The Challenges of the Bioclimatic Architecture in Romania

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Abstract. The Bioclimatic Architecture is an architectural style, new as terminology in the history of architecture, but old in its principles, that can be found in the history of the vernacular architecture since the first types of houses appeared. Nowadays, due to the need of eco-friendly ways of building and due to the need of green energy consumption, it emerged in different architectural styles aiming to develop the built space in different manners. Green, Passive, Solar and Bioclimatic Architecture. Each one of them is depending on the natural factors, but from all of them, Bioclimatic Architecture uses all the natural resources available on the site through the volume of the construction in passive ways, sing reduced amounts of energy. First bioclimatic models appeared in hot climate, where they successfully responded to the only needs of cooling the interior air by solar protection and by natural ventilation, and also using the thermal inertia for providing warm air during the cold summer nights. The main problem appears in the temperate zone where, during the winter time, the need of active systems for providing higher indoor temperature appears as a warm indoor temperature against the sub-zero outside temperature. This paper aims to highlight the particularities of Romanian continental climate that influences the bioclimatic model, to mark the limit where the passive bioclimatic principles stop, and from where the active systems begin.

1. Introduction
Nowadays, the buildings are becoming an increased presence in the natural landscape. Due to the risen number of the population, the construction sector is increasing at a rapid rate. The globalization effect manifest in construction by a worldwide uniformity of building techniques and materials which led to a high level of waste and pollution due to the fabrication and building process. Almost 50% of the global waste comes from construction sites. Besides the amount of energy used in the whole building process, additional energy is required for running the equipment needed for running the finalized buildings. For taking control over this high level of energy consumption and pollution produced in the building process, new methods of designing and planning the cities at all scales is required.

During the energy crisis of the middle 20th century, Olgyay was the first researcher in the modern period who saw a solution for a greener way of building. He identified the potential of Solar Orientation and the great relation that exists between the nature and the building itself. The work of Olgyay were among the first theoreticians who offered their knowledge in a book on the Passive Architecture and the Bioclimatic Architecture and of a new model of the Solar Architecture. Many researches have been made in the new field with a lot of new discoveries of methods of environmental determination, methods and strategies of designing a building and systems were developed to assure thermal comfort and to produce energy for a building using on-site resources.
The most successful examples of bioclimatic buildings have been developed in warm and hot climates, perfectly adapted to their environment. Having to protect the building against the high temperatures during the day and to maintain a constant temperature during the night, the buildings managed to rely exclusively on the passive methods. Even though multiple examples of bioclimatic houses were built in Europe, in continental and cold climates, one problem still remained: how can a true bioclimatic house behave in a climate where the passive methods are not enough to assure a thermal comfort during the whole year, during each season? How can a true bioclimatic house maintain the thermal comfort during the winter, when outside are -10 degrees Celsius? At which point the passive methods of bioclimatic architecture stop and where the active systems begin? That is an issue that affects the proper developing of the bioclimatic houses in the temperate zone in Europe, by thus Romania which makes the subject of this paper.

2. Romania’s bioclimatic conditions
Characteristic for Eastern Europe, Romania is defined by a continental climate, that features extreme seasonal differences with hot summers and cold winters. Influenced by the Black Sea, the Romanian coast has a milder climate influenced by the air masses that come from the inland.

![Figure 1. Romania’s climate map.](image)

The average temperature during a year is between 8 °C in the Northern part of the country and 11 °C in the Southern part. Even the daytime temperatures vary from -21°C (figure 1) during the winter, up to 25-40°C in the summer days. The southern plain regions are hotter than northern and eastern regions where the temperatures are moderate, there are cooler nights in the summer and below zero night’s temperatures in the winter. Annual average rainfall is about 600mm, with extreme quantity in the mountains even up to 1000mm, and down to 400 on the coast. All the year has considerable quantities of rainfall, spring being the driest season.

Köppen - Geiger classification: according to Beck, H.E et al., 2018, Romania had between 1980 and 2016 predominant Cold, no dry season, hot summer (Dfb) in the Transylvania, Moldova and Banat regions, situated in the two-thirds of the northern part of the country (figure 2). The peaks of the Carpathian Mountains had a Dfc classification with cold, no dry season and cold summer. The rest of the country had cold, no dry season hot summer (Dfa) in the southern plains region, and Arid, steppe,
cold (BSk) in the Dobrogean region, along the sea shore part of the country, where k signifies middle-latitude climate (average annual temperature below 18 °C).

Starting with the last decade, the climate is changing globally at a rapid rate. Building constructions that are designed taking into consideration their climate might represent a good strategy for the moment, but in decade or more, the environment, being in a continuous change, might influence in a different way the building. In a situation like this, the strategies used for a building might not work anymore in the parameters calculated during the planning.

![Figure 2](https://www.nature.com/articles/sdata2018214)

**Figure 2.** Köppen-Geiger climate classification map for Romania years 1980-2016
Source: "Present and future Köppen-Geiger climate classification maps at 1-km resolution". Nature Scientific Data. link: [https://www.nature.com/articles/sdata2018214](https://www.nature.com/articles/sdata2018214)

Source: Beck, H.E., Zimmermann, N. E., McVicar, T. R., Vergopolan, N., Berg, A., & Wood, E. F.

![Figure 3](https://www.nature.com/articles/sdata2018214)

**Figure 3.** Köppen-Geiger climate classification map for Romania prediction for years 2071-2100
Source: "Present and future Köppen-Geiger climate classification maps at 1-km resolution". Nature Scientific Data. link: [https://www.nature.com/articles/sdata2018214](https://www.nature.com/articles/sdata2018214)

Source: Beck, H.E., Zimmermann, N. E., McVicar, T. R., Vergopolan, N., Berg, A., & Wood, E. F.
For tackling the unpredictability of climate conditions, a map was developed by Beck, H.E et al., 2018, that predicts, following to mathematical factors, the climates across the globe (figure 3). Köppen-Geiger climate classification map for Romania prediction for years 2071-2100 indicate that each region will have a hotter and dryer climate. The arid, steppe, cold (BSk) classification will be taken over almost the entire country and, in its place, it can be found the arid, desert, hot (BWk). The mountains above 1000m altitude will have cold, no dry season with warm and hot summer (Dfa and Dfb) and the regions with 600-1000m altitude will have a temperate, no dry season, hot summer (Cfa). Every form of relief change to a different climate, with warmer winters and hotter summers.

Romania has a population of 19.53 million distributed along the country, with the highest density in the plain regions. In the last years, many new residential districts were developed near the big cities in open field, and a lot of rural and natural amateurs have built houses in rural places, in a more natural landscape, isolated from other settlements. As resulted from the Köppen-Geiger climate classification, two major regions characterise the country, plain regions and hill and mountain regions. The plain regions have lower day-night differences, in the summer. The higher altitude regions having lower temperatures during the year, during the winter more snow accumulations are present. Hence, two bioclimatic strategies are presented.

**Figure 4.** Diagram presenting how the Romanian limitations generates the bioclimatic methods Source: Author

The first strategy refers to a house located in the plain area, in the south of the country. By highlighting the limitations and the advantages, it would narrow the application of the methods and it would increase the efficiency of them.

Limitations: Very hot summers with low difference between day-night temperatures, which raises the problem of the interior air by the natural ventilation, the hot exterior air would go into the house. Because of the absence of the day-night differences, the house must be kept cooled and shaded by the sun, which leads to minimised solar gain. The very low temperatures in the winter, during both the day and the night, the house must be well insulated and to have proper design of the wall-glazing ration for minimising the heat losses. So, the minimised solar gain combined with below-zero outside temperatures require a good heating system, a thick insulation and reduced glazing.
Advantages: The soil allows building a basement which would help for natural ventilation and cooling the air. Using the earth to cover the house and use it as a natural insulation is an advantage, resolving many problems. The climate and the fertile soil offer the possibility to plant a high variety of plants, of any height, and have a biophilic design that protects the house against the sun and it offers refreshed oxygenated air outside and inside of the house.

The second strategy refers to a house located in the hills or in the mountain area, in the central and north of the country, where most of the region is wooded due to the big parcelling, exception being the downtowns of the cities.

Limitations: The presence of the tall vegetation might represent a problem in solar gain. Same as plain region’s situation, the solar gain must be minimised due to the winter below-zero temperatures. However, in the summer, solar gain combined with an interior building element with high thermal mass would have a good efficiency due to the high difference of day-night temperatures. The high possibility to find hard rock substate on site might affect a basement. Also, the slope of the terrain sometimes rises up issue of underground water during rain falling or snow melting. An important issue on the mountain and hill region is the orientation. If the house is located on a northern side of a mountain, it will be almost all day shaded with no solar gain. Other situations, when the site is well oriented to south, with one or multiple mountains located in south direction, the house might have certain hours when it might be shaded. The absence of the sun will limit the use of the passive methods. So, for mountain and hill region, the location of the site must be well analysed before designing the house, or even better before purchasing the lot.

Advantages: The high hill and mountain areas, covered with wood offer a great possibility of sun protection. By having locally sourced wood and stone, the specialized workforce can be used for building with these materials. Also, the stone, sometimes found plenty the site, can be used for thermal mass. The slope of the roof, when possible, can be used for a semi-basement building, that would help for a cool air natural ventilation.

Bioclimatic methods: After establishing the climate conditions and narrowing the area of application, a set of methods are generated, which are presented in the diagram from the Fig. 3. An exemplification of the method applications which has as model a one storey house, on a flat site, with explication on each method can be found in Fig. 4, 5 and 6.
3. Active systems that complete the bioclimatic strategies
As it is resulting from the previous chapter, the Romanian temperate climate rises multiple issues in applying only bioclimatic passive methods when designing a house. Still, active systems that use reusable energy must be installed for compensating the shortcomings.

Using only the solar power, multiple systems can be installed on the roof and underground. Firstly, the photovoltaic panels (PV) are required for obtaining the electrical power needed for running the other systems. Installed on the south facing roof slope, the PV’s dimensioned for house surface and energy demand, are transforming the solar power by captioning the sunlight into a flow of electrons by the photovoltaic effect. In the plain region, with Dfa and BSk classification, the intensity of the solar irradiation is 1350 kWh/m²/year, so the efficiency of the PV is high, taking into consideration that a nZEB house must have a maximum consumption of 50 kWh/m²/year. One of the very important way of using the PV in the most efficient way is to have the energy demand supplied with electricity through the day, during the time the PV are producing energy, for avoiding the charging of the batteries.

![Figure 6. Bioclimatic scheme – Water use](image1)
Source: Author

![Figure 7. Bioclimatic scheme – Biophilic methods](image2)
Source: Author
lowering the number of the battery’s cycles, their lifespan is considerably increasing. So, the PV are necessary to power the other active systems.

The main system that needs to be installed and completes the passive methods is the heating system. During the cold days of spring, autumn and winter, a heating system is highly needed. A central HVAC unit can be installed for both cool air and hot air ventilation. The unit can be connected to a solar air collector and to an air intake from the basement. The solar collector is used for heating during the cold seasons. Installed under the roof cover or under a ventilated façade, which works in a similar principle as Trombe Wall’s room, but in a reverse mode. The outside finishing is heated by the sun rays, even in the winter, while the air’s temperature from the small room behind it is increasing. The heated air is afterwards aspirated by the HVAC unit. The cool air take from the basement works in same way for an active cooling of the interior space when natural ventilation is not efficient in hot summer days, when the air has the relative humidity level under 30% or over 50%.

The solar panels are great for both heating the domestic water, but also for heating the coolant that runs either through the HVAC unit, or through radiators.

![Figure 8. Bioclimatic scheme – Active systems](image)

**Figure 8.** Bioclimatic scheme – Active systems

Source: Author

4. Results and discussions

Romania’s climate conditions present multiple challenges in bioclimatic approach. The extreme seasons differences really push the bioclimatic methods to the limit and require additional active solutions. The natural resources can be used for both approaches, active and passive solutions. The solar energy is very efficient for powering a heating system that can work by ventilation or by radiation, and also to heat air or to heat a type of coolant. The windows opening can be opened for natural ventilation, because it would let the outside hot air to go inside the house, so, the same ventilation system can be used for the cool air ventilation in hot summer days, in the situation when a basement can’t be build, with the help of an underground pipe system.

Literature mainly refers to that refers to the bioclimatic and passive architecture is dedicated to warm and hot climates, where their principles can be applied with maximum efficiency. But still, important populated and developed regions around the globe are located in the continental temperate climate zones, which require additional solutions due to the extreme temperatures. Many researches are required for improving the adaptability of the house on the local conditions and to establish the best hybrid solution that combines active and passive solution with the best use of the local natural resources.
5. Conclusions
The large field of application of the bioclimatic principles, at this point, represents a great performance for a house adaptability at the local climate conditions. The extended practice across many countries in hot and warm climates stands as a good starting point for other climates. Romania’s bioclimatic challenges are produced by the extreme seasonal differences. By analysing the limitations and the advantages of the Romanian climate and geography completed with a set of active solutions, a hybrid bioclimatic set of principles will emerge.

References
[1] C. Schittich, “In detail Solar Architecture”, Publishers for Architecture 2003
[2] D. Thorpe, “Passive Solar Architecture Pocket Reference”, Routledge, 2018.
[3] C.G. Manuel and C. Gustavo, “Bioclimatic Architecture in Warm Climates - A Guide for Best Practices in Africa”, Springer, 2012.
[4] M. Košir, “Climate adaptability of buildings – Bioclimatic design in the light of climate change”, Springer, 2019
[5] P. Lapithis, “Bioclimatic Architecture and Cyprus”, Pantheon Cultural Association, 2018
[6] Romanian Normative for thermotechnic calculation of the building construction element, Indicative C107-2005
[7] T. E. Johnson, “Solar Architecture – The direct gain approach”, McGraw-Hill; 1st edition, 1981
[8] Vilnius Gediminas Technical University, Faculty of Architecture, Department of Urban Design, “Bioclimatic principles in architectural design – A way to better buildings, Arfu-13, 2014