IMPLICATIONS OF A NEW METHODOLOGY APPLIED ONTO MODELS OF TRADITIONAL RESIDENTIAL BUILDINGS IN THE VILLAGES OF SERBIA

M. Pucar[1] S.Simonovic[2] and N.Jankovic[3]

1. Institute of Architecture and Urban & Spatial Planning of Serbia, Belgrade, Serbia, email: mp@iaus.ac.rs; pucarmila@gmail.com
2. Institute of Architecture and Urban & Spatial Planning of Serbia, Belgrade, Serbia, email: sania.simonovic@gmail.com
3. Faculty of Architecture, University of Belgrade, Serbia, natasha.jankovic@gmail.com

ABSTRACT

This paper shows the research results regarding the possibilities of bioclimatic and energy reconstruction of residential areas in the villages of Serbia. The principles of the traditional residential buildings built in the different regions (mountains, lowland, and hilly terrains) of Serbia have been investigated together with a work methodology related to the potentials of reorganizing the houses along with the reconstruction of residential and auxiliary facilities regarding energy efficiency and use of renewable energy sources. Based on a detailed study of the contemporary rural way of life, the subject of this paper is to explore the building methods of reconstruction for the existing houses, which includes a system of basic principles and spatial solutions based on specific typological ground features. This procedure involves a detailed analysis of the regional characteristics of each area in order to create an appropriate environmental context for the set of standard housing model proposals. Climatic, geological, biological and aesthetic aspects of design, respecting the principles of traditional architecture, involve appropriate types of structural and foundation systems.

Keywords: traditional residential buildings, bioclimatic reconstruction, energy efficiency, renewable energy

1 INTRODUCTION

In 2010, the Serbian Chamber of Engineers announced a competition for improving the ways and technologies of constructing residential buildings in the villages of Serbia – under the name "BEAUTIFUL SERBIA". The aim of the competition was to find different solutions for constructing residential buildings in villages with regard to the regional differences, in the form of instructions and basic principles, but by topics: organization of building and lot (homesite); analysis of the potentials of phase construction; type of constructive system; form depending regional characteristics. The next task was to suggest the instructions, as well as appropriate spatial solutions for: lowland regions (Vojvodina), mountain regions and hilly terrain regions (Šumadija and Pomoravlje). The criteria for project assessment were: observing the principles of traditional building; researching the contemporary lifestyle in villages; respecting and using bioclimatic potentials of a certain region; the quality of suggested measures for the reconstruction of the existing and design of new buildings and homesites (lots); implementation of the principles of sustainable building; selection of building materials; recycling; waste water filtering; waste disposal; attitude towards nature etc. The authors of this paper have won the first prize in the competition. By means of textual explanations, graphic enclosures and photo-documentation, the basic principles of traditional building have been analyzed for all three regions, together with the contemporary lifestyle in villages and their attitudes towards tradition. Guidelines have been given for designing new and reconstructing existing houses and lots. Guidelines were also given for forms depending on the area and climate, as well as suggestions and measures for designing and building environmentally-friendly and energy efficient houses; the use of materials; infrastructural systems; ways of water recycling; waste materials etc. For each region, a special 70- page study has been written; and part of that research is presented in this paper [1].

Some of the basic principles of traditional building in different regions of Serbia possess certain elements of bioclimatic architecture. Identification of these elements, as well as their implementation and operation over a longer period, positive examples as well as negative ones have not been researched enough. Impacts and potentials for implementing these elements into modern processes of planning, design and building have also not been researched. On the other hand, contemporary lifestyles have also brought new demands that traditional building cannot completely meet. Respect for tradition, climate conditions, and observing bioclimatic principles and potentials of location, integration into the modern concept of building, as well as the new needs of the population have been the starting points of the competition's solution concept. Topics

the authors have dealt with are the possible ways of building and reconstructing houses and homesites. How to build sustainably; how to reconstruct the existing residential buildings and the ancillary buildings within one or more households are all important questions, whether from the aspect of practical implementation or the aspect of improving the conditions of comfort and quality of living for the people in those buildings. The attitude towards tradition can be sensed regarding the reconstruction of the existing houses, rather than the building of new ones [2, 3].

One particularly sensitive issue that needs due attention is the reconstruction of protected residential ambients according to bioclimatic principles, principles of energy efficiency and ecological sustainability. Throughout Serbia, there are settlements in such a poor construction, energy and functional state. On the other hand, those are usually very valuable ambients that need to be preserved. The population living in them is mostly impoverished, often old and not capable of doing basic renovations, such as roof repairs or dampness protection. The buildings are deteriorating over time, and life in them is uncomfortable and risky. The state does not have any earmarked funds for such specific ambients, and a special problem presents the fact that the objects are in private ownership. There are no favorable loans intended for this type of works [4]. Due to the limited space, in this paper an overview was given of only one segment of the research carried out by the authors not only for the competition, but over the past years as well. This primarily refers to the potentials of energy and ecological reconstruction in rural settlements, based on bioclimatic principles of planning and design in different regions of Serbia.

2 BASIC CHARACTERISTICS OF TRADITIONAL ARCHITECTURE IN SERBIA

2.1 Vojvodina – basic characteristics

Vojvodina is located in the northern part of Serbia. The urban planning concept of the Vojvodina village has originated from the natural and social circumstances that were partially changing in different development phases. The public administration played a key role in the forming of a type of a "ribbon settlement" with determined homesites at the end of the 19th and beginning of 20th century, with the distribution of land and its division into lots. The lots are elongated, perpendicular to the street and mostly facing east-west, which facilitates the best quality orientation to the south of a building. This has in fact determined the development of the house. All of the buildings on the lot are oriented towards the inner yard and do not have openings towards the neighbor's lot. Such a spatial concept offers the possibility of organizing the inner yard with multiple functions (work, manipulative space, living-room, dining space etc.) The Vojvodina homesite is absolutely of a proper rectangular shape with a front of roughly 40m and depths of 100 to 150m. The homesite is divided into three main surfaces: 1/yard with a house facing the street and barn, 2/stables with hayloft and stalls for smaller animals in the middle and 3/garden, orchard or vineyard at the back. The surface areas are separated by fencing. Today, most of the homesites in Vojvodina are lots that by their width make half of the original ones, i.e., around 16 to 20m of the front [5].

Traditional residential architecture of Vojvodina has been formed and developed as a response to the bioclimatic characteristics of the region. The facade with the porch facing the yard is always oriented towards the south or east, rarely to the west, and never to the north. Regardless of the spatial development of the house that can be very large in dimension, the Vojvodina house is always a ground-floor house with a porch (Figure 1).

Figure 1. Typical Vojvodina house: appearance from the street (left), porch facing the yard (right)

The simple model of a Vojvodina house with a porch, developed over time as a response to the climatic characteristics and functional needs, should be the basic starting-point and answer to the question of how to build houses in the future in this region.

2.2 Mountain house – basic characteristics

After studying traditional mountain houses in Serbia, it can be concluded that there is no unique typology for all mountain areas. Therefore, grouping elements that are somewhat similar, and which refer to spatial organization, lots, form and use of materials. These elements have been formed as a consequence of the lifestyle in relatively harsh climatic conditions, specific terrain, insufficiently developed infrastructure, specific agricultural production and livestock breeding. The elongated shape of the homesites, oriented by their shorter side towards the inclination, with the objects that follow the contours of the terrain inclination by their longer sides, as well as the road direction (street), is the most favorable concept of orientation and organization of a rural household in mountain areas. This basic model is complemented by the following principles: security, minimal communications and access, terrain adaptability; potentials for gradual extension of residential rooms; summer kitchen is part of the residential function and must strongly and easily connect to the main house. The work and ancillary rooms are organized in rows and levels with interconnected clearances (Figure 2).

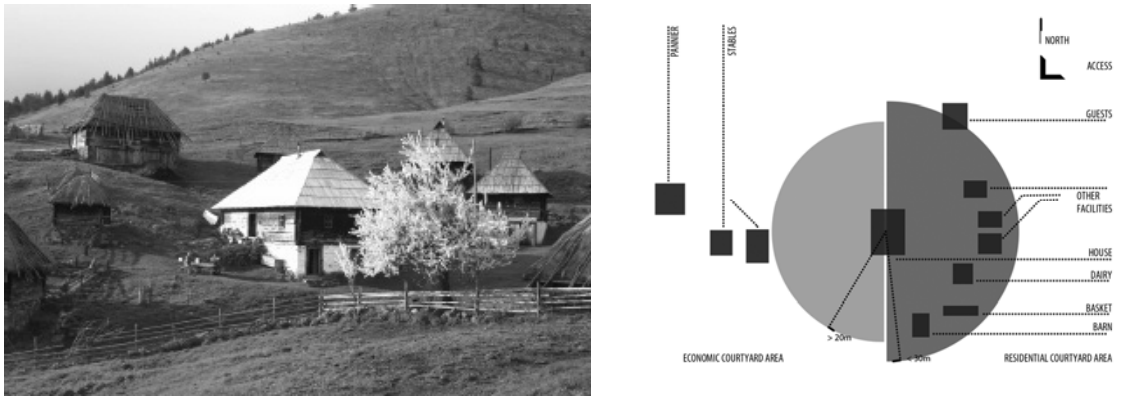


Figure 2. Typical mountain house (left) and organization scheme of the house and croft

The aim of this research carried out by the authors' of this paper is to offer modern solutions to future builders; this will lead to formative, functional and technological improvements, while respecting the environment and link with nature. The main starting-point of this approach would be to adapt the homesite and house to the existing natural and built surroundings, while taking into account the needs of the contemporary user regarding the esthetic, functional and technological demands of the present.

2.3 Šumadija and Pomoravlje – basic characteristics

The basic house development type in this region is a rectangular two-part building with the main entrance and porch along the longer side facade and not the front one. Firstly in Pomoravlje, and later in the western parts of Serbia, a new type of three-part house, with a kitchen in the middle and two residential rooms on the sides. The entrance room is always in front of the kitchen and, in different areas, it has different forms: open porch, closed verandah, small ante room etc. Underneath one room, there is a cellar, and the attic is still not used. Later, a new type of storey house is developed that is basically an above-mentioned type of three-part house over the ground floor in which the residential kitchen, pantry and cellar are located. (Figure 3).

Figure 3. Typical houses of Šumadija and Pomoravlje

Pomoravlje and the eastern parts of Central Serbia, regardless of the fact that they are physically close to Šumadija, show other concepts of rural architecture and a different structure of yard and settlement. The main reason for this is the population's origin, which mainly migrated from Kosovo and Metohija and partly from Macedonia, and they brought with them the habit of living in dense settlements and a way of building in the post and petrail system, and not from beam wood.

The size of the Šumadija and Pomoravlje territory conditioned many particularities related to the local environment in view of yard organization, architecture, building technology; so common characteristics and values that essentially characterize these parts have been taken into account in this research.

3 ARCHITECTURAL ORGANIZATION AND FORM IN THE FUNCTION OF ENERGY USE OPTIMIZATION

3.1 Recommendations for achieving energy efficient houses

From the extensive research carried out for the above-mentioned competition, some of the measures and recommendations have been singled out related to design and building of energy efficient houses in the villages of Serbia. For the house to be energy efficient, some demands have to be met, such as the following:

- proper orientation; mainly south-oriented residential rooms without big shading in the winter and with sun protection during the summer;
- high degree of insulation;
- thermal (heat) zoning;
- quality windows that seal well;
- compact form of foundation and facade;
- natural airing (passive) cooling;
- protection systems against sun and thermal losses;
- materials- local, natural with high accumulation level.

Additional requirements referring to low energy efficiency and passive solar house imply the use of

- passive solar systems and
- acrylic solar systems.

Additional measures:

- sewage and water supply lines should be short and well-insulated;
- energy efficiency and environmental devices and systems, which save energy and water etc. building

Some recommendations are for all climate regions and refer to the compact way of building, which implies the following:

- design of a compact form of building, which reduces the outdoor surface as much as possible, thereby reducing thermal energy use;
- attempt to reduce the envelope surface as much as possible. When determining the most favorable envelope surface, the most important is the degree of glazing. The envelope surface of a building is important when determining the amount of insulation material necessary and energy use in heating. It should also be considered that by reducing the envelope to a minimum the allowed level regarding illumination and airing is achieved quickly;
- the volume of the building has an impact on the thermal characteristics, which should be taken into account;
- energy requirements of a building are defined to a certain extent by is form. In one-family buildings, greater attention should be given to the energy aspects of energy saving, so this type of living could become closer to the more favorable values of a more compact way of building;
- openings on the building, such as windows, doors, air holes, chimneys should be placed so they reduce thermal losses in winter, and increase cooling in summer.

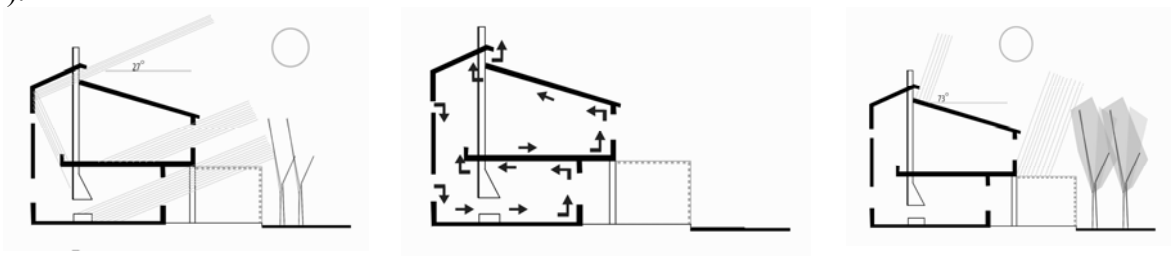
4 POTENTIAL IMPLEMENTATION OF SUNROOMS AND GREENHOUSES

The most frequently used passive solar system is the sunroom, and by building one the best energy results are achieved. In addition to the energy benefits, by building a sunroom, a quality sun-lit and green space which increases the square footage and improves the quality of living is obtained [6].

Solar energy exploitation in the passive way consists of the following: the glass surface of the sunroom transmits the sun rays into the space where they are "captured" (greenhouse effect). In winter, the space inside the sunroom is heated and the heat is absorbed by the massive walls and floor that accumulate the heat. They become a thermal mass, which after sunset and during nighttime radiate heat into the room.

For the heat to be retained inside the sunroom it is necessary to have screens that are lowered during the night preventing the heat to escape outside. To prevent overheating in the summer, certain protective

measures must be projected so direct solar radiation does not fall onto the glass surface during the day (Figure 4).



(a) (b) (c)

Figure 4. The way a sunroom functions: (a) winter-daytime (b) winter-nighttime (c) summer-daytime [1]

The suggested examples of a solar house refer to the reconstructions of traditional Vojvodina, mountain and Šumadija houses. The ecological and energy benefits primarily refer to the many possibilities of adapting the residential surface areas to the climate conditions. The sunroom becomes the most quality part of the house, which takes over the function of the contact zone between the indoor and outdoor residential space. It facilitates the necessary contact with the external space,i.e., with the sun, greenery and nature (Figure 5,6,7).

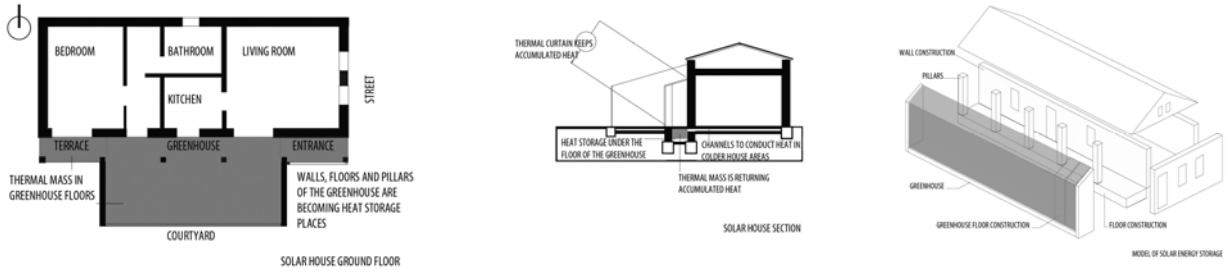


Figure 5. Vojvodina – example of reconstructing a house with sunroom

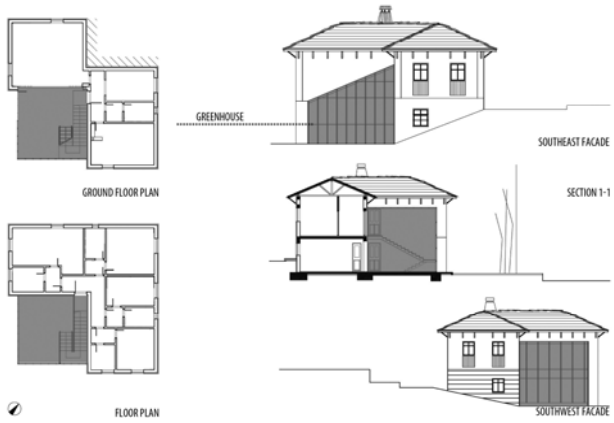


Figure 6. Mountain house – example of reconstructing a house with sunroom

During the coldest cloudy winter days, the thermal screens of the sunroom do not permit big thermal losses. Quality and well-dimensioned thermal insulation on the north side of the house and the sunroom, as a protective contact zone on the south side, contribute to the reduction of transmission and ventilation thermal losses; which is the basic condition for rational energy use. Air temperature in the sunroom during sunny winter days can be higher for even 10^{o}C than the outdoor temperature, so the sunroom can be comfortable for use even in winter. In spring and autumn, the temperature can be pleasant for living. By closing the thermal screens after sunset the accumulated heat from the construction of the solar house maintains the needed room temperature, which leads to rational energy use.

During summer, it is important to prevent direct insolation of glazed surfaces, so there is no overheating, not only of the sunroom but the house as well. During the summer, vertical glazed surfaces can be dismantled, or

they can open so there is vertical airing. Different systems are projected for the protection against direct solar radiation.

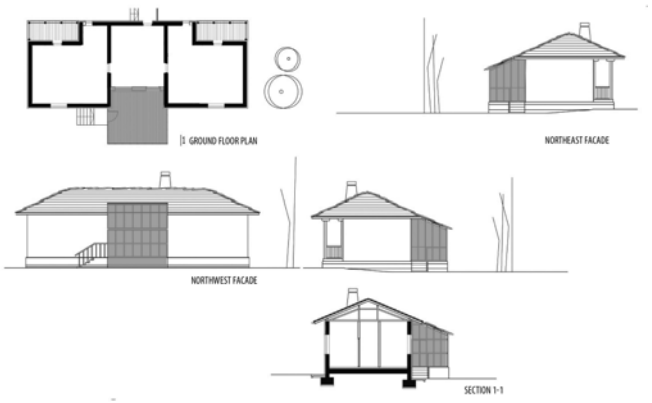


Figure 7. Šumadija and Pomoravlje – example of reconstructing a house with sunroom

5 FINAL REFLECTIONS

Analyzing the possibilities for implementing the principles of bioclimatic design in the reconstruction of houses and homesites in different regions of Serbia, it can be concluded that there is great potential and possibility for energy saving, achieving energy efficiency, implementing renewable energy sources and improving the comfort of living.

Based on the extensive research the authors' have carried out regarding the potentials of applying new methodologies during the reconstruction and building of new objects for residence in rural settlements of Serbia, only one element of passive solar architecture has been singled out in this paper – the sunroom, which can help in achieving different benefits and can bring the following contributions:

- architectural (creating new models of residence, balanced development of rural area, achievement of better conditions of living and increase in residential surface area);
- energy supply (rational consumption and energy saving – reducing energy needs);
- environmental (healthier and more humane living, reduction of CO_2 emissions);
- biological (bringing living closer to the natural surroundings);
- improving the conditions of comfort (thermal, visual, lighting);
- economic (incentives for investments, return of investment by reducing energy consumption);
- social and educational (positive examples of "good practice" influence the raising of people's awareness about the importance of rational energy use) etc.

ACKNOWLEDGEMENTS

This paper is part of research conducted within the scientific project 'Spatial, environmental, energy and social aspects of developing settlements and climate change – mutual impacts'(TR 36035) and the project "Studying climate change and its influence on the environment: impacts, adaptation and mitigation" (43007) financed by the Ministry of Education and Science of the Republic of Serbia

REFERENCES

[1] Competition for improving the ways and technologies of constructing residential buildings in the villages of Serbia: "Beautiful Serbia", Serbian Chamber of Engineers, 1st award in the competition, Pucar, M., author and project-leader; Simonović, S., co-author; Janković N., co-author, 2010.

[2] M. Pucar, Rational energy use and implementation of renewable energy sources as conditions for a sustainable development of settlements in Serbia, *Counseling: Principles and practices of sustainable development of settlements in Serbia*, *Serbian Association of Urban Planners,* Kosjerić, 2000.

[3] M. Pucar, Potentials of implementing renewable – non-exhaustive –energy sources in rural settlements of Serbia, *Scientific-professional counseling: Changing villages,* Predejane, 2001.

[4] M. Pucar, M. Pajević, M Jovanović-Popović, Bioclimatic Features of Some Historical Settlements in Serbia and Montenegro, PLEA'94: Passive and Low Energy Architecture, Israel, 1994.

[5] B. Kojić, *Rural Architecture and Ruralism*, Građevinska knjiga, Beograd, 1973.

[6] M. Pucar, Bioclimatic Architecture – glazed spaces and passive solar systems, monograph, IAUS, 2006.