefits from the investment in energy savings);
- prices of energy carriers (must be consistent for a place and time of the calculation);
- the evolution of energy prices (increase will favour the energy related investment);
- lifespan of components that indicates the period for replacement and new investment needed. Cheaper product may have a shorter lifespan and could lead finally to higher global costs. Correct and consistent way of estimation of life span of components and measures is important for comparison between products and solutions. This is why the revision of the data for components (life span, annual maintenance and disposal costs) listed in Annex D has been agreed by CEN/TC 228 and inputs from manufactures will be needed.

Examples of sensitivity analysis on some of most influencing parameters are in **Figure 5** and an example of combination of influencing parameters in different scenarios is in **Figure 6.**

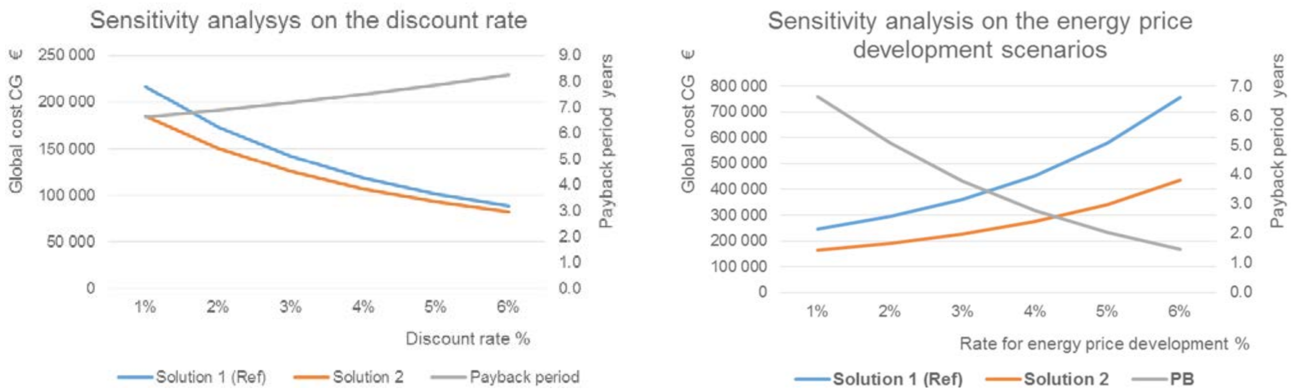


Figure 5. Example of sensitivity analysis on the most influencing parameters.

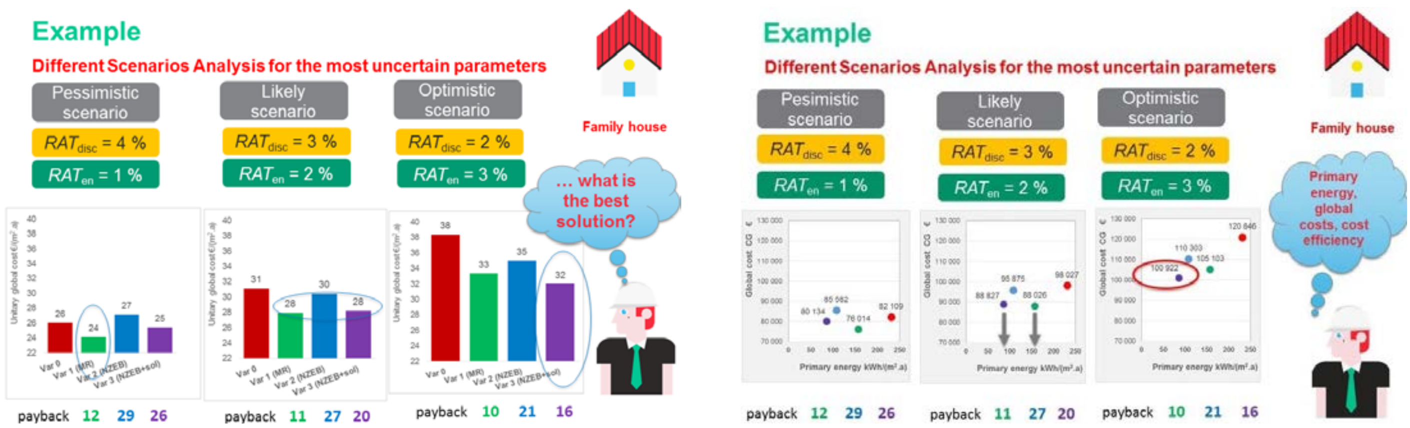


Figure 6. Examples of different scenarios (pessimistic, likely and optimistic) for most influencing parameters.

Comparison of different options and reporting

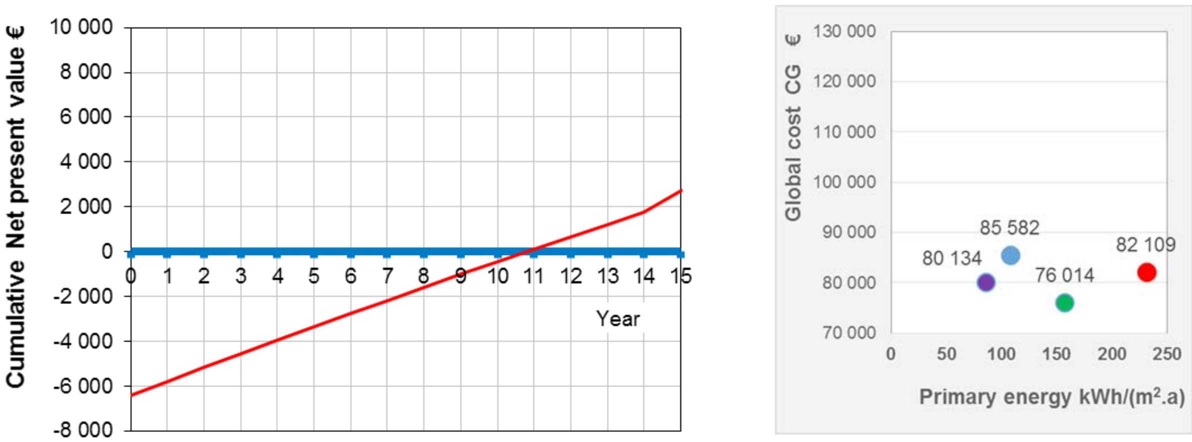
The global costs approach allows comparison of unlimited number of solutions.

The payback period is used to compare the cost efficiency of the solution under consideration to a reference situation. For existing buildings, the reference is usually the actual state (doing nothing). For new buildings, the reference could be a building that satisfies the minimum requirements of the national regulation.

The cost efficiency of proposed solution is usually ensured if the life span of investment is greater than or equal to the payback period.

Examples of reporting outputs and application in the decision making process for cost efficiency and cost optimality of solutions are in **Figure** 7 and **Figure 8.**

As shown in **Figure 6** not only global costs should be the main driver for the recommended cost optimal solution. The **primary energy** and the **energy class** in EPC are important aspects for climate commitments and future obligations for building owner that could bring him the non-energy benefits or cause losses (subsidies, green/brown taxes, attractiveness, better/worse IAQ, secure for increase of energy prices). Therefore, in the case of similar global costs for different solutions the solution with lower primary energy should be recommended.



a) Payback period

b) Global costs

Figure 7. Example of reporting the outcome from calculation of Payback period and Global costs

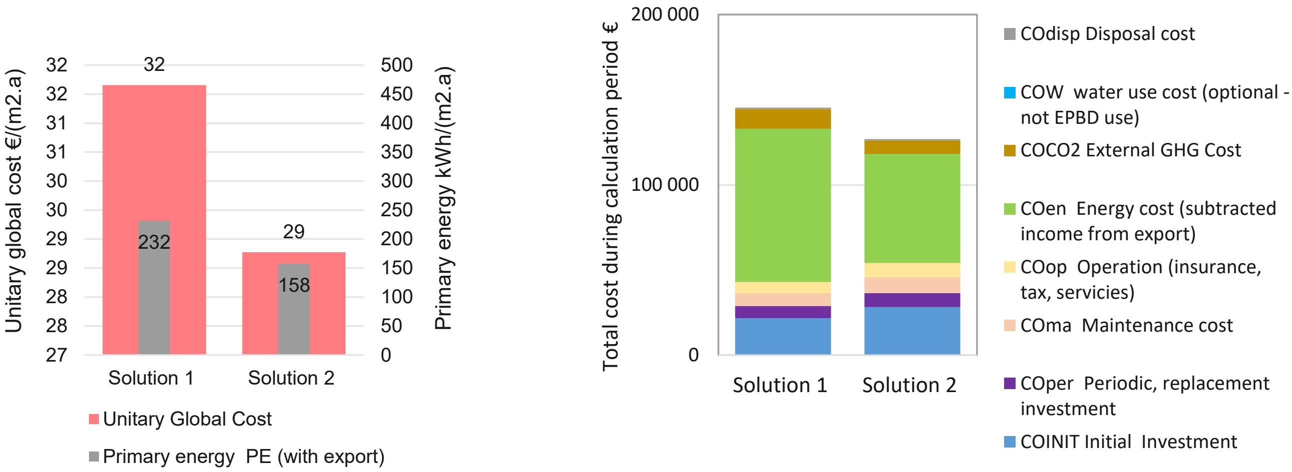


Figure 8. Example of more detailed reporting of global costs for two different solutions.

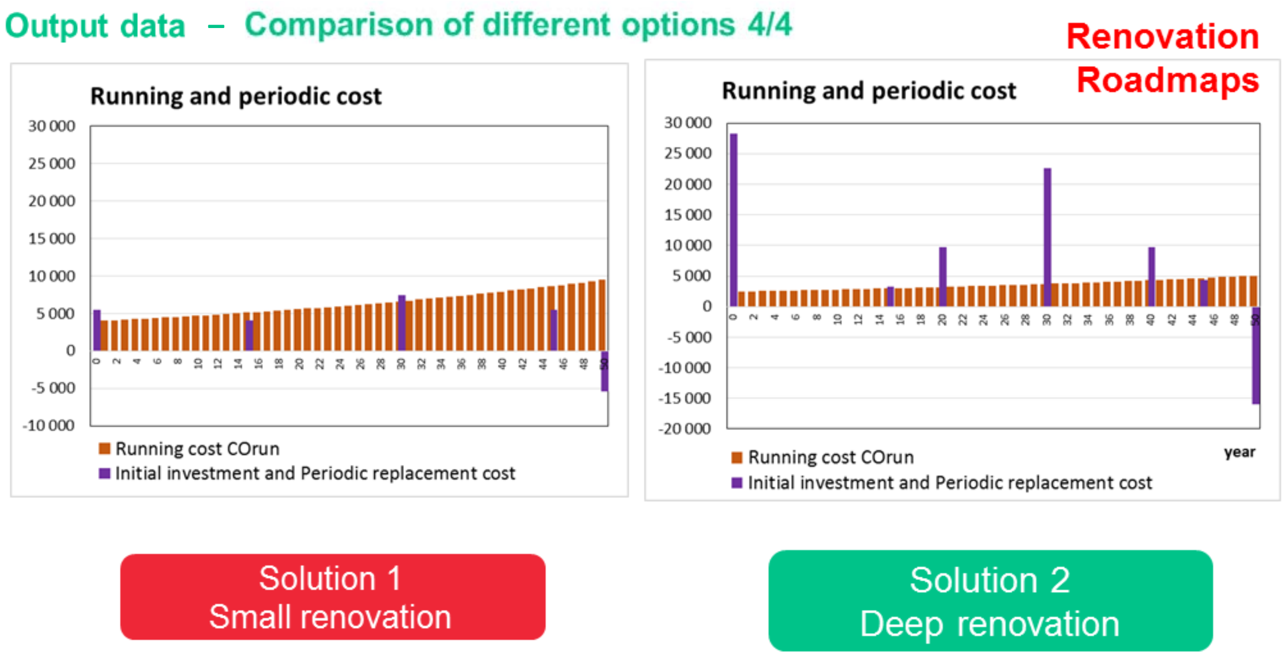


Figure 9. Example of comparison of the annual running and periodic replacement costs for different level of renovation

Graphs with the annual costs as presented in **Figure 9** allow to schedule the investment in renovation based on the life span of components taking into account the running costs and periodic replacement costs as well as the evolution of energy and components prices.

These graphs could be part of **renovation roadmaps** and building **renovation passports** as they can indicate the years with important investments needed.

Conclusion

EN 15459-1 is a powerful tool for the decision making process with many possible applications. It allows the comparison of different solutions and find the most effective approach for building owner for renovation or new building construction towards NZEB.

The specific of this standard is that many inputs are not as exact as for energy performance calculation because of uncertainty of several inputs looking far in the future. Economic results are closely related to the project under consideration, and it may be difficult to make general conclusion. Consideration of different scenarios is therefore recommended in the daily professional work for risk mitigation.

The corrections needed in the standard, discovered during the development of the CEN-CE training, are addressed and corrected in the training materials. The proposal for changes will be delivered for the next revision of this standard. The non-energy benefits as better commercialisation of building due to attractiveness and better indoor environment quality will be also recommended to be considered for future revision of this standard. ■

References

[1] Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings, amended by Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 amending Directive 2010/31/EU on the energy performance of buildings and Directive 2012/27/EU on energy efficiency,

[2] The Commission delegated regulation (EU) No. 244/2012 supplementing Directive 2010/31/EU of the European Parliament and of the Council on the energy performance of buildings by establishing a comparative methodology framework for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements.

[3] EN ISO 52000-1:2017 - Energy performance of buildings — Overarching EPB assessment — Part 1: General framework and procedures

[4] EN 15459-1:2017 - Energy performance of buildings - Economic evaluation procedure for energy systems in buildings - Part 1: Calculation procedures

[5] CEN-CE, Horizon 2020 project, www.cen-ce.eu