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International Energy Agency

EBC Annex 56 Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation

Project Summary Report

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International Energy Agency

EBC Annex 56 Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation

Project Summary Report

Edited by

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Cover picture: Examples of cost-effective energy and carbon emissions optimization in building renovations
Source: University of Minho

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Project Summary

Existing buildings present a tremendous potential, not only to reduce energy use and emissions, but also on other areas of the political agenda. In many developed countries, the renovation of the existing building stock is a relevant and important part of the actions to deal with climate change mitigation. Regardless of this significant potential, it has been hard to fully exploit it.
Several standards and regulations related to energy consumption, mainly developed over the current century, have increased the levels of exigency, supported by energy efficiency measures involving a significant investment in envelope and building systems, as well as on-site generation of energy from renewable sources. However, the application of existing standards and regulations in building renovation, with requirements and measures adopted from new buildings, often result in expensive processes and complex procedures hardly recognized by users, owners and promoters.

In existing buildings, from a cost-benefit perspective, the optimal balance between measures to reduce energy use and energy harvesting from renewable sources, will be different from the case of new buildings, as well as between the various types of existing buildings with very different technical, functional, cultural and economic constraints.

It is then relevant to investigate the balance between these two kinds of measures in order to discover how to achieve the best results (reduction of energy use, reduction of carbon emissions, comfort improvement, overall added value) with less effort (financial investment, depth and duration of the intervention, user's disturbance).

EBC Annex 56 project explored the cost-effective optimization of energy use and carbon emissions related building renovation. The project investigated the best balance between the highest efficiency of the buildings' envelope, the technical building systems and deployment of renewable energy[1], considering the following purposes:

- Definition of a methodology for the establishment of cost optimized targets for energy use and carbon emissions in building renovation;
- Clarification of the relationship between the emissions and the energy targets and their eventual hierarchy;
- Determination of the cost-effective combinations of energy efficiency

[1] Only specific RES systems were taken into account in the investigations, namely geothermal and air-water heat pumps, wood pellets and wood logs heating systems, solar thermal and photovoltaic systems and also some existing district heating systems with a variable share of renewables.

measures and carbon emissions reduction measures;

– Highlight the relevance of the additional benefits (co-benefits[2]) achieved in the renovation process;
– Development and/or adaption of tools to support the decision makers in accordance with the methodology developed;
– Selection of exemplary case-studies to encourage decision makers to promote efficient and cost-effective renovations in accordance with the objectives of the project.

The methodology (graphically shown in Figure 1 its basic concept) has been developed to be used by interested private entities and agencies for their renovation decisions as well as by governmental agencies for the definition of regulations and their implementation, in line with EBCs mission of developing and facilitating the integration of technologies and processes for energy efficiency towards near-zero energy and carbon emissions in the built environment.

The methodology outlined draws among other sources from the newest developments within the recast of the Energy Performance of Buildings Directive (EPBD) of the European Union and methodology development in International Energy Agency (IEA) Solar Heating and Cooling Performance (SHC) activity in EBC project, 'Annex 52: Towards Net Zero Energy Solar Buildings'.

The developed methodology provides the basis for the assessment and evaluation of packages of renovation measures, which intend to improve the energy performance of existing buildings (Ott, W. et al., 2017). It includes the possibilities of going beyond the cost-optimal level until the limit of the cost-effective reduction of energy and carbon emissions. Additionally, it includes a methodological framework for the integration of embodied energy use in the lifecycle impact assessment (Lasvaux, S. et al., 2017) and also for considering the additional benefits (co-benefits) (Almeida, M. et al., 2017) and the overall added value achieved in the renovation process.

With the objective of making further use of the methodology, we have adapted several existing tools and developed a new tool to support the various decision makers in their renovation strategies or in evaluating and optimizing renovation measures for reaching and defining nearly-zero carbon emissions in buildings renovation (Romagnoni, P. et al., 2017).

[2] Co-benefits refer to all benefits (as well as to possible negative co-effects of energy related measures) resulting from energy efficiency related renovation measures and deployment of renewable energy besides the direct benefits like less energy use, reduced carbon emissions and energy cost reductions. Often, co-benefits are relevant or even decisive for overall value added by energy related building renovation (difference in the market value of the building before and after improvement of its energy performance) but are not integrated adequately in the decision making processes for the particular renovation project. Co-benefits of energy related renovation accrue on the building level for the building owner or user (like increased user comfort, fewer problems with building physics, improved aesthetics, ...) as well as on the society or macroeconomic level (like health benefits, job creation, energy security, impact on climate change, ... For additional information see (Almeida, M., et al., 2017), available online in http://www.iea-annex56.org/

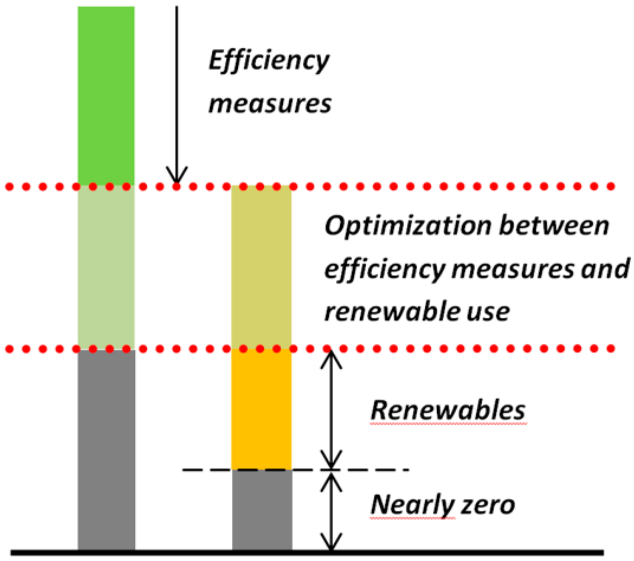

Figure 1. Concept for an optimized combination of energy efficiency measures and renewable energy measures in building renovation with a nearly-zero energy and emissions target (Geier S., Ott W.)

The development of the methodology and related investigations have been supported by significant feedback from realized, on-going or intended renovation projects, which have been investigated on a scientific basis (Mørck, O. et al., 2017; Venus, K. & Höfler, K., 2017; Blomsterberg, A. et al., 2016). The application of methodology on these buildings allowed us to develop guidelines presenting relevant and useful recommendations for the main target groups of the project that are professional building owners and policy makers (Almeida, M. & Ferreira, M., 2017a; 2017b).

The need of a new approach to building renovation has been consolidated by the results of the investigations carried out. This new approach to the large-scale renovation of the existing building stock relies on three major pillars, namely:

– To consider a life-cycle perspective;
– To take adequately into account carbon emissions in addition to primary energy;
– To take into account achievable co-benefits.

Investigations carried out on the results achieved by existing renovated buildings and also from parametric calculations using the developed methodology with the simulation of diverse renovation scenarios, reveal the potential for cost-effective renovations achieving primary energy reductions of 37% to 97% and carbon emissions reduction of 47% to 92% (Mørck, O. et al., 2017; Venus, K. & Höfler, K., 2017; Bolliger R. & Ott, W., 2016). Considering that buildings are responsible for a significant share of world energy use and emissions, the expected impacts of a large scale deployment of ambitious, yet cost-effective, building renovation combining energy efficiency measures and the use of renewable energy are therefore very relevant.

Several issues relating with the conclusions and findings from the project remain to be investigated, including:

- The comparison between district heating and decentralized heating;
- Building renovation with focus on zero emissions;
- Strategies and methods to overcome barriers to low energy and emissions building renovation.

The project has been developed in constant contact with the industry by the organization of several workshops in the participating countries, with the scientific community by the participation in national and international conferences, and particularly in collaboration with EBC project, 'Annex 57: Evaluation of Embodied Energy & Carbon Dioxide Emissions for Building Construction' in what concerns embodied energy consideration and Life Cycle Assessments (LCA).

Project duration
2012 - 2017 (completed)

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Project Outcomes

1. Background

Building sector has become an important target for carbon emissions reduction, energy consumption and resources depletion due to its relevance in all these important areas. Many of the energy related policies have their main focus on new buildings but, due to low rates of replacement of the existing buildings, it is crucial that energy performances in existing buildings are improved.

Most of these buildings are not able to reach the new energy standards due to design and construction constraints. The achievement of significant reductions of energy consumption and carbon emissions may not always require a highly efficient solution for the envelope, which sometimes involves complex construction works that discourage the owners. In fact, the use of renewable energy sources harvested on site may also be used to foster the reduction of non-renewable energy consumption and also the reduction of carbon emissions.

The main challenge is to understand how far it is possible to go with energy conservation and efficiency measures, and when start using renewable energy becomes more efficient. Thus, we have developed a new methodology to be used in the decision making process for energy related building renovation, allowing to find a cost-effective balance between energy consumption, carbon emissions and overall added value achieved in the renovated building.

2. Objectives

The objectives of the project were to:

- define a methodology for establishing cost optimized targets for energy consumption and CO_2 emissions in building renovation,
- clarify the relationship between CO_2 emissions and energy targets and their eventual hierarchy,
- determine cost effective combinations of energy efficiency and renewable energy supply measures,
- highlight additional benefits achieved in the renovation process,
- develop tools to support decision makers in accordance with the developed methodology, and
- select exemplary case studies to encourage decision makers to promote efficient and cost effective renovations.

3. Methodology and Scope

The project scope is residential buildings and office buildings without complex HVAC technologies. It aims at defining and assessing energy renovation activities in a cost-effective way, optimizing the energy use and carbon emissions reduction. The methodology explores the full scope of cost-effective reduction of carbon emissions and energy use, going beyond the cost-optimal level by considering co-benefits and the overall added value achieved in the renovation process (Ott, W. et al., 2017).

Figure 2 shows a generic graphic definition of the life-cycle cost (LCC) evaluation. The project focuses on the measures with energy performance beyond the cost-optimal renovation scenarios, approaching the zero energy and the zero carbon emissions levels. The goal is to start with the cost-optimal approach and go further, balancing energy efficiency measures and the use of renewable energy sources to reach the lowest energy use and carbon emissions level, lowest embodied energy in materials and the most achievable co-benefits associated to the renovation process.

The methodology uses a life-cycle costs approach, balancing the energy consumption

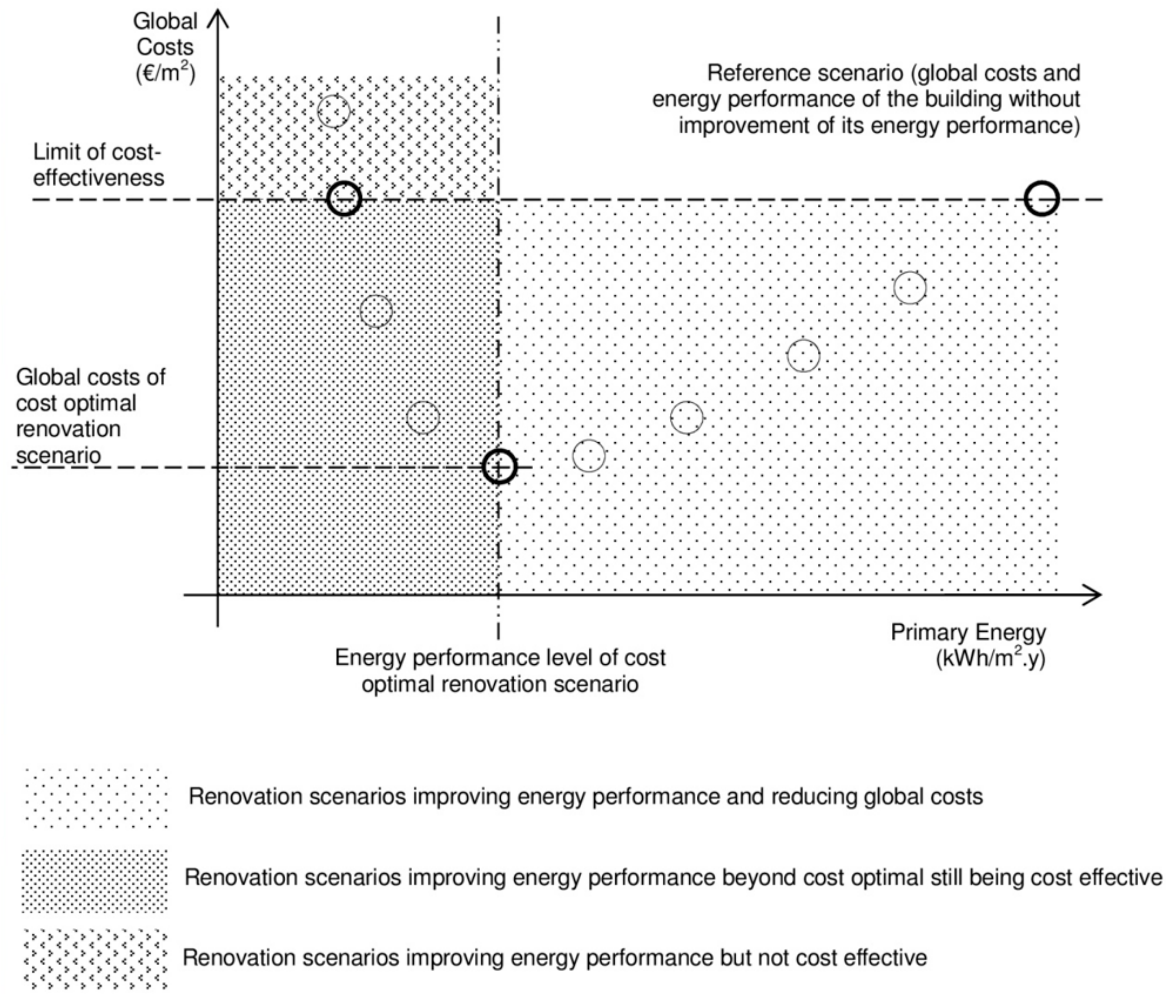

Figure 2. Identification of cost-optimal and cost-effective level of energy performance

and global costs for a life-cycle of 30 to 60 years, for each analysed renovation scenario. The comparison between the renovation scenarios is always related to a reference case, known as “anyway renovation”, which means a renovation that does not consider any energy related improvements.

To perform the assessment, different renovation scenarios improving the energy performance of the building envelope combined with the use of different combinations of building integrated technical systems are created, and their energy use, related carbon emissions and global costs are calculated.

In order to include the environmental impact of the solutions in the LCC, a simplified LCA may be performed allowing assessing the global warming potential and the embodied energy of related to each renovation scenario. With these results, not only the energy and carbon emissions related to building operation are considered in the assessment but also those related with the materials used in the renovation process (Lasvaux, S. et al., 2017).

Furthermore, we have also adopted a qualitative way of relating the energy renovation measures with the co-benefits that potentially result from the application of those measures. The owner/user’s interests are considered by placing their willingness to pay for added co-benefits against the results from the LLC assessment (Almeida, M. et al., 2017).

4. Investigation and Results

The developed methodology has been used to investigate the balance between energy efficiency measures and the use of renewable energy measures, searching for the most cost-effective strategy to renovate existing buildings to low energy performance levels on several buildings from the participating countries. These include real buildings that have undergone energy related renovations (Mørck, O. et al., 2017; Venus, K. & Höfler, K., 2017) and also generic buildings that are characteristic of significant portions of the existing building stock of the participating countries (Bolliger R. & Ott, W., 2016).

For each investigated case study, parametric calculations were performed to identify the cost-effective renovation packages. The parametric studies were performed based on the developed methodology, including LCC and LCA. After, the several renovation packages were also analysed considering the co-benefits that potentially result from the combination of the selected renovation measures.

Considering the objectives of the project and the application of the methodology to the generic buildings earlier defined, the following five main hypotheses were formulated and after validated with real data from the case studies analysed from a life-cycle costs perspective:

– Hypotheses #1 - The energy performance of the building after renovation rather depends more on how many building elements are renovated than on the energy efficiency level reached by each individual building element: this is largely confirmed in different country contexts, mainly in the generic buildings. The findings reflect the fact that the first few cm of insulation added have the highest impact in reducing the U-value of a certain building element.

– Hypotheses #2 - A switch to renewable energy systems (RES) reduce emissions more significantly than energy efficiency measures on one or more envelope elements: this is clearly confirmed in the generic buildings and in the case studies for the investigated RES and climatic zones. It is important to notice that only some types of systems using RES were taken into account in the different case studies. Results indicate that considering also costs, it is favourable to switch the heating system to RES and, at the same time, renovate the building envelope to a cost-effective level instead of first insulating the envelope to a maximum level and then cover the remaining energy needs with renewable energy.
– Hypotheses #3 - A combination of energy efficiency measures with RES does not change significantly the cost-optimal efficiency level: this is confirmed for a large share in both the generic buildings and the real case studies. Results indicate that, if measures reducing energy needs are combined with the replacement of the heating systems, there are synergies between the energy efficiency measures and renewable energy measures. Synergies result if demand side measures reduce peak capacity of the heating systems, once this reduces the RES costs.
– Hypotheses #4 - Synergies are achieved when a switch to RES is combined with energy efficiency measures: this is confirmed without exception for all generic buildings investigated and for most of the case studies analysed. Results are a further indication of synergies that exist between RES and energy efficiency measures and that cost-effective renovation does not mutually exclude RES based measures and energy efficiency measures. For using synergies it is important that the heating system is not replaced before energy efficiency measures are carried out.
– Hypotheses #5 - To achieve high emissions reductions, it is more cost-effective to switch to RES and carry out less far-reaching renovations on the building envelope than to focus primarily on energy efficiency measures alone: this is fully confirmed for most generic buildings and case studies investigated.

These findings may lead to reappraising the basic strategies for ambitious energy related renovation of existing buildings. Since costs are a major challenge and barrier for ambitious building renovations, it is crucial to consistently exploit the range of cost minimizations while still ensuring the achievement of ambitious energy savings and carbon emissions mitigation targets. As explained above, this can be a reason for a change in priorities among RES deployment and energy efficiency improvements within building renovation processes (Bolliger R. & Ott, W., 2016).

The evaluation of the embodied energy and embodied carbon emissions in building renovation is part of the overall methodology of the project. It is possible to include or exclude the embodied energy and embodied carbon emissions in the LCC calculations in order to make the methodology flexible. The main objective of the LCA in detailed case studies was to determine the relevance of the embodied energy in materials in building renovation. Global results show that the inclusion of embodied energy and carbon emissions in the methodology does change neither the cost-effective solutions nor the best renovation packages in terms of total primary energy and carbon emissions. Indeed, the inclusion of embodied energy and carbon emissions in the assessment only influences the achievable reductions depending on the embodied energy and carbon emissions of the measures applied (Lasvaux, S. et al., 2017).

Considering the co-benefits achieved with the energy related renovation measures, all main elements of the building envelope should be improved to a minimum energy performance level, in accordance with the local climate, in order to maximize these co-benefits. In most cases, this improvement represents just a small increase in the global costs when compared with the cost-optimal solution and it is still cost-effective when compared with the "anyway" renovation (Almeida, M. et al., 2017).

The results from the investigations point out the need of a new approach to the large-scale renovation of the existing building stock. This new approach relies on three major pillars, namely: to consider a life-cycle perspective, to take adequately into account carbon emissions in addition to primary energy and to take into account achievable co-benefits (Almeida, M. & Ferreira, M., 2017b).

Pillar #1 - Buildings are in general long lasting structures, their renovation implies large investments and the development of long-term strategies considering a life cycle approach is necessary. In order to achieve the long-term carbon emissions targets needed to mitigate climate change, in line with the objectives of the Paris Agreement, acting only on new buildings is not enough, mainly because of the low rate of replacement of the existing building stock. Switching conventional heating systems to renewable energy, increasing the extent of energy related renovation whenever one or more building elements are in need of refurbishment "anyway" and making use of the potential of the buildings for using solar energy to produce electricity, represents the biggest potential for energy savings and carbon emissions reductions in the building sector. Improving the energy performance of a building and switching to RES, is not just a contribution to mitigating climate change and to saving resources. This often saves costs. The analysis of the cost-effectiveness of a certain package of renovation measures is done using a cost/benefit analysis by several possible methods. The simplest method is the simple payback method calculation, where the payback period is the length of time required to recover the cost of an investment and the longer these periods are, the less attractive such investments are. The simple payback does not take into account any benefits or costs that occur after the initial investment has been recovered and, therefore, there is a tendency for the cheapest solutions to become the most attractive ones. This simplified analysis leads to the missed opportunity of improving the buildings' energy performance in a more effective way. Nevertheless, this analysis is frequently used in standards and national regulations. On the other hand, the LCC analysis may include the total lifespan of the building or the period for which the renovation is being planned. Costs and benefits of each alternative are analysed along their life time and expressed in annualized costs or net present value. It includes the investment costs, energy costs, operation and maintenance costs and any residual value of the building at the end of the period considered in the analysis. LCC analysis is an adequate approach because it accounts for all cash outflows and inflows over the period under analysis and it discounts the value of the money to adjust the cash to its present value.

Pillar #2 - Carbon emissions need to be considered in target setting and standards at least at the same level as energy. The investigations carried out during the development of this project showed that there is, in general, a large potential for cost-effective renovations that reduce both carbon emissions and non-renewable primary energy use. Both energy efficiency measures and measures to promote the use of renewable energy sources can contribute to these objectives. It was observed that renewable energy measures often have the potential to reduce carbon emissions more powerfully and at lower costs than energy efficiency measures, which underlines the importance of more strongly taking into account renewable energy measures in future policy making. Nevertheless, important reasons were also identified to justify carrying out energy efficiency measures, especially those beyond the cost-optimal level. Among these reasons, can be pointed out the thermal comfort and other co-benefits such as noise protection or reduced pathologies.

Pillar #3 - Co-benefits resulting from energy and carbon optimized building renovations (like increased user comfort, fewer problems with building physics, etc.), have to be identified and combined with the impacts of carbon emissions and energy reduction measures in the decision making process. The renovation of the existing building stock, improving significantly its energy performance, can deliver a broad range of co-benefits to the inhabitants of the buildings and to society. However, the evaluation of the benefits from energy related renovation programmes and policies focuses mainly on energy savings, leading to the underestimation of the positive impacts of building renovation, which may lead to sub-optimal investment decisions and policy design. While co-benefits could act as a driver for building renovation, the fact is that they are not adequately perceived by the users benefitting from them or by the investors taking the renovation decisions. The problem also extends to specialists supporting investment decisions: Energy specialists tend to focus solely on energy-related effects such as primary energy consumption and costs and professionals from other fields (such as health professionals or economists) are unlikely to be consulted in the context of building renovations. This means that information to increase the perception of co-benefits, as well as interdisciplinary cooperation, is needed to fully take into account the extent of the non-energy benefits and to let them influence investment decisions and policy design.

5. Recommendations

The work developed within this project allowed to formulate a set of recommendations that should be considered by policy makers in the definition and design of new policy programs and regulations and by building owners when defining their building renovation strategies.

Recommendation # 1 - Introduce new targets to reduce carbon emissions in addition to existing energy targets

The setting of an emissions related target supplementing existing energy targets would allow overall cost optimization and maximum freedom of choice. It would provide freedom to select the most appropriate energy related measures within building renovation to reach related targets. Energy efficiency requirements of the building envelope are particularly suited up to the cost-optimal levels of the building envelope; beyond that point, it is advantageous to put the focus on nearly-zero emissions or nearly-zero non-renewable energy use. The choice between energy saving measures, increasing energy efficiency and deployment of renewable energy for a particular building will then depend on the prerequisites of the building, on the framework conditions and on the cost/benefit ratios of possible measures.

For building owners, in addition to carrying out energy efficiency improvements in building renovation, it makes sense to consider reaching nearly-zero emissions in existing buildings, to make an important contribution to protect the climate.

For policy makers, it is advisable to introduce a target to reach nearly-zero carbon emissions in existing buildings undergoing a major renovation, complementing existing energy efficiency requirements. If this is not cost-effective, for example because the heating system would not have to be replaced anyway in the near future, exceptions can be made or subsidies can be allocated for these cases considering the co-benefits from a macroeconomic perspective. For buildings connected to a district heating system, it is possible to reach the goal of nearly-zero carbon emissions collectively by transforming the energy source of the district heating system. In such cases it is advisable to develop the most favourable strategy in cooperation with building owners.

Recommendation # 2 - Shift to technical systems based on renewable energy

In terms of single measures, the most significant measure to reduce carbon emissions from energy use in buildings is often a switch of the heating system to renewable energies. It is also in many cases a cost-effective measure.

For building owners, before a conventional heating system is replaced by one with the same energy carrier, it is advisable to take into consideration a switch of the heating system to renewable energy; in many cases, this is ecologically and economically attractive over a life-cycle perspective. For buildings connected to a district heating system, it is advisable to take into account the current energy mix of the district heating system and the possibility that a switch to renewable energies may occur in the future for the entire district heating system.

For policy makers, it is adequate to make a switch to renewable energy mandatory when a heating system is replaced, similarly to energy improvements of the building envelope. Exemptions may still be granted from such a rule if the building owner can show that such a measure would not be cost-effective from a life-cycle perspective, or subsidies can be allocated for these cases considering the co-benefits from a macroeconomic perspective. Exemptions could also be made if a building is connected to a district heating system which either already has a high share of renewable energy or for which a plan exists to switch to renewable energy.

Recommendation # 3 - Make use of synergies between renewable energy measures and energy efficiency measures

The moment when a heating system needs to be replaced, is an ideal moment to carry out a major renovation involving both the heating system and one or more elements of the building envelope. This allows creating synergies between renewable energy measures on the one hand and energy efficiency measures on the other hand.

For building owners, the replacement of the heating system is an excellent opportunity to carry out renovation measures on the building envelope as well, creating synergies. If carried out together, the investments in the building envelope result in savings on the investment costs for the heating system, because the more energy efficient a building is, the smaller can be the dimension of this system. Furthermore, several measures of the building envelope are preferably combined. It is necessary to look in each case separately, to what extent it makes sense to postpone or schedule earlier than necessary renovation measures of some building envelopes, in order to make use of such synergies.

For policy makers, it is recommendable that standards and other policy measures (for example subsidies), create incentives to combine renovation measures on the building envelope with a replacement of the heating system, in order to make sure that reductions in energy use and emissions are achieved most efficiently. Exceptions could be made for buildings connected to a district heating system, which already has a high share of renewable energy or for which a switch of the district heating system to renewable energy sources is already planned.

Recommendation # 4 - Shift from cost-optimality to cost-effectiveness

Since in building renovation cost-optimal solutions do not result in nearly-zero energy buildings, it is indispensable to go a step further and tap the full potential of cost-effective energy related renovation measures with respect to a reference case.

For building owners, to obtain the largest possible impact from building renovation in terms of contributing to the reduction of carbon emissions or primary energy use, it is advisable to carry out the furthest possible reaching renovation package which is still cost-effective when compared to the reference case, rather than to limit oneself to the cost-optimal renovation package. Taking into account the co-benefits, it is possible to extend the renovation measures that are considered cost-effective even further.

For policy makers, it is recommendable that standards do not limit themselves to make an energy performance level mandatory up to the cost-optimal level but to make also further measures mandatory as long as they are cost-effective with respect to a reference case.

Recommendation # 5 - Make use of opportunities when renovations are made "anyway"

The need to renovate buildings' envelope or their technical installations represents an opportunity for improving energy performance. Many energy efficiency measures are profitable when a renovation of the related building elements is needed anyway to restore their functionality. For example, repainting or repairing a wall, or making a roof waterproof again. In such a case, the life-cycle costs of a scenario with an energetic improvement of the building performance can be compared with a scenario in which only the functionalities are restored. The actual costs of the energy measures will then only comprise the difference between these two scenarios.

For building owners, whenever a renovation of an element of the building envelope or of the building integrated technical systems needs to be carried out anyway, this is a good opportunity to improve the energy performance but also to improve other building envelope elements. This option, besides the energy and costs benefits, maximizes the co-benefits from the intervention and consequently the added value to the building.

For policy makers, it makes sense that standards for achieving improvements in energy performance focus on the situation when one or more building elements are in need of renovation anyway. An understanding of the current status of the building stock is essential to clearly define the strategy and timing for building renovation.

Recommendation # 6 - Take into account the complexity of building renovation in standards, targets, policies and strategies, introducing flexibility into regulations

A large number of factors have an influence on determining which measures for a reduction of energy use and carbon emissions mitigation are technically possible and economically viable for the renovation of a given building. The identification of cost-effective solutions yielding far reaching energy or carbon emissions reductions is therefore more complex than for new buildings. At the same time, the need to identify such least-cost paths and to tailor requirements accordingly is high.

For building owners, the complexity of building renovation and the large investments needed require the development of long-term strategies for maintenance, energy improvements and carbon emissions improvements for each building, taking into account their specific situation and also considering the co-benefits from these interventions. It is advisable to develop either a strategy towards a major renovation or a strategy to renovate the building in steps over the years. In the latter case, the measures which are undertaken in one step ideally already include the preparation of further renovations in the future.

For policy makers, to achieve a large reduction in energy use and carbon emissions in existing buildings most effectively, it is important that standards, targets and policies take into account the complexity of building renovation while seeking for cost-effective solutions. Flexibility is needed to give renovation strategies a chance to enable the transformation of the building stock towards low energy use and a nearly-zero emissions level. This includes the flexibility to reach these targets step by step over time.

Project Participants

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Finland	VTT – Technical Research Center of Finland
Italy	IUAV - University of Venice Politecnico di Milano, Building Environment Science & Technology
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Country	Organisation
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Sweden	Lund University
Switzerland	econcept AG, Zürich University of Applied Sciences Western Switzerland

Project Publications

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EBC and the IEA

The International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster international co-operation among the 31 IEA participating countries and to increase energy security through energy research, development and demonstration in the fields of technologies for energy efficiency and renewable energy sources.

The IEA Energy in Buildings and Communities Programme

The IEA co-ordinates international energy research and development (R&D) activities through a comprehensive portfolio of Technology Collaboration Programmes. The mission of the IEA Energy in Buildings and Communities (IEA EBC) Programme is to develop and facilitate the integration of technologies and processes for energy efficiency and conservation into healthy, low emission, and sustainable buildings and communities, through innovation and research. (Until March 2013, the IEA EBC Programme was known as the IEA Energy Conservation in Buildings and Community Systems Programme, ECBCS.)
The R&D strategies of the IEA EBC Programme are derived from research drivers, national programmes within IEA countries, and the IEA Future Buildings Forum Think Tank Workshops. These R&D strategies aim to exploit technological opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy efficient technologies. The R&D strategies apply to residential, commercial, office buildings and community systems, and will impact the building industry in five areas of focus for R&D activities:

- Integrated planning and building design
- Building energy systems
- Building envelope
- Community scale methods
- Real building energy use

The Executive Committee

Overall control of the IEA EBC Programme is maintained by an Executive Committee, which not only monitors existing projects, but also identifies new strategic areas in which collaborative efforts may be beneficial. As the Programme is based on a contract with the IEA, the projects are legally established as Annexes to the IEA EBC Implementing Agreement. At the present time, the following projects have been initiated by the IEA EBC Executive Committee, with completed projects identified by (*):

Annex 1:	Load Energy Determination of Buildings (*)
Annex 2:	Ekistics and Advanced Community Energy Systems (*)
Annex 3:	Energy Conservation in Residential Buildings (*)
Annex 4:	Glasgow Commercial Building Monitoring (*)
Annex 5:	Air Infiltration and Ventilation Centre
Annex 6:	Energy Systems and Design of Communities (*)
Annex 7:	Local Government Energy Planning (*)
Annex 8:	Inhabitants Behaviour with Regard to Ventilation (*)
Annex 9:	Minimum Ventilation Rates (*)
Annex 10:	Building HVAC System Simulation (*)
Annex 11:	Energy Auditing (*)
Annex 12:	Windows and Fenestration (*)
Annex 13:	Energy Management in Hospitals (*)
Annex 14:	Condensation and Energy (*)
Annex 15:	Energy Efficiency in Schools (*)
Annex 16:	BEMS 1- User Interfaces and System Integration (*)
Annex 17:	BEMS 2- Evaluation and Emulation Techniques (*)
Annex 18:	Demand Controlled Ventilation Systems (*)
Annex 19:	Low Slope Roof Systems (*)
Annex 20:	Air Flow Patterns within Buildings (*)
Annex 21:	Thermal Modelling (*)
Annex 22:	Energy Efficient Communities (*)
Annex 23:	Multi Zone Air Flow Modelling (COMIS) (*)
Annex 24:	Heat, Air and Moisture Transfer in Envelopes (*)
Annex 25:	Real time HVAC Simulation (*)
Annex 26:	Energy Efficient Ventilation of Large Enclosures (*)
Annex 27:	Evaluation and Demonstration of Domestic Ventilation Systems (*)
Annex 28:	Low Energy Cooling Systems (*)
Annex 29:	Daylight in Buildings (*)
Annex 30:	Bringing Simulation to Application (*)
Annex 31:	Energy-Related Environmental Impact of Buildings (*)

Annex 32: Integral Building Envelope Performance Assessment (*)
Annex 33: Advanced Local Energy Planning (*)
Annex 34: Computer-Aided Evaluation of HVAC System Performance (*)
Annex 35: Design of Energy Efficient Hybrid Ventilation (HYBVENT) (*)
Annex 36: Retrofitting of Educational Buildings (*)
Annex 37: Low Exergy Systems for Heating and Cooling of Buildings (LowEx) (*)
Annex 38: Solar Sustainable Housing (*)
Annex 39: High Performance Insulation Systems (*)
Annex 40: Building Commissioning to Improve Energy Performance (*)
Annex 41: Whole Building Heat, Air and Moisture Response (MOIST-ENG) (*)
Annex 42: The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (FC+COGEN-SIM) (*)
Annex 43: Testing and Validation of Building Energy Simulation Tools (*)
Annex 44: Integrating Environmentally Responsive Elements in Buildings (*)
Annex 45: Energy Efficient Electric Lighting for Buildings (*)
Annex 46: Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (*)
Annex 47: Cost-Effective Commissioning for Existing and Low Energy Buildings (*)
Annex 48: Heat Pumping and Reversible Air Conditioning (*)
Annex 49: Low Exergy Systems for High Performance Buildings and Communities (*)
Annex 50: Prefabricated Systems for Low Energy Renovation of Residential Buildings (*)
Annex 51: Energy Efficient Communities (*)
Annex 52: Towards Net Zero Energy Solar Buildings (*)
Annex 53: Total Energy Use in Buildings: Analysis and Evaluation Methods (*)
Annex 54: Integration of Micro-Generation and Related Energy Technologies in Buildings (*)
Annex 55: Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance and Cost (RAP-RETRO) (*)
Annex 56: Cost Effective Energy and CO_2 Emissions Optimization in Building Renovation (*)
Annex 57: Evaluation of Embodied Energy and CO_2 Equivalent Emissions for Building Construction (*)
Annex 58: Reliable Building Energy Performance Characterisation Based on Full Scale Dynamic Measurements (*)
Annex 59: High Temperature Cooling and Low Temperature Heating in Buildings (*)
Annex 60: New Generation Computational Tools for Building and Community Energy Systems (*)
Annex 61: Business and Technical Concepts for Deep Energy Retrofit of Public Buildings (*)
Annex 62: Ventilative Cooling (*)
Annex 63: Implementation of Energy Strategies in Communities
Annex 64: LowEx Communities - Optimised Performance of Energy Supply Systems with Exergy Principles (*)
Annex 65: Long-Term Performance of Super-Insulating Materials in Building Components and Systems (*)
Annex 66: Definition and Simulation of Occupant Behavior in Buildings (*)
Annex 67: Energy Flexible Buildings (*)
Annex 68: Indoor Air Quality Design and Control in Low Energy Residential Buildings (*)
Annex 69: Strategy and Practice of Adaptive Thermal Comfort in Low Energy Buildings (*)
Annex 70: Energy Epidemiology: Analysis of Real Building Energy Use at Scale
Annex 71: Building Energy Performance Assessment Based on In-situ Measurements (*)
Annex 72: Assessing Life Cycle Related Environmental Impacts Caused by Buildings (*)
Annex 73: Towards Net Zero Resilient Energy Public Communities (*)
Annex 74: Competition and Living Lab Platform (*)
Annex 75: Cost-effective Building Renovation at District Level Combining Energy Efficiency and Renewables (*)
Annex 76: Deep Renovation of Historic Buildings Towards Lowest Possible Energy Demand and CO_2 Emissions (*)
Annex 77: Integrated Solutions for Daylight and Electric Lighting (*)
Annex 78: Supplementing Ventilation with Gas-phase Air Cleaning, Implementation and Energy Implications

Annex 79:	Occupant-centric Building Design and Operation
Annex 80:	Resilient Cooling
Annex 81:	Data-Driven Smart Buildings
Annex 82:	Energy Flexible Buildings towards Resilient Low Carbon Energy Systems
Annex 83:	Positive Energy Districts
Annex 84:	Demand Management of Buildings in Thermal Networks
Annex 85:	Indirect Evaporative Cooling
Annex 86:	Energy Efficient Indoor Air Quality Management in Residential Buildings
Annex 87:	Energy and Indoor Environmental Quality Performance of Personalised Environmental Control Systems
Annex 88:	Evaluation and Demonstration of Actual Energy Efficiency of Heat Pump Systems in Buildings
Annex 89:	Ways to Implement Net-zero Whole Life Carbon Buildings
Annex 90:	Low Carbon, High Comfort Integrated Lighting
Annex 91:	Open BIM for Energy Efficient Buildings
Working Group -	Energy Efficiency in Educational Buildings (*)
Working Group -	Indicators of Energy Efficiency in Cold Climate Buildings (*)
Working Group -	Annex 36 Extension: The Energy Concept Adviser (*)
Working Group -	HVAC Energy Calculation Methodologies for Non-residential Buildings (*)
Working Group -	Cities and Communities (*)
Working Group -	Building Energy Codes

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