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To cite this article: T Mihăilescu 2018 *IOP Conf. Ser.: Mater. Sci. Eng.* **399** 012039

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# Standard economic bioclimatic solar individual houses – four hypostases

**T Mihăilescu<sup>1\*</sup>**

<sup>1</sup> Transilvania University of Braşov, Romania

\* E-mail: t.mihailescu@unitbv.ro

**Abstract.** In the present Romanian architectural practice for individual houses and/or residential areas, designing the architectural objects in order to function together with the nature seems to be neglected. This happens despite a great variety of bioclimatic solutions materialized in the traditional houses of all the Romanian geographical regions, in an old and rich history of traditional architecture. The approach starts with a historical overview, analyzing several examples of traditional houses in all the regions of Romania so as to identify the traditional bioclimatic solutions used to better adapt the architecture to the environment. This constitutes the source of inspiration for the four modern standard economic bioclimatic (solar) houses designed for the geographical and climatic parameters of Braşov, Romania, and destined for the middle class families. The concept is simple, based on modesty, involving minimum costs for building and using the houses, as well as for a comfortable life. The projects also offer all the premises for an efficient use of complementary systems for producing and storing energy from the environment (if opted for). The aim is to optimize the relation between the natural and the built environment in order to maximize the comfort, efficiency and economy in all the aspects of a family living in a bioclimatic house (form, function, building materials, equipments, living space, quality of life, etc.). In this respect, the architecture of the four standard economic bioclimatic (solar) individual houses presented represents a neutral and simple so-called "extruded box", as an interface between humans and environment, as a chance to better explore ourselves.

## 1. Premises, historical and contemporary context, problems

In the Romanian architectural practice for individual houses and/or new residential areas, designing the architectural object in order to function together with the nature seems to be neglected in the majority of the situations. This may be related to five main factors: 1) a certain reticence of the people to live in a bioclimatic (solar) house (the absence of information, trust, interest, cultural and/or mentality reasons), 2) a design process ignoring by default the conditions/principles involved by the bioclimatic (solar) architecture, preferred are instead : an architecture of representation of the clients' social status and dreams rather than an architecture of the economy, and/or an architecture as a manifest of the architect's dreams, accepted by the clients sometimes despite their real needs, 3) inadequate sites, 4) local/regional real estate realities, and 5) the absence of a real financial help from the state for complementary systems creating energy from natural and clean sources. This happens in spite of a great variety of bioclimatic solutions materialized in the traditional houses of all the Romanian geographical regions in an old and rich history of architecture adapted to the environment.



The historical overview, which analyses almost all the examples of the traditional houses in all the regions of Romania, despite their local/regional particularities, shows that all the houses seem to share the same passive/solar/bioclimate characteristics to better adapt the architecture to the environment: 1) simple structures, smart-simple but efficient details and local building materials (mainly wood, but also mud, stone, and/or bricks), 2) north-south orientation: maximal openings/main living areas towards south, minimal openings/secondary functions towards north, 3) a very simple and efficient function and a smart way to use all the interior available space, 4) cheap and effective solutions for insulation (against water, cold, heat and wind), 5) exterior areas, placed close to the house, for storage of provisions (firewood, rain water, food, food for animals) and shelter for domestic animals, and 6) the north-south section of the volume designed to use at its best the sun angles, with the "invention" of *prispa* / the porch, having a) an "open" facade towards the south, using the roof to have complete shadow in the summer, and as much sun as possible in the winter in order to maximize the sun heat, and b) a "blind" facade towards the north, to better isolate the house and minimize the heat loss.

Above all, the local differences (also a result of other kinds of adaptations), the (Romanian) traditional architecture seems to demonstrate convergent adaptation: the same response to the same problems.

Ten examples of traditional houses, chosen from significant historical/geographical regions of Romania (conserved within *Dimitrie Gusti* Village Museum in Bucharest, Romania; photo by Teofil Mihăilescu, 2015), are emblematic for the result of the historical approach leading to the identification of the traditional bioclimatic solutions used to better adapt to the environment (figures 1 to 7).



**Figure 1.** Traditional houses in Dobrogea (SE Romania, at the Black Sea, Danube and Danube Delta): (left) in Jurilovca (Tulcea), and (right) in Ostrov (Constanța); 19<sup>th</sup> century.



**Figure 2.** Traditional houses (hills regions) in Romania: (left) Rușețu (Buzău), 20<sup>th</sup> century, in Muntenia (S Romania), and (right) Nereju Mic (Vrancea) in Moldavia (W Romania), 19<sup>th</sup> century.



**Figure 3.** Traditional houses (hills regions) in: (left) Stănești (Argeș) in Muntenia (S Romania), and (right) in Curtișoara (Gorj), in Oltenia (SW Romania); 19<sup>th</sup> century.





**Figure 4.** Traditional houses in Transylvania (central-northern Romania, mountain/hills region): (left) Clopotiva (Hunedoara), 20<sup>th</sup> century, and (right) Șanț (Bistrița-Năsăud), 19<sup>th</sup> century.



**Figure 5.** Traditional houses: (left) Berbești (Maramureș) in Maramureș (N Romania), and (right) Straja (Suceava) in Bucovina (NE Romania, mountain region); 18<sup>th</sup> century.



**Figure 6.** *Prispa* / (aprox.) the porch - The southern exposure in the history of the traditional Romanian architecture, from the Black Sea/plains/Danube (left) to the Carpathian mountains (right).



**Figure 7.** The northern exposure in the history of the traditional Romanian architecture, from the Black Sea/plains/Danube Delta (left) to the Carpathian Mountains (right).

## 2. Inspiration, goals, keywords

The inspiration for the concept of the Standard economic bioclimatic (solar) individual house (SEBIH) came from: 1) the history of the (Romanian) traditional architecture, 2) the bioclimatic/passive modern architecture, 3) a personal/professional change of paradigm concerning the philosophy of life and a sustainable way of life, 4) the need of independence in a world of dependence (having the "plan B"), 5) living as a statement: a neutral, simple exterior, for a complex interior personal/intellectual life [1].

The Eco-Goals tend to be close to the Passivhaus German Standard: 1) for heating: less than 15 kWh/m<sup>2</sup>/year, 2) for thermal insulation:  $U \leq 0.15 \text{ W/(m}^2\text{k)}$ , 3) for windows and doors:  $U \leq 0.80 \text{ W/(m}^2\text{k)}$ , 4) for final energy: less than 50 kWh/m<sup>2</sup>/year, within a concept governed by seven keywords: economy, independence, efficiency, modesty, sustainability, functionality, statement.

### 3. Proposal, context, architectural concept

The approach starts from the premise that cheap, efficient individual houses could be realized, which would be independent or multiplied within real estate investments, with local resources (materials, workers), for middle class families. They would be designed with simple solutions and within the frame of the bioclimatic architecture's principles, also using (at choice) complementary systems for producing and storing energy from the environment (sun, wind, water and/or earth). The approach here developed is based on a previously published research of the author, *Cheap type solar bioclimatic individual houses for residential areas* [2].

#### 3.1. Context: geo-climatic parameters, sun angles, site

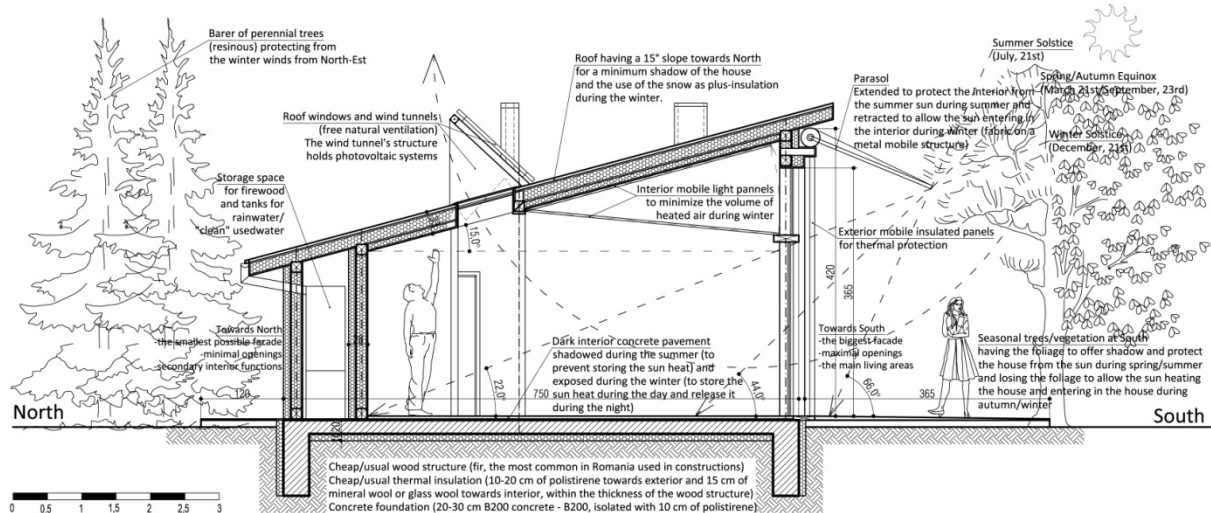
The houses are designed for the geographical and climatic parameters of Braşov (Transylvania), Romania: latitude: +45.66 (45°39'36"N), longitude: +25.61 (25°36'36"E), time zone: UTC+2h, altitude ~540 m, temperature variation summer/winter +/- 23°C. The sun angles are: a) 19°-24° (considered 22°) at 13.00 h on December, 21, at the Winter Solstice, with the sunrise at E and sunset at W, b) 42,5°-45° (considered 44°) at 12.00 h on March, 21, at the Spring Equinox and on September, 23, at the Autumn Equinox, with the sunrise at E and sunset at W, and c) 66°-70° (considered 66°) at 13.00 h on June, 21, at the Summer Solstice, with the sunrise at N-E and sunset at N-W [3] (Figure 8).

The SEBIH - Standard economic bioclimatic (solar) individual house projects require a small dedicated north-south oriented site (about 500 m<sup>2</sup>, even less), preferably flat or having a light slope towards south, or a bigger site (about 1000 m<sup>2</sup> or more), offering the freedom to orientate the houses on the north-south direction, in a proper context and (predictable) neighbourhood, allowing the sun to reach the house all day long, from sunrise to sunset.

#### 3.2. Concept: architectural invariants, building materials, philosophy

The SEBIH - Standard economic bioclimatic (solar) individual house concept is simple, based on economy and modesty. The main invariants in their architecture and design are: 1) a compact, modular, linear, "extruded" volume for a minimum physical and visual impact within the environment, with an architectural expression given by its linear south façade, 2) a north-south orientation: the biggest façade, maximal openings and main living areas towards south and the smallest façade, minimal openings and secondary functions towards north, 3) a very simple wooden structure, realized as much as possible with local building materials and local human resources (not necessarily a very qualified human resource), 4) a very simple and efficient function, with a smart way to use the interior available space, 5) an improved, efficient and smart insulation (against water, cold, heat and wind), 6) a section of the volume designed to use at its best the sun reference angles at solstices/equinoxes, 7) adaptive options for living with the nature as well as isolating the house against elements when relevant, 8) multiple role active and passive heating sources to ensure a complete independence during the local cold months (November-February), 9) multiple role exterior areas for resources storage close to the house (firewood; rain water or used but "clean" water used within the house, for recycling it to the toilets and/or for watering the garden), 10) vegetation within the site for the benefit of the house by having a "barer" of perennial trees (resinous), permanently offering protection from the winter winds of the north, and a seasonal vegetation (trees with seasonal foliage, but also vine), disposed at the south to provide shadow from the sun during the summer and offering the sun warmth for additional heating of the house during the winter, and 11) freedom of aesthetic options concerning the façades.

In order to use at its best the sun energy, the houses should be placed at the north side of the site in order: 1) to receive the biggest amount of sunlight during the winter months from sunrise to sunset, and 2) to prevent being in the shadow of other architectural objects built nearby at S, E, W.



**Figure 8.** General concept-section for the Standard economic bioclimatic (solar) individual house, covering all the seasonal situations within a year and showing the adaptive response of the house.

The houses presented also have a symbolic value within their dimensions: lots of the interior spaces are dimensioned using the golden ratio, the height of the south windows and the width of the front terrace have 365 cm (the number of the days in a year), the rooms for the children are positioned to east (sunrise, "present in the future") and the matrimonial bedroom is positioned to west (present as "future past", sunset) as each day starts with its symbolic "birth" at sunrise and ends with its symbolic "death" at sunset (figure 8).

### 3.3. Heating/ventilation, water, electric power

The heating/ventilation for the bioclimatic (solar) individual house should be realized both passively and actively, on condition that the entire volume is almost perfectly isolated.

The passive heating is realized using the large windows, the dark interior pavement of the concrete foundation to store the heat from the sun and release it during the night (as it is exposed to the sun up to 80% of its surface), and using the additional heat generated by the electricity and kitchen equipments. In the good sunny winter days, up to 50-80% of the total heat requirements of the house can be supplied this way [4].

During the cold periods, active heating is used as follows: the traditional tiled/glazed stoves positioned to heat two spaces (D), a traditional kitchen stove (F) and a chimney (E) with firewood, and/or regular, common efficient appliances based on natural gas and/or electric power. In the bathrooms, the heating and the hot water could be provided by the little traditional iron/bronze stoves with a water boiler (C) using an insignificant quantity of any kind of firewood with a maximum result. For an extra-insulation of the volume of the house and to minimize the loss of the interior heat during the winter nights, the windows have an exterior plus-protection offered by a series of mobile insulated panels (G), which could "seal" the house.

The series of the roof windows (H) of the house are both sources of natural light and wind tunnels [5] (for a free natural ventilation), and have a parasol structure which could hold photovoltaic systems. As alternative, a ventilation system with heat recuperating systems could be used during the winter.

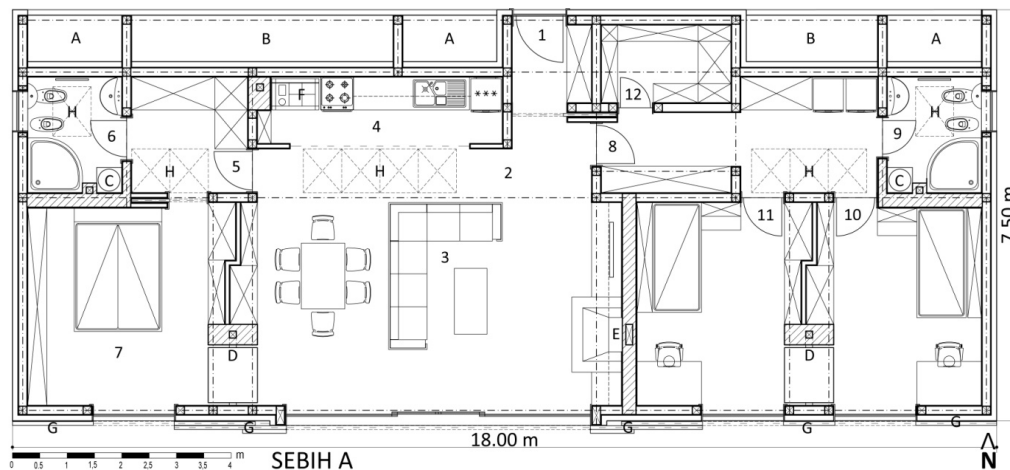


The house tends to use drinking water only for the human subsistence, and the rain water, collected gravitationally from the roof in the water tanks (A) nearby the bathrooms and kitchen, for other needs. Heated water is produced as much as possible by the solar systems [6].

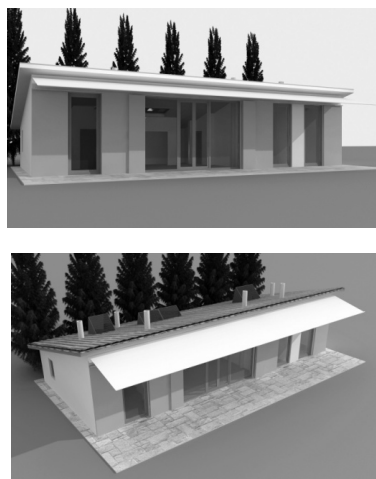
The electric power could be partially produced by photovoltaic systems [7] and/or by small turbines using the wind power [8]. The house is equipped with electric equipments of energy class A or superior. The led technology provides all the artificial light.

### 3.4. The four Standard economic bioclimatic (solar) individual houses A, B, C, and D

**3.4.1. Standard economic bioclimatic (solar) individual house A.** It is a house designed for a family with two adults and two children, having a total built area of 135.00 m<sup>2</sup>, of which 94.00 m<sup>2</sup> for living (figures 9, 10). Of a total of 74.70 m<sup>2</sup> of the south facade, 36.50 m<sup>2</sup> are windows (48.86%). To minimize the volume of heated air, as well as the loss of heat through the big windows of the main facade during the winter, of the total of 317.84 m<sup>3</sup> of the interior air volume, only 275.72 m<sup>3</sup> is heated (86.75%), the rest of 42.12 m<sup>3</sup> (13.25%) being isolated at will by the light interior mobile panels. The house has: an access wind fang (1), functional and efficient circulations (2, 5, 8), a living room and a dining area (3), a kitchen (4), a matrimonial bedroom (7), two bathrooms (6, 9), two children rooms (10, 11), a pantry (12). The storage spaces for firewood is designed at the north (B) of 6.00 m<sup>2</sup>/15.20 m<sup>3</sup>, and for water tanks (A) of 4.35 m<sup>2</sup>/9.50 m<sup>3</sup>, collecting it from the roof.

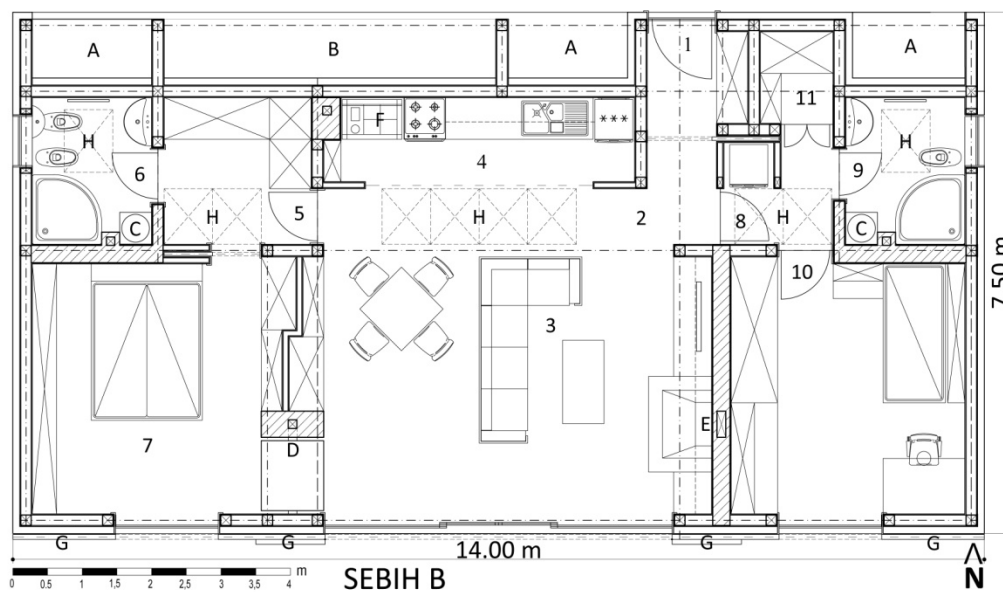


**Figure 9.** Plan of the Standard economic bioclimatic (solar) individual house A.

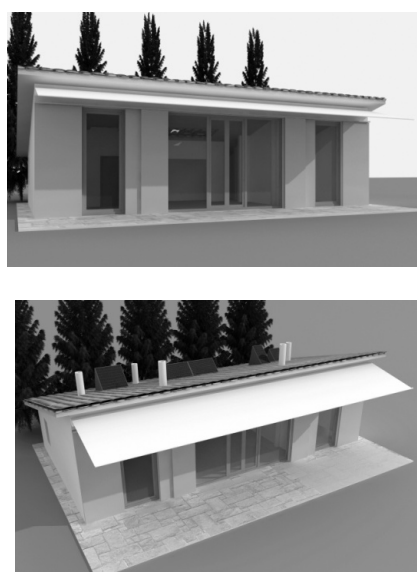


**Figure 10.** Concept perspectives of the Standard economic bioclimatic (solar) individual house A.

**3.4.2. Standard economic bioclimatic (solar) individual house B.** It is a house designed for a family made up of two adults and one child, having a total built area of 105.00 m<sup>2</sup>, of which 79.00 m<sup>2</sup> for living (figures 11, 12). Out of a total of 58.10 m<sup>2</sup> of the south facade, 29.05 m<sup>2</sup> are windows (50.00%). To minimize the volume of heated air as well as the loss of heat through the big windows of the main facade during the winter, out of the total of 194.24 m<sup>3</sup> of the interior volume, only 168.50 m<sup>3</sup> are heated (86.75%), the rest of 25.74 m<sup>3</sup> (13.25%) being isolated at will by the light interior mobile panels. The house has: an access wind fang (1), functional and efficient circulation spaces (2, 5, 8), a living room and a dining (3), a kitchen (4), a matrimonial bedroom (7), two bathrooms (6, 9), a room (10), a pantry (11). To the north, the house has a storage spaces for firewood (B) of 4.05 m<sup>2</sup>/10.12 m<sup>3</sup>, and for water tanks (A) of 4.35 m<sup>2</sup>/9.50 m<sup>3</sup>, collecting the water from the roof.



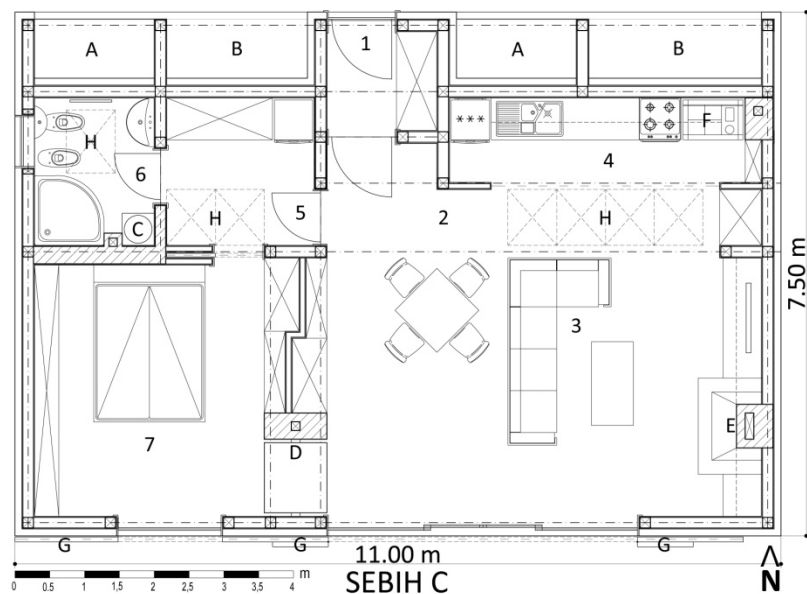
**Figure 11.** Plan of the Standard economic bioclimatic (solar) individual house B.



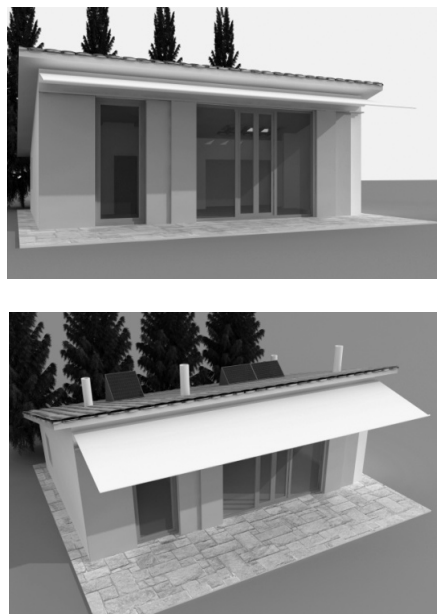
**Figure 12.** Concept perspectives of the Standard economic bioclimatic (solar) individual house B.



**3.4.3. Standard economic bioclimatic (solar) individual house C.** It is a house designed for a family with two members, having a total built area of  $82.50 \text{ m}^2$ , of which  $62.00 \text{ m}^2$  for living (figures 13, 14). Out of a total of  $46.65 \text{ m}^2$  of the south facade,  $21.68 \text{ m}^2$  are windows (46.47%). To minimize the volume of heated air, as well as the loss of heat through the big windows of the main facade during the winter, out of the total of  $247.22 \text{ m}^3$  of the interior volume, only  $214.46 \text{ m}^3$  is heated (86.75%), the rest of  $32.76 \text{ m}^3$  (13.25%) being isolated at will by the light interior mobile panels. The house has: an access wind fang (1), functional and efficient circulation spaces (2, 5), a living room and a dining (3), a kitchen (4), a matrimonial bedroom (7), a bathroom (6). To the north, the house has the storage spaces for fire wood (B) of  $4.05 \text{ m}^2/10.12 \text{ m}^3$ , and for the water tanks (A) of  $2.90 \text{ m}^2/6.38 \text{ m}^3$ .

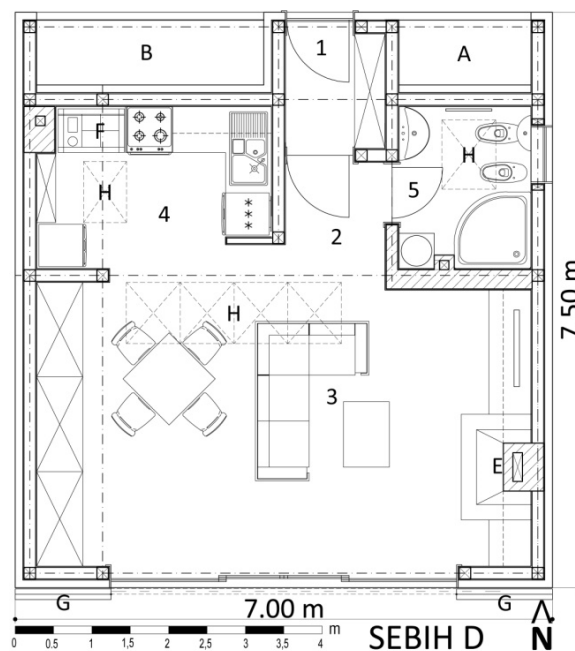


**Figure 13.** Plan of the Standard economic bioclimatic (solar) individual house C.

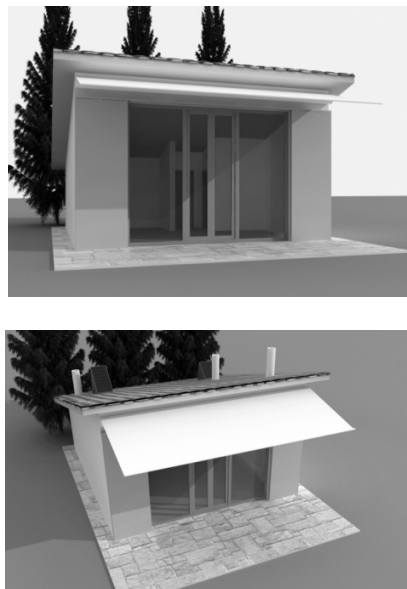


**Figure 14.** Concept perspectives of the Standard economic bioclimatic (solar) individual house C.

**3.4.4. Standard economic bioclimatic (solar) individual house D.** It is a house designed as a little country holiday cottage for a couple, having a total built area of  $52.50 \text{ m}^2$ , of which  $38.00 \text{ m}^2$  for living (figures 15, 16). Out of a total of  $29.05 \text{ m}^2$  of the south facade,  $16.24 \text{ m}^2$  are windows (56.52%). To minimize the volume of heated air, as well as the loss of heat through the big windows of the main facade during the winter, of the total of  $123.61 \text{ m}^3$  of the interior volume, only  $107.23 \text{ m}^3$  is heated (86.75%), the rest of  $16.38 \text{ m}^3$  (13.25%) being isolated at will by the light interior mobile panels. The house has: an access wind fang (1), a functional and efficient circulation (2), a living room and a dining (3), a kitchen (4), a bathroom (5). To the north, the house has the storage spaces for firewood (B) of  $2.51 \text{ m}^2/5.62 \text{ m}^3$ , and for the water tanks (A) of  $1.45 \text{ m}^2/2.24 \text{ m}^3$ .



**Figure 15.** Plan of the Standard economic bioclimatic (solar) individual house D.



**Figure 16.** Concept perspectives of the Standard economic bioclimatic (solar) individual house D.

#### 4. Conclusions

The estimated average price of such a standard economic bioclimatic (solar) individual house in Romania, realized with local building and human resources, could be about 250 Euro/m<sup>2</sup> without V.A.T. This is considerably less than the average estimated building price of a similar house of the same built area, in a similar site, and realized with different building materials (concrete, bricks) and different technologies (estimated at about 400 Euro/m<sup>2</sup> without V.A.T. in present) [9], or even realized with similar materials and technology but not paying attention to specific (solar) bioclimatic design and philosophy generating a significant economy. Above the affordable price, the bioclimatic architecture involves also a way of life. Therefore, an entire way of thinking about living should be changed, involving a change of paradigm in mentalities and the help of the professionals, media and governments/local administrations for the urban actors to be motivated in choosing the bioclimatic architecture as a step forward towards sustainable development [10].

The main premises in both designing these SEBIH - Standard economic bioclimatic (solar) individual houses and living in them are: 1) to learn from the valuable lessons and experiences of the history of the (Romanian) traditional architecture, 2) to accept a way of life involving a set of different life and living principles than the ones we are used to within the post-modern society/the contemporary matrix, 3) to optimize the relation between the natural and built environment in order to maximize the efficiency and economy in all the aspects of (personal) life, 4) to adopt a sustainable way of thinking and of life, offering yourself the chance of a relative or almost complete independence in a world of dependence: having the famous "plan B".

Living in a Standard economic bioclimatic (solar) individual house is a statement and means choosing a way of life. Traditional adaptive solutions are integrated in such a house, both using the qualities of the elements and offering protection from elements, as well as modern solutions translated in these simple, economic, efficient, modest "green" buildings, having a "life" almost together with the life of their inhabitants.

In this respect, the architecture of the Standard economic bioclimatic (solar) individual houses means a neutral, decent, modest, a simple so-called "extruded box", apparently lost in the nature, open to the southern sky, as a (bright) interface between humans and environment, and a chance to develop a very complex personal/family/intellectual interior life and better explore ourselves.

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