How can we renovate deeply if we don't know what that is?

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Abstract

Although the European Union (EU) requires its Member States to renovate deeply there is no common definition of DR (deep renovation/refurbishment/retrofit) at EU level, let alone a global definition. So, what is DR?

Research work, combined with a series of webinars bringing global experts on DR together, attempts to solve these global issues. The series of webinars gives attendees a chance to deepen the discussion, with the aim of producing a clear set of deep renovation definitions. This will also allow for a set of criteria that will determine the best practices in the EU and the US to be disseminated to experts, building stakeholders and policy makers.

The definition of DR varies between the regions. In Europe most definitions focus on heating, cooling, ventilation and hot water and the general understanding is that these should lead to an improvement of at least 75 % in the before and after performances of the treated building. In the US the definitions are less harmonised, there is no clear definition of an energy renovation that is consistently used throughout the US Building Sector. Most commonly DR in the US only demands an improvement in the range of 30 %–50 %, however, this is based on full energy consumption including appliances.

A better understanding of DR and the major challenges surrounding this issue will support policy development at regional and national levels and demand global action.

Introduction

Although the European Union (EU) requires its Member States to renovate deeply there is no common definition of DR (deep renovation/refurbishment/retrofit) at EU level, let alone a global definition. So, what is DR?

The buildings sector is responsible for around a third of total global energy use and more than 30 % of global energy-related CO_2 emissions. Given that only a small percentage of new buildings are built each year, the existing building stock presents us with a huge opportunity to reduce these emissions and meet current climate change targets.

The Global Buildings Performance Network (GBPN) has elected the implementation of a 'deep' scenario as its main objective. This involves making standard best practice policies and state-of-the-art technologies by 2020, a time-frame of less than 10 years. For existing buildings this means that energy efficiency improvements must be standard practice for all renovations.

At present, there is no generally agreed definition for DR, on the contrary there are many different understandings of the term across the regions. The acronym "DR" is used throughout this project because different regions use different terms for the action of a deep improvement. The most commonly used are: deep renovation, deep retrofit and deep refurbishment. This paper reports on a unique attempt to come up with a clear and harmonised definition for DR.

Most examples of DR are still small and at an experimental or pilot stage. The fundamental goal of this on-going project is to up-scale DR and make it a key initiative for the existing building stock. For this purpose, this project sets out to identify the necessary criteria in selecting best practice policy

packages. The research work looks into the specific sub-criteria that characterise some policy packages as best practices, thus encouraging the routine adoption of DR projects to become widespread.

Context

In order to identify existing definitions GBPN conducted a desk study on current state of the play and looked at existing projects and definitions. The main part of the experience was found in European Union (EU) and the United States (US).

CONTEXT: DR IN THE EU

In order to identify existing definitions GBPN conducted a desk study on current state of the play and looked at existing projects and definitions. The main part of the experience was found in European Union (EU) and the United States (US). The recast of the EU's Energy Performance of Buildings Directive (EPBD) (Directive 2010/31/EU) is one of the most ambitious in the world in terms of renovation of buildings. However, it does not mention the term "deep renovation". The EPBD lays down the application of minimum requirements to the energy performance of existing buildings; building units and building element that are subject to major renovation. A "major renovation" in the EPBD means the renovation of a building where:

a. The total cost of the renovation relating to the building envelope or the technical building systems is higher than 25 % of the value of the building, excluding the value of the land upon which the building is situated; or

b. More than 25 % of the surface of the building envelope undergoes renovation.

This definition identifies a "window of possibility" for a "deep renovation". The minimum energy requirement will be set by the individual member state; however, this must be based on the EPBD Article 4 that states a minimum energy performance requirements "are set for building elements that form part of the building envelope and that have a significant impact on the energy performance of the building envelope when they are replaced or retrofitted, with a view to achieving cost-optimal levels". This does not prescribe deep renovation but provides an opportunity to renovate with energy performance as a priority, including for building envelope elements that are retrofitted or replaced.

Deep Renovation is, however, mentioned in the EU's recent adopted Energy Efficiency Directive (EED) (2012/27/EU) from 2012 in Article 5. This obliges member states to renovate 3 % of the total floor area of public buildings. These renovations must meet at least the minimum energy performance requirements that it has set in application of Article 4 of the EPBD (stated above). This applies to all buildings over 250 m^2.

Article 4 in the EED requires member states to establish a "a long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private. This strategy must encompass "policies and measures to stimulate cost-effective *deep renovations* of buildings, including staged deep renovations".

On the 30th of July 2012, the European Parliament published a report on the "on the proposal for a directive of the European Parliament and of the Council on energy efficiency and repealing Directives 2004/8/EC and 2006/32/EC". In this report the European Parliament published a proposed definition for deep renovation (Amendment 28, Article 2, paragraph 1, point 27.a) (European Parliament, 2012). The commission proposed, "'deep renovation' means a refurbishment that reduces both the delivered and the final energy consumption of a building by at least 80% compared with the pre-renovation levels."

The building community, stakeholders and politicians in the EU are beginning to take an interest in deep renovations. Other definitions of deep renovation that GBPN have come across during its research are:

- RENOVATE EUROPE – Deep renovation can achieve a reduction in energy consumption of between 60 % and 90 %, for the majority of Europe's buildings. When this building renovation takes place, all available energy saving technologies must be incorporated (RenovateEurope, 2013).
- EURIMA & Laustsen – Energy performance reductions can be classified systematically as factor 2, 4, 6 or 10 renovations, indicating energy consumption reductions of 50 %, 75 %, 84 % or 90 %, respectively, compared to pre-renovation performance (EURIMA, 2011).
- IEA – Deep renovation: Deep renovation is the renovation that doesn't lock the savings potential. Deep renovation is achievable only if the overall energy performance of the building is considered when designing the renovation programme (Saheb, 2012).
- ROCKWOOL's "potential" DR definition: Normally, deep renovation is undertaken in conjunction with a major renovation of the building or buildings and/or as part of the standard 30–40 year renovation cycle, using a cost-optimal approach. In poorly performing buildings, energy performance can often be improved by a factor of four, or between 65 %–95 %, compared with pre-renovation levels, primarily by reducing final energy consumption." (Bowie, 2012).

CONTEXT: DR IN THE US

The US Department of Energy (DOE) is a Governmental department whose aim is to promote energy technology and innovation in the US. The DOE have set a "Better Buildings Initiative" challenge that pushes for a 20 % reduction of energy across a portfolio of commercial and industrial buildings by 2020.

The DOE has designed "Advanced Energy Retrofit Guides" (AERGs) for existing buildings in order to assist building stakeholders in the selection of energy efficiency improvements. Within these guides they claim "deep retrofits can reduce a building's energy use by over 50 %. Deep retrofit projects combine many O&M and standard retrofit measures in an integrated whole-building design approach".

"Deep" Retrofit in the US is supported by some influential organisations whose missions are to stabilize and reverse the emissions that the 'Building Sector' contributes to. Some descriptions of "deep" retrofits in the US:

- NEW BUILDINGS INSTITUTE – Conventional retrofits typically result in savings of only 15 % to 25 %, whereas recent deep retrofits showed 30 % to 60 % savings in a wide range of projects (NBI, 2012).

- THE ROCKY MOUNTAIN INSTITUTE – We define deep energy retrofits as a whole-building analysis and construction process that achieves much larger energy cost savings – sometimes over 50 % reduction – than those of conventional, simple retrofits and fundamentally enhances the building value (RMI, 2012).
- 1000 HOME CHALLENGE – "Deep retrofits take a whole-building approach, addressing many systems at one time. Projects are strategically implemented over time, with the goal of achieving multiple energy-saving benefits from each project. Deep retrofits are most effective for buildings with poor overall efficiency and a variety of systems nearing the end of their useful life (Wiggington, 2012).

Process

This research work investigates DR and attempts to solve some global issues using a tiered approach; by organising three webinars and conducting an online survey with a group of selected experts. So far, this process has brought thirty global DR experts together from different continents and regions to clarify and harmonise DR definitions, to discuss the analytical framework for selecting best practices and to seek common goals and topics for future collaboration.

THE SELECTION OF EXPERTS

This research work brings frontend specialists together; GBPN selected the experts based on their expertise and interest in the development of policy actions to up scale DR. The tiered process includes the same core group of experts to ensure that harmonisation is gradually increased and that a common framework for future collaboration is developed. Within this group, the experts were active in six regions of the world. Thus far, this process has brought together thirty international DR specialists.

FIRST WEBINAR

The first webinar allowed for all conditions found within a deep renovation definition to be explored. After summarising the GBPN research, the participants provided expert opinion on the pre-requisite conditions for the definition of deep renovation. The second part included presentations on the current status of the EU and the US, respectively. The Webinar was highly interactive; following the presentations there was opportunity for comment and discussion on each topic.

The results of the first webinar supported our research findings: there is no clear regional or global deep renovation definition. These findings led us to further investigate the definition of deep renovation and the GBPN designed a 'Deep Renovation Definition Questionnaire'.

QUESTIONNAIRE

GBPN established a "Deep Renovation Definition Questionnaire" specifically designed to target the issues and ambiguities that arose during the research and webinar. This was sent out to the same group of experts. The questionnaire was completed by 23 of the 30 experts, responding from different regions and sectors. These experts were asked a series of different questions relating to the definition. The questionnaire allowed for the essential conditions of a deep renovation to be defined individually by each expert. The final conditions considered within the DR Questionnaire were:

- Absolute and relative targets.
- Energy demand and energy consumption.
- Energy or CO_2 savings.
- Primary or final energy.
- Type of final use to be included.
- Level of relative targets.
- Final consumption after renovation.
- Best term for DR.

Although there were some areas of agreement there were also issues where further clarity was required. The results – the agreed definitions and the problematic areas – were presented during the second webinar.

SECOND WEBINAR

The second webinar presented the findings of the questionnaire aiming to resolve any unsolved issues. This webinar drew many conclusions from the questionnaire; however it also brought to light further complications when defining a deep renovation, these included:

- Saving targets: building type.
- Saving targets: building vintage.
- Savings target: individual building or group of buildings.
- Saving targets: local climate.
- Staged deep renovation.

Further discussion on these questions will take place in the laboratory of "More and Deeper Renovation" at the **GBPN.org** website.

Results

The questionnaire looked more closely at some of the definitions, which were presented in the first webinar. In particular it aimed to clarify the different terms of DR and how these were perceived in the GBPN regions and in the rest of the world.

Geographically, the 23 experts are active in six different regions around the world: China, Europe, India, Latin America, South-East Asia and US. Approximately one-quarter of the experts were active in more than one region. Almost 80 % of the respondents work in the EU and 40 % in the US.

QUESTION 1. SHOULD POLICIES SET ABSOLUTE OR RELATIVE TARGETS FOR SAVINGS?

Around 75 % of the respondents think that policies should set both relative and absolute targets. However, many experts mentioned that defining an appropriate relative and absolute target is challenging, due to the differences in building types, geographies, climate zones, etc.

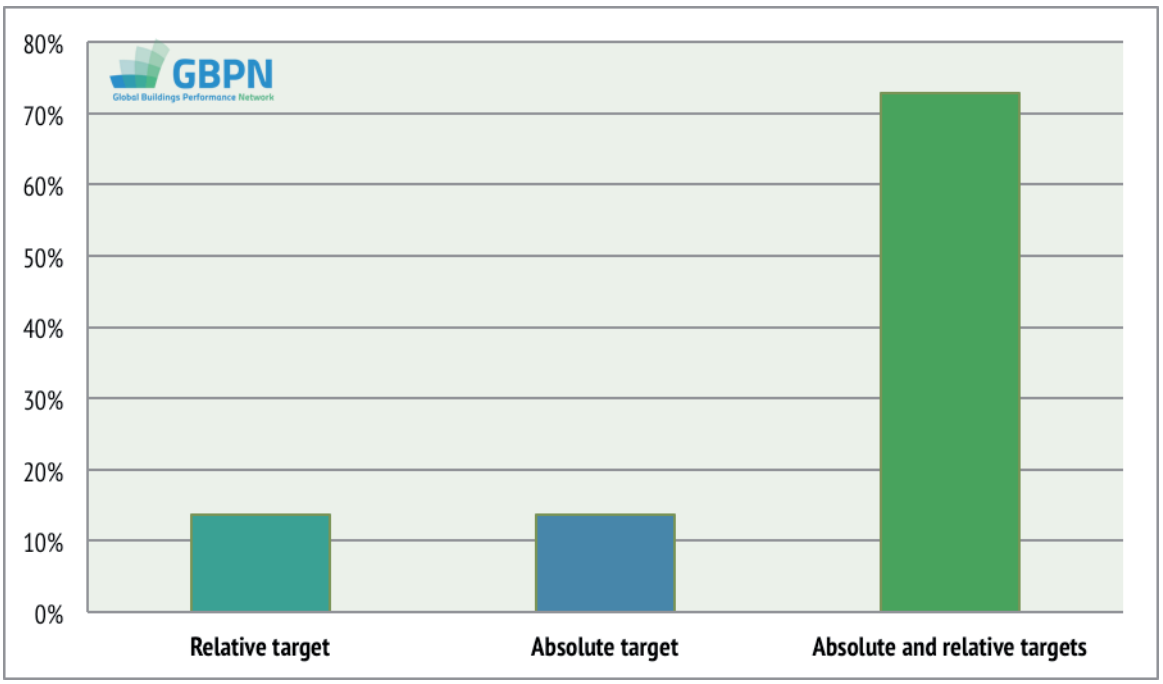

Figure 1. Findings: Absolute and Relative Targets in per cent.

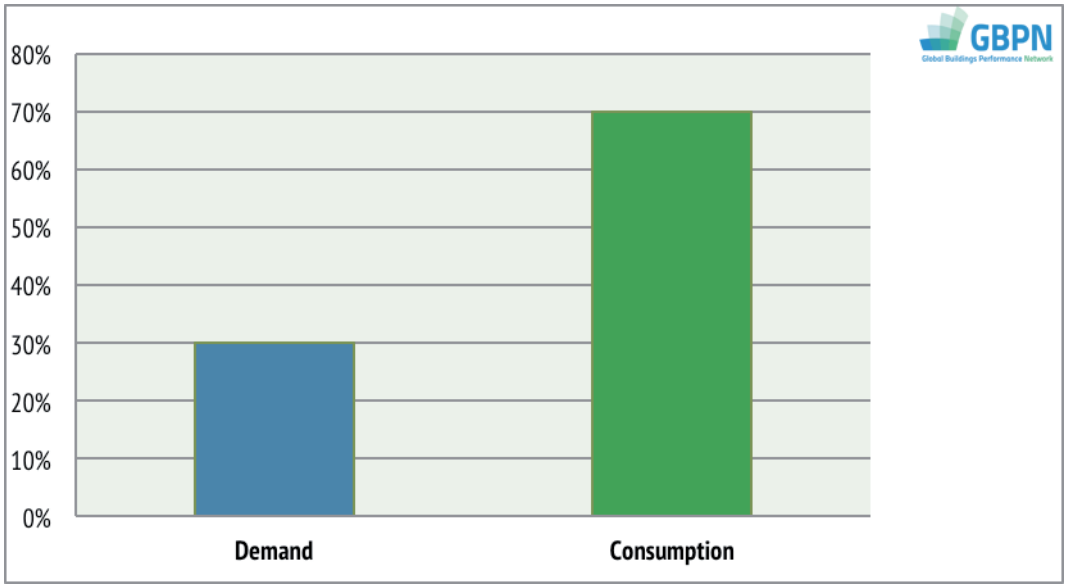

Figure 2. Findings: Energy Demand and Consumption.

QUESTION 2. SHOULD THE TARGETS BE BASED ON ENERGY DEMAND OR ENERGY CONSUMPTION?

The energy consumption, which is the amount of energy consumed in the form in which the user acquires it, will reflect behavioural/occupancy loads, degree-days and other effects on the energy consumption of the building, as well as design flaws.

The energy demand data (amount of energy required by the systems installed in a building to maintain the habitable conditions of the indoor environment), is easier to obtain, and indicates what the theoretical or designed energy demand (or use) would be under normal conditions, even before the building is taken into use. Demand and consumption are closely related and usually show a certain convergence.

Both energy consumption, which is the measured or metered values and the energy demand, which is the estimated or calculated energy are worth considering when defining the targets.

The general opinion of the experts is that targets should be expressed in terms of consumption. However, all experts agree that this is more difficult to quantify as in order to accurately calculate the building's consumption, the installation of smart meters is required. Furthermore, in the EU, tenant consumption data is not open sourced; this is seen as being controversial as it effectively depends on user behaviour (even a very efficient building used incorrectly can have a large energy consumption).

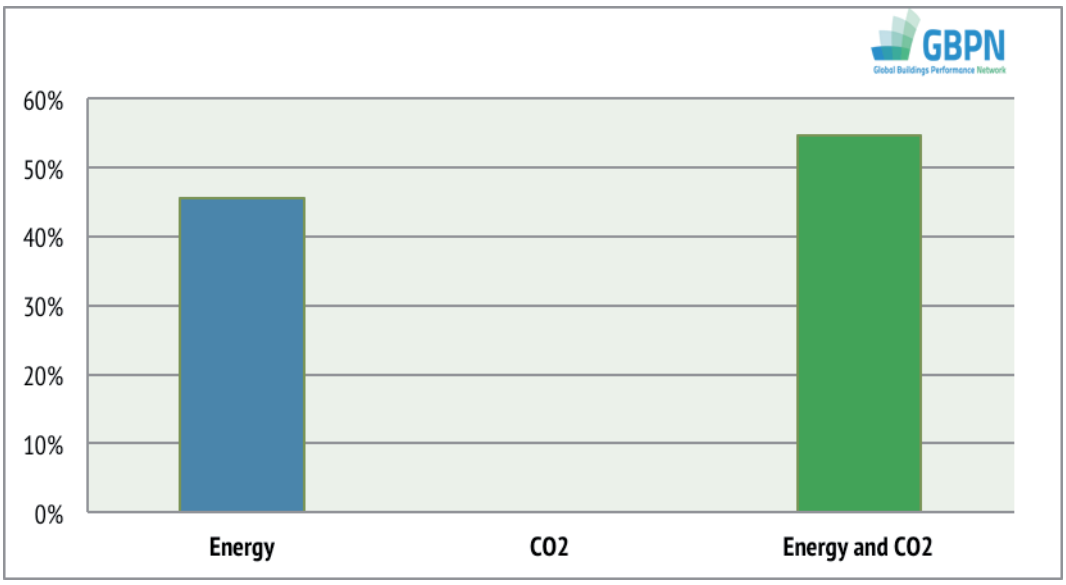

Figure 3. Energy and CO_2 savings.

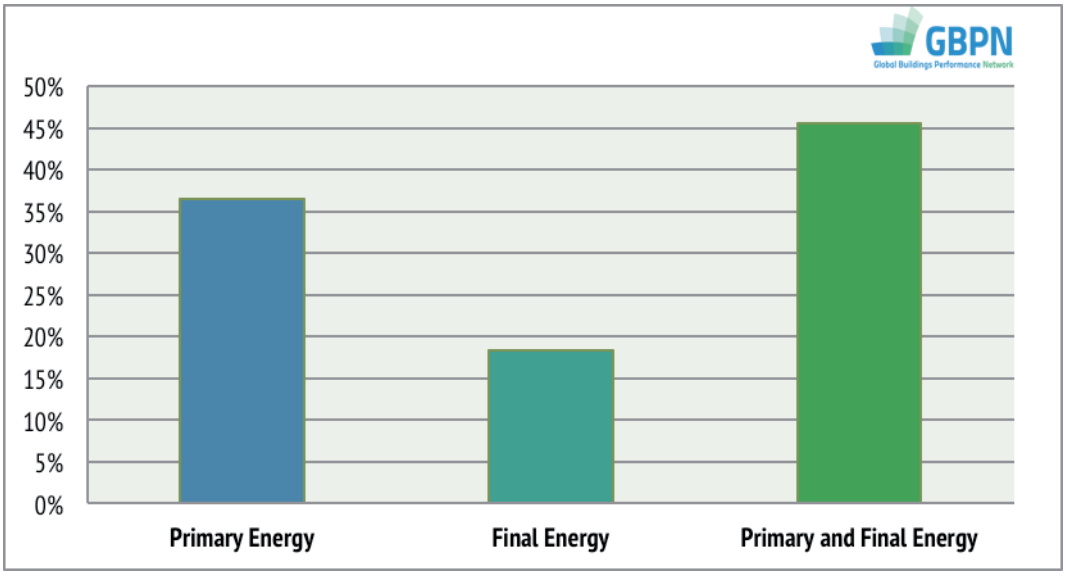

Figure 4. Primary Energy and Final Energy Targets.

QUESTION 3. WHAT KIND OF SAVINGS SHOULD DR POLICIES INCLUDE? (ENERGY OR CO_2)

Most experts consider that the main focus of DR should be based on the energy performance or a combination of energy performance and CO_2 emissions. The only way for the building sector to meet ambitious CO_2 targets is to drastically reduce the energy required by the building stock.

QUESTION 4. THE ENERGY TARGET SHOULD APPLY TO … (PRIMARY OR FINAL ENERGY)

Almost 50 % of experts would consider using both final and primary energy in the definition of DR. The other results showed that most experts consider primary energy targets before final energy targets. A sensible approach would be to link:

- Final energy use to the building, in order to encourage efficient design and operations; and
- Primary energy to associated carbon emissions in order to encourage carbon free generation and efficient distribution on the part of the utilities.

QUESTION 5. ENERGY USE SHOULD INCLUDE … (HVAC/DHW/APPLIANCES/LIGHTING)

The majority of experts consider that loads from HVAC, DHW, lighting and appliances should be considered in the definition. However, the results show large regional differences. Most European experts consider the definition of the 'energy performance of a building' to be as stated in the EPBD: "the calculated

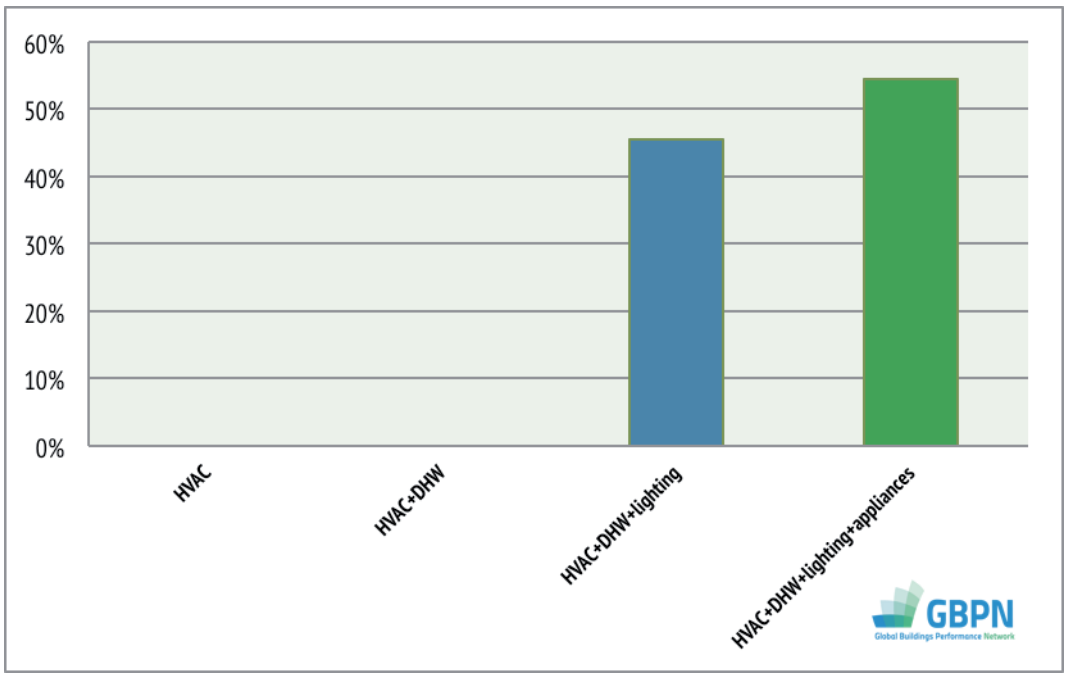

Figure 5. Energy Use of a Deep Reduction Includes.

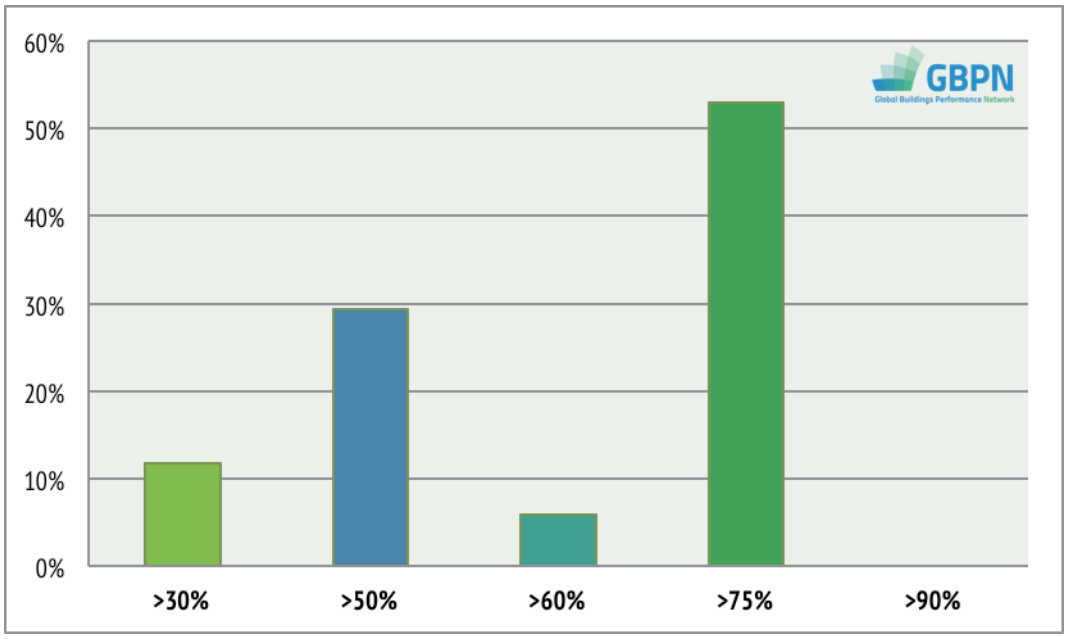

Figure 6. Relative Energy Saving Target.

or measured amount of energy needed to meet the energy demand associated with a typical use of the building, which includes, inter alia, energy used for heating, cooling, ventilation, hot water and lighting". The US experts consider all energy uses of a building, including appliances.

QUESTION 6. IF A RELATIVE ENERGY SAVINGS TARGET WERE CONSIDERED, WHAT SHOULD THIS TARGET BE?

Almost 60% of the participants in the survey think the relative target should be higher than 75% (compared to the status before the renovation) and most of these are Europeans.

About one-third of the respondents think relative targets should be set as a minimum of 50 % whilst having mechanisms available to go deeper. These respondents suggest that the target should be set depending on the vintage and condition of the building.

All the experts who selected a minimum relative target of 30 % were from the US, whilst most European experts pledged for more than 75 % (all European experts wanted a reduction of more than 50 %). The regional differences were also aligned with the differences in the terms of a DR definition (renovation and retrofit).

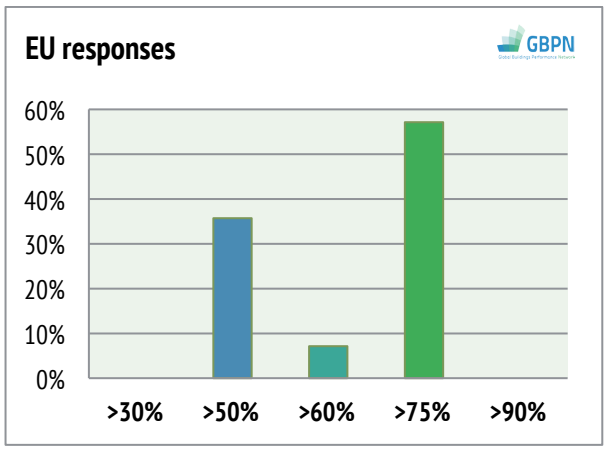

Figure 7. EU Relative Savings Target.

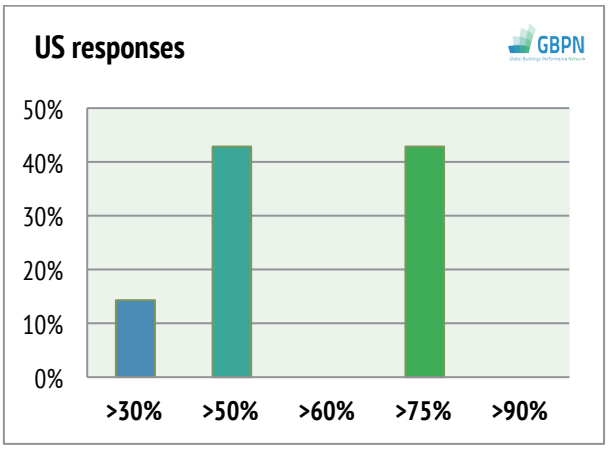

Figure 8. US Relative Savings Target.

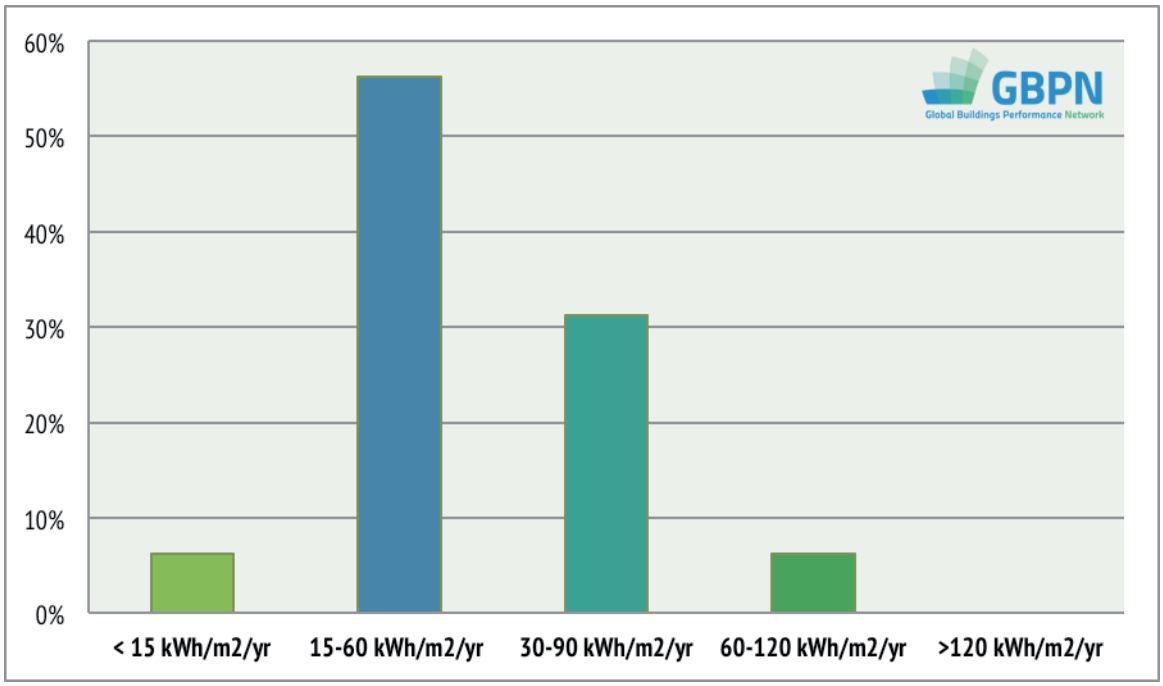

Figure 9. Final annual energy consumption: energy target. kWh per m².

Finally, some experts expressed difficulty in responding to this question as they felt that there are too many variables, i.e. where these targets are set, the age of the building stock, the type of construction, and what is possible in terms of efficiency and renewable requirements.

QUESTION 7. WHAT SHOULD THE FINAL ENERGY CONSUMPTION (ABSOLUTE TARGET) BE AFTER A DEEP RENOVATION?

Around 90 % of the respondents think the absolute target should be less than 80 kWh/m²/yr. Almost 60 % of the respondents think that an absolute target should be between 15–60 kWh/m²/yr.[1]

QUESTION 8. WHICH TITLE DO YOU FIND THE MOST APPROPRIATE? AND HOW WOULD YOU LIKE TO SEE DR DEFINED?

While the nuances between the three titles are not significant for almost 20 % of the experts, the other 80 % think there are some clear differences. "Deep Renovation" is the term used the most in Europe. Furthermore, the EU Energy Efficiency Directive[2] mentions the term "Deep Renovation" and includes measures that focus on the building shell. In the US, most of the respondents use the term "Deep Retrofit" and include measures focusing mainly on the systems. Out of the 23 experts, nobody used the term "Deep Refurbishment". The second webinar concluded the analysis – that the term used in the US is "deep retrofit" and the term used in the EU is "deep renovation".

1. < 5 kWh/m²/yr is <4.7 kBtu/ft²/yr, 15–60 kWh/m²/yr is 4.7–18.8 kBtu/ft²/yr, 30–90 kWh/m²/yr is 9.4–28.2 kBtu/ft²/yr, 60–120 kWh/m²/yr is 18.8–37.6 kBtu/ft²/yr, >120 kWh/m²/yr is >37.6 kBtu/ft²/yr.

2. More information on the EED available here: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:315:0001:0056:EN:PDF.

It is agreed by all experts that the appropriate level at which to prescribe a relative or absolute target depends on a wide range of issues such as the type of the building, its climatic environment and use, the loads considered and the choice of which metric (final/primary or demand/consumption) is used to describe performance.

DR Definitions

Based on the findings collected in the research, the webinars and the questionnaire some definitions relating to deep renovations were established. Please find these definitions below

Deep renovation is a comprehensive term that captures the full potential of improvement works, with a main focus on the building shell, of an existing building or group of buildings that leads to a very high energy performance. The primary energy consumption, which includes, inter alia, energy used for heating, cooling, ventilation, hot water and lighting after the deep renovation of an existing building is less than 60 kWh/m2/yr. The renovated buildings consume 75 % less primary energy compared to the status of the existing building/s before the renovation.

Deep retrofit implies replacing existing systems with similar ones that are of higher quality and performance and leads to a better energy performance of an existing building. The primary energy consumption includes energy used for heating, cooling, ventilation, hot water, lighting, installed equipment and appliances. After the deep retrofit the buildings consume 50 % less primary energy compared to the status of the existing building/s the retrofit.

Deep refurbishment means to bring something back to its original characteristics and implies a renewal undertaken primarily for aesthetic reasons.

Deep Reduction or **Deep Energy Reduction** is a term used in US for a deep renovation or a deep refurbishment, which aims at more than 75 % reduction in energy use in comparison with that prior to the improvement.[3]

Some definitions based on relative targets can support the clarification of deep renovation projects and can help to separate the level of ambition in DR projects. In order to further clarify the definitions of deep renovation GBPN propose some relative definitions, which can clarify the level of ambition in DR.

Factor Two or Factor 2 Renovation: A renovation with energy consumption reductions of 50 % compared to pre-renovation performance.

Factor Four or Factor 4 Renovation: A deep renovation with energy consumption reductions of 75 % compared to pre-renovation performance.

Factor Six or Factor 6 Renovation: A deep renovation with energy consumption reductions of 84 % compared to pre-renovation performance.

Factor Ten or Factor 10 Renovation: A deep renovation with energy consumption reductions of 90 % compared to pre-renovation performance.

Zero-Carbon-Renovation: A deep renovation with large-energy consumption reductions, where the remaining energy needed by the building is carbon neutral.

Zero-Energy-Renovation: A deep renovation with large-energy consumption reductions, where the remaining energy needed by the building is supplied as renewable energy on site.

Normally, DR actions take place at national level or in a local context. Special attention should therefore be given to the translation of the previous terms into different languages.

Conclusions

The project concluded strongly that there is a need for a better, clarified and more harmonised definition of DR. When establishing best practice criteria for packages and policies, it was found that this needs to be based on a deep definition.

A clear distinction was found between the terms deep renovation and a deep retrofit; experts from the EU found that renovation was the term most commonly used, whereas experts from the US found that retrofit was the term used. Generally, the definition relating to a deep renovation aimed for the deepest reductions of all the terms, these improvements mainly concern the building envelope. The definition of a retrofit focuses mainly on the building's systems.

Deep renovation is the term used to describe a deep improvement in the EU. A deep renovation mostly focuses on heating, cooling, ventilation and hot water and the general understanding is that this should be improved by at least 75 % and/or have a primary energy consumption after renovation of less than 60 kWh/m^2/yr.

Deep retrofit is the term used to describe a deep improvement in the US. In the US there is a less harmonised DR definition – there is no clear definition of an energy renovation used consistently throughout the US building sector. Most commonly deep renovation in the US demands an improvement in the range of 30–50 %, but is based on full energy consumption including appliances.

The relative targets or the final energy consumption after a deep renovation project will range within the values mentioned in the previous definitions depending on climate zones, loads and type of buildings and should be specified at local level. Most participants agree that it is necessary to include both absolute and relative targets as well as targets for energy use and carbon emissions when accurately defining a deep renovation. A limitation arose when trying to define an absolute target as it was found that the question was insufficiently detailed and therefore caused inaccuracy in the results.

The amount of collaboration that has been seen throughout the initial steps of this project shows that the DR community is in need of more information and is committed to finding ways to share knowledge between regions. Considering the level of interest in the GBPN "DR" project and participation from such a variety of stakeholders and regions, it is apparent that this subject is of high importance to the building community. However, even though there is a strong interest in the subject the experts explained that there is a lack of good DR databases where experts can share and discuss relevant case studies. The GBPN laboratory on "More and Deeper Renovation" plans to provide a forum for this kind of discussion.

3. Thousand Home Challenge http://thousandhomechallenge.com/.

NEXT STEPS … FURTHER COLLABORATION AND RESEARCH: LABORATORY ON "MORE AND DEEPER RENOVATION"

The GBPN have established a knowledge platform for collaboration on deep renovation, the "Laboratory on More and Deeper Renovation". The platform will consist of a discussion forum and an interactive research tool where project results and findings can be presented, discussed and clarified. This platform will be part of the GBPN website.

The laboratory will comprise of different subsections that are organised into themes, these will be used to discuss current topics in detail. The laboratory's subsections will be used to introduce different topics that will help to upscale and deepen renovations, GBPN propose some of these topics:

- DR definitions.
- Best practice DR criteria for building projects.
- Best practice policy packages that support up scaling DRs.
- Barriers & Costs of DR projects.

These topics will change over time as the research develops. All material gathered from the website during discussions (including comments, feedback and information) will be used to enhance GBPN's on-going research.

The next step for the GBPN is to use the information and advice gathered in the collaboration forums of the laboratory, the DR definitions and further research to develop criteria for selecting best practices for individual projects or groups of buildings. GBPN will then identify and analyse best practices in DR policy packages that support the upscaling of deep renovations.

The GBPN call for action and collaboration from different global and regional actors involved in deep renovation. The knowledge platform is an online space that:

- Encourages anyone interested in deep renovation to become involved and share his or her knowledge and ideas.
- Supports DR policy development and informs how we can begin to implement deep renovations globally.
- Contains material not only from the GBPN network but also from other organisations and partners.

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Glossary

AERG – Advanced Energy Retrofit Guides
CO_2 – Carbon dioxide
DHW – Domestic hot water
DOE – US Department of Energy
DR – Deep renovation/refurbishment/retrofit
EED – EU Energy Efficiency Directive
EPBD – EU Energy Performance Building Directive
ESCO – Energy Service Company
EU – European Union
GBPN – Global Buildings Performance Network
GHG – Greenhouse gas
HVAC – Heating, ventilation, and air conditioning
kW – Kilowatt
kWh – Kilowatt-hour
MEP – Member of the European Parliament
nZEB – Nearly Zero Energy Building
O&M – Operations & Maintenance
US – United States