# Cost-optimal levels for energy performance requirements

*The Concerted Action's input to the Framework Methodology*

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| **Session** | **7 April 2011, 09:00-12:30** |
| **Chairs** | **Kirsten Engelund Thomsen&Hans Erhorn** |
| **Editor** | **Kim B. Wittchen &Kirsten Engelund Thomsen** |
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| **Reviewer** | **Wolfgang Jilek** |
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# 1 Introduction

A Working Group (WG) in Concerted Action 2 (CA2 EPBD) called "Cost-optimum procedures" was created in December 2010 in order to support the European Commission in its work of establishing the framework methodology on cost optimal energy performance requirements for buildings per delegated act. This framework methodology will then be used by Member States to be developed into a full and atonally adjusted methodology for determining the cost optimal level in a certain national context.

This WG aims to merge relevant knowhow and experience concerning the Comparative Methodology Framework in order to exchange the knowledge between the MS and support the European Commission.

Three major activities were performed, that are reported in this document:

- Creating common understanding and insight in the possibilities to set up a framework, based on exchange and discussion among the participants. There is hardly any sound experience in comparing requirements against cost optimal levels especially for the existing building stock.
- Managing a survey among the MS based on a questionnaire feeding into the Commissions consultation from the preparation for the Framework Methodology.
- Organizing a discussion session within the Concerted Action 3 (CA3) meeting in Luxembourg, and report the results.

A representative of the CA3 reported the main conclusions of the working group's work during the second expert meeting on 6 May 2011.

The WG consists of 7 persons from 4 Member States (MS): Hans Erhorn (Germany), Roger Hitchin (UK), Bart Poel (The Netherlands), Heike Erhorn-Kluttig (Germany) and Søren Aggerholm, Kim Wittchen & Kirsten Engelund Thomsen (DK). This report was produced with input from all members of the WG.

The recast of the EPBD obliges MS to: “assure that minimum energy performance requirements for buildings or building units are set with a view to achieving cost-optimal levels”. MS shall also: “take the necessary measure to ensure that minimum energy performance requirements are set for building elements that form part of the building envelope and that have a significant impact on the energy performance of the building envelope when they are replaced or retrofitted, with a view to achieving cost-optimal levels“ (EPBD art. 4.1; preamble 14). According to EPBD article 5, the European Commission has to provide a Comparative Methodology Framework (by July 2011) and accompanying Guidelines as a basis for the MS to compare their minimum Energy Performance Requirements against cost optimal levels, and report the results to the Commission.

# 2 Programme of the session

The purpose of the sessions in Luxembourg and a final report is to provide considerations on possibilities regarding the development of the Comparative Methodology Framework and accompanying guidelines. These considerations include advantages and points of attention. The report seeks to achieve integrated recommendations and a consistent set of integral considerations addressing the practical adequateness of the framework.

- Introduction to the session (Kirsten)
- Challenging issues for establishing a cost effective methodology (Bart Poel)
- Presentation of Framework (Robert Nuij, EC)
- Presentation of Methodology approach (Hans Bloem, ISPRA JRC)
- Questions and answers
- Review of questionnaire on national cost methodologies (Kim Wittchen)
- Plenum discussion about future challenges.

# 3 Topic

## 3.1 Background

The EPBD obliges MS to: "assure that minimum energy performance requirements for buildings or building units are set with a view to achieving cost-optimal levels". MS shall also: "take the necessary measure to ensure that minimum energy performance requirements are set for building elements that form part of the building envelope and that have a significant impact on the energy performance of the building envelope when they are replaced or retrofitted, with a view to achieving cost-optimal levels" (EPBD art. 4.1; preamble 14).

Cost-optimal level is defined as: "the energy performance level which leads to the lowest cost during the estimated economic lifecycle". MS will determine this level taking into account a range of costs like investments, maintenance, operating costs, energy savings. The economic lifecycle is determined by each Member State. It refers to the estimated economic lifecycle of a building or building element. Cost-optimal lies within the cost efficiency range (EPBD art. 2.14).

The Commission is charged with producing a Comparative Methodology Framework and accompanying guidelines. In effect, MS are required to show, every five years, that their building energy requirements are reasonably close to levels that can be shown to be cost-optimal in their particular national circumstances. We know from previous Working Group questionnaires that MS approach the setting of minimum performance standards from different perspectives.

From the Draft Working Document on COMMISSION REGULATION the comparative methodology: "The comparative methodology framework is not meant to harmonise the minimum energy performance requirements per se, but to ensure that the level of ambition of every EU Member State in its given context is similar. Performance requirements are set by the Member States depending on local factors such as climate, resource availability and economic development. This ensures an equitable approach towards Member States with different levels of progress and experience. As such, it also fully respects the nature of Directive 2010/31/EU which is a framework Directive leaving the necessary scope for Member States to implement the provisions of the Directive in the most appropriate way. Such an approach can encourage a convergence of ambition levels and a peer pressure element, as was already laid out in more detail in the Impact Assessment that accompanied the proposal for Directive 2010/31/EU."

The EPBD obliges MS to report on the comparison between the minimum energy performance requirements and calculated cost-optimal levels using the Comparative Methodology Framework provided by the Commission (EPBD Art 5.2, 5.3, 5.4 and Annex III). The report should also provide all input data and assumptions made. The comparative methodology Framework is accompanied by guidelines from the Commission to enable the MS to:

- Define reference buildings
- Define energy efficiency measures
- Assess the final and primary energy need of reference buildings and measures
- Calculate the cost of the energy efficiency measures by applying the comparative methodology framework principals.

The Commission will also provide information on estimated long-term energy price developments.

In case the comparison shows that the requirements are significantly less than the cost optimal level, MS need to justify this to the Commission. In case the gap cannot be justified a plan has to outline steps to significantly reduce the gap. The Commission shall publish a report on the progress of the MS.

The recast EPBD does *not* demand that MS set their minimum performance requirements at levels that are cost-optimal. It *does* require them to report how their requirements differ from cost-optimal levels(implicitly as far as underperformance is concerned). If there are "significant" differences – exceeding 15 % (presumably meaning that they allow energy consumptions that are 15 % higher than would be cost-optimal) - MS should justify them or plan steps to reduce the difference. Clearly this first requires the calculation of a cost-optimal requirement.

In order to design an adequate framework with accompanying guidelines it is crucial to determine the basic set up of the Framework, which includes:

1. Credibility and acceptance:
   There should be a balance between the effort to apply the framework and the quality and usability of the outcome.
2. Accuracy and transparency:
   The comparison (comparison of one MS against its own benchmark, not comparing different MS with each other)process as a whole(e.g. quality and transparency of the assumptions, input data, the methodology and the way the outcome is expressed) should fit the purpose of the comparison. The outcome should provide a sound basis for the discussion that might be necessary in case of an unacceptable gap.
3. Consistency between countries:
   The method should be consistent when applied to different countries. From a point of fair justice the MS should be equally judged. This does not imply that a comparative method has to be uniform in all details. It has to provide flexibility to allow MS to take their local context into account.
4. Common EU parts versus national parts:
   Preferable the methodology should have a clear distinction between parts that are uniform for all EU MS and national parts that can be defined nationally based on the national situation.

## 3.2 Scope of the methodology

### 3.2.1 Different domains

Regarding cost optimum levels for energy requirements two domainscan be distinguished:

- At the national level: to develop and implement requirements applied to individual buildings that result in aggregate cost optimal solutions, and preferably are cost-effective in the vast majority of buildings. They should be applicable in the whole building stock in an unambiguous way. In reality the national requirements will not bring about the cost optimal level for every single project. Nevertheless the deviation from the optimum should be limited and acceptable for the market. The requirements have to be strict and clear. The challenge of setting requirements at the national level is to make energy performance improvement happen in practice. Diversity at national level (building tradition, structure of the market, legislative context, cultural context, etc.) will determine the most effective approach to achieve cost optimal levels.

- For the European Commission the task is to check if the MS set requirements on an ambition level that is comparable with cost optimal levels. Explicit comparison between MS is not the focus. Significantly lower requirement levels than cost optimal should be detected and adjusted. In case cost optimal levels are not reached a discussion between the Member State and the Commission will take place to clarify the approach. Based on this more in depth insight the Commission can require a plan to adjust the requirement levels.
- This implies that the framework is a first check that provides MS and the Commission a reliable indication, insight in the requirement levels and a handle for further exchange and inquiry in case of underperformance.

Anadditional objective that is not mentioned as such in the EPBD itselfcould be to provide guidance for a framework for the national cost-effectiveness and cost-optimality assessment of building energy standards, to assist those MS who do not currently have a formal procedure in place. Serving this additional purpose however should not lead to a detailed Framework that obliges MS that want to apply there national cost benefit procedure, to set up a detailed shadow procedure just for reporting purposes to the Commission. Therefore this guidance should preferably be dealt with separately, in order to avoid inefficiencies.

There is a huge diversity within MS regarding the buildings stock, the economic context and other non-technical characteristics. This is even more the case in the EU as a whole. It therefore seems unrealistic to base a judgement on the energy performance requirement levels on a methodology that is very deterministic and tries to reflect the wide diversity within the EU in a very detailed way. The degrees of freedom combined with the uncertainties of the input data in such a detailed methodology will also result in an ambiguous outcome. A more simple approach may provide a sufficient clear result in a much more transparent way, thus providing a good basis for further and more detailed discussion between the Commission and the MS.

This simple approach leaves the MS the authority to create an effective national approach.

Therefore a reasonable preference would be to focus on the European objective to “detect and adjust underperformance” by means of an indicative methodology that is as simple and transparent as possible. This also serves a fair judgement among the MS.

## 3.3 Perspectives for determination of cost-effectiveness and cost-optimality

Cost-effectiveness and cost-optimality can be considered from several different perspectives, each of which will usually provide a different result. We summarise three important perspectives:

- of society as a whole: the “macro” economic perspective
- of individual end-users
- of idealised end-users: the “micro” economic perspective

Each of these serves a different purpose and MS will, no doubt, assign a different importance to each of them when setting requirements.

Analyses for all the perspectives share the same basic structure, but differ in their scope and the appropriate values of some parameters. All three perspectives consider costs and benefits over the assumed life of a building, including replacement costs for components or systems that have shorter life than that of the building. All apply discount rates to future benefits (and to costs) so that those which occur further into the future have a smaller influence than those close to the present time. In principle, all three can be evaluated in terms of “nominal” prices that include inflation, or in “real” terms that ignore it (but may include expected future price changes that are above or below average inflation). It is also important to acknowledge that there is a distinction in social acceptance between requirements for new and existing buildings. In the case of new buildings the owner cannot really observer the cost efficiency, since he has no clear reference. For the existing buildings this is quite different. On project level the savings can and will be compared to the investment from the perspective of the investor/owner. Therefore it is much more sensitive to set minimum energy requirements in case of major renovation. Societal acceptance is an important consideration.

### 3.3.1 The societal “macro” perspective

This is a basic approach to regulatory policy-making from an economic perspective. It is used when the justification for introducing energy performance regulation is to make organisations or individuals take actions that do not reflect their own direct interests (and are therefore unattractive as investments) but can be shown to be beneficial to society as a whole.This is comparable to the work normally done in cost benefit assessments for policies. An alternative – or complementary - approach would be to use taxation and financial policy to better align users perceptions with societal aims.

This approach takes into account all the costs incurred by any part of society, and all the benefits that result irrespective of where they occur. There is no distinction here between costs and benefits that fall on different sections of society: it is the net balance that is important.

The macro perspective includes benefits (and costs) of “externalities” (such as damage from climate change associated with carbon dioxide emissions). Since there is rarely a market price for such externalities (except for industry), it is necessary to devise “shadow prices” that reflect estimates of the value of such implications. Future costs and benefits are discounted at a “social discount rate” which is typically quite low, say 3% pa in real terms. With the macro approach, taxes and subsidies are ignored, since they represent a transfer of money from one part of society to another, rather than an aggregate cost or benefit. For all perspectives, there is also the risk that they will not be maintained over the building lifetime.

### 3.3.2 The end-user perspective

This perspective is important when the objective of regulation is to address “market barriers” that prevent owners and occupants taking actions that are in their direct interest, but which they do not recognise as being so. It is also important as a means of assessing the risk that regulation will be seen as unfair by significant groups of those subjected to it.

End-users face a number of practical constraints when considering energy efficiency investments. These include – but are not limited to – lack of information, lack of motivation, limited access to or alternative calls on capital, uncertainty about whether an investment will increase the market value of the building, the division of costs and benefits between landlords and tenants. Minimum building energy performance requirements can bypass some of these barriers by – in effect - demanding a certain level of investment.

This perspective only includes costs and benefits that are faced by the potential investor, which include taxes and subsidies. The cost of obtaining capital is generally significantly higher than the discount rates assumed in societal assessments.

In addition, apparently similar households or businesses in identical buildings can have very different occupation patterns and temperature requirements, resulting in equally varied energy demands. Since the direct costs of building energy efficiency measures do not generally depend on the occupants a package of measures that is cost-efficient (or cost-optimal) for one set of occupants may not be so for others. The extent of objections to regulatory requirements will depend on the number of end-users who feel disadvantaged, and by what extent.

Detailed assessment of the end-user perspective is complex and difficult and is rarely attempted when setting building energy standards.

### 3.3.3 The idealised end-user "micro" perspective

Because of the difficulty of assessing the detailed end-user perspective, it is common practice to use instead an idealised end-user perspective. This typically involves the definition of "typical" users and the assumption that the market barriers referred to above can be ignored. This makes the analysis more tractable but, in effect, hides differences between different groups of end-users and the resulting "social equity" issues.

In principle, prices for both idealised and real end-user perspectives should be those existing (or expected) in the marketplace. For reasons that are not clear, the idealised end-user perspective is often used with a discount rate that is below the market cost of capital.

## 3.4 Costs efficiency approach

### 3.4.1 Cost efficiency vs. cost optimality

The concepts of cost-efficiency and cost optimality are related but different. Cost-optimality is a special case of cost-effectiveness. A measure or package of measures is cost-effective when the cost of implementation is lower than the value of the benefits that result, taken over the expected life of the measure. Both are based on comparing the costs and (priced) savings of a potential action – in this case of introducing a particular level of minimum energy performance requirements for buildings. Future costs and savings are discounted, with the final result being a „net present value". If this is positive, the action is „cost-effective" (for the particular set of assumptions used in the calculation). The „cost-optimal" result is that action or combination of actions that maximises the net present value.

Cost optimality is relatively easy to determine for single measures operating in well-defined conditions – for example, the optimal insulation thickness for pipework operating at a constant temperature in a constant-temperature environment. It is a considerably more difficult process for complete buildings, and even more so for combinations of buildings such as a national building stock.

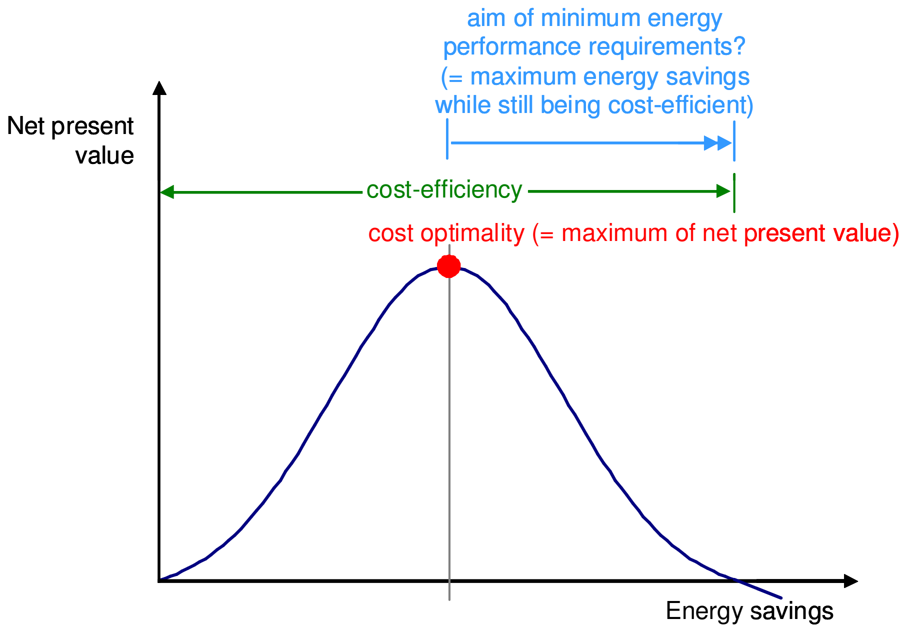



**Figure 1.** *Scheme presenting cost-optimality and cost-efficiency.*

Figure 1 illustrates the principles of cost-optimality and cost-effectiveness. In reality the distribution may not be uni-modal (it may have local optima). Typically the optimal level is less clear-cut than in the illustration and may be sensitive to data uncertainties. Also for one building type there is a cloud of curves dependent on the real building and the cost-optimal measure combination for detached single family house 'a' might be at least slightly different than for detached single family house 'b', let alone be different than those curves for row houses, etc.

As the aim of the EBPD and its recast is to accelerate energy savings in buildings and not to gain as much money as possible from energy savings, the question must be whether cost-optimality by maximising the net present value is reaching far enough. The cost optimal methodology was chosen as being the best balance between investment and benefit.Higher targets imply more upfront investment costs that need to be financed.In order to realise the ambitious goals of the reducing the energy use and the $CO_2$ emissions by 20% each and increasing the renewable energy supply by 20% by the year 2020, the focus should probably be to maximise the energy savings in buildings while still being cost-efficient. This will of course have to take into account safety margins for future changes in energy prices and interest rates.

One of the challenges for performing cost-efficiency calculations is the definition of the correct baseline. The baseline can influence the result of calculation as the perspective can change due to possible so-called anyway measures such as for example costs for scaffolding (compared witheither no insulation measures or simply a smaller insulation thickness). Possible baselines for the application at new buildings can be:

- Requirements based on health and safety
- Currently existing requirements defined in the national regulations

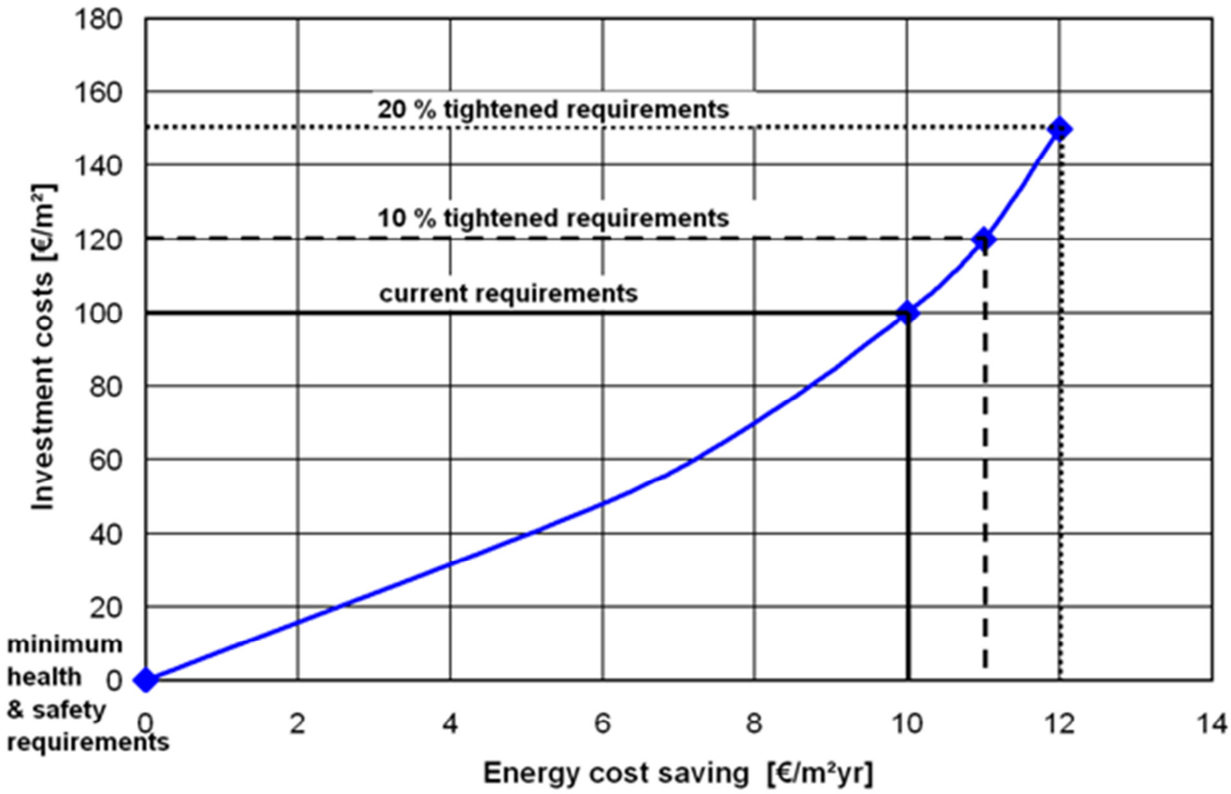



*Figure 2.Exemplary cost-benefit diagramme of different level of requirements (FhG).*

The figure above shows the huge influence of the baseline on the economic assessment of the tightening of requirements. If the result of a 20% tightening is compared to the current requirement (50 €/m² additional costs versus 2 €/m² yr = 25 years) a much longer payback time will occur than if the results are compared to the minimum health and safety requirement (no energy saving aspects just avoidance of condensation and mould growth). The result of the comparison with the minimum health and safety requirements is 150 €/m² additional costs versus 12 €/m² yr = 12.5 years.

With existing buildings an additional baseline could be the current state of the building. This would however be very complicated to calculate on national level as the energy quality and other influences like the type of construction is very diverse over the whole building stock.

### 3.4.2 Sensitivity studies

Many calculation parameters like investment costs, energy prices and their increase as well as discount (interest) rates are not really fixed but

- based on assumptions,
- average values for a country but in reality dependent on the region or even town, or
- average values for a period of time but in reality changing slowly or more rapidly (e.g. oil price, or
- dependent on specific negotiations of the building owner with for example the energy supplier (energy prices for towns or big companies) or the construction companies.

Thus the net present value calculation can be strongly influenced by such assumed parameters or average parameters but the result of the calculation is not necessarily valid for all building owner types, all regions and all cases. Furthermore some values like the price increase and the interest rates are predicted based on available experiences. If the real price increase and/or interest rate are different the calculation may result in (slightly) wrong numbers.

Therefore the calculations have to be extended by sensitivity studies. In those studies the unclear parameters have to be varied and the deviation of the results be analysed in order to find out whether the general statement is still valid or how far the real result can differ.

In many studies for fixing minimum energy performance requirements at least the energy price increase and the interest rate have been analysed by using different values.

## 3.5 Reference buildings[1] and energy saving measures

Article 5 of the EPBD (recast) requires MS to establish the comparative methodology framework in accordance with Annex III and to differentiate between different categories of buildings. Annex III states that MS shall define reference buildings that are characterised by and representative of their functionality and geographic location, including indoor and outdoor cli-mate conditions. The reference buildings shall cover residential and non-residential buildings, both new and existing ones.

There is no further clarification on the required reference building types for the cost-optimal assessment. Yet, Annex I includes a list of building categories into which buildings should be adequately classified for the purpose of the energy performance calculation:

- single-family houses of different types
- blocks of flats
- offices
- educational buildings
- hospitals
- hotels and restaurants
- sports facilities
- wholesale and retail trade services buildings
- other types of energy-consuming buildings.

This classification could be used or further developed for the reference buildings of the cost-optimal methodology.

Ideally reference buildings are defined based on the characteristics of the building stock and the research purpose they are meant for. They can have two main purposes: to represent the aggregate stock of buildings affected by regulation; and to identify sectors that would be disadvantaged by requirements that might, nevertheless, be cost-optimal overall.  Due to the limited (or lack of) knowledge about the building stock, the choice of reference buildings has a more arbitrary nature. This arbitrary element in picking reference buildings might be a source for deviation and inconsistency in the comparison. Also the use of different service systems in comparably constructed buildings and as well as different user typologies will multiply the number of reference buildings.

[1] It has to be mentioned, that the term reference building is used in the MS in different perspectives. Some countries use this term to define the energy performance requirements via a 'reference building approach'. This is not a representative building type but a mirrored building with the same geometry, user profiles, etc. and a defined set of (reference) technologies, which results in a maximum allowed primary energy use for this specific building.

Work in Concerted Action II Core Themes Certification and Procedures showed that the MS experience a special challenge with mixed-used buildings. Though these kinds of buildings cannot easily be represented by reference buildings as they differ significantly from each other it might be necessary to have in mind that they also form a considerable part of the countries' building stock.

Additionally the building size might have influence on the results as it can affect both the cost and the energy side of the equation. , therefore it could make sense to further categorize building types such as apartment blocks (small multi-family houses vs. high-rise apartment blocks), office buildings (small office buildings vs. large office towers) etc. The size partly also influences the necessary or possible building service systems. Some cost-saving technologies might not be useable in bigger size buildings while other might become cost-efficient especially here.

The 4 MS participating in this WG currently use the following number of reference buildings:

| Country | residential buildings | non-residential buildings |
|---|---|---|
| England and Wales | 4 | 8 |
| Germany | 4 | 15 |
| Denmark | 3 | 1 |
| The Netherlands | 6 | 25 |
| Average | 4 | 12 |

However it has to be mentioned that in at least two of the countries the development of a bigger set of (official) reference buildings is either completed or currently on-going.

Several past and current EU projects collect(ed) information on existing national reference buildings or try to develop national sets of reference buildings.The Intelligent Energy Europeproject TABULA (contract no. IEE/08/495/SI2.528393) is one of them. TABULA aims to create a harmonised structure for European building typologies (www.building-typology.eu) with residential buildings in focus.

The possible list of energy saving measures will probably show less diversity. An important issue for the existing building stock is the extent to which the effect of an energy saving measure depends on the present performance of the building or building element. Adding insulation to a non-insulated or to a moderately insulated structure has a greater impact than adding it to a well-insulated one. This can be handled by differentiating the reference buildings for the existing stock, but this complicates assessment (and is likely to result in more complex regulations). A related question is whether regulations should be cost-effective for all reference buildings.For the sake of consistency and transparency it is important to clarify the definitions and the quality/validity of the underlying data and assumptions of the set of reference buildings and measures.

During the WG session on setting minimum energy performance requirements but also during a presentation of the Commission it was discussed how to deal with **bundling of measures**. Bundling is the practice of assessing a package of measures without considering them separately. A package may have a positive net present value while containing some measures that are not cost-effective. In other words, better financial value may be obtained by omitting part of the package.

Some packages of measures such as for example combining insulation measures with a new heating system can result in synergy. Insulation measures do not only reduce the energy use of the building they also decrease the heating load offering the possibility to use smaller and cheaper heating units and emission systems. This cost reduction can only be achieved if both types of measures are considered as a combination.

Bundling of systems has to be taken into account especially if the goal of the energy performance requirements is to reach the maximum energy saving while still being cost-efficient.

## 3.6 Calculation method

It has to be considered, that the EPBD mentioned that EC will be delivering just a framework of a method and not a method itself. National assessment methods differ substantially (regarding energy and cost benefit calculations with its assumptions) and also the process to establish or tighten requirement levels differs. As cost-efficient requirements are strongly depending on the used assessment method, the MS have to use their own assessment method even if it is not based on a CEN standard, otherwise the results can't be compared to the real situation in the country.

The outcome of Concerted Action II shows, that the use of CEN standards instead of the national calculation method is currently practically not useful, as the CEN standards in the current version are not consistent and applicable as a package. Some standards do not cover the whole challenge of the EPBD; others are not suitable for the existing building stock. All this was one of the main reasons, why CEN got a second mandate to redevelop the standards.

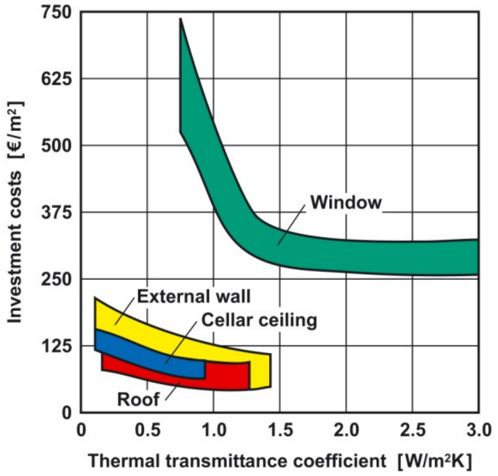
Apart from the fact that the calculation methods differ per Member State, the MS also express their energy requirements differently. Some MS for instance are setting whole building requirements based on primary energy per floor area; others use an indicator that also neutralises the shape of the building. Some use the notional building approach. Energy requirements for existing buildings can be set on whole building or element level. How can the Framework deal with this diversity?

Calculation of cost optimality is likely to be defined differently (within the freedom of the framework) among the countries, and in many cases this is not the only aspect that is taken into consideration when tightening requirements. For example also the skills to apply a technology and macro-economic effects are of importance. The question is how to derive consistent judgements on cost optimal levels when there is a huge diversity in methods, definitions and assumptions that dominate the outcome. The risk in this approach is that the validity of many national input variables and assumptions should be checked in order to validate the outcome of the comparison.

## 3.7 Parameter values

In the table below a list of parameter values is given, stating the special issues to deal with for each parameter and if possible a range for the normal values of each parameter.

| Parameter | Comments |
|---|---|
| Construction elements | *New buildings*: future constructions are not predictable as they depend on building tradition and development of new materials. Many different types.<br>*Existing buildings:* Many different possibilities for constructions.<br>Costs have to be fixed for the insulation product, for the fixing, shading, windows and doors, glazing, frame, sealing and installation etc. |

| | |
|---|---|
| Installations | They are difficult to predict for new buildings.<br>Generation and storage equipment, distribution and radiators, control devices.<br>*Ventilation systems:* if mechanical ventilation, then the costs has to be accessed.<br>*Cooling:* Investment costs shall include generation system, distribution, control devices and installation.<br>*Lighting:* type of lighting system, type of luminaire, control system, application to increase use of daylight and installation.<br>*Building automation and control:* building management system and installation. |
| User patterns | User patterns are strongly influenced by cultural aspects and are different for different building types but also from user to user. Variations in user patterns can easily result in energy consumptions that vary between -50% and +150% of the average consumption in identical buildings.Therefore the user patterns have to be adapted to national conditions. |
| General economic context | The development of energy prices, the inflation rate, the cost of products, the additional cost, building systems, labour and maintenance costs etc. are difficult to predict. The same goes for discount rate, real interest rate and market interest rate. |
| Costs | The investment costs for energy efficient technologies are depending very much on different influence parameters like availability in the country and at the building site, seasonal and regional economic situation, mass production, etc.<br>The figure shows the range of costs for different construction elements accord in different building projects in Germany realised in the period 2008 to 2010. The used costs have to reflect the national situation. The use of mean costs from a European database will create a not tolerable inaccuracy and is therefore <u>not</u> applicable.<br> |

| | |
|---|---|
| Climate | Climate changes are a factor which is nearly impossible to predict.There are currently different types of climate data used: TRY data which are generated from historical data sets (last 20 to 40 years) or actual weather data. This difference may cause a difference of more than 10 % in energy demand. |
| Building stock | The typology of buildings in MS can differ a lot (age, size, construction material), so the availability and reliability of reference buildings is a problem. The number of needed reference buildings may thus become unmanageable high if all building types, ages, and usages are to be represented. |
| Connection to energy supply (grid or storage) | Costs are difficult to predict.The energy quality (primary energy) of the net can differ very much, depending on the generation source (waste energy of fossil fuel). |

# 4 Description of cost-effective procedures in 4 countries

The four countries who participated in the WG have described their national approaches towards a cost optimal procedure for energy efficiency requirements in new and existing buildings.

## 4.1 England and Wales

### 4.1.1 Context

***Policy***

The over-arching policy objective is to reduce national carbon emissions by 80% relative to 1990 by the year 2050. In particular, three-year national carbon budgets are set by the independent Committee on Climate Change. Other relevant policy objectives relate to reducing fuel poverty and maintaining supply security.

(Note that, while the emphasis is on moving forwards in a cost-efficient and risk-managed way, the underlying cost-benefit of the policy is taken as justified by the Stern report and similar analyses).

The standard UK rules for assessing the impact of policies include a real discount rate of 3.5% for 30 years and 3% pa thereafter: risk to be assessed separately. Applied at a societal level to include shadow prices for externalities (most relevantly standardised figures for the social cost of carbon emissions)

***Regulatory Impact Assessment Process***

The rules and requirements for Regulatory Impact Assessments are formally set out in Treasury (Finance Ministry) guidance. They are not specific to Building Energy Regulation, but apply generally in order to ensure (as far as possible) consistency of approach between measures.

***Building Regulations***

For new buildings and major refurbishments, the primary compliance metric is the calculated carbon emissions from a building, compared to those of a “notional” building of identical geometry, use and climate but with standard U-values, equipment efficiencies etc. There are also elemental minimal performance requirements, which are generally “backstop” values (for example, to reduce the impact of later changes such as the replacement of a biomass boiler by a fossil-fuel one).

For existing buildings (not undergoing major refurbishment) regulation is basically elemental in nature (including boiler efficiencies), with some trades-off permitted.

### 4.1.2 Regulatory Impact Assessment (RIA)

RIAs are required to include:

- competition assessment
- small firms impact test
- legal aid
- sustainable development
- carbon assessment
- other environment
- health impact assessment
- race equality
- disability equality
- gender inequality
- human rights
- rural proofing

This synopsis focuses on the main one affecting building energy requirements, which relates to the cost-effectiveness of proposed changes. Details of RIAs for Building Regulations vary a little with each revision, reflecting the nature of the changes proposed. This synopsis is based on the RIA for the 2010 Regulations. There are actually 2 RIAs – one which was published as party of the consultation on proposed changes, and a shorter one at implementation stage. The policy objective was to achieve a 25 % aggregate reduction in carbon emissions across the new-build stock compared to the previous regulations. An unusual feature of this assessment was that two options were considered:

- a simply 25 %reduction for all buildings, retaining the existing notional building
- a redefinition of the notional building. This was expected to be able to achieve the same aggregate savings at lower overall cost because the “flat” reduction would require some building types to use more expensive technology.

Although in this case there was formal examination of different levels of requirement for non-dwellings, this is not a general procedure. The RIA is essentially a cost-benefit check on proposed changes that have been developed through a mixture of economic calculations and pragmatic assessments of other factors (such as the likely speed of adaptation of the supply chain to adapt).

The RIA is a social cost-benefit exercise: end-user impacts are not a formal part of it, but the costs and savings used in the assessment are reported and can be used (with some adjustments) to assess end-user impacts.

At the same time that the energy requirements of the Building Regulations were revised, the ventilation requirements were altered. The RIA covered both areas.

### 4.1.3 New Buildings: Base Case

The base cases are buildings satisfying the requirements of the previous Regulations.

For the RIA, 4 dwelling designs and 8 non-dwellings were modelled. These were chosen to be representative for different parts of the new-build stock, with aggregate savings and costs being weighted to reflect their prevalence in the new-build stock.

A set of elemental performance levels was determined such that all the base case buildings were just compliant with the existing regulations.

### 4.1.4 New Buildings: Proposed Regulations

Each of the base case buildings then had to be “redesigned” (maintaining the same geometry) to be compliant at lowest capital cost with the new regulations. For non-dwellings, they were also modelled with 20% and 30% savings.

The capital and running costs were then calculated for each building using the proposed calculation methodology, and aggregated. Only one weather set is used (Although the regulations permit any of 14 weather sets to be used, the differences are relatively small).

### 4.1.5 New Buildings: Life Cycle Assessment

The key features of appraisal methods are set down by the Treasury. Prices and discount rates are “real” (not adjusted for inflation) and net (of tax and subsidy). A building life of 60 years is used, with like-for-like replacement of elements of shorter life. The policy is assumed to stay in place for 10 years (so the benefits apply to all new buildings constructed in that period). The discount rate is 3.5% pa for the first 30 years and 3% pa thereafter. This is the social time preference rate: risk should be assessed separately (risk premiums are not generally recommended). Gas is the assumed heating fuel (except for small flats which are assumed to have electric heating).

Prices generally are assumed to be fixed (in real terms) but fuel prices are projected according to the “central” case provided by the Department of Energy and Climate Change.

Externalities are priced into the assessment:

- emission reductions for gas are valued at a shadow price for carbon
- emission reductions for electricity are valued at the ETS price
- an additional benefit is added for reduced damage cost from construction of new power generation plant
- benefit is also given for the avoided marginal cost of investment in renewable energy

The impact of pre-existing policies should be taken into account. For new buildings, the RIA notes that some of the costs and benefits attributed to the assessment may be overstated because of other policies.

#### 4.1.6 New Buildings: Results

Regulatory Impact Assessment (RIA) for the most recent upgrade to requirements for the energy performance of new and refurbished buildings[2].

Dwellings:

- the 25% reduction is cost-effective under either form of regulation. This conclusion does not rely on the benefits from externalities.

Non-dwellings:

- the 25% reduction is only cost-effective with revision of the notional building
- without the inclusion of externalities the 25% is marginally cost-effective with the change of notional building definition, and marginally not cost-effective with a simple % reduction.

#### 4.1.7 New Buildings: Sensitivities

Sensitivity assessments were carried out for variations of:

- energy price
- carbon price
- construction rate
- for non-dwellings only: required carbon emission levels.

#### 4.1.8 Existing Buildings: Dwellings

Requirements for existing buildings are elemental. For assessment purposes, they have been grouped into generic activities:

- extensions
- conservatories
- replacement windows and boilers
- renovations
- loft and garage conversions

The base case is the pre-existing requirements: the test is whether the *change* is cost-effective (not whether the requirement is cost-optimal).

One or more example cases for each activity were chosen for analysis – details are not very explicit in the RIA, which notes that data are often sparse. The cost and savings are aggregated to an overall set of figures.

Life cycle analysis is then applied, in the same manner as for new buildings. There are several other policy instruments for the improvement of existing dwellings: it is assumed that only 50% of the potential savings (and costs) can be attributed to Building Regulations.

*Results*

Without the inclusion of the value of externalities, only the requirements that apply to activities that are involve new construction (extensions and loft and garage conversions) are cost-effective.

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[2] This is a summary of a lengthy document: the policy target was a 25% reduction in aggregate carbon emissions compared to existing requirements. The RIA examined two ways of doing this – either as a simple % reduction of the target emissions or by redefining the ”notional building” [in effect the set of reference buildings] in a way that seemd likely to apportion cost more equitably between market sectors. It also looked at the costs and savings for 20% and 30% reductions.

When externalities are included all except “renovations” (essentially improving the insulation of existing walls and roofs) are cost-effective.

### 4.1.9 Existing Buildings: non-dwellings

Although the UK probably has better information on the non-dwelling stock than many other countries, the RIA judged that there is insufficient data to accurately estimate the overall improvement in energy efficiency that would occur from amendments to the Building Regulations. It therefore only gives illustrative figures which should be considered with caution.

These show that, without the value of externalities, the proposed requirements would be marginally non cost-effective. When externalities are included, there are “large net benefits”

## 4.2 Germany

### 4.2.1 Basics

All energy performance requirements for buildings, set by the German Government, have to be based on the rules fixed in the German (business) law for saving energy in buildings (‘Energieeinspargesetz-EnEG’). Herein the requirements for any relevant decree have to consider the following fundamentals:

*‚Die in den relevanten Rechtsverordnungen aufgestellten Anforderungen müssen nach dem Stand der Technik erfüllbar und für Gebäude gleicher Art und Nutzung wirtschaftlich vertretbar sein. Anforderungen gelten als wirtschaftlich vertretbar, wenn generell die erforderlichen Aufwendungen innerhalb der üblichen Nutzungsdauer durch die eintretenden Einsparungen erwirtschaftet werden können. Bei bestehenden Gebäuden ist die noch zu erwartende Nutzungsdauer zu berücksichtigen. ‘*

Translation:
‚Requirements which are fixed in the relevant decrees have to be technically feasible (realised with state of the art technologies) and economically feasible for buildings of the same type and use. Economically feasibility is realised if the necessary costs can generally be paid back by the savings within the usual usage period. For existing buildings the remaining usage period has to be considered.’

### 4.2.2 General methodology

There is no ‘standardised’ methodology for setting up minimum energy performance requirements. However since several tighteningsof energy requirements the responsible ministries (Ministry for Transport, Buildings and Urban Planning, Ministry for Economy and Technology, Ministry for the Environment, Nature Conservation and Nuclear Safety) ask groups of experts in this field to perform studies for both, the societal perspective and more into detail the building owners’ perspective.

Figure 3 shows the type of requirements fixed in the German building decrees over more than the last 50 years. Figure 4 contains an overview of the tightenings of the energy performance requirements in buildings.

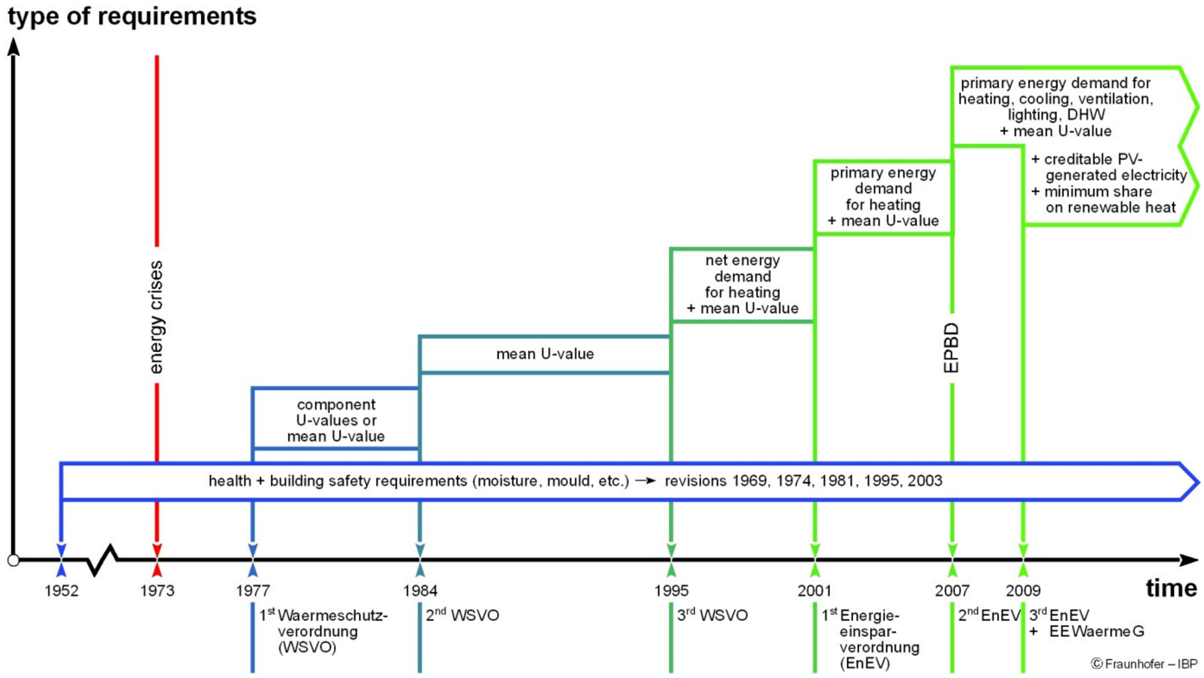



*Figure 3.Type of German energy performance requirements from 1952 to 2010.*

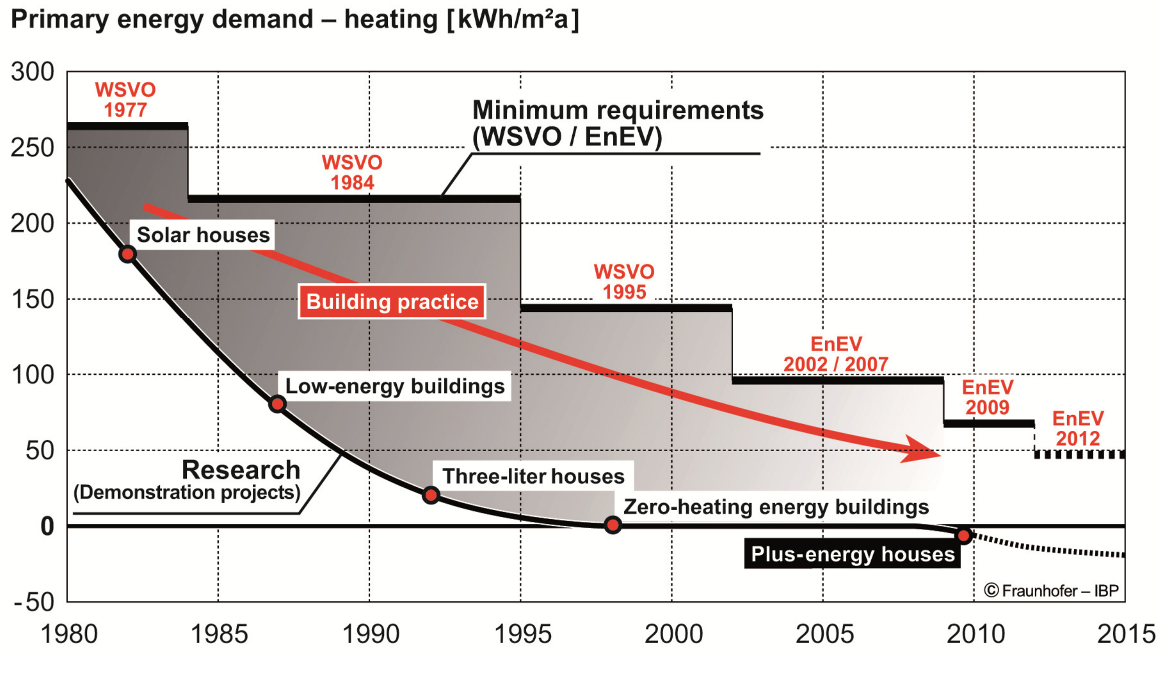



*Figure 4.Development of the minimum energy performance requirements for detached single family houses in Germany in comparison with national research and demonstration projects which are used to show that new technologies are close to market application and a further tightening is feasible.*

There exists no thoroughly regulated methodology for the studies. The description in the report is based on the last tightening which happened in 2009. The aim of the studies is to show the impact of a further tightening of the at that time actual requirements (from 2007). The results were used for reasoning of the tightening which happened in 2009. The societal impact study (macro perspective) for this tightening was published in 2008 while the two studies on the building owners' perspective (micro perspective) were published in 2009.

*It was a two-step procedure*

First the economical calculations have been made by Fraunhofer-Institutfür System- und Innovationsforschung (ISI), BSR – Sustainability, European Climate Forum (ECF), Öko-Zentrum NRW and Potsdam-InstitutfürKlimafolgenforschung (PIK). The goal was to make a study as basis for the political roadmap for the next years. The study tried to find out which measures would help most cost-efficiently to reduce the energy use and the $CO_2$ emissions in Germany. These calculations compare not only building related measures, but also those in the transport sector, the energy generation, etc. The result of these calculations are cost potential diagrams that sort the measures according to the energy and cost-efficiency. They set the general tendency of what needs to be done within the next years.

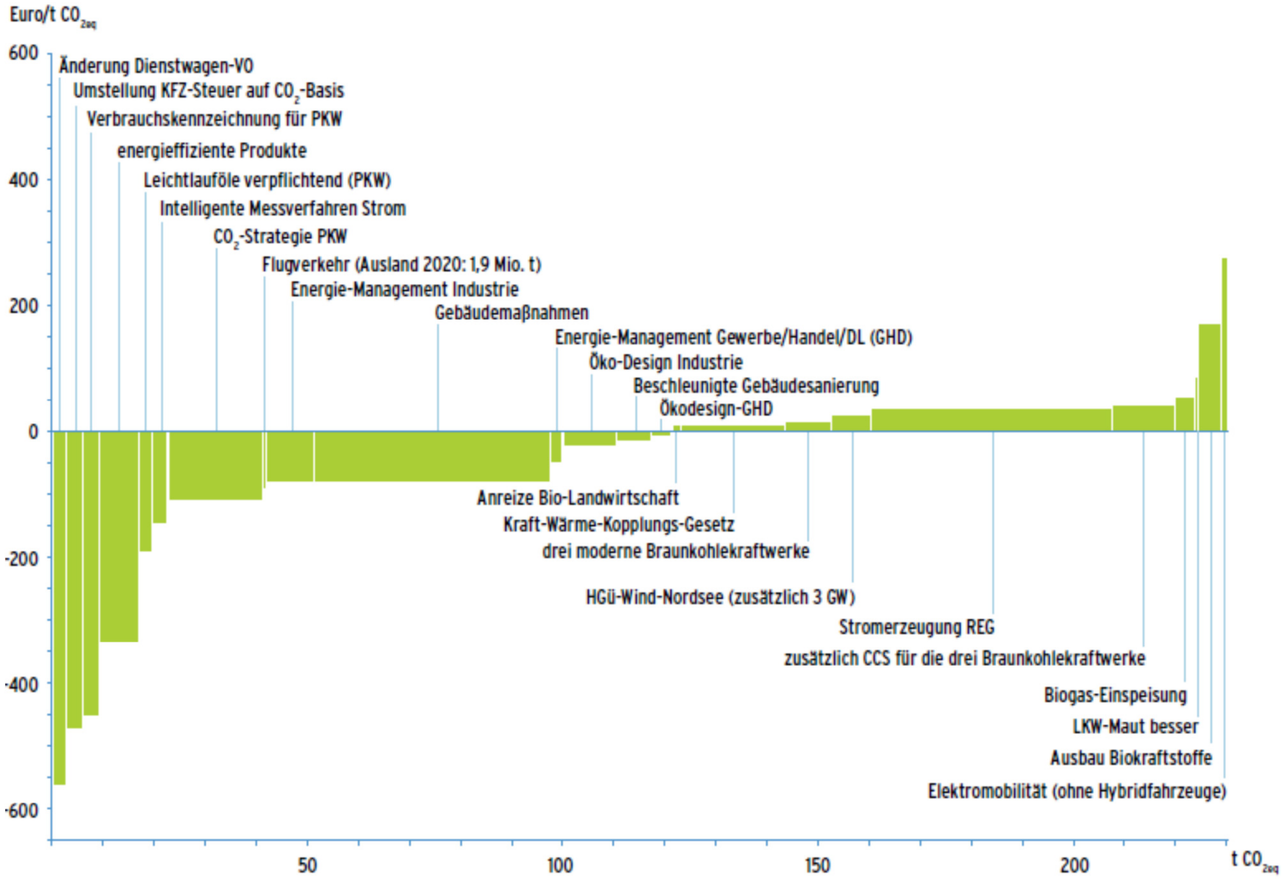



*Figure 5. Avoidance costs of different $CO_2$ equivalent reduction measures.*

After the political decision has been made to further tighten the energy performance requirements for buildings a second round of calculations has been initiated; this time from the building owners' perspective and reflecting the energy savings and the necessary costs only. Here the starting point is the current requirements. The measures necessary for the planned tightening (based on the results of the economical calculations) are compared to the current requirements by assessing the additional investment costs and the saved energy. The idea is to prove that for the tightened requirements the net present value within the regarded calculation period is positive. The requirements have to be cost-efficient (but not necessarily cost-optimal). These calculations have been made by a consortium consisting of Ingenieurbüro Hauser, Fraunhofer Institute for Building Physics, ITG Dresden and Schiller Engineering.

### 4.2.3 Economical calculations (societal perspective)

The economic calculations assess the $CO_2$ equivalent avoidance costs for various measures for the German society [1] including their impact until 2030. These measures cover transport, energy production, commerce, agriculture and buildings (see Figure 5). The only characteristics assessed are societal costs and $CO_2$ equivalents, no externalities like embodied energy or others.

In the study a detailed list on estimated energy prices for every 5th year is included, but there is no general energy price increase rate fixed. No specific building measure is mentioned, the assessment is made for a generally improved quality of buildings and for new buildings with tighter requirements.

### 4.2.4 Financial calculations (building owners' perspective)

There is no standardised procedure for the financial calculations that comes to effect for each tightening like using the exactly same type buildings, the same type of bundled measures, the same inflation rate or interest rate. Those are fixed according to the current situation (building types and bundled measures proposed by the organisations doing the calculations) and are being discussed with and have to be agreed by the responsible ministries (BMVBS and BMWi). However the general strategy how these calculations are made is similar and supervised by the building and the economical ministry.

The further explanations are based on the last two studies, which are described in detail in references [2] and [3]. The first study [2] deals with the tightened requirements for new residential buildings and the second one [3] with new non-residential buildings. For both building types (residential and non-residential) the net present value according to VDI 2067 which is equivalent to EN 15459 was the basis of the calculation. Both studies have the aim to show that the foreseen tightened requirements can be realised for all type buildings with a positive net present value during a calculation period of 20 years. The presented results are however the dynamic amortisation period. (If the amortisation period is smaller than 20 years, it is the same results as having a positive net present value during 20 years). This is regarded as easier to understand for the public.

There are several boundary conditions which are the same for both studies:

- Energy price increase: 1 %
- Energy prices:
  - Gas and oil: 0.075 €/kWh
  - Electricity: 0.20 €/kWh
  - Electricity for heat pumps: 0.15 €/kWh
  - (District heating: 0.055 €/kWh; not used in the studies, still the price was indicated)
- Interest rate: 3.5 %
- Sensitivity studies for:
  - Energy price increase: 0,8 % (non-residential) and 0.8 %, 0 % and 3 % (residential)
  - Interest rate: 2 % and 5 %

The calculations do only include the energy and the costs, no externalities, not even $CO_2$ equivalents. Neither embodied energy nor disposal costs are regarded. There are other studies that take into account this type of input, but they are not the basis for the tightening of building energy performance requirements.

The additional investment costs are proposed by the experts responsible of the studies based on their experiences or other documented cost data, but they are checked by the ministry.

The following type buildings have been used for the studies:

- Residential buildings:
    - Detached single-family house
    - Row middle house
    - Double house
    - Multi-family house
- Non-residential buildings:
    - Office building with 50 % transparency in the façade
    - Office building with 100 % transparency in the façade
    - Office building with 50 % transparency in the façade and office cooling
    - Office building with 100 % transparency in the façade and office cooling
    - School A with showers
    - School A without showers
    - Hotel
    - Supermarket
    - Production hall with ventilation by window opening
    - Production hall with mechanical exhaust ventilation
    - School B with ventilation by windows
    - School B with mechanical ventilation
    - High-rise office building
    - Congress centre
    - Shopping centre

German current requirements are defined by a reference technology approach. The planned building has to be designed in that way, that the energy performance is as good as or better than that of the same building when a defined set of technology is applied. So the German government does no longer fix the energy performance of a building directly by a maximum (primary) energy use but indirectly via the definition of the reference technology set. This approach is used since 2007 for non-residential buildings and since 2009 for all buildings. Before that a direct requirement in kWh/m²a primary energy was used depending on the building shape.

The calculations for residential buildings in the study have been made for the 2007 requirements (as benchmark) by using as heat generator a low-temperature oil boiler and for the 2009 tightening with a reference technology of a condensing oil boiler plus solar DHW. The additional investment costs for the better boiler and the solar technology and for improving the building quality in order to reach the foreseen tightening have been assessed for all building types and it has been proven that the dynamic amortisation period is lower than 20 years for each building type.

For the non-residential buildings the starting point of the calculations has been the reference technologies which are defined in the energy decree in 2007. They have been compared to the reference technologies foreseen for 2009. These are dependent on the building type and partly on the included technologies in the building to be assessed (e.g. cooling and ventilation technology). The main change here was as well from low-temperature boilers to condensing boilers with thermal solar technology. Additional tightenings have been made in the insulation quality, the fans and pumps efficiency and the lighting technology. It has to be understood that the reference technologies only show one example of how the requirements can be met.

Similar to that, the studies only prove that the tightened requirements can be met with a combination of measures that are at the same time cost-efficient but not necessarily cost-optimal. Additional combinations of measures are free to assess by the building owner but not regarded in the study. That means if one package is cost-efficient the tightening is o.k. The market will see whether alternative packages are more cost-efficient or less.

State of the art technologies are the basis for the reference technologies fixed for the reference buildings. Only technologies that can be calculated with the used standards (DIN V 4108-6 and DIN V 4701-10 for residential buildings respectively DIN V 18599 for all buildings) can be assessed according to the required standard. Though there are possibilities to use an alternative method for assessing other technologies, these are not often used. Especially DIN V 18599 includes many technologies that can't be assessed in other countries. The state of the art technologies are defined by an adviser (advisory board) to the ministry, following the results of the study and have to be accepted by the ministry.

Subsidies have next to no impact to the studies. As photovoltaic is not a reference technology the subsidies have no impact here. Other subsidies only apply for energy concepts that go beyond the requirements are therefore of no impact either. Currently there are subsidies for the following specific technologies: heat pumps, PV, biomass boilers, micro-CPH and solar thermal heating (special requirements apply). These are not taken into account as the subsidies may change or end during the period the energy performance requirements are in force.

The methodology is not reviewed. As written above there is no standardised methodology. It is slightly dependent on the organisation that does the calculations. However the central points (use of several type buildings, basis is net present value/dynamic amortisation period, combination of measures to reach a certain tightening) will be more or less the same.

Calculations are being made for certain associations/federal states or for cities that want to go beyond the requirements of the state. If those would result in very different conclusions the associations/federal states would complain publicly.

There are no ex post assessments carried out. The next calculations are done for the next tightening.

The requirements for existing buildings in the past are not so much based on a specific study but mostly on experiences. If building components are exchanged this can be realised nearly always with state of the art technologies similar to the reference technologies for new buildings. Therefore the requirements for replacements can be set similar to new buildings. There is a slight allowance for existing buildings though, see paragraph 1 'remaining usage period'. The alternative general primary energy requirement for existing buildings is 140 % of the one for new buildings as well.

#### 4.2.5 References

[1] Jochem et al.: Investitionen für ein klimafreundliches Deutschland. Eine Studie im Auftrag des Bundesministeriums für Umwelt, Naturschutz und Reaktorsicherheit. Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit (BMU) (editor). 2008.

[2] Maas, A.; Oschatz, B.; Erhorn, H.: Entwicklung eines Normenteils zur DIN V 18599 für Wohngebäude in Zusammenhang mit der Fortschreibung der EnEV. Endbericht. Forschungsprogramm Zukunft Bau. 2009.

[3] Maas, A.; Schiller, H.; Erhorn, H.: Beurteilung energetischer Anforderungen an Nichtwohngebäude in Zusammenhang mit der Fortschreibung der EnEV. Endbericht.ForschungsprogrammZukunftBau. 2009.

## 4.3 Denmark

### 4.3.1 Energy requirements in the Danish Building Regulations

***New building***

The energy requirements to new building in the Danish building regulations consist in:

- An Energy Frame in kWh/m² per year
- A requirement in W/m² building envelope (excl. of windows and doors) limiting the design heat loss through the building envelope.
- Specific minimum requirements to the different building elements (constructions in the building envelope and installations).

All three requirements have to be fulfilled at the same time. The energy frame being the main requirement. There is an energy frame for dwelling and an energy frame for non-dwellings. Special types of non-dwelling e.g. shopping centres and hospitals are handled by additions to the energy frame in relation to e.g. high lighting or high ventilation requirements. The two last requirements limit the possibility to choose none passive solutions or to choose installations with bad energy efficiency.

In the regulations there are both a mandatory energy frame requirement to building 2010 and a definition of a voluntary low energy building 2015 frame expected to be mandatory for all buildings from 2015. The voluntary 2015 frame can be made mandatory for selected area if the local authority decides to do so. There is on-going work on setting a low energy 2020 frame with the same legal conditions as the 2015 frame. The 2010, 2015 and expected 2020 frame are approx. on a level of 75, 50 and 25 % compared to the past 2006/8 frame.

***Existing buildings***

The energy requirements to existing buildings consist in minimum requirements to the building elements (constructions in the building envelope and installations) involved in case of:

- Change of use of building (e.g. barn or industrial building being converted to dwelling, commercial or institution)
- Major renovation of building (more than 25 % of building value or building envelope)
- Complete renewal of elements (e.g. new windows or new boiler)
- Partly renewal of elements (e.g. new roofing or new planking)

The energy requirement to the constructions in the building envelope depends on type of case. In case of major renovation of building or partly renewal of constructions in the building envelope the actual requirement to the implementation also depends on the profitability for the building owner. If the implementation of the full requirement is not profitable to the owner less or none has to be implemented.

The requirement to an installation in a new building and in case of renewal of an installation in an existing building is the same.

### 4.3.2 Financial costs - benefits

New buildings

The financial costs and benefits to the building owner in relation to tightening the energy frame requirements to new buildings is evaluated based on four example buildings:

- A single family house
- A row house
- A multi-family house
- An office building

Different energy measures are added one by one to each example building, see example in table below. The order of the measures are by holistic view point on parameters as aesthetics, constructability, availability, constructer preference and economic. It is not possibly to arrange the measures in any general optimal order.

The expected "to days" (2010) actual investment for implementing each measure are calculated based on the standard price book for building constructions (*V&S prisbøger*) where possibly. For new types of solutions not included in the price book the investments are estimated best possibly. Al prices are exclusive of value added tax. Energy prices include energy taxes. All prices are adjusted to 2010 price level.

The investments for the same measures in the future (2015 and 2020) are estimated based on expected marked and price trend when the "to days" new and extra efficient solutions gets ordinary. In general a decrease in investment on approx. 20 % for additional insulation in the building envelope is expected in relation to the solutions getting ordinary. For other product e.g. high efficient triple glazed window a higher decrease in price is expected.

*Example of financial costs – benefits analysis in relation to on-going work on setting the low energy building 2020 energy frame requirements in the Danish Building Regulations. Single-family house with district heating. Expected 2020 prices adjusted to 2010 price level. Draft results. 7.50 DKK approx. 1.00 Euro.*

| Measure | Investment DKK/m² gr. floor area | | Service life, years ** | Simple pay back, years | Net present value DKK/m² gr. floor area | | NPV/ Invest. |
|---|---|---|---|---|---|---|---|
| | Measure | Sum | | | Measure | Sum | |
| 3 layer energy glazing | 46 | 46 | 20 | 16 | 6 | 6 | 0.13 |
| Composite windows | 44 | 90 | 40 | 17 | 40 | 46 | 0.90 |
| Ground slap +150 mm | 102 | 192 | 60 | 92 | - 54 | - 8 | - 0.52 |
| Loft +100 mm | 100 | 292 | 60 | 49 | - 11 | - 19 | - 0.11 |
| External walls +40 mm | 75 | 367 | 60 | 25 | 118 | 99 | 1.58 |
| Pump | 1 | 368 | 20 | 1 | 20 | 119 | 15.32 |
| BMV and add. tightness | 133 | 502 | 20 | 16 | - 8 | 111 | - 0.06 |
| External walls +60 mm | 112 | 614 | 60 | 81 | - 52 | 60 | - 0.46 |
| External walls +50 mm * | (90) | | 60 | 111 | (- 54) | | (- 0.60) |
| PV 3.8 m² | 51 | 664 | 20 | 10 | 43 | 102 | 0.84 |
| Total | 664 | 664 | - | - | 102 | 102 | 0.15 |

* Not included in the final estimate.

** Standard lifetime for energy upgrading of selected building elements as defined in the Danish Building Regulations 2010.

Not all single measures seem to be cost efficient, but the accumulated sum of the measures is expected to be cost effective in 2020. The flexibility of the energy frame requirements in the Danish Building Regulations allows adjusting measures included in the real building to be selected as the most cost efficient.

The energy consumption in the buildings with different energy supply is calculated using the national calculation core.

For each measure the energy saving and the energy cost saving are calculated.

Two types of economical evaluations are performed:

- Simple pay back
- Net present value (NPV)

The simple pay back is used to evaluate the benefit of the individual measure when compared to the expected service life time. The simple pay back gives a simple overview but cannot be used to evaluate a package of measures.

To be able to evaluate a package of measures the net present value is used. The net present value is calculated for each measure and for a package of measures.

In the economic calculations the following economical parameters are used:

- Net interest rate
- Net energy price increase

The net interest rate and the net energy price increase are based on statistics for the past combined with expectation for the future. The net interest rate is corrected for taxation. Sensitivity analyses are also performed with a higher interest rate.

The inputs to the calculations are only additional (marginal) investment to establish the measure and annual energy cost savings over the service life time of the individual measures. All other cost and saving are considered equal or of little influence on the result. When calculating net present value for a package of measures the net present value for each measure is simply summarised. Any rest value of measures with long life time is considered equal to the rest future energy cost saving of the measure.

The investments and net present values to reach each step in energy class dependent on time for the implementation is summarized in the table below.

*Investment and relative net present value (NPV) in DKK/m² gr. floor area summed up to reach each step in energy class. Single-family house with district heating. Draft results.*

| Energy class | 2010 prices (actual) | | 2015 prices (expected) | | 2020 prices (expected) | |
|---|---|---|---|---|---|---|
| | Investment | NPV/Invest. | Investment | NPV/Invest. | Investment | NPV/Invest. |
| 2010 | 570 | -0.19 | 389 | 0.17 | 367 | 0.27 |
| 2015 | 744 | -0.19 | 526 | 0.14 | 502 | 0.22 |
| 2020 | 967 | -0.22 | 701 | 0.07 | 664 | 0.15 |

It is thus obvious that there is a need to further develop the measures to make them cost efficient up to 2020. If the decision on tightening the 2020 requirements was based only on actual prices and development, it would not have been possible.

### 4.3.3 New buildings

#### *Societal economics*

All governmental societal economic calculations in Denmark has to be in accordance with the guideline from the Danish Ministry of Finance (*Finansministeriet: Vejledning i udarbejdelseafsam-fundsøkonomiskekonsekvensvurderinger*). Specifically related to energy related project the Danish Energy Agency has an additional guideline that also have to be used (*Energistyrelsen: Forudsæt-ninger for samfundsøkonomiskeberegningerpåenergiområdet*). The guideline from the Danish Energy Agency also includes future energy prices and inflation up till 2030.

In the societal economics all prices are exclusive of tax. Two types of societal economic evaluations are performed:

- Net present value (NPV)
- $CO_2$ reduction costs

According to the guidelines from the Ministry of Finance, an interest rate of 6.0 % pa.has normally to be used. In the societal economic calculations related to requirements to new building in the Building regulations the Danish Enterprise and Construction Authority has decided to use a more realistic interest rate of 3.0 % pa. According to the guidelines also $CO_2$ savings have to be discounted with the interest rate. Sensitivity analyses with a higher interest rate of 5.0 % pa. are also performed.

An example of societal net present value and $CO_2$ reduction costs are in the tables below.

*Example of the societal economic for the single family-house with district heating also used in the previous tables. Expected 2020 prices adjusted to 2010 price level. Draft results.*

| Measure | Net present value DKK/m² gr. floor area | | $CO_2$ reduction costs DKK/ton $CO_2$ | |
|---|---|---|---|---|
| | Measure | Sum | Measure | Sum |
| 3 layer energy glazing | -19 | -19 | 1 646 | 1 646 |
| Composite windows | -5 | -25 | 330 | 882 |
| Ground slap +150 mm | -82 | -106 | 9 852 | 2 941 |
| Loft +100 mm | -64 | -170 | 3 925 | 3 245 |
| External walls +40 mm | 6 | -164 | - 196 | 1 919 |
| Pump | 6 | -157 | - 713 | 1 673 |
| BMV and add. tightness | -61 | -218 | 3 069 | 1 917 |
| External walls +60 mm | -87 | -305 | 8 415 | 2 455 |
| PV 3.8 m² | -18 | -323 | 481 | 1 996 |
| Total | -323 | -323 | 1 996 | 1 996 |

*Societal economics summed up to reach each step in energy class. Single family house with district heating. Draft results.*

| Energy class | Net present value in DKK/m² gr. floor area | | | $CO_2$ reduction costs in DKK/ton $CO_2$ | | |
|---|---|---|---|---|---|---|
| | 2010 prices | 2015 prices | 2020 prices | 2010 prices | 2015 prices | 2020 prices |
| 2010 | -434 | -197 | -164 | 2 847 | 2 179 | 1 919 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2015 | -563 | -366 | -218 | 2 647 | 2 006 | 1 917 |
| 2020 | -737 | -542 | -323 | 2 706 | 2 201 | 1 996 |

Due to the lack of energy and personal taxes in the societal calculations, the societal net present values are more critical than the net present value for the building owner shown in the previous tables. The present $CO_2$ reduction costs for other none building measures to day e.g. energy supply system measures are 200 - 300 DKK/ton $CO_2$ expected to increase to 500 – 1 000 DKK/ton $CO_2$ over the period 2020 - 2050.

#### 4.3.4 Existing buildings

The financial costs and benefits to the building owner in relation to energy saving measures in existing buildings are analysed on building element level based on simple payback for each measure.

The calculation is based on a profitability factor defined as:

$$Profitability\ factor = \frac{Annual\ saving \times Service\ life\ time}{Investment}$$

If the *Profitability factor*> 1.33 it is required to implement the measure

Annual saving is first years saving. The Service lifetime is from the table of standard values shown below.

In relation to renovation of single elements e.g. in the building envelope the investment are only the additional costs related to the additional energy efficiency of the element - not the basic renovation costs. In relation to major building renovation (25 % rule) the investment are the total cost for elements not needing renovation. If an element is completely changed e.g. new windows or new boiler is installed the minimum requirements applies without profitability calculations.

The same type of calculation are performed when setting the requirements and in relation to renovation of specific buildings. To facilitate the easy use of the requirements in relation to renovation of specific buildings guidelines are developed for typical situations, see examples in the annex.

The net present value curves in relation to additional insulation of constructions are in most cases very flat near the optimum point and the economic are to a wide extent not sensitive to variation in actual insulation thickness of +/- 25 %, see example on next page.

The identification of least insulation thickness in the existing construction to make improvements economical beneficial and the optimal final insulation thickness from a marginal view point are performed using a spread sheet.

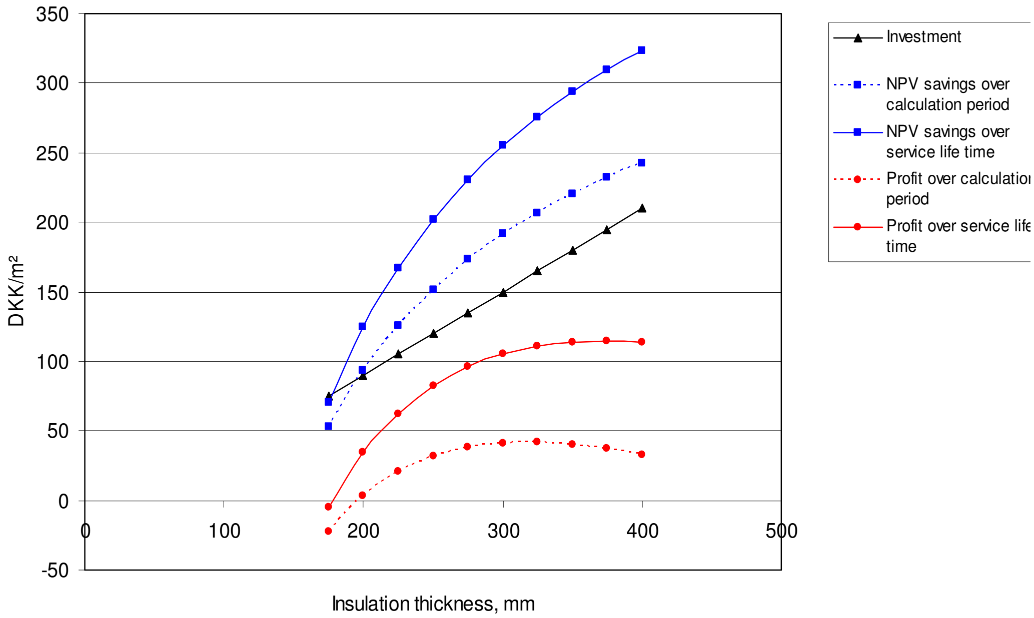



*Figure 6.Example of net present value calculation of additional loft insulation in existing buildings.150 mm insulation before implementation of measure.*

*Example of profitability calculation of additional loft insulation in existing buildings. Marginal final insulation and marginal start insulation. NB: "," are being used as decimal separator in this table!*

**Optimal final insulation**

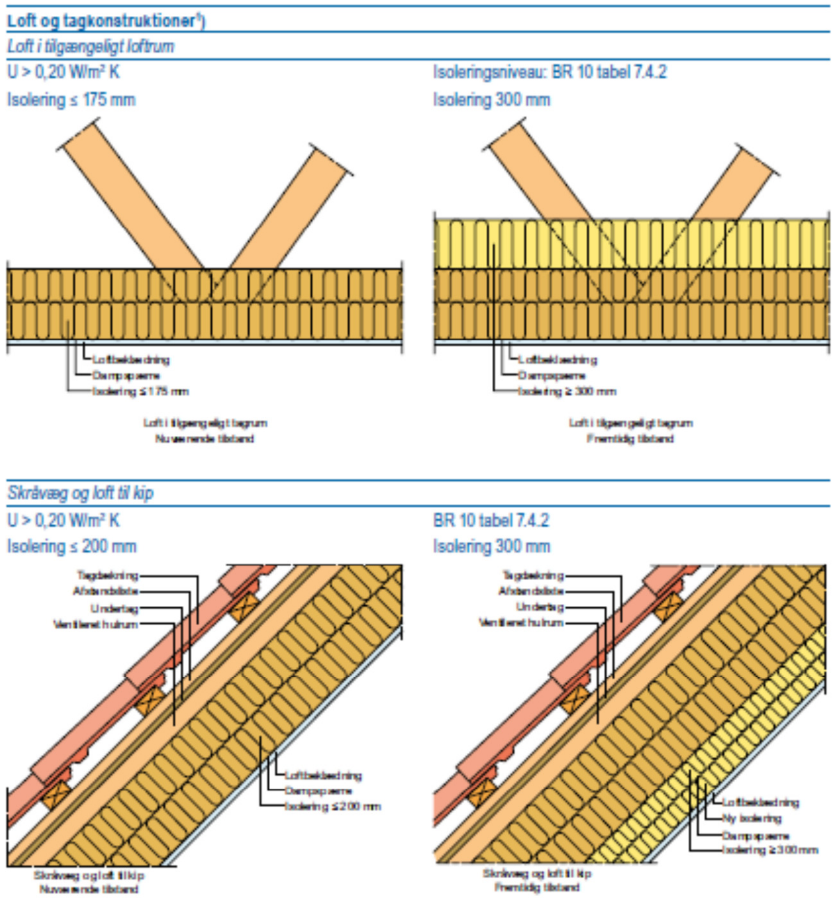
| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| U-value | 0,05 | 0,10 | 0,15 | 0,20 | 0,25 | 0,30 | 0,35 | W/K m² |
| + 10 mm isol. | 0,000667 | 0,002632 | 0,005844 | 0,010256 | 0,015823 | 0,022500 | 0,030247 | W/K m² |
| Investment | 6,00 | 6,00 | 6,00 | 6,00 | 6,00 | 6,00 | 6,00 | DKK/m² |
| Saving | 1,22 | 4,80 | 10,66 | 18,71 | 28,87 | 41,05 | 55,19 | DKK/m² |
| Economic | -4,78 | -1,20 | 4,66 | 12,71 | 22,87 | 35,05 | 49,19 | DKK/m² |
| | 0,000 | 0,110 | 0,000 | 0,000 | 0,000 | 0,000 | | |
| **Marginal U-value** | **0,110 W/K m²** | | Marginal isolering | | | 319 mm | | |

**Marginal start insulation**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Start insulation | 0 | 50 | 100 | 150 | 200 | 250 | 300 | mm |
| U-value | 2,222 | 0,555 | 0,317 | 0,222 | 0,171 | 0,139 | 0,117 | W/K m² |
| Investment | 251 | 221 | 191 | 161 | 131 | 101 | 71 | DKK/m² |
| Saving | 3853 | 812 | 378 | 204 | 110 | 52 | 12 | DKK/m² |
| Economic | 3602 | 590 | 186 | 43 | -21 | -49 | -59 | DKK/m² |
| | 0 | 0 | 0 | 184 | 0 | 0 | | |
| Marginal start insulation | 184 mm | | **Marginal start U-value** | | | | **0,18 W/K m²** | |

### 4.3.5 Examples of rentable energy saving measures in existing buildings in relation to renovation (from annex to Danish Building Regulations 2010)

Present status: Improved:




## 4.4 The Netherlands

This section briefly describes the Dutch approach to tightening the energy performance requirements based on cost efficiency considerations and acceptance by the market. Prior to this description in order to create a better understanding the following section provides a short outline about the Dutch transposition of the EPBD into legislation and regulations regarding energy performance requirements and certificates and how the energy performance is assessed in order to meet the requirements.

### 4.4.1 Outline of the legislation

***General structure of the Energy Performance legislation***

In the Netherlands the building legislation (decrees and regulations) is based on the Housing Act (see Figure 7), which has been in place for many years. The “Building Decree” and the “Decree Energy Performance of Buildings” (BEG) are the basic legislative provision which transposes the EPBD into Dutch legislation. The BEG is worked out in an underlying regulation: the Regulation on Energy Performance of Buildings (REG). The legislation appoints codes of conduct or standards to support the quality of the execution in practice.

### *Energy Performance Certificates*

The issuing of Energy Performance Certificates (see Figure 7) in case of construction, sale or renting out of buildings and on displaying the certificate in public buildings, has been transposed through the Decree Energy Performance of Buildings (BEG) and more specific by the REG. the In the REG specific requirements on form and content of the Energy Performance Certificate are given. The legislation related to the certificates appoints a code of conduct to guarantee the quality of the assessment: the BRL-series:

- BRL 9500 sets requirements for the assessment process, the energy experts and the NL-EPBD-process certificate, which authorizes experts within a certified company to issue Energy Performance Certificates;
- BRL 9501 sets requirements for the calculation method of the energy performance of existing buildings to be used for building certification.

Both BRL's refer to formal publications issued by ISO, providing detailed information on the assessment process, calculation method and the testing of the software.

## 4.4.2 Energy Performance requirements

### *New buildings and major renovation*

The energy performance requirements (see Figure 7) for both new and existing buildings are part of the Building Decree. This decree has already been in force since 1995, and sets the specific Energy Performance Coefficient (EPC) requirements that new buildings and buildings that undergo major renovation have to meet. These EPC-requirements vary depending on the user typology of the building and are sharpened on a regular basis. All new buildings and renovations that require a building permit are obliged to meet the EPC-requirements; the size of the building does not matter for this obligation.

### *Existing buildings*

In case of the renovation of existing buildings the Building Decree also sets minimum requirements on component level, specifically regarding ventilation and insulation. These requirements are complementary to the overall EPC requirements and act as a bottom line on component level in case of renovation. Depending on the nature of the renovation local authorities can grant exemption from the EPC-requirements on building level, but then the requirements on component level are still to be honoured.

Insulation requirements are set by means of a required Rc value. The Rc value means the Heat Resistant of Constructions. There have been minimum Rc values for constructions/building elements since 1965 (wall, roof, floor, window) for new buildings and (major) renovations which require a building permit. There have been no reinforcements on Rc value since 1992, since these requirements are complementary to the EPC requirements for the building as a whole, which are sharpened regularly.

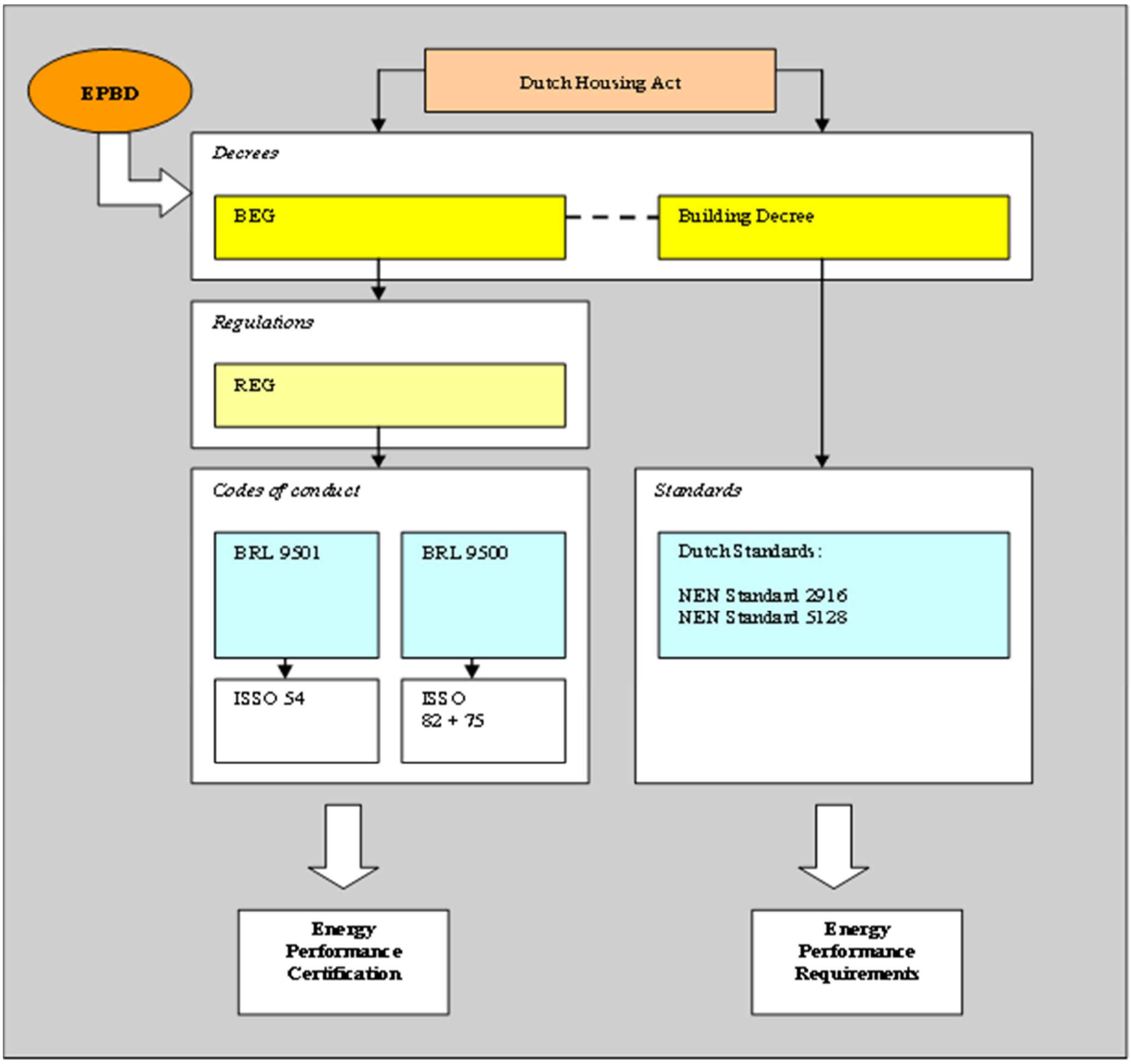



*Figure 7.The EPBD and the Dutch legislation regarding the Energy Performance Certification and energy performance requirements.*

### *Calculation methods (see figure 1)*

In the Netherlands the calculation procedures for the energy performance of buildings (certificates as well as requirements) are based on asset rating (or calculated rating) for the whole building. Two different sets of calculation methods have been developed.

For new buildings and major renovations the method has been available since 1995. It is described in two official standards, NEN standard 2916 for non-residential buildings and NEN standard 5128 for residential buildings. The energy performance is expressed in an Energy Performance Coefficient (EPC). The EPC is an indicator presenting the energy efficiency of a building. Requirements for the EPC are set in the Building Decree.

For existing buildings the energy performance is expressed in an energy performance indicator called the Energy Index (EI). This calculation method is based on the original Dutch EPA method, and is presented in ISSO publication 82 and 75 for residential and non-residential buildings.

Both calculation methods will be combined into one approach that differentiates between new and existing buildings and residential and non-residential buildings. According to plan this combined approach will be in force before 2013.

### 4.4.3 Tightening energy requirements; a deliberate process

Cost-effectiveness and impact assessment

#### *Requirements on building level for new buildings and major renovations*

There is a long history in the Netherlands regarding the tightening of energy performance requirements for new buildings and major renovation. To illustrate the progression of the requirements over the years the EPC requirements from 1995 until 2015 are plotted in Figure 8. In 2020 the goal for new buildings is to achieve the nearly energy neutral level.

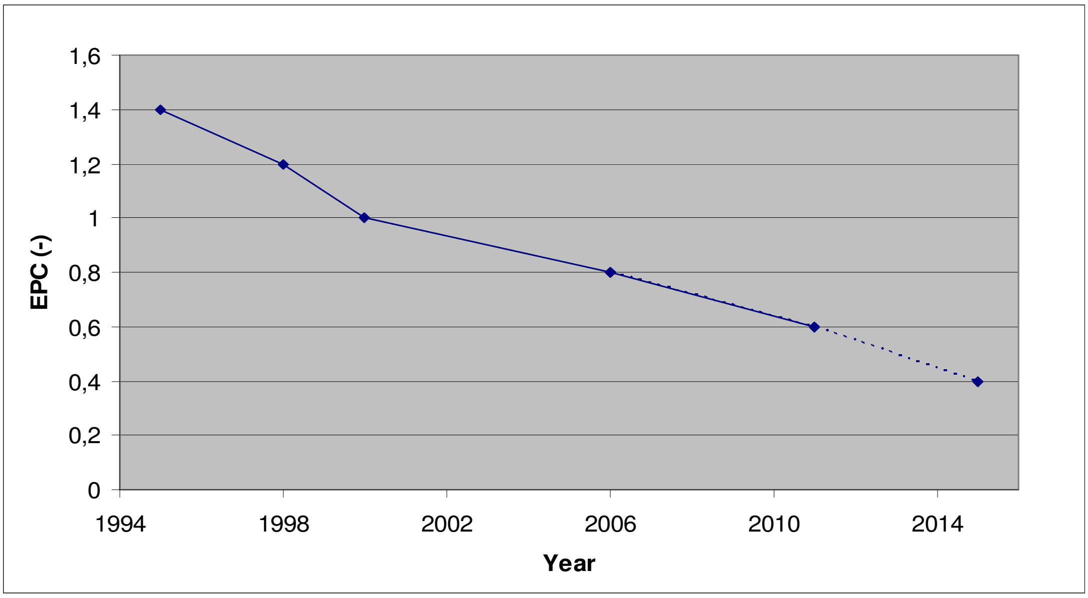



*Figure 8.Regular sharpening of EPC requirements for residential buildings. The Energy Performance Coefficient (EPC) is an abstract indicator of the overall energy performance of a whole building. It is a way of expressing the total primary energy consumption. The calculation of the EPC value takes into account: insulation, heating installation, hot water, lighting, auxiliary energy, renewable energy. The EPC-requirements should be met in construction of new buildings and major renovation of existing buildings by taking energy efficiency measures and honouring minimum requirements. Before the building permit is issued the EPC calculation must prove that the EPC-requirements are met.*

*The overall energy performance requirements for whole buildings are set as a 'maximum EPC value'. In 1995 this value was set at 1.4, and this was sharpened over time until 0.6, which is the current requirement (maximum EPC-value 0.6). The dotted line presents future plans for reinforcements in 2015.*

#### *The process*

The sharpening the energy requirements is initiated by the government and reflects the climate policy targets. To increase the effectiveness of more tight requirements the government organizes consultation with relevant actors in the market through a committee consisting of market representatives. They discuss studies performed and provide relevant market perspectives. The final proposal is discussed in the Exchange Platform Building Regulations also representing the market. They perform an advisory role towards the government.

#### *The determination of the requirement level*

In order to adjust the level of the EPC-requirements the cost-effectiveness of different packages of measures that can contribute to the desired level of energy efficiency is regarded. The feasibility of a specific level of EPC-requirements is investigated. These studies focus on the level of cost-effectiveness of different packages of measures applied to a series of reference buildings. Sensitivity studies provide the bases for the adjustment of the requirements. For this purpose a set of relevant reference buildings has been developed both for residential and non-residential buildings, which is assumed to be representative for the 'building practice'. Sensitivity studies and impact assessments are also performed related to other relevant impact factors (besides cost-effectiveness), like the effect on; (indoor) air-quality, administrative burdens, use of water and environmental impact of other used resources, comfort aspects, indoor air quality, market acceptance, employment rate, practical applicability, enforcement efforts, etc. Besides these impact assessments and sensitivity studies based on the defined set of reference buildings specific thematic studies are also performed. These studies focussed on the potential $CO_2$ reduction of requirement levels for the whole building stock or parts thereof.

The adjustment of the energy regulations follows in principle the same procedure, except for the fact that the approach is being updated every time it is applied.

### *Existing buildings requirements on component level*

Through the years the level of the component requirements is tightened based on the technical developments and the ability from the market to deal with the proceeding developments. The level of component requirements for floor, wall and roof from 1965 on is depicted in Figure 9.

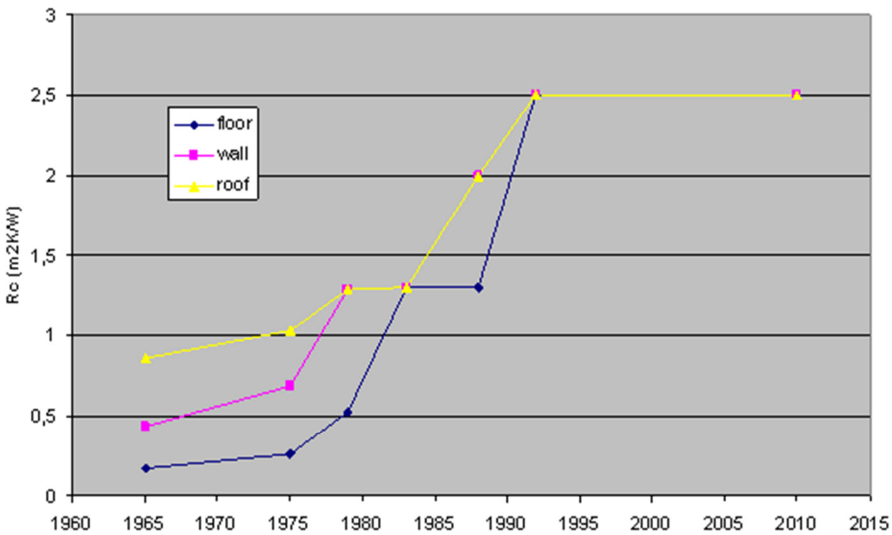



*Figure 9.Minimum requirements on component level. The Rc (the thermal resistance of the structure) is commonly used in the Netherlands to set energy performance requirements for building elements (wall, roof, floor, etc) complementary to the overall energy performance requirement for the building as a whole: the Energy Performance Coefficient (EPC).*

As stated earlier, the present the requirements are set through the Energy Performance Coefficient (EPC); the component requirements act as a bottom line. Regarding the energy performance requirements on building element level, cost-effectiveness is at the present not specifically considered in setting the requirements. For long these component requirements were complementary to the requirements on building level or they are only related to minor renovations on element level. In view of the EPBD recast the component requirements will be extended and reset before 2013. The level of the component requirements will be set analogous to the "whole building requirements", aiming for cost optimal and at the same time practical levels.

### *The Environmental Law sets additional energy requirements to existing buildings*

In addition to the requirements laid down in the building regulation the Environmental Law also sets energy requirements for a section of the non-residential buildings. For existing non-residential buildings that use more than 50.000 kWh of electricity and/or 25.000 $m^3$ of gas the Environmental Law requires that the organisations that use these buildings take all cost-effective energy saving measures with a simple pay-back time less than 5 years. A list with measures is and pay-back time is available. This requirement is enforced on municipality level and part of the environmental permit for the activities of the organisations. This obligation is related to a 'duty for environmental care'. When the organisation uses more than 200.000 kWh of electricity and/or 75.000 $m^3$ of gas, they can be obligated to have an energy advice so the organisation can be guided in taking the most efficient energy saving measures.

# 5 Questionnaire summary

To attain an overview of the current situation in the MS a questionnaire was circulated (February 2011). The Commission was consulted on the questionnaire to ensure maximum usefulness of the WG's results.Questions were arranged in 5 groups: On the national approaches in general; On technical building systems; On national input data; On low energy buildings/ RES and cost optimality and On CEN standards.

The questionnaire was circulated to the 27 MS plus Croatia and Norway. 20 questionnaires were answered, but not all questions were answered from all respondents. When applicable, answers from individual countries are shown in tables using Internet country codes as identifiers. The 20 answers came from at (Austria); be (Belgium – Flemish region); bg (Bulgaria); de (Germany); dk (Denmark); ee (Estonia); es (Spain); fi (Finland); gr (Greece), hr (Croatia); hu (Hungary); ie (Ireland); lv (Latvia); lu (Luxembourg); nl (the Netherlands); ro (Romania); se (Sweden); sk (Slovenia); no (Norway); and uk (United Kingdom – England & Wales).

## 5.1 On the national approaches in general

*Q1. At what level do you calculate the cost optimal requirements?*

Most MS (11) use a microeconomic approach, i.e. financial perspective, perspective of the investor when settling the cost optimal requirements in their current procedure. In 3 MS the macroeconomic approach, i.e. economic perspective, society's perspective, is being used, while 5 MS answered that they use both approacheswhen deciding on cost optimum measures.

One country, Austria, uses another approach. "A method is not available yet. There is an Austrian Standard on the economic assessment of heating systems (ÖNORM M 7140 2004-11-01, "Economic comparison calculation of energy systems based on the extended annuity-method", under revision, to ensure compliance with EN 15459 Energy performance of buildings - Economic evaluation procedure for energy systems in buildings) and an Austrian Standard on the economic assessment of construction components (representing the economic assessment of the building shell, ÖNORM B 8110-4, "Economic optimising of thermal insulation", under revision, draft issued on 2011-03-01). There was the attempt to combine both approaches and as a starting point the group developed a tool for the calculation of cost optimal requirements, based on the calculation procedure of the energy certificate, and the two Austrian Standards mentioned above. Excel-Tool: see attachment. Other experts developed other tools, which have been discussed in the respective committees (ON-K 175, ON-K 235) of the Austrian Standards Organisation. ÖNORM M 7140 also takes into account external costs for $CO_2$."

The answers from Austria do thus refer to the Austrian Standards described above and the method on which the informal Excel-Tool is based upon. The Excel Tool is only available for residential buildings.

*Q1.1. If your country uses both approaches: Do you have separate methodologies for micro and macro level perspective?*

Only 5 MS uses both the micro and the macro level approach in the definition of cost optimum measures, and 4 of those use the same methodology for the two situations – though with different values for some of the input parameters. One country, Norway, uses a different methodology for the two levels.

*Q1.2 If your country uses the macroeconomic level approach: Do you take into account externalities and which ones if so (environmental such as $CO_2$, pollution, soot, energy security, employment etc.)?*

| MS | Answer |
|---|---|
| **at** | ÖNORM M7140 also takes into account external costs for $CO_2$ (emissions caused by heating energy), however, the numbers need a revision. |
| **be** | - |
| **bg** | - |
| **de** | As externalities different GHG emissions combined to a $CO_2$ equivalent emission are considered in the macroeconomic (society's perspective). The study is comparing building related $CO_2$ equivalent emission savings to other kind of savings in different areas such as transport, industry, commerce, etc. Other externalities might be considered in other studies not closely linked to the building energy performance requirements. |
| **dk** | For both new and existing buildings Denmark uses both the macro and micro economy approach. For existing buildings however the macro economy approach is primarily being used in setting the general level of requirements. |
| **ee** | - |
| **es** | - |
| **fi** | - |
| **gr** | - |
| **hr** | - |
| **hu** | - |
| **ie** | GHG emissions, shadow price of public funds, administrative costs.). |
| **lv** | Not applicable. |
| **lu** | - |
| **nl** | - |
| **ro** | - |
| **se** | $CO_2$ and sulphur included as taxes in energy prices. |
| **sk** | - |
| **no** | We take into account externalities such as $CO_2$, energy security, employment, etc. However, externalities are sometimes only assessed in a qualitative way. |
| **uk** | Cost of carbon (damage cost estimate for fuels, ETN price for electricity); avoided cost of new power generation; avoided investment in renewable supply. |

*Q1.3. When setting the discount rate do you think other factors should be taken into consideration such as energy security? (This means that the discount could be negative.)*

This question was answered “yes” by 4 countries while 6 answered “no”.

*Q2 Is embodied energy included in your national methodology?*

In 17 countries embodied energy is not taken into account in the cost optimum procedure while 3 have chosen to take it into account.

*Q3 Do you pursue a global approach or a component/element approach at national level?*

In no country the component approach is being used solely. In 6 countries both approaches are being used while 11 countries use both approaches.

In 2 countries, namely Latvia,and Spain another approach is being used. The comment from these countries was:

- Spain: “*None of them. We have used the energy need for heating as an indicator for the whole building. The capital cost for cooling is very difficult to be quantified, as it depends on elements as movable shades (awnings, night ventilation…).*”
- Latvia: “Method refers to the standard EN 15459”.

*Q4 How could the net present value concept as well as the steps laid out in Annex III of the EPBD be simplified without undermining the methodology?*

| MS | Answer |
|---|---|
| **at** | I don´t know. |
| **be** | - |
| **bg** | Will be subject in the updated legal acts. |
| **de** | In Germany the responsible ministries think that a significant ratio of the public does not completely understand the net present value. Therefore the procedure is slightly adapted and a dynamic amortisation period for the combination of measures is calculated. The general calculation method and the boundary conditions are the same as for the net present value. If the dynamic amortisation period is lower than 20 years for all building types, the combination of measures (and the foreseen tightening) is regarded as being cost-efficient. Cost-optimality is not the goal. The relevant law would allow to go for further requirements as it asks that the investments for the measures have to be cost-efficient within the life span of the measures (not of the building). |
| **dk** | In Denmark increases in energy costs is assumed to be equal to the increase in mortgage.<br>Existing buildings: An energy saving measure is considered cost effective if the annual saving in currency multiplied by the lifetime of measure and divided by the investment is greater than 1.33. This mean the investment has to be paid-back within 75 % of the life-time of the measure.<br>New buildings: The net present method could be simplified by limiting the building related input to the investment and the annual energy savings. The interest rate, the inflation and the energy cost still need to be given. |
| **ee** | - |
| **es** | We do not see the suggested metrology complicated. We are waiting for the data from the commission for applying it with reliable data. |
| **fi** | For example excluding the geographic location from the net present value concept. It would be easier to use one geographic location that represents "average value" for the whole country/region. |
| **gr** | We do not think it needs simplification. |
| **hr** | - |

| MS | Answer |
|---|---|
| **hu** | Under discussion – as it became clear yesterday (16. March 2011) at the EDM, fog covers many questions. |
| **ie** | Define a net present value approach to be applied on a whole building basis. MS should decide appropriate DF and should have some discretion in no. of years and building types. MS should be allowed include $CO_2$ emissions if they wish. |
| **lv** | There is no common view on this issue. |
| **lu** | No further simplification – for the element approach reference elements would be helpful. |
| **nl** | Because the methodology is still under development it's difficult to answer this question in a concrete way. The field of developing national requirements and providing a methodology to check them on EU level is very divers and complex. In order to develop a strategy for a comparative methodology on EU level the pitfall is to reflect the diversity by moving towards a high level of detail, creating a methodology that is likely to have a poor accuracy and is not very unambiguous/transparent, also such an approach might be time consuming to execute. Assuming that the objective of the method is to check whether a Member State is underperforming regarding requirement levels, the Netherlands favour a strategy to tackle the diversity and complexity by simplification instead of going into detail, unless detail is necessary. Thus serving transparency and unambiguousness. A consequence for example could be to provide in a set of simplified reference buildings that allow for the adjustments for the national context within MS and still can provide in a suitable comparison for the intended purpose (checking the level). |
| **ro** | There is no need for simplification. |
| **se** | Strongly restrict the number of reference buildings.<br>Big problems with existing building as they are their own reference buildings and we cannot calculate one reference building for every existing building. |
| **sk** | Net present value itself and steps in Annex III do not need simplification to be all aspects taken into account.  Perhaps influence of some input parameters or aspects will be negligible in real calculation, but more detailed study would be appropriate to define which can be simplified for which building type. |
| **no** | Some of the aspects in Annex III should be unnecessary to include in the methodology and should be up the MS to decide, for instance estimated long-term energy price developments and primary energy need. |
| **uk** | Could omit residual value. If standardised parameter values are acceptable, could pre-calculate some factors. |

*Q5 In the case of a rented building, how do you take into consideration the owner-tenant dilemma and the fact that the owner does not get (all) benefits from the investment?*

| MS | Answer |
|---|---|
| **at** | A lot of discussion, but no solution yet. |
| **be** | This is problem especially for social housing companies. It is foreseen in law that the social housing companies will be able to ask a higher rent if the building is more energy efficient. Now the rent only depends on the size of the house and the income of the tenant. But this measure is not yet applicable – further parts of the legislation are needed. It means now that social housing companies have to build higher standards with the same budget. Another solution could be to rise the budget for social housing, or to build less social housing project but with higher performances. I expect the minister to take some decision in this topic during the coming 2 years. Minister for social housing and energy is the same person at this moment.<br>An owner in the private sector can ask a higher rent. This is market driven. As most builders are owners (70 %), this is not the biggest issue. For the private investors that rent out buildings, it's important to know enough in advance what the sharpening of the legislation will be. |
| **bg** | Not a clear question. |
| **de** | There is a law in Germany that allows the building owner to transfer energy-related renovation to the tenant with up to 11 %/year of the costs to the rent. For new buildings the rent can be fixed freely which can take into account higher investment costs. The market however does not allow the higher rent in all cases. |
| **dk** | Especially valid for existing buildings: It is planned to make a shift in the concept of looking upon the rent and the cost for heating and domestic hot water as being two separate things. In the future it will be considered as one cost for renting and operating the space. Potential limitations will thus be on the global cost, and not only on the rent-part. |
| **ee** | It`s hard question, but it will be important do educate tenants to ask before renting the building/flat energy performance ratios, it will increase the energy efficient rented buildings prices. |
| **es** | We do not take into consideration this topic. |
| **fi** | There is no owner-tenant dilemma in Finland. Energy costs are included in the rent. |
| **gr** | - |
| **hr** | - |
| **hu** | This question is not important in Hungary, practically no residential building is being built for rent (and this was the case in the last two decades, too). |
| **ie** | Advertising of BERs for rented properties will help.<br>Tax reliefs for landlords of rented properties who do energy efficient refurbishments will also help. Eg. If landlord does energy efficient refurbishment if he received a tax relief over following 4 or 5 years against the amount spent this may encourage him to improve property.<br>Energy certificates should be used to support financial instruments. |
| **lv** | There is no common view on this issue. |
| **lu** | The calculation is done for the measure itself not taken into account the investor type. |
| **nl** | In the Netherlands the energy performance requirements are not specifically set and calculated from an owner perspective. The split-incentive (owner-tenant) dilemma is not taken into account because the time-frame over which cost-efficiency is calculated is connected to the expected lifetime of a building. However, the split-incentive dilemma is an important aspect within the market consultation. For example: in the Netherlands there is a system that provides guidance to the maximum height of the rent for residential buildings that are being rented out. This system is based on credit points that are allocated to a residential building (for instance for aspects like living space, comfort and energy efficiency). The rent is set based on the credit points a dwelling receives on the specific aspects. If an owner improves the energy efficiency of a build- |

| MS | Answer |
|---|---|
| | ing, the building receives more credit points and the rent may be raised since energy costs for the tenants will decrease, thus providing in a system of (partial) pay-back for the owner in order to overcome the split incentive problem. |
| **ro** | The specified dilemma is not taken into consideration. |
| **se** | This is a market failure and needs to be quantified. In Sweden the tenants pay rent for the heated apartment so the impact does not matter as much as where the tenant pays for the heating. |
| **sk** | We do not treat this in this stage. Generally this aspect should not be taken into account because/besides the fact that the rented buildings have to fulfil the same obligatory requirements also the use of building often changes in its lifespan (is not rented during all lifespan). Also if the investment is benefit only for tenant there is an advantage for owner on real estate market. |
| **no** | No. |
| **uk** | All benefits are valued, irrespective of to whom they accrue. It is essentially a societal assessment without consideration of equity issues. |

*Q6 If your country uses carbon as a metric: How could the cost optimal methodology be amended in order to follow a carbon reduction strategy?*

| MS | Answer |
|---|---|
| **at** | I don´t know. |
| **be** | Not applicable. |
| **bg** | Yes, but will be subject in the updated legal acts. |
| **de** | For the detailed requirement setting Germany does not use $CO_2$ equivalent, but it uses carbon dioxide equivalent emission reduction potential for the economic perspective study. The costs (incl. savings) and the $CO_2$ equivalent avoidance potential are compared between different measures. |
| **dk** | Costs for $CO_2$ quotas can replace/complement energy costs in the calculations. The price for emitting 1 ton $CO_2$ depends on the quota market price. |
| **ee** | We do not use carbon as a metric. |
| **es** | In case of a carbon reduction strategy the requirements will be recalculated. We have done a preliminary calculation of these requirements with the present data, the methodology does not depend on the data, but the results do. |
| **fi** | We don't use carbon as a metric. |
| **gr** | We do not use carbon as a metric. |
| **hr** | - |
| **hu** | In Hungary energy terms are used. |
| **ie** | Ireland uses energy as a metric. |
| **lv** | There is no common view on this issue. |
| **lu** | Integrate $CO_2$ costs as cost element. |
| **nl** | The Netherlands doesn’t use carbon as a metric. |
| **ro** | Not the case. |
| **se** | We don’t. |
| **sk** | There is no national methodology. Generally it is not decided yet from the side of Commission if the cost-optimal requirements will be set from microeconomic (investor) or macroeconomic (society) point of view. If the microeconomic (investor) point of view will be chosen, the carbon as a metric is not appropriate. It depends on general conditions. |

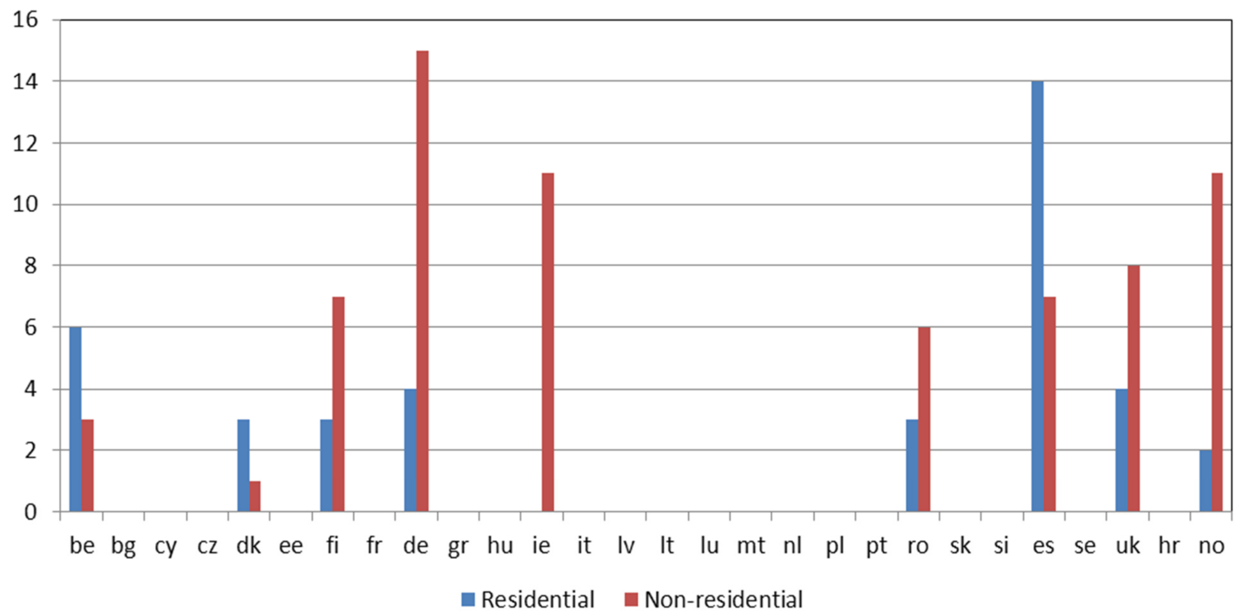
| MS | Answer |
|---|---|
| **no** | Normally energy reduction is used as a metric. If carbon is used as a metric for cost-efficiency assessment quota European prices for $CO_2$ can be used in a cost optimal methodology. |
| **uk** | This is reflected by the inclusion of shadow prices for externalities such as for carbon emissions. The overall carbon reduction strategy is part of the framework within which the assessment is carried out. |

*Q7 Do you already have a national classification for buildings (=set of reference buildings) that is consistent with what is laid down in Art 5 and Annex III of the EPBD?*

Among those countries who answered this question it is almost fifty-fifty between those who already have a set of reference buildings (9 countries) and those who do not have a set (8 countries).

*Q7.1 If "yes", how many reference buildings does your classification comprise (for residential and non-residential)?*

For those countries that use reference buildings in the assessment of cost optimum measures, the number of different building models ranges from 0 to 14 in residential reference buildings and between 0 and 15 non-residential reference buildings as indicated in the figure below.




*Q7.2 Is there evidence on variation between different building types in your national classification so that it would justify a rather detailed classification?*

Among those countries who answered this question, 8 claims that there is evidence that a rather detailed classification is necessary while 2 do not have the same consideration.

*Q8 How do you classify buildings along use patterns and how do you deal with multifunctional buildings?*

| MS | Answer |
|---|---|
| **at** | Residential and non-residential buildings, the latter sub-divided into: offices, administrative buildings, schools, kindergarten, hospitals, restaurants, hotels, boarding houses, nursing homes, retail, indoor swimming pool, event location, sports centre.<br>Mixed use residential buildings: classified as residential, as long as other types of use in total occupy less than 10 % of heated gross floor area.<br>Mixed use non-residential: choose the building use which is the majority as long as other types of use occupy less than 10 % of heated gross floor area. If one type of use exceeds 10 %, the building has to be divided, and zones are dealt with separately. |
| **be** | "Calculation for residential buildings is made for each residential unit (e.g. apartment). If there is another function e.g. on the ground floor, a separate calculation is made for the ground floor.<br>Small parts of offices (<800m³) that are attached (internally) to a residential building, an industrial building or another type of building, must not be calculated separately. |
| **bg** | There is a special regulation for energy performances. |
| **de** | In general the reference building approach is used. The study for non-residential buildings however used 15 different type buildings. Several use patterns are included. Even one building use includes several usage profiles. There was no mixed-used building used as type building, but the reference building approach allows also to fix the energy performance requirements for mixed-used buildings. |
| **dk** | In Denmark only two use patterns are being used: residential and non-residential buildings.<br>Only two uses are defined in the Danish legislation, namely residential and non-residential buildings. Two calculations must be made if the minor share of the building is above 20 % of the heated gross floor area. If the minor share is less than 20 %, this share is being considered the same as the major share. |
| **ee** | We have 8 types according to our minimum requirements:1) Detached houses (also semi-detached and terraced houses); 2) Apartment buildings; 3) Office and administrative buildings; 4) Commercial buildings, hotels, other accommodation and catering facilities, and trading and service facilities; 5) Buildings and recreational buildings; 6) Educational buildings and research facilities; 7) Health care facilities; 8) Indoor swimming pools. While a building has multifunctional purposes, each part of the building which has a separate use and the heated space of which exceeds 10 % of the heated space of the entire building, shall be determined an energy performance ratio corresponding to the use of that zone. Zones with an area below 10 % shall be included in the composition of other zones irrespective of its use. Maximum permitted energy performance ratio of a building is the weighted average energy performance ratio of the use of the parts of the building calculated on the basis of heated space. |
| **es** | We have on the one hand the residential buildings. On the other hand the tertiary buildings on which we consider 12 different hourly pattern of use. If the building uses different patterns we consider it like that. And the reference building has the same use. |
| **fi** | Not at the moment, but we will set typical use patterns for different building types in the building requirements that are under preparation. Multifunctional buildings are classified accordingly. |
| **gr** | Buildings are classified in 11 categories (1 residential and 10 other uses in the tertiary sector). In the case of multifunctional buildings different certificates are issued for each separate use. |
| **hr** | - |
| **hu** | The less is the number of individual buildings in a given category (e.g. hospitals, wellness facilities, airports) the less is the chance that a usable reference can be selected (with small numbers the statistical method has no sense), thus in this case a notional building is to be defined by the designer himself as reference. |

| MS | Answer |
|---|---|
| **ie** | Usage patterns are defined by function of building e.g. Library vs. school vs. office. Regarding multi-function buildings – it is unsure. |
| **lv** | There is no common view on this issue. |
| **lu** | Residential buildings are classified in two groups: single/double family houses and multi-family houses. For non-residential buildings there are 13 different building categories and a zone based calculation. |
| **nl** | In the Netherlands we have one user pattern for residential buildings, and 10 for non-residential buildings. In the energy performance studies 4 non-residential patterns are being used. In case of mixed use, the approach is to apply the dominant user pattern to the building. |
| **ro** | A detailed classification is made according to building types defined in EPBD. For multifunctional buildings the energy performance certificate (EPC) is issued for the main destination or for each part of building with different use (as separate EPC). |
| **se** | Each part is weighted with the heated area as weighting factor. |
| **sk** | The reference buildings have not been set yet. |
| **no** | In such cases the multifunctional building is divided in different zones. |
| **uk** | The performance requirement calculation process requires each space in a building to have one of a (large) number of standardised activities to be assigned to it. (These also apply to the “notional “comparator building), This can deal with multifunctional buildings – and also with variations within classes of buildings of similar generic description, such as “hotels”. |

*Q9 How many packages of measures do have to be considered for establishing the cost optimal threshold?*

| MS | Answer |
|---|---|
| **at** | Not available. |
| **be** | More than 100 packages of measures were calculated. Improvement steps for each measure were defined: e.g. ameliorating the U-value in steps of 0.05 W/m²K. All different combinations of all different steps for all the measures were calculated. Specific software is used to do this type of calculation. It results in something like this, was the lowest point for each % primary energy use, and is the cost-optimal solution for a specific energy performance level. Were the curve is lowest, you can find the economic optimum (in this example: +/- 64 % of the 100 % level) |
| **bg** | Will be subject on updated legal basis. |
| **de** | In Germany the cost-optimal threshold is not fixed at all. The studies have to prove that the foreseen tightenings are cost-efficient. For this one package per building type is used, based on the foreseen reference technologies that shall be fixed in the energy decree. Other combinations can be more or less cost-efficient but will have to be at least the same energy performance as the reference technologies. |
| **dk** | The cost optimum threshold is not decided yet. |
| **ee** | It is hard to say exact number, there should be taken into account lots of measures to work out cost optimal threshold. Different computer programs like Genopt help to find it. |
| **es** | Three packages: A) REDUCED: it consist only improvements on the insulation level, and windows quality. B) BASIC: it consists of the REDUCED package plus amelioration of thermal bridges. C) EXTENDED; consists of the BASIC package plus amelioration of thermal bridges on the windows contours and better air tightness. |
| **fi** | No answer yet. |
| **gr** | - |
| **hr** | - |
| **hu** | - |

| MS | Answer |
|---|---|
| **ie** | For a new dwelling passive measures should be prioritised with renewables second. The cheapest passive measures are the same for all dwellings. The trade-offs usually need to be made between ventilation (natural ventilation or DCV or MVHR), windows (double or triple glazing) and renewables Therefore package should be passive measures + ventilation+ windows (triple or double). Renewables should be an option.<br>For an existing dwelling the cheapest measures are insulation, boiler and control upgrades, windows and renewables.<br>Buildings other than dwellings are passive measures and then renewables.<br>Perhaps some hierarchy/flowchart is needed when selecting packages…? |
| **lv** | There is no common view on this issue. |
| **lu** | Not yet defined. |
| **nl** | There is not a defined number of packages that has to be considered. In practice a wide range of relevant packages that can lead to meeting the EPC requirements are considered. |
| **ro** | A minimum number of packages is not established as mandatory. The return period for investment for the selected package is limited instead. |
| **se** | 3.14592 as average. |
| **sk** | The packages of measures have not been defined yet. |
| **no** | There is no standard answer for this. It will depend on the problem that is to be considered. This had varied between different assessments. In some cases only one package of measures has been considered. In other assessments up to five different packages of measures has been compared. |
| **uk** | The current test is whether a proposed change of regulations is cost-effective (not explicitly whether the regulations are cost-optimal). Since the regulations are framed in performance terms, specific packages are not predefined. For each building type a package of measures that is judged to be the least cost practical way of achieving the desired performance is applied. Usually additional sensitivity tests are carried out. |

*Q10 What rule is applied in order to choose "marketable" technologies?*

| MS | Answer |
|---|---|
| **at** | Not available. |
| **be** | Each standard technology that is included in the calculation methodology is a possible measure. I presume that some innovative new technologies will be calculated in a new study, even if they are not yet really a part of the methodology. |
| **bg** | No such rules. |
| **de** | State of the art technologies are the basis for the reference technologies fixed for the reference buildings. Only technologies that can be calculated with the used standards (DIN V 4108-6 and DIN V 4701-10 for residential buildings respectively DIN V 18599 for all buildings) can be assessed according to the required standard. Though there are possibilities to use an alternative method for assessing other technologies, these are not often used. Especially DIN V 18599 includes many technologies that can't be assessed in other countries. The state of the art technologies are defined by an adviser (advisory board) to the ministry, following the results of the study and have to be accepted by the ministry. Those technologies have to be available on the market of course. |
| **dk** | No special rules regarding marketable technologies, common sense are being applied. |
| **ee** | It is hard question, but if we took the whole building, then designer-architect have more possibilities to solve problem. |
| **es** | At the end we have centred on the REDUCED package, as the building workers are not yet trained to do their job in the required way. |

| MS | Answer |
|---|---|
| **fi** | No answer yet. |
| **gr** | - |
| **hr** | - |
| **hu** | - |
| **ie** | All technologies should be quality assured for market i.e. they should meet Harmonised EN standards or have ETAGs. In Ireland proper materials means hEN certified products or Irish Agreement Certified or equivalent. |
| **lv** | There is no common view on this issue. |
| **lu** | Not yet defined. |
| **nl** | A mixture of costs, (expected) availability on the market, risks in terms of comfort and health, practical aspects to apply the technologies (skills), proven performance and reliability is applied. |
| **ro** | No defined rule. |
| **se** | Functional requirements, the result is counted not the technology. |
| **sk** | - |
| **no** | Normally “marketable” technologies are considered is the assessments. |
| **uk** | A mixture of cost and (expected) availability on the market. |

*Q11 Do you include assumptions on decrease of prices of new technologies and if so, which?*

| MS | Answer |
|---|---|
| **at** | Not available. |
| **be** | I don’t have specific information about this. |
| **bg** | No legal act. |
| **de** | There are no assumptions of decrease of prices included as the proof of cost-efficiency has to be valid from the start of the new energy decree being valid. A proof that assumes that the tightening is cost-efficient after 2 or 5 years if prices decrease would be of no use. |
| **dk** | Several scenarios for various technologies have been calculated taking into account price cuts over time due to estimates of the technology development. This has been used to define the new energy requirements in the Danish Building Regulations.<br>Future cost for different technologies are not included in the ordinary cost calculation. |
| **ee** | No, we haven`t yet worked out our cost optimal procedure, but it will be quite hard to take into account assumptions on decrease of prices of new technologies. |
| **es** | No. |
| **fi** | No answer yet. |
| **gr** | - |
| **hr** | No. |
| **hu** | Expecting scenarios from multinational companies. |
| **ie** | No. costs are current costs. However it is flagged in impact analysis that they are likely to reduce. However as this reduction is hard to predict it is not included in the forecasts. |
| **lv** | There is no common view on this issue. |
| **lu** | No. |
| **nl** | Yes, to a certain extend. |
| **ro** | No assumptions are made on the evolution of new technologies prices. For each building (at energy audit level) the costs are evaluated by the energy auditor for buildings taking into account actual market costs. |
| **se** | No, functional requirements, the result is counted not the technology. |

| MS | Answer |
|---|---|
| **sk** | - |
| **no** | No. |
| **uk** | No. |

*Q12 Do you think it is reasonable to already include a future higher property value in resale for more energy efficient buildings and if so how would you quantify that?*

| MS | Answer |
|---|---|
| **at** | How to calculate: based on the energy saved compared with an average building. We did a study on this issue in Austria together with real estate experts and developed a calculation guideline. |
| **be** | I don't have information on this. At this moment, the persons that estimate the value of a building don't look to the energy performance indicator. They have a system of their own to estimate the value. The location of the building and the size are in most cases the dominant factor for the value. |
| **bg** | Yes. |
| **de** | Future resale is not yet considered. The property value includes so many other influence factors that it is not easy to be quantified. |
| **dk** | Future resale is not yet taken into account and no studies have been made in Denmark to confirm a potential higher price for an energy efficient building. |
| **ee** | I think it would not be reasonable, because in the future standard level should be energy efficient building - not energy efficient buildings prices should decrease. |
| **es** | No. |
| **fi** | Maybe in the future. It is most useful on well-functioning property markets. |
| **gr** | - |
| **hr** | - |
| **hu** | - |
| **ie** | It is a relative value. Currently house prices are dropping so it may be more appropriate to present as an index against the mean price of property. It seems reasonable in a falling market that it has some value. In a rising market it may not be as important LOCATION AND OTHER FACTORS ARE MORE IMPORTANT. As energy prices increase this factor will become more important. |
| **lv** | There is no common view on this issue. |
| **lu** | The higher property value has to be taken in account if the building is sold before the lifetimes of the different components end (residual value). |
| **nl** | Including a higher property value is taking care of a split incentive when a building changes owner. This is implicitly taken care of in a macroeconomic approach. In a microeconomic approach from the owner perspective added property value could be estimated. |
| **ro** | No: the final value of an energy efficient building is usually higher than a "classical" one and, on the other hand, it is a market issue and the artificial increased property value would not be beneficial. |
| **se** | This is the Net present value method, intrinsic. |
| **sk** | - |
| **no** | Not relevant. |
| **uk** | The life cycle costing includes all estimated future savings, irrespective of to whom they accrue. It therefore implicitly assumes that this is reflected in the resale value of the buildings. A theoretical alternative would be to truncate the analysis after the expected ownership (or occupation) period (perhaps 7 years or so) but include resale value explicitly. This would add complexi- |

| MS | Answer |
|---|---|
| | ty, especially as the increased value is uncertain and apparently small at present. |

*Q13 Do you define the economic lifetime of a building in your national methodology?*

One third (6 countries) of those who answered this question define an economic lifetime of a building in their national methodology, while two thirds (11 countries) do not.

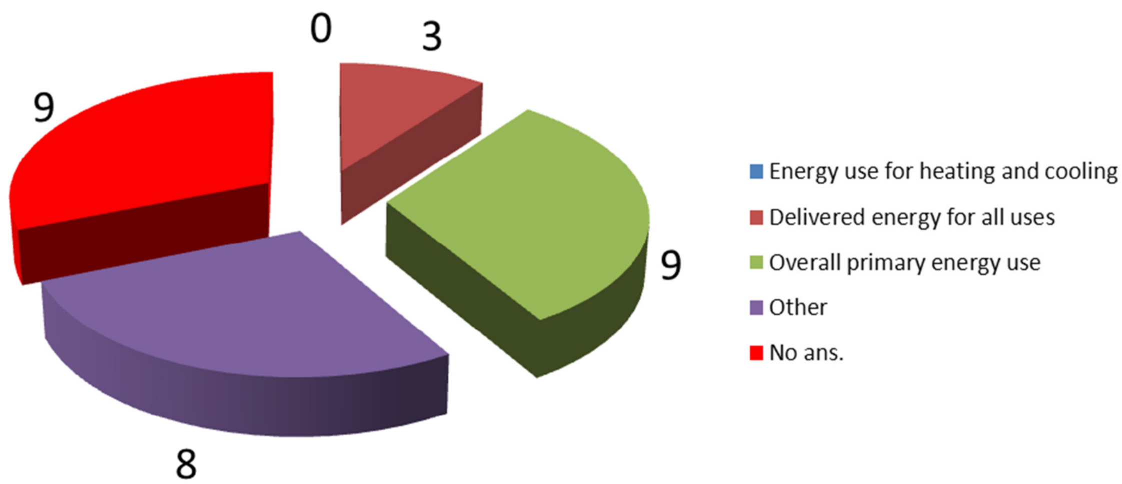
*Q14 What calculation period do you use and do you work with residual values?*

| MS | Answer |
|---|---|
| **at** | The Austrian Standard B 8110-4 does not provide any guideline on how to deal with assumptions required for economic calculations, but only states that calculations should be project specific.<br>The Austrian Standard M 7140 supplement 5 provides guiding and reference values for input-data (utilisation period of components, cost of maintenance as percentage of investment cost, increase of prices of components, increase of price of energy carriers, external costs for $CO_2$). |
| **be** | 30 years for residential buildings. 20 to 25 years for non-residential values. Residual values are calculated according to the CEN standard EN 15459:2008: if a measure is already changed (e.g. boiler). |
| **bg** | - |
| **de** | Overall primary energy use. |
| **dk** | We doesn`t calculate economic lifetime. |
| **ee** | - |
| **es** | 0 |
| **fi** | - |
| **gr** | - |
| **hr** | - |
| **hu** | - |
| **ie** | Currently calculations are to 2050. Residual values are not taken into account. |
| **lv** | There is no common view on this issue. |
| **lu** | 25 years for existing buildings and residual values for new buildings. |
| **nl** | A typical period is 30 years. The Write-down on HVAC systems is 15 years, for structural measures like insulation the write-down is assumed to be 50 years. The bottom line is that additional costs for measures should be paid back within the lifetime of the measure. |
| **ro** | For thermal rehabilitation / energy upgrading solutions – the following values are quantified: period of return of investment in energy savings solutions, energy saved price for estimated lifetime of the proposed solutions and investment costs. The calculation is dynamic, taking into account the net present value. |
| **se** | 40 years normally. |
| **sk** | After considering 25, 30 and 35 years, we have retained 30, as the building characteristics were the same, practically independently of the lifetime (the costs were obviously greater but not the cost optimal solution for the requirements). |
| **no** | Normally we have used 50 years as the life span of the building and 20 – 30 years for technical installations. |
| **uk** | Building life 60 years: shorter-lived elements assumed to be replaced like for like; policy life 10 years. No residual value. |

*Q15 Are passive solutions included in your national calculation method?*

In 12 of the countries who answered this question passive solutions are taken into account while in 4 countries they are not.

*Q16 What is the outcome of the calculations?*




*Q17 Are ex post assessments of your national cost efficiency calculations carried out?*

In 4 countries among those who answered this question an ex post assessment of the cost efficiency calculations has been carried out, while 11 countries have not carried out such an assessment.

Q18 How often are the requirement levels reviewed/adjusted in your country?

Generally – in those countries where a validity period has been decided upon - requirement levels are being reviewed and if appropriate adjusted for intervals between 3 and 5 years.

| MS | Answer |
|---|---|
| **at** | Requirement levels are being adjusted in the course of implementing the EPBD Recast. |
| **be** | There is an obligation to study the level of the requirements each two years. After 2006, we had sharpening in 2010. Next steps are foreseen in 2012 and 2014. |
| **bg** | 1999, 2005, 2009. |
| **de** | We have attached a graphic that shows the development of the minimum energy performance requirements for detached single family houses in Germany in comparison with national research and demonstration projects which are used to show that new technologies are close to market application and a further tightening is feasible. The last tightenings have been in 2002 (2007 for non-residential buildings), then 2009. The next one is foreseen for 2012. This would mean 2-3 tightenings in 10 years. |
| **dk** | Every 5 years, 2006, 2010, 2015, 2020. |
| **ee** | Approximately after two years. Minimum requirements for energy performance established in 2007; in 2009 we little bit change the methodology and in 2013 we are planning to decrease energy performance ratios. |
| **es** | Every 5 years starting at 2011. |
| **fi** | Typically every third year. |
| **gr** | Not defined yet. |

| MS | Answer |
|---|---|
| **hr** | Not changed since 2008. |
| **hu** | Requested by the EPBD. |
| **ie** | Every 3 years. |
| **lv** | Regulatory requirements for building envelopes were approved in 2001 and came into force on the 1st of January 2003. |
| **lu** | Has to be defined. |
| **nl** | In the Netherlands we have had 5 EPC reviewing in 16 years, which means on average every 3-5 years. |
| **ro** | Usually the requirements are reviewed each 3 to 5 years or whenever needed. |
| **se** | 2002, 2006, 2009 and 2011 so far. |
| **sk** | - |
| **no** | Minimum every fifth year. New regulations were implemented in 2007 and 2010. |
| **uk** | In the past every 5 years, in future every 3 years. |

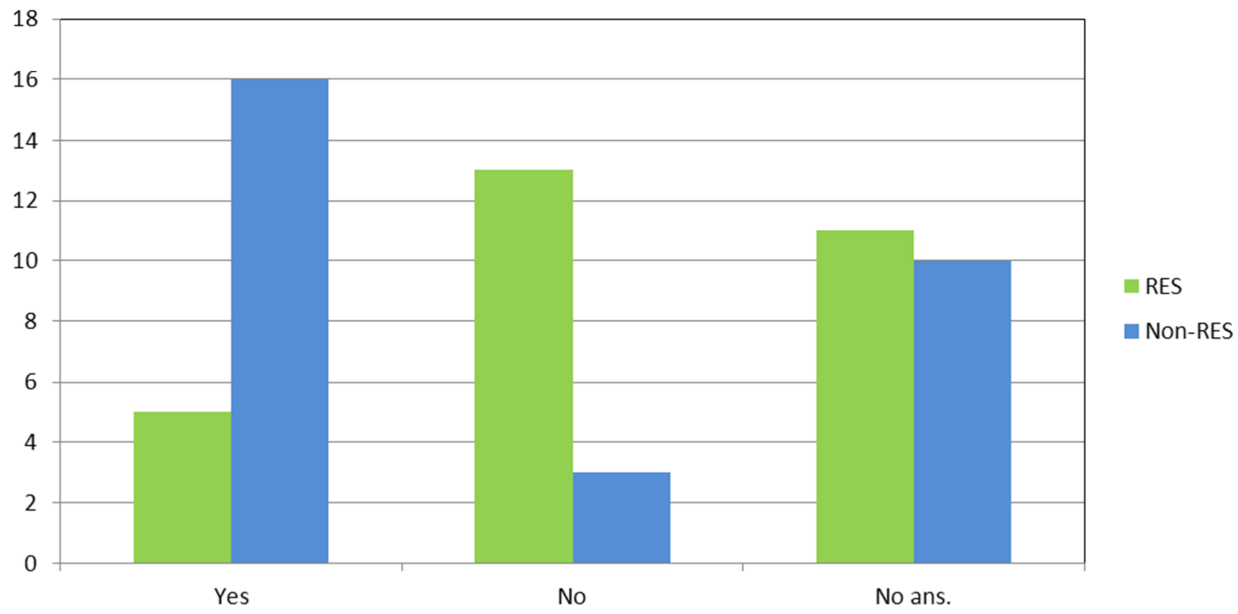
## 5.2 On technical building systems

*Q19 Would you agree that in order to establish technical building system requirements you would always need to consider the whole building?*

In 14 of the countries who answered this question the answer stated was „yes" while in 6 countries the answer was „no".

*Q20 Do you intent to include lighting systems requirements into the cost optimal approach for (non)residential buildings?*

In most countries who answered this question, lighting is or will be included in the cost optimal approach for non-residential buildings. On the other hand, in residential buildings lighting will probably not be included – in most countries.



## 5.3 On national input data

*Q21 Which source of information do you use to predict energy price developments?*

| MS | Answer |
|---|---|
| **at** | Austrian Energy Agency, E-control, scientific studies on energy scenarios. |
| **be** | European Forecasts. |
| **bg** | National statistics, state energy regulatory commission. |
| **de** | The basis of the energy prices is the data of the federal statistical office. The energy price development is predicted by a price increase rate based on documented experience. A certain rate is proposed to the ministry which has to agree or will propose another one. Sensitivity studies are made for some alternative price developments. For the last reports the energy price increase was taken to 1 %. Sensitivity analyses include energy price increases of 0.8 % (non-residential buildings) and 0.8 %, 0 % and 3 % (residential buildings). |
| **dk** | International Energy Agency energy statistics and forecasts. |
| **ee** | Statistic data. |
| **es** | We have guessed different scenarios. |
| **fi** | Existing statistics. |
| **gr** | World Energy Outlook published annually by IEA. |
| **hr** | Present price. |
| **hu** | Who knows? - We are looking for such information. |
| **ie** | Electricity and Gas Prices from October 2010: Due to full deregulation of the market, prices are now sourced from the prices gathered for the EU Gas & Electricity Price Transparency Directive. Prices are updated 6 monthly. |
| **lv** | There is no national information source. |
| **lu** | National and international data. |
| **nl** | Based on national data on energy price development. |
| **ro** | National values and price strategies. |
| **se** | We predict the energy price will follow the inflation. |
| **sk** | - |
| **no** | We have normally used current price level. |
| **uk** | "Central case" projections from the relevant government department (DECC) - to ensure consistency with other national policies. Separate prices for each fuel and for electricity. |

*Q22 What energy price levels do you assume in your national methodology and do you differentiate between different sources of energy (oil, gas, LPG, biomass, other)?*

| MS | Answer |
|---|---|
| **at** | The Austrian Standard B 8110-4 does not provide any guideline on how to deal with assumptions required for economic calculations, but only states that calculations should be project specific.<br>The Austrian Standard M 7140 supplement 5 provides guiding and reference values for input-data (utilisation period of components, cost of maintenance as percentage of investment cost, increase of prices of components, increase of price of energy carriers, external costs for $CO_2$). |
| **be** | For residential buildings: the impact of different levels of energy prices was calculated.<br>For non-residential buildings there was no sensitivity analysis. This last study was done with 15 real buildings (no reference buildings) and it was not possible to calculate the same amount of packages with different energy prices (manual calculation input instead of specific program)." |
| **bg** | National statistics, state energy regulatory commission. |

| MS | Answer |
|---|---|
| **de** | Yes, the energy price differentiates between the different energy sources. In the financial studies the following prices are used:<br>gas and oil: 0.075 €/kWh;<br>electricity: 0.20 €/kWh;<br>electricity for heat pumps: 0.15 €/kWh;<br>(district heating: 0.055 €/kWh);<br>biomass,<br>LPG are not yet considered." |
| **dk** | The energy price differs from energy source to energy source. In SBi reports on economic analyses concerning new building energy requirements the following prices are used:<br>District heating: 0.40 DKK/kWh (approx. 0.05 €/kWh)<br>Natural gas: 0.70 DKK/kWh (approx. 0.09 €/kWh)<br>Electricity: 1.5 DKK/kWh (approx. 0.2 €/kWh)<br>Biomass and LPG is not yet considered as these sources have a marginal market share. |
| **ee** | We haven`t yet worked out our cost optimal methodology. |
| **es** | By the time been we are considering only oil (diesel-oil). |
| **fi** | We don't have national methodology for cost-optimal calculation, thus no rules for energy price levels. Main energy sources are electricity, district heating, oil and biomass. |
| **gr** | We differentiate among different energy sources. The energy price levels are published annually by the Ministry of Environment, Energy and Climate Change. |
| **hr** | Present price for each sources of energy. |
| **hu** | Question of the future. |
| **ie** | Electricity and Gas Prices from October 2010: Due to full deregulation of the market, prices are now sourced from the prices gathered for the EU Gas & Electricity Price Transparency Directive. Prices are updated 6 monthly. Oil, gas, LPG, biomass, and electricity are differentiated. |
| **lv** | There are no national energy price levels. |
| **lu** | Energy sources are differentiated. |
| **nl** | Separate prices for electricity and gas (as the two most used energy sources in the Netherlands). About 0.25 Euro per kWh electricity, and about 0.56 Euro per $m^3$ of gas (depending on provider). |
| **ro** | For economical calculations actual prices (without subsidies, e.g. for residential) are taken into account. The prices are considered for each type of energy and rates of development of the price for energy are considered. |
| **se** | Each energy source has its own price. Current price. |
| **sk** | - |
| **no** | Normally we have use electricity prices. |
| **uk** | "Central case" projections from the relevant government department (DECC) - to ensure consistency with other national policies. Separate prices for each fuel and for electricity. |

*Q23 Do you have national available data for projected district heating price developments and biofuel price developments? If not, how do you quantify future energy costs for those?*

| MS | Answer |
|---|---|
| **at** | District heating companies provide information; scientific studies on energy scenarios. |
| **be** | - |
| **bg** | National statistics, state energy regulatory commission. |

| MS | Answer |
|---|---|
| **de** | The energy price development in the financial studies is foreseen as similar for all energy carriers. The studies did however not yet include biofuel and district heating as they are based on the reference technologies (which is never biofuel or district heating).The economic studies are made with defined foreseen prices (in 5 year steps) dependent on the energy carrier up to the year 2030. |
| **dk** | Yes, the Danish Energy Agency have made several studies and predictions on energy price developments, e.g. for biomass and district heating. |
| **ee** | No. |
| **es** | There are some data at national level, but it has not been used yet. |
| **fi** | No. |
| **gr** | - |
| **hr** | No. |
| **hu** | Question of the future. |
| **ie** | No- all forecasts are based on gas, oil and electricity. |
| **lv** | No appropriate national available data. |
| **lu** | Yes – best guess for future energy costs based on national and international data. |
| **nl** | The price for district heating is connected to the price of natural gas in the sense that a maximum is set. Providers are free to offer a lower price. The development of the district heating price is expected to follow the predicted gas price. Biofuel (biomass) is a small market and the development of the price is dominated by the price development in Germany. |
| **ro** | No. Hardly. |
| **se** | Statistics Sweden. |
| **sk** | - |
| **no** | I think we have national data for this, but normally these prices follow the electricity price more or less. We usually assume the energy prices will be more or less the same as average electricity prices. |
| **uk** | Limited information only. But assessment of policy is based on buildings that use grid electricity and gas (LPG for some buildings): these are by far the most common situations. |

*Q24 What general inflation rate do you assume?*

| MS | Answer |
|---|---|
| **at** | No general value, project specific. |
| **be** | 2 % which was the Belgian average of the last 10 years. |
| **bg** | National statistics. |
| **de** | The interest (discount) rate in the financial studies is assumed to be 3.5 % for both residential buildings and non-residential buildings. Sensitivity analyses include alternative interest rates of 2 % and 5 %. |
| **dk** | The Danish economy is closely linked to the Eurozone, and Denmark has committed itself to follow the same rules as apply within the Eurozone. |
| **ee** | - |
| **es** | Three different scenarios. |
| **fi** | We don't have national methodology for cost-optimal calculation, thus no assumptions. |
| **gr** | - |
| **hr** | - |
| **hu** | Question of the future, outside of the Euro zone everything is floating. |
| **ie** | Does not appear to be in calculation. Future oil prices increase but make up of increase is not |

| MS | Answer |
|---|---|
| | available. |
| **lv** | It is not specified. |
| **lu** | 0 to 2 % |
| **nl** | The assumptions for revision of the requirements are discussed in an advisory committee (market actors). The inflation rate is adjusted periodically. |
| **ro** | Usually the calculations are performed using EUR and a general inflation rate of 4 %. |
| **se** | The calculations are made in real terms. |
| **sk** | - |
| **no** | This is included in the real interest rate, normally set to 4 %. |
| **uk** | Assessments are carried out in real terms (i.e. without general inflation). |

*Q25 What discount rate is assumed in your national methodology and are there different rates for commercial vs. non-commercial projects and/or existing vs. new buildings?*

| MS | Answer |
|---|---|
| **at** | No general value, project specific. |
| **be** | Residential sector: 5 % = the average discount rate for loans on 25 years.<br>Non-residential sector: 6.5 %: this includes a risk rate that investors expect. |
| **bg** | National statistics, state energy regulatory commission. |
| **de** | As the discount rate for the societal perspective is not documented in the specific report this is unclear. |
| **dk** | Macro level: According to the guidelines from the Ministry of Finance an interest rate of 6.0 % p.a. should be used. In the societal economic calculations related to requirements to new building in the Building regulations the Danish Enterprise and Construction Authority has decided to use a more realistic interest rate of 2.0 % p.a.<br>Micro level: In the economic calculations the following parameters are used:<br>Net interest rate: 0.0 %<br>Net energy price increase: 1.0 % |
| **ee** | - |
| **es** | Three different scenarios, only for new buildings. |
| **fi** | We don't have national methodology for cost-optimal calculations, thus no assumption. |
| **gr** | - |
| **hr** | - |
| **hu** | Question of the future, not agreed yet. |
| **ie** | A common discount rate of 4 % is used. |
| **lv** | It is not specified. |
| **lu** | Discount rate: 5 to 6 % - no different rates. |
| **nl** | The question is too undefined to be able to answer. |
| **ro** | Only inflation rate and rate of development of energy price are used. |
| **se** | 4 % we make sensitivity analysis to handle the variation. |
| **sk** | - |
| **no** | In our national assessments we use the real interest rate (4 %) as discount rate, for calculation the present value of energy efficiency measures. |
| **uk** | 3.5 % pa.for the first 30 years and 3% pa thereafter (standard national assumptions for all policy assessments; real interest rates; risk handled separately). These are societal values in real terms. |

*Q26 Do you have different discount rates for societal and individual perspective?*

Most countries that answered this question and use both the societal and individual approach do not use different discount rates for the two calculations.

| MS | Answer |
|---|---|
| **at** | No. |
| **be** | We have no calculations form the societal perspective. |
| **bg** | No. |
| **de** | No. |
| **dk** | It is not defined and nor is it included in the methodology. It is not necessary. |
| **ee** | - |
| **es** | Not applicable. |
| **fi** | We don't have national methodology for cost-optimal calculation. |
| **gr** | - |
| **hr** | - |
| **hu** | Question of the future, not agreed yet. |
| **ie** | NPV is societal only. |
| **lv** | It is not specified. |
| **lu** | No. |
| **nl** | The Netherlands use the societal perspective. |
| **ro** | No. |
| **se** | No. |
| **sk** | - |
| **no** | No. |
| **uk** | The formal assessment is from a societal perspective. Logically, the user perspective should use a typical cost of capital (or opportunity cost) – to the extent to which a typical value can be determined. |

*Q27 Are disposal costs defined and included in your national methodology?*

All countries – 11 - who answered this question state that disposal costs are not taken into account in the national methodologies. One country however stated that disposal costs should become part of the national methodology, but no such methodology exists in the country in question.

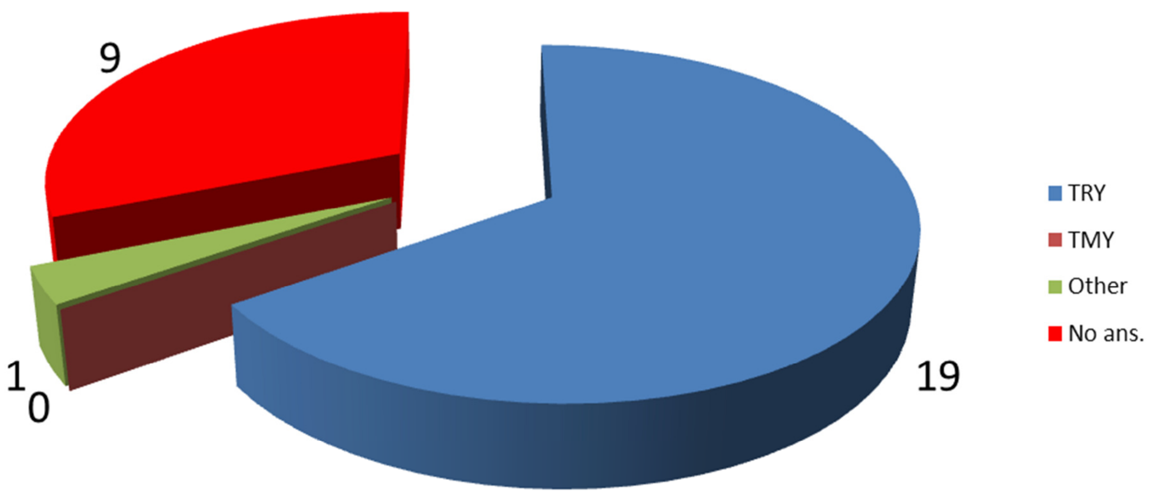
*Q28 Which data source for the investment costs do you use in your country?*

| MS | Answer |
|---|---|
| **at** | No official data source; own data, publications, tender, German BKI (Baukosteninformationszentrum). |
| **be** | Information of the company that makes the calculation. There is no national database with investment costs. |
| **bg** | National statistics, state energy regulatory commission. |
| **de** | Experiences from the experts performing the study. The costs are discussed with the ministry and mirrored with their experience. |
| **dk** | The expected "to days" (2010) actual investment for implementing each measure are calculated based on the standard price book for building constructions (V&S prisbøger) where possibly. For new types of solutions not included in the price book the investments are estimated best possibly. Al prices are exclusive of value added tax. Energy prices include energy taxes. Al |

| MS | Answer |
|---|---|
| | prices are adjusted to 2010 price level. |
| **ee** | - |
| **es** | Manufacturer and professional associations. |
| **fi** | Investment costs are based on target price method, which is widely used in construction sector. |
| **gr** | - |
| **hr** | Current prices. |
| **hu** | Question of the future, not agreed yet. |
| **ie** | Industry sources |
| **lv** | It is not specified. |
| **lu** | Database and literature study. |
| **nl** | Studies are performed on a regular basis to calculate and assess default values for investment cost. They are based on statistical data on building cost and cost calculation models. |
| **ro** | Actual market values are used, together with standardised maximum allowed specific costs for thermal rehabilitation packages from public investments. |
| **se** | Calculation consultant and different companies in the market provide their costs. |
| **sk** | - |
| **no** | Such data collection is normally left to the analyst who is performing an impact assessment to study the impact of proposed new requirements. Data can be taken from national databases or by collecting empirical data from the building industry. |
| **uk** | From specialist cost consultants who advise developers and who analyse the actual costs of completed projects. |

*Q29 Which kind of climate data do you use for the analyses?*

Most countries – 18 - who answered this question use Test reference Years (TRY) in their energy performance calculations. No countries use Typical Meteorological Years (TMY) but 1 country uses other data source. This country is the Slovak republic where they use a special variant of a TRY climate data set Reference years that takes into account forecasts of climatic changes.




*Q30 Do you consider the cost of the space needed for a technology installation as cost factor? (This is not included in EN 15459)*

Most countries (15) who answered this question do not consider the cost of the space needed for a technology installation as cost factor while 2 countries (Ireland and Sweden) state they do.

*Q31 Is an economic efficiency sensitivity analysis performed?*

There is almost an even distribution of „yes" and „no" answers from the countries who answered this question. 10 countries stated that an economic efficiency sensitivity analysis has been performed while 8 countries have not performed this kind of analysis.

## 5.4 On low energy buildings/ RES and cost optimality

*Q32 If the current and future national building code in your country requires a minimum share of RES already: Do RES based solutions have to be cost effective?*

Most countries (9 or 60 %) stated that RES solutions should be cost effective to be required in future Building regulations. The remaining 6 countries (40 %) stated that RES not necessarily need to be cost effective to become required in future building regulations.

*Q33 Do you think that renewables should be included in the cost optimal framework?*

Inclusion of RES in the cost optimal framework was appreciated by 13 of the countries who answered this question and seen as being needless by 3 countries.

*Q34 Do you have estimations on whether a nearly zero energy building (according to the definition in the EPBD) in your country will be cost optimal by 2020?*

| MS | Answer |
|---|---|
| **at** | No estimations available, because method is not defined. |
| **be** | It seems at this moment to be beyond cost optimal. But it is not known how prices – both of energy and of the solutions – will evaluate. |
| **bg** | No |
| **de** | A study on that is under preparation. |
| **dk** | A study on this topic is currently on-going. |
| **ee** | We hope so, that it will be cost optimal. We haven`t yet worked out nearly zero energy building definition, but it is in progress and we will include to our work cost optimal calculations. |
| **es** | Not yet. It should be cost optimal for that date, but the text of the EPBD Recast is not clear in this respect. |
| **fi** | We don't have estimations. |
| **gr** | No |
| **hr** | Probably not. |
| **hu** | What is the distance between the near zero and zero? If they are far away it may be cost optimal. If precisely zero, neither in Hungary nor in many other countries will zero be optimal. |
| **ie** | No |
| **lv** | Estimations have not yet been done. |
| **lu** | No |
| **nl** | In the Netherlands there are a number of studies and practical experiences (on-going) regarding this theme, but it's too early to draw conclusions on this aspect. |
| **ro** | No |
| **se** | No |
| **sk** | No |

| MS | Answer |
|---|---|
| **no** | Yes, to a certain degree. |
| **uk** | This is a controversial subject. The answer depends on the definitions of "nearly zero" and "cost optimal". |

## 5.5 On CEN standards

*Q35 Do you think standard EN 15251:2007 (Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics) and/or equivalent national standards are sufficient to ensure the indoor air quality (knowing that the cost optimal methodology normally only focus on energy and costs)?*

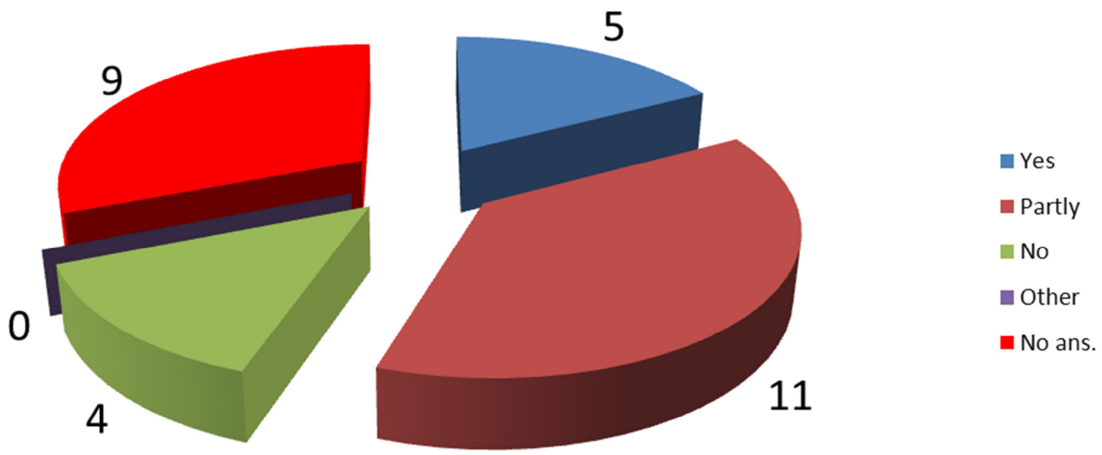
There was an even distribution between "yes" and "no" answers – 8 each - to this question among those countries who answered.

*Q36 Is your national methodology (partly) based on CEN standard EN 15459 for global cost calculation (net present value) (as opposed to other valuation methods such as annuity method etc.)?*

Most countries (10) stated that their national methodology do not meet the specifications stated in CEN standard EN 15459 for global cost calculation. While 6 countries stated that their methodology is partly or fully in line with CEN standard EN 15459.

*Q37 Do you think that the current set of EPBD standards can serve as a basis for the energy performance calculation even if not yet adapted to the needs of the recast?*

Most countries (16) who answered this question stated (fully or partly) that the current set of EPBD standards can serve as a basis for the energy performance calculation. 4 countries do not think that the current set of standards can serve as calculation basis.

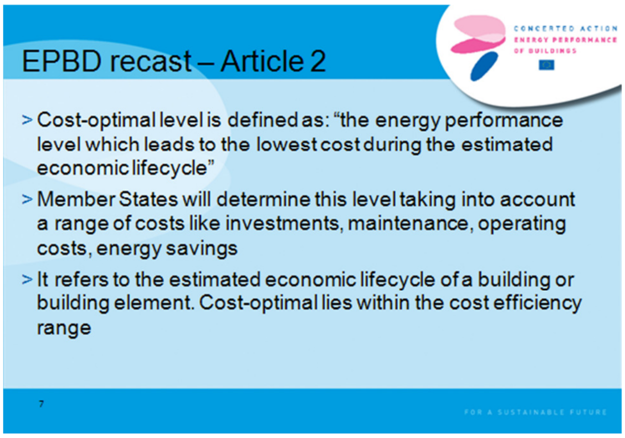


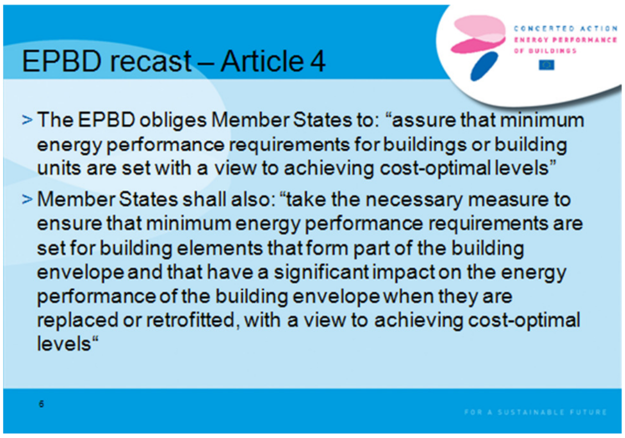

*Q37 Would a new CEN/CENELEC standard (in addition to EN 15459) on cost optimality calculation be helpful for implementation (even if only available in 2014-2015)?*

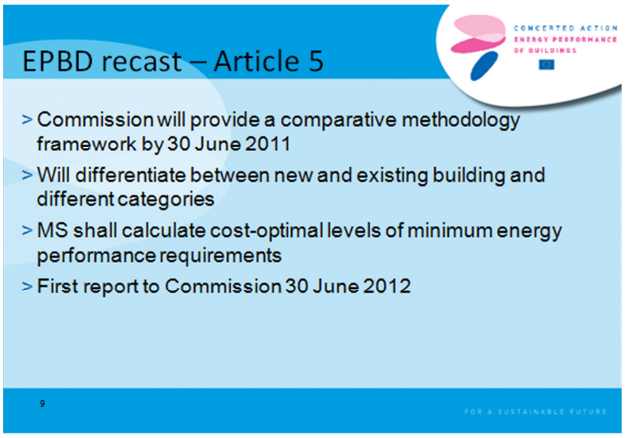
There was an even split (9 each) between "yes" and "no" answers to this question from those who answered.

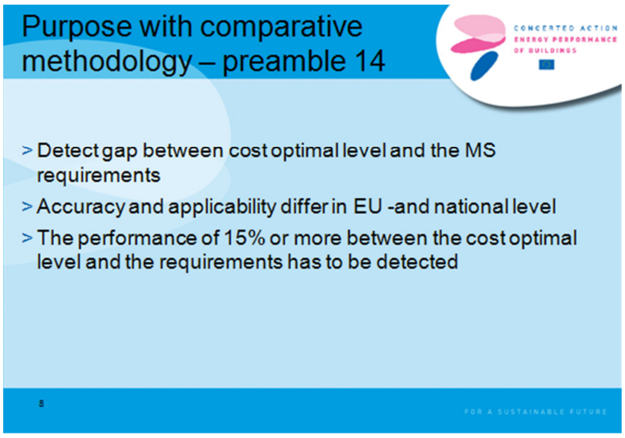
# 6 Executive SUMMARY and DISCUSSIONfrom Luxembourg session

Kirsten Engelund Thomsen opened the first session on costoptimum procedures in CA3 with a description on the purpose for this WG,which was launched at the last plenary meeting of CA2. She gave a short introduction to Articles 2, 4,and 5 in the EPBD recast, which deals with the cost optimality issue. Further she focussed on Preamble 14 that sets rules for the acceptable difference between the national approaches and the overall European framework.




The programme of the double session was outlined as:

- Challenging issues for establishing a cost-effective methodology (Bart Poel, the Netherlands)
- Presentation of Framework (Robert Nuij, EC)
- Presentation of Methodology approach (Hans Bloem, ISPRA JRC)
- Review of questionnaire on national cost procedures (Kim B. Wittchen)
- Four central issues for discussions

## 6.1 Challenging issues for establishing a cost-effective methodology (Bart Poel, the Netherlands)

This introduction to the challenges and points for discussion of a common European framework for a costoptimum methodology try to highlight some of the issues and to interpret the wording of the EPBD recast. The introduction comprises:

- EPBD on cost-optimal levels
- Challenges of the existing stock
- Challenges

## The EPBD on cost-optimal levels

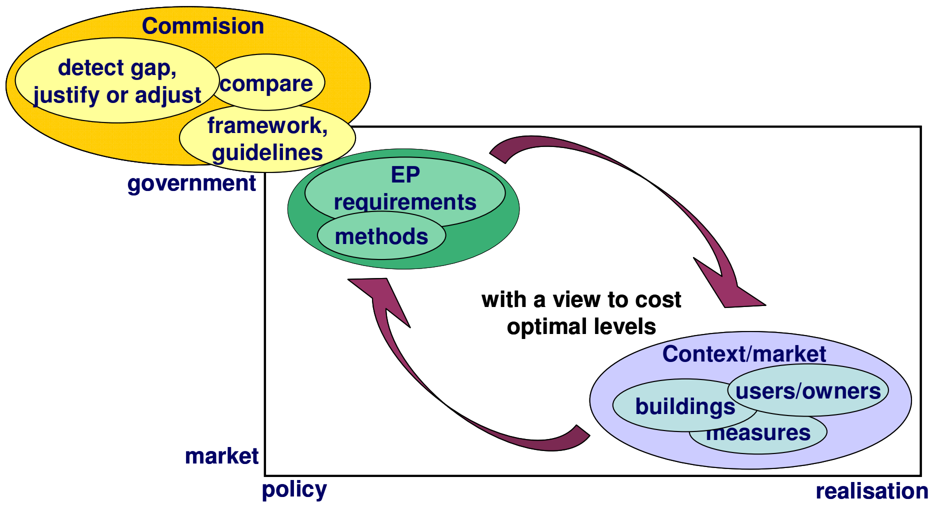
Article 4: MS will set requirements "with a view to achieving" cost-optimal levels (in reality) and MS will calculate cost-optimal levels according to a comparative methodology framework according to Article 5.

Article 5: Implies that two things are being compared: 1) a cost-optimal level of minimum energy performance requirements calculated according the framework (provided by the Commission) and 2) the minimum energy performance requirements in force in the individual MS.

Thus, there are two issues to distinguish between concerning the ambition level of minimal energy performance requirements. **First**,MS are obliged to set the minimum requirements "with a view to achieving" cost-optimal levels. The aim is the improvement of the building stock in a "more or less" cost-optimal way. **Secondly,** the comparative methodology framework and the accompanying guidelines will provide an approach to evaluating the minimum requirements regarding the cost-optimal level based on comparison. The focus of the comparison is on detecting significantly less efficient requirements and to adjust the gap in case it cannot be justified.

- Setting requirements calls for subtlety and sophisticated considerations adjusted to the national context in order to achieve effectiveness in practice.
- The comparison has a more strategic goal,i.e. to detect gaps. Guidance (the framework) is needed to make it sensible and valid.
- Does the framework also determine parts of national procedures?

Setting requirements and comparing national regulations can be illustrated as shown in the figure below.




## Challenges of the existing stock

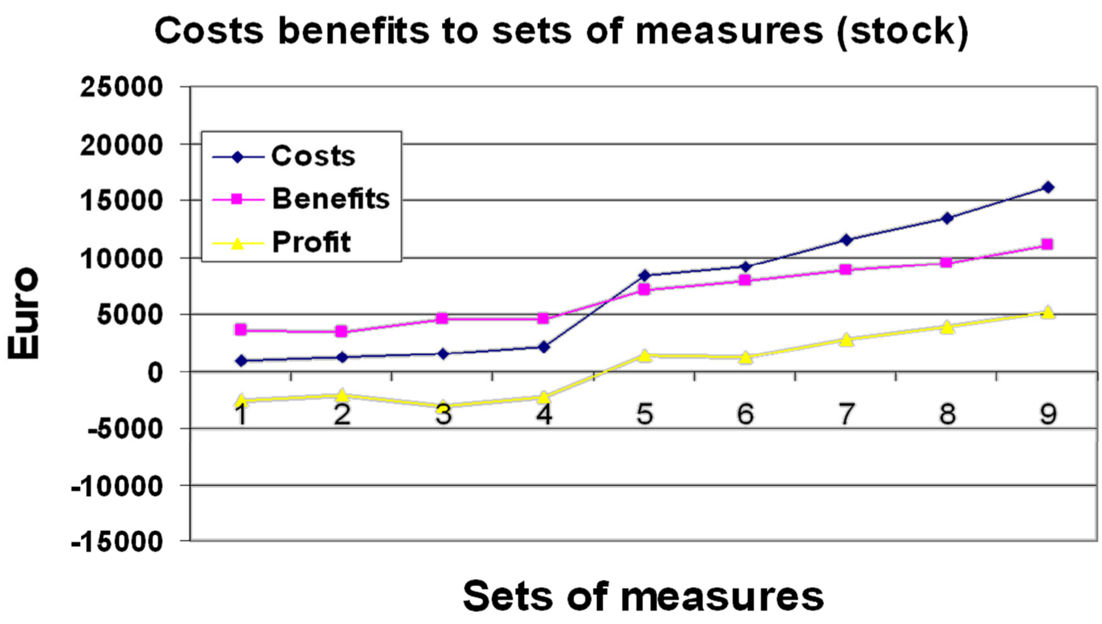
Some issues for consideration regarding cost optimum procedures for the existing building stock can be emphasised:

- For new buildings, cost efficiency is not very verifiable as they are subject to a design process and the constant evolution of new technologies. Furthermore energy consumption in new buildings is based on calculated energy consumption and assumptions about the performance of equipment and users.

- For existing buildings, cost efficiency will be experienced. Acceptance can be a problem asthe user knows the energy bill, the investments and savings – and if they do not converge, it will raise discussions.
- Multi vs. single performance decision-making will become an issue as other aspects than energy play a very important role for the investment in improvements.
- Private versus societal perspective needs to be addressed. Different outcomes from the two approaches may raise a discussion of which approach should be decisive.
- There may be investments competing with investments in energy-saving measures like life-style improvements (kitchens, gardens, roofs, etc.), new home electronics; education of children etc.
- Split incentive between actors, within large companies, in case of selling (added property value).
- Whole building or component requirements can result in different solutions with the risk that one optimum solution identified e.g. on the component level will be a hindrance for a better (later) solution on whole building level.
- Many of the energy improvements in the existing building sector are driven by major renovation initiatives and it is crucial that information about the combination of other planned works and energy improvements is communicated in a proper way in order to ensure cost optimum solutions.

A study performed in the Netherlands on 32000 real, existing dwellings showed that it is very difficult to talk about an optimum in the traditional mathematical sense. An optimum should rather be seen as a range of (competing) solutions that are more or less equal in terms of cost efficiency. The figure below illustrates the results of this investigation (NB: the yellow line should be mirrored in the x-axis).

Results are based on calculated real buildings, with standard user loads and average costsover a period of 20 years. The graphs clearly show that there is no significant optimum, but maybe a range of acceptable solution sets. The results depend strongly on the input variable and assumptions.



One input parameter that is known to play an important role in the final energy consumption is user behaviour. Identical buildings with different users often show a factor 3 to 4 in energyconsumption (residential as well as non-residential). There is little or no knowledge about user behaviour in reality (averages, distribution, EP dependence). Changes in user behaviour can result in large differences of the energy savings.

Should we in that case use conservative values in our calculations, for the sake of societal acceptance?

Thus there are a number of points with respect to the existing building stock that requires special attention:

- Acceptance of legislation is more sensitive than for new buildings
- There is a mix of different objectives:
  - realising substantial improvement of the EP
  - aiming at cost-optimal solutions
  - ensuring societal acceptance
  - efficient legislation
- On the national level, interdependencies in legislation and market mechanisms play an important role
- How can we ensure that the framework choices will contribute to the improvement of the EP on national level
- Feasibility studies, evaluations on national and EU levels will provide better understanding and adjustments of the framework
- Setting too many targets should be avoided (try to subdivide into sub-targets, EU check and national approach).

## 6.2 Comments on the framework approach (Robert Nuij, EU)

Robert Nuij from the European Commission gave some statements on the current situation of the progress of work related to the common framework on a European cost optimum procedure. The statements are collected as:

- Cost-optimal methodology framework will be used by MS to check whether their existing minimum energy performance requirements are cost optimal (within a range of about 15 %)
- Guiding principles:
  - Do no harm!
  - EC will focus on what should be defined centrally
  - What can usefully be left to MS will be left to MS
- JRC is appointed to develop the methodology details
  - A draft framework should be ready for the expert meeting on 6 May!
  - The framework is still expected to be ready by the end of June 2011
- The legal act will most likely include a revision clause to allow for changes, once experience has been gained.

### 6.3 Comparative framework methodology for calculating cost-optimal levels of minimum energy performance requirements for buildings and building elements (Hans Bloem, JRC)

Hans Bloem gave a presentation on the status of the work on preparing a framework for a European cost optimum procedure.

The scope of the framework methodology is defined as: *The costoptimal methodology shall cover new and existing residential and non-residential and shall be used to determine Minimum Energy Performance Requirements for both buildings and building elements level with the latter encompassing the building envelope, as well as technical building systems for heating, cooling, ventilation, hot water, lighting and a combination thereof*.

The plan for preparing the framework can be outlined as:

- Cost-optimal energy performance levels for MS building codes
- LEGAL document
  - Open for interpretation
  - Based on CEN package of energy standards
- GUIDANCE document
  - Informative and guiding
  - Including minimum reporting requirements
- A proposal for the framework will be presented on 6 May 2011 in Brussels.

The framework calculation of cost-optimal levels of minimum energy performance requirements in national building codes will be defined in 3 steps.

Step 1: Definition of reference buildings and energy-efficient measures.

Step 2: Calculation (according to national adaptations of EPBD-related EU standards) of the energy performance of the reference buildings and energyefficiency measures. Net present value cost calculation of energy efficiency measures.

Step 3: Compare calculations and assess cost-optimal level on the national level and report to the Commission (data, method transparency). The framework will include a template for reporting calculation results to the Commission. The first reports are expected in 2012.

There are still a number of open issues that need to be addressed. Among them are:

Definitions:

- EPBD, CEN
  - Reference buildings, taking into account climate conditions.

Calculation of life-cycle costs using net present value concept:

- Full cost vs. additional cost
- Calculation period (20, 30 years)
- Energy price development
- Expected economic lifecycle.

Review of cost-optimal requirements:

- Reviewing period.

EPBD is the legal document while CEN is informative:

- Reference building and energy efficiency measures (where are the boundaries?)
- Expected economic lifecycle
- Calculation period and calculation steps
- Major renovation of existing buildings.

### Discussion summary

There are still some open issues that need to be clarified and there will be close contact between the Joint Research centre and the delegates of the EPBD Concerted Action to ensure that the concerns of the MS are taken into account. Among these issues is the fixation of primary energy factors, which may lead to a decision to using final energy instead.

The CEN standards have not been fully implemented in all MS; however it is anticipated that CEN standards will evolve over time and hopefully meet the national and local needs. The framework for calculating cost-optimal levels for energy performance will refer to CEN standards, but these standards are only suggestions and local or national methods or adaptations can as always be applied. Hopefully,that CEN standards will be fixed at the earliest possible stage as MS intend to have national methods that do not conflict with CEN standards. Moreover, MS do not like to change their methods too often.

## 6.4 Summary of questionnaire

Kim Wittchen gave a summary of the answers received from the MS on the questionnaire circulated in preparation of the session. The summary is given in Section 5Questionnaire summary.

## 6.5 Challenges

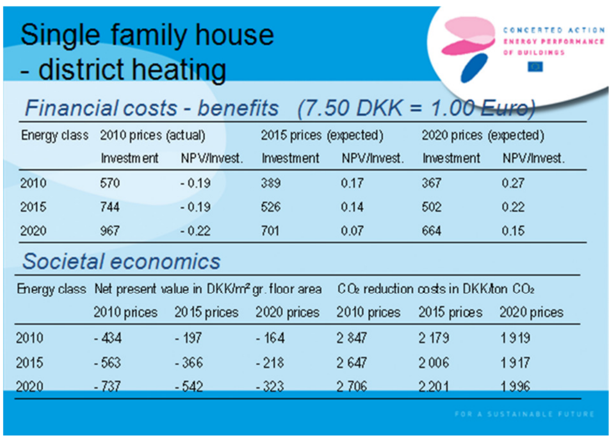
Many challenges need to be addressed when defining a European framework for cost-optimal levels, but a few needs to be highlighted. Each topic was presented using examples to illustrate the challenges and afterwards discussed in plenum.

- How to define the economic perspective (Søren Aggerholm)
- How to handle the cost-optimal issue (Roger Hitchin)
- How to define reference buildings and measures (Bart Poel)
- How to establish costs and prices (Hans Erhorn).

The following slides were used to illustrate the issues.

### Private vs. societal economics

The slide shows an example calculation carried out in preparation for the energy requirements in the Danish Building Regulation 2020 (minus in front of numbers means “poor economy”).




| Energy class | 2010 prices (actual) | | 2015 prices (expected) | | 2020 prices (expected) | |
|---|---|---|---|---|---|---|
| | Investment | NPV/Invest. | Investment | NPV/Invest. | Investment | NPV/Invest. |
| 2010 | 570 | - 0.19 | 389 | 0.17 | 367 | 0.27 |
| 2015 | 744 | - 0.19 | 526 | 0.14 | 502 | 0.22 |
| 2020 | 967 | - 0.22 | 701 | 0.07 | 664 | 0.15 |

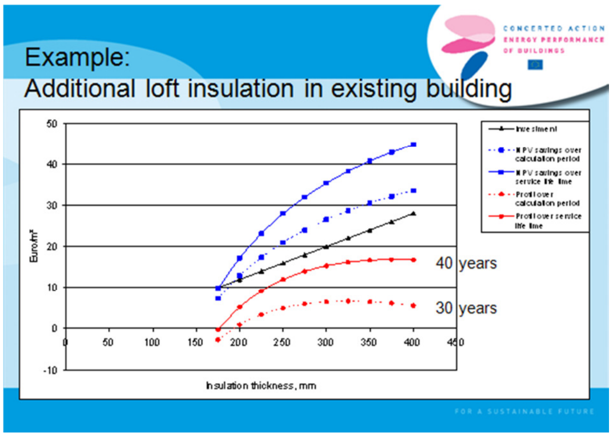
| Energy class | Net present value in DKK/m² gr. floor area | | | $CO_2$ reduction costs in DKK/ton $CO_2$ | | |
|---|---|---|---|---|---|---|
| | 2010 prices | 2015 prices | 2020 prices | 2010 prices | 2015 prices | 2020 prices |
| 2010 | - 434 | - 197 | - 164 | 2 847 | 2 179 | 1 919 |
| 2015 | - 563 | - 366 | - 218 | 2 647 | 2 006 | 1 917 |
| 2020 | - 737 | - 542 | - 323 | 2 706 | 2 201 | 1 996 |

### Discussion summary

From the presentation, it seems to be more economically efficient to stay at the 2015 level compared with the 2020 level, but keeping the EP requirements unchanged is not an option which has been considered in Denmark. Given this fact, it is evident that energy taxation will have a huge impact on the cost-optimal results.

When focusing on cost-optimal calculations, it is important to be aware the implementation of a cost-optimal solution may conflict with a better, and more cost-optimal solution in the future. Thus, there is a need to try to predict the future, making sure that good solutions do not block the way for even better solutions.

The framework will not dictate either a societal or an economic methodology, but it should be left to the MS to decide which method that is the more appropriate for their situation. From the governments' perspective, a societal method will naturally be the optimal solution. Looking back, only marginal energy savings would have been implemented if they had been analysed from the private finances perspective. However, development have shown that techniques improves and economics changes, i.e. decreased price for energy-efficient windows.Societal economics are also very well defined –and governments will always try to make the publicdo the right thing by issuing taxes or other incentives.




## The cost-optimal issue

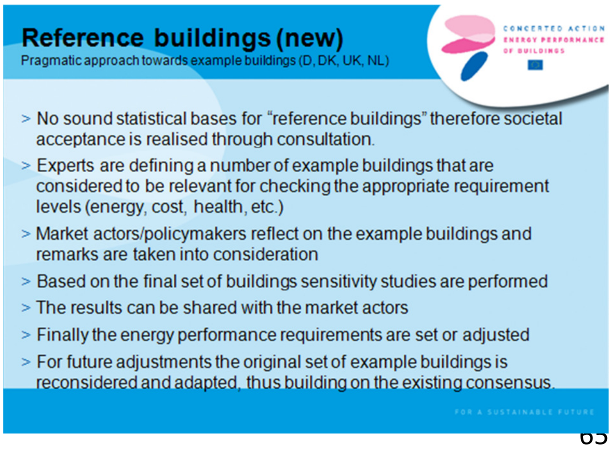
The curve for the NPV for increasing loft insulation is a Danish example. Superposing curves from different buildings with different slopes will result in a fluffy and very flat curve for cost optimality.

## Discussion summary

Follow-up works needed in combination with any energy improvement may change the whole result. Therefore, it will be essential to include these kinds of considerations in the calculation methodology. Furthermore, changes in energy prices are very crucial for the slope of such NPV value curves.

The cost optimum is ideally one single point, but in reality it should rather be considered a range of values. With respect to the complexity of buildingsand any other uncertainty of such calculation procedure, the optimum is rather a range than a single point on a curve.

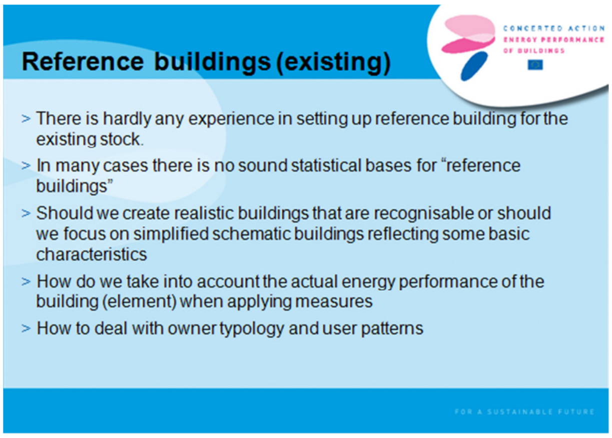
All MS should perform sensitivity analyses to investigate possible, reasonable scenarios and consider how political decisions can be based on these calculation results.




## Reference buildings (new)

The slide briefly outlines how reference buildings were established in the 4 countries who participated in the WG - and it was done more or less in the same way in the 4 countries. It should be noted that for new buildings, it is not reference buildings, but example buildings that have been used in the analyses.

### Reference buildings (existing buildings)




There is hardly any experience on this issue and where there is it focuses residential buildings only.

We may easily end up having thousands of reference buildings if the entire existing building stock should be represented and especially if all variations of technical installations should be represented as well.

Furthermore, it is important to decide if user patterns should be part of the reference building in the existing buildings stock.

### Discussion summary

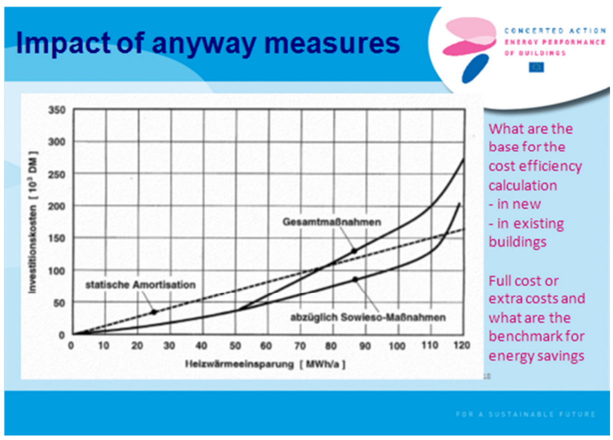
New buildings:
In the 4 MS participating in the work on this topic, only a limited number of reference buildings were used for non-residential buildings.

It is recommended to use a full cost basis for calculation of the present standard for new buildings. For new buildings, the starting point is a building that just fulfils the minimum requirement, and no redesign of the reference building is foreseen in the calculation to meet the increased energy performance. Furthermore, from a society perspective,there must be a set of minimum requirements that ensure a good and healthy indoor climate.

Existing buildings:
In general, minimum requirements are not applicable for existing buildings.

In one calculation method, a reference building is not being used to calculate the overall cost-optimal level, but the individual components separately. Costs and savings are calculated for the actual building. For the actual building,the reverse policy may be more appropriate, i.e. there are only requirements for proving that a measure is not cost-efficient. Calculations on existing buildings are made under the assumption that certain (the actual) technical installations are in place.

### Costs and prices

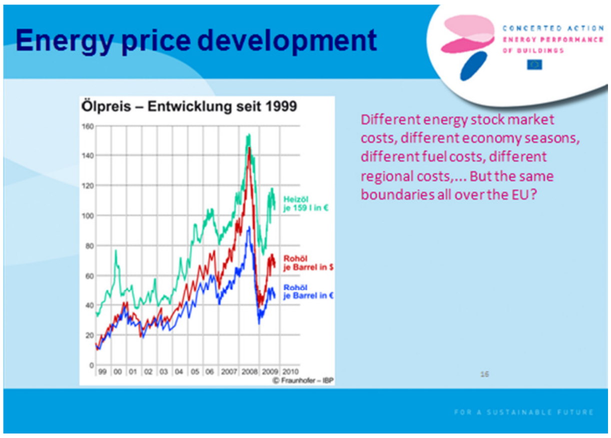


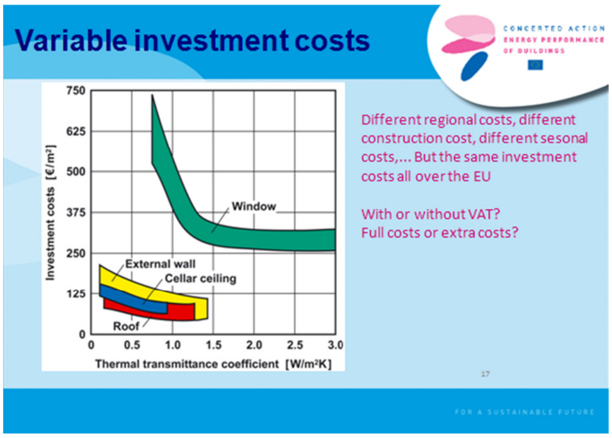

The three slides at the right illustrate how variations in costs and prices influence the outcome of a cost optimality analyses. Given this information, 3 questions need to be addressed:

Should it be possible to have different boundaries from MS to MS or should we use a European central source for energy price?

Investment costs differ a lot (seasonal, annual, …), and also within the same MS. Should it be net or gross investment costs?

What kind of benchmark do we need to use when calculating energy savings?




### Discussion summary

Energy prices differ a lot from MS to MS and should thus be defined by the MS individually. For comparison across Europe, a central database would be an invaluable tool, including prices, $CO_2$ emissions, renewable energy, etc.

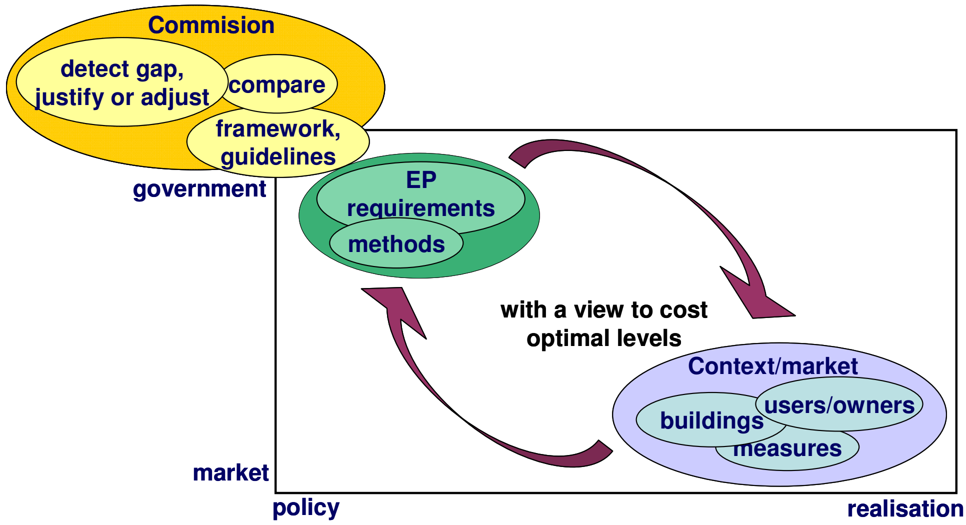
For the purpose of “selling” energy savings, a very poorly insulated building as an optimal starting point, but in reality a starting point according to the current standard as stated in national building regulations will make the calculations more reliable.

# 7 Summary and recommendations

### Uncertaintiesin the approach in general

Cost optimality as a theoretical concept is well established. However, in the context of comparing minimalrequirements that should be set with a view to achieving cost optimal levels per Member State its application is far from straightforward given in particular the additional complexity that the EUlegislation is a framework Directive and the calculation methodologies and requirements are set at national level. In particular, there are choices of methodology (for example, between a societal or end-user perspective) which may have significant impact on the outcomes. There is no clear-cut „right” or „wrong” approach to this type of choice as each addresses a different issue and different MS place different emphasis on each. More detailed procedural decisions (such as the choice of reference buildings) will also affect outcomes. Inevitably there is general uncertainty about much of the input data.

Another source of uncertainty is the stratification in three levels that should be dealt with (real buildings; national legislation; EU framework).




The ultimategoal is to achieve a cost optimal improvement of buildings in reality. This should be enforced by national minimum energy performance requirements. The step from the specific building to national requirements is already complex and requires a subtle process and sufficient knowledge of the building stock and the market. Feedback loops between government and market through survey studies and consultation are essential to achieve an effective approach. The pitfall is that reference cases and typical measures are defined and that they are considered being reality. Learning cycles mirroring legislation with reality are crucial for effective implementation. This also implies that modification of legislation over the years is important.

On the highest aggregation level the European Commission establishes the framework for the methodology and asks MS to compare their national minimum requirements with cost optimal levels and report on the outcome. In case there is a significant gap that cannot be justified MS should take measures to bring the requirements in line with cost optimal levels. It is important to understand that a too rigid comparison methodology can have a negative effect by reducing the reliability on national level due to prescribed EU approaches that are less valid nationally and also because the flexibility to modify the national approach can be reduced. The emphasis of justification of requirement levels towards the Commission by means of reference buildings and lists of measures may increase the risk that reality is too easy confused reference buildings and seemingly cost optimal levels based on reference buildings turn out to be sub optimal in reality.

Apart from these risks it is without doubt that a Comparative Methodology Framework is a powerful instrument to guide MS in the process of checking the level of their minimum energy performance requirements and to strongly improve the energy performance of the building stock. Also sharing of knowledge and experiences between MS will be stimulated through the common procedure laid down in the Framework.

### Spectrum for designing the framework

In terms of practical implementation, this means that there is a spectrum of choices between the extremes of:

- a tightly-defined procedure defining all parameters needed for the calculation at EU level with which all MS should attempt to comply;
- aframework allowing MS a free choice of assumptions (subject to there being reasonable supporting evidence).

The first of these would ensures more (but imperfect) comparability between MS, but requires them to carry out assessments that are additional to those that they need to do to satisfy national assessment requirements. When the framework requires national assumptions to be replaced by prescribed EU-data, the outcome of the comparison might by less validfor the specific practice in a Member State. Consequently adjustment of the requirements has the risk of being cost suboptimal in reality for buildings that have to comply with the requirements.

The second option to allow MS a free choice seems closer to the intent expressed in the EPBD Recast (*to identify whether minimum performance requirements are reasonably close to being cost-optimal*) - but only in the context which each Member State chooses to operate.The free choice providesMS with the ability to better attune to the national context and create more effective requirements. The deviation of the approach between MS increases the need for supportive evidence and can require a less harmonised report to the Commission.

Some MS may choose to analyse many reference buildings and perform several sensitivity studies, MS with experiences over many years in setting cost efficient requirements will know where to focus and how to justify their approach. They should not be obliged to perform superfluous calculations, with the risk that the Commission will find the information hard to analyse, while a more focussed approach is also for the Commission easier to judge.

*A balance should be found between the harmonization of the comparison procedure with the results transparently reported in a reporting format. Furthermore, the comparison procedure must easily match the national calculation procedure. The approach could be to allow modification from a prescribed approach under the condition that they can be justified properly.*

### Defining the reference buildings and energy saving measures

In case of defining reference buildings* there is a distinction between new buildings and existing buildings.

**New buildings**

For new buildings there is no clear population in statistical terms as a basis for a reference. The reference buildings need to reflect future building characteristics and expected energy/indoor climate concepts in a proper way, in order to study cost optimal ambition levels. In many countries there is experience using this reference building approach for setting minimum energy performance requirements for different building categories. A limited inquiry showed that a number of countries defined a set of reference buildings based on expert judgement combined with acceptance of the stakeholders in the market. Through the years these sets were revised and they form an accepted basis for cost efficiency studies. Typically these buildings are rather simple, although they reflect all necessary building characteristics and possibilities to incorporate energy saving concepts, to create valid results from the sensitivity studies.

*From the experience of several countries, it seems a satisfactory approach to have experts, in consultation with the market, define a number of not too complicated reference buildings for different user typologies. Based on these buildings, sensitivity studies can lead the way to cost optimal levels.*

**Existing buildings**

For existing buildings there is hardly any experience in the MS with regarding the determination ofreference buildings for the purpose of setting minimum requirements in a cost efficient or optimal way. Reference buildings can be used to assess cost optimal levels for the comparison of minimum requirement for the existing buildings or building units as a whole, or for requirements related to building elements as such (e.g. roof, wall, heating system, and cooling system).Reference buildings can be defined based on the use, geometry, age, energy performance characteristics, user patterns, maintenance condition of the elements, etc. Based on knowledge of the building stock an intelligent composition of a consistent set of reference buildings can lead to a significant reduction of the number of reference buildings, without affecting the quality of the cost optimal comparison.

*When comparing minimum energy performance requirements, extensive cost efficiency studies can be executed for all building categories and related reference buildings. However, it is of great importance also to allow a more comprehensive set of references and to provide the flexibility in the framework to do so. Of course, the reduction to a smaller but still consistent set should be justified to the Commission regarding its validity for all relevant building categories.*

### Energy saving measures

Putting together a list of energy saving measures is relatively simple. In the case of new buildings packages of measures will be taken into account to establish cost optimal levels. In identifying the packages it is important to apply the so-called TriasEnergetica. In case of the existing buildings stock the energy saving of the measure depends on the energy characteristics of the building as it is. Both packages and single measures can be applied to existing buildings undergoing a major renovation. In case of maintenance or renovation the cost for energy measures should be defined as additional cost. These costs are sometimes hard to determine. Preferably the TriasEnergetica should also apply for the existing building stock. In practice with maintenance driven interventions in a building this is not always possible. The diversity and practical restrictions that occur in the existing stock complicate the energy efficiency analyses and causes a lot of uncertainties. Nevertheless improving the existing building stockis crucial for the realisation of the climate targets.

*Analysing the cost efficiency of measures in the existing building stock is common practice in consultancy for specific buildings. For the purpose of setting or comparing energy performance requirements, measures have to be judged in a more general and transparent way in order to be valid for enforcing requirements. There is hardly any experience how to do this properly. It is therefore of great importance to organise knowledge exchange and to share experiences. The framework should take into account the fact that adjustments and refinement shall be needed in the near future.*

### Calculation method and parameters

In order to be in line with the national context it is essential that MS use the national methods in force while comparing the minimum energy performance requirements with cost optimal levels. This results in a lot of different calculation methods with as many sets of definitions. Also the value of parameters depends on the way they are defined in the national methodology. However the energy calculation has to be in line with Annex I of the EPBD (recast) and the principles of the cost efficiency calculation will be outlined in a CEN standard that has to be applied. A limited number of parameters can be set on European level. The Commission will prescribe some values like a trend in the development of the most common fuel prices.

*Allowing national approaches for the calculation and parameters implies that the methodologies as well as input data and constant parameters should be explained and justified in a transparent way to the Commission. Otherwise, a fair justification of the minimum energy performance requirements is not possible.*

# 8 Future directions

The Concerted Action EPBD has stated its willingness to help to develop and test workable procedures. This WG reiterates that willingness and hopes that future collaboration between MS and the Commission will result in procedures which are, as far as is possible, clear, robust and widely acceptable.

The topic is an individual core theme in CA3. Questions and issues related to the topic will thus be discussed over years to come.

The framework of the methodology will be published in summer 2011 and therefore MS are encouraged to give comments and early experiences at the next CA3 meeting 13-14 December 2011 in Vienna. Furthermore, MS that already have a national cost efficiency approach are invited to present their methodology.

# 9 Appendix – Questionnaire (empty)

## On the national approaches in general

1. At what level do you calculate the cost optimal requirements?
   Select ...

   1.1. **If your country uses both approaches:**
   Do you have separate methodologies for micro and macro level perspective?

   Yes: ☐ No: ☐

   1.2. **If your country uses the macroeconomic level approach:**
   Do you take into account externalities and which ones if so (environmental such as $CO_2$, pollution, soot, energy security, employment etc.)?
   Click to input text.

2. Is embodied energy included in your national methodology?

   Yes: ☐ No: ☐

3. Do you pursue a global approach or a component/element approach at national level?
   Select ...

4. How could the net present value concept as well as the steps laid out in Annex III of the EPBD be simplified without undermining the methodology?
   Click to input text.

5. In the case of a rented building, how do you take into consideration the owner-tenant dilemma and the fact that the owner does not get (all) benefits from the investment?
   Click to input text.

6. **If your country uses carbon as a metric:**
   How could the cost optimal methodology be amended in order to follow a carbon reduction strategy?
   Click to input text.

7. Do you already have a national classification for buildings (=set of reference buildings) that is consistent with what is laid down in Art 5 and Annex III of the EPBD?

   No: ☐

   Yes: ☐, Please explain: Click to input text.

   7.1. **If "yes",** how many reference buildings does your classification comprise (for residential and non-residential)?
   Click to input text.

8. How do you classify buildings along use patterns and how do you deal with multifunctional buildings?
   Click to input text.

9. How many packages of measures do have to be considered for establishing the cost optimal threshold?
   Click to input text.

10. What rule is applied in order to choose "marketable" technologies?
    Click to input text.

11. Do you include assumptions on decrease of prices of new technologies and if so, which?
    Click to input text.

12. Do you think it is reasonable to already include a future higher property value in resale for more energy efficient buildings and if so how would you quantify that?
    Click to input text.

13. What calculation period do you use and do you work with residual values?
    Click to input text.

14. Do you think that calculating the energy demand for a building as follows:
    1. energy use for heating and cooling,
    2. delivered energy for all uses,
    3. overall primary energy use

    is fully appropriate to take into account gains from passive solutions?
    If not what do you propose as an alternative?
    Click to input text.

15. Are ex post assessments of your national calculations carried out?

    Yes: ☐ No: ☐

16. How often are the requirement levels reviewed/adjusted in your country?
    Click to input text.

## System level

17. Would you agree that in order to establish building system requirements you would always need to consider the global context (i.e. the other building features and requirements of the reference building)?

    Yes: ☐ No: ☐

18. Do you intent to include lighting systems requirements into the cost optimal approach for (non)residential buildings?

    Yes: ☐ No: ☐

## On national input data

19. Which source of information do you use to predict energy price developments?
    Click to input text.

20. What energy price levels do you assume in your national methodology and do you differentiate between different sources of energy (oil, gas, LPG, biomass, other)?
    Click to input text.

21. Do you have national available data for projected district heating price developments and biofuel price developments?
    If not how do you quantify future energy costs for those?
    Click to input text.

22. What general inflation rate do you assume (**if your country is not in Eurozone**)?
    Click to input text.

23. What discount rate is assumed in your national methodology and are there different rates for commercial vs. non-commercial projects and/or existing vs new buildings?
    Click to input text.

24. Are disposal costs defined and included in your national methodology?
    Click to input text. If "yes", please explain how.

25. Do you consider the area of space needed for one certain technology installation as cost factor? (This is not included in EN 15459)

    Yes: ☐ No: ☐

26. Is a sensitivity analysis performed?

    Yes: ☐ No: ☐

## On low energy buildings/ RES and cost optimality

27. **If the current and future national building code in your country requires a minimum share of RES already**: Do RES based solutions have to be cost effective?

    Yes: ☐ No: ☐

28. Do you think that renewables should be included in or excluded from the cost optimal framework?

    Yes: ☐ No: ☐

29. Do you have estimations on whether a nearly zero energy building (according to the definition in the EPBD) in your country will be cost optimal by 2020?

    Yes: ☐ No: ☐

## On CEN standards

30. Do you think standard EN 15251:2007 (*Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*) and/or equivalent national standards are sufficient to ensure the indoor air quality with the cost optimal methodology focussing only on energy and costs?

    Yes: □ No: □

31. Is your national methodology (partly) based on CEN standard EN 15459 (*Energy performance of buildings - Economic evaluation procedure for energy systems in buildings*) for global cost calculation (net present value) (as opposed to other valuation methods such as annuity method etc.)?

    Yes: □ No: □

32. Do you think that the current set of EPBD standards can serve as a basis for the energy performance calculation even if not yet adapted to the needs of the recast?
    If not, indicate what aspects are missing.

    Yes: □ No: □ If "no", please elaborate!

33. Would a new CEN/CENELEC standard on cost optimality be helpful for implementation (even if only available in 2014-2015)?

    Yes: □ No: □