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INSPIRATION AND EXPERIENCES FROM THE JOINT ANALYSIS OF SHINING EXAMPLES OF COMPREHENSIVE ENERGY RENOVATION BUILDING PROJECTS WITHIN IEA EBC ANNEX 56

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Abstract

The International Energy Agency established in 2011 an Implementing Agreement within the Energy in Buildings and Communities Program to undertake research and provide an international focus on Cost Effective Energy and Carbon Emissions Optimization in Building Renovation (EBC Annex 56). The project aimed at developing a new methodology to enable cost effective renovation of existing buildings while optimizing energy consumption and carbon emissions reduction. Gathering of case studies was one of the activities undertaken to reach the overall project objectives. Among the case studies, a selection of "Shining Examples" was made to encourage decision makers to promote efficient and cost effective renovations. This paper presents the results of the analyses made on these Shining Examples.

Keywords - case studies, energy renovation, barriers and constraints, anyway renovation, RUE/RES balance, co-benefits

1. Introduction

Within IEA EBC Annex 56 [1], the gathering of case studies is one of the activities undertaken to reach the overall project objectives, because it is a recognized fact that the process of decision-making has to be strongly supported by success stories from real life and experiences and lessons learned from practice.

The specific mission of the case study activity of the Annex 56 project is to provide significant feedback from practice (realised, ongoing or intended renovation projects) on a scientific basis. The main objectives of this work are:

- To understand barriers and constraints for high performance renovations by a thorough analysis of the case studies and feedback from practice in order to identify and show measures to overcome them;
- To align the methodology developed in Annex 56 with practical experiences;
- To support decision-makers and experts with profound, scientific based information (as result of thoroughly analysed case-studies) for their future decisions;
- To show successful renovation projects in order to motivate decision-makers and stimulate the market.

The 19 case Studies gathered within Annex 56 were studied at two different levels. Level 1 – the "Shining Examples" and level 2 – the "Detailed Case Studies. Within level 1, 18 "Shining Examples" of the 19 case studies were selected to encourage decision makers to promote efficient and cost effective renovations is provided. In level 2 a deeper analysis was performed on 6 of the 19 case studies in order to evaluate the impact and relevance of different renovation measures and strategies within the project. This paper will focus on the "Shining Examples", gathered mainly for motivation and stimulation purposes, highlighting the advantages of the energy and carbon emissions cost optimized renovation.

2. Shining Examples collected

The compilation of Shining Examples has been documented in a "brochure", which presents the Shining Examples in a fixed format showing for each project pictures and easily comprehensible graphics, highlighting the added value of the renovation. The brochure published by the project [2] presents 18 Shining Examples from 9 countries. Table 1 presents an overview of the collected Shining Examples.

3. Analyses of Shining Examples

A cross-section analysis of the Shining Examples has been carried out to identify similarities, differences and general findings. The results of this analysis are presented in 5 sections covering: barriers/solutions, anyway measures, rational use of energy/renewable energy supply (RUE/RES) balance of measures, co-benefits and country/climate specific measures.

3.1 Barriers/Solutions

The implementation of energy renovation projects in the building sector is not just a technical and/or economical matter. It involves the users/inhabitants/owners of the buildings, whom in some cases have to leave the buildings for a shorter or longer period. Additionally, those who pay for the energy renovation are not always those who benefit from it. Therefore, energy renovation projects often run into barriers that may hold up the project. It is then necessary that owners, technical consultants and policy makers find solutions to overcome these barriers.

Table 1. The 18 Shining Examples collected and documented

	Country	Site	Building type
	AUSTRIA	Bruck an der Mur	Non residential
	AUSTRIA	Kapfenberg	Multi family
	CZECH REPUBLIC	Kamínky 5	Non residential
	CZECH REPUBLIC	Koniklecová 4	Multi family
	DENMARK	Sems Have, Roskilde	Multi family
	DENMARK	Skodsborgvej, Virum	Single family
	DENMARK	Traneparken, Hvalsø	Multi family
	ITALY	Ca' S.Orsola, Treviso	Multi family
	ITALY	Ranica, Bergamo	Single family
	NETHERLANDS	Wijk van Morgen, Kerkrade	Single family
	PORTUGAL	Lugar de Pontes, Melgaço	Single family
	PORTUGAL	Montarroio, Coimbra	Single family
	PORTUGAL	Neighborhood RDL, Porto	Multi family
	SPAIN	Corazón de María, Bilbao	Multi family
	SWEDEN	Backa röd, Gothenburg	Multi family
	SWEDEN	Brogården, Alingsås	Multi family
	SWEDEN	Maratonvagen, Halmstad	Multi family
	SWITZERLAND	Les Charpentiers, Morges	Multi family

In a pre-study on barriers and solutions carried out in the context of this work, four different categories of barriers were identified:

- Information issues;
- Technical issues;
- Ownership issues;
- Economic issues.

The information issues can be either confusing information, i.e. different opinions expressed by different professionals, or incomplete information. It can also be lack of clear requirements, lack of inspiration or lack of knowledge about possibilities, potential benefits and added values. The technical issues are mainly related to lack of well proven systems and lack of complete solutions consisting of packages of technologies. The ownership issues generally have to do with who has to pay for the investment in energy renovations and who saves the money – not always the same person(s). The economic issues can be as simple as too high investments needed, which often are also coupled with lack of incentives. Additionally, there may be uncertainty as to how much money can be saved from the energy renovation (sometimes just the comfort is improved) and finally, lack of economic understanding or knowledge.

The analysis of the Shining Examples reveals that the barriers met were sometimes a combination of different kinds of barriers including information, economic and ownership/user issues. Tenants in rented apartments are often in focus as critical elements in the renewal process as for example in the Swiss case, where it was important to keep the largest possible number of tenants in their apartments during the renovation. In Denmark, tenants came into play in a different way as the democratic requirements in the Danish housing rent laws demand that tenants vote for the energy renovation before it can be initiated.

In Portugal, the financing was a barrier in both cases and also in both, the lack of knowledge by some stakeholders and different opinions among involved partners, were issues necessary to deal with. In all cases, the solutions found to overcome the barriers met were quite straightforward and can be summarized in one word: “perseverance”. Many of these projects could not have been implemented if a single person or team had not taken ownership of the project and had fought for their completion.

The overall conclusion from the analysis of the 18 Shining Examples is that for 7 of these there were apparently no barriers worth mentioning. For 7 of them, the barriers were mainly of administrative matter – for example delay caused by poor project leadership. For 6 of the cases, the economical/ financing issues created barriers causing problems and delays. This conclusion differs somehow from the result of the pre-study. This may be explained by the fact that those were general barriers, which block the carrying through of energy renovation projects, whereas in the Shining Examples they were obviously overcome.

The Shining Examples documented may be characterized as forerunners and therefore not typical energy renovation projects.

3.2 Anyway measures

The expression “anyway measures” was chosen to highlight the inevitability of the costs associated to maintaining, extending or replacing building materials, equipment and systems to keep the building fully functional, or to make it contemporary.

The definition of a “Cost Effective Energy and Carbon Emissions Optimization in Building Renovation” calculation requires a reference scenario. Having in mind that the optimization costs include all expenses regarding the optimization and related procedures (soft costs), it is fair to assume “anyway measures” costs deducted from this total investment, as they would occur anyway without optimization. In fact, these “anyway measures” can be triggers for intervention, as demonstrated later.

That insulation of external walls has been applied in the majority of the “Shining Examples” can be explained by the fact that external walls require “anyway measures” that range from regular condition verifications to periodic paintings or substitution due to wear and tear. The “anyway measures” costs account for scaffolding or other lifting methods to execute the work, workmanship, materials and soft costs. In the end the aesthetics is improved or maintained, and the value of the building increases, or at least does not decrease. The optimization measure costs can then be calculated accounting the expenses directly related to the optimization measure, subtracted by the values that would happen in the “anyway measures“.

The Shining Examples show that the need for renovation or maintenance - the need for the “anyway measures”, created most of the opportunities for renovation. In programmed change situations it would be fair to assume that “anyway measures” can consider recent solutions that represent the local trends: if a district heating system is available, it is natural to consider that a system renovation would use the network solution. “Anyway measures” consist frequently in exchanging the existing system by an equivalent one that will be more efficient due to the normal evolution of equipment, regulations and certification.

3.3 Which measures (RUE/RES balance)

When tackling energy consumption reduction in existing building renovation, two major approaches (often combined in one project) describe most of the options: those that reduce energy consumption, associated to a Rational Use of Energy (RUE), and those related to supplying the existing needs with Renewable Energy Sources (RES).

In several of the Shining Examples energy consumption reductions (RUE) were achieved by improving the performance of the building envelope and recovering heat from the ventilation losses, and for others significant use of solar panels or renewable-based district heating (RES) was used to complement the remaining needs. What both show is that each combination is a direct result from the existing context, the available solutions and sources, and significant integration efforts. Depending on the climate severity, period/quality of construction and many other factors (see topic Barriers/Solutions) the buildings behave differently, create different baselines and require different intervention strategies.

Many of the RUE measures included the renovation of the boundaries with poor thermal performance (roofs, ceilings, walls, windows and floors with insufficient or no insulation), with particular focus on those in need of renovation due to wear and tear (see topic "Anyway measures"). The improvement of energy conservation noticed in roofs ranged from 65% to 95%, while in the walls it ranged from 50% to 90%. It is important to notice that in walls the U-values after renovation vary from 0.45 $W/m^{2o}C$ in warmer climates to 0.11 $W/m^{2o}C$ in more severe ones. In roofs, the variation ranged from 0.64 $W/m^{2o}C$ to 0.08 $W/m^{2o}C$, in the same situations. In the particular case of windows, the improvements ranged from 15% to 75%, where countries and specific locations with higher demands for heating demonstrate the use of a wider range of high performance windows (triple glazing is rather common).

In most of the examples, the RUE measures were taken as a first step to reduce the energy demand while improving the occupants' comfort, while reducing the amount needed from RES production. The Renewable Energy Sources approach was implemented in most of the buildings either by connecting to existing district heating structures fuelled by biomass or garbage combustion, or using biomass based heating systems. Many also included solar thermal panels for domestic hot water and/or heating or solar photovoltaic (PV) panels. See chapter 3.5 for detailed information about this.

3.4 Co-benefits

When only energy savings and costs are considered to estimate the value of improving the energy performance of existing buildings, disregarding other relevant side-effects from the implementation of the renovation measures, the full value of the intervention might be significantly underestimated. Several terms are used in the literature for side-effects that arise from building renovation such as co-benefits, non-energy benefits (NEBs) and multiple benefits. In Annex 56 the term co-benefits is used to include all effects of energy related renovation measures besides reduction of energy, CO_2-emissions and costs. These co-benefits can have significant values which are most often disregarded in the cost-benefit analysis.

In Annex 56 the following co-benefits were considered: 1) Thermal comfort, 2) Natural lighting and contact with the outside environment, 3) Improved air quality, 4) Reduction of problems with building physics, 5) Noise reduction, 6) Operational comfort, 7) Reduced exposure to energy price fluctuations, 8) Aesthetics and architectural integration, 9) Useful building areas, 10) Safety (intrusion and accidents), 11) Pride, prestige, reputation and 12) Ease of installation.

It is one of Annex 56 goals to evaluate possible forms of integrating co-benefits in the methodology for cost effective energy and carbon emissions optimization. However, these benefits are often difficult and nearly impossible to quantify and measure accurately, which makes it much more difficult to add their contribution into a traditional cost-benefit analysis. Some of the co-benefits occur as a consequence of reduction of energy consumption, CO_2-emissions and costs respectively while others occur as a side effect of the renovation measures (e.g. less noise through new windows).

Many issues determine whether occupants find energy renovation to be successful. The co-benefits in the Shining Examples include a big variety of issues like better indoor climate, comfort and architecture.

Positive experiences from co-benefits might, if communicated to building owners or tenants help to overcome some of the barriers that homeowners and housing associations are experiencing.

3.5 Country / climate specific measures

The energy renovation technologies implemented in the Shining Examples has been systemized according to the country or climate. Here is a summary of the energy renovation features:

- All examples carried out insulation of the envelope in one way or another. One Austrian and one Swiss example have changed the facade with new facade elements including active and passive elements or added an extra module for passive solar use;
- 17 examples have changed windows or glazing; Southern European countries typically use double layer-glazing, where central and northern Europe use triple layer glazing;
- 14 examples have received mechanical ventilation with heat recovery;
- 9 of the examples have solar thermal features mainly for domestic hot water;
- 7 projects have installed PV-plants – only one of them in southern Europe;
- Half of the cases have improved their lighting by LED or other efficient light;
- Half of the cases have new or improved heat distribution systems such as thermostatic valves, insulation of tubes or implemented individual meters;
- 13 of the 18 examples have changed or improved their heat supply: three of the examples have solar heating as heating supplement;
- Four heat pumps have been installed:
  - Two have installed water-to-water (ground coupled) heat pumps;
  - One example has a reversible heat pump with boreholes for cooling in the summer and heating in the winter;
- One example has air-to-air heat pump (also working as air conditioning system);
- Four new gas boilers were installed and one example has a gas driven CHP system;
- Two have installed wooden stoves for heating and either cooking or domestic hot water, and one has biomass district heating;
- One has installed a new district heating substation.

Three examples have implemented some kind of cooling system: One of them is a “classic” air conditioning system. This is one of the South European examples (Portugal), where the summer is quite hot. In this case the window area has been increased, improving the use of daylight and increasing heat gains, which are useful during winter. On the other hand, the increase in window area also led to higher heat gains during summer and the necessity of dealing with cooling needs. Also, in this example heat recovery of the ventilation air is not applied due to the low savings potential because of the relative mild winter in this region of Portugal.

A cooling/heating system in Austria consists of a reversible heat pump with deep drillings.

4. Energy savings

One of the reasons for collecting the Shining Examples was to show building owners what energy saving potential lies ready for harvesting in a variety of building types and climates. In this chapter an analysis of the energy consumption before and after energy retrofit has been carried out in order to create an overview of the impact of the energy saving strategies that have been carried out. This has been done in the following way: The energy consumption before the renovation took place, after the renovation by rational use of energy (RUE) measures, the renewable energy (RE) contribution and the final net energy consumption have been mapped and compared in histograms. Thereby it is possible to evaluate the impact of implementing the RUE technologies and the RE technologies (solar energy) contributions separately and together. Both energy consumption before and after the renovation have been obtained by measurements.

The Shining Examples have been divided in three groups: Public buildings (schools & offices), single family buildings and multifamily buildings.

Public buildings

Only two public buildings were studied, an elementary school located in Kaminky, Czech Republic and The Federal Ministry of Justice of Bruck/Mur in Austria. Both buildings present a fairly high energy reduction by the incorporation of RUE by 63% and 83% for the school and the official building respectively, as it can be seen from Figure 1.

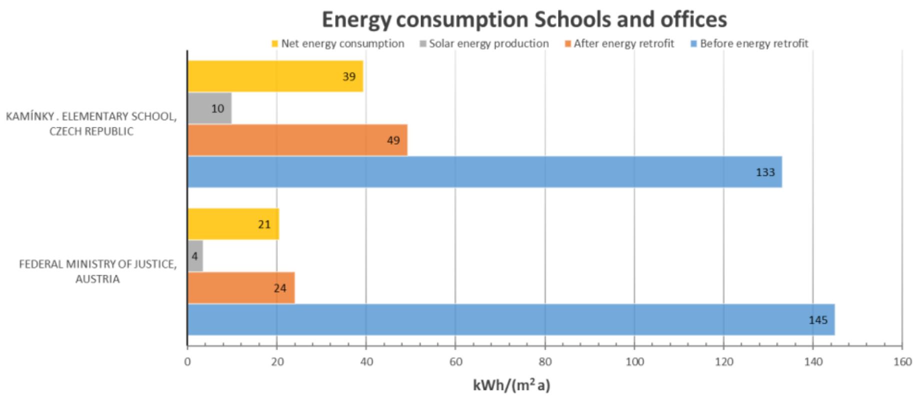

Fig. 1. Overview of the Energy consumption before and after energy retrofit for the two public building cases

Single-family buildings

Four single-family buildings were analysed, two of them from Portugal, one from Italy and one from Denmark (see Figure 2). By the foreseen use of RUE and RE technologies Montarroio, PT becomes a “Nearly Zero Energy Building”. Solar thermal and biomass energy supply 95% of the heating and DHW demand after the energy renovation.

Via Trento from Italy and Lugar de Pontes from Portugal present a considerable heating consumption reduction of 93% and 90%, respectively, after the RUE renovation. In addition, solar thermal collectors have been incorporated to the building reducing the heating consumption by additional 33% and 43%.

The single family house from Denmark shows a heating energy reduction of 42% after renovation and in addition 10% more is reduced by the incorporation of solar thermal collectors.

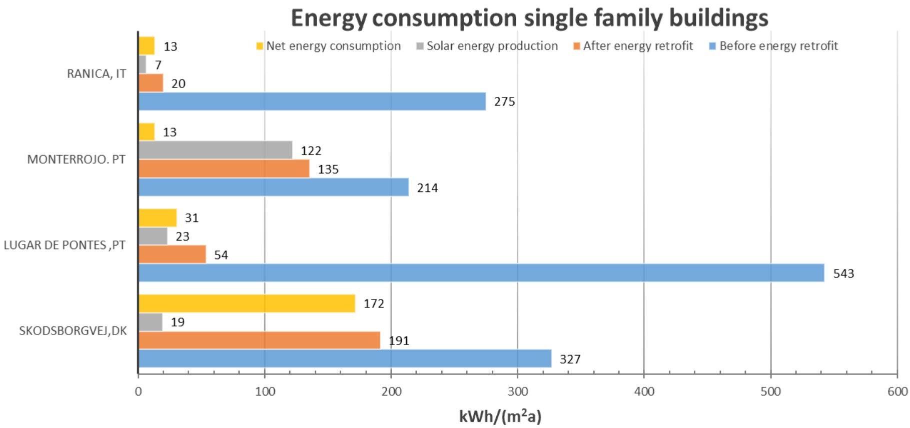

Fig. 2. Overview of the Energy consumption before and after energy retrofit for the four single-family buildings

Multifamily houses

The Shining Examples are predominantly multifamily buildings. The 11 projects are shown in Figure 3. The most remarkable heating energy consumption reduction is seen in Switzerland: 83% is reached by the integration of a passive solar façade and a new gas cogeneration system.

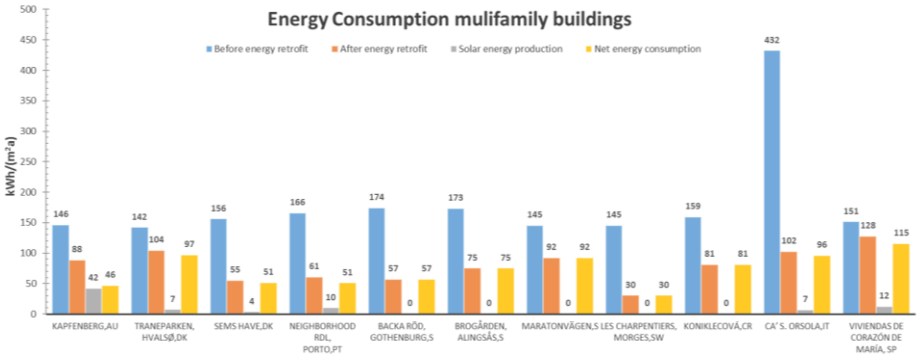

Fig. 3. Overview of the Energy consumption before and after energy retrofit of multifamily buildings

Among the Shining Examples located in the South of Europe, Ca'S. Orsola in Italy presents a heating energy reduction from RUE by 77%. It should be noted, though, that the building was in very poor shape and the energy consumption before renovation has been calculated based on this condition. After the renovation the heating demand is provided by geothermal and solar thermal systems. In addition, the building has been equipped with a small PV electrical contribution of 2 kWh/m^2. The building from Spain stands out by its low energy RUE and RES reduction, since only 50% of the DHW consumption is supplied by a solar thermal system.

The highest percentage of solar energy contribution, both solar thermal and PV electrical, is found in Kapfenberg, Austria, reducing by 48% the total energy consumption after energy renovation by RUE.

The Shining Examples in Sweden and the Czech Republic do not have any RES-system, but the total energy consumption has decreased by over 50% by RUE-systems.

Overall energy savings by RUE and RES

For most of the Shining Examples the energy reduction reached by implementing RUE technologies lies between 40% and 83% - extremes are 16% and 90%. The RE contribution to the remaining energy demand lies between 7% and 47% - extremes being 0% and 90%. The total energy reductions achieved by the combination of RUE- and RE-technologies are between 40% and 95%. Here the extremes are 29% and 98%.

Conclusions

The Shining Examples may be characterised as forerunners initiated by "first movers" and therefore the experiences documented may be somewhat different from what other new renovation project may meet. However, the multidisciplinary design approach of these examples demonstrates the potential of the renovation measures. As a whole they state that this potential can be harnessed in the scope of existing building renovations, from single family to multi-family buildings.

The analysis of the Shining Examples demonstrates that a “one size fits all” approach is unviable in the diversity of contexts where a “Cost Effective Energy and Carbon Emissions Optimization in Building Renovation” is needed. Case by case these examples show that the implemented RUE / RES measures were a consequence of local opportunities and constraints, ownership and local laws, and not only a design option.

Acknowledgement

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References

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