CONCERTED ACTION
ENERGY PERFORMANCE OF BUILDINGS

(CT2) Existing Buildings & Systems - 2018

Status in June 2018

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KEYWORDS

existing buildings; renovation; technical building systems (TBS); inspection schemes; databases; heritage

1. Introduction

Existing buildings and the technical systems within them are covered by the main themes:

1. minimum requirements for the energy performance of existing buildings, especially those undergoing major renovation;
2. energy performance of technical building systems in existing buildings, including their monitoring and control;
3. regular inspection of heating and air-conditioning systems; and
4. alternatives to regular inspection.

The scope of the EPBD in respect of these themes is set out under Article 7 *(Existing buildings)*, Article 8 *(Technical building systems)*, Articles 14 and 15 *(Inspection of heating and air-conditioning systems)*, and Article 16 *(Reports on the inspection of heating and air-conditioning systems)*. Other relevant parts are Article 4 *(Setting of minimum energy performance requirements)* in relation to existing buildings, and Article 6 *(New buildings)* for consideration of high-efficiency alternative systems on major renovation.

With a few exceptions, the provisions of the EPBD (Directive 2010/31/EU) were to be applied by MSs by July 2013. Since then, implementation activities by the MSs have mainly focused on refinement and consolidation, rather than on major changes. Further revisions of the EPBD (by way of Directive (EU) 2018/844) entered into force in July 2018, and MSs will have to transpose the revised provisions by March

2020. However, other legislation also aims to improve the energy performance of buildings, which suggests that an integrated approach to implementation may be beneficial. This includes the development of a long-term strategy for building renovation, formerly part of the EED (Directive 2012/27/EU) but now transferred to the EPBD, as well as other provisions of the EED, such as energy efficiency obligation schemes (for energy suppliers), energy auditing (of consumers and enterprises) and installation of smart meters. The RESD (Directive 2009/28/EU) also contains relevant requirements, which are considered in the Central Team report on New Buildings. Furthermore, a new set of standards to support the EPBD has been prepared. These standards were adopted after a formal vote in late 2016, and MSs will decide how they are to be used when reviewing their regulations.

By way of the most recent amendments to the EPBD, an important additional theme has emerged. This is '*smartness of buildings*' and the concept of '*smart readiness'* – meaning the provision of smart features that it might not be possible to use immediately, but will become valuable as a consequence of other developments. Examples of smart features that might be unusable or insignificant at present but may play a more important role in future include:

- the ability of a building to manage itself efficiently;
- interaction with its occupants in a user-friendly manner;
- responding to external conditions, by postponing or advancing some of the electrical or heating load;
- contribution to the smooth, safe and optimal operation of connected energy assets;
- vehicle charging facilities.

Smart buildings will require much better control of their integrated technical building systems, including effective monitoring and feedback, and to that extent they have a strong connection with the second of the main smart features listed above.

2. Objectives

The objectives are:

- To develop a wider understanding of the detailed requirements and options in the EPBD concerning the performance of existing buildings, technical building systems, intelligent monitoring and control, and the inspection of heating and air-conditioning systems.
- Within these themes, to identify and explore the topics currently of greatest interest to MSs, to observe the progress made and share the experience of successful implementation and difficulties encountered.
- To consider the overlap with other directives, notably the EED and RESD, and investigate the potential for better integrated regulation and activities.

3. Analysis of Insights and Main Outcomes

3.A. Analysis and insights

3.A.1 Topics of concern for CA EPBD IV

MSs have already set the minimum performance requirements for existing buildings, including technical building systems, and have created regular inspection schemes or equivalent alternative measures. More recently, efforts have been made to improve them, and to fill any gaps. At the beginning of the CA EPBD IV, CA members were asked which topics were at that time of greatest interest or concern to them, and this has helped to direct the subsequent work. The areas identified were:

- the overall ambitions and long-term objectives for the existing building stock, step-by-step renovation and the effectiveness of each step, goals for packages of renovation measures and energy efficiency measures in suburban and low-income areas where there is no investment capacity;
- ensuring that overall requirements for the building (as opposed to requirements for components) do not become obstacles to refurbishment, raising the rate of refurbishment through incentives, motivating building owners, and making the EPBD more simple and transparent for building owners and tenants;
- dealing with the diversity of the building stock (types of construction, age, occupancy, etc.), allowing for the preservation of historic buildings, recognising occupants with special needs (e.g., the elderly);
- consideration of "*high-efficiency alternative systems*" for major renovations, renewable energy source technologies in existing buildings;
- what is "*technically, functionally, and economically*" feasible, realistic prediction of energy savings and calculation versus measurement;
- long-term retention and re-use of EPC data, achieving coherent results from EPC when a "new" building has become an "existing" building;
- other sources of data for existing buildings, the identification of qualifying buildings to ensure that regular inspection takes place, analysis of the data from EPC and regular inspections, and wider usage of EPC databases;
- essential features of "*intelligent metering*" and "*active control systems*" for technical building systems and how they should work, the role and capabilities of building energy management systems (BEMS);
- continuous monitoring of heating, ventilation and air-conditioning systems to assess the energy performance and reduce the need for regular inspection;
- alternative measures to replace regular inspection of air-conditioning, and evaluation to determine the equivalent impact.

The CA EPBD IV work on existing buildings has concentrated on these ten main areas of current interest, together with other topics that emerged later when it became clear what amendments to the EPBD were being agreed.

Highlights of 3.A.1	During the lifespan of the CA EPBD IV, the general aim is to refine and improve existing policies, regulations, and schemes. The amendments to the EPBD (May 2018) bring significant changes and additions to be implemented later. The topics of interest for existing buildings are becoming more specific and, in many cases, more technically detailed. Overall, they comprise: renovation, feasibility and cost-effectiveness, monitoring and control, data management and analysis, inspection and alternatives to inspection. Monitoring and control are expected to acquire much greater importance in the context of smart buildings and smart-readiness.

3.A.2 Strategic objectives for renovation

The obligation to provide a long-term strategy for the renovation of the building stock has been transferred from the EED to the EPBD; the EPBD also sets the minimum energy performance requirements that apply to renovation works. Consequently, the impact of the EPBD on the depth of renovation is now accompanied by the wider role of raising renovation rates. Performance is expected to rise over time, with the prospect of reducing energy consumption by existing buildings, as well as by new buildings, until it falls to NZEB levels. The long-term strategic outlook can anticipate this development.

The long-term renovation strategies have to include measures to stimulate deep renovations of buildings, including staged deep renovations, where "*deep renovation*" means work leading to a very high energy performance and the reduction of energy consumption by a significant percentage. However, the EPBD legislates for "*major renovations*", defined by reference to the total cost (relative to building value), or by the affected proportion of the surface area of the building envelope. Neither deep nor major renovations are required to go beyond what is cost-effective.

In the working document accompanying the COM (2013) 225[1], deep renovation means at least 60% primary energy savings compared to the status of the existing building before the renovation; this can be considered as an official interpretation. In addition, other documents[2] indicate that *"... the multi-objective nature of cohesion policy, contributing to economic, social and territorial cohesion, requires an integrated approach and should be used in support of the deep renovation of buildings in order to meet the energy efficiency targets for 2020 and beyond. As such, the sole focus on a simple payback period is not appropriate in the context of long-term energy efficiency investments. Rather, the aim should be to encourage deep renovations leading to significant (typically more than 60%) efficiency improvements*".

DG Energy, with the support of the JRC, assessed the first national renovation strategies[3] due in 2014 and found that only a few MSs reported "*planned*" measures for energy efficiency in buildings, while the vast majority reported only existing policies. The section related to forward-looking perspective to guide investment received the lowest average rating in the assessment exercise. This seemed to indicate that most renovation strategies lack a clear long-term vision. Few included research and development, though that could be the key to cost-optimality and lower costs, generally.

More recently, the CA EPBD has discussed the assessment of the second national renovation strategies[4], which were due in 2017. Twenty-one (21) of the strategy documents from MSs had been fully revised and the others partly revised. Considerable improvements were found in the assessment scores, some by a large margin, and nearly all fulfilled the requirements of EED Article 4. More data had been collected and analysed by the MSs, with a better range of scenarios. Fifteen (15) MSs put forward their long-term vision with targets for 2050.

Discussion at the CA EPBD shows that the over-riding problem for many MSs is the legacy of a large amount of housing, especially multi-apartment blocks, that is in poor condition and suffering from neglect and weak management. The immediate need is for stricter regulation and building codes to raise standards significantly, though not to such an extent that it becomes too expensive to comply with them. Experience has shown that it is possible to reduce energy demand in older housing from about 200 kWh/m^2 per year to less than 70 kWh/m^2 per year, but there are many technical and financial barriers to overcome.

Some of the barriers are:

- the difficulty for building owners in carrying out renovation projects, particularly because of the large amount of time and organisation needed;
- lack of confidence in predicted savings;
- payback times are too long to form an effective incentive for private finance;
- funding schemes are not available, or are too limited;
- reluctance to take out loans;
- distrust of administrative procedures and officials;
- different interests of stakeholders in buildings under shared ownership or with multiple tenants.

Solutions include making procedures simpler and more transparent, and using IT platforms to hold data, record progress, and link stakeholders. Financial models need good guidelines, standardised contracts and other documents. More needs to be done to reduce the burden on building owners. MSs feel that more research and development is necessary, especially to establish what is cost-effective under different circumstances.

The European Commission has launched the "*Smart Finance for Smart Buildings*" initiative, which, in close cooperation with the European Investment Bank (EIB) and the MSs, supports the development of flexible energy efficiency and renewable financing platforms at national level to make more attractive financing options available on the market. This initiative will:

- encourage the more effective use of public funds, in particular through financial instruments and investment platforms;
- help aggregation and assistance with project development;
- make energy efficiency investments more trusted and attractive for project promoters, financiers and investors, by providing them with access to market evidence and performance track records available from the De-risking Energy Efficiency Platform (DEEP) and by developing a commonly accepted framework for underwriting investments in this area.

Where there has been a long history of energy efficiency policies, supported by tax incentives and subsidies, it has been possible to set more ambitious targets. In Germany, a CA EPBD study tour was able to examine 60-year old apartment blocks in Frankfurt, which previously had little or no insulation and were now undergoing deep renovation to achieve 80-90% energy savings. CO_2 emissions were expected to be reduced from 52 kg/m^2 per year to 5 kg/m^2 per year, in line with the city's policy objective of decarbonisation by 2050. In Denmark, strong regulations aim for a 35% reduction in energy consumption by 2050 (Figure 1), with building codes setting limits of 30 kWh/m^2 per year in existing buildings and 20 kWh/m^2 per year for new buildings. One novel idea has been to build a "*library*" of typical buildings for which standardised solutions can be adopted during renovation.

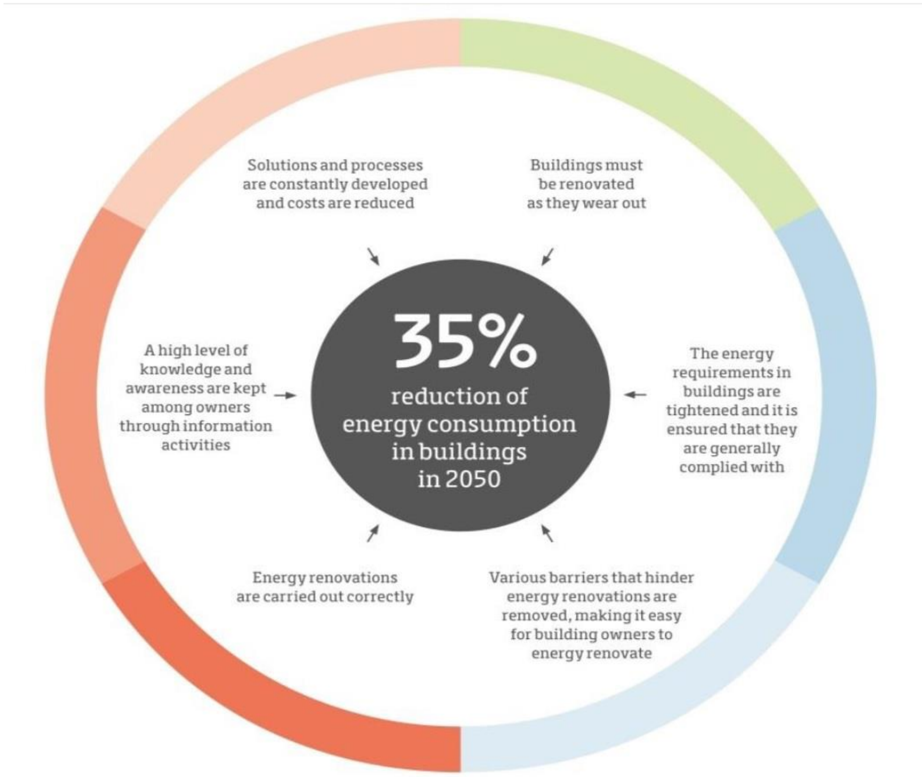

Figure 1. Activities in long-term renovation plans.

The costs of widespread renovation programmes may be too high for governments to bear, and more needs to be done to encourage building owners to pay for this themselves. In housing, the cost may well exceed 20,000 € for deep renovation of a typical home. Key components of programmes designed to motivate building owners are:

- information: more about the wider benefits of energy renovations (e.g., greater comfort, increased asset value, healthier indoor conditions), as well as savings in energy costs;
- investment: convincing homeowners that renovation will add value to the property and produce a positive return;
- trust: raising confidence in the ability of contractors to carry out improvement works competently and at competitive prices, assisted by codes of practice for the building trade and standardised improvement packages where possible.

Questions for further investigation include:

- ensuring that targets for overall performance (as opposed to component/elemental performance) of individual buildings do not become a deterrent to action;
- how longer-term goals should be expressed, and their level of ambition;
- building renovation passports;
- whole policy packages for renovation.

As noted earlier, amendments to the EPBD adopted in May 2018 move the obligation to produce a long-term strategy for building renovation from the EED (Article 4) to the revised EPBD (new Article 2a). The final meeting of the CA EPBD IV anticipated and debated this. It is expected that future CA EPBD activity will concentrate on how the transfer is brought into effect, and on further work on the new provisions in Article 2a, including:

- progress monitoring and roadmaps that include measures, measurable progress indicators and indicative milestones at 10-year intervals;
- the role of smart financing, including techniques such as aggregation of projects to make the funding process easier, de-risking to make projects more attractive to investors, and leverage of public funds to obtain greater benefits from the private sector;
- greater emphasis on the conscious assessment of feasibility and cost-effectiveness;
- facilitation, such as one-stop shops and building renovation passports;
- improvements to data availability and modelling;
- the relevance of building renovation to other policies, such as the alleviation of energy poverty and the needs of the elderly;
- wider benefits that are not limited to energy saving, such as those related to health, safety and air quality.

Highlights of 3.A.2	Difficulties that have been found when implementing renovation strategies are: • the legacy of many buildings in poor condition, suffering from neglect and poor management; • balancing available funding against the longer term horizon of deep renovation and NZEB; • persuading building owners to invest in energy efficiency measures themselves; • simplifying procedures, and providing help for building owners to follow them; • raising confidence in the quality and competence of renovation contractors; • developing standard solutions to reduce the costs in typical cases.

	Future work is likely to focus on: • progress monitoring and roadmaps; • smart financing and facilitation for renovation projects; • acknowledgement, identification and measurement of the wider benefits.

3.A.3 Expanding the use of databases

The majority of MSs have been using databases to keep EPCs and reports from regular inspection of heating and air-conditioning systems since these schemes were introduced for the EPBD about 10 years ago. A large amount of data has now been collected, which can be used to show the condition of the building stock, engage the general public, and encourage further investment in energy efficiency. It can also be used to examine the rate of change, assess the impact of existing policies, inform future policy development, and support research.

Earlier CA EPBD work indicated that there is value in having strong linkages between databases for the EPBD and others that hold building data for different reasons. Linkage gives an opportunity to fill gaps and check consistency wherever there is duplication. Questions then arise about definitions, compatibility, and accuracy. There are also data protection, privacy and disclosure concerns when links are made between databases holding data that has been gathered for different purposes.

Databases are in use across the MSs, but in many cases they are not being used beyond the minimum requirements of the EPBD. However, there are some known examples of:

- ***EPC/inspection databases being used to provide input data for other databases:***
  property valuation and taxation databases, building stock statistics, monitoring and quality controls, planning procedures, and reporting of progress in National Energy Efficiency Action Plans;
- ***existing databases (other than EPC) used to provide input data to the EPC database:***
  property identification details, including address, building type, names of owners and former owners, maps, local climate correction factors, and the credentials of the energy expert who produced the EPC;
- ***databases used to help achieve national policy targets, or implement EU directives other than the EPBD:***
  development of building codes, the renovation strategy for the EED, setting energy-saving goals for different stakeholders, energy-saving targets and planning, and other actions to evaluate and improve the quality of buildings;
- ***databases used to support research:***
  databases of EPCs and inspection reports have already become a valuable source of national building data; an example (in the UK) is a research project on the national stock of air-conditioning systems, in which it was possible to analyse 500 inspection reports and EPCs for the same buildings.

MSs vary in their approach to disclosure of this type of data, some having open source databases and others limiting access under restrictive data protection rules.

The advantages of combining databases are: providing answers to questions about buildings (in the absence of other sources of knowledge); informing policy development; improving quality controls;

avoiding unnecessary duplication; increasing the motivation for building improvements; engaging the market; and supporting social research. The drawback is that the development of complex databases is seen as expensive, and gathering more data is expected to lead to more complicated inspection procedures and calculations.

A single database containing all building information would be ideal, but the reality of trying to achieve this poses many problems. Data is usually acquired at different times by different agencies and for different purposes, meaning that underlying assumptions may be incompatible, and content and data formats different. Preventing further divergence through future development requires strong overall control. The barriers and risks are illustrated in Figure 2.

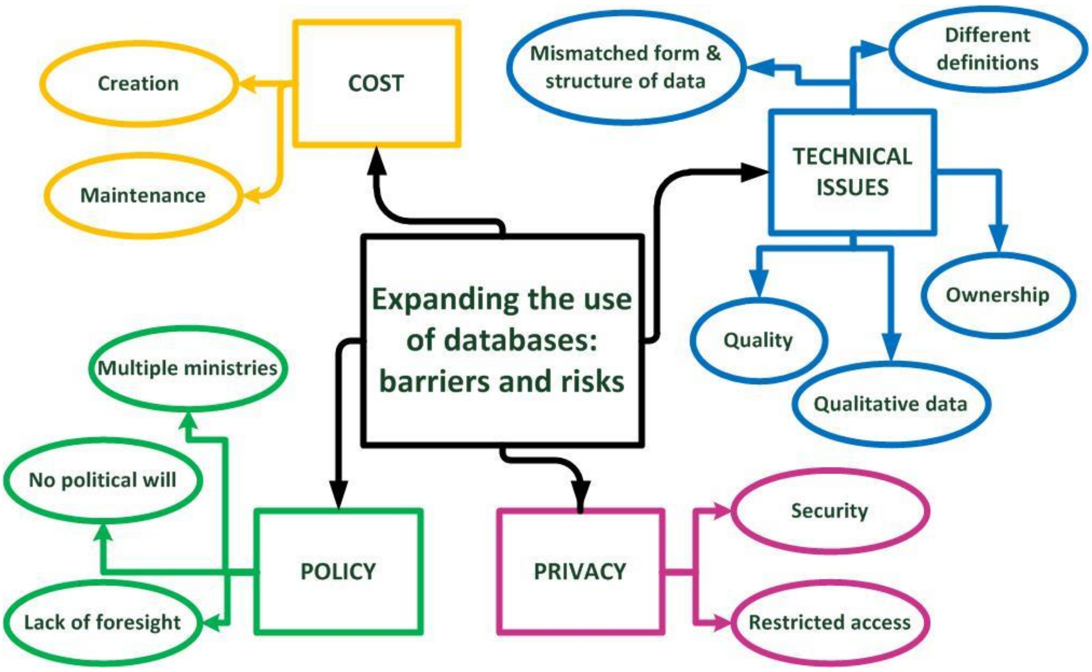

Figure 2. Expanding the use of databases: barriers and risks.

The main difficulties experienced by MSs in setting up, maintaining, and combining databases for buildings include:

- changing or conflicting rules (e.g., EPC rating scale, different definitions of treated floor area);
- privacy barriers to free circulation of information;
- not being able to locate all buildings, or all heating and air-conditioning systems;
- building ownership data not sufficiently up to date;
- low level of assessors' technical skills;
- industry resistance to supplying new information demands;
- independent control systems (and quality control more generally) for databases, and successfully applying sanctions.

Although they see the opportunities for wider systems, MSs generally have a cautious approach to expanding the use of databases.

The following ideas are among those being considered:

- use of data for strategic thinking and planning of long-term energy savings;
- more accurate and useful information for building occupants; recommendations could be made for a building at the point of sale based on data from case studies of similar properties; larger mortgages would be made available for a buyer wanting to carry out the improvements;
- innovation, gap analysis and data mining would provide opportunities for the development of new energy efficiency solutions;
- open data: information could be opened up to anyone who wants access via a simple, government-provided gateway; the market would be expected to find novel uses for this data.

It is usually necessary to refine and combine raw EPC information with other data before use in a wider context. Understanding and compensating for errors and incompatibility at a technical level (e.g., definitions and measurement conventions) is necessary to produce coherent data sets. Statistical data can be used to fill in gaps and provide a complete data set for individual buildings. Aggregated data is of little commercial value, as it does not identify the buildings in need of particular energy efficiency measures.

To exploit buildings data successfully there is a need for vision and careful planning, and to fully understand the requirements when mining data. Many common barriers exist across MSs. The potential advantages of combining databases must be weighed against the cost. Although many ideas have been put forward for developing and using coherent datasets, most have not yet been put into practice.

The amending EPBD makes explicit reference to the collection of data for buildings. Article 10, (6a) and (6b), requires EPC databases to allow data to be gathered on measured or calculated energy consumption, and that at least aggregated anonymised data shall be made available for statistical and research purposes. CA experience indicates that most MSs already have well established EPC databases and they should be able to comply with these requirements without difficulty.

<table>
<tr><td>Highlights of 3.A.3</td><td>Databases of EPC and inspection reports are currently in widespread use across MSs but they are generally being used only to support the minimum requirements of the EPBD.

There are many interesting possibilities to expand their use, including strategic thinking, information for building occupants, data mining, support for research projects, and open data.

There are significant barriers when doing this, in terms of multiple ownership, disparate purposes, technical issues, privacy, cost of development, and the ongoing costs of reconciling data from different sources.</td></tr>
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3.A.4 Heritage buildings

Heritage buildings present a particular set of challenges, as upgrading to improved levels of energy performance may be intrusive, visible, and unacceptable. Alterations to the building fabric can lead to a change of character; examples of the insensitive use of exterior wall insulation on old buildings in France have been observed and illustrated in a journal article[5]. Although MSs apply minimum performance standards to major renovation work, the EPBD allows exemption to be given to buildings of special architectural or historical merit. The obligation to renovate public buildings under Article 5 of the EED contains a similar exemption, insofar as compliance with minimum energy performance requirements would unacceptably alter their character or appearance.

MSs are aware that meeting the same minimum levels of energy performance after renovation entails far higher costs for heritage buildings than for other buildings. They also have to satisfy numerous organisations and authorities with a strong interest in building preservation. There is a considerable amount of available guidance on the renovation of special buildings, as well as a range of technical solutions, such as concealment of sensors, wireless links, automatic window control, underfloor heating. Some MSs (notably Germany) have taken a numeric approach to the relaxation of requirements, in which targets for heat loss through components in W/m^2 per K, or overall energy intensity in kWh/m^2 per year, are modified according to the type of building and the difficulty of renovation. Targets can be set as a reduced proportion of those applicable to a reference building (Figure 3).

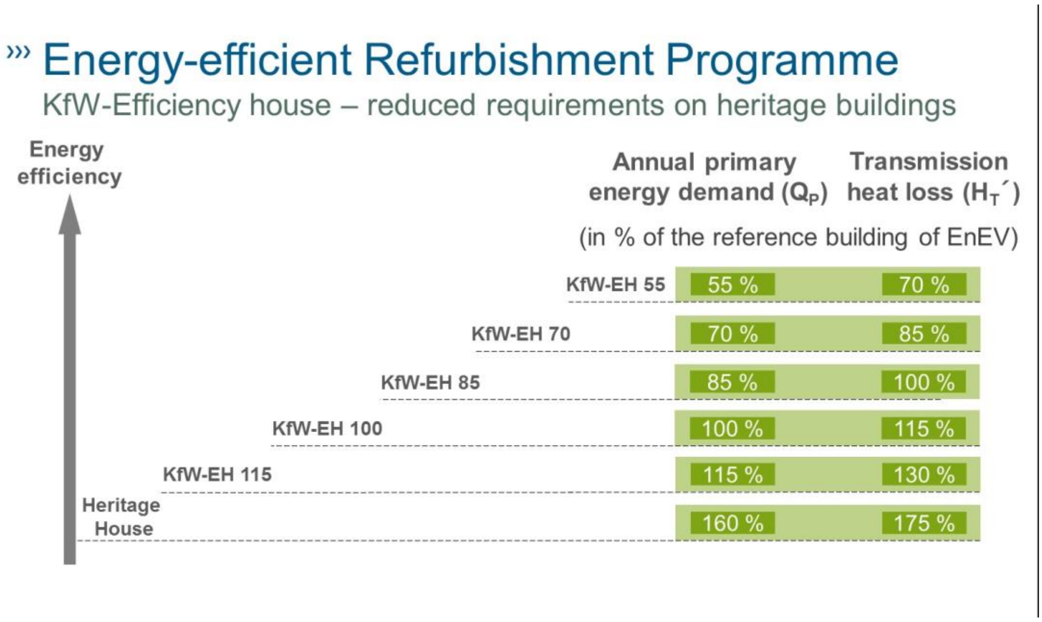

Figure 3. Reduction of targets by proportion.

Enquiries have shown that about two-thirds of the MSs have a recognised definition of heritage buildings and have established principles to be followed concerning preservation of their external appearance. A similar number allow exemption, to some degree, from the minimum performance requirements that would normally apply during major renovation. Fewer than half have published guidance or rules concerning energy efficiency improvements to heritage buildings. For some MSs, heritage buildings are not a priority, while in others a mild climate means that improvement of the thermal envelope is not always necessary.

One concern is funding schemes linked to increases in energy performance, under which heritage buildings do badly in comparison with others. Seen as an investment, the benefit/cost ratio is relatively poor. Most countries do not allow for special rules (a "*heritage factor*") when energy efficiency projects are competing for funds, and if they have to compete then it is on equal terms. There is no such competition where national funding for heritage buildings is treated separately.

An integrated approach to take account of the EPBD, EED, and RESD is seen as advisable, though the aim of renovation projects is usually not limited to saving energy and reducing environmental impact. Renovation extends the life of the building, and raises the quality of living and working spaces as well as improving occupant satisfaction. However, efficiency and cultural heritage are often the responsibility of different ministries. This requires a holistic approach and planning (Figure 4) with co-operation between technical and cultural experts in different teams. In monumental buildings, energy performance may be considered a minor aspect, while factors such as tourism play a much bigger role. This is acknowledged in the Namur Declaration on the objectives and priorities for a common European Heritage Strategy[6], which places a high value on the contribution of heritage to quality of life, the living environment, and Europe's attractiveness and prosperity.

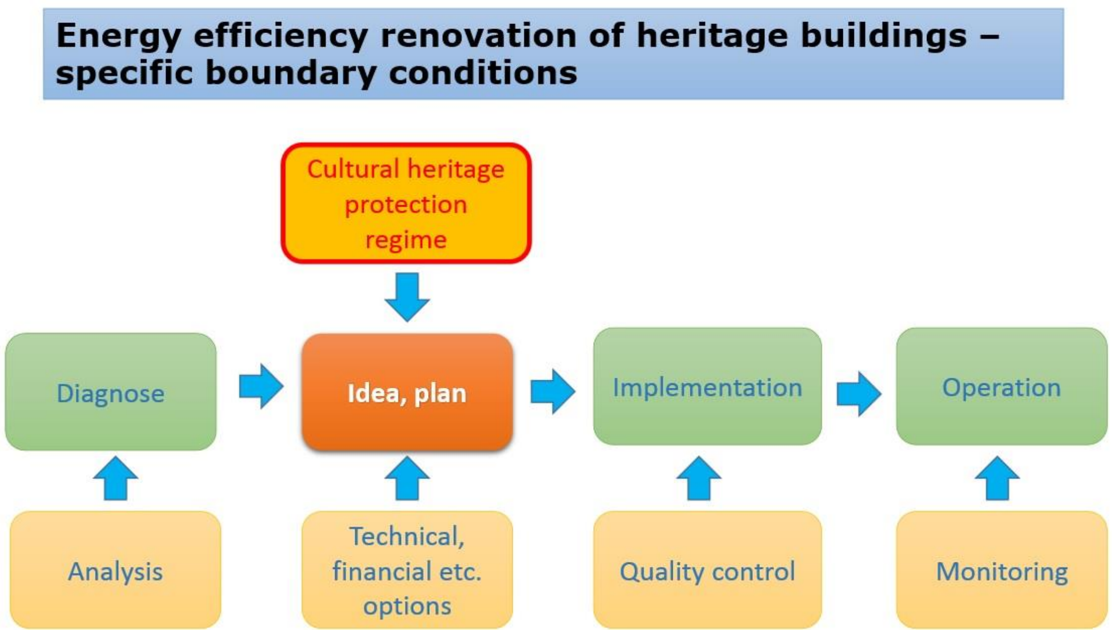

Figure 4. Planning for renovation of heritage buildings.

A thorough assessment of an historic building and its energy consumption is necessary before a renovation project is planned. One successful approach is to categorise the different types of historic construction: this helps to identify suitable and cost-effective solutions that have worked in the past and to generate guidance for the future. This has allowed historic renovation to become somewhat simpler and less expensive.

Some future prospects are:

- wider categorisation of historic building types, with corresponding guidance and best practice;
- further development of renovation guidelines by reference to previous experience based on building categories;
- attention to the greater importance of technical building systems and energy management systems where it is not feasible to improve insulation and airtightness of the building fabric;
- specific guidance for installation of renewable energy source technologies in sensitive buildings;
- climate-specific solutions, applicable across a number of countries;
- better co-ordination of government departments responsible for energy, culture, and heritage.

Highlights of 3.A.4	Renovation of heritage buildings is restricted in scope and it is relatively expensive to achieve a high level of energy performance. Funding for renovation is difficult to obtain if competing on the basis of the benefit/cost ratio. Some relaxation of the minimum performance requirements is necessary. Energy efficiency and heritage are the responsibilities of different government departments and good working relationships are needed. Categorisation of building types helps to identify suitable and cost-effective solutions, leading to better guidance for future projects.

3.A.5 Technical Building Systems

Technical building systems (TBS) comprise installations that provide heating, hot water, air-conditioning, ventilation, and lighting. In the revised EPBD, the definition has been expanded to include building automation and control, as well as on-site electricity generation, including systems using energy from renewable sources. They are addressed in EPBD Article 8 *(Technical building systems)*, now replaced in the amending EPBD by Article 8 (*Technical building systems, electromobility and smart readiness indicator*). Furthermore, heating and air-conditioning systems are subject to requirements for regular inspection, set out in EPBD Articles 14 and 15 *(Inspection of heating and air-conditioning systems)* and Article 16 *(Reports on the inspection of heating and air-conditioning systems)*.

The scope and implementation of the EPBD in regard to TBS and regular inspections have been explored extensively by the CA EPBD in earlier meetings. Before the amending EPBD, Article 8 mentioned that (with the exception of lighting) requirements must be set for the overall energy performance, installation, dimensioning, adjustment and control of systems in existing buildings. During the CA EPBD IV, these topics were revisited to consider the impact of air-conditioning inspection schemes and the report "*Unleashing the power of the EPBD's Article 8*".

In the discussions held during the CA EPBD IV, it was shown that the status of air-conditioning installations is becoming more widely known as a result of regular inspection, from which experience has been accumulated with common findings and the improvements that are most frequently recommended.

However, some MSs have chosen to introduce 'alternative measures' instead of regular inspection, in which case they must produce a report every three years to demonstrate that these measures have equivalent impact.

The principal questions for both heating and air-conditioning inspection schemes concern maintenance, monitoring, and the differentiation of actions by reference to the type and age of the installed plant. It has been found that most recommendations arising from inspection are 'quick fixes' concerning operational hours, controls and routine maintenance. Other factors were the need for accessible energy meters, regular analysis of readings, presentation of understandable and useful information without data overload, and the motivation of building managers. Points for debate are whether defects are more likely to be noticed during maintenance or inspection, the prospect for commercial online monitoring services, the feasibility of linking the frequency of inspection to the age of the plant, and the system's size above which regular inspection is clearly a better policy than 'alternative measures'.

Little is known about the energy savings achieved as a consequence of regular inspection. They depend on the extent to which recommended improvements are taken up. Nevertheless, this has to be estimated for the purpose of comparison with 'alternative measures' when MSs have to report on equivalent impact; in 2014, a CA EPBD working group produced a framework for writing such reports. An analysis has been carried out concerning the reports already published on the EC website. This analysis found that these MSs had faced difficulties in acquiring sufficiently detailed data and creating energy models on plausible assumptions. In at least one case, these difficulties were successfully overcome with a comprehensive stock model of system types, power ratings, age, and replacement rates, combined with reasonable expectations of utilisation, coefficients of performance (COP), annual energy consumption, quality of maintenance, and degradation profiles.

The report "*Unleashing the power of the EPBD's Article 8*" [7] (March 2017) draws attention to the generally poor and unambitious regulatory treatment of TBS. It claims that there is huge potential for energy savings in TBS, but most MSs have not taken the opportunity (encouraged by the EPBD) to introduce stronger regulations to achieve that. The contribution of prospective energy savings to the national targets could be equal to that of the whole of the rest of the EPBD. To do so would require a wider understanding of the effective measures that can be implemented on *systems*, rather than on individual components, and of how to optimise their energy performance. The greatest scope for savings is from the TBS *replacement* in *existing* buildings, which occurs naturally at the time of the building's refurbishment or the expiry of TBS life. Effective regulation would need to refer to the minimum energy performance levels that are reasonably achievable for each of the different systems and technology types, and to include technically specific requirements for installation, adjustment and control. While this would be difficult initially, and there were practical objections to confront, the cost would not be unduly high compared with the achievable energy saving benefits.

In the amending EPBD, the threshold for inspection has been raised to 70 kW for both heating and air-conditioning systems. The idea is to focus more strongly on medium to large buildings (e.g., offices, shops, and apartment blocks with communal services to more than 10 units), where inspections are most effective. Ventilation systems will be inspected in the case where they are integrated with heating or air-conditioning systems above the specified threshold. In addition, the amending EPBD allows the inspection to be replaced by monitoring in buildings equipped with electronic monitoring and building automation and control systems. Electronic monitoring of TBS informs building owners/managers when the system efficiency has significantly decreased and when system maintenance is necessary. It has been shown that this was a cost-effective substitute for regular inspection. Furthermore, building automation and control systems will be required by 2025 in very large non-residential buildings (system capacity above 290 kW for heating or air-conditioning), provided they are technically and economically feasible. Finally, the amending EPBD requires the installation of self-regulating devices for room temperature in new buildings, as well as in existing buildings when heat generators are replaced, on the condition that the installation is economically and technically feasible.

Highlights of 3.A.5	Improvements to TBS, including the regular inspection of heating and air-conditioning, have the potential to save very large amounts of energy in existing buildings. In the case of air-conditioning inspection, valuable experience has been acquired concerning common faults and most frequently recommended improvements. Where 'alternative measures' have been adopted in place of regular inspection, sophisticated models now exist to predict and compare their impact: these are needed for the 'equivalence reports' that must be prepared at three-year intervals. A report in March 2017 claims that regulations for TBS are not sufficiently ambitious, and far more could be achieved at a moderate cost, mainly by focusing on the energy performance of whole systems as opposed to the individual products and components.

3.A.6 Smart Buildings and Smart Readiness

Smart Buildings and Smart Readiness are relatively new concepts. In the context of the amending EPBD, smartness refers to three key functionalities of a building and its technical building systems:

(a) maintaining good energy performance and operation of a building in a more automated and controlled manner, including (for example) the adaptation of energy consumption to maximise the use of RES when available;

(b) responding to the needs of the occupant and reporting on energy use, while maintaining healthy indoor climate conditions and paying attention to user-friendliness;

(c) offering flexibility of the building's overall electricity demand in relation to the supply grid, with active and passive as well as implicit and explicit demand response (for example, by load shifting).

Annex 1a of the amending EPBD sets out the purpose of the smart readiness indicator. It is to assess the capabilities of an individual building as above, covering features for energy saving, benchmarking and flexibility, and enhanced functionalities and capabilities resulting from more interconnected and intelligent devices. Assessment for smart readiness must take into account features such as smart meters, building automation and control systems, self-regulating devices for indoor air temperature, built-in home appliances, recharging points for electric vehicles, energy storage, interoperability of features, as well as the benefits for indoor climate conditions, energy efficiency, performance levels and enabled flexibility.

Smart buildings and smart readiness depend strongly on automation, monitoring and advanced controls for TBS, all of which have been referenced previously in Articles 8, 14, and 15 of the recast EPBD (May 2010). Assessment of buildings for 'smart readiness' will revive interest in these technical topics. Many of the energy saving features now described as 'smart' are techniques that are not new, though they may have received little attention while they were simply an optional part of the advanced control or of building energy management systems (BEMS). A few examples are:

- careful division of a building into zones, with set points for temperature, which are automatically allowed to vary slightly according to weather conditions;
- night cooling by mechanical ventilation, deployed to reduce the necessity for active cooling on the next day;
- measurement of CO_2 levels to identify more densely populated parts of a building and temporarily raise the ventilation rate;
- temporary restraint of the TBS for heating, hot water and cooling during times of peak demand on the supply grid, with a financial reward for doing so, offered through flexible time-of-day pricing tariffs.

The latter is an example of readiness to participate in schemes that are not yet widely available, though the capability to do so can still be recognised.

The CA EPBD has devoted some attention to smart buildings and smart readiness in anticipation of the amending EPBD. Concepts and terminology have been explored and debated, and discussions were held on the evolution of 'smart' features, in the expectation that MSs will need to review and strengthen their regulations for TBS.

The CA EPBD has also played an active role in the widespread consultations for the EU study to support setting up a Smart Readiness Indicator (SRI)[8]. In the initial study, ending in August 2018, the project team has identified eight (8) impact criteria for ten (10) domains (sets of building services). A comprehensive taxonomy of smart functions within each domain has been drawn up. The vision is the development of a SRI that can differentiate individual buildings and reflect something end-users understand and care about, and hence stimulate change that supports policy objectives. Development of the relevant metrics and a suitable scale for the results is a technical challenge, and it is acknowledged that there is a need for the careful definition of smart service functionality and functional levels, and that the impacts ascribed to different levels should be estimated with a reasonable degree of confidence. Depending on MSs' wishes, it is possible that smart readiness assessment could be connected to energy performance calculation and EPCs (e.g., become an additional module in the existing procedures), though the calculation methodology for the indicator will have to consider impacts wider than energy or primary energy.

At the end of December 2018, a second study started in order to consolidate the earlier results and support the preparation by the EC of the legal acts that will establish the SRI.

Highlights of 3.A.6	Smart Buildings and Smart Readiness are included within the amending EPBD. The key elements are using controls and automation to maintain good energy performance, responding to the occupants' needs and adding flexibility by introducing demand response. This supplements the existing provisions for TBS, especially in regard to automation, monitoring and feedback to occupants. A technical study launched by the EC to support the development of the SRI and the related calculation methodology concluded in August 2018. It has already tentatively identified impact criteria and technical domains (sets of building services) that could be considered in the calculation of the SRI.

3.B. Main Outcomes

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
Objectives for renovation of the building stock	• building renovation strategy is required by EED (soon to be a requirement of the EPBD instead); • "deep renovation" and "*major renovation*" have different definitions; • "*major renovation*" need not be planned but is subject to minimum standards; • legacy of housing in poor condition; • NZEB standards for the longer term	• strategies not yet linked to the NZEB vision; • payback times too long to attract private investment; • difficult for building owners to initiate renovation projects, even with available funding	• simplification of procedures; • better information and help for building owners; • progress towards standardised solutions; • raising trust and confidence in contractors; • new requirements for a long-term strategy as defined in Article 2a of the amending EPBD; • progress monitoring and 'roadmaps'; • smart financing and facilitation for renovation projects; • identification, acknowledgement, and measurement of the wider benefits
Expanding the use of databases	• databases not used except to support the basic requirements of the EPBD; • significant barriers: technical issues, privacy, and cost of development	• many possibilities to expand database use; • need for vision and good planning to ensure value is provided	• using data for strategic thinking and planning for long-term energy savings; • providing information for building occupants; • wider access to open data
Improvement of heritage buildings	• restricted opportunities; • higher costs to achieve good energy performance; • energy efficiency often a minor aspect	• need for clear definitions and guidance, some relaxation of minimum requirements, different funding streams or rules, coordination between	• categorisation of construction types to facilitate reference to earlier solutions; • greater attention to technical building systems

Topic	Main discussions and outcomes	Conclusion of topic	Future directions
	of renovation projects	different government departments	when fabric alterations are not feasible
Technical Building Systems	• very large potential for energy savings; • experience gained from the regular inspection of air-conditioning systems; • study of reports from MSs on the alternatives to the regular inspection of air-conditioning systems; • reported lack of ambition in MSs' regulations for improvements to systems in existing buildings	• common faults revealed by regular inspection are related to operational hours, controls, and routine maintenance; • comprehensive models now developed for the assessment of alternatives to regular inspections; • need to optimise performance at system level, rather than simply at product and component level	• the amending EPBD brings significant changes to the requirements for TBS and regular inspection; • in particular, continuous performance monitoring will become an alternative to regular inspection; • large installations for heating and air-conditioning to be equipped with building automation and control systems by 2025; • overall TBS energy performance to be assessed whenever a system is installed, replaced or upgraded
Smart Buildings and Smart Readiness	• unfamiliar terminology, with precise definitions yet to emerge; • main functions are automation, monitoring, feedback, advanced control, and demand response; • progress of the EU study to develop a SRI	• heightens the role of TBS with advanced controls, invoking new features; • prospect of SRI assessment procedure similar to, and allied with, that for EPCs; • SRI calculation methodology not confined to the fundamental units of energy or primary energy	• implementation of the amending EPBD, which introduces the SRI; • SRI calculation methodology yet to be developed and refined; • conclusions from the first technical study to devise methodology and assessment procedure (August 2018); • second technical study started at the end of December 2018

4. Lessons Learned and Recommendations

Minimum requirements on building renovation, and renovation strategies (required by the EED), should look forward to NZEB levels of performance as the long-term objective. While that may be relatively straightforward in the MSs with a long history of regulations to improve energy performance, it is more difficult in those that have a large legacy of buildings in poor condition and limited funding programmes. The more urgent short-term requirement is to renovate to reasonable standards, as widely and as quickly as possible, without the additional expense and technology risk that accompanies "*deep*" renovation. However, that may perpetuate sub-optimal performance over the longer term. For private investment in building renovation, more needs to be done to simplify the process, help and encourage building owners, develop "*standard*" solutions for typical buildings, and increase confidence in contractors. Transfer of the obligation to produce a long-term building renovation strategy from Article 4 of the EED to Article 2a of the amending EPBD will focus MSs' attention on a number of new requirements (summarised under Main Outcomes above).

There is a need for vision and effective planning to expand the use of databases and exploit their full value, in particular to target building renovation programmes, improve compliance with building codes and support stronger and better quality schemes for energy performance certification. The potential advantages of combining databases must be weighed against the cost. Combined databases are already used in several MSs, for example to provide input data to EPC, and using EPC data for monitoring of property value, planning purposes, and building stock statistics. A number of barriers such as incompatible data conventions, conflicting rules, different updating cycles, and privacy restrictions are common across most MSs. A thorough understanding of the limitations, with compensation for errors and incompatibility at a technical level, is necessary to produce coherent and reliable data sets.

For heritage buildings, it is more expensive to renovate to the same standards, and sometimes impossible without unacceptable changes to appearance and building character. Exemption is permissible under the EPBD and EED, but relaxation, rather than total exemption, is preferable. Schemes that set proportionately reduced performance targets on a numerical basis, according to circumstances, can be used widely without having to consider too many special cases. Categorisation and "*standard*" solutions, when possible, help to reduce costs. Where changes to the building fabric are not acceptable, greater attention should be given to obtaining very high performance from technical building systems to compensate.

During the CA EPBD IV, it was shown that progress with inspection schemes for air-conditioning systems has built up experience on the most common faults and recommendations for improvements. Where alternative measures have been chosen, some comprehensive models have now been developed to assess and compare impact for the purposes of 'equivalence reporting'. In regard to regulating for the better performance of TBS, a greater understanding and emphasis is needed of the behaviour of whole systems, rather than individual products or components.

Smart buildings and a SRI form part of the amended EPBD, and the work to develop the calculation methodology and assessment procedures is in progress. This is intended to run in parallel with the established calculation and assessment procedures for the energy performance of buildings that deliver EPCs. However, SRI metrics will not be limited to energy, and at this stage it is not yet clear if it will become feasible (and desirable) to combine SRI and EPC procedures.

Endnotes

1. COM (2013) 225: Report from the Commission to the European Parliament and the Council : Financial Support for Energy Efficiency in Buildings

2. COM SWD (2013) – SWD (2013)143 final

3. Synthesis report on the assessment of Member States' building renovation strategies, http://iet.jrc.ec.europa.eu/energyefficiency/

4. Assessment of the second Member States' long term renovation strategies, https://ec.europa.eu/jrc/en/publications-list

5. Société pour la Protection des Paysages et de l'Esthétique de la France, www.sppef.fr/2016/11/15/sites-monuments-n-223/
   and their article "Isolation Thermique par l'Extérieur: Deux Ans de Combat, de la Loi au Décret", www.sppef.fr/wp-content/uploads/2016/11/sppef_article-ite-sites-monuments-n%C2%B0223.pdf

6. 6th Conference of Ministers Responsible for Cultural Heritage, April 2015, www.coe.int/nl/web/chairmanship/belgium-news/-/asset_publisher/QLBOlIyuxE9F/content/6th-conference-of-ministers-responsible-for-cultural-heritage/16695

7. See www.ecofys.com/files/files/ecofys-2017-optimising-the-energy-use-of-tbs-final-report.pdf

8. The study "Support for setting up a Smart Readiness Indicator for buildings and related impact assessment"; see http://smartreadinessindicator.eu/

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement № 692447.