Smart Housing in Sustainable Development

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Abstract. Reducing the energy consumption is one of the pillars of sustainable development. In European scale is consumed nearly 40 % of power on operation of buildings because we spend 90 % of our time inside the buildings. Reducing energy consumption of buildings can be considered as the basis for innovative solutions for housing construction and rehabilitation of housing stock in the future which also generates significant user experience - ensuring a healthy indoor environment with an optimal design of the building. Paper presents an interesting solution of energy saving rooftop extensions - SOLTAG concept, which is the result of collaboration of experts from several countries including Slovakia.

Keywords: rooftop extension · sustainable housing · modular housing

1 Introduction

The latest initiative of the European Commission in the field of environment is to reduce CO_2 emissions, which buildings release. The newly released Directives already in some European countries contributed to energy savings of 25 to 30 % higher than previously required. Until the year 2015, the EU's energy consumption also gradually decrease. But it also means that housing will need to address issues of major importance. Statistics show that over the past decades, global energy consumption has been growing by approx. 2 % annually [1]. For the period by 2030, the reference scenario of the International Energy Agency projects a marginally slower growth in global energy consumption by 1.7 % annually. At the same time for the period, the projection expects 1.7 % annual growth in atmospheric CO_2 emissions [1]. Per capita consumption of electricity varies in different countries.

The average electricity consumption in the household sector of the energy market in Slovakia is 2.5 MWh per year and the average electricity price is approx. 140 EUR/MWh (excl. VAT). As presented above, the highest average electricity consumption in the household sector of the energy market is in Cyprus and Slovenia, with an average of 4.2 MWh and 4.0 MWh per household and year. The price of electricity (without distribution charges and VAT) is the highest in Malta and Cyprus, approx. 219 EUR/MWh and 145 EUR/MWh, respectively [2].

The new millennium is marked by new technologies and still more people's demands for comfort and quality of living are rising. Every day of an human being is

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extremely valuable and to use it fully, it is necessary to accelerate and simplify the performance of routine activities by deployment of central management systems such as lighting, heating and air conditioning, which provide more efficient operation and reduce energy consumption and optimization, which means SMART Technologies Simply said, intelligent and smart features provide more functionalities in our houses.

Even greater savings could be achieved, however, the implementation of intelligent networks of sensors which would bring together smart homes with smart cities which current research focuses on. Subjects which are being tested are processors, sensors, and network connectivity built into articles of daily activities which may perform in the future management the role of technology in building and contributing to optimal utilization of urban resources. Except of introduction (implementation) of intelligent home control systems, it is also necessary to take into account the "green living" (environmentally friendly) and "modular housing".

Modular housing is focused on the actual needs of people and also on the possible future development of their living situations with regard to safety, optimum availability of kindergartens, schools, health facilities, offices as well as the public transport station. The modular design is based 90 % on the quality of industrially pre-prepared elements. Its advantage is that the material and facade appearance can be customized, the same types of windows and doors can be used which helps achieving a high-quality combination of old and new. The modular system can be combined also with a conventional design.

The response to demands of energy-efficiency and in terms of CO_2 -neutral housing of the future has become the SOLTAG project, which is the result of cooperation between urban planners, architects, experts on energy and daylight, research institutes, university departments, housing associations and manufacturing companies from housing sector which are dealing with energy efficiency of buildings. This system is designed as a solution for adaptation of roof - a flat (module), which can be built up on existing residential buildings with flat roofs, without the need of connecting it to the current energy system of the building. Principles of the project can also be used in new buildings [3].

2 SOLTAG Project – Modern and Sustainable Way of Housing

Approximately 60 % of investments in the construction sector of Europe are in the fields of conversion, revitalization, restoration and rehabilitation. Most projects try to involve important current topics, such as sustainability, material saving, increasing the supply of housing and enlarging the building itself.

Building the housing units on the roof of existing buildings can meet the criteria of modern era for housing reconstruction. It enables to extend the housing space in the building, modernize the facilities, and adapt the housing units to the modern requirements, and to the segmentation of the housing demand. The construction of the new housing units does not require the additional space, so it is sustainable from the view of land saving. The new housing units do not need the new foundations, and thus a large quantity of saved materials and the amount of diminished construction waste. Related flow of materials is

reduced. Rooftop extension also enables solving the problem of the flat roofs that are not very suitable for the climate with frequent precipitation and icy winters. The leaking roofs then have to be repaired frequently. Sloping roofs on the contrary have the longer lifespan, can add the additional architectural value to refurbished building and the space under the sloping roofs is than effectively used for attics [4].

The really high effects from the rooftop extensions can be achieved when sustainability measures, renovation of all building and energy efficiency measures are combined together with the housing market analysis. Situation in housing market can be the source of the new opportunities. For instance there may be the demand for the penthouses, high quality, non-standard elegant houses that may cover more than one floor, and may have the garden on the roof as well. The roofs of the houses are suitable for the construction of such housing units, especially if there are nice views from the rooftops on surrounding areas which are highly valued by many families. Refurbished buildings, together with the revitalization of the surrounding areas have important positive externalities for the area. As a result of it, the local market value of the housing units grows and more positive tenant mix can be achieved, although in some examples the effects of the gentrification may be expected. Surely enough, the bank which provides the mortgage credits for the clients in rooftop extensions should benefit from the rising value of the real estate that reduce their mortgage risk. Comprehensive refurbishment also provides the opportunity to make the existing housing stocks more enjoyable by for instance with enlarging the balconies or rearranging the facade. Adding the additional housing units may help also to solve some of the problems of family life cycle. Older families may need less space for living, because they already had raised children, however they do not want to move out from their habitual neighborhood. Therefore if they obtain the possibility to move to the new smaller housing units, on the rooftop, they may be quite satisfied. Although many high-rise buildings need renovation, they are often situated in the attractive areas of the town, for instance close to the centre, or in relatively quiet environment. After their refurbishment, their value can substantially increase.

The new housing units on the top of the buildings may become the interesting source of revenue for the owners. From such revenues, the costs of the older refurbished part of the building can be partly offset. This moment is especially important for the social houses, but also for the condominiums. For instance in the Eastern European countries people often lack the necessary resources to pay the full costs of the building renovation. Revenues from selling the rooftop extension may become the additional source of financing such reconstruction, so the financial burden is reduced.

The important initiative in the area of the refurbishment of the panel housing is SURE-Fit (Sustainable Roof Extension Retrofit) project funded by the European Commission in the framework of Intelligent Energy program. The project is oriented on the rooftop extension retrofit for high-rise social housing in Europe. Participants in the projects are Netherlands, France, Germany, Italy, Slovakia, Czech Republic, Poland, Sweden and Denmark. The main goals of the project are defined as:

1. Consolidate the existing cutting edge technologies and best practices of roof top extension retrofit for high-rise social housing and develop process models and custom-made guidelines for broader implementing the innovative solution in Europe.

2. Disseminate the knowledge and promoting the application of the integration of small-scale RES (renewable energy systems) installations, particularly PV panels, into the rooftop extension retrofit for high-rise social housing in Europe.

The rooftop extension as defined in the project may help to cope with several problems of the high-rise buildings. First of all it is the funding of their comprehensive refurbishment. Selling the additional housing units on the rooftop enables to create the additional financial sources that can be used for the refurbishment of the whole multiple-family houses, making the financial burden for the existing owners lower. The use of innovative technologies, such as better insulation materials, photovoltaic (PV) modules etc. enables to produce the energy neutral housing units on the top of existing houses.

The important moment of the retrofit scheme is intelligent flexible design (IFD) of the new housing units. Approach of IFD buildings includes:

- a smart, systemized approach of producing and delivering affordable and comfortable roof top extensions,
- a reduction of waste production (re-use of existing building structures, possible re-use of demountable and modular IFD components),
- less maintenance which is required over the building's lifetime.

The refurbished building may stimulate urban area improvement as a joint effort between the local authority, housing associations, market parties, and the citizens [5].

The current trend of reducing the energy consumption of buildings is an ideal solution for low energy concept. Technology of those houses, however, requires stricter requirements for theoretical preparation of the project - proper selection of building components and particularly the observance of technological processes and quality of construction.

The complex project in the use of prefabricated systems (see Figs. 1, 2 and 3) is the SOLTAG concept. This system uses energy roof, which integrates sunlight with photovoltaic cells. The basis of the system was to achieve a balance between heat gain, insulation capacity and air exchange. Thus designed house can be described as "energy production plant", which in addition to savings has also pleasing and healthy indoor environment.

Sample house of this type was able to realize in 2005 by an expert within Demohouse project research in Denmark. SOLTAG is an example of the future sustainable housing. It responds to the strict European Union legislation in the field of reducing CO_2 emissions and also reduce overall energy consumption in the construction. The house is designed as a pair of prefabricated modules that forms the rooftop extension of the apartment buildings built in the 60−70 years.

The concept of roof extensions SOLTAG was included in the international project ANNEX 60 - Building restoration with the use of prefabricated systems. The aim of this project is to evaluate the advantages and possibilities of prefabrication in the reconstruction of existing residential buildings, to improve quality and accelerate the implementation of measures which result is the achievement of low-energy standard. According to experts, the project builds on trends in the approach to reduce energy consumption of buildings in Western Europe, where high hopes are put just into

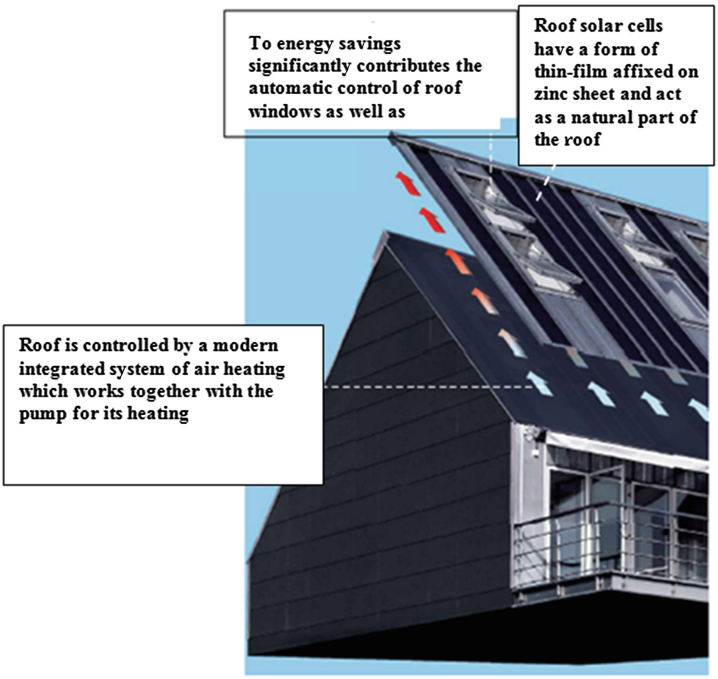

Fig. 1. Energy roof superstructure of SOLTAG concept [3]

Fig. 2. SOLTAG project - prefabricated system [3]

prefabricated systems, reducing the energy intensity of older buildings and the construction level of the maximum extension of the physical and moral life of the building.

3 Potential of Rooftop Extensions in Europe

The SURE-Fit team tried to estimate the maximum theoretical potential of the rooftop extensions in Europe. The methodological approach has been following. On the basis of the national statistics, the number of low-rise building (the buildings with maximum

Fig. 3. Rooftop extension (SOLTAG system) in the City Copenhagen, Denmark [6]

of eight floors) was found. From this number, the selected buildings were from years from 1960 to 1980. According to the opinion of the expert team, it does not make sense to build the rooftop extension on older buildings because their lifespan will be too short or they may be protected as the historical buildings. Roof topping on the buildings built after 1980 could be less efficient, because these buildings will need comprehensive refurbishment later, and they are also more energy efficient. Later the experts defined on how many low-rise buildings (built from 1960−80) the rooftop extensions could be mounted [6]. The resulting appraisal of number of buildings suitable for rooftop extensions depended on the character of housing ownership in the different countries and the expert opinions. The resulting estimation of the potential is shown in the following Table 1. A total number of 7,369,763 dwellings belongs to the theoretical potential of the rooftop extensions in Europe.

Table 1. Potential of rooftop extensions in Europe [7]

	Total # Dwellings	Multi-family	Low-rise	Built '60-'80	Max. potential
WEST EUROPE					
Austria	3,261,368	1,699,173	1,359,338	429,551	211,554
Belgium	4,097,125	1,028,378	984,158	245,165	87,397
France	28,668,114	12,413,293	7,855,063	2,694,287	987,456
Germany	38,709,853	20,864,611	1,9612,734	9,620,217	600,000
Luxembourg	171,870	50,014	41,912	11,830	6,719
Netherlands	6,634,647	2,063,375	1,925,129	965,928	391,201
NORDIC					
Denmark	2,540,543	985,731	883,215	282,756	35,000
Finland	2,548,043	1,467,673	1144785	585257	32,7744
Sweden	4,312,018	2,237,937	1,790,350	662,429	314,654
SOUTH EUROPE					
Greece	5,467,049	2,219,622	1,775,697	783,083	214,565
Italy	27,300,961	20,311,915	1,5701,110	6566029	807153
Portugal	5,044,526	1,140,063	1,115,438	420,007	111,932
Spain	20,954,701	9,953,483	6,907,717	3,666,944	1,245,844

(*Continued*)

Table 1. (*Continued*)

	Total # Dwellings	Multi-family	Low-rise	Built '60-'80	Max. potential
GREAT BRITAIN & IRELAND					
Ireland	1,281,840	110,238	8,8191	22,753	10,683
Great Britain	21,130,360	3,951,377	3,856,544	1,218,263	732,176
CENTRAL EUROPE					
Czech Republic	3,826,042	2,161,714	1,431,055	65,8493	60,000
Hungary	4,313,887	1,449,466	1,113,190	535,094	145,813
Poland	12,535,678	7,910,013	4,833,018	1,798,800	741,106
Slovakia	1,667,631	858,830	536,769	281310	104,085
Slovenia	777,758	220,883	193,494	109281	35,626
NORTH EAST EUROPE					
Estonia	617,440	421,094	336,875	168775	43,881
Latvia	958,085	679,283	543,426	219,544	74,645
Lithuania	1,292,554	791,043	632,834	202,507	55,487
TOTAL	**19,8583,96**	**95,049,225**	**74,778,852**	**32,191,958**	**7,369,763**
		48 %	**38 %**		**4 %**

4 Conclusion

Reducing the energy consumption of buildings, reducing CO_2 emissions and increasing the share of renewable energy sources in the construction and reconstruction is a hot topic which nearly all the countries of Europe and the world deals with now. Most of these problems are connected to housing renovation and equipment in a way that the technical solution significantly improved their thermal characteristics as well as the effectiveness and efficiency of technical equipment. SOLTAG project is addressing a modern and sustainable way of living, which uses the latest knowledge and technology to reduce energy consumption of buildings. Described concept is an example of using the prefabrication system in the reconstruction of existing residential buildings, which has great advantages in faster and more efficiently improving the quality of the reconstruction work during the implementation. Offers the possibility to optimize the prefabricated panels with improved thermal insulating integrated in the latest technology and last but not least, with lower production costs thanks to repeatability and variability of solutions.

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