The Importance of Renovation and Renewable Energies for Carbon Neutral Building

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Abstract. Energy consumption is one of the most crucial factors of sustainability. Our existing building stock is one of the biggest energy consumers in the world and that is why having to focus on the minimization their energy usage. More countries and the E. U. set the goal for carbon neutralization of building sector in the year 2050. The regulations for newly built require them to be buildings can be energy efficient. What should be done with the existing buildings? The paper aims at to look inside the REHOUSE renovation project supported by the European Union. The project offers several innovative renovation packages which can be used during the renovation of old buildings. Some of these packages develop active energy saving proposals such as Multi-sourced heat pumps driven by renewable energy or Smart wall system and Intelligent window. Others offer a passive solution such as the Adaptable dynamic building envelopes and PanoRen facades. All these innovations based on applied science knowledge and use the finite element modelling or other physical science tools. It is expected that the program of energy retrofit renovation will provide more research interest.

1 Introduction

The global warming is a proven fact with a possible dramatic consequence even in the near future [1]. One of the main root causes is the increase of carbon dioxide emissions to the atmosphere [2] by transportation, manufacturing products and operational energy production. Energy production is connected to the building sector using energy which is responsible for about 40% of all carbon dioxide emissions. This 40% can separated two main parts. One third of energy used in the building sector is devoted to the manufacturing of building materials and the building processes, and two thirds is for supply the operational energy demand of the world building stock [3]. These two thirds of energy generate 27% of the total carbon dioxide all over the world, which is a very significant emission. The other important fact is that within the building stock the ratio of new building is very low. The majority is the old building, which means they dominates the energy efficiency of the building stock average. The life span of an average residential building is around 100 years which can varying depending on the region the function and the materials. Consequently, the replacing all buildings takes a

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very long time, much longer than the need to reduce energy consumption. By the year of 2050, around half of the building stock will still be standing even if the demand for new buildings rises steeply in the next few decades [3]. It is needed to handle separated the new buildings and the old buildings. In case of new buildings, the local building code represents the prescriptions for the features and parameters of buildings including the energy class. In different countries has different classification methodology for ranking buildings. One of the most important grading aspects is the energy efficiency e.g. determine the yearly energy consumption related to one square meter even in old buildings.
These facts emphasise the importance of renovating the existing buildings, which consume much more energy than would be accepted for sustainability and even for carbon neutralization of the building sector.

Renovation is as important as the nearly zero energy building codes [4] in different regions and countries. In the last decades more efforts had been made to improve the energy efficiency of existing buildings. That means development projects in which innovative technologies are worked out for existing buildings having a higher energy consumption. The reduction of energy demand is advantageous for all stakeholders including the owner of a building, the operator who pays the bills, and the region and also for the environment.
Recent paper would offer a brief insight into the REHOUSE [5] renovation project in which several renovation solution are developing and testing. The different renovation methodologies can be applied in wide range of old buildings, there are several ones comprises active or even smart component, and there are others just a sustainable environment friendly solutions.

2 Renovation packages developing in REHOUSE project

Over the course of 4 years the project will develop innovative and holistic solutions for efficient, cost-effective, and sustainable renovation processes. The solutions will be deployed across four demonstration sites in Greece, Italy, France, and Hungary. This will include detailed designs, pilot set-up and demonstrations to validate the solutions. If proven successful, the renovation solutions can be introduced to the market, implemented on a large scale, and eventually contribute to speeding up the current rate of renovation.
Among the four demonstration buildings, there are two university dormitories one social house and a condominium. In the social house the social issues [6] were discussed in more detail.

The project is led by the CARTIF [7] research organization in Spain and its 25 implementing partners. There are also technology developing companies, and universities, local municipalities and professional communication partners.
Several studies have been made for the global view of energy use and optimal control methodology for energy management such as in the paper of Vamvakas et al. [8] concerning REHOUSE project.

2.1 Multi-source heat pumps

Heat pumps have been widely used in recent years, but most of the products on the market heat sources are restricted to a single heat source. The heat pump developed in this project can use multisource energy sources, such as solar, geothermal, air and thermal energy from storage systems. The heat source temperature varies to a large extent, in order to provide space heating and cooling, and domestic hot water. It considers both heating and cooling and temperature variations of the heat source and is able to adapt to varying integrated set-ups.

The proposed heat pump (Figure 1) can achieve an improved COP, compared to conventional heat pump systems, reaching up to 4.5.

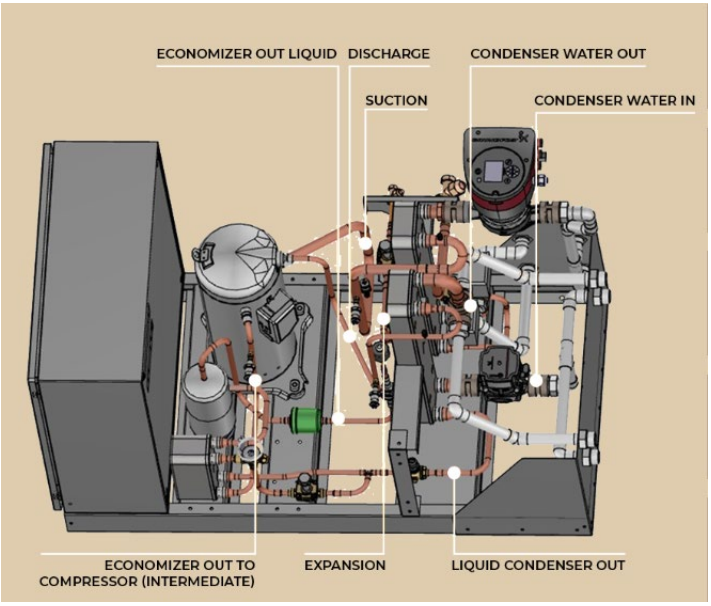

Fig. 1. The structure of the multisource heat pump system (source: rehouse-project.eu)

The multisource heat pump combines more natural heat sources and integrates their advantageous by supplying a thermal energy storage system which is the built-in source of the heat pump. This energy optimized control system provides the highest efficiency even reaching the CoP value above 4. Another innovation integrates the heat pump with a solar panel system. The multisource heat pump is a universal solution for almost all heating purposes with a higher efficiency and energy yield.

2.2 Adaptable / dynamic building envelope

During a renovation the most common method is to put additional thermal insulation outside the walls. The adaptive dynamic building envelope (ADBE) provides many other active elements to increase the energy efficiency of the façade and the building (Figure 2). The ADBE structure system adapts to solar panels, energy storage systems and a cooling fan for reducing the overheating of a wall in summer. ADBE has a modular design and supports the high-level prefabrication production, by minimizing the site work time and disturbance. Another advantage of the system is it's easy to installation reducing the cost and the local waste. The system also offers a high water and air sealing for decrease air filtration and heat loss. ADBE makes it easy to install sensors and monitoring units and a control unit for the active elements, by so this could be the BIM system.

Fig. 2. Manifested Adaptable dynamic building Envelope system (source: CERTH)

2.3 Smart wall

A “smart wall” is a multifunctional wall system that combines fully prefabricated panels with eco-friendly insulation, a slim type of fan coil for heating and cooling, a mechanical ventilation system with (HEPA, active carbon or range adhesive) filters and an energy recovery unit with 70% efficiency, batteries, commercial PV panels, and high-performance windows with smart blinds to control for improved visual comfort (Figure 3).After prefabrication, the panels, they are installed on the building in a simple way. However, the design should be more accurate and double-checked to reap the benefits of the system.

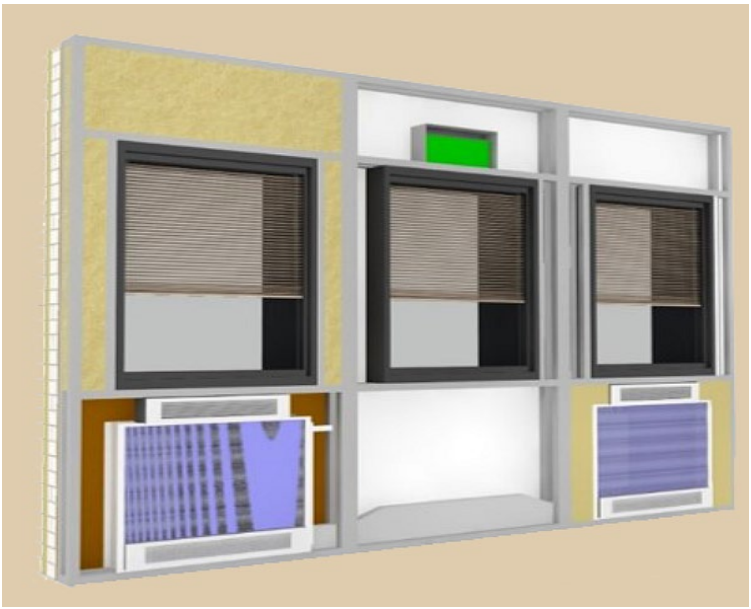

Fig. 3. Modular system of a Smart wall (source: rehouse-project.eu)

2.4 Centralized holistic renovation kit

The renovation package four is a complete renovation kit for central heating and cooling systems. It is designed around a reversible commercial air-water heat pump powered by an on-site BIPV (architecturally integrated photovoltaic) and connected to a thermal energy storage tank: Thermal Energy Storage (TES) which is stratified with PCM (phase change materials) inside Figure 4).

Fig. 4. Energy storage tank of a centralized holistic renovation kit (source: rehouse-project.eu)

The centralized holistic renovation kit combines high energy efficiency with high ratio recycling technologies including the bio-sourced materials and other recycled components from the construction value chain.

2.5 Multipurpose façade system

There are many kinds of existing walls needing additional facade insulation system. Beside their thermodynamic advantage, the facade systems provide a completely new design for old buildings and change the appearance of the building. The multipurpose facade system consists of pre-manufactured panels which will be anchored to the wall. After the connecting anchors are fixed to the wall, implementation is incredibly fast. The only follow up work is sealing and the cover the connection lines of the panels and their footing. To be more design and energy efficient, the system consists of several layers, which can be optimized to the type of function and climate of the location.

2.6 PanoRen multifunctional facade

PanoRen is a further developed system like the cross laminated timber (CLT) technology. This is combined with thermal insulation and timber hybrid panels, with a natural external appearance of CLT panels but having a very high thermal resistance compared to the CLT. This system will be used to install the French demonstration site located in eastern France.

Fig. 5. Fixing PanoRen panels to a wall (source: rehouse-project.eu)

This technology improves existing passive buildings, depending on their wall thickness and other factors. (Figure 5) shows the methods to perform the renovation and quickly change the design of a building.

2.7 Intelligent Windows System

Windows are the most crucial points where buildings lose the most energy. This is the fact in heating and cooling. The Intelligent Window Systems (IWS) mitigates this effect by reducing up to one half of the heat loss in heating season and heat gaining in cooling season. It can be used for existing or new windows in any type of building. It can be directly integrated into a multipurpose envelope such as ADBE or any other mounted façade structure

on the facade. This provides a huge advantage in renovation even if a wall is not insulated. Since the Intelligent Windows can be seen from outside, these elements need a design to harmonize with the style and size of the building.

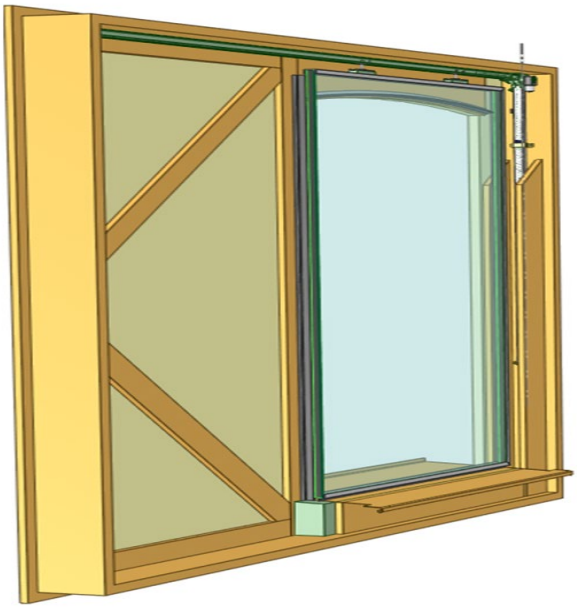

Fig. 6. The structure of the Intelligent Windows System (source: rehouse-project.eu)

An extra advantage is that Intelligent Window Systems can be installed in front of old windows instead of replacing them (Figure 6). Replacing windows is very costly, causing much dirt and disturbance, and requires replacing work both inside and outside. It is cheaper to use this innovative window adaptation than changing a window. The use of Intelligent Windows does not cause a significant amount of waste which would result from replacing an old window.

3 Conclusions

The REHOUSE project is only one of many other projects which try to solve the energy problems of buildings, consequently, to reduce energy consumption. From these examples shows the wide range possibilities to develop the energy efficiency of the existing buildings. The three main area of this innovation is the wall insulation, the efficient energy production and the minimization the energy transmission of window structures. All three is crucial if we see the energy amount used or saved in a year or even more the life span after renovation.

The REHOUSE project offers more solution for the façade insulation which is the biggest surface all over the world in buildings. The specialty of the project to develop not only simple façade insulation, but a structure host smart solutions built-in the façade system such as ventilation, solar panels for energy production, and energy storage systems. The project offers a solution for reduce the energy loss throughout the windows which solutions can work both in heating and cooling mode.

The two insulation innovations focus to the natural based materials instead of artificial or synthetic products. The binderless bonding of cellulose is a radical new innovation,

because the most harmful parts of the natural based materials are the glue which is mostly chemical product. Synthetic glue is a harmful contamination in case of recycling also.

It should be mentioned that the project not only develop the renovation solutions but also test them in life scale demonstrating buildings. There are four buildings will be used the different renovation packages in France Greec Italy and Hungary, two or three renovation packages will be tested in each one. These demo building's goal to make measurable the effect of the innovation package. For this reason, there were worked out a monitoring system in the chosen demo buildings, and started to measure the energy and indoor conditions of original conditions that data will provide the base line for comparison. After the renovation the monitoring system will continuously collect the data and make the buildings energy efficiency comparable to the original stage. The monitoring system collect and log all data for energy consumption including the electricity the natural gas or any other such as renewable energy sources if it exists in the original phase. The indoor air condition covers temperature humidity VOC (volatile organic compound) vibration which means mainly the noise and lastly the lighting conditions. For being able to normalize the data must measure the outdoor conditions too. These measurements happen by means of weather station measuring the temperature humidity wind speed and solar radiation. All these data are collected and stored several project partners server and will be used when the date after renovated will be available expectedly in the end of 2025. The data help to calculate the wide range of key performance indicators called KPIs. There are more groups of KPIs regarding the building envelope, the resource uses the comfort conditions the economics the social and of course the environmental. In all group there are several indicators which will evaluate the renovations from these aspects..

As it was mentioned in the very beginning the carbon neutral building sector is double challenge, one side is the new built houses and the second is the existing building stock. The REHOUSE project partners agree that the second one is significantly higher task to be solved. In case of new building the question can be solved simply by changing the regulation means the local building code. In case of existing building how to oblige the owner or operator to improve the energy efficiency of the buildings? The question has an emphatic social and of course economical aspects cannot ignored. From technical side the scientist and developing companies have to offer the solutions for efficient renovation in the frame like the REHOUSE project.

4 Acknowledgement

This article was prepared in the frame of the REHOUSE project (Renovation packagEs for HOlistic improvement of EU's bUildingS Efficiency, maximizing RES generation and cost-effectiveness, supported by the European Commission EU Programme Horizon-CL5-2021-D4-02-02 under Grant Agreement Number: 101079951. The authors would like to thank the rest of the REHOUSE partners for their support. All related information of the project is available at https://rehouse-project.eu/

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