EFFICIENT ENERGY FOR EU CULTURAL HERITAGE

D 7.8 Proposal for the integration of historic buildings in the EPBD

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0 Summary

The aim of this document is to give input to the EPBD and CEN EPBD working groups under Mandate M/480.

Input to the EPBD

Within the EU project 3ENCULT we discussed the status of historic buildings in the EPBD, especially what additional requirements within the EPBD would help to realize a more ambitious energy saving level in historic buildings and what are its pros and cons. The findings were related to EPBD requirements that are valid for historic buildings, EPBD requirements of which Member States are allowed to exempt historic buildings and the possibility to add a requirement in the EPBD for an obligatory analysis of energy saving potentials&options in historic buildings.

Seen as useful for historic buildings are:

- The regular inspection of large heating, ventilation and air-conditioning systems
- National requirements for building systems that are replaced or upgraded, under the condition that new systems should always be respectful of the building inner architectural character and necessary indoor climate for protection of the construction and present works of art as well as for users comfort and effective operation of building functions
- Producing an energy certificate for historic buildings, preferably by an expert on energy in historic buildings (who has followed specific training and test to be included in an experts positive list) and accompanied by a logo including both energy and heritage value figures and explanation that warns the user that a skilled design team including peculiar expertise shall be consulted to judge the proposed measures
- A (new) requirement in the EPBD for an obligatory analysis of energy saving potentials&options in historic buildings performed by an expert with the advice or review of conservation expert, so in an early phase of the renovation of an historic building energy saving potentials&options are at least considered. It is suggested that CEN 346, working groups 8, that focuses on energy efficiency in historic buildings, can develop guidelines for the analysis, describing issues, such as the education level of consultants performing the analysis for historic buildings, etc.

Input to the CEN EPBD working groups

All energy performance calculation methods are a simplification of reality, and uses assumptions and preconditions. Due to uncommon construction aspects or details, the methodology might not fit some historic buildings, which might affect the usability of the energy performance calculation methods. Items that need specific attention related to the energy assessment of historic buildings have been discussed in a multidisciplinary team and questions and advice to the CEN EPBD working groups are formulated on 4 topics, of which the most important are:

- Typical construction differencesThe typical high building mass is taken into account accurately enough for the calculation of yearly energy use in the monthly method described in the CEN standard (EN 13790) and no additions in the CEN standards are requested related to thick walls with high moisture buffering that leads to seasonal storage of water, since there is only a small effect on the yearly energy balance of those buildings.

  We ask the CEN EPBD working groups to check whether very large floor height and deviant window-to-floor ratio don't cause unelectable errors in the energy calculation on several points, such as the internal and solar heat that rises to the ceiling, the emission efficiency of the heating or cooling system, due to deviant temperature profile over the floor height

- Non-standard use and functionality

We ask the CEN EPBD working group whether they can suggest a method how to deal with large user behaviour differences and how to estimate energy savings or energy saving potential when the situation before and after renovation is not comparable in terms of functionality and use.

- Lack of information on current performance

We ask the CEN EPBD working group to develop methodologies to take into account typical historical materials and historical constructions, such as air space windows and unheated roof spaces.

We ask the CEN EPBD working groups to standardize and/or refer to alternative measurement methods to determine the air leakage that are suitable in historic buildings, taking into account the extreme high leakages (which often need two or 3 blower doors simultaneously for the test) and preferable low costs of the measurement method

We ask the CEN EPBD working groups to take into account in the judgment of HVAC systems that ventilation control is often focused on humidity instead of indoor air quality.

- Ways of expressing energy performance of a building for historic buildings

We ask the CEN EPBD working groups to help member States for both the formula approach and the notional building approach to work out the boundaries for judgment of the building energy use on the separate levels of the Trias Energetica.

- Indoor comfort conditions and dynamic behavior of historic buildings

We ask the CEN EPBD working groups to deepen the matter, defining specifications and standardized approaches for model calibration and sensitivity analysis, e.g. in the form of validation test cases. In addition, we ask CEN to make sure the calculation procedures are suitable foroptimization purposes to find the most effective solution-sets.

- Natural ventilation

We ask the CEN EPBD working groups to make the calculation method suitable to evaluate the effect of ventilation and assess its effective triggering of comfort enhancement and cooling demand reduction. This could be important for historic building where the architectural configuration were defined to exploit this possibility and where is difficult to install a mechanical ventilation system.

Contents

1 Aim and status of this document and why advice to the EPBD and CEN especially on historic buildings

The aim of this document is to give input to the **EPBD** and **CEN EPBD working groups** under Mandate M/480:

- The input to the **EPBD** focusses on the Directive itself: (listed) historic buildings are at the moment exempted from some of the EPBD requirements. However, legislation is a proven instrument to help reaching energy ambitions. The Energy Performance of Buildings Directive (EPBD) is such an instrument, put in place on an European level and influencing legislation in all Member States in respect of energy use in the build environment. Integration of historic buildings in the EPBD will be a driving force in striving towards the ambitious goals set. Therefore it is fruitful to rethink these exemptions in a multidisciplinary team, including conservators, architects, engineers and EPBD experts, and to discuss possible additional requirements that would gain historic buildings in the long run.

- The **CEN EPBD working groups** that we give input to, are in the process of preparing a second generation of CEN standards to support the EPBD. The update intends to support the implementation of the recasted EPBD and a better harmonization of the national standards, which are used in the national implementation of the EPBD in the Member States.

  From 3ENCULT, our input is given to this particular CEN groups on two specific topics:

  1. The assessment of the energy use or energy performance of historic buildings and

  2. Ways of expressing the energy use of historic buildings.

  Both are main topics within the CEN standards. However, the scope of the CEN standards is buildings in general and not historic buildings. Historic buildings are a specific categories of existing buildings: due to their historic value not all potentially possible energy saving measures are possible and specific solutions might be necessary. Some buildings are exempted from certain energy saving measures that are mandatory for other buildings according to the EPBD. But, that doesn’t mean that these buildings wouldn’t benefit from such measures: to reduce the energy bill, to increase comfort, and to preserve the construction. To be able to balance cultural value and energy savings, a good energy assessment is certainly not enough, but in itself crucial: for evaluation purposes, but also for communication purposes among experts of multidisciplinary background.

  In principle the energy use of historic buildings can be assessed by the CEN EPBD standards as good as of any building, but the deviating character of the buildings makes specific attention to the assessment procedure not superfluous.

The results per topic are given in the next chapters, where chapter 2 addresses the input to the EPBD itself and chapter 3 the input to CEN EPBD working group.

The multidisciplinary team that discussed these topics contained the following disciplines: conservation experts, technical experts, architects and engineers in charge of the retrofit works, local offices for protection of monuments.

2 Input to the EPBD

2.1 Background: why give input to the EPBD

Legislation is a proven instrument to help reaching energy ambitions. The Energy Performance of Buildings Directive (EPBD) is such an instrument, put in place on a European level and influencing legislation in all Member States in respect of energy use in the build environment. Integration of historic buildings in the EPBD will be a driving force in striving towards the ambitious goals set. However, (listed) historic buildings were left out the EPBD in the first place. To realize an ambitious energy saving level in historic buildings and really have impact in Europe, integration of historic buildings in the EPBD might be a fruitful tool.

Within the EU project 3ENCULT we discussed the status of historic buildings in the EPBD: what does the EPBD require from historic buildings and is this realistic? From what requirements are historic buildings exempted, under what conditions, and is this indeed necessary? Can we think of additional requirements within the EPBD that would help to realize a more ambitious energy saving level in historic buildings and what are its pros and cons.

All these topics were discussed via a questionnaire and in a workshop. The results are presented in the next paragraphs.

2.2 Current status of historic buildings in EPBD

In table 1, globally the framework that is set by the (recasted) EPBD for existing buildings is given. In the second column is shown whether these requirements are also valid for listed historic buildings or under what conditions they are exempted. [1]

Main EPBD requirements for existing buildings	**Valid for (listed) historic buildings**	**Conditions for exemption**
When existing buildings undergo major renovation, the renovated building or renovated parts have to meet national minimum energy performance requirements. In addition or as an alternative, requirements may be set for the renovated building elements.	No, see conditions	Member States may decide not to set or apply these requirements to the following categories of buildings: • Buildings officially protected as part of a designated environment or because of their special architectural or historical merit, in so far as compliance with certain minimum energy performance requirements would unacceptably alter their character or appearance; • Buildings used as places of worship and for religious activities;
If a significant part of a building envelope is retrofitted or replaced, the energy performance of this building element needs to meet national minimum energy performance requirements.	No, see conditions	Idem, as above
Energy performance certificates are required when a building is constructed,	No, see conditions	Idem, as above

sold or rented out to a new tenant and for all buildings bigger than 500m^2 which are occupied by a public authority and frequently visited by the public (in the latter case, the certificate also needs to be displayed).		
If building systems (heating systems, hot water systems, air-conditioning systems, large ventilation systems) are installed, replaced or upgraded, national system requirements shell be met.	Yes	System requirements shall be applied in so far as they are technically, economically and functionally feasible.
Large heating, ventilation and air-conditioning systems need to be inspected regularly.	Yes	No exemptions

Table 1: Main requirements set by the (recasted) EPBD for existing buildings and exemptions for historic buildings. Note that Member States may decide to exempt listed historic buildings under the mentioned conditions, but may decide otherwise as well. And note the above is an interpretation of the EPBD made by the author, and that national interpretation in Member States might differ on details.

Requirements that are required for historic buildings

Of the main requirements for existing buildings only two are also required from all listed historic buildings, namely

- that building systems (heating systems, hot water systems, air-conditioning systems, large ventilation systems) shall meet certain national system requirements when they are replaced or upgraded;
- and that large heating, ventilation and air-conditioning systems need to be inspected regularly.

The regular inspection of large heating, ventilation and air-conditioning systems was judged unanimously as a good idea by the multidisciplinary team that discussed this issue via a questionnaire, to guarantee proper functioning and behaviour of these systems and to check the system settings regularly.

In general, national requirements for building systems that are replaced or upgraded are also seen as possible, but the choice, functionality and functioning of the systems should always be respectful of the building inner character and take into account the necessary thermal and hygrometric comfort that is necessary to protect the construction and present works of art (e.g. fresco's), giving an acceptable comfort level for the users (occupants and/or visitors) and still be economically feasible under those conditions. Obviously this could often go hand in hand, but should always be considered carefully. In this context the implementation of climate monitoring might be quite useful.

Requirements that aren't required for historic buildings

Of the main requirements for existing buildings Member States may exempt the other three for buildings that are officially protected as part of a designated environment or because of their special architectural or historical merit, in so far as compliance with these requirements would unacceptably alter their character or appearance. These three requirements are:

- National minimum energy performance requirements after major renovation, for the whole building or the renovated elements;
- National minimum energy performance requirements for the parts of the building envelope that are retrofitted or replaced (only valid when significant parts are concerned);
- Presenting a valid energy performance certificates to a new owner or new tenant.

The desirability of these requirements are discussed in the next paragraph.

2.3 Reconsidering existing exemptions for historic buildings in EPBD

The three main requirements for existing buildings of which Member States may exempt listed historic buildings were discussed in a multidisciplinary team via a questionnaire and workshop. The outcome is presented below.

National minimum energy performance requirements after major renovation, for the whole building or the renovated elements

Although some see national minimum energy performance requirements after major renovation as a means to ensure energy saving and increase indoor climate for people as well as the historic construction and possible present artefacts, the general consensus was that, even if a certain level of energy improvement is indeed desirable, it is not always feasible for historic buildings. When approaching the retrofitting of an historic building (considered as a whole system), more than the usual parameters such as energy, must be considered for the energy and economic balance, such as comfort, function to be ensured, costs and the heritage value. Instead of having national minimum energy performance requirements on energy alone, a multidisciplinary approach for the optimization of possible retrofitting configurations is important to ensure having exploited as much energy saving and IEQ enhancement potentials as possible.

National minimum energy performance requirements for the parts of the building envelope that are retrofitted or replaced

The requirement asks that a minimum insulation level is used if an element of the envelope (façade, window, door, roof, …) is replaced. It seems evident that this is possible if the element is replaced anyway: if it doesn't harm the historic value of the building to remove the old element for a new one, it shouldn't be too hard to make the new element energy efficient. After all, the requirement doesn't demand a minimum insulation level of existing parts, so there is no obligation, for instance, to insulate historic windows with an extra layer on the inside or outside.

However, changing an element of the envelope, might influence the indoor climate and that might risk the construction or possible present artefacts. For instance, changing the windows might influence not only the heat transmission through the window, but also change the air-infiltration, resulting in a more humid indoor conditions that, in its turn, can negatively influence the historic construction and content of the building.

Although it could be desirable to make energy saving measures obligatory that lead to a certain energy savings level and are technically and economically feasible, this seems practically inoperable.

Furthermore, when energy saving measures are evaluated, it is important not only to prevent damages to the building and its artefacts, but also to prevent the so called 'lock in effect'. Lock in effect means that a certain energy saving measure is taken that is cost effective in itself, but not optimal and that prevents the step to an optimal level in the future. This occurs for instance when single glazing is replaced by normal double glazing instead of high insulation glazing: the step from single to double glazing might be cost effective, but once the double glazing is present a step to high insulation glazing will not be cost effective anymore, so that step will never be taken. If the step from single glazing to high efficiency glazing is not possible in the short run, it might be better to do nothing and wait until this step can be taken directly, instead of opting for a sub optimal choice.

In the light of this lock in effect, incentives to promote more expensive innovative measures might be worthwhile. Where for instance national financing or other instruments are considered in the transition to nearly zero- energy buildings, promotions to trigger innovations to avoid the lock in effect in historic buildings is advisable to consider.

Presenting a valid energy performance certificates to a new owner or new tenant

In general there was agreement among the multidisciplinary team that making an energy certificate for (listed) historic buildings, as is done for all other buildings as well, is a good idea. One of the arguments is that the new owner or new tenant of the building needs to be provided with the most transparent information available about the energy quality of the building he owns or rents.

On the other hand, there is some skepticisms, mainly because of bad experiences with the quality of the certificate in general, due to the presumed lack of expertise of the consultant that makes the certificate. The complex nature of historic buildings makes it even more important that the certificate is made by an expert, preferably an expert who has experience with energy in historic buildings.

In addition, it should be clear to the recipient of the certificate that the energy saving measures, that are obligatory mentioned on the certificate, aren't evidently suitable for listed historic buildings[1]. These measures do not take into account that there might be extra barriers to implement them due to the historic character of the building. Suggested is that in case of listed historic buildings a logo including energy and (if available) heritage value figures is introduced, as well as an explanation that warns the user that a skilled design team including peculiar expertise shall be consulted to judge the possible measures.

2.4 Considering possible new requirements for historic buildings in EPBD

One of the tasks of 3ENCULT is to investigate how the European Energy Performance Directive (EPBD) can be used to encourage energy saving measures in historic building, of course without becoming a burden in the fragile balance between optimal energy saving and not unacceptably altering the character and appearance of historic buildings. Requirements don't necessarily have to involve mandatory energy saving measures, as requirements such as a mandatory certificate or mandatory inspection of systems shows. The advantage of these kind of requirements is that no actual energy saving measures are forced upon a building, but designers, decision makers, engineers and/or owners and tenants are confronted with information and possibilities they might not have considered otherwise.

A fruitful possible new requirement for historic building that has been considered in a workshop in our multidisciplinary team is the option that an obligatory analysis is made of energy saving potentials&options. The results of the discussion are described below.

Obligatory analysis of energy saving potentials&options

The idea behind an obligatory analysis of energy saving potentials&options is, that in an early phase of the renovation process of an historic building energy saving measures are at least considered. The analysis can show what measures might be fruitful from energy point of view and which don't need additional consideration.

Such an analysis is not yet part of the EPBD, but a comparable analysis is: namely an obligatory one for larger new buildings to consider the technical, environmental and economic feasibility of (i) possible exploitation of climate context and building architectural features (ii) high-efficiency alternative systems, such as cogeneration, heat pumps and district heating, before construction starts. The analysis itself is mandatory, but implementing the positive evaluated measures is not.

The advantages of an obligatory analysis of energy saving potentials&options for historic buildings are several:

- As said, that in an early phase of the renovation process of an historic building passive and active energy saving measures are at least considered, and biases about impossibilities are taken away where possible;
- Awareness is raised about possible innovations, increasing the chance that these are considered seriously;

[1] This concern was raised during a combined workshop with the EU projects 3ENCULT and Co2olBricks

- The large amount of analyses for historic buildings creates a breeding ground for promotion of energy saving products and solutions for historic buildings: industry that focuses on retrofitting measures for historic buildings can use the analysis to promote their products and solutions, e.g. by providing help or tools with which an analysis can be performed in the scope of the EPBD that shows the advantages of peculiar retrofitting measures specifically developed for historic buildings;

In general, all participants in the multidisciplinary workshop agreed with the usefulness of this analysis. The suggestion was made to refer to CEN 346, working group 8, that focuses on energy efficiency in historic buildings, to develop guidelines about what should and shouldn't be taken into account in the analysis, especially from a conservators point of view. A typical aspect that might differ between historic and non-historic buildings for instance is the comfort level that is assumed in the energy calculation compared to the comfort level that is created in reality[2]. The level of expertise needed from the consultant that will make the analysis, is also an issue that CEN 346, wg 8 can help answering, since this is already a topic of their concern. And they can advise on whether and when measurements are needed connected to the energy analysis: in principle, to judge the energy efficiency of measures in a historic building, measurements are no added value, but to be sure that a new measure won't harm the construction or artefacts in the building, there indeed could be a need for measurements. At least a warning is in order that an expert with the proper background should judge the potential risks in practice. The analysis can also be accompanied by a guideline that deals with economic analysis. The 3ENCULT protocol that is being developed in our project, can serve as a starting point for the CEN group when they develop a guideline for performing an analysis to evaluate energy saving measures in historic buildings.

The suggestion was raised to evaluate the success of the earlier mentioned mandatory analysis of the feasibility of high-efficiency alternative systems, so lessons learned can help the implementation of an analysis of potential energy saving measures for historic buildings.

Of course the analysis also has disadvantages, which mainly are that it costs time and money to make it. Extra costs are never welcome, but getting historic buildings within city centers used again has already a mark of being costly, compared to building new buildings outside the city. Serious extra costs might scare potential new owners away. On the other hand, such analyses are only worthwhile when they are of good quality, and for historic buildings often being quite complex, the analyses won't be too cheap. Financial aid or help in kind to make the analysis for historic buildings might solve this problem. Industrial parties that develop solutions for historic buildings might be of help here by creating a win-win situation: promoting their product and helping with the analysis. Of course this only works when there is enough trust about the quality of the analysis and little problem with potential conflict of interest.

There might be opportunity for financial subsidies from municipalities: In some countries there are already incentives in place to help to make districts with many unoccupied homes attractive again. Renovating historic buildings and getting them used again is part of that bigger picture and might therefore have a chance to get financial help from those resources.

2.5 Conclusions

Within the EU project 3ENCULT we discussed the status of historic buildings in the EPBD and especially what additional requirements within the EPBD would help to realize a more ambitious

[2] In non-historic buildings often a high comfort level is assumed in the energy calculation, even if in reality the comfort level is lower. This is a principle choice for benchmarking reasons, to avoid that a reduction in comfort is used as a way to save energy. In TC 346, wg 8 this could be a topic of discussion: there might be good reasons for another approach for historic buildings, although one should realize that the 'equal comfort' concept is used for non-historic buildings when we want to benchmark the energy use of historic buildings compared to non-historic buildings.

energy saving level in historic buildings and what are its pros and cons. This paragraph summarizes the findings.

- Some requirements in the EPBD do not exempt listed historic buildings. Large heating and air-conditioning systems need to be regularly inspected, which was judged by the multidisciplinary team of 3ENCULT as a reasonable requirement also for historic buildings. Also the EPBD requires national requirements for building systems that are replaced or upgraded. In principle this was agreed upon by the team, but with the warning that the choice, functionality and functioning of the systems should always be respectful of the building inner character and take into account the necessary thermal and hygrometric comfort that is necessary to protect the construction and present works of art (e.g. fresco's) and still be economically feasible under those conditions.
- Member States may exempt listed historic buildings under certain conditions from national minimum energy performance requirements for the parts of the building envelope that are retrofitted or replaced. The team agrees that exemptions should indeed be possible. Although it seems reasonable to replace parts of the envelope by high efficiency products when they are being removed anyway, we should be aware that new elements in the façade may influence the indoor climate and that might risk the construction or possible present artefacts. On the other hand, where possible, high energy efficient products should be encouraged. Moreover, to avoid the lock in effect, incentives to promote more expensive innovative measures might be worthwhile.
- In general there was agreement among the multidisciplinary team that for transparency reasons making an energy certificate for (listed) historic buildings, as is done for all other buildings as well, is a good idea. Where the complex nature of historic buildings makes it preferable that the certificate is made by an expert who has experience with energy in historic buildings. Also it is suggested that in case of listed historic buildings a logo, including energy and (if available) heritage value figures[3] on the certificate and an explanation warns the user that a skilled design team shall be consulted to judge the proposed measures

  Finally, it was suggested to add a requirement in the EPBD for an obligatory analysis of energy saving potentials&options in historic buildings. The idea behind an obligatory analysis of energy saving potentials&options is that in an early phase of the renovation process of an historic building energy saving measures are at least considered. The analysis can show what measures might be fruitful from energy point of view and which don't need additional consideration.

  Such an analysis makes that 1) in an early phase of the renovation process of an historic building energy saving measures are at least considered, and biases about impossibilities are taken away where possible, 2) awareness is raised about possible innovations, increasing the chance that these are considered seriously, and 3) creates a breeding ground for promotion of energy saving products for historic buildings.

  It is suggested that CEN 346, working groups 8, that focuses on energy efficiency in historic buildings, can develop guidelines for the analysis, describing issues such as the education level of consultants performing the analysis for historic buildings, etc.

[3] The development of heritage value figures is a task that might be taken on by CEN TC 346, WG4

3 Input to the CEN EPBD working groups

3.1 Background - The energy assessment in the CEN EPBD Standards

The CEN EPBD Standards together form a methodology to estimate the energy use of a building. This estimation can be used for various purposes. In relation to the EPBD it is mainly used to determine whether a building complies with the energy performance requirements in a country or to derive an certificate, often expressed in a label class: A, B, C, D, E, F, G (but note that these labels aren't used in all counties).

There are several ways to perform an estimation of the energy use of a building. Among these couple of software tools were used in 3ENCULT: PHPP, for steady-state calculation and EnergyPlus for dynamic simulations, both closely relates to the possible methods described in the CEN EPBD Standards.

3.2 Why look at the energy assessment from historic buildings point of view

All energy performance calculation methods, whether they are very simple, very detailed or something in between, are a simplification of reality. This means that various aspects of reality have been captured within assumptions or preconditions.

These assumptions and predictions are based on features of a global range of building (or building component) designs. Buildings that are fairly unconventional and that therefore deviate from this range might not be covered well enough by the estimation. This holds for all types of buildings: contemporary buildings, historic buildings and other buildings. For the calculation method to be useful, it is important to fix the objectives of the calculation (heating and/or cooling energy demand assessment, retrofitting possibilities evaluations, control optimization, etc.) and to find out whether a building fits well enough within the assumptions and predictions.

Some historic buildings may well fit the assumptions and predictions, but due to uncommon construction aspects or details the methodology might not fit some historic building. For the calculation method to be usable in a large range of historic buildings it is necessary to put our finger on as much of these uncommon construction aspects or details as possible, so adaptions on these aspects in the assumptions of the calculation can be made that better fit the situation.

Therefore we are looking for typical aspects on which a historic building, or at least some historic buildings, might deviate from more common buildings and which might influence the energy use of that building. The aspects we identify will be communicated to the CEN EPBD working groups. This way we can hopefully influence the CEN EPBD energy calculation standards, so they'll be able to estimate the energy use in historic buildings, and more importantly the energy saving potential of energy measures in historic buildings, as good as possible. For achieving our project goal, this is a necessary boundary condition.

3.3 Items that need attention

Items that need specific attention related to the energy assessment of historic buildings have been identified, by means of a questionnaire and several discussions in a multidisciplinary team, which included conservation experts, technical experts, local offices for protection of monuments architects and engineers in charge of the retrofit works. These items can be categorized in three main groups:

1. Typical construction differences
2. Non-standard use and functionality

3. Lack of information on current performance

The items are discussed per group below:

Typical construction differences

- High building mass

  Some historic buildings have constructions with very high building mass that buffers heat or cold. The calculation needs to be able to take these extreme high building masses into account.

  Within the 3ENCULT project team, there is agreement among the building physics experts and experts from CEN that for the calculation of yearly energy use, the monthly method described in the CEN standard (EN 13790) is accurate enough for historic buildings on this aspect. So no changes on this point are requested at this moment, also because it is expected that the new EN ISO 13790, which is the main CEN standard on the assessment of the energy demand, will replace the monthly method for a new simple hourly method that probably will suite our special building category better.

- Thick walls with high moisture buffering that leads to seasonal storage of water

  Some historic buildings have thick walls from materials with high moisture buffering, such as adobe or others. These thick historic walls will uptake humidity during summer time, and all the year round if there is not a good protection against driving rain. If the building is heated in winter, the inner part of the wall will be warm and dry, but the outer part remains humid. There is an extra energy need of the building, due to the latent heat that evaporates at the inner part of the wall during the heating season. However, in the cold and humid outer part, condensation takes place. The enthalpy of the condensing water vapour will rise the temperature at the cold (outside) part of the wall, which reduces the heat transmission losses through the wall. This effect could be described as a wall with a smaller U-value. This (positive) effect compensates (partly or to a large extent) the (negative) effect of the energy need for evaporation of the inner part of the wall.

  In total, because of this compensating effect, the humidity effect can be neglected, at least if not a high accuracy is needed. The remaining effect on the energy use of the building of the seasonal moisture is too small to justify the effort to perform a sophisticated dynamic long-term hygrothermal calculation. In most cases the "dry" calculation method is good enough. Calculations performed in the dissertation by Jürgen Schnieders [2] confirm this hypothesis.

  There is agreement among the building physics experts and experts from CEN within the 3ENCULT project team that the monthly method described in the CEN standard (EN 13790) is accurate enough for evaluate heating demand of historic buildings taking into account moisture buffering, so no changes on this point are necessary for a good enough estimation of the yearly energy balance. Further studies for specific climate conditions and for evaluating all final energy uses as well as comfort conditions might be useful.

- Large floor height

  Some historic buildings have very large floor height, which has several effects:

  - It makes internal heat and solar heat less usable, since heat will rise to the ceiling;
  - It influences the emission efficiency of the heating or cooling system, due to the different temperature profile over the floor height.

  Our advice to the CEN EPBD working groups is to check the effect of these two points.

- Indoor comfort conditions and dynamic behavior of historic buildings

We ask the CEN EPBD working groups to deepen the matter, defining specifications and standardized approaches for model validation and sensitivity analysis, e.g. in the form of validation test cases. In addition, we ask CEN to make sure the calculation procedures are suitable for optimization purposes to find the most effective solution-sets.

- Natural ventilation

  We ask the CEN EPBD working groups to make the calculation method suitable to evaluate effect of ventilation and assess its effective triggering of comfort enhancement and cooling demand reduction. This could be important for historic building where the architectural configuration were defined to exploit this possibility and where is difficult to install a mechanical ventilation system.

Non-standard use and functionality

- Utilization of a historic building can be quite different from a more common building

  The utilization of a historic building can be quite different from a more common building and the utilization might change after renovation. Different zones in the building can also have strongly different user behaviour. Diverse usage of different zones, e.g. unused zones because of constructive limitations like cellars with high moisture problems because of missing water proofing at the basement or unused roof zones because of lack of knowledge about roof insulation. Flexibility in user behaviour input in the calculation might be important here. A notional building approach with flexibility in user profiles might better fit in with the variation in utilization of historic buildings.

  Another issue is how to deal with changes in functionality before and after renovation: before renovation the building is often not used or used differently. Energy use and energy saving before and after can't be compared.

  A question to the CEN EPBD working group is whether they can:

  - Suggest a method or methods how to deal with large user behaviour differences among historic buildings and among historic buildings compared to other buildings. Maybe a notional building approach with large flexibility in user profiles is a solution (where of course the profiles that are being used should lie within principle boundaries of comfort for users and protection of building structure) ?;

  - Suggest a method or methods how to estimate energy savings or energy saving potential when the situation before and after renovation is not comparable in terms of functionality and use.

- Inflexibility of national software tools

  In various Member States the national software tool(s) used to calculate the energy performance of existing buildings aren't flexible enough to fit the input parameters necessary to calculate historic buildings, even though the standard (on national and/or international level) does give flexibility to use these input flexibility.

  We ask the CEN EPBD working groups whether they could describe a general rule in the umbrella document (for instance) that regulates that flexibility in national software fits the flexibility in the standard.

Lack of information on current performance

- No lab-reports with material properties or system performances of various ancient materials/systems available

Of various materials/systems used in some historic buildings no lab-reports with material properties or system performances are available. This might be a problem because if the base rate of energy use isn't estimated good enough, the effect of energy saving measures might be largely over or under estimated.

A question to the CEN EPBD working groups is to develop a method to derive these values or procedures how to cope with these situations need to be developed. Because the energy saving properties of the old situation often will be poor compared to the renovated situation. Therefore the need to know these in detail is probably not large enough to justify the expenses of a measurement method. So the solution might lie more in databases with typical material properties probably per country or region, and guidelines or procedures how to use these databases. This might be a topic to address within CEN TC 346, wg8 also or in cooperation between the two groups. A starting point of such a database is already developed within an European project and accessible via the following link: http://www.building-typology.eu/country.html

- Typical historical materials and historical constructions

  Some historic buildings have typical materials and constructions that perform differently, such as air space windows and cold roof constructions. These need to be taken into account in the assessment:

  - Air space windows: Air space windows are window constructions that are created in case of refurbishing of historic windows by adding double or triple glazing at the inner side of the window and keeping the historic window (single glazing) at the outside. What happens is that there will be a large temperature drop at the (gas filled and coated) double or triple glazing, then there is some temperature drop in the air space, finally, the temperature of the single glazing is close to ambient temperature. If there is any (even small) leakages from room air to this air gap, the humidity will condensate at the single glazing. To avoid this effect, a small opening (gap at the upper and lower part of the frame) has to be made in order to allow some convection of dry ambient air. This way the dew point of the air in the air gap is reduced and any condensate is avoided.

    The calculation of the U-Value of the whole glazing system is calculated according to EN 673:2011. However, to avoid condensation practical experience shows that the amount of ventilation in the air gap should be higher than EN 673:2011 assumes. The high flow rate through the air gap cools down the air in the gap, hence the real U-value is higher than calculated according to EN673.

    We ask the CEN EPBD working groups to develop a calculation method to estimate the real U-value of such solutions, which will be very helpful for refurbishing of historic buildings, since these type of window constructions are frequently applied.

  - Unheated roof spaces:

    Unheated roof spaces refer to unused and unheated attics, which would be outside of the balance boundary in an energy balance calculation. The thermal envelope for the calculation would normally be the uppermost ceiling. However, if the uppermost ceiling and roof have comparable thermal properties, taking only the uppermost ceiling into account would be too pessimistic. A solution is to calculates an effective U-value and effective radiation coefficients that result from the combination of the uppermost ceiling and roof. These effective values can be applied to the uppermost ceiling area for the energy balance calculation.[4]

[4] Note that such a calculation is included in the current version of the Passive House Planning Package (PHPP 8.1), that is used within 3ENCULT.

We ask the CEN EPBD working groups to develop a calculation method to estimate the effective heat loss trough an unheated (roof) spaces.

- Air leakage is unknown:

A problem in many existing buildings is that the air leakage is unknown. In historic buildings the air leakage can be expected to be high and the effect on energy use can be large. On the other hand, the moister balance in an historic building can be quite critical, therefore a larger air leakage than 'normal' can't be sealed just like that. Consequently, performing air leakage measurements can be important. And although these cost money, possible damage to the construction after renovation is costly too. Ordinary blower door tests are not evident. Due to the massive leakage often two or three blower doors are needed to create enough air pressure.

One of the 3ENCULT deliverables [3] describes a blower door method that is suitable for historic buildings. An alternative that is used in historic buildings as well is the tracer gas dilution method (concentration decay measurement), where CO_2 is used as tracer gas. This is an existing measurement technique (EN ISO12569:2012) but due to the use of CO_2 instead of the normally used tracer gas, the measurement is reasonably cheap.

We ask the CEN EPBD working groups to refer within the EN 15242 (that described the method to determine the ventilation and infiltration air flow for the energy use calculation) to the alternative measurement method that is described in EN ISO 12569:2012 to determine the air leakage that is suitable in historic buildings, taking into account the extreme high leakages and preferable low costs.

- Lack of information about the existing (old) installation (HVAC)

Often there is a lack of information about the efficiency and functioning of the existing installation/HVAC system.

An additional issue is that the ventilation ratios in historic buildings and the control strategies can principally differ from normal situations. Especially the humidity control is important and ventilation control is often focused on humidity instead of indoor air quality, which results in relative high ventilation rates.

We ask the CEN EPBD working groups to take into account the diverging functioning and control of HVAC systems in historic buildings in the estimation of the energy performance methodology of these buildings.

- The boundaries of the thermal zones are not always easy to define

The boundaries of the thermal zones are not always easy to define, because of the co-existence of conditioned and un-conditioned zones having the same function and the same relevance within the building. Procedures how to define these boundaries need to be developed, taking into account things like the possibility of exclusion of humid cellars, the distinction between conditioned and unconditioned spaces and conditions such as the need for a physical separation as boundary.

Since the CEN EPBD working groups are already working on this issue under the current second mandate of the EU, no further request regarding this point are asked related to historic buildings.

3.4 Additional issue: Ways of expressing energy performance of historic buildings

Why consider different ways of expressing the energy performance of historic buildings

In the scheme below (figure 1), the link among the energy assessment, the energy label and ways to express the energy performance is depicted: The energy assessment results in a total energy use of the building, expressed in the energy use of the building or maybe the energy use per m^2.

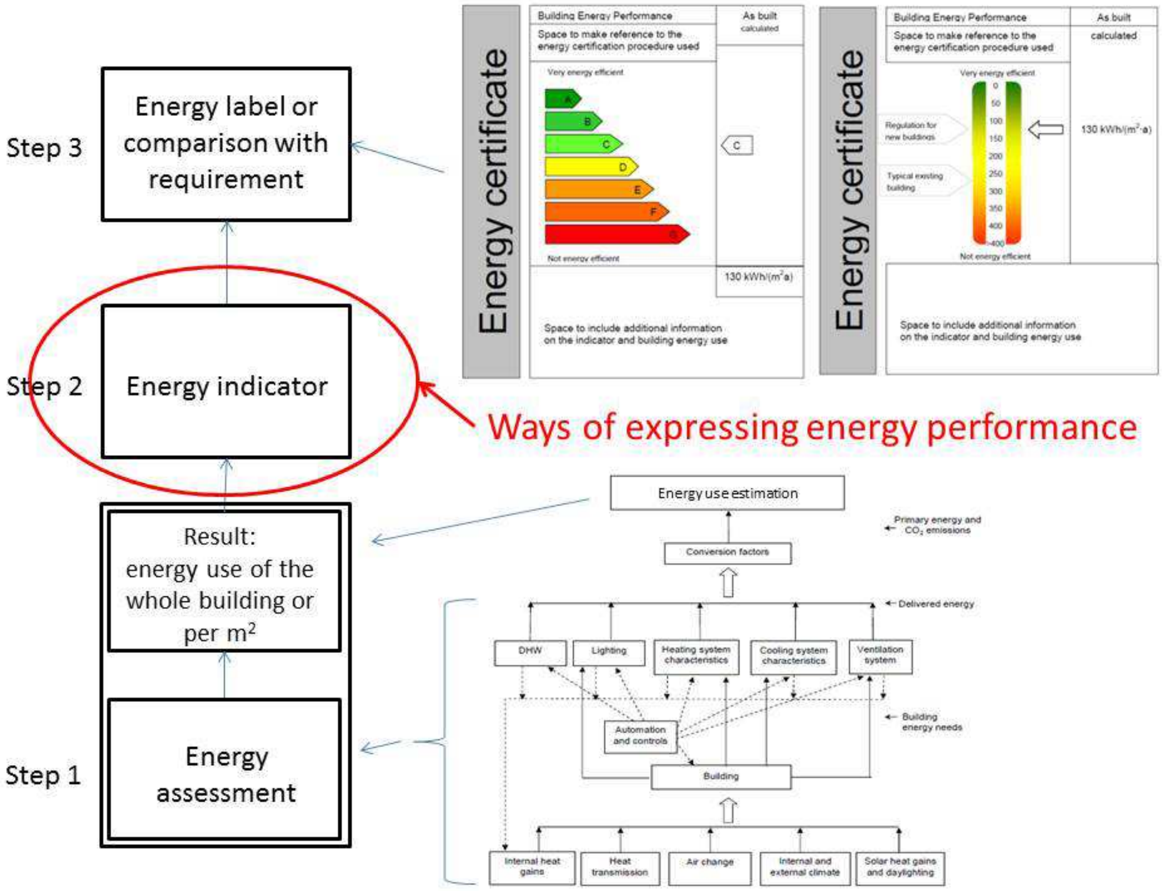

Figure 1: From energy assessment to energy label: position of ways to express energy performance in this procedure

Before the energy assessment result (step 1) can be turned into a classification used on the energy label (step 3, e.g. A, B, C, etc), the total energy use needs to be translated into an energy indicator (step 2). The aim of such an indicator is to neutralize or normalize certain impacts and with this to be better able to compare energy uses of buildings.

Impacts that you might want to neutralize or normalize are for instance the parameters shown in table 2 (except from the last row, the table is adapted from EN 15217:2007 Energy performance of buildings – methods for expressing energy performance and for energy certification of buildings.) The impact of a parameter may be modified either by specifying particular values or procedures for the data used in the energy assessment (step 1), or by adjustment of the energy index (step 2).

Parameter	**Possible reason**
Climate	To adapt the level of technologies requested to the climate
Building function	To adapt the requirements to the different designs, uses and feasible technologies
Building size	To avoid unduly onerous requirements on detached houses and too low requirements on large compact buildings. To adapt the requirements to buildings with different sizes and shapes.
Ventilation rate	To prevent too costly requirements for buildings or uses which require a high ventilation rate
Illumination level	To prevent too costly requirements for buildings or uses which require a high illumination level
Qualitative heritage value level (high, medium, low)	To justify specific solutions and/or retrofitting approach

Table 2: Parameters with reduced or neutralized impacts

The reason to consider various ways of expressing the energy performance of a building for historic buildings is that some ways of expressing might solve problems for instance with the large differences among user behaviour in historic buildings. Various ways of expressing the energy performance are listed in the next section, with pros and cons. This overview includes comments and remarks given in a workshop among the multidisciplinary members of the 3ENCULT project team.

Examples of ways of expressing the energy performance, with some pros and cons

Table 3 below shows various ways of expressing the energy index of a building with pros and cons.

<table>
<tr><td colspan="2">1. Energy index expressed in absolute total energy use of the whole building</td></tr>
<tr><td colspan="2">Remark:
The size of the building isn’t neutralized: a building with an energy use of 13.000 kWh scores 10 times better than a building with an energy use of 130.000 kWh, although it might be 10 times smaller.</td></tr>
<tr><td>Pros:
• Most direct link with energy costs</td><td>Cons:
• Comparison among buildings is almost impossible.
• Comparison before and after renovation of the same building of course is possible. Disadvantage there is that the initial level of energy efficiency is than decisive of the reduction that is possible.</td></tr>
<tr><td colspan="2">2. Energy index expressed per m^2 usable (conditioned) floor area</td></tr>
<tr><td colspan="2">Remark:
The example certificate in figure 1 uses an energy index per m^2. The example building has an energy index of 130 kWh/m^2. So class C in this example is bounded e.g. by 120 kWh/m^2 and 150 kWh/m^2 (the boundaries are not given in the example, so this is only a guess). The size of the building is neutralized: a building of 100 m^2 with an energy use of 13.000 kWh and a building of 1000 m^2 with an energy use of 130.000 kWh, both have an energy use of 130 kWh/m^2 and score a C (in this example). Note that this is the approach, which is used in 3encult for energy balance calculations of historic buildings using PHPP and also in the primary energy demand requirements for historic buildings in the EnerPHit criteria.</td></tr>
<tr><td>Pros:
• Comparison among buildings possible, especially within a certain building type (see cons)
• The situation before and after renovation can now be judged related to other buildings as well: not only how much % improvement is realized (which depends on the initial level of efficiency of the building), but also the level of improvement on a more ‘absolute’ scale.</td><td>Cons:
• Building shape has large impact on comparison (e.g. flats will do much better than villa’s, while renovation cannot change the loss area).
• Also other impacts aren’t neutralized.
• Link with energy costs is less evident</td></tr>
</table>

3. Energy index expressed by using a formula: Energy index = absolute total energy use (as 1. in this table) divided by a standardized energy use, expressed in a formula that is a function of one or more parameters as mentioned in table 1.

So: EI (= Energy Index) = E_{total} (= absolute total energy use) / $E_{standard}$ (= standard energy use)

Remark:

- The simplest formula is a formula that is only a function of the usable/conditioned floor area. E.g.: $E_{standard}$ = 100 x A_g (=usable floor area). An example building with an energy use of 13.000 kWh and floor area of 100 m^2 has an EI of 1,3 (EI (= Energy Index) = E_{total} (= absolute total energy use) / $E_{standard}$ (= standard energy use) = 13.000 / 100 x100).
- The number 1,3 itself has no physical meaning, only that the building uses 1,3 times more energy than the standard. The level of the standard can for instance be placed at the center of the building stock or at the border of a certain class (e.g. the border between class A and B). If class C is bounded by 1,2 and 1,5 than this buildings scores class C. Borders of the label classes and constants in the formula are of course fitted on one another.
- In the above example the formula doesn't have much added value compared to item 2. in this table. But more complex formulas are possible, taking into account various of the items from table 1. E.g.: $E_{standard}$ = 40 x A_g + 50 x A_{loss} (= loss area). A building with 100 m^2 floor area and 120 m^2 loss area and an energy use of 13.000 kWh scores an EI of: 13.000 / (40x100+50*120)=1,3. Again: Borders of the label classes and constants in the formula are of course fitted on one another and on the level of neutralization that is wanted.
- Besides floor area and loss area other parameters can be neutralized in the formula.
- Note that this method is used in many countries in the EU (e.g. Belgium, Netherlands, France) to determine the energy performance and label class of new and existing buildings, residential as well as non-residential. For residential buildings often the formula uses floor area and loss area as parameters only, for non-residential buildings, the formula might be more complex.

Pros:

- Comparison among many buildings possible, also among different sizes, shapes, types etc (to a certain extend)
- The situation before and after renovation can now be judged related to other buildings as well: not only how much % improvement is realized (which depends on the initial level of efficiency of the building), but also the level of improvement on a more 'absolute' scale.
- Typical aspects of a certain building type can be neutralized and have no negative or too positive impact on the energy label. E.g. if a high ventilation rate is needed in a certain building function, the formula for that building type can incorporate ventilation rates in the calculation of the standard energy use, so this effect is neutralized.

Cons:

- No link with energy costs
- EI has no physical meaning, even link between EI and absolute or even relative energy use is gone.
- Fit needed between constants and EI, based on effect-study with various example buildings.
- Fit will never be perfect for all buildings in the same typology. Makes it less transparent.
- The system might be misleading for decisions on interventions.

4. Energy index expressed by using the notional building approach. The basis is the same as described under 3.: Energy index = absolute total energy use (as 1. in this table) divided by a standardized energy use: EI (= Energy Index) = E_{total} (= absolute total energy use) / $E_{standard}$ (= standard energy use) . The difference is that the standardized energy use is determined via the notional building. A notional building is the same building as the building that is assessed, only containing certain default energy saving measures, e.g. a fixed level of insulation and a fixed efficiency of the boiler. All aspects that are not fixed have the same level as the building that is assessed, e.g. loss area, orientation, window area, user behaviour.	
Remark: • With this method all parameters that aren't fixed in the notional building are neutralized. So e.g. if the infiltration rate is not fixed in the notional building this parameter also is neutralized, since the same infiltration rate is used in the assessment of the building as well as in the calculation of the standard energy use, by which it is divided. • Parameters that change due to renovation, need to be fixed in the notional building, otherwise the effect is diminished. • Aspects such as floor area, loss area, orientation can't be changed by renovation, so neutralizing them seems logical. • Note that this method is already used in various countries in the EU (e.g. Germany, UK, Hungary) for label and/or the energy performance requirements check. It is thought to be useful especially for non-residential buildings, since there the user behaviour can be so different even within one building type (compare a hotel with 6 beds with one with 150 beds, a pool, shops, restaurant etc etc). The level of the fixed parameters is often chosen at the requirement level for new buildings. But it is also possible to choose the fixed parameters at a level of no energy efficiency at all (no insulation, single glazing, low efficiency of the boiler, etc).	
Pros: • As 3. In addition: • The flexibility of neutralization is high; transparency also • Unknown parameters have less effect (only a second order). • Especially aspects as specific user behaviour can now be taken into account in the energy assessment as it is in practice. • An aspect such as loss area is neutralized automatically by using the notional building approach. This is an advantage, since loss area often is a given fact.	**Cons:** • As 3. In addition: • There is no encouragement to improve parameters that are neutralized. E.g.: if infiltration rates are unknown, they don't affect the EI, but improving this parameter doesn't affect the EI either. So which parameters are fixed and which aren't is crucial. • Due to the previous issue, this method is less useful for new buildings, if one wants the instrument to lead to compact buildings.

Table 3: Ways of expressing the energy index (non-exhaustive list)

All methods described above judge the energy performance of a building as a whole. Besides an energy performance on building level, for renovation of buildings, a judgment of components on itself is also important, for instance for step by step renovation. These component judgments are unrelated to the energy performance on building level and therefore not discussed here,

It is seen as valuable by the multidisciplinary team that discussed the above methods that the energy performance can be judged on the three levels of the trias energetica: 1) on the demand level, 2) on the level including renewable energy and 3) on the level where also the fossil fuel use is taken into account. We ask the CEN EPBD working groups to help member States for both the formula approach and the notional building approach to work out the boundaries between these levels (what components and aspects belong to what level; e.g. is the heat recovery from ventilation air part of the heat balance or not?). The reason is that, although the energy performance on building level remains the most important level, renewable resources are scares, also when used in historic buildings and information about the decreasing of the energy use on the demand level is crucial. Therefore it is important to have information about the extend in which the heating demand is or can be reduced. This information is (partly) hidden when the building is heated with renewables with a low non-renewable primary energy factor, which diminishes the energy use, resulting in the possibility to neglect energy saving measures.

3.5 Conclusions

All energy performance calculation methods, whether they are very simple, very detailed or something in between, are a simplification of reality. This means that various aspects of reality have been captured within assumptions or preconditions. Some historic buildings may well fit the assumptions and predictions, but due to uncommon construction aspects or details the methodology might not fit some historic building, which might affect the usability of the energy performance calculation methods for historic buildings. Items that need specific attention related to the energy assessment and ways of expressing the energy performance of historic buildings have been discussed in a multidisciplinary team and questions and advice to the CEN EPBD working groups have been formulated. A summary of this is given below:

- Typical construction differences
    - High building mass: although historic buildings can have much higher building mass that buffers heat or cold than average buildings, there is agreement that this aspect is accurately enough for monthly or yearly heating demand calculation taken into account in the monthly method described in the CEN standard (EN 13790);
    - Thick walls with high moisture buffering that leads to seasonal storage of water: The moisture buffering that is typical of some historic building constructions, does influence the energy use of those buildings. However the effect is too small to justify the introduction of sophisticated dynamic long-term hygrothermal calculations within the energy calculation. Therefore no additions in the CEN standards are requested;
    - Large floor height and deviant window-to-floor ratio: Our advice to the CEN EPBD working groups is to check whether very large floor height and deviant window-to-floor ratio don't cause unelectable errors in the energy calculation, due to 1) less usability of internal heat and solar heat that rises to the ceiling; and 2) deviant temperature profile over the floor height that influence the emission efficiency of the heating or cooling system.
    - Indoor comfort conditions and dynamic behavior of historic buildings

  We ask the CEN EPBD working groups to deepen the matter, defining specifications and standardized approaches for model validation and sensitivity analysis, e.g. in the form of validation test cases. In addition, we ask CEN to make sure the calculation procedures are suitable for optimization purposes to find the most effective solution-sets.

- Natural ventilation

  We ask the CEN EPBD working groups to make the calculation method suitable to evaluate effect of ventilation and assess its effective triggering of comfort enhancement and cooling demand reduction. This could be important for historic building where the architectural configuration were defined to exploit this possibility and where is difficult to install a mechanical ventilation system.

- Non-standard use and functionality
  - Utilization of a historic building can be quite different from a more common building: A question to the CEN EPBD working group is whether they can: 1) Suggest a method or methods how to deal with large user behaviour differences among historic buildings and among historic buildings compared to other buildings (Maybe a notional building approach with large flexibility in user?); and 2) Suggest a method or procedure how to estimate energy savings or energy saving potential when the situation before and after renovation is not comparable in terms of functionality and use.
  - Due to inflexibility of national software tools: We ask the CEN EPBD working groups whether they could describe a general rule in the umbrella document (for instance) that regulates that flexibility in national software fits the flexibility in the standard.
- Lack of information on current performance
  - No lab-reports with material properties or system performances of various ancient materials/systems available: A question to the CEN EPBD working groups is to develop a method to derive these values or procedures how to cope with these situations need to be developed. This can possibly be based on databases with typical material properties per country, and guidelines or procedures how to use these databases. The development of databases and guidelines could possibly be addressed by CEN TC 346, wg8 and based on existing databases (such as http://www.building-typology.eu/country.html).
  - Typical historical materials and historical constructions:
    - Air space windows: If double or triple glazing is placed at the inner side of an historic single glazed window, ventilation in the gap is forced to avoid condensation of the cold window in the gap. The ventilation rate within the gap is higher than assumed in EN 673:2011, which overestimates the effective performance of the combined construction. We ask the CEN EPBD working groups to develop a calculation method to estimate the real U-value of such solutions, which will be very helpful for refurbishing of historic buildings, since these type of window constructions are frequently applied.
    - Unheated roof spaces: Unheated (roof) spaces are placed outside the energy balance calculation, but the energy use is overestimated if they are not taken into account. We ask the CEN EPBD working groups to develop a calculation method to estimate the effective heat loss trough unheated (roof) spaces.
  - Air leakage is unknown: We ask the CEN EPBD working groups to standardize and/or refer to alternative measurement methods to determine the air leakage that is suitable in historic buildings, taking into account the extreme high leakages (which often need two or 3 blower doors per test) and preferable low costs of the measurement method

  - Lack of information about the existing (old) installation (HVAC): We ask the CEN EPBD working groups to take into account the diverging functioning and control of HVAC systems in historic buildings in the estimation of the energy performance methodology of these buildings, taking into account that ventilation control is often focused on humidity instead of indoor air quality.

  - The boundaries of the thermal zones are not always easy to define: Since the CEN EPBD working groups are already working on this issue under the current second mandate of the EU, no further request regarding this point are asked related to historic buildings.

- Ways of expressing the energy performance of historic buildings
  - The reason to consider various ways of expressing the energy performance of a building for historic buildings is that some ways of expressing might solve problems for instance with the large differences among user behaviour in historic buildings. The CEN EPBD Standards give the possibility for all the discussed methods. However a judgment on the separate levels of the Trias Energetica isn't supported, while especially a judgment on demand level is seen as particularly valuable. Therefore we ask the CEN EPBD working groups to help member States for both the formula approach and the notional building approach to work out the boundaries between these levels.

4 References

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