CONCERTED ACTION
ENERGY PERFORMANCE OF BUILDINGS

(CoCa) Synergy and Networking to maximise impact of the EPBD - 2018

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1. Introduction

A shared focus on building performance is within the scope of several initiatives that aim to facilitate the implementation of EU energy policy. The coordination of resources can maximise impact and avoid duplication of work occurring in Europe and, beyond that, focuses on improving building energy performance. This is pursued by monitoring projects and initiatives funded at EU and national level that contribute to the successful implementation and uptake of the EPBD, by promoting capitalisation of actions and providing opportunities for brainstorming sessions and knowledge transfer during the CA EPBD IV plenary meetings and the back-to-back stakeholder events.

The Central Team on "Collaboration with other Concerted Action (CAs) programmes and EU projects" (CoCa) investigates elements that are common with the other CAs (CA RESD[1] and CA EED[2]). This notably includes RES integration in buildings, energy efficiency policy for monitoring and development, integration of databases, strategies for energy renovation of existing buildings, the role of consumers, financial instruments to activate the market, smart meters data collection and the role of flexible buildings for smart grids, training and accreditation.

Exemplary country initiatives that support the coordinated implementation of the EPBD and other directives also provide data for this analysis.

The interaction of the EPBD with CEN standards is also briefly analysed. CA EPBD IV supports the national implementation of CEN standards by discussing typical conditions and values for calculations.

The collaboration theoretically covers most of the EPBD articles and mainly focuses on EPBD Articles 2, 3, 4, 5, 6, 7, 9, 10, 11, 18, 19 (review) and 20 in this reporting period.

2. Objectives

An effective implementation of the EPBD can only be achieved if key stakeholders are engaged in the process. In order to support this, the CA EPBD collaboration and networking with other EU initiatives aims at:

2.1 Creating synergies with other Concerted Actions for EU energy policy implementation

Collaboration with other CAs aims at pooling different expertise and facilitating the joint implementation of common/complementary topics of the directives, maximising impact and avoiding redundancy.

The aim is to investigate and discuss topics that appear in the directives, collecting views and insights from MSs through discussions in plenary meetings, and sharing outcomes with the other CAs. Specific objectives included:

- investigating barriers and solutions for wider penetration of RES in NZEB and smart buildings;
- highlighting EPBD links with and contributions to long-term renovation strategies (EED Article 4);
- providing guidance to measure and promote energy performance in public buildings (EED Article 5);
- raising new ideas for collaboration on building renovation-related articles in the EED and the EPBD and ensuring maximum use of related results in the CA EPBD and the CA EED.
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2.2 Maximising impact of various initiatives in the EU

A lot of experience on EPBD implementation has been gained through EU funded research and innovation programmes and projects (IEE, Horizon 2020), involving a wide range of stakeholders. Dissemination of best practices and knowledge management of outcomes from these initiatives is key to stimulate new ideas for the most efficient implementation of the EPBD.

The engagement of key EU stakeholders is particularly important in the search for better data, methodologies and tools to monitor the progress of energy performance of buildings and to improve decision-making in the building sector.

Contributions from specific initiatives (e.g., QUALICHeCK project, CEN)[3] have been considered, insofar as they analysed energy performance requirements' enforcement “on the ground” and the national viability of EU common energy performance calculation standards.

Improved knowledge of innovation and new technology initiatives on building digitalisation and optimisation of building systems allows exploring the principles of - and the barriers to - smart ready buildings and their potential to further supporting a more efficient and consumer focused energy system.

Results of various EU projects (mentioned in the following paragraphs) have been presented and discussed to investigate wider use of EPBD databases and to show the effectiveness of innovative approaches on financial mechanisms promoting energy efficiency, RES integration, advice to homeowners, policy making, and other issues related to EPBD provisions.

3. Analysis of Insights and Main Outcomes

3.A. Analysis and insights

The following paragraphs describe topics and results of discussions in the CA EPBD IV on common or complementary issues with other CAs as well as EU initiatives and projects, carried out from November 2015 to June 2018.

3.A.1 Commonalities and complementarity with other CAs

The first CA EPBD IV plenary meeting (Copenhagen, November 2015) allowed for an overview of collaboration priorities between the three CAs, which were all represented during the meeting. This was actually the only common meeting opportunity, but bilateral exchanges were also ensured during that period.

3.A.1.1 Coordinated implementation of the three directives and collaboration priorities with the other CAs

Coordinated implementation of building-related articles in the three directives depends on the specific national institutional framework and on how responsibilities are assigned and coordinated.

A questionnaire sent to the experts of the CA EPBD IV showed that in 50% of MSs implementation of the three directives lies within the same ministries or organisational teams or at least with teams frequently liaising with one another during their work.

The same survey, answered by 16 MSs in November 2015, allowed for the prioritisation of topics for collaboration:

- methodologies for measuring the progress of energy efficiency, including regular reporting to the EU Commission on NZEB (EPBD Article 9), on financial incentives (EPBD Article 10) and on monitoring and verification (EED Articles 4, 5, 7, 14);
- RES in buildings (EPBD Articles 2, 3, 4, 6, 7, 9, Annex I; RESD Articles 3, 13, 14, 16; EED Article 14);

- use of EPCs and integration with other datasets like heating and air-conditioning inspection data (EPBD Article 18), governmental buildings data and existing building stock (EED Articles 5, 4);
- financial instruments and policy packages (EPBD Article 10, EED Articles 4, 7, RESD Article 3);
- synergy between inspection of heating and air-conditioning systems (EPBD Articles 14-15) and energy audits of enterprises (EED Article 8);
- intelligent metering of technical building systems (EPBD Article 8) and smart metering of customer energy consumption (EED Article 9) that can potentially share data display, transmission, and storage;
- modelling of the building stock and developing/monitoring action plans for the energy performance of buildings (EED Articles 4-5, EPBD Article 9);
- coordination of capacity building actions (EPBD, EED, RESD).

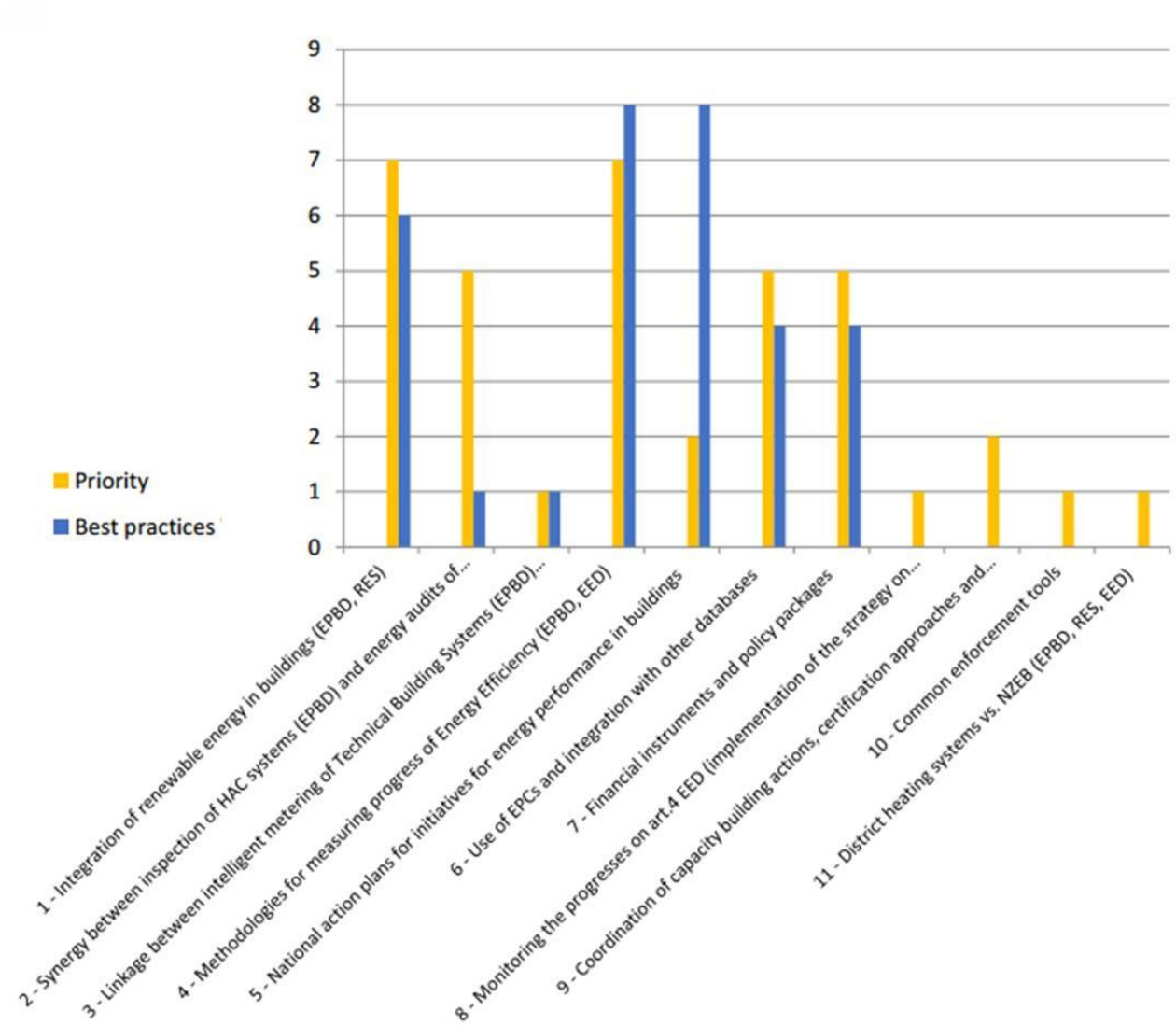

Figure 1. Priorities for collaboration with and experience from other CAs. From CA EPBD CoCa session, at the CA EPBD IV plenary in Copenhagen, November 2016: Reply by 16 MSs).

3.A.1.2 Vision on collaboration priorities from CA EED and CA RESD

During the first CA EPBD IV plenary meeting in Copenhagen, the above listed topics found support by CA EED members. Moreover, it was underlined how the RES and the EPB Directives can complement and help each other to achieve respective goals: high RES integration and high energy performance. CA RESD further indicated that support schemes for district heating and cooling (RESD Article 3) and the role of the consumers (and prosumers[4]) including information and training (RESD Article 14) are collaboration priorities.

In particular, comprehensive assessment of alternative measures, district heating and cooling (DHC) and combined heat and power (CHP), was raised as a common interest between the three directives.

3.A.1.3 Lessons learned on renovation-related articles in the EED and the EPBD

Increased, deeper and better uptake of building renovation is addressed at different levels in the EPBD (at building level) and the EED (at stock level). Different topics are addressed: long-term renovation strategies, the improvement of energy performance and methodologies for measuring progress, training, information and advice to consumers, data collection, and energy efficiency measures to achieve the long-term ambition. During the CA EPBD IV meeting in Bucharest, in October 2017, the results of a CA EED survey on new (2017) renovation strategies (EED Article 4) and ideas for future collaboration (also following the amended EPBD)[5] were presented and discussed.

Thus, a non-comprehensive list of topics and sub-topics that would improve effectiveness of building renovation if approached in a synergistic way was discussed: the link between the individual and the collective level of building renovation, the exemplary role of public and heritage buildings, consumer-centred approach and capacity building, programmes to stimulate investment, smart buildings and the multiple benefits of an improved building stock.

CA EPBD delegates prioritised the following topics for future collaboration:

- consumer first: links between the smart readiness indicator (SRI) and consumer behaviour, as well as among EPCs and energy audits, inspection, metering/billing (including the role of ICT and IoT), and related issues, such as consumer's privacy and feedback);
- building stock data: quality/origin/availability/terminology/links to the EU Building Stock Observatory;
- mechanisms for smart financing (aggregation, de-risking, leveraging investments).

New ideas for synergy also included: involving cities in building renovation aggregation for financing and better use of the EU Smart City Information System, long-term renovation strategies, links to other policies including local-level policies, impact of Research and Development, definition of cost-effectiveness levels.

Highlights of 3.A.1	The overall strategy for collaboration of the three CAs is set during a yearly meeting between the coordinators, while other opportunities for collaboration and information exchange are considered when setting up the relevant CA plenary meeting agendas. Because of differences in timing of the ongoing contracts for the three CAs, no formal joint Working Group could be established between them, but continuous interaction was ensured through mutual participation in CA meetings and information exchange.

	MS delegates agree that reinforced collaboration among the CAs concerning building renovation issues is required, starting from mutual experience on the role of the consumer, on smart financing, on data quality and management. Involving the city level and bringing specialists from outside the CAs are also seen as beneficial.

3.A.2 Better data to monitor and take action on building performance

There is often limited access to good quality data on the building stock characteristics, although this is needed to efficiently monitor EPBD implementation and to enable sensible decisions on the energy use of the building stock. The following paragraphs describe relevant initiatives that were presented at CA EPBD meetings in the period 2015-2018 to capitalise MSs' knowledge in this field.

3.A.2.1 The EU Building Stock Observatory – data collection by the CA EPBD

The **EU Building Stock Observatory**[6] was launched by the European Commission on 30 November 2016, as part of the "Clean Energy for All Europeans" policy package. The Observatory monitors the energy performance of buildings across Europe through a range of indicators and tracks several aspects including: energy efficiency of buildings (at national and EU level), certification schemes, available financing for building renovations, energy poverty levels, etc. A second stage (2017-2018) is running, which will produce relevant bottom-up statistical building data, and update and expand the snapshot produced in the 1st phase (February 2015 – July 2016).The CA contracts on the EPBD had already been collecting relevant information on some of the key characteristics of the European building stock from MSs. These data were referred to as "Key Implementation Decisions" (KIDs), as they aim at measuring the status of EPBD implementation in each EU country. The CoCa Central Team worked on creating better interaction between the CA EPBD KIDs and the EU Building Stock Observatory, to avoid duplication of efforts. MSs agreed to improve KIDs using interactive, searchable databases and data mapping. This should allow for the EPBD *Key Implementation Decisions* indicators to become more accessible and reliable in providing information on the EU policy impact. In particular, EPBD data will be included, such as minimum requirements for new buildings and existing building renovations, NZEB levels, number of EPCs and of heating/air conditioning inspections. The main concerns during the collection of the new set of CA EPBD IV *Key Implementation Decisions* were the need for routine assessment and recording of data quality and origin, as well as the use of consistent terminology and definitions (e.g., definition of public buildings).

3.A.2.2 Integration and use of EPBD databases

MSs are currently establishing building-related databases with different purposes, data structure and administrators, as well as different access rights and formats for users. EPBD repositories, mainly recording EPC and Inspection data, have already been managed for several years and are increasingly used, not only for control and compliance goals (EPBD Article 18), but also to complement other sources with the aim of enabling evidence-based policies and monitoring the progress of energy efficiency in buildings. EPC data in its raw format is potentially misleading, and it is usually necessary to refine and combine EPC information with other data before use in a wider context. Barriers include datasets with no common identification and issues concerning accuracy (outdated, default and incomplete data), privacy (restricted or limited data access), management skills of resources. Integration of different existing datasets (census, inspections,

cadastre, incentives, gas registers, energy networks, bills, revenue agencies, etc.) is technically difficult and costly. Efforts remain, however, rather uncoordinated and there is a general lack of information on buildings in relation to energy issues.

The IEE **EPISCOPE**[7] project (involving 17 EU countries), started from the classification of building typologies according to their energy related properties (based on the previous IEE TABULA project) and developed a methodology to monitor the progress of building energy performance with regards to national targets. The project modelled the building stock from three main data sources: full inventories of buildings, surveys and the EPC database. In Slovenia, this resulted in finding differences among data sources, proving the advantages of the use of EPC data for the EED's National Energy Efficiency Action Plans (NEEAPs) and for the renovation strategies mentioned in Article 4 of the EED. This led to the creation of an energy registry of buildings (EnRen). This is a comprehensive database which integrates the national real-estate registry (REN) 2008, with renovation data from Eco-fund subsidies, EPC data from 2015 and the results of the REUS 2015 survey on energy efficiency on a sample of households. In the EnRen registry, moreover, data is updated at each regulatory assessment or inspection and is stored in open XML format to enable commercial software tools to support the assessment process. Thus, multiple people can access and review the data, resulting in error reduction.

IEE **REQUEST2ACTION**[8] (involving 9 EU Countries) investigated the use of EPCs to target retrofit funding and programmes. Improved access to EPC-related datasets and services are expected to facilitate analysis and decision making by financiers in The Netherlands, by local authorities in Slovakia and by regional authorities in Italy and Scotland (UK). In Scotland, the EPC database was combined with 10 other datasets, including RES and fuel poverty, to create a comprehensive, reliable, up-to-date energy performance profile for all the properties. The project found solutions to remove erroneous records, establish EPC representativeness and statistically predict performance when EPCs were not available. In Italy, a pilot web-based planning support system (DIPENDE[9]) was developed, which integrates top-down and bottom-up territorial data from EPCs, from census and from governmental incentives in the Lombardy region (2 million EPCs in 2015). This geo-referenced tool aggregates data at municipal level, allowing insight into links between age, typology, and average building energy performance after retrofit. The Portuguese web portal (CASA+) promotes the implementation of the energy efficient measures recommended in the EPC, letting the consumer contact suppliers and report on achieved renovations and impacts (savings, quality, comfort), and simultaneously gathering new data. This is part of a broader EPC data use in Portugal, which includes developing and monitoring policies (see Figure 2). As a result of the same project, in the Greek portal (EnergyHubforall), different sources of information are brought together, including EPCs issued before and after renovation. In Austria, in order to monitor building retrofit, available information from different province sources (including regional EPC data) was combined to the national declaration scheme *klimaaktiv*, issuing a certification of energy efficiency, good design and execution, material quality and comfort (also see "*EPC to access savings"* in the thematic Report CT3 – Certification, Control system and Quality).

EEPPA[10], the Climate KIC study on the commercial and technical potential for an EU wide EPC services company, showed that access to relevant EPC data is still difficult. In particular, privacy issues still impede disclosing data to the private sector (banks, property portfolio holders). While current technical challenges of an EU wide EPC database is prohibitive, commercial services based on national/regional EPC data are practicable mostly for local administrations.

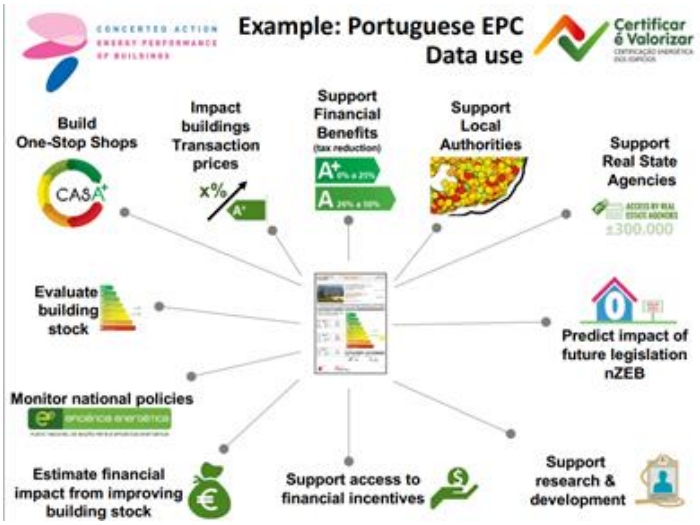

Figure 2. EPC data use in Portugal (source: ADENE).

As reported by **BPIE**[11], widespread EPC registers in the EU are a precious source of information. However, they are dramatically different in scope and comparison at EU level is currently challenging. The setting up of a database for EED Article 5 is a less common approach: only ten MSs in 2015 had a database for public buildings and some of them include only governmental buildings. In spite of the potential overlapping, possible links between an EPC database and EED Articles 4 and 5 are not fully utilised and considered.

3.A.2.3 Impact of the EPC on property value

According to a survey elaborated in the context of the preparation of the CA EPBD meeting in Bucharest, in October 2017, several studies have been carried out in 19 MSs to analyse the impact of the EPC rating on property value, after the one commissioned by the European Commission (EC) in 2013. Most of the studies used a "*hedonic price framework methodology*". This method can be applied to quantify the value that people are willing to pay for each characteristic when the price is known, and to predict prices of an item before it is known. Nevertheless, few delegates are aware of this impact, since this issue has been investigated by governmental bodies only in 5 MSs. Experience using data collected from real estate agencies, as cost information is not usually stored in the EPC database, has been reported from 5 countries, all stating that both high and low EPC ratings affect the property price.

According to real estate agents surveyed as part of the IEE **ZEBRA2020**[12] project, several aspects rated in the process of home appraisal can be linked to the EPC; for example, running costs as well as the cost surplus associated with high energy performance rating for renting or buying a building unit. The 2016 study made both survey and data analysis, and covered 12 MSs. The study also revealed that real estate agents do not generally believe that there is a cost surplus associated with buildings with high energy performance rating for renting or buying (except in Germany).

A self-paid research titled "*What will you pay for an 'A'?*" by **BALLARAT** Consulting[13] performed a cross analysis of existing studies related to the impact of the EPC on property value. The comparison findings were not as clear as it was expected, due to different factors and parameters used in the various studies. Beyond energy efficiency as an independent parameter, key parameters to account for were: location, period of construction and date of sale. Many of the studies expressed prices in different ways. When related to the energy class, this could occur as percentage price increase comparing successive classes (e.g.

upgrade from D to C class), or referring to the average or lowest class ('C' rating or 'G' rating, generally). All studies agreed that properties with a higher EPC rating gain a higher price. For example, in the case of Finland, the price premium for the top three EPC ratings (A, B, C) compared to the D rating, varies from 3.3% to 1.3% depending on location, age and date of sale of the flat, whereas the price difference between the same ratings (A, B compared to D) is 6.6% in Denmark and 11.3% in Wales.

Highlights of 3.A.2	MSs have taken advantage of their participation in EU funded projects on building stock data both to develop harmonised databases and/or to integrate existing databases. Although wider use of EPBD databases is not common practice in MSs, new services provide trustworthy easy-to-use building performance data from EPBD databases and can contribute to monitoring retrofit and the impact of governmental incentivising programmes, and to developing or adjusting policies (R&D, NZEB, transaction prices, long-term renovation strategies, etc.) The CA EPBD enhanced the use of and the access to national EPBD Key Implementation Decisions (KIDs). Integration into the new EU Building Stock Observatory, a comprehensive framework of building and energy data, appears to be an interesting opportunity. Cost information is not usually stored in the EPC database, so the impact of EPC rating on property value is assessed through data collected from real estate agencies or market surveys. Studies are not comparable, but a link between property value and the EPC rating is proved.

3.A.3 RES integration in buildings and smart buildings

Buildings are playing an increasingly active role in the transition of the energy sector from a fossil-fuel based supply and passive consumer role towards:

- energy flexible buildings supporting RES-based energy systems, matching energy demand and generation from various renewable sources;
- empowered users/occupants who can interact with the building through control, anticipate operation or maintenance and ultimately contribute to a higher building performance;
- automated maintenance and efficient operation of buildings thanks to electronic monitoring and control.

Business models can provide investment opportunities for building owners (e.g., facilitating access to capital, financing of up-front costs, outsourcing of technical and economic risks, and offering further energy related services) and for other actors involved. A CA EPBD IV technical session in Vilnius investigated existing business cases and provided evidence of the main barriers to the wider introduction of RES and building energy flexibility. The topic is relevant for EPBD Article 10 on financial incentives and market barriers, but also Articles 6 and 7 on economic feasibility of high-efficiency alternative systems in existing and new buildings, Article 9 on NZEB (action plans) and Article 19 on the EPBD review.

3.A.3.1 Business models for RES integration

Some countries have legislative frameworks that may support new business models, but there is low awareness across the CA EPBD participants about these mechanisms. Examples include:

- A business model for heat pumps rolled out by energy service companies (ESCOs) in Denmark that can raise consumer's awareness on heat pumps and at the same time create a new way of funding where the consumer will just pay for the service while the selected ESCOs will be responsible for investment and maintenance.

- Croatia has a regulatory framework for green electricity purchase and an action plan for green public procurement. According to this legislation, local governments should consider district-heating projects using RES for new development areas. RES integration is encouraged by green electricity certification. Large companies buy guaranteed green electricity and benefit from marketing their social responsibility and sustainability.

- In Portugal, a 'one-stop-shop' is being created to connect the supply-and-demand side for the implementation of RES measures (solar thermal, PV, biomass). Political and market conditions highly influence the role of the various actors for RES penetration.

- ESCOs are currently being involved in some countries (Greece, Slovenia, Italy) for public buildings. MSs complain that some of the actors (e.g., heat suppliers) are motivated more by financial benefits than by energy efficiency or emissions reduction. Moreover, the split incentives barrier is to be taken into account by business models and their feasibility varies according to the country-specific regulation in the rental sector.

- In all the presented cases, the development of new business models took advantage from existing governmental schemes that are considered as a value to capture, provided that they are steady enough. Therefore, governments play an important role in supporting business models, facilitating access to capital and changing legislation.

3.A.3.2 Business models for smart buildings

Traditionally, energy companies matched demand and supply of electricity by controlling the rate of generation. This is becoming harder since more and more renewable electricity is produced in periods when there is low need to use it. The importance of storage is dramatically growing and the decrease in prices for decentralised solutions could change the demand-response ratio.

According to a presentation from BPIE in the second CA EPBD IV meeting in Vilnius[14], "*in 4-5 years, a growth of 70% is expected in demand-response, with a high potential in the heating and cooling sector. Dynamic energy pricing is needed to provide incentives to modulate demand*". Smart metering and controls enable a reduction of the energy consumption and a smart interaction between buildings, their occupants and the energy system. A pilot project in Ireland using smart meters, dynamic prices and consumer information showed that the participants who had an in-home display were able to reduce consumptions by 3.2% overall and by 11.3% at peak-time[15].

In Germany, the use of grid-optimised storage systems, helping to reduce grid stress and increase local grid capacities is incentivised through a repayment grant covering up to 100% of investment costs with a term of 5, 10 or 20 years. Both heat storage and battery storage with PV and grid connections are supported. Electrical systems that are eligible for this scheme include new PV systems with batteries, new electric

battery systems for existing PV (installed after 2013), and PV systems smaller than 30 kWp. Only stationary storage systems are eligible for funding but consumers who are generating surplus electricity can use it for any purpose, including charging electric cars.

3.A.3.3 RES integration - Attractive District Heating and Cooling solutions

District heating and cooling is highly efficient and allows the use and combination of different energy inputs and RES. Opportunities and service concepts that make district heating and cooling from RES attractive to both users and suppliers were investigated in a CA EPBD IV session in Valletta (February 2017).

Work undertaken as part of the CA EED found that the main barriers to wider adoption of district heating and cooling are investment costs, low return on investment and low heating demand in mild climates. According to the 2016 CA EED survey, investors find district heating an attractive opportunity in 25% of applicable MSs, although the level of interest depends on the energy source and technology used. Moreover, RES are the most interesting energy source of district heating to investors.

The **EU IEE SmartReFlex**[16] project has investigated a range of political, financial, skill-based, organisational, social and physical barriers. Key requirements to transition to 100% RES district heating and cooling were identified as heat planning at local level (GISs provide an opportunity), low temperature district heating grids, early recognition of available land and direct involvement of consumers.

The **H2020 SDH**[17] project showed that a cooperative model has been introduced where the utility service is owned by the users in Denmark. In Saltsburg (Austria), two social housing companies, the city and the utility sustained the initial investments to develop a microgrid for new buildings, where the cost of 30% solar fraction of annual heat demand is included in the rent. In Sweden, a municipality has promoted net metering of heat from distributed solar plants (solar thermal collectors feed heat into the city's district network and subsystems at several locations) via a contract with the utility company. Moreover, increasing urban density and rising oil prices have encouraged the expansion of district heating, so that today 50% of the heat market and 90% of multi-family houses are served by district heating, mostly privately owned.

Highlights of 3.A.3	According to MSs, the main barriers to a wider introduction of RES for NZEB and solutions for smart buildings reside in cost, information, grid capacity, lack of skills, dealing with social acceptance, usability and political barriers. Relying on the individual response of households will not work without aggregators and innovation driven by technology companies. Technical regulations, clear guidance and RES integration with smart buildings are needed in the EPBD. Strategic local and regional heating and cooling planning, effective regulation and financial support measures are key success factors for district heating and cooling. Nowadays, only a few different district heating and cooling investment and ownership models are known. GISs look like an opportunity for new business models within the "Big Data" challenge, as well as the direct involvement of consumers.

3.A.4 Long-term renovation strategies

3.A.4.1 Best practice and remaining gaps in long-term renovation strategies

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 amended EPBD (new Article 2a). In May 2016, in Vilnius, the CA EPBD analysed the relationship between long-term strategies for "*cost-effective deep renovations of buildings*" (EED Article 4) and the goals of achieving savings within the EPBD. Within the first 2014 long-term renovation strategies, a few countries (e.g., Spain, Denmark, Croatia, Lithuania) appeared to better respond to the EED Article 4 (a) to (e)) requirements of the strategy, also linking them to the EPBD implementation experience. Nevertheless, the relationship between the implementation of EED Article 4 and EPBD Article 9 (plans for NZEBs) but also between EPBD cost-optimality and cost-effective approaches of renovation remained insufficiently explored. According to the first evaluation of MSs renovation strategies[18], elaborated by the Joint Research Centre (JRC), a range of innovative approaches to stimulate investment already existed. These regulatory, financial, and communication schemes are often mentioned in MSs lists according to EPBD Article 10. Some outstanding examples, like the Horizon 2020 **SUNShINE** project[19] proved feasibility of ambitious renovation (65% energy consumption reduction through measures on space and water heating) and innovative bankable and aggregated investment projects. In Latvia this resulted in encouraging the homeowner through a simple and transparent process, including a central IT platform to store data, benchmarks, and stakeholder networking. Guidelines, inbuilt monitoring and standardised contracts, were considered to be elements of the successful model for stimulating deep renovation. Important improvement suggestions highlighted from the first long-term renovation strategies evaluation included scenario analyses that can be further linked to EPBD implementation, monitoring data and a clearer picture of the non-residential sector. Links between achieving increased renovation rates, funding and data use (e.g., from the EPC) were recommended to be strengthened in the future.

The recent ongoing long-term renovation strategies evaluation, presented by **JRC** at the CA EPBD workshop in Frankfurt, in May 2018, shows progress from the first to the second (2017) version. According to the JRC, MSs updated their first strategies in different ways: 21 of them provided full revised strategies, while 9 just updated some sections. Compliance to EED Article 4 requirements has generally improved in the second versions, as showed in Figure 3.

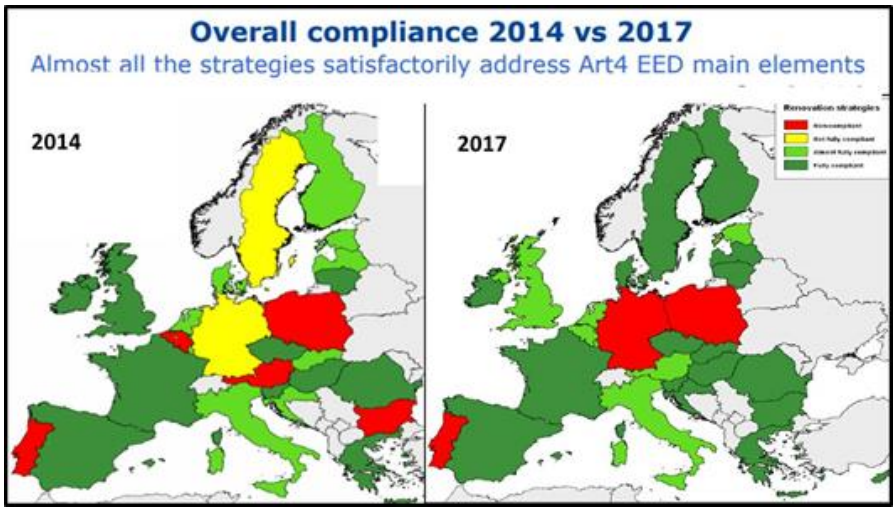

Figure 3. Compliance of 2014 and 2017 MS long-term renovation strategies *(source: JRC).*

The majority of the strategies now include a 2050 goal (15 MSs) and measures to alleviate energy poverty (17 MSs). Data collection and analysis, e.g., for the non-residential building stock, are better covered and improved. More MSs included scenario analysis in the renovation options for deciding the most appropriate cost-effective interventions. Forward-looking perspectives to guide investment decisions (Article 4d) and expected energy saving and wider benefits (Article 4e) can still be improved. Remaining gaps are mainly evaluation and monitoring, which can be further improved (e.g., through proper indicators). It has also emerged that while, in 2016, national teams working on renovation strategies were rarely the same as those working on the EPBD (see paragraph 3.1), in 2018, half the CA EPBD delegates' organisations had been recently involved in the second long-term renovation strategies, with 4 delegates playing a key role.

In light of the amendments proposed by the European Commission in the context of the Clean Energy Package (including the proposal to transfer long-term renovation strategies requirements from EED Article 4 into the EPBD Article 2a) the CA EPBD discussions in Bucharest (October 2017) and Frankfurt (May 2018) looked into how building renovation strategies have been dealt with so far under the EED. This included looking at the challenges, successes and areas for improvement, aiming to establish a foundation for new work in the CA EPBD V. In these meetings, delegates highlighted particular areas for valuable collaboration with the CA EED.

According to the CA EED experience, factors preventing the uptake of renovation are mainly based on financing and the lack of credible data on the performance of energy efficiency measures. Effective long-term renovation strategies should gain the consensus of all stakeholders and their cooperation, secure long-term political commitment and the availability of stable financing, and be based on reliable and objective analysis of the impact of renovation work, such as energy and cost savings, air quality or thermal comfort improvements. Moreover, data collection and management (preferably by independent bodies) need to be increased – an inventory of best practices on building renovation would be beneficial. This could help reduce the perceived risk of energy efficiency measures and, therefore, increase financial investment. Potential collaboration with the CA EPBD was identified in policies linking the national and local level of renovation, innovative policy measures to overcome the existing barriers to renovation, integrated approach in heating and cooling, smart buildings-cities-grids concepts, heat and electricity market integration, energy efficiency mechanisms addressing property owners with low income, low credit ratings and liquidity. As for 2050 scenarios, based on the results of the CA EED workshop on modelling (Munich, March 2017), multiple approaches are used in MSs, which can support energy efficiency implementation in the medium-long term. Nevertheless, within their National Energy Efficiency Action Plans, MSs rarely use modelling for single sectors (12.7% of modelling purposes), so the application of these approaches to long-term renovation strategies appears impracticable. Top-down data has higher availability and is cheaper to collect, although bottom-up energy demand models are essential for projecting trends in energy end use sectors. Ireland and The Netherlands use a combination of top-down and bottom-up approaches: top-down for projections and bottom-up to assess the impact of sectoral policies. Coordination of various inputs, ministries and agencies, as well as double counting, remain the main barriers to scenario making.

3.A.4.2 New Article 2a, one-stop shops, building passports, energy poverty

The new EPBD Article 2a on long-term renovation strategies intends to provide greater consistency and coherence to the EU building energy performance policy. New obligations and elements were added compared to EED Article 4; for example, considering potential trigger points in the life-cycle of the building for renovation and stimulating the option for staged deep renovation through schemes such as the building

renovation passport. There will also be a greater focus on accessible and transparent advisory tools, as well as assistance instruments to owners and investors (the so called "*one-stop shops*") and actions to target the worst performing segments of the national building stock.

In Valletta (February 2017), the Energy Advice Exchange presented an analysis of good practice in energy advisory services[20] all over Europe, highlighting, moreover, the links to EPBD, EED, RESD articles and the importance of the consumer-centred approach in renovation strategies.

During the Frankfurt in-depth workshop (May 2018), a review of existing examples of one-stop shops that can assist building owners and investors, from renovation planning and financing to delivery, monitoring and quality checking, has been provided. Hence, clusters of services exist (e.g., in Belgium), which are available to clients through a single contact point and are led by architects, contractors, energy providers and public authorities. Success of one –stop shops seems to reside in the right combination of a business model and the customer's understanding of the need to renovate.

RenoWatt, partner of the **H2020 CITYNVEST**[21] project, was seen as the best example of a one-stop shop at the moment, but still not covering the whole concept. It is a programme for the renovation of public buildings enhancing energy efficiency by grouping smaller projects to remove all kinds of barriers, technical, legal, administrative and financial. The financial model is based on Energy Performance Contracting. One-stop shops can have a theoretical top-down approach, but, at present, bottom-up approaches are more commonly led by market parties, even if not fully structured.

According to MS delegates, one-stop shops should target and adapt to the situation (e.g., tenure, building type and financial situation), define a standardised minimum service package and explain the different steps of renovation in a user-friendly way, including links to incentive schemes, grants and loans. The concept also has a potential conflict of interest: an independent entity or public authorities to ensure quality assurance were both mentioned. One-stop shops need to be relevant at a local level by having both a physical and a digital presence and be attractive for customers. Many stakeholders were mentioned as key one-stop shop players: energy and climate advisors, energy suppliers and municipalities. Direct actors can also be homeowners and building associations, financiers, energy assessors and installers. Several different players were mentioned as possible responsible authorities for one-stop shops: building energy authorities, municipalities and housing companies.

Step-by-step (or staged) renovation works could be the solution to achieve the full potential of benefits from retrofit that is not generally undertaken in one single stage. Some inspiring step-by-step mechanisms, also linked to the concept of the building renovation passport, are already being practiced in Germany and Belgium and in EU projects. In the first case a **'renovation roadmap'** is generated, providing an overview of the measures for the specific building, implementation assistance and supporting material for the energy consultant. The measures selected also take into account the homeowner's financial status. A step-by-step scheme provides the owner with information on measures' prioritisation, indicating, for each measure: energy and cost savings, capital investment required, subsidies available and pay-back period (also see CA EPBD Thematic Report "Certification, Control system and Quality").

The **IEE EuroPHit**[22] project (Deep energy efficiency step-by-step retrofits to EnerPHit standard) developed a standard to enable the certification of renovation works to existing buildings in order to achieve quality. The EnerPHit standard promotes high component criteria, based on certified Passive House components. The standard criteria can differ among countries, e.g., with tailored U-value standards. The project developed several pilots on single-family homes (cost range from 7,000 – 95,000 €) and both residential (single and multi-family buildings) and non-residential buildings. CA EPBD delegates estimated the main

advantages of current step-by-step models: standardised and holistic approach, expert training and guidance, minimum improvement required (and pre-certified), integration in a broader quality approach widely applicable to different climates, user-friendliness and owner involvement.

The ongoing **H2020 iBRoad**[23] project designs, develops and demonstrates building renovation passports, customised individual roadmaps (on a 15-20 years horizon) in support of deep renovation. This new approach will generate useful insight for forward-looking policies by providing data from energy audits and building logbooks (5 layers of information, 23 topics, 66 sub-topics).

As for **energy poverty**, most MS delegates are not aware of the official definitions. MSs seem to use definitions that are not officially quantified. External presentations from **DOOR**[24], a Croatian NGO, recommended that energy poverty should include consideration of household income and dwelling conditions. It was emphasised that energy poverty should not be targeted as a separate area and be rather integrated into the general policy for the improvement of the whole building stock. Some current programmes are sharing examples and data: the **European Energy Poverty Observatory**[25] and the **ENGAGER Network**[26] (European and wider).

Highlights of 3.A.4	To establish a foundation for the new work, the CA EPBD looked into how building renovation strategies have been dealt with so far under the EED, including challenges, successes and areas for improvement. Compliance to EED Article 4 requirements have generally improved in the second versions of long-term renovation strategies, including long-term scenarios and data management recommended within CA EED discussions. Guidance to investment and de-risking, monitoring and wider benefits of building renovation can still be improved. Particular areas for valuable collaboration on long-term renovation strategies in order to get experience from the CA EED were identified: linking the national and local level, building and district smartness, heat and electricity market integration, energy poverty. New elements in the new EPBD Article 2a have been analysed and exemplified with the contribution of external initiatives: existing examples of one-stop shops, first experience in step-by-step renovation roadmaps, definitions and indicators for energy poverty.

3.A.5 Contribution from other initiatives

Further dialogue and collaboration occurred on other topics addressed over the 2015-2016 period. They are presented below and further detailed in other Central Team reports.

3.A.5.1 Improving the energy performance of heritage buildings

When dealing with major renovation, the EPBD and the EED contain an exemption for heritage buildings. EED Article 5 (Exemplary role of public bodies' buildings) allows two approaches, either compiling a default inventory of relevant buildings or an alternative approach including estimate of improvements. CA EED contributed to the CA EPBD debate to give policy guidance for advancement in energy performance of heritage buildings, highlighting the existence of energy efficiency programmes (eight within the NEEAPs) that also include military and historic buildings. CA EED also showed the results of an internal survey

compiling knowledge of energy consumption data, level of importance of different heritage buildings, pros and cons from the MSs' experiences about the "default" or the "alternative" approach.

Definition of cost-effectiveness of the governmental buildings renovation projects, incentivising programmes, information on "before-after" energy performance in EPCs for public funding of Article 5(1) projects and deeper knowledge of actual energy consumptions that can help de-risking investments (e.g., from ESCOs) were identified as possible common fields of interest between the two CAs.

3.A.5.2 CEN Standards

The CA EPBD IV Core Team members also had the opportunity to discuss relevant developments of CEN/TC 371 standards on energy performance of buildings, in particular the study carried out on behalf of the European Commission on their usability, based on example cases. Comments from the MSs about practical implementation of the new CEN standards and on the transition from the current ones were collected and communicated to the contractors developing the study. The outcomes of this work are summarised in the Central Team Report on "Technical Elements".

3.A.5.3 Reliability of EPCs and quality of the works

The **IEE QUALICHeCK**[27] project (involving 9 EU Countries) collected best practices in relation to the quality of the EPC input data and the construction works, including compliance with applicable standards and application of penalties. CA EPBD feedback on key success factors was aligned with the recommendations from the project that are not common practice in all MSs yet, e.g., systematic and targeted control on the quality of the construction work, collection of EPC data in a central database or certification of products.

Other external contributions occurred under other Core Teams and are described in the related reports.

Concerted Action for the Energy Efficiency Directive - CA EED	Concerted Action for the Renewable Energy Sources Directive - CA RES	European Committee for Standardisation (CEN)
Buildings Performance Institute Europe - BPIE	EPISCOPE project	QUALICHeCK project
REQUEST2ACTION project	EEPPA project	SUNShINE project
European Commission, Joint Research Centre - JRC	SmartReFlex project	Energy Advice Exchange project
ZEBRA2020 project	Citynvest project	

Figure 4. List of external stakeholders and projects contributing to CA EPBD IV.

3.B. Main Outcomes

The main areas to be considered for a coordinated implementation of EPBD, EED and RESD have been identified and discussed within the CoCa Central Team:

- Priorities among collaboration practices (CA EED and CA RESD at CA EPBD, Copenhagen November 2015);
- Cost-optimality/cost-effectiveness of measures for EED Article 5 (CA EPBD at CA EED, The Hague March 2016);
- Role of RES in NZEBs (CA EED at CA RESD, Vienna May 2016);
- Management of public heritage buildings regarding energy efficiency (CA EED at CA EPBD, Vilnius June 2016).
- RES integration - Attractive district heating and cooling solutions (CA EED at CA EPBD, Valletta February 2017);
- Other CAs: Analyse EED articles – lessons learned on renovation (CA EED at CA EPBD, Bucharest October 2017);
- Long Term Building Renovation Strategies - Highlights from CA EED (CA EED at CA EPBD, Frankfurt May 2018);
- MSs' modelling approach and how they can support energy efficiency implementation - Highlights from CA EED (CA EED at CA EPBD, Frankfurt May 2018);
- Overview of CA EED financing issues, focus on renovation (CA EED at CA EPBD, Frankfurt May 2018).

CA EPBD IV covered all topics on CAs commonalities identified at the beginning of the action (Copenhagen 2015) with the exception of the topics "*Synergy between inspection of technical building systems and energy audits of enterprises*" and "*Intelligent metering of technical building systems and smart metering of customer energy consumption*". The latter raised interest for future discussion on changes and innovation (e.g., smart building, building automation and control systems) entailed by the amended EPBD.

Collaboration with the other CAs and EU initiatives contributed to the following outcomes:

Topic Contribution from/to	Main discussions and outcomes	Conclusion of topic	Future directions
Complementarity with other CAs • CA EPBD • CA EED • CA RESD	Discussion about priorities for collaboration. A transfer of knowledge occurred during the different CA plenary meetings (in 6 CA meetings) and through continuous informal exchange. The bases for renovation strategy work (new Article 2a) in the CA EPBD harvesting the outcome of CA EED work have been laid.	Common topics have been identified and analysed(*): • promotion and role of RES* • methodologies for measuring progress of energy efficiency in public heritage buildings* • cost-optimality/cost-effectiveness* • smart financial instruments and policy packages • links between local and national policies On building renovation: • role of the consumer; • data quality/integration; • smartness (in buildings, districts, cities) and smart financing.	Future CA EPBD work on RES integration (primary energy factors, attractive district heating and cooling) and smart buildings could feed into the other CAs' work and stimulate further common effort. Future priority in CAs' collaboration: • opportunities for better control, automation, monitoring (links among EPCs, energy audits, inspection, metering/billing, building automation control); • persuasive information for consumers; • role of ICT and IoT; • how to share responsibilities on long-term renovation strategies.
Better data to monitor and take action on building performance • EU Building Stock Observatory • EPISCOPE • REQUEST2ACTION	Discussion focused on: • combination between CA EPBD Key Implementation Decisions and the EU Building Stock Observatory; • integration and wider use of EPBD databases to help	Integration of Key Implementation Decisions in the EU Building Stock Observatory is at study (a CA EPBD IV working group has been set up). Wider use of EPBD databases can help understand the housing stock, monitor energy efficiency progress	Further investigation is ongoing on the benefit of improved display of and access to Key Implementation Decisions. Further debate on wider use of EPBD databases could address interaction

Topic Contribution from/to	Main discussions and outcomes	Conclusion of topic	Future directions
• EEPPA (Climate-KIC) • BPIE • ZEBRA2020 • Ballarat Consulting	energy efficiency progress monitoring and decision making; • links between EPC and governmental incentives databases. Property value assessment methodologies are hardly comparable. Data on property value are mostly collected from real estate agencies.	and develop a strategy, but it is not a common practice. MSs think it is worth linking public incentives with the improvement in the EPC rating as Article 10 of the amended EPBD requires. Half of them are starting using EPC databases in this sense. Recent studies agree that properties with a higher EPC rating gain a higher price in the majority of MSs.	with EED (Articles 3, 4 and 5). Further integration of CA EPBD Key Implementation Decisions into the Building Stock Observatory. Monitor progress in the effective use of EPC data.
Business models for RES integration and smart buildings • BPIE • CA EED • SmartReFlex • SDH	Interests, roles and needs of stakeholders in energy services business are changing, with an emerging tendency among consumers to invest in private energy generation and building automation. Knowledge of innovative business models was investigated. Main barriers and role of actors were discussed. Attractiveness of RES district heating for stakeholders.	Barriers for RES integration reside in cost, information, grid capacity and skills, social acceptance and usability. Low awareness of solutions like business models and how to link them to existing incentives emerged. There is no clear opinion on who should make the initial investment for the transition. Disruptive market change would require aggregators. Although 25% of MSs find district heating an attractive opportunity, business models are little known (with the exception of surveys from EU projects).	Integration of buildings into the wider energy system, relationships to and impacts on other key sectors (e.g., electro-mobility in the transport sector), role of the consumer and of building energy management systems, de-risking investments, are elements of the 2016 Clean Energy for all Europeans policy package. External stakeholders (e.g., automation industry) should be involved in the discussion. RES district heating local planning, best practices, stakeholder participation and the role of GIS to be further investigated. Tracking business models for district heating and cooling.

Topic Contribution from/to	Main discussions and outcomes	Conclusion of topic	Future directions
Long term renovation strategies • EC JRC • SUNShINE • CA EED • Citynvest • EuroPHit • iBRoad	Level of interaction between long-term strategies for "cost-effective deep renovations of buildings" and the goals of achieving savings in EPBD was investigated. The JRC 2014 and 2017 long-term renovation strategies assessment proved the improvement of compliance to EED Article 4 requirements and existing best practice of new EPBD amended Article 2a issues. One-stop shop and energy poverty concepts and examples have been presented. First experience of assisted step-by-step renovation and individual building passports (EuroPHit, iBRoad).	Compliance of long-term renovation strategies improved from 2014 to 2017 and gaps detected within CA EED and CA EPBD discussions are being filled. Some EU projects proved the success and feasibility of a holistic approach to promote investment. One-stop shops should be customised and user friendly, and should combine the business model with high awareness/skills. The step-by-step approach proves to be flexible in terms of tenure, building type and financial situation, so it is promising for replication in MSs. Sectoral modelling and combined use of both top-down and bottom-up data are rarely practiced in MSs. Long-term renovation strategies evaluation and monitoring and evidence of wider benefits can be still improved.	The renovation rate and depth (step-by-step or one-stage) are to be better linked and brought together. This will be further investigated within the discussion on new Article 2a. Preconditions to integrate step-by-step renovation/building passports into the EPCs for higher recommendation uptake (new Article 2a). Assess impact of combined advice and business models in one-stop shops. Track progress in the definition and integration of energy poverty. Investigate renovation targets and forward-looking perspective. Collaboration with CAs on: • coordination of long-term renovation strategies at national-local level; • building and district smartness; • promotion of investment (aggregation and de-risking);

Topic Contribution from/to	Main discussions and outcomes	Conclusion of topic	Future directions
			• data management and policy monitoring.
Heritage buildings and public buildings • CA EED	Examples of ways to finance heritage buildings and measure progress were provided.	MSs would welcome an integrated approach involving different responsibilities (teams, ministries) and competences (CA EPBD, CA EED).	Coordination and conflicts of integrated solutions covering EED and EPBD might be further addressed. See CT2 report.
EP calculation standards • CEN/TC371 Chair	Feasibility of application of CEN standards.	MSs' brainstorming and feedback.	See CCT1 report.
Compliance and quality • QUALICHeCK	Success key factors for better quality of EPC input data and quality of construction works were discussed.	General alignment with QUALICHeCK results. Monitoring and control are not common practice in MS.	See CCT3 report.

4. Lessons Learned and Recommendations

Better building data are a prerequisite for monitoring and decision-making, in particular for building renovation and exemplary public buildings. When combined with wider datasets, EPC data are valuable for monitoring and decision-making, especially if these datasets include information on building products, technical systems and real consumption. Experience reported within EU projects on this subject is not a common practice yet.

In the framework of a CA EPBD IV survey on Key Implementation Decision (KIDs), MSs' delegates agreed for the EPBD KID indicators to be improved. Their integration into the EU Buildings Stock Observatory is under investigation and this could help complementing existing statistics. In doing so, current data gaps in MSs could be reduced, and data visualisation and access to EU building performance data could be improved.

Several opportunities for better integration of EPBD requirements with the EED Article 4 in **building renovation strategies** have emerged. Financial packages with a holistic approach, taking into account the responsibility of the building owner are still rarely deployed. Nevertheless, they are regarded as a successful practice to stimulate cost-effective deep renovations of buildings. A unique definition, solving the dichotomy between "deep renovation" and "major renovation", would be well received by the MSs. The renovation rate and the renovation depth should be better linked.

The CA EPBD participants have little experience in linking existing incentive schemes with business models that can stimulate investment in **RES integration and smart buildings.** MSs consider that including clear requirements for both aspects in the EPBD is recommendable.

The opportunity of a univocal method for the assessment of the technical, environmental and economic feasibility of high-efficiency alternative systems for decentralised energy supply systems based on RES could prompt further collaboration between the CAs. In this framework, calculation of primary energy factors and attractiveness of district heating and cooling systems to fulfil minimum levels of RES in NZEBs are being investigated (the CA EPBD has set up a dedicated working group on this subject, at the agenda of the February 2017 plenary in Malta). These topics have great potential to develop synergies between the three directives.

Smart buildings are a priority in the framework of the EPBD amendment. Considering the novelty of the subject, future CA EPBD meetings will allow for brainstorming with particular focus on ICT solutions for optimal operation of the building and interaction with the grid. Such discussions will benefit from involvement of external stakeholders and other CAs' experience on the role of consumers, investors and demand-response service providers.

Endnotes

1. www.ca-res.eu/
2. www.esd-ca.eu/
3. http://qualicheck-platform.eu/, www.cen.eu/Pages/default.aspx
4. 'Prosumers' are active energy consumers, because they both consume and produce electricity?, definition according to the "Residential Prosumers in the European Energy Union", study JUST/2015/CONS/FW/C006/0127, Framework Contract EAHC/2013/CP/04, 2017
5. Directive (EU) 2018/844, https://eur-lex.europa.eu/legal-content/EN/TXT/HTML/?uri=CELEX:32018L0844&from=EN
6. https://ec.europa.eu/energy/en/eubuildings
7. EU IEE EPISCOPE project (2013-2016), http://episcope.eu/iee-project/episcope/
8. EU IEE REQUEST2ACTION project (2014-2017), http://building-request.eu/
9. DIPENDE webpage (Italian): www.portale4e.it/centrale_dettaglio_pa.aspx?ID=1
10. Climate-Kic European Energy Performance of Performance of Properties (EEPPA) pathfinder project, 2nd phase, www.climate-kic.org/projects/european-energy-performance-of-properties-analysis-eeppa/
11. Presentation in Copenhagen CA EPBD IV meeting, November 2015, based on experience in the EU Building Stock Observatory, in the data hub (www.buildingsdata.eu) and on the study "Energy performance certificates across the EU, a mapping of national approaches", BPIE 2014

12. EU IEE ZEBRA2020 project (2014-2016), The Impact of Energy Performance Certificates on property values and nearly Zero-Energy Buildings -Report for policy makers, http://zebra2020.eu/website/wp-content/uploads/2014/08/D3.1-Final-AR_RD_2.pdf

13. Brocklehurst, What will you pay for an "A"? – a review of the impact of building energy efficiency labelling on building value, 2017 ECEEE Summer Study, file:///C:/Users/ezcos/Downloads/6-033-17_Brocklehurst%20(1).pdf

14. Based on the publications "The active role of buildings in a transforming energy market", BPIE 2015, "Driving transformational change in the construction value chain", BPIE 2016, "Smart buildings in a decarbonised energy system", BPIE 2016.This pilot project conducted a cost-benefit analysis of 12 scenarios to implement smart metering in Ireland, also addressing residential apartments, "Smart Buildings in a decarbonised energy system", BPIE 2016

15. BPIE, "Smart Buildings in a decarbonised energy system, 2016. http://bpie.eu/wp-content/uploads/2016/11/BPIE-10-principles-final.pdf

16. EU IEE SmartReFlex project (2014-2017), smartreflex.eu/it/home/

17. EU H2020 SDH (Solar District Heating) projects (2016-2018), www.solar-district-heating.eu/en/sdh-projects/

18. 2016 JRC, Synthesis Report on the assessment of Member States' building renovation strategies

19. EU H2020 SUNShINE project (2015-2018), http://sharex.lv/en

20. C. Maby, L. Sunderland, R. Janssen, Efficiency First means Consumers First: the crucial role of energy advisory services in realizing the EU's energy ambitions, Discussion Paper Prepared by Energy Advice Exchange, 2016

21. EU H2020 Citynvest project (2015-2017), http://citynvest.eu/

22. EU IEE EuroPHit project (2013-2016), https://europhit.eu/

23. EU H2020 iBRoad project (2017-2019), https://ibroad-project.eu/

24. http://door.hr/english/

25. EU Energy Poverty Observatory, www.energypoverty.eu/

26. EU COST ENGAGER project, www.engager-energy.net/

27. EU IEE QUALICHeCK project (2014-2017), www.qualicheck-platform.eu

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