European Commission

# Energy Efficiency

# Building Renovation Challenge

## *Practical Approaches*

*Executive Agency for SMEs*

# Practical Approaches to the Building Renovation Challenge

## Executive Summary

This paper sets out the findings of a workshop which involved experts from EU-funded projects, organised around four parallel sessions.

The European building sector is fragmented and not yet able to offer holistic solutions for deep renovation at acceptable cost and quality. The building process usually involves multiple separated disciplines, which leads to additional costs and risk of failure. The renovation market is principally supply driven which can lead to a mismatch between the offered products and the end-user's needs. Many customers see high operating costs and poor environment as an acceptable alternative to the time-consuming, disruptive and risky renovation process. Further research and demonstration efforts are necessary in various domains relating to building renovation.

While most renovation decisions are taken at building level by individual owners, optimal integration of RES often requires planning and implementation at a district scale. This escalates from a single stakeholder decision to a multi-stakeholder decision. More research and demonstration is required relating to district level renewable energy sources (RES), more analysis and assessment of existing demonstrations, more opportunities for districts to learn from each other's best practice.

It is important that the market has trust in Energy Performance Certificates (EPC). Improved monitoring is needed to assess the correctness of EPC predictions. Policies could consider requiring Member States to set up monitoring campaigns that randomly check the relation between predicted and measured consumption, and developing a common methodology for such assessments, and incorporating them in European databases.

Decision making in building renovation is influenced by a number of non-technical stakeholders. We need to recognise who these stakeholders are, what drives them and what barriers they face. We need to focus attention more broadly on the multiple benefits of energy renovation and continue efforts to raise awareness.

## Introduction

Buildings are responsible for 40% of energy consumption and over a third of CO2 emissions in the EU. Most of the buildings that will exist in the year 2050 are already built. Renovation of the existing building stock is therefore key to meeting our long term energy and climate goals. In practice however this is very challenging due to a variety of technical, regulatory and other barriers. Action is required, including more research, demonstration of innovative solutions, and facilitation of their roll-out into the mass market.

The EU is taking on this renovation challenge via policies such as the Directives on Energy Performance of Buildings (EPBD)[1] and on Energy Efficiency (EED)[2]. In addition, action is being taken by research and innovation projects using the Intelligent Energy Europe (IEE) and 7th Framework Programme (FP7) funds and, more recently, the Horizon 2020 programme, as well as European Structural and Investment Funds (ESIF).

This paper sets out the findings of a workshop which was organised in December 2015 in Brussels by the Horizon 2020 Energy (Buildings) team of the European Commission's Executive Agency for Small and Medium-sized Enterprises (EASME), in conjunction with www.buildup.eu, the European portal for energy efficient buildings. The workshop involved experts from some 40 EU-funded projects, supported under Horizon 2020, FP7, IEE, and other regional and cross-border programmes. The participants represented a cross-section of the EU buildings sector (researchers, engineers, architects and other practitioners). Staff from across the European Commission also attended. The workshop was organised around four parallel sessions, with these common objectives:

- To identify the challenges that we still face in the renovation of the EU's buildings.
- To discuss the various practical soluions to those challenges and that are being developed using EU funds.

[1] *Directive 2010/31/EU on the energy performance of buildings*
[2] *Directive 2012/27/EU on energy efficiency*

During 2016 both the EPBD and EED are undergoing a process of review, led by the European Commission's Directorate-General for Energy (DG Energy) and the findings of this workshop are to form part of the evidence that is submitted for that purpose. The paper will also form part of the body of evidence that underpins the drafting of the ne xt work programme for energy efficient buildings under Horizon 2020.

## Policy Context

"Buildings play a prominent part in policies tackling energy use related to climate change, for example in the EU's Energy Union and the recent COP21 Paris Agreement", stated Vincent Berrutto, Head of EASME's Horizon 2020 Energy Unit as he opened the workshop. He added that there remains a large potential for energy savings through renovation of existing buildings, therefore the current Horizon 2020 work programme continues the support that has already been given through IEE and FP7 to tackle this complex problem.

"There is consensus about the problem of renovating Europe's buildings," added Paul Hodson, Head of the Energy Efficiency Unit at the European Commission's DG Energy, "even if there is none on the solutions". Mr Hodson highlighted several questions in this "key year for policy development":

•Is the EU framework for building renovation doing its job?

•Is the requirement for "major renovations" in the EPBD working as well as we would like it to?

•Is the EED delivering additional savings, and are they being delivered in the right way?

•Can we use these tools beyond their narrow focus, for example, to encourage smartness? Smartness means making buildings serve our comfort needs and help decarbonise our electricity system by smoothing peak loads. Should we describe or incentivise tools that help smartness and use of renewables?

•Human factors: how can we get consumers to think differently about renovation? How to ensure workers have the motivation to construct to a high quality?

•Finance: A strong policy framework combined with national efforts creates a sense of stability. We need more aggregated projects. How can we bundle together insulation projects for different individual house owners, and how can we de-risk investment in energy efficiency?

•How do we track progress? We need more and better data to understand what is happening as a result of our policies. An example of this is the BPIE Data Hub[3] and the forthcoming Buildings Observatory.

Adrian Joyce (Secretary General, EuroACE[4] ) urged policymakers to work for an ambitious framework at EU level to ensure that we renovate our buildings. He reported consistently low levels of awareness across Europe about the potential for renovation to support economic growth, and the other benefits of energy efficiency in buildings. "Building renovation projects are constantly asked to justify a payback of the energy efficiency investment that does not apply to other sectors" stated Mr Joyce, adding that the multiple benefits of energy efficiency could be "monetised and included in policy calculations". An ambitious target, he suggested, could be to ensure that the entire European building stock comprises Nearly Zero Energy Buildings (NZEB) by 2050.

In addition to funding research, demonstration and market uptake projects, the European Commission's policies on energy efficient buildings are also supported by the Concerted Action EPBD and Concerted Action EED. The Concerted Actions are fora to promote dialogue and exchange of best practice between the national authorities that implement the EPBD and EED Directives in the Member States of Europe. The coordinator of Concerted Action EPBD, Jens Laustsen, explained its work and core themes. Since it is by now acknowledged that renovation of buildings is a complex problem, the Concerted Action has decided to examine combined packages of measures. A summary of the progress made by the various countries in implementing the EPBD is to be published in early 2016.

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*[3] The Buildings Performance Institute Europe (BPIE) Data Hub is supported by several EU-funded projects, including ENTRANZE, ZEBRA2020, EPISCOPE and TABULA, and ODYSEE-MURE, which are helping to fill the gaps that existing in data on the energy performance of the European building stock. FP7 project CommONEnergy is also collecting data related to shopping centres.*

*[4] EuroACE is an official BUILD UP partner. For more information on the other partners which help BUILD UP communicate about energy efficient buildings, see http://www.buildup.eu/partners*

## Construction for energy efficiency

The European building sector is fragmented and not yet able to offer, on a broad scale[5], holistic solutions for deep renovation at acceptable cost and quality. The building process usually involves multiple separated disciplines, which leads to additional costs and risk of failure. The renovation market is principally supply driven which can lead to a mismatch between the offered products and the end-user's needs. Many consumers see high operating costs and poor environment as an acceptable alternative to the time-consuming, disruptive and risky renovation process.

## Identification of challenges

The principal challenges related to construction and renovation technologies were identified by the workshop participants, starting with an inventory of components. This provided an initial picture of the barriers to their development and market roll-out. The selected technologies were mapped, according to the individual participants, against their potential impact in a table. Participants were asked to rank the technologies on the table according to their impact using the following symbols:

*+ Very great impact*
*0 Significant impact*
*no indication  Not important or irrelevant*

| TOPICS<br>Impact/general applicability | Impact on efficiency | Impact on comfort | Impact on life cycle costs | Effort/ Applicability | Embodied energy |
|---|---|---|---|---|---|
| Insulation | +++++<br>0 | 00000 | 00 | | ++ |
| Windows | +++<br>000 | +++++<br>0 | +<br>0 | | |
| Ventilation | 000 | +++++ | ++++ | 000 | 0 |
| Airtightness | 000000 | 000 | | 000 | |
| DHW | ++++<br>0 | | +<br>0 | +<br>0 | |
| Heat generation | 0000 | 00 | | | |
| RES | ++++<br>0 | | +++++ | +<br>0000 | ++ |
| Storage | ++<br>0000 | | +++<br>0 | +++<br>0 | |
| Controls | +++<br>00 | +++<br>0 | 000 | 000 | |
| Lightning | 00000 | 000 | 00 | | |

[5] *One example of this large scale renovation is the Dutch initiative Energiesprong. See also this webinar recording on the subject.*

The principal findings of this exercise were as follows:

•Insulation has the largest impact on energy efficiency in buildings, and it also has substantial impact on thermal comfort. At the same time, the embodied energy of insulation materials[6] is important. Technological development of insulation products is already mature, although more research is needed into superinsulation materials (SIM) for specific cases and construction details as well as for application in historic buildings. Internal application of insulation[7], for example in historic buildings with protected facades, is also problematic and the associated risks of damp penetration, condensation and mould growth are not always acknowledged, especially for self-installers.

•Ventilation when applied to deep renovation is still a major concern especially in terms of impact on comfort, costs and applicability. Further technological development is necessary on ventilation products tailored to the renovation market.

•Air tightness also remains a major point of concern for deep renovation. Although technologies and procedures for delivering airtight buildings are by now well established, it is difficult to implement them in practice due to a shortage of appropriate skills.

•The impact of domestic hot water (DHW) systems in deep renovation is very significant, notably on costs.

•Renewable energy sources (RES) are important for renovation to NZEB performance levels, but costs remain high. Embodied energy is also a significant factor in RES.

•Energy storage is a key technology in NZEB renovation concepts, but its impact on cost and practicality is high, especially since the space that is needed for current thermal storage solutions can be problematic in existing homes.

[6] *The relationship between costs, embodied energy and RES is explored in Horizon 2020 project MORE-CONNECT*

[7] *Internal insulation in historic buildings was also explored by the completed European Territorial Cooperation project COOL BRICKS in the Baltic Sea region*

•Controls and control technologies are important in renovation, not only to improve the efficiency of building services but also to aid user control of energy performance, predictive maintenance and information on energy behaviour and behavioural change.

## Identification of Solutions

Awareness and competence are very important non-technological barriers to solve. A lack of competence or capacity plays a major role in ventilation, air tightness, storage technologies and controls (especially, utilizing the potential of controls). However, awareness is fundamental. Solutions to improve awareness can include more demonstration of best practice examples in accessible projects; presenting measurable, meaningful and (above all) understandable data in an attractive way (for example through use of gamification[8]); combining energy data with indoor environmental quality, health, and other information to give a more holistic picture that is more relevant to consumers. Recently completed IEE projects AIDA and PassREg both found organised study tours of best practice NZEBs to be an effective method of convincing municipal employees and decision makers of the importance of including NZEB performance in design and tendering criteria for their building projects.

Deep renovation and renovation to NZEB performance levels both require more integration of technology in holistic packages[9] if they are to be achieved on a mass scale. At the same time, integrated packages result in an integration of risks, which can lead to ambiguous responsibility and ownership of solutions. An important barrier that requires further work is the fact that the renovation market is principally supply driven rather than demand (consumer) driven. A comparison can be made with the automobile industry, which works with many suppliers but serves only one 'owner'.


**Example of series of one in mass production, four NZE renovated houses, Melick, The Netherlands, from project MORE-CONNECT.**

Additionally, series of one are possible in mass production processes, in other words a consumer can individually configure a new car. Several H2020 projects are currently working on solutions for buildings that offer series of one in mass production by prefabrication.

Several EU-funded projects are working on prefabrication and related innovations, including MORE-CONNECT, IMPRESS, BERTIM (all Horizon 2020) as well RETROKIT (FP7).

Cost remains a major barrier, and this is often exacerbated by the fragmented nature of the building sector and of renovation processes, with several separated disciplines working on site. This can be tackled with new processes and business models such as prefabrication and 3D printing coupled with collaborative design using Building Information Modelling (BIM). Several EU-funded projects are exploring new ways of designing and collaborating, including effective integrated use of BIM and Building Energy Management (BEM) systems. Examples include STREAMER which focuses on healthcare buildings, IMPRESS and SWIMing which are both developing cloud-based BIM systems, and NewTREND which is developing a collaborative design platform. Other specific solutions include:

•Modular so called 'no regret options' for staged renovation[10] that will not block later additions

*[8] Horizon 2020 project Tribe is developing a social game linked to real time data from buildings to enhance energy efficiency habits. See http://tribe-h2020.eu*

*[9] Integrated renovation packages are being explored by (among others) FP7 projects iNSPiRe, EcoShopping and HERB, H2020 projects REFURB, MORE-CONNECT and BuildHeat, and IEE projects NeZeR and RePublic_ZEB*

*[10] Projects that focus on staged or step-by-step renovation include EuroPHit (applying the Passive House Enerphit approach), STEP-2-SPORT (focusing on sports buildings).*

•Local factories for renovation at the district level (pop-up factories in a renovation area)

•Working alongside local resellers of renovation products for the DIY market  or online renovation stores for the DIY market (a kind of 'Reno-Alibaba.com')

Despite this, some renovation products are not always suitable for DIY installation by occupants, for example ventilation systems. Systems such as these will usually not be fully effective unless they are installed professionally and operated with appropriate guidance and information. In this scenario, the selection is not so much one of product but rather of the desired quality and outcome. The competence and skills of craftsmen and designers are addressed by the BUILD UP Skills initiative[11] as well as more recent Horizon 2020 construction skills projects[12]. In many cases the methods, training materials and courses are already available, but these need to be widely implemented and integrated into qualification and certification schemes.

It is sometimes difficult to come to a proper assessment of new technologies, especially on the concept level. Equally important is the question of how to assess and reward 'soft measures' in energy performance standards or calculations. For example, aspects such as training, awareness and education of users, continuous information on energy behaviour, and provisions for predictive maintenance and performance control are often very effective but are not necessarily rewarded in energy performance regulations.

Prefabrication has major potential to overcome barriers, since it is a combination of product (concept) innovation and process innovation. Prefabrication can drastically reduce the renovation time on site, offering less disturbance for occupants and possibilities for enhanced quality in construction arising from better controlled processes in the factory.

However, the applicability varies with different building typologies. 3-D printing is also becoming increasingly important, for example to solve problems with gauging, or to reproduce complex shapes in historic structures. Application of these new technologies depends on the possibility of applying one of three different strategies:

-Total replacement of facades and roofs

-Partial replacement

-Adding constructions/elements to existing constructions

## Policy recommendations

There remains a pressing need for practical training related to construction, e.g. air tightness.

Standards and regulations should offer the possibility to:

•Assess new innovative products and concepts, and design/use them effectively

•Reward 'soft measures' in energy performance calculations e.g. user awareness, information, training/education, predictive maintenance, etc.

Further research and demonstration efforts are necessary in the following domains[13]:

•Superinsulating materials for specific renovation details

•High performance windows and glazing systems e.g. in very cold climates

•Ventilation systems and products especially for renovation

•Compact and cheap storage systems, e.g. when renovating individual homes

•Embodied energy of materials and technologies, e.g.

[11] *BUILD UP Skills will soon have a dedicated website for construction skills hosted on the BUILD UP portal.*

[12] *Following on from the BUILD UP Skills initiative, five projects were funded under Horizon 2020 Energy Efficiency Call 2014 targeting Construction Skills for building professionals. They are PROF/TRAC and MEnS, (both of which are developing training courses for professionals to desing NZEB) ingREes (focusing exclusively on Slovakia and Czech Republic), BUStoB (focusing on the Netherlands) and Train-to-NZEB (featuring Passive House design principles).*

[13] *The European Commission's Community Research and Development Information Service (CORDIS) has recently published a Results Packs on the Energy Efficiency in Buildings that summarises EU-funded research in several of these subjects: Embodied energy, smart windows, retrofitting technologies, and indoor air quality.*

PV panels, aluminium and PVC windows

•Control technologies, predictive maintenance, providing meaningful and understandable data to consumers[14] in an attractive way e.g. smart metering

## Renewable energy and the district level

Integration of renewables in buildings often impacts the wider district. The district scale, ranging from streets and neighbourhoods up to the whole city provides for optimization of energy concepts. District energy systems and smart grids emerge as best practice approaches[15] to provide local, affordable and low-carbon energy supply.

While most renovation decisions are taken at building level by individual owners, optimal integration of renewables requires planning and implementation at a larger scale which goes beyond the "four walls" and touches on district or urban planning. This escalates from a single stakeholder decision to a multi-stakeholder decision entailing additional challenges: integration and synergies, balancing and flexibility, long- and short term storage, high upfront (shared) investments, cross-sector solutions, market structures and barriers, data and accounting, urban planning, policy and regulations at national and local level.

## Identification of challenges

On the technical level there is a lack of appropriate standards and studies that would help foster robust business models and consequently to convince policy makers and financial institutions of the viability of RES integration proposals. Integration of PV panels into infrastructure 'other than roofs' can be difficult, and roof space is often at a premium especially in dense urban areas. Integration in general at different scales raises questions about the system boundaries for storage and flexibility, and about overall robustness. There is a lack of best practice demonstration project in some technical fields, for example storage and integration of RES with low temperature district heating networks.

Appropriate ICT infrastructure is not always available, with more effort needed on simulation and algorithms.

On the political or regulatory level the process of gaining permissions and other legal requirements can be slow and cumbersome, for example in setting up frameworks for grid management.

The energy market is too fragmented; too many roles are taken up by too many stakeholders with a lack of cross-sectorial thinking. This has led to less long-term and integrated planning, which has been exacerbated by economic instability hampering business decision-making in some countries. There is a need to develop specific integrated business models which prepare for long-term payback since high upfront costs are to be expected. RES installations often come across problems with 'cross-ownership', or the superposition of rights on land and infrastructure. Not all decisions and rights are handled at the same political level (local, regional, national, EU) which can hamper integration and implementation of cross-sectorial solutions. In several countries disjointed policies can result in a difficult investment environment. For example, recent tax changes in Spain, continuing policy support for non-renewable centralized energy solutions in Belgium, and unexpected removal of government support for RES and low energy buildings in the UK. In cases of public housing, fixed rents can act as a disincentive to investment. There remains a need for experiments and demonstrations of new solutions, and a continued effort to update regulations and policies accordingly.

Significant challenges also remain in terms of society, consumers and user behaviour. Communication and awareness-raising are constant requirements at all levels. For example in residential buildings non-technical people are able to access energy controls, while occupants of transient buildings such as hotels can often be confronted with unfamiliar systems. There remains a need to support increased participation from the bottom (local level) up, in order to reach a critical mass of awareness and engagement. District level solutions can be effective in this regard.

There remains a general lack of awareness on the

*[14] FP7 project NEWBEE has developed various ICT tools aimed at helping building owners and SME's carry out retrofitting projects.*

*[15] UNEP, 2015. "District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy".*

benefits of high energy performing neighbourhoods, with approaches that are designed 'too technologically' without taking into account the complexities of consumer desires and behaviour.

## Identification of solutions

Examples of low regulatory zones are available in the Netherlands and Belgium. The Dutch initiative on "Freezones" allows organised groups of stakeholders to apply for relaxation of regulations in a variety of areas, including renewable energy. Examples of this approach include the proposed Amsterdam South-East Freezone as well as the future Energyville[16] site in Genk , Belgium where the site owners can experiment within a low-regulatory energy environment. The Living Streets in Ghent (Belgium) are an example on how bottom-up low-regulatory zones were created with many different stakeholders for mobility issues – this kind of approach could also be applicable to RES installations. There is sufficient knowledge available by now on the benefits and blessings of the integration of renewables in the built environment, even if questions remain about the amount of regulation or certainty that would be needed for investors in such a zone. Some key concepts to build on are responsibility-building, empowerment, cooperative-thinking, "sharing is the new owning".

More widespread application of Life Cycle Costing (LCC) would help improve long-term decision-making.

Strict application of NZEB performance at the building scale often entails additional costs which can be mitigated by broadening one's view to the district, where the locations and typologies of other buildings and infrastructure can offer RES possibilities which are not available within the site boundary. In this manner, energy-positive buildings can balance those buildings which are too costly to renovate to NZEB performance. Is it possible therefore to work with averages at district scale? Is there a need for an NZEB concept at district scale? Visionary architects and urbanists already take into account the context or environment of new and renovated buildings when considering services, orientation and ecological concerns. Setting energy performance requirements at the district scale would force designers to think outside their "red line" plot area, allowing them the freedom to reap the many benefits which are available at that level for integration, storage, flexibility and balancing.

## Policy recommendations

Policies could consider providing support for:

-Low-regulatory zones to speed up the energy transition through living labs.

-Defining high building performance at the district level. The current focus of NZEB is on the building rather than the district, even though many problems cannot be addressed in individual renovations. Vienna is developing a district level energy performance certificate, building on the existing Swiss "2000 Watt Society" as well as a similar Austrian initiative.

-Bottom-up initiatives from engaged citizens and local authorities, as national or regional governments might be less aware of what is actually happening at local level. Examples can be found in case studies from the COHERENO project.

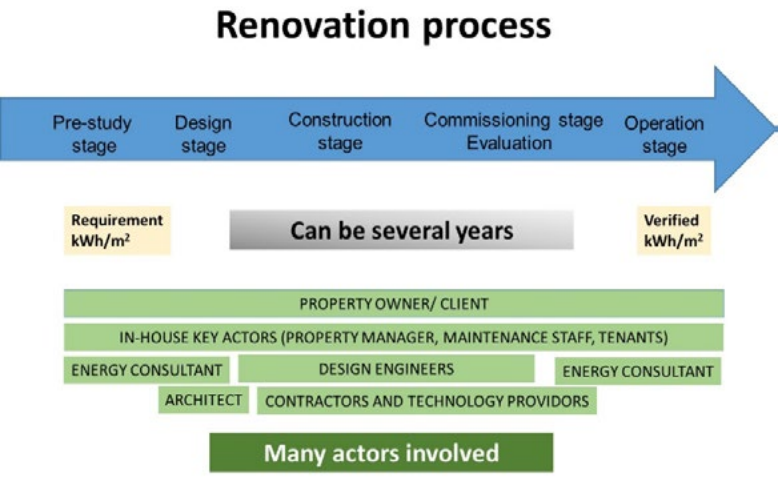
-More research and demonstration of district level renovation incorporating RES (such as FP7 projects ZenN, R2Cities and EFFESUS), more analysis and assessment of existing demonstrations, more opportunities for districts to learn from each other's best practice[17].

[16] *Energyville is also coordinator of the STORM district heating and cooling project*

[17] *An example of this is the "Replication Cluster" jointly managed by FP7 projects EU-GUGLE and SINFONIA.*

## Performance and compliance

In order to convince more building owners to go ahead with energy renovation projects it is crucial that the forerunners are able to demonstrate that their projects actually succeeded in achieving the necessary quality for high energy performance. However, the building process usually starts with an initial concept followed by a number of different steps before finally reaching the operation phase. The time from concept to building site is usually long, perhaps several years. This extended design period involves a large number of different actors with varying levels of influence on the final energy performance of the building. This can make it difficult to actually achieve the energy performance that was set at the beginning of the process.




In renovation projects it can be difficult to compare energy performance before renovation with the final built result, since the renovation in itself often alters the building in a variety of other ways, for example by improving the indoor environment and offer better possibilities to use the facilities. Levels of activity and numbers of users may be different: the building's users may not be the same, and may not display the same energy behaviour before and after renovation.

Particular consideration and guidance is therefore needed to ensure that the quality of the built result matches the ambition and actually achieves the desired energy savings. Performance, compliance and Energy Performance Certificates are the core subjects of IEE project QUALICHeCK.

## Monitoring

Monitoring serves a number of purposes including:

- Information : to create confidence that the building is operated correctly.
- Utilisation : to clarify whether the occupancy/utilisation of the building is appropriate.
- Compliance : to give confidence that the renovation work has been carried out correctly and in line with the set of requirements, and as a tool for enforcement.

Depending on the purpose of the monitoring, the required effort will be quite different. If monitoring is to be used for compliance purposes there will be pressure for a correct assessment of the reliability of the results. Although monitoring is an important tool in evaluation of an energy renovation it should not only measure energy performance (kWh/m²) but also:

- Indoor climate (e.g. temperature, air quality)
- Airtightness
- The rebound effect
- Weather conditions
- Occupancy

In addition, reliable data would be required on investment and operational costs as well as the duration of the investments. The challenges vary depending on the purpose of the monitoring campaign, and also depend on the building type (e.g. renovated office building versus an individual dwelling).

The accuracy of monitoring is also more important in very low energy buildings, where energy consumption can be small compared with energy losses and gains. Another challenge with monitoring is the normalisation of energy use, which should take into account the following parameters:

•Outdoor climate correction: temperature, solar radiation, wind, etc.

•Indoor climate (i.e. temperature, air quality, visual comfort)

•Occupancy related aspects (internal gains, building use)

It can be very challenging to identify the actual starting point of a building's renovation. Historical monitoring data are seldom available and it is usually not possible to wait for data collection. The duration of the monitoring period is also an issue to consider, for example half a year, or all seasons.

## Energy Performance Certificates (EPC)

There are various possibilities to use this tool[18] in the context of performance and compliance. However, there are some concerns with the present status of EPC information such as:

•Correctness of the calculation tool or data collection of energy use behind the EPC-method, i.e. is the calculation method able to predict with sufficient accuracy the consumption and indoor climate?

•Are the input data reliable and is the EPC-rapporteur competent?

Questions remain about the usability of some EPC models in the context of monitoring and compliance and as a tool for achieving the required quality of construction. Even if the EPC is not able to be used directly for performance and compliance of a specific building, it can be an effective tool for large institutional owners of building portfolios to select which buildings to prioritise for renovation.

## Performance gap

In addition to the issues mentioned previously under monitoring, there are several other challenges associated with matching the designed and actual energy performance of a renovation project. It is difficult to obtain instantaneous information on energy use, although this is important in order to take action. There are too few appropriate commissioning tools available. The lack of capacity and training of persons involved in the process is problematic - this includes many actors in the building process as well as the building's end users.

## Identification of Solutions

New and better sensors are starting to become available on the market. Effective and smart analysis of monitoring data is crucial, and this needs to be further developed (e.g. FP7 project PERFORMER). The ability to compare monitoring results with neighbours or similar building typologies could be part of a strategy to increase levels of ambition and motivate action.

Monitoring should stimulate an accelerated learning curve regarding energy efficiency, operation and energy behaviour for all actors. Monitoring also needs to provide answers to questions about the performance obtained, and give confidence regarding the quality and performance of the renovated building.

Various bodies can carry out inspections and checks for compliance. In some situations minor renovations such as cavity wall insulation can be carried out by approved suppliers who offer a guarantee. Independent certification such as Passive House is also becoming more important.

Several EU-funded projects are dealing with monitoring of renovation projects and monitoring of impact of energy efficiency measures. Experience shows that simulation tools often overestimate energy savings for building renovations to high energy performance, due to various factors including modelling assumptions (indoor temperature before and af-

[18] *Energy Performance Certificates are examined in detail by IEE projects QUALICHeCK (in the context of quality and compliance), EPISCOPE (in the context of tracking rates of renovation) and Request2Action (monitoring the uptake of EPC recommendations).*

ter), unexpectedly poor performance of certain techniques and materials, and poor execution. There is also a problem of underestimation of performance, notably in old buildings before renovation is carried out. There is a need for better knowledge about how to use simulation tools with more correct input data. Once again, training and education are needed for the whole chain of actors from designers through craftsmen to end users. Compliance is crucial for the future uptake of solutions, and partially depends on having a competent value chain.

Performance based contracting can be a useful solution for certain technologies, for example for PV installations, replacement of lighting fixtures, and other specific single measures. It is less certain that performance based contracting would work as effectively in larger and more holistic renovation projects where several contractors are involved, or renovations that involve long payback periods.

## Policy recommendations

It is important that the market has trust in the Energy Performance Certificates (EPC) or similar tools. A major part of this trust is linked to the usability and representation of the predicted performances before and after renovation. Various experiences show that frequently the consumption before renovation is overestimated as well as the savings by retrofit measurements. Improving the reliability of these predictions is clearly a priority. Monitoring campaigns can be very useful to assess the correctness of the predictions, increase trust in the EPC outcomes and provide evidence for improvements.

Policies could consider:

- Requiring Member States to set up monitoring campaigns that randomly check the relation between predicted and measured consumption.
- Developing a common methodology for such assessments, and incorporating them in European databases.

Effective compliance and enforcement frameworks are crucial for meeting the medium and long term challenges of renovation. There are two principal approaches that could be followed:

1.Compliance checks based on what has been used as input data in EPC calculations and what is done in practice.

2.Compliance checks based on the measured energy consumption of buildings.

Both approaches require robust procedures to ensure that cases of non-compliance are accepted by all parties involved. For approach 1, this can be managed by developing a set of clear procedures, e.g.

- Allowing or imposing use of as-built input data for the EPC calculation, rather than using design stage input data as the basis for compliance checks.
- Assessing non-conformity at component rather than building level, such that a poorly performing component cannot be mitigated by a better result elsewhere in the building.

For approach 2, the challenges depend on the purpose of the action. If the purpose is to include measured consumption in the EPC then it is important to have a good normalisation process for the measured energy consumption. On the other hand if the purpose is to prove that a specific requirement has been met, this results in additional challenges. There becomes a need for a reliable prediction tool, so that designers and builders have a reasonable guarantee that a certain design and execution will result in compliance. It is also crucial to have a reliable normalisation procedure to translate measured consumption into a result which can be compared with the requirement. In case of non-compliance, procedures for identifying liabilities also need to be developed.

Shortly after the workshop took place DG Energy published its own EPBD Compliance Study[19].

[19] European Commission, 2015. "Energy Performance of Buildings Directive (EPBD) Compliance Study".

## Capacity building and decision support

Decision making in building renovation is influenced by a number of non-technical stakeholders. We need to recognise who these stakeholders are, what drives them and what barriers they face.

Relevant stakeholders include the following:

·Public authorities (national, regional, municipal, local), in their capacity as building owners, as enablers/ facilitators, as policymakers, or as financers.

·Building owners, either as landlords or as owner – occupiers.

·Industry players (suppliers, contractors, energy service companies).

·Professionals (architects, engineers, building managers, surveyors)

·Financing entities (public or private)

·Occupiers and end-users

## Identification of Challenges

Each stakeholder group faces specific challenges, some of them shared or even interdependent, some of them very specific. Process-related challenges are the most relevant. Challenges and barriers are aggravated when scaling up. In general, there is a lack of interaction between stakeholders (silos in authorities, dispersion of decision making) at all levels. Amongst owners and end users the main challenges are related to uncertainties and a lack of trust in technical and economic information related to the renovation schemes offered to them.

High upfront costs also pose a challenge, including extra costs associated with the need for increased knowledge, as well as time and effort to deal with these processes.

There is too much fragmentation of knowledge and regulations, and a lack of management capabilities to handle all aspects of the process (including multi-disciplinary skills). A mismatch between the costs and benefits of renovation (including the split incentive landlord-tenant dilemma[20]) is an entrenched

Specific circumstances such as cultural heritage, protected buildings or fragmented property ownership can add additional difficulties. NZEB performance is often not achievable for individual buildings, for example historic buildings that restrict certain technical options. There is a general problem of a lack of data that would give people confidence in knowing what needs to be done and whom to trust. Common understanding of data is also a problem.

## Identification of Solutions

Potential solutions include:

•Focusing attention more broadly on the multiple benefits of energy renovation. Disconnect from the "kWh" and "payback" rationale, towards values that are closer to consumers e.g. definition of home quality standards, addressing intellectual and emotional issues, health benefits. Recent reports by the International Energy Agence (IEA) and by the United Nations Environment Programme (UNEP DTU) provide hard evidence that energy renovation offers many benefits beyond cost savings.

•New, inclusive and empowering collaboration models at all levels: overcoming silos in regulations and policymaking[21]; "co-maker" schemes in industry (i.e. close partnerships between different manufacturers) that can secure cooperation beyond single projects; creating alliances at the district scale, giving each stakeholder a key role in a joint planned approach.

*[20] FP7 project EASEE is exploring technical solutions for multi-storey multi-owner residential buildings, while IEE project LEAF is developing toolkits for residents of such buildings and RentalCal assesses the commercial viability of renovating rented housing. For an overview of energy efficiency in public, cooperative and social housing see http://www.buildup.eu/news/45385*

*[21] H2020 project FosterREG explores the interaction of different levels of public policymaking for energy efficient urban regeneration, while HERON is carrying out socio-economic research on energy efficiency policies related to buildings. Project BUILD UPON brings together Green Building Councils from across Europe and is mapping the various stakeholders involved in large scale renovation.*

This kind of shared holistic approach with clearly defined models of cooperation helps provide security of investment and ensures the "buy-in" of stakeholders.

•Raising awareness: "learning by doing" schemes promote pilot actions which can serve as test beds for further action, refinement of processes and awareness-raising mechanisms (word of mouth, visits, addressing emotional elements for stakeholders). For example, IEE project CERtuS is helping southern European municipalities deliver NZEB renovation. Step-by-step measures can also help overcome fear of change.

•Mapping the availability of renovation possibilities across urban districts, to identify priority areas. Such maps have been developed as pilot case studies in the EPISCOPE[22] project .

## Conclusions

The year 2016 is a "key year for policy development" in building renovation. The European Commission will be reviewing two of the most important pieces of legislation, the Directives on Energy Performance of Buildings and on Energy Efficiency. Results of an initial public consultation on the EPBD have recently been published. In addition, expectations remain high for the public sector to lead by example in the renovation on Europe's building stock. All of this takes place in the context of the recent Paris Agreement on climate change which given Europe's policymakers a renewed impetus to work on saving energy. As we continue to work towards Europe's energy and climate goals, the European portal for energy efficient buildings www.buildup.eu will continue supporting collaboration and sharing of information across the buildings sector.

[22] *Since the workshop took place, the new Horizon 2020 project ENERFUND has started which further develops these maps.*

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