

# SUSTAINABLE BUILDING DESIGN AND ENVIRONMENT

MILJAN SUNJEVIC<sup>1,2</sup>, MIRJANA VOJINOVIC-MILORADOV<sup>2</sup>,  
DARKO REBA<sup>1</sup>, MILJANA ZEKOVIC<sup>1</sup>, BORIS OBROVSKI<sup>2</sup>,  
NEVENA ZIVANCEV<sup>2</sup>

<sup>1</sup> University of Novi Sad, Faculty of Technical Sciences,  
Department of Architecture and urban planning, Novi Sad,  
Serbia

<sup>2</sup> University of Novi Sad, Faculty of Technical Sciences,  
Department of Environmental Engineering and Occupational  
Safety and Health, Novi Sad, Serbia

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e-mail: [msunjevic@uns.ac.rs](mailto:msunjevic@uns.ac.rs)

Architecture and environment are naturally inseparable. Without understanding architectural relationship to natural systems and environment, it is impossible to design proper buildings. It is impossible to understand the natural environment without knowing how human intervention affects it – both positively and negatively. As man and nature begin to recognize their interdependence and relationship, the study of environment takes on a whole new holistic meaning.

In search for new alternative ways of energy sources, more attention is paid to innovation, energy conservation and thermal conductivity, sustainability and the environment (air, water, bio sphere and soil), as well as economical sustainability.

This research promotes the model for northern Serbian province of Vojvodina, through modern sustainable eco-buildings and energy conservation required level of sustainability can be achieved.

The paper is based on main integral and eco principles of environmental protection. Applying the interdisciplinary approach and environmental thinking we are creating the shifts in environmental protection strategy, the new values that are effective way of protecting the environment and preserving our planet, which is expected from the developed and the social society as well as from developing countries.

## KEYWORDS

thermal conductivity, full-potential calculation, total energy calculations, sustainability, innovation, eco-building

## 1 INTRODUCTION

Vojvodina is Northern Province of Serbia (Autonomous Province of Vojvodina), and is located in the in the Pannonian Plain. Geographically whole area of Vojvodina belongs in middle Europe, with surface of 21.500 km<sup>2</sup>. Population of Vojvodina is very multi-ethnic, and it has approximately 2 million people. Due to its multi-cultural and multi-ethnic identity Vojvodina have six official languages. Capital of Vojvodina is city of Novi Sad, with around quarter million people.

AP Vojvodina is member of The Assembly of European Regions, as first and only region that became member without it county being member of European Union or Europe Council. It is also cofounder of regional council Euro-region DCMT (The Danube–Criş–Mureş–Tisa), with mission in regional cooperation in economy, cultural and ecological development.

Vojvodina is very challenging regional center and leader in many branches. It is educational regional center; with school system divided in 3 levels and the fourth university level. University of Novi Sad consists of fourteen different faculties situated in campus area, with acceptance of Medical faculty and

Academy of Arts. Tourism is also very developed in Vojvodina. The Economy of Vojvodina is largely based on developed food industry and fertile agricultural soil. Agriculture is a priority sector in Vojvodina. Traditionally, it has always been a significant part of the local economy and a generator of positive and rich results, due to the abundance of fertile agricultural land which makes up 84% of its territory. Other branches of industry are also developed such as the chemical, electrical, oil, metal-Cu and construction industry. In the past decade, ICT sector has been growing rapidly and has taken significant role in Vojvodina's economic development. High- tech sector is a fast-growing sector in Vojvodina. Software development represents the main source of revenue, particularly development of ERP solutions, Java applications and mobile applications. IT sector companies mainly deal with software outsourcing, based on demands of international clients or with development of their own software products for purposes of domestic and international market. Vojvodina pays particular attention to interregional and cross-border economic cooperation, as well as to implementation of priorities defined within the EU Strategy for the Danube Region. It can be also considered as one of main crossroads in Europe. There are many important roads which pass through Vojvodina. First of all, the highway (E-75), which goes from Central Europe and the Horgos border to Hungary, via Novi Sad to Belgrade and further to the southeast toward Nis, where it branches: one way leads east to the border with Bulgaria; the other to the south, towards Skopje and Thessaloniki. Third highway (E-70) in Srem separates the west, towards the neighboring Republic of Croatia and further to Western Europe. Around the highway there is a network of local roads and railway lines. The three largest rivers in Vojvodina are navigable stream. Danube River with a length of 588 kilometers and its tributaries Tisa (168 km), Sava (206 km) and Begej (75 km). Among them was dug extensive network of irrigation canals, drainage and transport, with a total length of 939 km, of which 673 km navigable. Danube-Tisa-Danube Canal (DTD) is a canal system, which is unique hydro-engineering system for flood control and hydrotechnical management, melioration, forestry, water supply, waste water evacuation, navigation, tourism, fishing, hunting. [APV 2016] Although Vojvodina is plain, it has mild Mountain called Fruska Gora. The slopes of Fruska Gora are perfectly suited for growing grape arbors, and whole area is famous for its wines. Many people have been captivated by its picturesque beauty, due to its outstanding location which is famous for the peaceful and lucrative lifestyles of its inhabitants, and a perfect destination for sightseeing where tourists can relax and enjoy themselves in the spectacular natural environment. Since 1960, it was proclaimed national park, and it attracts a lot of visitors every year. Because there are a lot of Serbian Orthodox monasteries whole area is also known as Serbian Holy Mountain.

As Regional leader in many branches, Vojvodina have to find a way how to use its full-energy potentials, eco-construction and must be prepared to take leader role in sustainable development.

## 2 CURRENT SUSTAINABLE ENERGY CONDITION

Sustainable energy use is very low in whole Serbia (especially AP Vojvodina). Renewable energy share of total primary energy supply is only 13 %. Most of it is in form of hydro energy produced in hydropower plants in southern and central Serbia. While in Vojvodina renewable energy is only just emerging in form of wind energy produced in windmills. [UNECE 2015]

Average solar radiation in Serbia is about 40% higher than the European average, but Serbia still uses this energy in production far behind countries EU. This makes its potential almost totally unused. Wind energy is also far behind potentials. Serbia is very rich with winds. Especially in Vojvodina where beside wind riches, exists good infrastructure. Although wind energy potential is recognized, it still hasn't taken its swing. There are also rich thermal sources that are specially valued in world, but not fully appreciated in Serbia. Due to European energy strategy 2020 and other regulative that Serbian government has signed, government adopted a decree on encouraging production of energy from renewable energy sources. Autonomous Province of Vojvodina is encouraging renewable energy use by giving different subventions and adopting legislative acts.

## 3 FULL-ENERGY POTENTIALS OF VOJVODINA

Vojvodina is very energy wealthy and with high potential province. Beside non-renewable energy sources, it has potential to become regional leader in renewable energy use. As three main sustainable energy sources there are wind, solar and geothermal energy.

### 3.1 Wind potential

Wind energy potential in AP Vojvodina has been in focus of researchers from different institutions since year 1984. Results of several research project proved that wind energy potential is significant and that average wind power density is between 100 and 400 W/m<sup>2</sup>. However, taking into account other important aspects for utilization of wind energy potentials (accessibility, electric power network, road and railway infrastructure, etc.), the area of south-east AP Vojvodina attracted the most attention. That was motivation for further research efforts in this field.

In depth study of the wind potential in AP Vojvodina, entitled "Wind Atlas of AP Vojvodina", has verified previous results, but with more accuracy and confident. The study was performed using much convenient data, wind metrological data from 8 metrological stations all over the territory of AP Vojvodina in 10 years period. The results of study were precise maps of wind speed and wind power density for whole territory

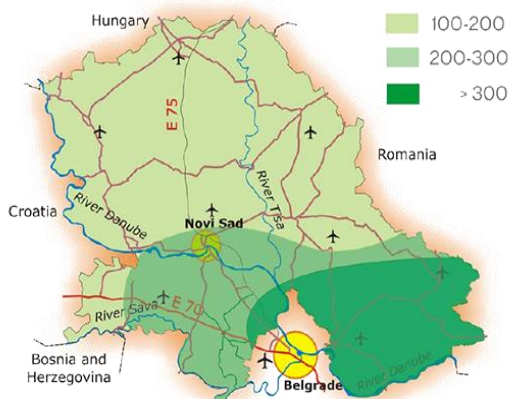


Figure 1. The average wind speed at a height of 100m (W / m<sup>2</sup>)

of AP Vojvodina at the heights of 10 m, 25 m, 50 m, 100 m and 200 m above the ground. Wind potential is significant especially for the height of 100 m and above, which corresponds to the height of pillar of modern wind turbines (1-5 MW). [Katić2012] Although there are very good conditions for exploitation of this kind of renewable energy, its potential is yet to be exploited.

### 3.2 Solar potential

In Vojvodina solar potential is above average in Europe. Average solar radiation is around 40% higher than Europe's average, but its use is still far behind EU countries. Vojvodina has 267 sunny days yearly, with average of 1400 kWh/m<sup>2</sup>. This great characteristic makes Vojvodina ideal for solar energy use, giving it another renewable energy source at disposal.

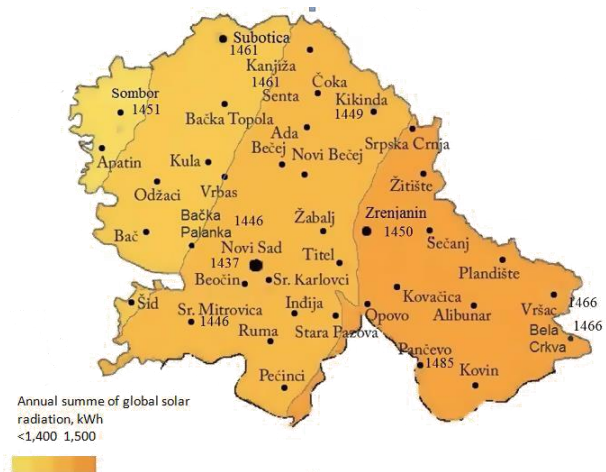


Figure 2. Annual summer solar radiation

### 3.3 Geothermal potential

First systematic and organized research of geothermal energy in Vojvodina started in 1969. and due to this day many new researches has been made. But all researches have proven that Vojvodina has great geothermal potential. [Mrazovic 2009] On relatively small depths (500m to 1000m) geothermal water appeared with warmth of 60-80°C. Thanks to that some part of geothermal potential has been used, but till recently that potential was partially forgotten. The commercial use of geothermal pumps returned geothermal energy back to the focus.

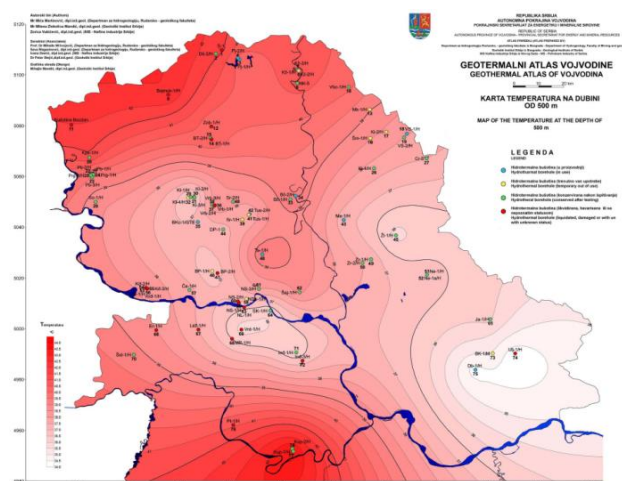


Figure 3. Geothermal potential of Vojvodina on 500m dept

#### 4 ENERGY SAVING POSSIBILITIES IN BUILDING DESIGN

Considering all renewable energy advantages of Vojvodina the highest level of use in sustainable building design can have geothermal and solar energy. While at the moment, wind energy with its great potential cannot be harvested directly and incorporated into the buildings. There are some indicators and new technologies are being developed at the moment for direct wind gathering, but for now it is far too expensive to be able to be called sustainable.

The region of Vojvodina for now should be concentrated on using cheapest and easiest to get energy at their disposal that can be implemented in buildings to make them more sustainable. Thanks to big research booms in sustainable industries, ways to gather solar and geothermal energy are cheaper and more proficient every day.

Solar energy can be in commercial way gathered by using photovoltaic or solar panels. Solar panels produce hot water and heating for the home, while photovoltaic panels produce electric current. On the other hand geothermal energy can be harvested by using geothermal pumps. Geothermal and water-source heat pumps are able to heat, cool, and, if so equipped, supply the house with hot water. Some models of geothermal systems are available with two-speed compressors and variable fans for more comfort and energy savings. Relative to air-source heat pumps, they are quieter, last longer, need little maintenance, and do not depend on the temperature of the outside air.

Although geothermal pumps save around 40% of energy they still has to be connected to the electric grid. To be able to release pump system from grid energy dependents, geothermal pumps will be connected in system with photovoltaic panels. This kind of system should be able to provide closed energy circle that works autonomously and which does not require additional energy sources. It should be able to provide itself sustainability, no greenhouse gasses emission and with great energy saving to be able to pay itself of after year or two, which is one of the basic goals of any model of sustainable development (MSD).

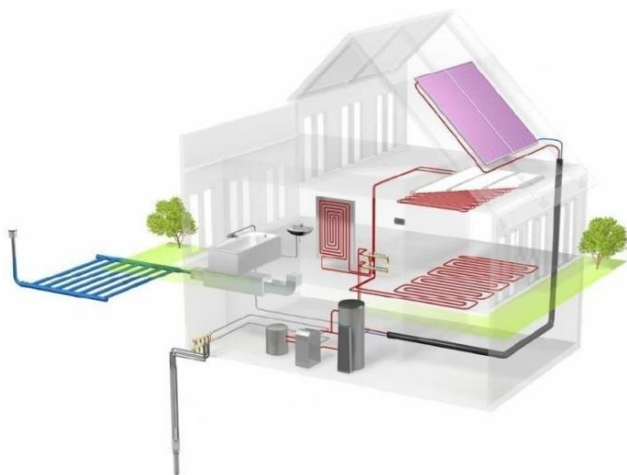


Figure 4. Model of sustainable energy home system

#### 5 INSTEAD OF CONCLUSION

Implementing benefit, easy, cheap, optimal material design (metallic, non-metallic and composite) and sustainable

ways of getting and preserving energy in building design is one of most important model of sustainable development missions. To be able to develop optimal model, we must be first familiar with specific environmental, climate, geochemical and other space characteristics and the way they can be used. Considering the high, unique, holistic environmental properties of nature and manmade heritage the model of sustainable development (MSD) can be functionally defined by next relation:

$$MSD = \int \sum (EC, CC, GC, SC, Mc, EcC, LF, nk)$$

Where:

EC-Environmental characteristics

CC-Climate characteristics

GC-Geological characteristics

SC-Spatial characteristics

MC-Material characteristics

EcC-Economical characteristics

LF-Legislative framework

nk-all other relevant characteristics

In Vojvodina there three optimal sources of getting energy are from wind, sun and geothermal waters. At moment the use of wind energy is not yet prepared for that, but soon we can expect great breakthrough in this field (in form of small wind turbines installed on building facade). Geothermal and solar energy are the most benefit sources of renewable type of energy, combining their abilities creates closed and sustainable energy system that will represent model of sustainable development (MSD).

In next few years Vojvodina/Serbia in accesses process European Union need to increase sustainability and renewable energy production and preservation through eco-building and eco-design.

Urban and industrial construction activities must be in accordance and harmonized with surroundings of the environment and nature, especially in the case of the use of alternative-green energy sources.

Model of sustainable development is based on effective use of energy, land and materials as important, key and critical factor in realization of sustainable development. It is vital importance to understand efficiency of resource through entire cycles which energents are going trough from source, trough distributive process do state of use. Results of sustainability analysis of MSD must be integrated in early process of building design, to secure full and long sustainability of model of sustainable development.

Calculation of full energy potential and prediction of total energy calculation (energy production and consumption) are basic premises for understanding of sustainable development that includes economy, ecology, environment, industry and prosperity of the society.

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**CONTACTS:**

M.Sc. Miljan Sunjevic  
University of Novi Sad  
Faculty of Technical Sciences  
Department of Architecture and Urbanism  
Department of Environmental Engineering and Occupational Safety and Health  
Trg Dositeja Obradovica 6, 21000 Novi Sad  
e-mail: [msunjevic@uns.ac.rs](mailto:msunjevic@uns.ac.rs)