CONSIDERATIONS ON METHODS OF SELECTION PASSIVE STRATEGIES AND VALORIFICATION REGENERABLE ENERGY SYSTEMS FOR „*NZEB*" & BIOLOGICALLY ACTIVE BUILDINGS

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INTRODUCTION

Imposing new energy exigency for the future buildings (nZEB & other buildings) requires, on the one hand, reviewing all the rules relating to design parameters thereof on the other hand strategies to ensure comfort in these buildings must be carefully analyzed and correctly considered within the rules as indoor climate, hygro-thermal comfort inside that it is influenced by external climate, building performance, user requirements and their behavior (physical activity, clothing). The paper presents an analysis the impact of different strategies insurance liabilities hygro-thermal comfort, by assessing the contribution of each strategy in providing indoor comfort indicators of established as models of static comfort (Energy Comfort Californian Code) and dynamic or adaptive, (55 ASHRAE,…). The analysis aims at identifying the best strategies passive acquiring comfort for different types of buildings and locations by exploiting adequate correlation external climatic data - comfort indicators / internal comfort parameters / comfort zones.

1. ARGUMENTS FOR A GOOD SELECTION OF THE HEATING / COOLING STRATEGIES SUITABLE FOR BUILDINGS

The accelerated depreciation of the environment has led to the intensification of research studies to determine the major causes of the phenomenon as well as the possible stop and recovery measures.

CO_2 emissions from the combustion process of classical fuels in the energy generation process for heating / cooling buildings have long been identified as having a major contribution to altering the terrestrial ecological balance. Consequently, measures have been proposed to reduce CO_2 emissions in this sector. These have been shown to have a positive impact on improving the process of CO_2 accumulation in the atmosphere and, respectively, an improvement in the Earth's ozone protective layer.

Experts estimate that building construction is one of the strongest dynamics: more than a quarter of the 2050 building stock exploited to be built. These predictions, followed by appropriate policies, can open a promising horizon to reducing CO_2 emissions by controlling their design process. At EU level, ambitious CO_2 reduction targets have been set, due to the reduction of the energy consumption (buildings) achieved by the combustion of classical fuels to „*near zero*” values respectively): reduction of greenhouse gas emissions up to in 2050, with approx. 80% compared to 1990 levels. Similar steps have been taken in other countries[1]. As a consequence of this measure, it is possible to achieve increased energy security by consistently reducing domestic consumption. Significant steps have been taken to establish a definition and instructions for implementing „*Near Energy Efficient Buildings*” (nZEB) in practice. In the revised Energy Performance of Buildings Directive (EPBD) in 2010, Article 9 introduced the requirement to bring energy performance of buildings to *Near-zero Energy Buildings*” (NZEB) from 2019 onwards public buildings and 2021 to all newly built buildings[2].

A very recent research has identified other major causes of ecological equilibrium depreciation at the Earth's level. The most important is the **alteration of the water cycle in nature** as a result of increased solar activity (*explosions & increase of electro-magnetic & proton/solar/solar field/solar winds with impact on the absorption capacity of CO_2 from the atmosphere in the seas and oceans*), which, according to their statement, would be responsible for the amount of CO_2

[1] America, China, Brazil, Japan, Upper Africa, Senegal, India, Australia, Canada & others

[2] The Directive defines nearly zero energy buildings as buildings with a high energy performance [...], with a low or almost zero energy requirement, to be ensured to a large extent from renewable sources, at the building site or nearby. There is a wide diversity of building traditions, climate conditions and different methodologies in the EU in the EU, which is why a uniform methodology for the implementation of this type of building (nZEB) has not been established in Directive 2010/31 / leaving the freedom of Member States in part to develop their own performance criteria for NZEB buildings and their own strategies, plans and roadmaps, taking into account national, regional and local conditions.

accumulated in a double atmosphere relative to the anthropogenic origin.

*The International Sustainable Building/**iiSBE** Initiative* focuses on: reducing energy consumption (water ...) at the building level, while reducing the amount of waste and noxious emissions generated over its lifetime.

2. A GLOBAL PERFORMANCE CRITERION FOR THE USE OF BUILDINGS IN A SUSTAINABLE ENVIRONMENT - THE "NET ZERO" CONCEPT

In the effort to define the most comprehensive actions *for a sustainable built environment*, the **Net Zero** concept has been promoted with the significance of a strategy for setting performance targets for the built environment based on local availability of renewable energy and water resources. Under this umbrella, other concepts have been developed to help define a sustainable built environment:

• ***nZEB/Net Annual Energy Net Buildup****≡a building that produces more energy than it* ***consumes using local renewable sources;***

- ***ZNC****/Zero Net Carbon:* This sets out for both new buildings and existing buildings a clear direction: towards a carbon-free environment (CO_2)[3].

- Promoting **Zero Carbon** buildings (ZNC) responds to the urgent need to mitigate the impact of CO_2 emissions from fossil fuel burning.

- **ZNC** building is defined as: *"a highly energy efficient building that produces or acquires sufficient carbon-free, renewable energy to meet annual energy consumption."*

- In a **ZNC** building, carbon energy consumption is reduced firstly by building design strategies and efficiency measures, then by generating renewable energy on site and finally by purchasing renewable energy locally.

- By establishing a *net zero* carbon-free energy balance, the ZNC definition can apply to all types of new and existing buildings with a relatively high or limited capacity to generate renewable energy on the spot (urban buildings dense).

- A broad carbon emissions reduction platform has been set up. The ZNC definition will play a significant role in guiding the design of buildings, urban development in general as well as operations for professional organizations and policy-makers[4].

- As a consequence of efforts to reduce CO_2 emissions, this year launched *the global 100% renewable energy platform* that responds to many of the goals set by the Net Zero concept. Within the platform, a particular emphasis is placed on local systems for the valorization of renewable energies.

- In addition to these performance criteria imposed on future buildings, complex measures are also sought to reduce the CO_2 content of the atmosphere through its energy recovery systems.

Note:

In many locations around the world, the CO_2 content has exceeded the critical threshold of 450 ppm, while many of the current ventilation rules account for about 350 ppm. Increasing fresh air flow is also accompanied by increased energy consumption for heating/cooling.

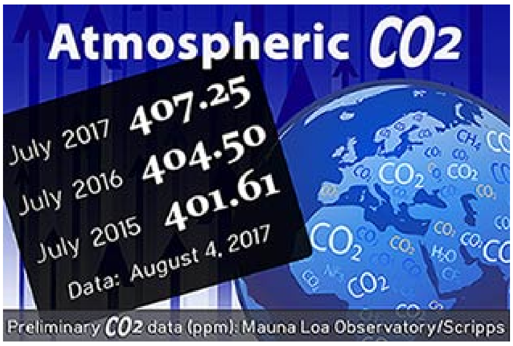


Figure 1. CO_2 content in the atmosphere (ppm) - Extract from Past-present-future-*(Source: https://www.co2.earth/co2).*

- A study conducted at the Technical University of Moldova, Department of Heat, Water, Gas and Environmental Protection, highlighted variations in the atmospheric CO_2 content (ppm) between 450 and 480 ppm.

• Net Zero Water Building (nZWB) Strategies / Net Consumption of Zero Water in Buildings.

Scientists have shown that water is a primordial resource formed with the formation of celestial bodies in a constant, solid, liquid, vapor, natural cycle with a natural cycle strictly correlated with other environmental components, whose balance has significantly changed lately, with major consequences on the climate. Energy Management in Buildings provides information on this requirement / quality / concept criterion imposed on future buildings and provides strategies for the design and implementation of buildings that meet this criterion. Under the proposed strategies, buildings and sites can be built to conserve natural water resources, contribute to improving water infrastructure and provide water to meet the critical needs of the building in the long run.

[3] In December 2015, the world reached a monumental consensus on the need to: a) limit global warming to "less than 2 ° C"; b) limit the rise in temperature below 1.5 ° C above pre-industrial levels.

[4] The volume of construction and reconstruction needed to be approached throughout the world over the next two decades, coupled with the need to dramatically reduce carbon emissions, requires clear action and approaches in defining, approaching, designing and operating ZNC buildings.

A building with a net water consumption is a building (built or refurbished) designed to a) minimize total water consumption, b) use alternative water sources, c) minimize waste water discharged from the building, to return the extracted water to the original source of water. NZWB buildings are actually water-neutral buildings in which the amount of alternative water used and the return water to the original water source is equal to the total water consumption of the building. Their purpose is to preserve the quantity and quality of natural water resources with (minimal damage), to reduce their exhaustion and to redirect water through the use of available alternative water sources, and to promote measures to streamline the use of water and consequently to minimize the use of fresh water supplied. The principle can be applied to a building or extended to a site / area larger than the strict one for the building. Basically, these buildings completely compensate for the use of water with alternative water plus return water to the original water source.

This strategy also mentions how to measure this quality criterion in general as well as in individual cases. The general relation of the measurement of the indicator is:

Alternative water used + returned water = the total quantity of water used

in which: *total water used* is the amount of water consumed within the boundaries of a building from all sources (potable and non-renewable, including freshwater and alternative water) over a year; *the used alternative water* is the amount of water consumed within a building from sustainable water sources that do not come from freshwater sources over a year; *return water* is the amount of water collected from construction systems (green infrastructure and waste water treated on site) and returned back to the original water source over a year.

• **Net Zero Waste**/*Zero Waste*; respectively the reduction of the amount of waste generated, by their selective collection, recycling, reuse, valorization and conditioning, almost as far as possible, in order of priority, at the local level and then collectively.

3. CONFORT CRITERIA ADDED TO NZEB BUILDINGS

Man's relationship with the indoor environment in which they operate is a complex relationship that may be characterized by the concept of comfort.

Comfort is a complex notion, synthetically defined by *"**the sense of well-being**/satisfaction felt by the human body in relation to the external environment"*.

Comfort issues have been the subject of multiple studies and research over the past 50 years to determine the comfort parameters required for building design, and recently the comfort parameters needed to evaluate their performance (especially energy) and control strategies.

Quality criteria relating to indoor environments aim at hygro-thermal, visual, electromagnetic, acoustic, sanitary comfort (indoor environment quality: air, pollutants, ... necessary water, ...). Parameters that characterize the indoor environment are relatively numerous and extremely variable over time.

Man (the user of the interior space) is influenced by the nature and dynamics of these parameters and in turn can contribute to changing the characteristics and dynamics of the environment in which he operates. There is a need to predict parameters that ensure a healthy, healthy and humid climate inside the human being and its activities and consequently the need to select / design the most appropriate strategies to ensure these requirements. For the promotion of nZEB buildings it is necessary to reconsider the concept of habitat as well as the mandatory limit values for the defining parameters of the different levels of comfort.

Some of the energy-efficient buildings are characterized by high leakage and high-insulation[5].

Other energy-efficient buildings (some of the *NZBE buildings, passive buildings, passive solar buildings, passive bio-climatic buildings*) rely on the human factor in the effort to ensure indoor comfort, which is why the comfort issue needs to be viewed differently from standard buildings.

The buildings of the future will be mostly intelligent, dynamic-adaptable buildings with dynamic climate characteristics and variable user requirements. In these buildings, comfort is characterized by dynamism itself and as such, the criteria for determining its parameters are other than in the cases listed above.

Among the above criteria, the thermal criteria are of major importance for the design and assessment of the performance of heating, cooling, ventilation, and air conditioning.

Parameters influencing the thermal and thermal comfort can be grouped into three main categories (Markus and Morris, 1980): ***a. physical parameters*** (*air temperature, radiant average of the enclosure walls, relative air humidity, relative air velocity inside the enclosure; atmospheric pressure, light intensity, noise level*); ***b. organic parameters*** (*age, sex, national characteristics of occupants*); ***c. external parameters*** (*level of human activity, type of clothing, social conditions*).

[5] They are virtually disconnected from the external environment and requires controlled interventions to ensure indoor temperature and humidity at the indoor.

The greatest influence on thermal comfort has: temperature, relative humidity, barometric air velocity and pressure, and clothing and lucrative activity. The positive or negative effect of a parameter can be improved or offset by another parameter.

For the design of NZBE buildings, it is important to set thermal comfort parameters so that they can be achieved with minimal energy consumption.

For this purpose, various models of *hygro-thermal (or thermal) comfort* have been proposed, each of which is correlated with the exigencies imposed on the buildings of that era. These are very important for the design of energy-efficient buildings. They quantitatively describe the climatic conditions for which people feel good from a thermal point of view. These conditions serve to ensure a comfortable thermal environment with minimal energy consumption, regardless of external climatic conditions.

The importance of achieving a comfortable indoor climate, as long as outdoor climate parameters vary over time, simultaneously with „avoiding unnecessary energy consumption" is among the declared objectives of the European Energy Performance of Buildings Directive.

There are two different types of thermal comfort assessment models: ***a) static; b) adaptive*** *(Appendix 1).* For a relevant analysis of a correct design of buildings, in the context in which they have to provide most comfort conditions through passive strategies in this paper, we will use an analysis tool that addresses several comfort models, namely *Climat Consultant*, developed by specialists on the American continent. This is useful in setting the best design strategies for energy-efficient buildings. It allows the analysis of the impact of different passive heating/cooling/ventilation strategies on different types of buildings under different climatic conditions.

4. COVERED OBJECTIVES. USED ANALYSIS INSTRUMENTS

Within the framework of the European Energy Performance Enforcement Directive[6], new energy quality requirements, differentiated in relation to age (new, existing) and time horizon (short (2020) and long (2050)), were required. In the short term, the new buildings will have to meet the requirements of the **nZEB**[7] buildings, and in the long run it will be necessary to bring existing buildings to the same quality requirements as those imposed on new buildings. The performance for which the building is qualified with the **nZEB** attribute is determined by each state → they differ from one state to another. On the other hand, the development strategies proposed by different states have taken into account the experience of the respective countries in the field, but this experience consisted of design measures for static comfort criteria and consequently includes solutions insufficiently adapted to the particularities of the environment location t and its dynamics[8].

The paper presents an analysis of the impact of the different passive strategies for purchasing comfort according to different comfort standards, considering the actual climatic data, respectively their impact on the different strategies (the temperature of the dry and wet thermometer, the direct, diffuse and reflected solar radiation, normal solar radiation or inclined plane, soil temperature at different depths, wind speed and direction, nebulosity, sunshine hours).

The design strategies considered in the *Clime Consult* analysis software (Appendix 2) are related to the comfort patterns and for each of them the software determines the number of hours of operation.

The software also allows partial analyzes for other types of strategies useful in achieving the hygro-thermal comfort conditions, namely: identifying the useful elements in assessing the impact of phase shift / MSF materials in the process of providing hygro-thermal comfort; assessing the possibilities of coupling with the soil; identifying the opportunity to harness the solar energy transported by direct /diffuse /global radiation; identifying the opportunity to capitalize wind energy with vertical or horizontal axis turbines etc.

In the analysis there were considered the comfort models, the strategies and the parameters, shown in Table 1.

The locations where the analysis was carried out were: Chișinău, Cahul and others.

The Climate data was extracted from the software Meteonorm 7.2. For the analysis, there was used the program:

- Opaque, to study the behavior of the building element, including those with MSF embedded in a dynamic climate: it allows the evaluation of heat losses / intakes through the element throughout the year (Fig.1);

[6] Directive 2010/31 / EU of the European Parliament

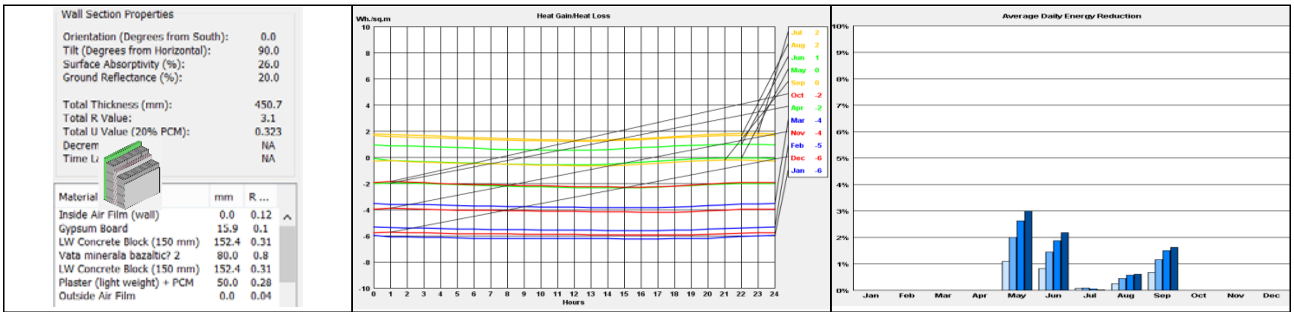
[7] Annual energy balance building for ”near-zero” heating/cooling and renewable energy generation systems.

[8] Under these conditions there are nZEB buildings for which it is proposed to over-isolate and hyper-seal: the hyper-seal requires controlled aeration / active systems that can interfere with the thermal balance of buildings during summer periods; on the other hand, once designed and executed, buildings must ensure humidity and comfort in summer and winter by adequately controlling the strategies for purchasing it. In the context of current climate changes and the occurrence of increasingly long periods and increasing winter-summer climatic differences, hyper-insulated and watertight buildings designed to provide comfort in winter with resources minimum energy requirements may require relatively large energy resources during the summer period.

Table 1. Strategies and parameters for the comfort of different models.

No. crt.	**Comfort models & Strategies**	**UM.**	**Value**		
1.	**Comfort models** *:		**1.*****	**2**	**3**
	Comfort Low –Min, Comfort Effective Temp @ 50 % RH (ET)	^{0}C		1	
	Comfort High –Min, Comfort Effective Temp @ 50 % RH (ET)	^{0}C		20.0	20
	Max. Wet Bulb Temperature	^{0}C		23.3	23.9
	Min. Dew Bulb Temperature	^{0}C		17.8	18.9
	Summer comfort shifted by this Temperature	^{0}C		2.2	
	Winter Clothing Indoor (1.Clo=long pant, sweater)	clo		2.8	
	Summer Clothing Indoor	clo		**1**	
	Activity level Daytime	met		**0.5**	
	Max. relative humidity	%			50
	Min. Dew Point Temperature	^{0}C			-2.8
2.	SUN SHADING ZONE: (Defaults to Comfort Low)			**1.1**	
	Min. Dry Bulb Temperature when Need for Shading Begin	^{0}C		22.8	20.0
	Min. Global Horiz. Radiation when Need for Shading Begin	Wh/m^2		315.5	315.5
3.	HIGH THERMAL MASS ZONE				
	Max. Outdoor Temperature Difference above Comfort High	^{0}C		8.3	8.3
	Min. Nighttime Temperature Difference below Comfort High	^{0}C		1.7	1.7
4.	HIGH THERMAL MASS WITH NIGHT FLUSHING ZONE				
	Max. Outdoor Temperature Difference above Comfort High	^{0}C		16.7	16.7
	Min. Nighttime Temperature Difference below Comfort High	^{0}C		1.7	1.7
5.	DIRECT EVAPORATIVE COOLING ZONE: (Defining by Comfort Zone)				
	Max. Wet Bulb set by Max. Comfort Zone Wet Bulb	^{0}C		**20.0**	**20.0**
	Min. Wet Bulb set by Min. Comfort Zone Wet Bulb	^{0}C		**11.0**	**6.6**
6.	TO STAGE EVAPORATIVE COOLING ZONE: (Defining by Comfort Zone)				
	Efficiency of indirect stage	%		50	50
7.	NATURAL VENTILATION COOLING ZONE:				
	Terrain category to modify wind speed (2=suburban)	type		2	2
	Min. Indoor Velocity to Effect Indoor Comfort	m/s		**0.2**	0.2
	Max. comfortable velocity (per ASHRAE std. 55)	m/s		1.5	**1.5**
	Max. Relative Humidity	%		90	90
	Max. Perceived Temperature Reduction	^{0}C		**3.7**	3.6
	Max. Wet Bulb Temperature	^{0}C		**22.8**	**22.8**
	Percentage Acceptability Limits (80%-90%	%	90		
	Min. Monthly Outdoor DB Temperature (10^{0}C or less)	^{0}C	10		
	Max. Monthly Outdoor DB Temperature (33.5^{0}C or less)	^{0}C	22.6		
	Comfort Low – Min. Operative Temperature in this Climate	^{0}C	18.4		
	Comfort High – Max. Operative Temperature in this Climate**	^{0}C	27.3		
8.	FAN-FORCED VENTILATION COOLING ZONE				
	Max. Mechanical Ventilation Velocity	m/s	0.8	0.8	0.8
	Max. Perceived Temperature Reduction (MinVel, Max RH, Max WB match Natural Ventilation)	^{0}C	3.0	3.0	3.0
9.	INTERNAL HEAT GAIN ZONE				
	Balance Point Temperature below witch heating is need	^{0}C	12.8	12.8	12.8
10.	PASSIVE SOLAR DIRECT GAIN LOW MASS ZONE:				
	Min. South Window Radiation for 5.56 ^{0}C Temperature Rise	Wh/m^2	157.7	157.7	157.7
	Thermal Time Lag for Low Mass Buildings	hour	**3.0**	**3.0**	**3.0**
11.	PASSIVE SOLAR DIRECT GAIN HIGH MASS ZONE:				
	Min. South Window Radiation for 5.56 ^{0}C Temperature Rise	Wh/m^2	157.7	157.7	157.7
	Thermal Time Lag for Low Mass Buildings	hour	12	12	12
12.	WIND PROTECTION OF OUTDOOR SPACES:				
	Velocity above witch Wind Protection is Desirable	m/s	8.5	8.5	8.5
	Dry Bulb Temperature Above or Below Comfort Zone	^{0}C	11.1	11.1	11.1
13.	UMIDIFICATION ZONE: (Defining by and below Comfort Zone)				
14.	DEZUMIDIFICATION ZONE: (Defining by and below Comfort Zone)				

* The comfort criteria considered are presented in Appendix 1; ** (Air velocity is controlled by opening/closing windows); *** 1.Adaptive Comfort model in ASHRAE 55/2010; **** 2.ASHRAE Handbook of Fundamentals Comfort Model, Through 2005); ****** 3.California Energy Code Comfort Model, 2013



a. Structure prefabricated vertical element	b. Contributions and losses through the PCM construction element are lower relative to the PCM-free element	c. Daily average value of energy savings due toPCM

Figure 1. Dynamic behavior of PCM building element located on the outside.

• Climate Consulate, a highly useful software in assessing the impact of deployed strategies to ensure comfort parameters for different comfort patterns in different locations and different neighborhoods. It allows the number of active hours for each strategy to be determined, and its weight in the global process of thermal comfort. Other strategies not included in the software can be analyzed;

• The TRNSYS Platform, for assessing the overall behavior of the building and associated installation systems (these analyzes will be presented in a later work).

• Software: HEED[9], designing energy-efficient buildings.

These analytical tools were chosen because they allow for complex analyzes, consideration of all the climate impact parameters of the desired location, and highlight the extremely strong dependence of climatic parameters that are not considered in the classical design (the structure of the solar radiation, the wind direction, …).

The comfort patterns present in the analysis software Climate Consult

➲ ***California Energy Comfort Code***, static comfort model, implicitly included in the Climate Consultant. It is assumed that the indoor temperature required for thermal comfort does not change with the seasons. The comfort range is defined by maximum and minimum internal static temperature limits.

➲ ***The Adaptive Comfort model***, which takes into account the capability of adapting the occupants of a building to climatic variations according to the season and its location/climate zone, is at the other extreme. *The model is defined in:* a) **ASHRAE 55:** spaces are supposed to be naturally ventilated and occupants can open and close the windows ⇒*their thermal response will depend in part on outside conditions and will have a wider range of comfort than in buildings with central heating/cooling systems*; b) **EN 15251**

➲ Between these two extremes, there are two other model options in the Climate Consultant:

➲ ***Predicted Mean Vot/***PMV model based on the Fanger-based model and also described in: *a) ASHRAE 55 b) EN 15251*

➲ ***ASHRAE handbook*** with the basic elements of the Comfort models.[10]

5. RESEARCH RESULTS

5.1. Working hypotheses

The building under consideration was a residential building.

The sites considered in the analysis were: Chișinău, Calafat, Palanca, Bălți, Slobozia, respectively locations with particularities of the dynamics of different climatic parameters. The related climatic data was extracted from METEONORM 7.2. The comfort criteria considered were those set out in point 2.

For the analysis, information on different climatic parameters of interest (number of hours with temperature/direct radiation/global radiation/coverage, ... in the range ...).

[9] which can exploit TRNSYS analysis facilities and other performance analysis software for transient systems.

[10] The last two models assume that people will adapt to the climate change by changing their clothing: two comfort zones (winter and summer) are defined based on a change in comfort / comfort characteristics.

Each of these models has particularities that recommend them in certain building design and fittings, respectively, for buildings where comfort in summer is achieved with: ***a) active systems:*** *California Energy Cod Comfort, Predicted Mean Vote and ASHRAE Handbook with the basics of Comfort models*; ***b) passive systems:*** *Adaptive Comfort Model;* ***c) with mixed systems:*** *both.*

The comfort patterns are differentiated by the indoor comfort temperature mode and the warm weather comfort mode when comfort can be provided with active or passive systems[10].

For the design of the buildings and related systems as well as for the evaluation of their energetic performances, the comfort models were formalized in order to establish the variation ranges of the hygro-thermal comfort parameters. For the characterization of the buildings in relation to the hygro-thermal comfort, there is a set of Predicted Mean Vote (PMV) [2], [3], [4] [6]. The internal comfort rules have a more limited applicability (SR EN 7730[10]) or more (SR EN 15251, ASHRAE 55).

5.2. The obtained results

The obtained results were represented as:

- graphs with hourly/daily / monthly variations and average values (maximum averages, minimum averages) and monthly and hourly averages of the main climatic parameters: dry and wet thermometer temperature; direct, normal, diffuse, global sun radiation, reflected by soil with different coatings, inclined; the degree of coverage of the sky; direct normal illumination; number of hours of sunshine, soil temperature at various depths, wind speed and direction (Table 2);
- the psychrometric charts with comfort zones and the impact of comfort (passive and active) comfort strategies on indoor comfort (Table 3);
- the centralized table with the adaptive comfort parameters obtained for different locations (Table 4);
- the impact of different strategies for achieving a comfortable indoor climate in different comfort and location models (Table 5).

An analysis of the represented sizes allows the selection of the heating/cooling strategies to be analyzed, respectively the appropriate heating/ cooling systems (forced ventilation cooling...) (Table 5).

For a better understanding of the obtained results and the consequences deriving from them, the observations and interpretations made on the basis of the graphical results represented are associated with the graphs.

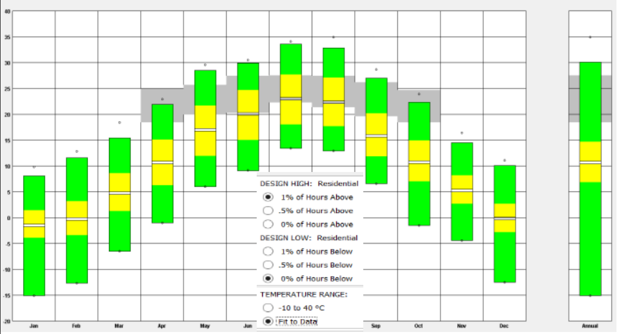
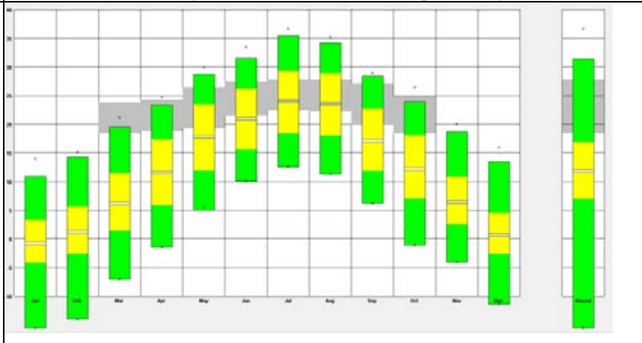
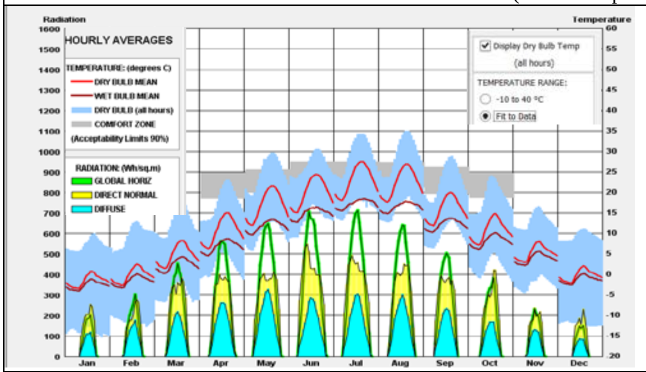
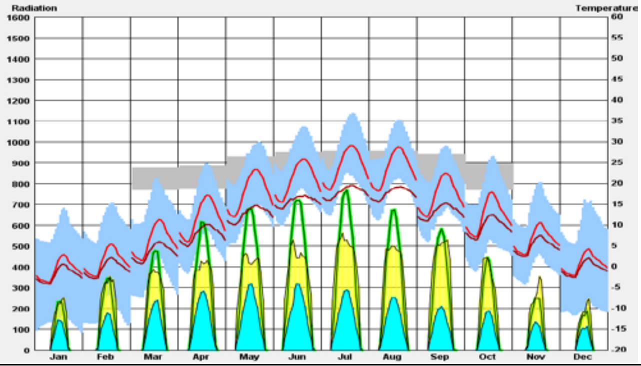
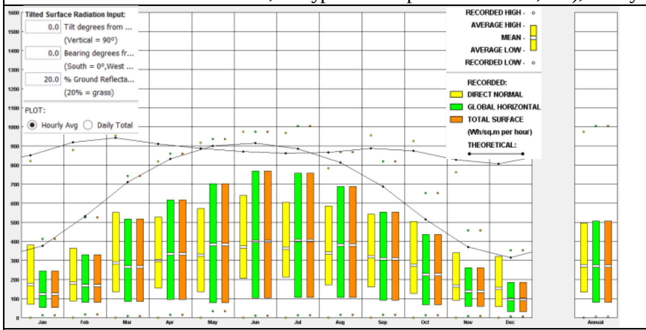
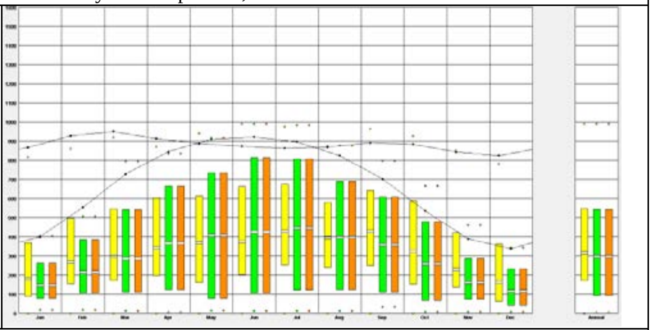
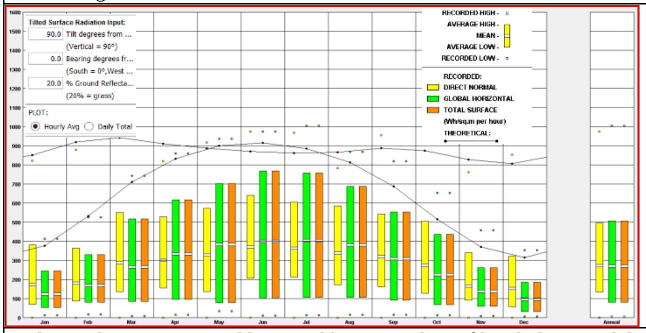
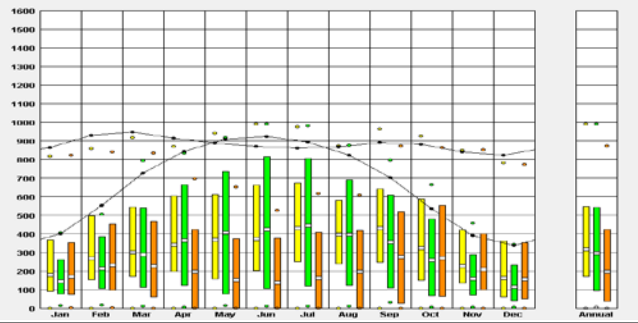
Table 4. Indoor comfort parameters for different models and locations.

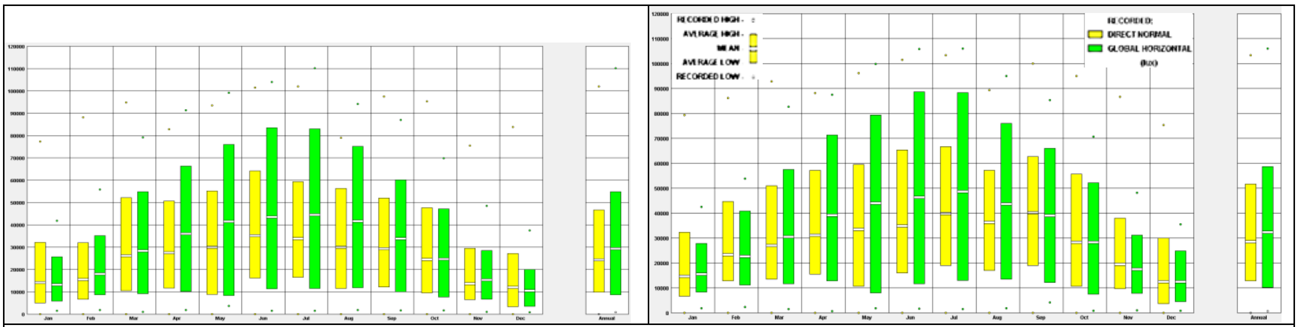
Size, limits \ Localities	Chișinău	Cahul	Palanca	Slobozia	Bălți
Acceptance limits (%)	90,0	90,0	90,0	90,0	90,0
Minimum monthly average of outdoor temperature a GTdry *	10,0	10,0	10,0	10,0	10,0
Maximum monthly average of outdoor temperature a GTdry *	23,2	24,1	23,9	22,3	22,3
Low comfort - Minimal operating temperature at this location	18,4	18,4	18,4	18,4	18,4
High comfort - Maximum operating temperature at this location	27,5	27,8	27,7	27,2	27,2
**GTdry / GTwet dry/wet globothermometer*					

Table 5. Extract from the results of the research with the impact of different strategies for achieving comfortable indoor climate, in different comfort and location models.

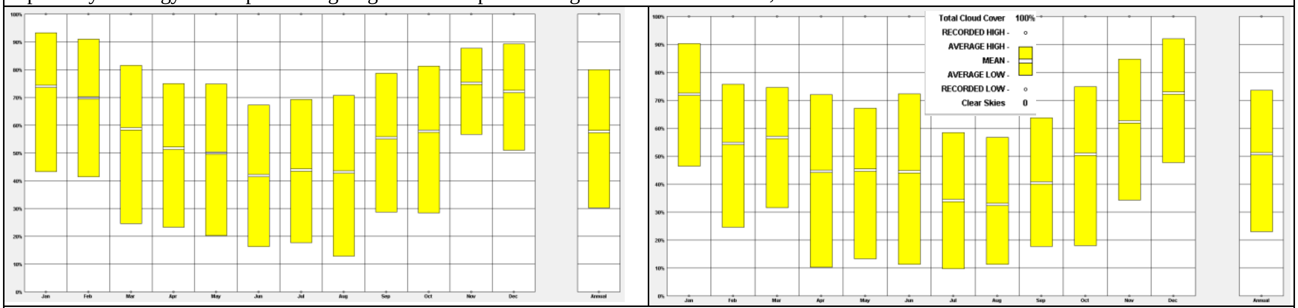
Locality	Model Confort	Comfort purchasing strategies																															
		1-Comfort		2-Shading windows		3- Heat mass with high inertia		4- Heat mass with high inertia washed at night		5- Cooling by direct evaporation		6- Evaporative cooling in two stages		7- Cooling by natural ventilation		8- Cooling by mechanical ventilation		9- Internal thermal inputs		10- Passive solar inputs from low thermal masses		11- Passive solar inputs from high thermal masses		12- Wind protection of outdoor spaces		13- Humidification		14-Dehumidification		15-Cooling and dehumidification		16 Heating & humidification (if needed)	
		h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%	h	%
Chișinău	1	0	0	0	0	0	0	0	0	0	0	0	0	953	10.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	1211	13.8	672	7.7	0	0	279	3.2	0	0	435	5.0	0	0	404	4.6	2080	23.7	0	0	1219	13.9	78	0.9	0	0	0	0	48	0.5	4378	50.0
	3	1174	13.4	546	6.2	292	3.2	298	3.4	247	2.8	270	3.1	1175	2.0	111	1.3	2124	24.2	840	9.6	1233	14.1	81	0.9	0	0	199	2.3	72	0.8	4155	47.0
	4	783	8.9	897	10.2	0	0	692	7.9	0	0	0	0	0	0	589	6.7	2156	24.2	0	0	1219	13.9	78	0.9	0	0	0	0	103	1.2	4378	50.0
Cahul	1	0	0	0	0	0	0	0	0	0	0	0	0	1088	12.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	1379	15.7	852	9.7	0	0	0	0	0	0	577	6.6	0	0	517	5.9	1966	22.4	0	0	1338	15.3	79	0.9	0	0	0	0	130	1.5	4025	45.9
	3	1284	14.7	712	8.1.4	0	0	424	4.8	0	0	0	0	0	0	0	0	2022	23.1	0	0	1363	15.6	84	1	0	0	298	3.4	142	1.6	4029	46.0
	4	878	10.0	1102	12.6	0	0	849	9.7	0	0	0	0	0	0	691	7.9	2013	23.0	0	0	1338	15.3	79	0.9	0	0	0	0	178	2.0	4025	45.9
Palanca	1	0	0	0	0	0	0	0	0	0	0	0	0	1008	12.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	1379	15.7	852	9.7	0	0	0	0	0	0	577	6.6	1088	12.4	0	1966	2045	22.4	0	0	1338	79	0.9	11.2	0	0	65	0.7	123	1.4	4025	45.9
	3	1248	14.7	712	8.1	395	4.5	424	4.8	304	3.5	337	3.8	235	2.7	153	1.7	2022	23.1	971	11.1	1363	15.6	84	1.0	0	0	298	3.4	142	1.6	3701	42.2
	4	878	10	1102	12.6	0	0	849	9.7	0	0.	0	0	0.	0.0	706	8.1	2013	23.0	0	0	1338	15.3	79	0.9	0	0	0.0	0.0	174	2.0	4025	45.9
Slobozia	1	0	0	0	0	0	0	0	0	0	0	0	0	813	9.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	2	1379	15.7	852	9.7	253	2.9	0	0	0	0	577	6.6	0	0	517	5.9	1966	22.4	0	0	1338	15.3	79	0.9	0	0	398	14.5	130	1.5	4025	45.9
	3	878	10.0	347	4.0	93	1.1	0	0	0	0	0	0	0	0	0	0	2192	25.	0	0	1275	14.6	81	0.9	0	0	302	3.4	47	0.5	4676	53.4
	4	616	7.0	707	8.1	0	0	418	4.8	0	0	0	0	0	0	518	5.9	2202	25.1	0	0	1272	14.5	77	0.9	0	0	183	2.1	35	0.4	4666	53.3

Table 2. Complex climate behavior in the cities of Chisinau and Cahul. Processed data, statistically based on the ground meteorological measurements in the site or in the vicinity and with the help of the weather satellites.

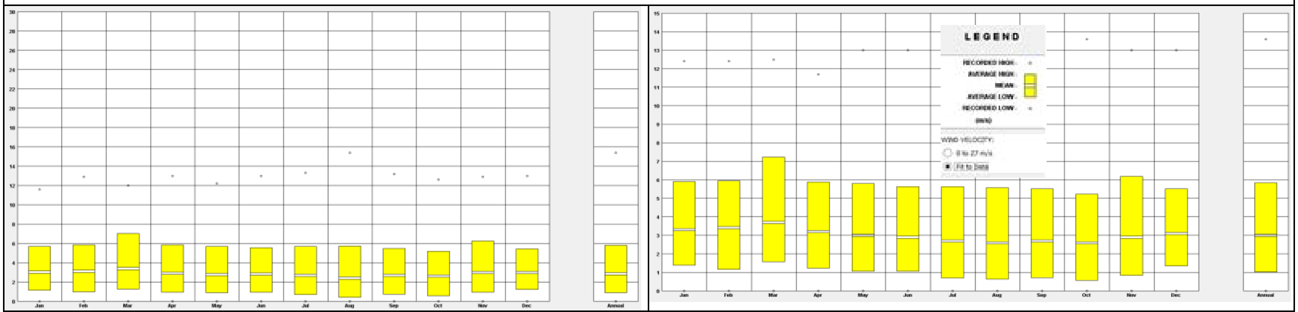
<table>
<tr><td>*Location:* ***Chisinau****, Moldova; Latitude/Longitude: 47.0°N/28.83°E Local Time: + 2h from Grennwich; Data source: MN7.2.; Station Number: WMO; Altitude: 132m; The comfort criterion considered: adaptive comfort.*</td><td>*Location:* ***Cahul,*** *Moldova; Latitude/Longitude: 45.902°N/28.195°E; Time: + 2h from Grennwich; Data source: MN7.2.; Station Number: 999 WMO; Altitude: 71m ; The comfort criterion considered: adaptive comfort.*</td></tr>
<tr><td>
</td><td></td></tr>
<tr><td colspan="2">1. Air temperature: a) varies at different intervals: (Chişinău: $Ta \in (-15 \div 35)^0C$; Cahul $Ta \in (-20 \div 37)^0C$)); the dynamics – in time and amplitude determine different comfort zones (Chisinau: April-October, Cahul: March-October)</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td colspan="2">2. The graphs are represented: monthly average of daily values for: the dry/wet temperature of the globe (variations: Chişinău: $T_{t,us} \in (-3.5 \div 28,0)^0C$; $T_{t,um} \in (-4. \div 18.5)^0C$; Cahul: $T_{t,us} \in (-4.5 \div 29,5)^0C$; $T_{t,um} \in (-4.8 \div 19.5)^0C$); direct / diffuse/global solar radiation (observations: the size and structure of solar radiation – direct, diffuse, global – differ from one location to another and show important variations in structure, requiring design operation with each component in the report with the characteristics of the tire materials, the type of solar panels/collectors, etc.); hourly values for dry bulb temperature; Comfort zone.</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">3. The graphs are represented by: monthly mean values of hourly horizontal, horizontal, global horizontal sun radiation, total with indication of monthly average values (maximum, mean and minimum) and maximum/medium/minimum horizon of direct/global horizontal and surface radiation, for each month.
There are significant differences in radiation behavior, both in time and in structure.</td></tr>
<tr><td></td><td></td></tr>
<tr><td colspan="2">4. The graphs are represented by: monthly mean values of hourly horizontal, horizontal, global horizontal sun radiation, total with indication of monthly average values (maximum, mean and minimum) and maximum/medium/minimum horizon of direct/global horizontal and surface radiation, for each month on a vertical surface. It is observed: lower values of the total radiation received by the vertical surface relative to the horizontal surface; the reduction ratio had fallen from one location to another.</td></tr>
</table>



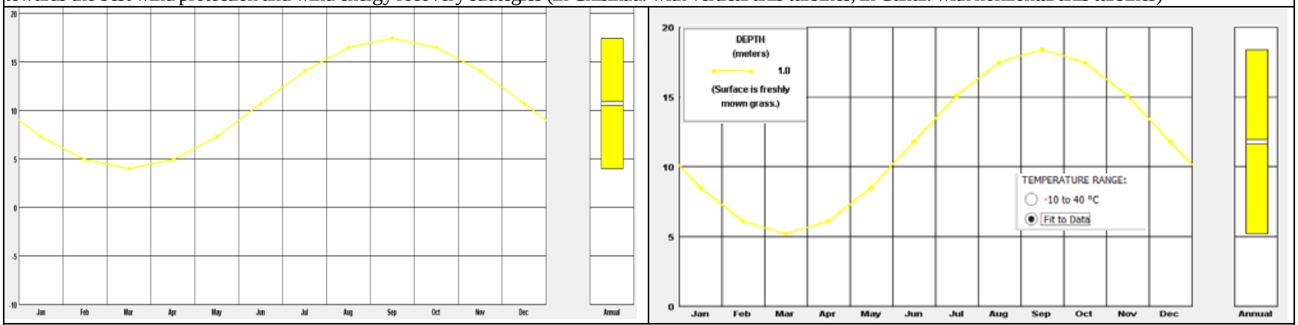
5. The graphs are represented by: monthly average values (minimum / maximum record values, maximum/average/minimum average values) of normal, global direct illumination. Significant differences in lighting behavior, differences with impact on lighting control strategies by shading systems or active windows, respectively on energy consumption for lighting and also for protection against blindness are noted, both in time and in structure.



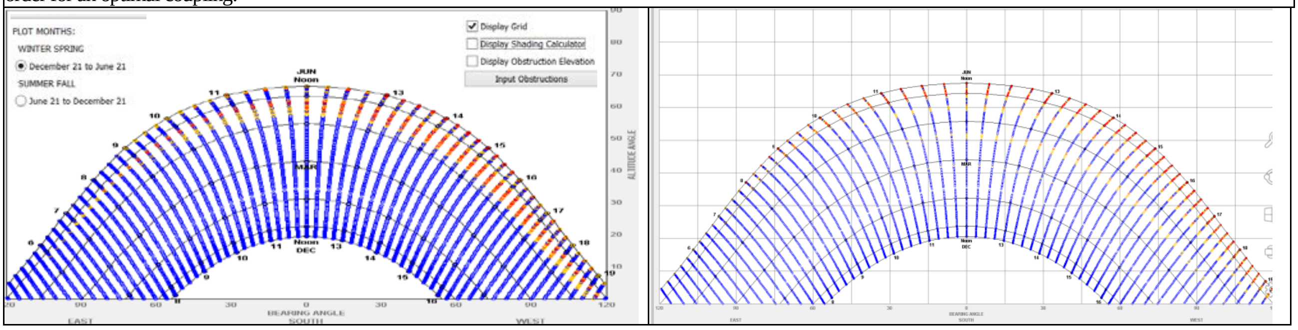
6. Graphs are the monthly averages for the degree of sky coverage. There is a large difference between the two locations and a correlation between it and the direct radiation received in the two locations.



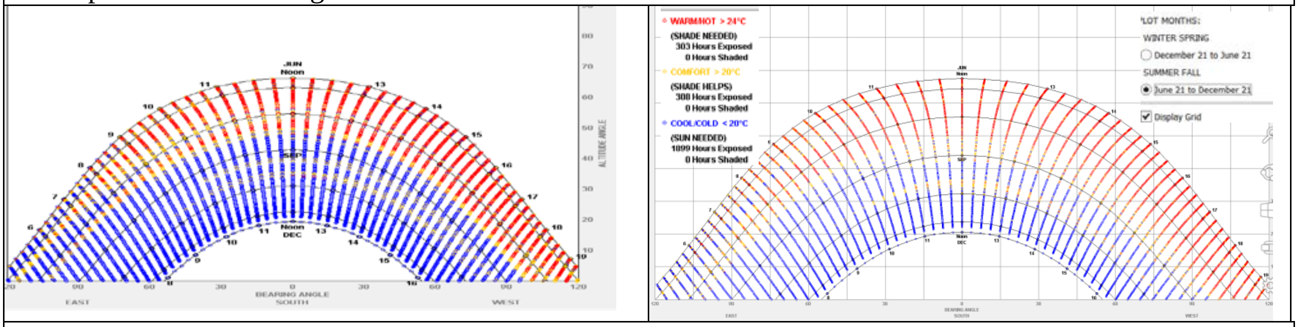
7. Monthly and annual averages for wind speed are represented in graphs: There is an important difference between the two locations, which allows orientation towards the best wind protection and wind energy recovery strategies (in Chisinau: with vertical axis turbines, in Cahul: with horizontal axis turbines)



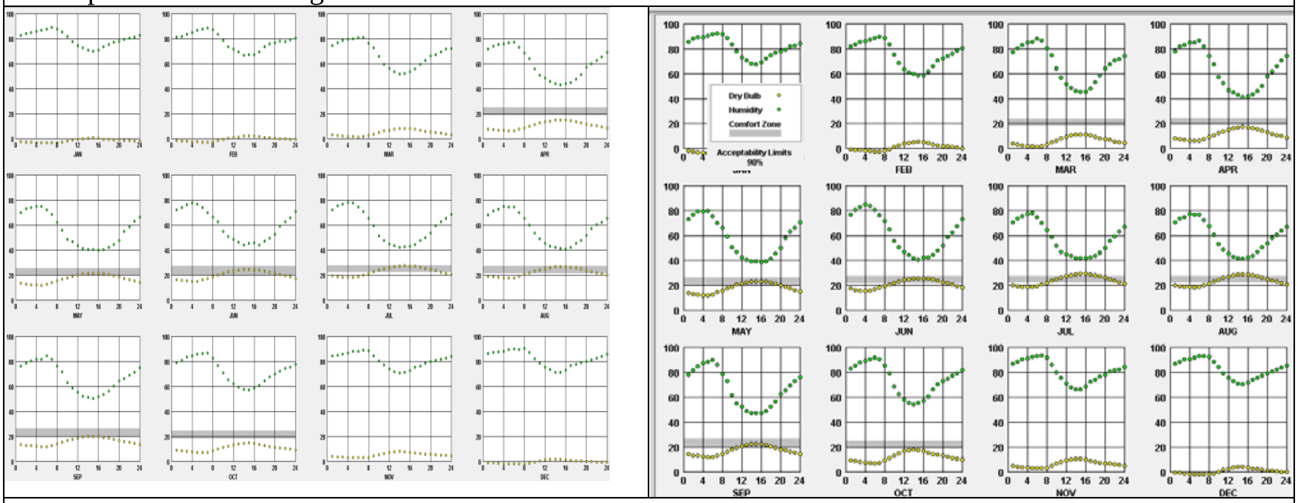
8. The graphs are the monthly and annual average values for soil temperature at 1 m depth (in the case of the surface of the soil cultivated with flowers): There is a significant difference between the two locations. The analysis of the data on the Moldavian area and on different types of covering surfaces led to the conclusion that the evolution of the temperature in the soil can be very different, in value and in time, with maximum and minimum annuals at different times and with thermal spans (max-minimum) extremely large. Also, the evolution of soil temperature is strongly dependent on the depth of assessment and soil characteristics. The information is important in the actions of coupling the building with the soil, respectively exploiting the solar energy stored in the soil and the proper conformation of the building in order for an optimal coupling.



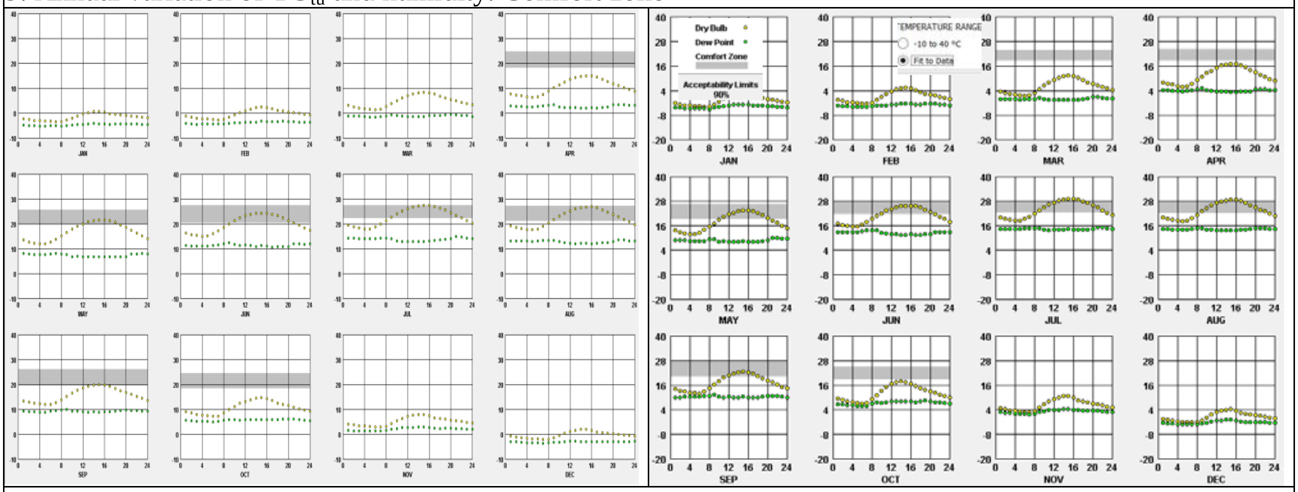
11. Map with solar shading



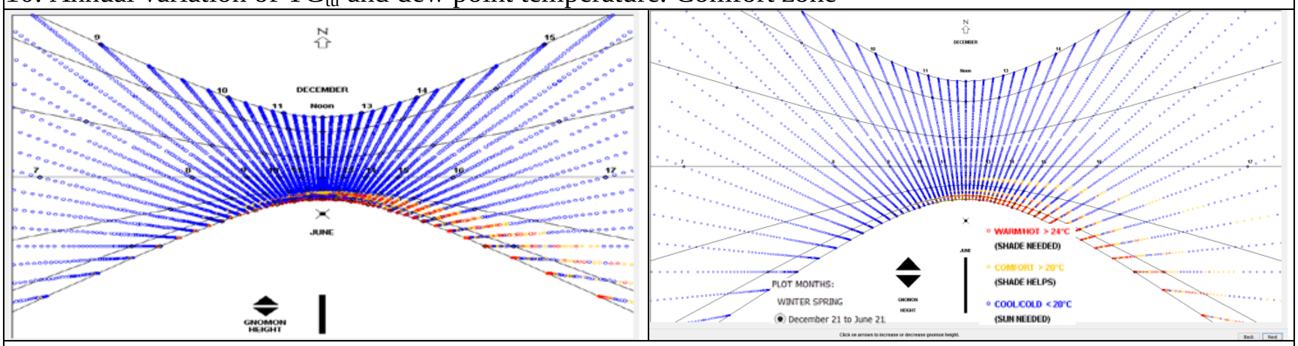
12. Map with solar shading



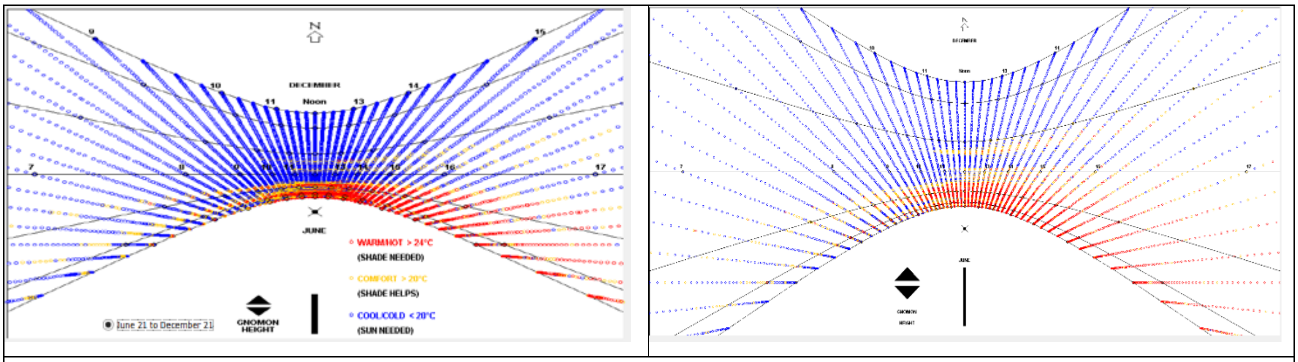
9. Annual variation of TG_{tu} and humidity. Comfort zone



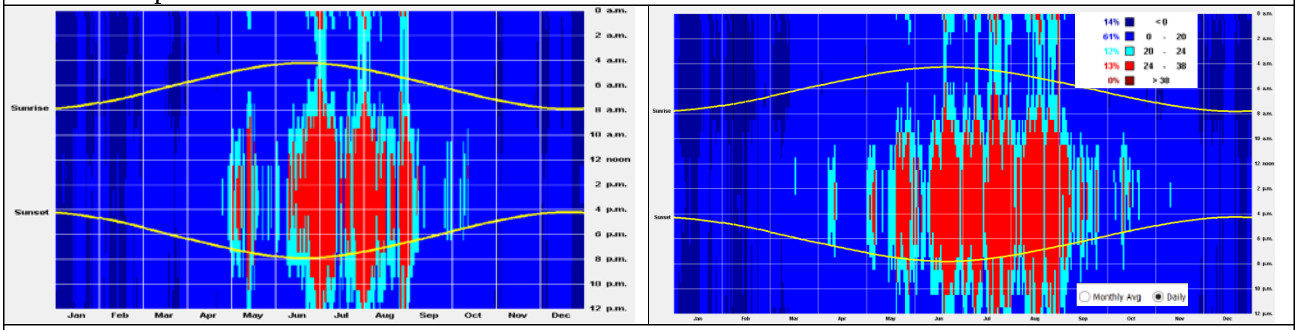
10. Annual variation of TG_{tu} and dew point temperature. Comfort zone



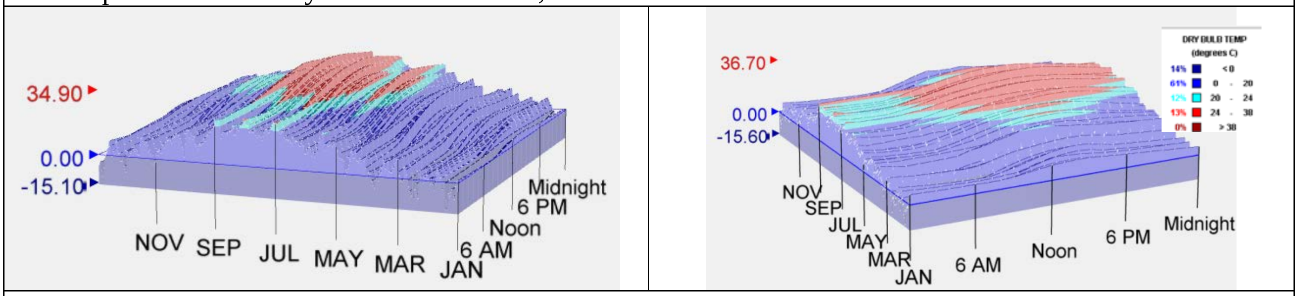
13. Solar map



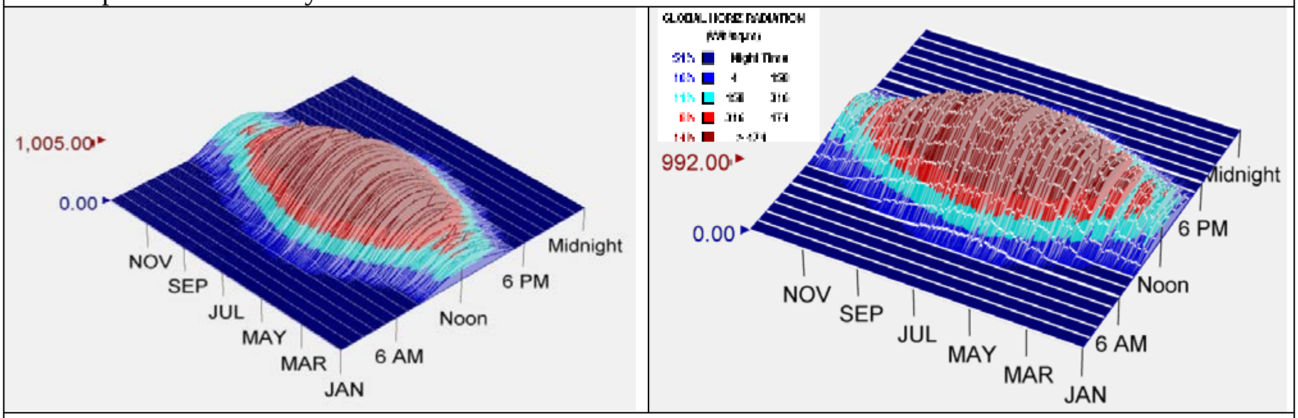
14. Solar map



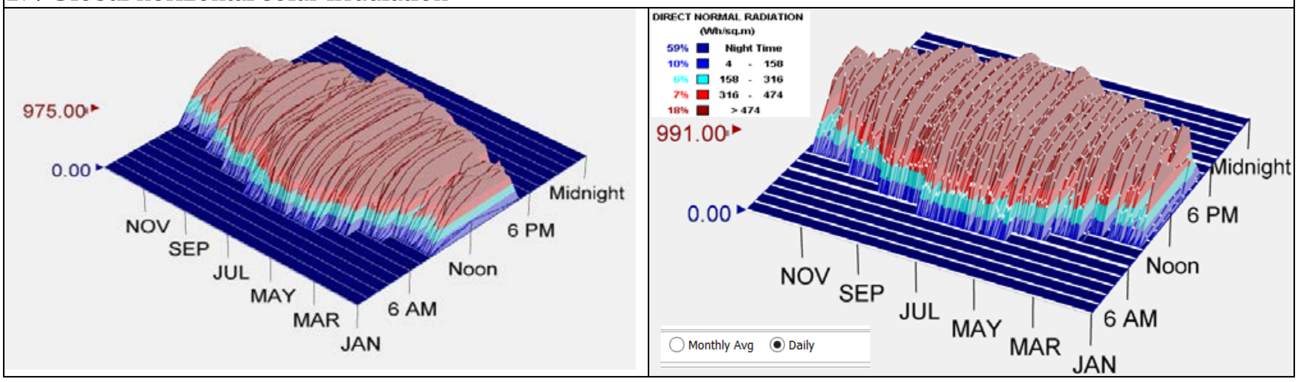
15. Temperature of the dry-time thermometer, Tab. of time



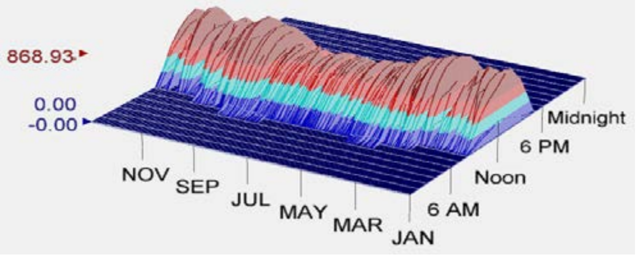
16. Temperature of the dry thermometer

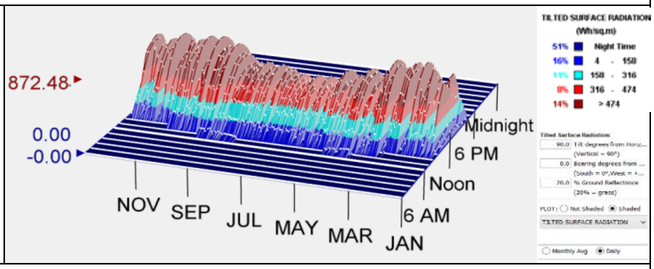


17. Global horizontal solar irradiation

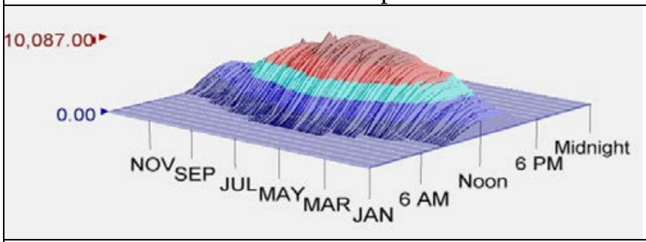


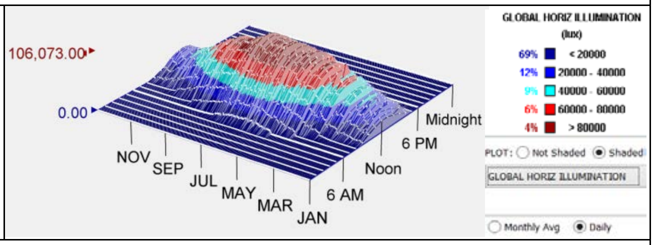
18. Normal direct solar irradiation



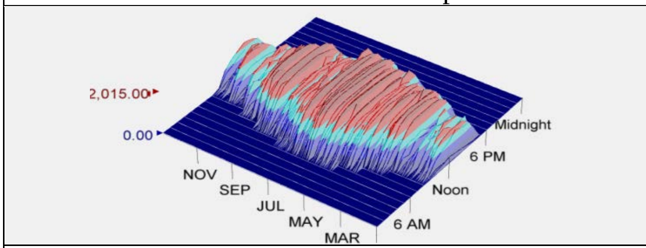


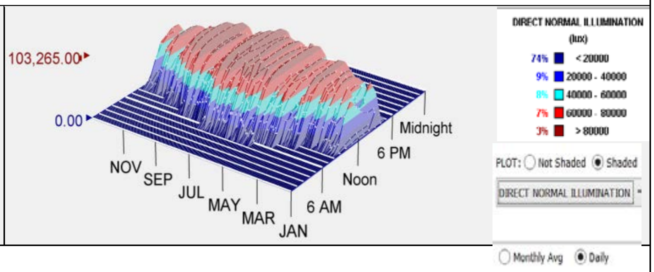
19. Solar radiation on a vertical plane



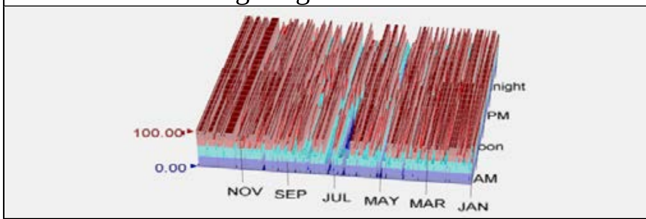


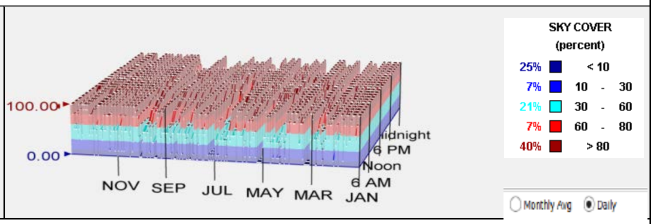
20. Global illumination in horizontal plane



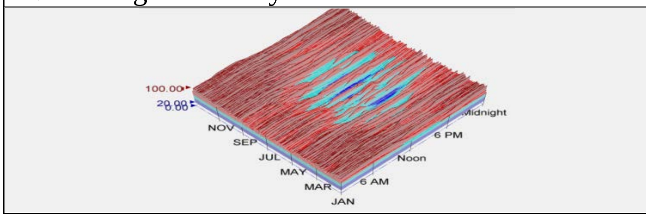


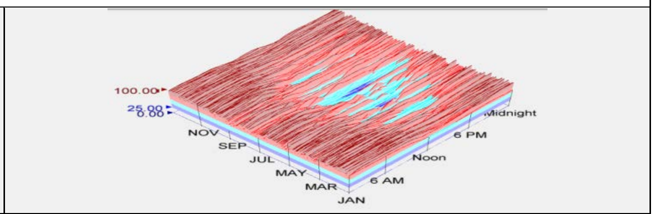
21. Direct normal lighting



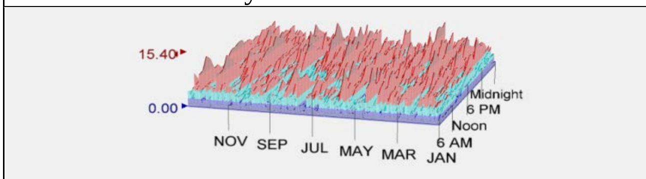


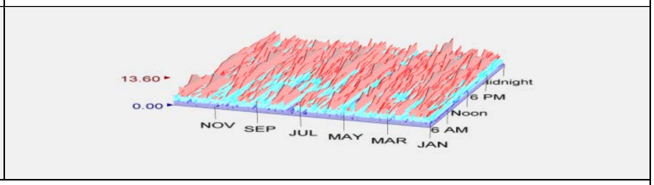
22. Coverage of the sky



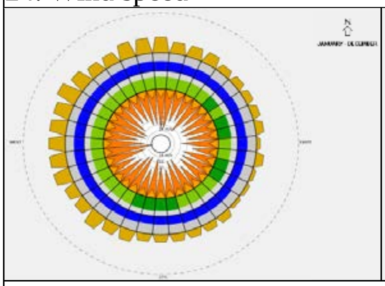


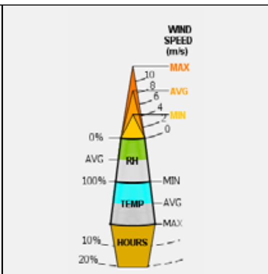
23. Relative humidity

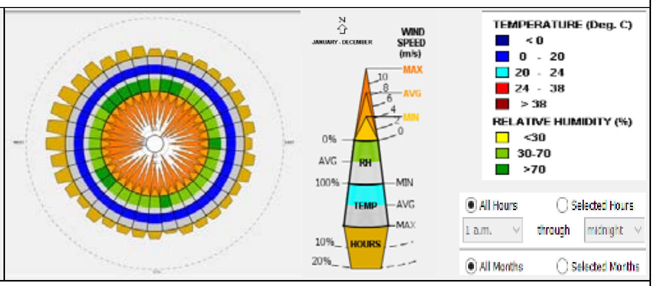




24. Wind speed

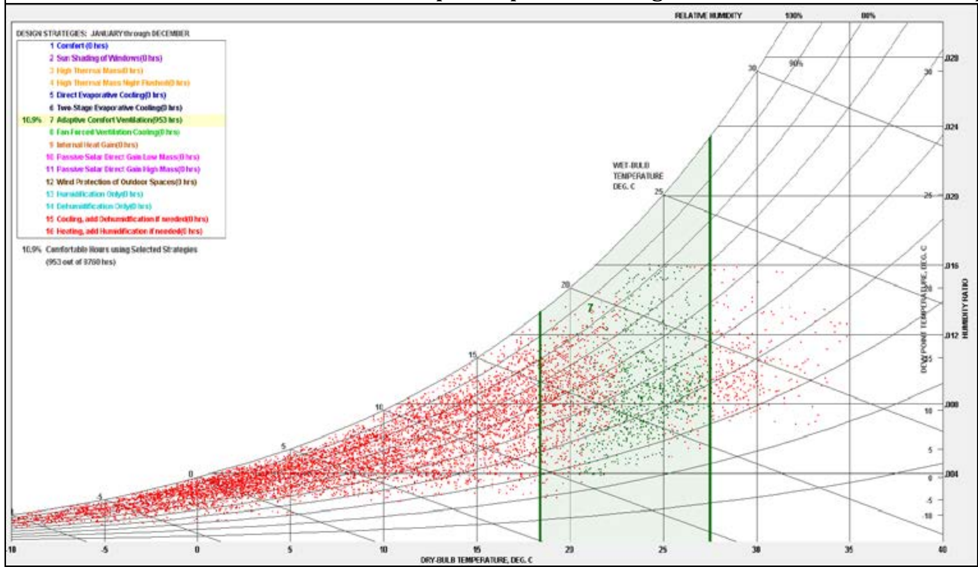


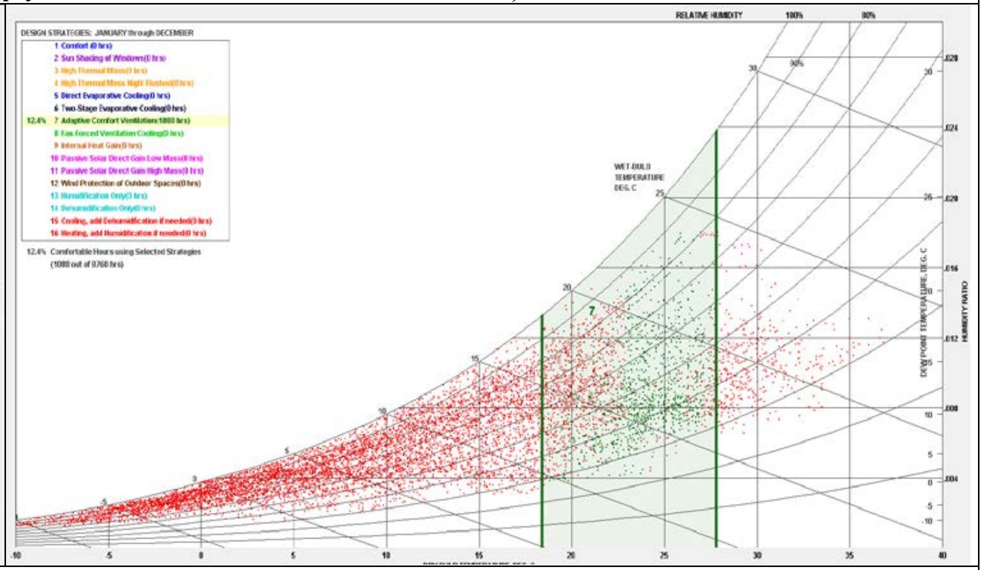




25. Cardinal wind

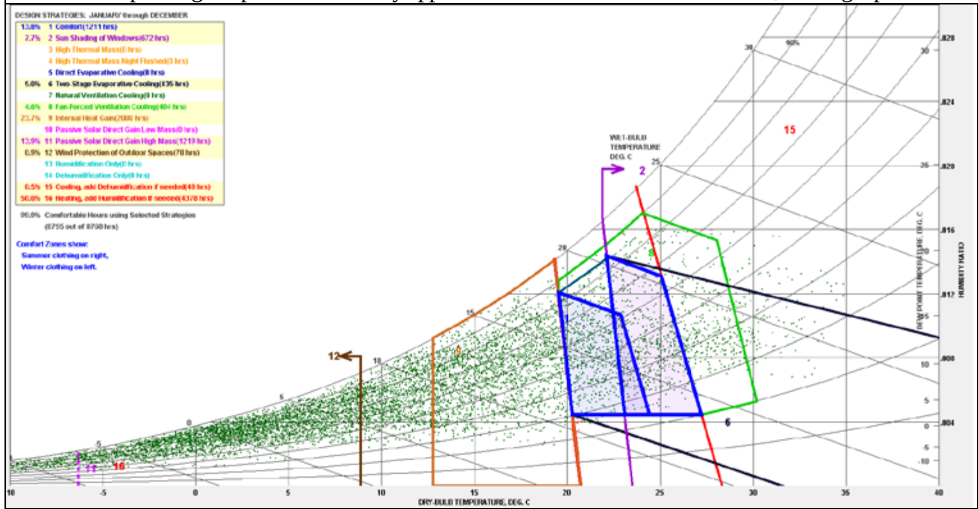
Table 3. The impact of passive strategies to ensure indoor comfort - psychrometric charts with comfort zones for *Chişinău and Palanca*

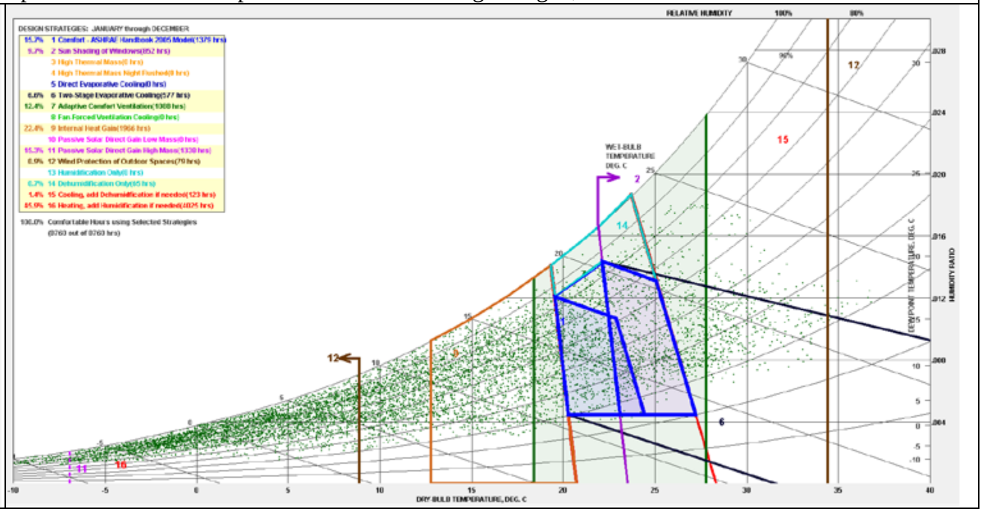




a) Psychrometric-comfort graph ASHRAE 55-2010 (with PMV). It is noted that:

- the passive adaptation strategies of the user to the outdoor climate can ensure indoor comfort only for a limited period (different from one location to another);
- other passive strategies are required to increase the comfortable period;
- summer operating temperature differs by approx. 10C from one location to another, making it possible to capitalize on the location's particularities in the cooling strategies;

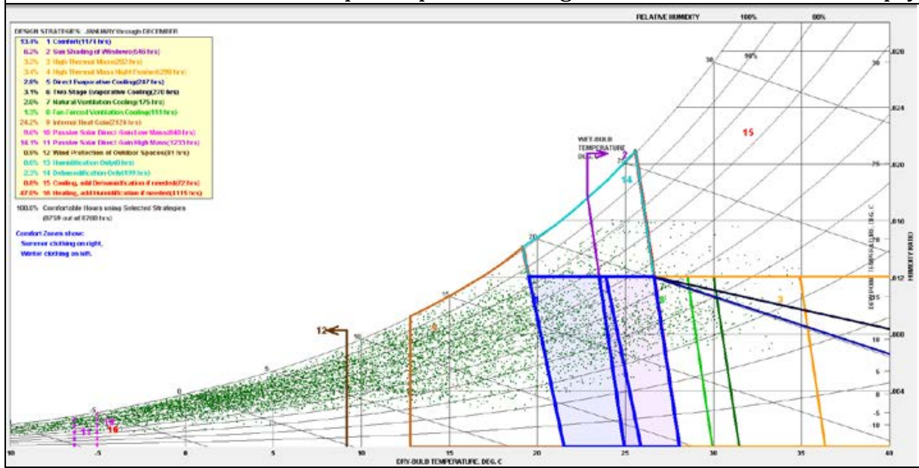


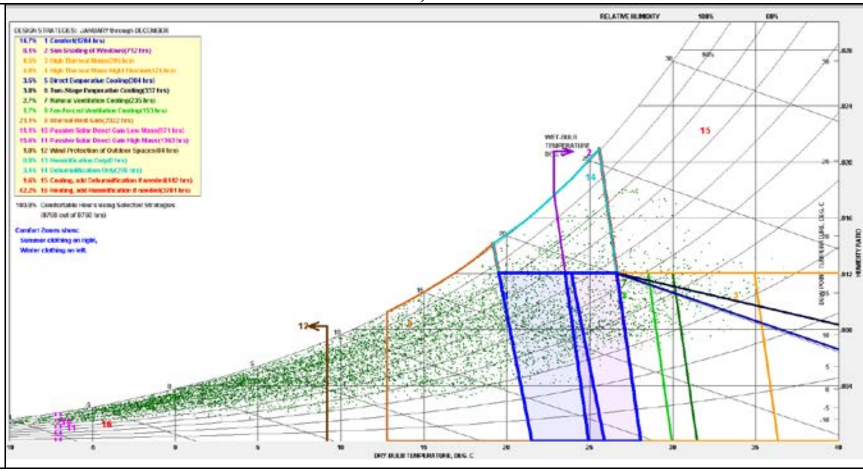


b. Psychrometric-comfort graph ASHRAE 55-2005 (with PMV).

In this case, it is possible to couple several passive strategies to ensure the hygro-thermal comfort.

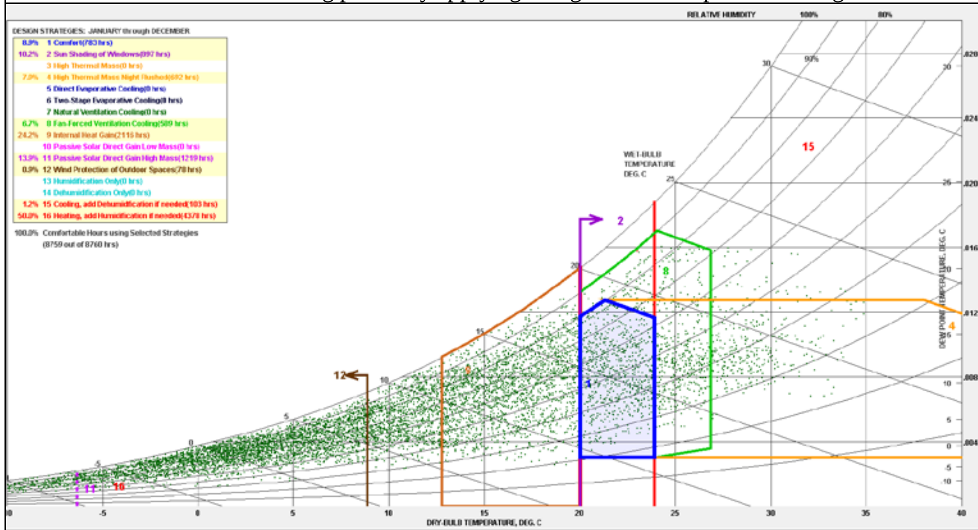
Tab. III. The impact of passive strategies to ensure indoor comfort - psychrometric charts with comfort zones for *Chișinău and Palanca - Continuation*

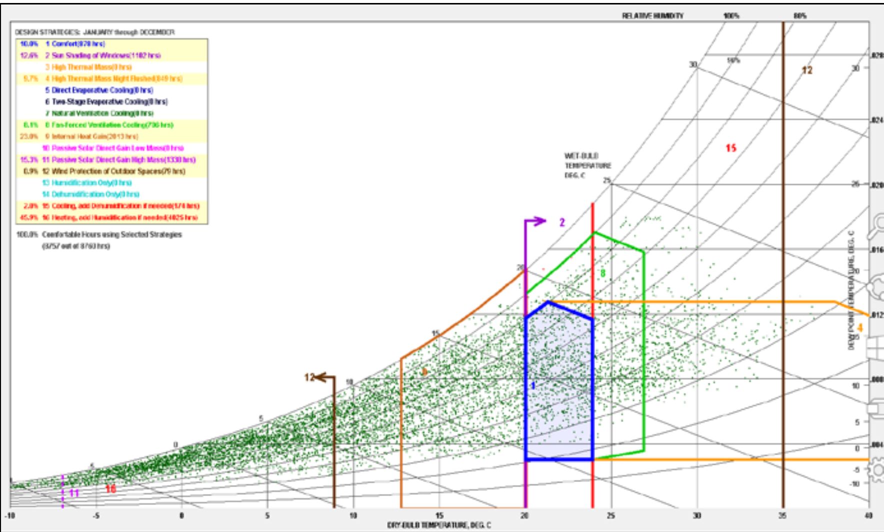




c. Psychrometric-comfort graph according to the Handbook ASHRAE.

There is a reduction in the heating period by applying a large number of passive strategies.





d. Psychrometric-comfort graph according to the Californian Energy Comfort Code.

The comfort model is a static one and it is not possible to select all possible passive strategies that are operable.

Table 6. The climatic parameters of interest for the analysis of the strategies for ensuring the comfortable environment in the buildings of the Republic of Moldova.

The variable	Comfort model	Interval	Location				Remarks
			Chișinău	Cahul	Slobozia	Palanca	
Temperature of the dry thermometer [^{0}C] in annual percent (%)	1,4	<0	11	14	18	13	It is recommended to use PCM in exterior finishes throughout the RM area. The use of thermodynamic insulation is recommended for Chisinau and Cahul.
		[0,20)	65	61	67	64	
		(20,24]	11	12	9	11	
		(24,38]	13	13	6	11	
		>38	0	0	0	0	
	2	<0	11	14	18	18	
		[0,20)	66	61	67	66	
		(20,27]	16	17	12	13	
		(27,38]	7	8	2	3	
		>38	0	0	0	0	
Wind speed (m/s)	1,2,3,4	<2	24	25	32	11	Chisinau: it is recommended to use turbines with vertical axis for servicing buildings located in town; Slobozia: the use of hybrid turbines, vertical axis turbines for servicing buildings located in urban areas is recommended, and for extravilan buildings it is recommended to use horizontal shaft turbines; Palanca: the use of horizontal shaft turbines is recommended; Cahul: the use of hybrid turbines (horizontal axis and vertical axis) is recommended.
		[2,3)	65	20	20	14	
		(3,5]	11	34	30	36	
		(5,9]	0	20	16	35	
		>9	0	1	2	4	
Table 6. Continuation							
Global horizontal radiation [Wh/m^2]	1,2,3,4	night	51	51	51	51	Palanca and Slobozia: the use of photovoltaic solar panels using direct and diffuse solar radiation coupled with solar-thermal collectors is recommended. Chişinău and Cahul: the use of solar thermal panels and photovoltaic panels is recommended.
		[4,158)	15	16	20	19	
		(158,316	11	11	11	10	
		(316,474	9	8	7	8	
		>474	14	14	11	12	
Direct normal radiation [Wh/m^2]	1,2,4	night	60	59	65	63	
		[4,158)	10	10	11	11	
		(158,316	7	6	5	5	
		(316,474	7	7	5	6	
		>474	16	18	14	15	
Tilted/vertical surface radiation [Wh/m^2]	1	night	51	57	58	57	
		[4,158)	15	19	23	22	
		(158,316	11	10	8	9	
		(316,474	9	8	6	7	
		>474	15	7	5	6	
Direct normal illumination (lux)	1,2,3,4	<20000	75	74	79	77	Special precautions are required to shade the glazed surfaces on the SE, S, SV faces, as far as possible with the level of light radiation. The use of glasses with dynamic control of light and thermal radiation is indicated. Glass types and shading systems must be correlated with illumination to avoid shading.
		[20000,4	10	9	8	8	
		(40000,6	7	8	7	6	
		(60000,8	6	7	4	6	
		>80000	2	3	2	3	
Grund temperature (monthly average, surface is freshly mown grass) max/min	1	Depth, m	1	1	1	1	The use of soil-water/soil-to-air heat exchangers as well as the soil coupling must be correlated with the temperature profile of the soil. For Chisinau localities the minimum installation depth is 1.5 ÷ 2 m depending on the soil cover; For Cahul, Slobozia and Palanca, seasonal heat exchangers are efficient at mounting at depths of up to 4m; Heat exchangers for geothermal heat pumps at about 10m.
		$T_{max./monthly}$	18.5/9	18.3/9	15.3/9	18/9	
		$T_{min./monthlyy}$	6/3	5.3/3	3.3/3	4.5/3	
Sky cover (%)	1	<10	24	25	17	20	Solar radiation must be diminished in relation to the degree of coverage of the sky in order to have a measurable radiation.
		[10,30)	6	7	5	6	
		(30,60]	21	21	19	18	
		(60,80]	7	7	6	6	
		>80	42	40	53	51	

6. CONCLUSIONS

In the current hygro-thermal configuration of the buildings on the territory of the Republic of Moldova it is necessary to actively heat the buildings for a heating period = approx. 50% τ_{an}.

Under these conditions, the most effective measures to reduce energy consumption are the conservative ones:

- isolation (preferably dynamic isolation);
- use of phase shift materials/PCM;
- inclusion of thermo-active systems in the tire elements (opaque and glazed).

So: in the Moldavian area, the climatic conditions of the winter period require special energy conservation measures as well as the presence of thermo-activation strategies of the tire elements, as far as possible adaptable.

Between 11-20% of the annual heating / cooling energy needs can be ensured through fully passive strategies. Pro Arguments: Cooling of buildings is necessary for a very short period of time $\tau \in (72—172)$ h (in the analyzed cases), respectively $3 \div 7$ days $\Rightarrow$ the possibility of using efficient local solutions with impact in the important reduction of energy consumptions cooling systems for buildings with mechanical cooling systems (with split heat pumps, ...) and avoiding systems operating at low yields. Effective summer cooling strategies can be controllable natural ventilation systems, adaptable window shading systems. During the winter, the window shading strategies correlated with the direction and intensity of the solar radiation, the activation of the thermal masses, the utilization of the solar intakes can be used. Humidification / dehumidification strategies do not lead to visible efficiencies.

The adoption of passive heating / cooling strategies for residential buildings located in locations on the territory of the Republic of Moldova can provide indoor humidity for max. 20% of the annual period (respectively for the summer period).

For the summer, the most suitable strategy is the organized natural ventilation. If this strategy also adds direct passive solar inputs (through light or large mass elements) and window shading strategies, cooling buildings are no longer needed.

Appropriate comfort control strategies should be correlated with specific climatic periods.

Adapting to outside climate by controlling window closure / opening is not an effective strategy for northern locations.

The objective coupling of passive strategies can reduce heating costs.

By using passive and active local regenerative energy resources, it is possible to reduce the costs of classical fuels and the release of noxes.

Maintenance of NZBE buildings in the comfort zone is ensured if they are designed by:

- the standard of passive buildings to operate during winter, but with appropriate technologies to help reduce sunlight in the summer.
- the standard of passive buildings for the summer period but with the punctual provision of indoor climate control strategies for cold weather (natural aeration strategies) ...
- the use of the renewable energy recovery systems in strict correlation with location and availability.

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