Hutsul *grazhda* - wisdom of traditional rural architecture as the guidelines for designing contemporary bioclimatic buildings.

Dariusz Heim, MSc Eng. [1]
Wlodzimierz Witkowski, MSc Eng. Architect [2]

Technical University of Lodz. Faculty of Civil Engineering, Architecture and Environmental Engineering. Al. Politechniki 6, 90-924 Lodz, PL
[1] Department of Building Physics and Building Materials. E-mail: darkheim@p.lodz.pl
tel. (48.42) 631.35.60, fax (48.42) 631.35.56.
[2] Institute of Architecture and Urban Planning. E-mail: wlodek@rosiosk.lodz.pl
tel. (48.42) 631.35.33, tel./fax (48.42) 636.78.73.

1. INTRODUCTION

The Hutsuls are an ethnographic group of Ukrainian mountains people inhabiting the slopes of the Eastern Carpathians, mainly in the river-basins of Pruth and Tcheremosh (at the present Ivano-Frankivs'k district, Ukraine). Due to lack of plough-land, the basic occupation of the Hutsuls was cattle and sheep shepherding. Traditional Hutsul dwellings were located mostly at the height of 500-1000 metres above sea level, in the mountains higher than 2000 metres (Tchornohora range). Hutsul settlement was of reclusive character - separate farmsteads were scattered far from each other at the mountainous slopes.

The climate of the Hutsul Lands is characterised with traits typical for mountain regions. Vegetation period lasts 4 to 6 months, depending on the height above the sea level. Summer is warm and sunny, the average air temperature in July is about 13-16°C. Winters are long and frosty (the average air temperature in January is about -5°C). There are relatively strong, south-western winds, year average precipitation is 700-1000 mm depending on the place (in November, December and February more than 110 mm). Snow cover is even up to 70 cm; in top parts of the mountains snow lies even for 4 months. Mountains are covered with old spruce and fir forests, river valleys also with leafed forests. Summits are covered with mountain pastures.

Observations and measurements made in the Hutsul Lands for many years together with the survey of specialist ethnographic literature have rendered it possible to acquire knowledge on the rules and forms of the traditional architecture of this region. In the past, the most fully developed and characteristic form of building was a solitary, wooden, enclosed single-manor farmstead - *grazhda*, which concentrated the whole of the Hutsul farm buildings around the inner yard. It consisted of the typical dwelling room, surrounded by additional rooms (farm sheds for livestock, halls and chambers), covered with the common roof, and the massive wooden enclosure (with their own roof), equipped with tight gate. (Figure 1 and 2b).

This architecture was formed in an evolutionary way with no professionals (in the contemporary understanding of the term), but with using experience conveyed from generation to generation. Due to the fact that traditional rural societies are usually very conservative, also the process of forming architectural solutions used by the Hutsuls was long. *Grazhda* was developed to the form that is known contemporary from research only in the 17th c. or even at the beginning of 18th c. [4,5]. With only minor modifications it lasted up to the period before WW II. It started to disappear because of introduction of more efficient heating systems and social and economic transformations.

Besides *grazhda*, there were - at the same time - other spatial forms of Hutsul dwelling houses, from the simplest ones (Figure 2a) to those surrounded with additional rooms.

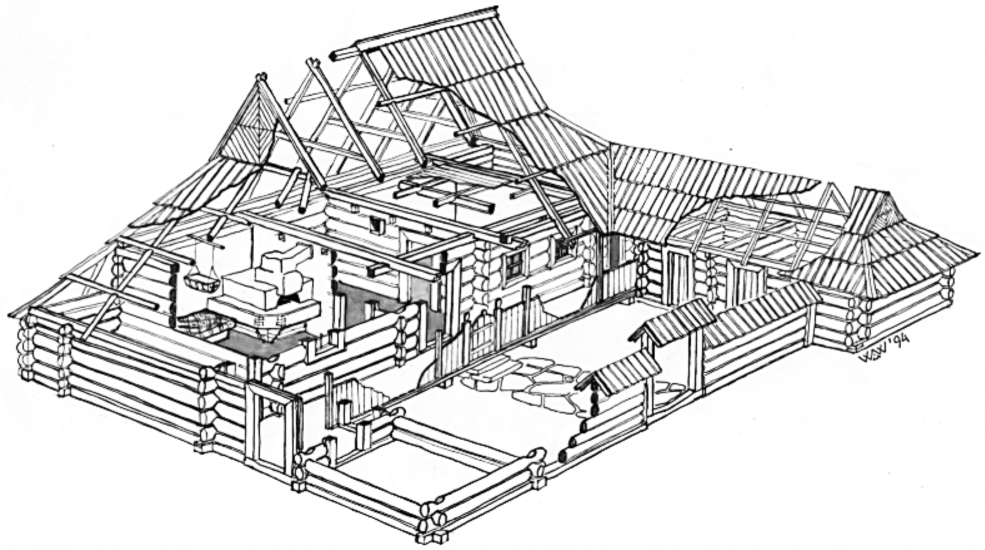

Figure 1. Perspective view of the synthetic example of Hutsul *grazhda*.

2. ENERGY SAVINGS STRATEGIES

The authors defined some characteristic features of the Hutsul *grazhda* that may be helpful in contemporary design of single bioclimatic dwelling houses.

Location:

dwellings protected from winds and snow-storms, choice of the place preceded by long surveys, orientation of the house to the sun, the dwelling harmoniously fitted to natural landscape - colour, surface characteristics, and form - ‘non-aggressive’ aesthetics.

Form and function:

minimum functional programme resulting from real needs; the spatial form of building resulting from the programme; buffering zones on the North, West, and East sides; gallery in front of the house - summer ‘room’ and communication corridor under the roof; aerodynamic form of the building, angle of inclination, and form of the roof dependent on precipitation and covering material; window openings on the South side only, optimum size of the openings, window shutters; optimum place for the heating unit; walls made warmer with layers of fire-wood and hay.

Material and construction:

local wood, minimum woodworking - energy saving, durability of wood adequate to local conditions, easy assimilation to the nature after the period of using - enclosed cycle of materials and energy circulation (utilisation, recycling); only local impact on the nature; construction adequate to: physical characteristics of the material, local conditions (climate, wind, precipitation), and functional programme.

Using:

evolutionary process of creation - ‘wisdom’ of the building as the wisdom of generations; almost enclosed circulation of energy and materials; natural fuel (local wood), using the same heat for heating, cooking, conserving, and storing food; only natural waste.

Initial calculations results obtained for simple and advances Hutsul buildings were presented in previous work [3]. They inspired and encouraged the authors to make further, more precise analyses.

In this paper important role of additional rooms and the front enclosure for wind reduction and heat transfer through the walls was confirmed. The differences in results of heating energy demand and internal temperature for two types of Hutsuls houses was presented.

3. TWO MODELS OF EXEMPLARY HUTSUL COTTAGES.

Advanced numerical techniques were used to confirm an ecological character of Hutsul buildings and authors' main thesis pointed above. The geometrical models of two synthetic examples were created within ESP-r advanced building simulation program based on mathematical model proposed by Clarke [2]. Simple Hutsul cabin and *grazhda* were established as a multi-zone thermal system represented by several control volumes described by their geometry, construction and operation. Both the models are theoretical but all the data were taken from typical Hutsul buildings. They were obtained from available literature and architectural measurements made by the authors [6,4,5].

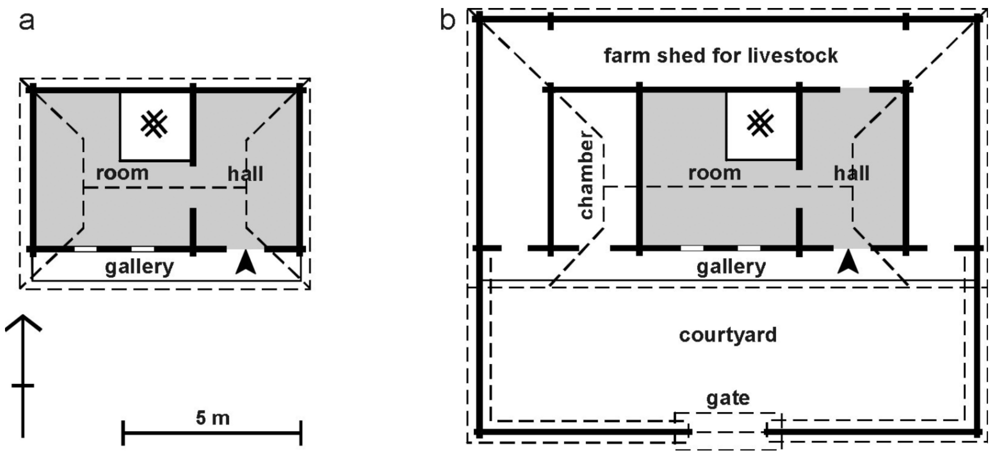

Figure 2. Schemes of plans of selected types of Hutsul houses chosen for calculations: a) simple cabin b) *grazhda*

3.1. Geometry.

Simple cabin and *grazhda* (Figure 2) were modelled separately within ESP-r program. The three-zone major part of the buildings, consisting of the room, the hall and the under roof space, is common in both the cases. In *grazhda*, two extra zones – farm sheds for livestock and the chamber – surround the room and the hall and separate them from external environment. The main room is 4.5m long and 4.5m wide, with two windows in south external wall and it is the only dwelling space in the building. The room is connected with exterior by the hall as a buffer space with two doors: one from the hall to the room and the other one from the hall to the outside environment.

3.2. Construction and materials.

Due to local source of construction materials, only wood was used to construct Hutsul buildings. The external and internal walls were defined as a homogenous timber wood construction with an overall thickness of 13.5cm and 10cm, respectively. The ceiling over the room and the ground floor were wooden as well but there was no ceiling over the hall. Thin and leaky wooden tiles (long shingles) covered the roof space. Temperature below 0°C on external wall surface for *grazhda* allows taking into account additional snow layer. It reduces the value of heat transfer coefficient and protects against heat looses through the walls. We cannot do the same assumption for simple cabin, where the external surface temperature above 0°C causes melting of the snow layer, which is in contact with the wall.

3.3. Operations.

The internal heat gains for the zones were the source of uncertainty. According to the authors' experience, about six persons, at the average, lived in the building. For the simulation, we assumed six persons staying in the room during the night and four persons during the day. Additional energy inputs from animals were defined in farm shed for *grazhda* only. The room, the hall and the under roof space were connected to each other and with external environment by ventilation network. The magnitude of the network component and type of connection were estimated from the authors' measurements. Only small gaps between the zones and the exterior (cracks between each timber-woods beams or around the windows) and some openings inside the building were defined but their size was another source of uncertainty. There was no direct airflow connection by the door from outside to the room (because of the hall). The buffer spaces around the room exert a real influence on infiltration. The number of air changes per hour is two times smaller for *grazhda* then for simple cabin but it is still not less then 0.4 – 0.6 ac/h.

Typical Hutsul chimneyless stove was built from a clay on the wooden frame. For the simulation, we assumed 2.5 kW heating unit in the room. The heating unit works periodically from 8:00-10:00 a.m. and 4:00-9:00 p.m. and, as we expected, it should guarantee internal room temperature between 10 and 15°C as the effect of its high thermal mass.

3.4. Boundary conditions.

Unfortunately, no realistic climatic data for any Eastern Carpathian region are available for the authors. That is why it was decided to choose the relatively similar period of one week from realistic weather data for Poland. The period from 15 to 21 of January was selected, as it consisted temperature, direct solar radiation and wind speed similar to the monthly averages in the Hutsul Lands [1].

4. SIMULATION RESULTS AND ANALYSIS.

Indoor resultant temperatures were calculated for every zone in the building. The maximum temperature difference between the room in *grazhda* and the room in simple cabin was about 2.5K during the night and 2.0K during the day (Figure 3a).

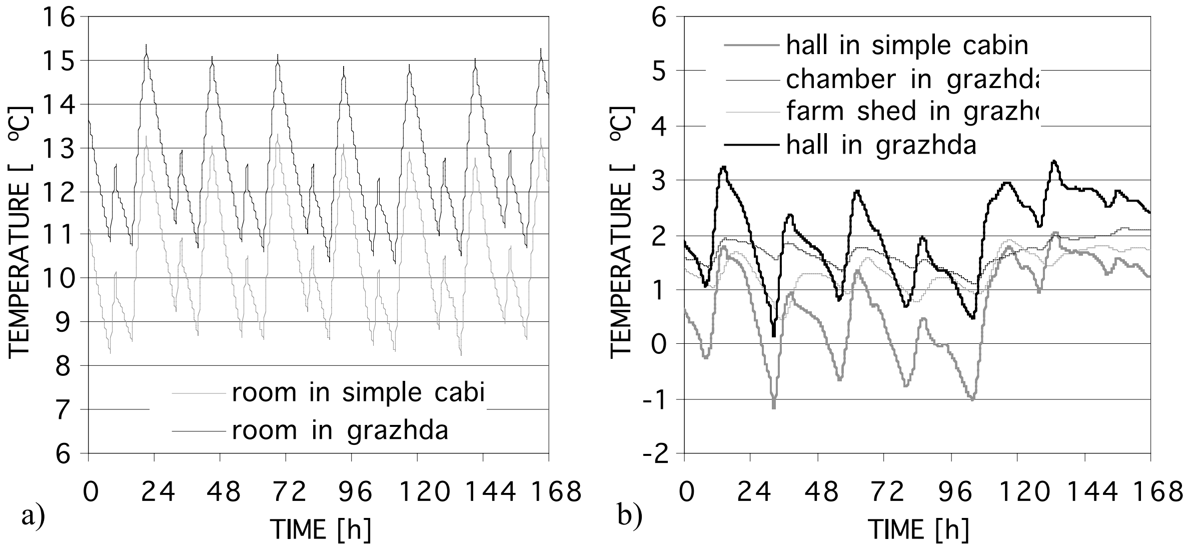

Figure 3. History of internal resultant temperature in selected zones.

Percentage temperature distribution in the dwelling room (Figure 4) shows much better thermal comfort conditions for *grazhda* (resultant temperature over 12ºC during 50% of test period) then for simple cabin. On the other hand, the heating energy coming from the room is utilised in buffering zones as well and allows to keep their temperature over 0ºC (Figure 3b).

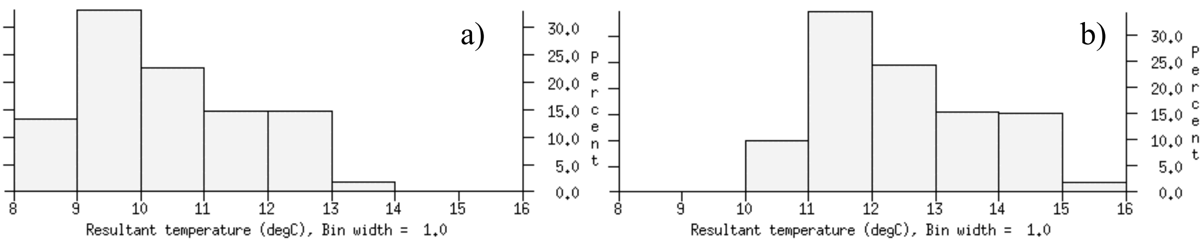

Figure 4. Room's resultant temperature frequency distribution for
a) simple cabin and b) *grazhda*.

It was noticed that heat conduction through the room's walls is 40% lower for *grazhda* then for simple cabin (Figure 5b). Also infiltration through the walls and roof was reduced to 60% owing to more aerodynamics shape of *grazhda* (Figure 5a). All the results above show that the buffering spaces around the room have a great impact on heat conduction through the wall and infiltration rate.

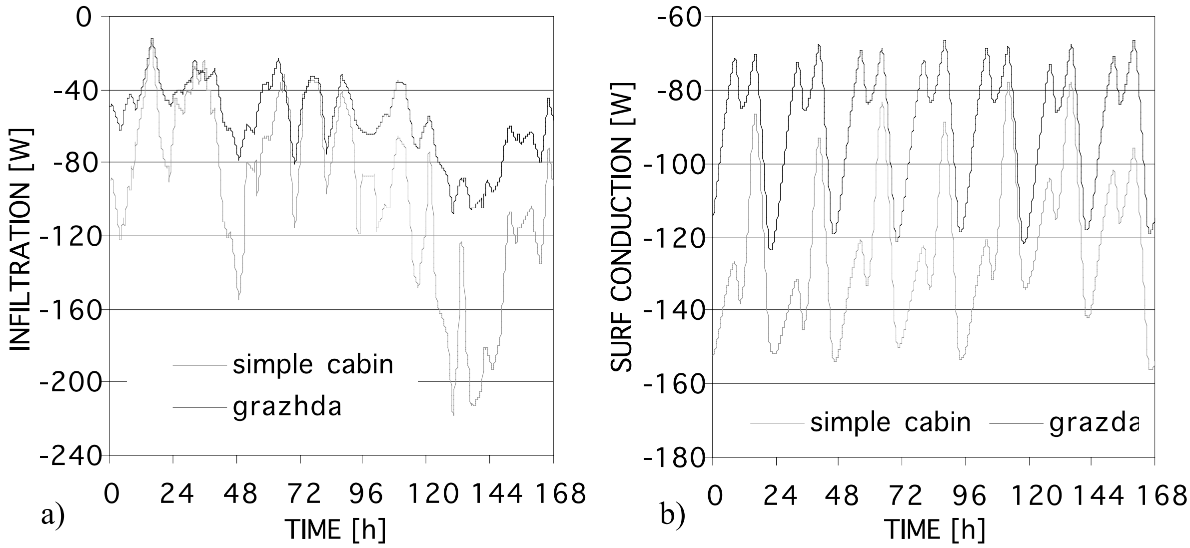

Figure 5. a) Infiltrate heat flux and b) Conductive heat flux through west wall in the room

If we extend heating period for simple cabin to reach the same value of mean temperature we can estimate the differences in energy consumptions in both the cases. As it was expected, we have about 22% less energy consumption in *grazhda* then in simple cabin. However, there was no fuel limitation in the Carpathian region. That is why we are almost sure that better indoor quality was more important for the Hutsuls than reduction of fuel consumption.

5. CONCLUSIONS

Results of computer simulations for selected period of January show that simple solutions and experiences, conveyed from generation to generation, helped the Hutsuls create the most efficient building system as possible. Only a few guidelines were analysed but obtained results let us formulate the conclusions below:

5.1. For the same, additional, external source of energy (limited to 2.5 kW power heating unit), resultant temperature in grazhda is higher then in simple cabin about 2.0K during the day and 2.5K during the night. It allows us to reach higher thermal comfort for dwellers in grazhda, then in simple cabin, with the same amount of energy consumption.

5.2. If we equal heating set point for grazhda and simple cabin to the 14.5ºC (maximum value allowed to achieve in cabin with 2.5kW heating unit) the real savings in energy consumption are provided to be about 22%. However one week is too short period for such kind of conclusion; future analyses, for whole heating season with more realistic climatic data are necessary.

5.3. Relatively high thermal mass of fireplace reduce daily temperature fluctuation to 5-6 K, although heating unit is turned off for 10 hours during the night.

5.4. Additional external zones (farm shed and the chamber) protect against the wind and give the real savings in energy loosing for infiltration and heat conduction through the room's walls.

Moreover all changes in building structures during the evaluations were done in accordance with natural environment. There were no aggressive influences on surrounding, energy sources and materials. Neither advanced calculation technique, nor active energy systems were used in Hutsul buildings. On the other hand, only passive techniques allowed reducing energy consumption more than 20%. It proved that passive systems are sufficient enough and can be used regardless of localisation and environmental conditions, which is very important in developing countries. Because of the great potential of passive technologies philosophy works with, rather than in spite of, the local climate should be preferred.

6. REFERENCES

[1] Buczynskij J.O., Wolewacha M.M., Korzow W.O. 1971. Klimat ukrainskich Karpat (in Russian), Kiev.

[2] Clarke J.A. 2001. Energy simulation in building design, 2nd edition, Butterworth–Heinemann, Oxford.

[3] Heim D., Witkowski W. 2000. Grazda huculska jako przyklad drewnianej budowli bioklimatycznej (in Polish), Proceeding of V Scientific and Technological Conf. – Problems of Designing, Realisation and Utilisation of Low Energy Consuming Buildings – ENERGODOM-2000, pp. 111-118, Krakow-Zakopane.

[4] Mohytyč I.R. 1987. Typy ta rozvitok budivel’ seljans’koho dvoru, In: J. Hoško (Ed.) Narodna architektura Ukrajins’kych Karpat 15-19 st. (in Ukrainian), Kyjiv.

[5] Witkowski W. 2000. Huculska grazda (in Polish). In: W.A. Wojcik (Ed.), Budownictwo ludowe w gorach. Proceeding of Symposium, Krakow.

[6] Zukowski J. 1935. Huculszczyzna. Przyczynki do badan nad budownictwem ludowem (in Polish). *Biuletyn Historji Sztuki i Kultury*, Vol. III, no 4, Warsaw.