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CONSIDERATIONS OF THE DYNAMIC COMFORT INDICATORS IN VERY EFFICIENT ENERGETIC BUILDINGS

BY

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Abstract. Imposition of new energy requirements for future buildings (buildings NZB) requires a revision of the rules on their design parameters or rules on hygro-thermal comfort, adapting them to the changing demands that buildings and their improvement. On the other hand, the strategies to ensure comfort in these buildings must be carefully analyzed as indoor climate or comfort hygro-thermal interior is influenced by external climate, performance building and user requirements. The paper presents an analysis of the impact of climatic variations summer on indicators of comfort in buildings NZBE by evaluating them according to rules SR EN 15251 and ASHRAE -55. The analysis aims to highlight the dynamics indicators comfort in actual operating conditions different from those considered in the design process, and identifying strategies appropriate control.

Keywords: indoor quality environment; dynamics comfort indicators; passive strategy control of indoor quality.

1. Introduction

The notion of comfort is a complex notion, defined synthetically by

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”sensation of well/satisfaction that is felt by human body in relation to its external environment ".

Comfort problems related to have been in the last 50 years, the subject of the multiple studies and research designed to establish parameters of necessary comfort to building design. In recent years, the comfort parameters are required to performance evaluation (especially energetically) of the buildings and installations afferent, and to establish strategies to control installations systems.

Quality criteria relating to indoor ambiance aimed hygro-thermal comfort, visual, electro-magnetic, acoustic, health (indoor environmental quality: air emissions, ...; required water ...).

The parameters that characterize the indoor environment are relatively numerous and highly variable over time. Man, as a user of indoor space is influenced by the nature and dynamics of these parameters and, in his turn may contribute to altering the characteristics and dynamics of the environment in which he operates. Consequently there is a need to provide the appropriate parameters to ensure an optimal indoor climate in terms hydro-thermal and healthy for the human being and its activities. By default appears and the need for accurate forecasting of the values required to design the heating/cooling systems that ensure comfort and proper designing their control strategies.

In the current context, European and national, energetic and climatic, is absolutely necessary the reconsider the concept of habitat and the mandatory minimum values for defining the parameters for different levels of hygro-thermal comfort for the energy-efficient buildings.

Some of efficient energy buildings are characterized by hyper-tightness and hyper-insulation. These are practically disconnected from the external environment. These buildings require intervention controlled to ensure the hygro-thermal comfort inside. Other energy efficient buildings (some buildings NZBE, passive house, passive solar buildings, bio-climatic buildings, ...) are based on the human factor for ensuring the interior comfort indicators. For the energy efficient buildings, passive type, the comfort is an issue that should be viewed differently from standard type buildings.

Future buildings will be, in large part, smart buildings with smart tire , dynamic- adaptable so that they can adapt to the dynamic characteristics of the external climate and to the demands of users. In these buildings the comfort is characterized himself, by dynamism and, as such, the criteria for determining its parameters are different in the cases listed above.

Among the criteria above, thermal criteria are of major importance in terms of design and performance evaluation of heating, cooling, ventilation, and air conditioning.

The parameters that can influence comfort can be grouped the three major classes (Markus & Morris, 1980): a. The physical parameters (air temperature, mean radiant temperature of the walls of the enclosure, relative air humidity, velocity relative air into the enclosure; atmospheric pressure; light intensity, noise); b. organic parameters (age, sex, national characteristics of occupants); c. external parameters (level of human activity, type of clothing, social conditions).

The biggest influence on thermal comfort have: temperature, relative humidity, barometric pressure and air velocity and clothing and human work activities. Positive or negative effect of a parameter can be improved or offset by another parameter.

For design the NZEB building is important to establish the thermal comfort parameters, such that, it is obtained for a minimum consumption of energy.

To this end, they proposed different models of hygro-thermal comfort (or only heat), each of which is correlated with the requirements imposed buildings for that era. *Hygro-thermal comfort models* are very important for designing energy efficient buildings. They describe the quantitative limit climatic conditions for which people feel good in terms of heat. These conditions serve to ensure a comfortable thermal environments with minimal energy consumption, regardless of outside weather conditions.

The importance of a comfortable interior climate, while the outdoor climate parameters vary over time, simultaneously with "avoiding unnecessary use of energy" are among the declared objectives of the European Directive of buildings energy performance.

There are several models for comfort (Cotorobai *et al.*, 2009), of which are dominant and fit for energy purpose:

a) ***The Predicted Mean Vote (PMV),*** which is based on the proposed and reasoned model by Fanger;

b) **Adaptive Comfort model,** which takes into account the adaptive capacity of the occupants of a building at the seasonal climate variations and its location/climate zone.

Each of the mentioned models has certain particularities, which their is recommended in some design conditions and equipping of buildings, respectively, for buildings that ensure comfort in summer is achieved by:

i) Active systems: *The Predicted Mean Vote (PMV)*;

ii) Passive: *The Adaptive Comfort*;

iii) Mixed systems: *both models.*

The two models mentioned above differ between them by the mod of consideration the resultant temperature of indoor comfort, and respectively, by mod of consider the operative confort temperature in the warm period, when comfort can be provided with active or passive systems.

Designing systems for buildings and related facilities and to assess the energy performance of their comfort models were formalized in order to establish ranges of parameter values hygro-thermal comfort inside (design and energy performance assessment).

To characterize the comfort hygrothermal, both buildings in relation to this criterion, defined a set of global indicators comfort *(Predicted Mean Vote/PMV, Predicted Percent of dissatisfied/PPD; Temperature operative/To)* (ASHRAE Standard 55-1992, 2004; ISO 7730:2007; EN 15251: 2007). Rules relating to interior comfort have a narrower scope (SR EN 7730) or larger (SR EN 15251; ASHRAE 55).

2. Research Objectives

Imposition of new energy requirements for future buildings (buildings NZBE) requires the revision of these rules, adapt to new requirements and that their improvement.

Under the European directive to increase the energy performance of buildings has established itself providing new demands of quality energy, differentiated according to age buildings (new, existing) and time horizon (short (2020), Long (2050)). In the short term, new buildings will have to meet requirements NZBE buildings and, in the long term and existing buildings requires bringing the same quality requirements as those imposed on new buildings.

But the performances qualified attribute NZBE building are set by individual states and therefore they are different from state to state.

Under these circumstances it can meet NZBE building for proposing hyper- insulation and hyper- sealing.

Hyper-sealing requires aeration controlled or active systems that can affect the heat balance of buildings during summer. On the other hand, the buildings once designed and should provide comfort hygrothermal summer and in winter by appropriate control strategies provided for its purchase.

In the context of climate change and respectively in the manifestation periods sultry increasingly longer and of climatic differences Winter-Summer increasingly larger, the buildings hyper-insulated and hyper-tight designed for comfort during winter with minimum energy resources, may require energy resources relatively high for the comfort during the summer.

The paper presents an analysis of the impact of summer climate variations on comfort indicators in buildings NZBE, evaluating them according to SR EN 15251 and ASHRAE Standards-55. The analysis aims to highlight the dynamics comfort indicators in real operating conditions different from those considered in the design process, and identify appropriate control strategies.

To this end will be assessed:

a) indicators of comfort for the summer period, for a residential building that was purchased Hygrothermal comfort with passive cooling strategies designed in accordance with EN 12051 SR: 2007;

b) indicators comfort in hot climates during the summer, for the same building in order to identify the impact of these conditions on comfort category, respectively.

3. Research Results

3.1. Working Assumptions

In SR EN 12521: 2007 for residential buildings are set limits variation indicators comfort and calculation parameters for design in relation to quality classes, the means to provide comfort (active, mechanical/liabilities) and seasons climate. Recommended levels of indoor temperatures used in the design of residential buildings and related HVAC systems are shown in Table 1.

Table 1
Operational Temperature Values for Homes with Different Levels of Comfort
(extracted from EN 12521)

Building type	Category of comfort	**Operational temperature**	
		The minimum (for heating -Winter)	The maximum (cooling-Summer)
Rooms in residential buildings Sedentary:M= ~1.2 met; Clothing: ~1.0 clo	I	21.0	26.0
	II	20.0	26.5
	III	18.0	27.0

In Romania, but not only, over 50% of existing residential buildings are made in periods with much lower energy quality requirements in rapport with NZBE buildings, and, a large part of them will undergo modernization process. Packages of measures for renovation/modernization of existing buildings thermal recommended to use low-e windows. The paper presents an extract from an analysis of the impact of climate variations on maintaining comfort in existing residential buildings modernized or undergoing modernization, and for a building equipped with low-e windows.

For evaluating the radiation dosimetry, we analysed the behaviour of a triple windows with low-e glass in the simulation software Window 7 and I retained, for summer weather conditions, according to NFRC standard 100-200 (Te = 32ºC) the temperature the inner surface of the window (Tsi = 33.3ºC) (Fig. 1).

Note: (In recent years, in Romania, outside air temperature value exceeded for periods longer than 30 days Tae value = 32ºC, reaching extremes of Tae = 39ºC.

		Layer 1		Layer 2		Layer 3		
	Outside air	Outer surface	Inner surface	Outer surface	Inner surface	Outer surface	Inner surface	Inside air
U_{factor}	-18.0	-16.2	-15.9	3.7	3.8	13.0	13.2	21.0
SHGC	32	46.3	47.2	40.4	40.3	33.5	33.3	24.0

Fig. 1 − Air temperature, in different cross sections of the window, under standard NFRC 100-200 conditions, in the winter and the summer (Screen capture Windows 7).

The building model was made in TRNSYS and was simulated its behaviour under dynamic climate conditions of Iaşi. The simulation results on surface temperatures on the inside of the windows revealed in extreme conditions and values Tsi = 39.3ºC.

The radiant average temperature resulting from the room behavior analysis is:

a. for the standard climate conditions calculation *NFRC 100-200*: T_{MR},s = 28.4ºC;

b. in the extremal summer conditions: $T_{MR,s}$ = 30.4ºC

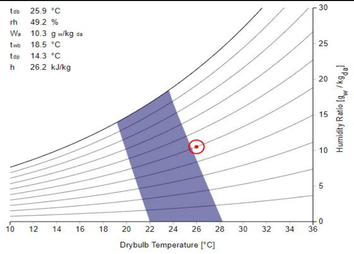
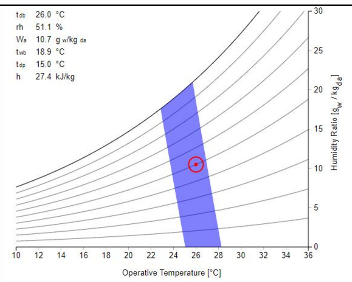
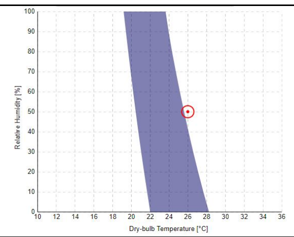
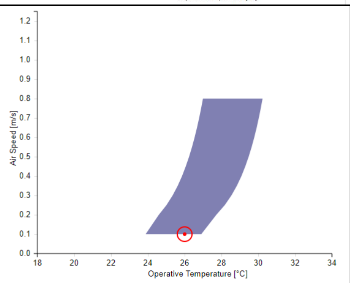
The analysis covered:

– to the establishment the indicators of comfort, in accordance with SR EN 12521 and ASHRAE-55, by method PMV and method of adaptive comfort, for the operation temperature indicated for the design of the residential buildings in category I and III (Table 1), with the parameters of indoor environment and the standardized parameters related to human metabolism for the summer period and for residential buildings;

– to the establishment the indicators of comfort, in accordance with Standard SR EN 12521 and ASHRAE-55, by PMV and Adaptive comfort method, for the operation temperature indicated for the design of the residential buildings in category I and III (Table 1), with the parameters of indoor environment and the standardized parameters related to human metabolism for the summer period residential buildings and for radiant average temperature in extreme conditions.

Table 2
Comparative analysis. Psychrometers graphics

I. PMV Method: ASHRAE-55							
Indoor environment parameters				Human parameters			
Air temperature	t_a	^{0}C	26	Metabolic rate	R_m	met	1.1
Mean radiant	T_{mr}	^{0}C	28.3	Clothing level (Thypical summer indoor	$N_î$	clo	0.5
Air speed	v_a	m/s	0.1				
Humidity	φ	%	50				

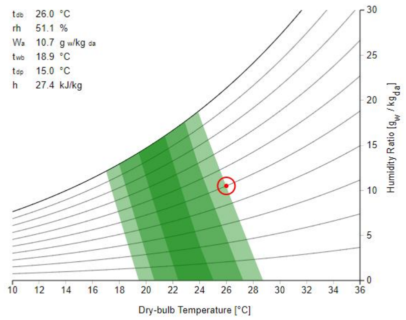
Chart	Graphic	Parameter	Value
a)Psychometric chart (air temperature)		PMV [%]	0.57
		PPD [%]	12
		Sensation	Slightly Warm
		Set	27
		Does not comply with ASHRAE Standard 55-2013*	
		***Note:** The abscissa is the dry-bulb temperature, and the mean radiant temperature (MRT) is fixed.. Each point on the chart has the same MRT, which defines the comfort zone boundary. In this way it can see how changes in MRT affect thermal comfort, yet each point will have the same MRT*	
Psychometric chart (ob)perative temperature)		PMV [%]	0.20
		PPD [%]	6
		Sensation	Neutral
		Set	25.7
		Complies with ASHRAE Standard 55-2013	
		***Note:** The abscissa is the operative temperature and for each point dry-bulb temperature equals mean radiant temperature (DBT = MRT). The comfort zone represents the combination of conditions with the same DBT and MRT for which the PMV is between -0.5 and +0.5, according to the standard.*	
c)Temperature – Relative umidity cart		PMV [%]	0.57
		PPD [%]	12
		Sensation	Slightly Warm
		Set	27
		Does not comply with ASHRAE Standard 55-2013	
		***Note:** This chart represents only two variables, dry-bulb temperature and relative humidity. The PMV calculations are still based on all the psychrometric variables, but the visualization becomes easier to understand*	
d)Air speed – operative temperature		PMV [%]	**0.2**
		PPD [%]	**6**
		Sensation	Neutral
		Set	25.7
		Complies with ASHRAE Standard 55-2013	
		***Note:** This chart represents air speed against operative temperature. The operative temperature for each point is determined by dry-bulb temperature equals mean radiant temperature (DBT = MRT). The calculation of PMV comfort zone is based on all the psychrometric variables, with PMV values between –0.5 and +0.5 according to the standard.*	

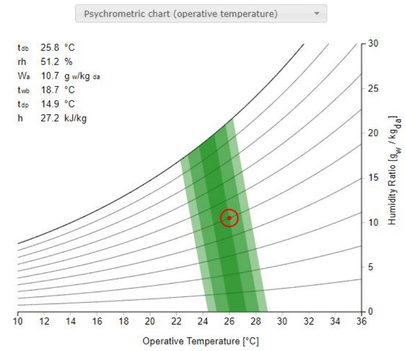
***** Each point on the graph is the same T_{mr}, within the limits of the comfort zone. ** Comfort zone: the combination of circumstances, the same T_{bu} and T_{mr} for which PMV ∈ [–0.5; 0.5] (as standard).

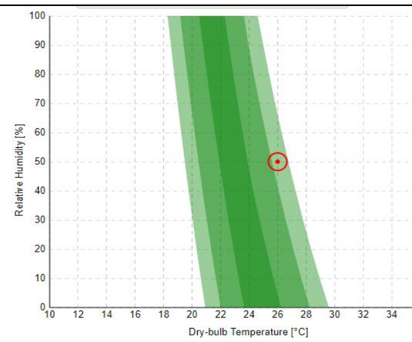
Note: Indicators comfort set for regulated interior comfort parameters not remains constants in different functional external conditions; operating point is established outside the comfort zone

Table 2

(Continuation)

<table>
<tr><td colspan="8">I. PMV Method: SR EN 15251</td></tr>
<tr><td colspan="4">Indoor environment parameters</td><td colspan="4">Human parameters</td></tr>
<tr><td>Air temperature</td><td>t_a</td><td>^{0}C</td><td>26</td><td>Metabolic rate</td><td>R_m</td><td>met</td><td>1.1</td></tr>
<tr><td>Mean radiant</td><td>T_{mr}</td><td>^{0}C</td><td>28.3</td><td>Clothing level (Thypical summer indoor</td><td>$N_î$</td><td>clo</td><td>0.5</td></tr>
<tr><td>Air speed</td><td>v_a</td><td>m/s</td><td>0.1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Humidity</td><td>φ</td><td>%</td><td>50</td><td></td><td></td><td></td><td></td></tr>
<tr><td>a)Psychometric chart (air temperature)</td><td colspan="3">
</td><td colspan="4">PMV [%]: 0.7
PPD [%]: 55
Category: IV
Does not comply with SR EN 15251 *

Note: *The abscissa is the dry-bulb temperature, and the mean radiant temperature (MRT) is fixed.. Each point on the chart has the same MRT, which defines the comfort zone boundary. In this way it can see how changes in MRT affect thermal comfort, yet each point will have the same MRT*</td></tr>
<tr><td>b)Psychometric chart (operative temperatture)</td><td colspan="3">
</td><td colspan="4">PMV [%]: 0.2
PPD [%]: 6
Catgory: I
Complies with ASHRAE Standard 55-2013

Note:*The abscissa is the operative temperature and for each point dry-bulb temperature equals mean radiant temperature (DBT = MRT). The comfort zone represents the combination of conditions with the same DBT and MRT for which the PMV is between -0.5 and +0.5, according to the standard.*</td></tr>
<tr><td>c)Temperature –Relative umidity cart</td><td colspan="3">
</td><td colspan="4">PMV [%]: 0.57
PPD [%]: 12
Category: III
Set: 27

Note: *This chart represents only two variables, dry-bulb temperature and relative humidity. The PMV calculations are still based on all the psychrometric variables, but the visualization becomes easier to understand*</td></tr>
<tr><td colspan="8">Note: Indicators comfort set for regulated interior comfort parameters not remains constants in different functional external conditions; operating point is established outside the comfort zone</td></tr>
</table>

Table 3

Comparative analysis. Psychrometers graphics

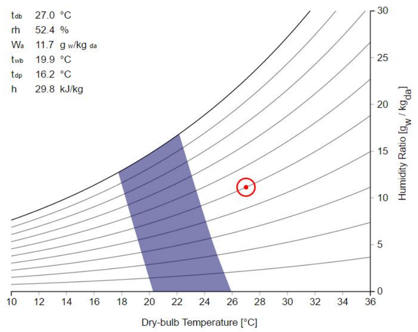
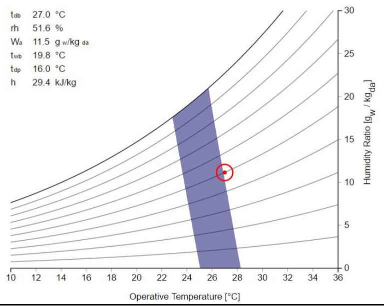
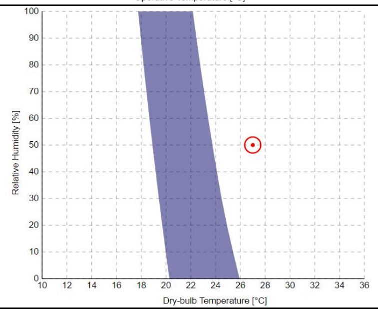
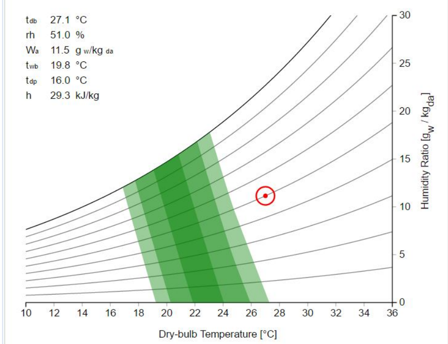
<table>
<tr><td colspan="8">a. PMV Method: ASHRAE-55</td></tr>
<tr><td colspan="4">Indoor environment parameters</td><td colspan="4">Human parameters</td></tr>
<tr><td>Air temperature</td><td>t_a</td><td>^0C</td><td>27</td><td>Metabolic rate</td><td>R_m</td><td>me</td><td>1.1</td></tr>
<tr><td>Mean radiant temperature</td><td>T_{mr}</td><td>^0C</td><td>30.4</td><td>Clothing level (Typical summer indoor clothing)</td><td>$N_î$</td><td>clo</td><td>0.5</td></tr>
<tr><td>Air speed</td><td>v_a</td><td>m/s</td><td>0.1</td><td></td><td></td><td></td><td></td></tr>
<tr><td>Humidity</td><td>φ</td><td>%</td><td>50</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">Psychometric chart (air temperature)</td><td colspan="3" rowspan="5">
</td><td>PMV [%]</td><td colspan="3">1.09</td></tr>
<tr><td>PPD [%]</td><td colspan="3">**30**</td></tr>
<tr><td>Sensation</td><td colspan="3">Slightly Warm</td></tr>
<tr><td>Set</td><td colspan="3">28.6</td></tr>
<tr><td></td><td colspan="3">Does not comply with ASHRAE Standard 55-2013*</td></tr>
<tr><td rowspan="5">Psychometric chart (operative temperature)</td><td colspan="3" rowspan="5">
</td><td>PMV [%]</td><td colspan="3">1.09</td></tr>
<tr><td>PPD [%]</td><td colspan="3">30</td></tr>
<tr><td>Sensation</td><td colspan="3">Slightly Warm</td></tr>
<tr><td>Set</td><td colspan="3">28.6</td></tr>
<tr><td></td><td colspan="3">Does not comply with ASHRAE Standard 55-2013*</td></tr>
<tr><td rowspan="5">Temperature –Relative humidity cart</td><td colspan="3" rowspan="5">
</td><td>PMV [%]</td><td colspan="3">1.09</td></tr>
<tr><td>PPD [%]</td><td colspan="3">30</td></tr>
<tr><td>Sensation</td><td colspan="3">Slightly Warm</td></tr>
<tr><td>Set</td><td colspan="3">28.6</td></tr>
<tr><td></td><td colspan="3">Does not comply with ASHRAE Standard 55-2013</td></tr>
<tr><td colspan="8">***** Each point on the graph is the same T_{mr}, within the limits of the comfort zone. ** Comfort zone: the combination of circumstances, the same T_{bu} and T_{mr} for which PMV ∈ [–0.5; 0.5] (as standard).</td></tr>
<tr><td colspan="8">**Note:** Indicators comfort set for regulated interior comfort parameters not remains constants in different functional external conditions; operating point is established outside the comfort zone</td></tr>
</table>

Table 3
Continuation

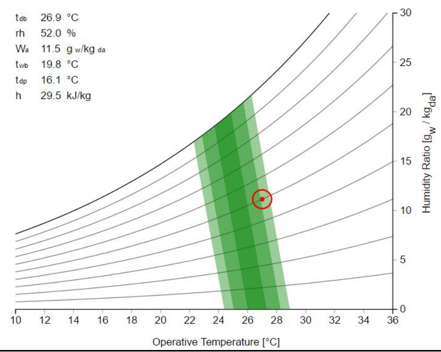
b. PMV Method: SR EN 12521							
Indoor environment parameters				Human parameters			
Air temperature	t_a	^0C	27	Metabolic rate	R_m	met	1.1
Mean radiant temperature	T_{mr}	^0C	30.4	Clothing level (Typical summer indoor clothing)	N_i	clo	0.5
Air speed	v_a	m/s	0.1				
Humidity	φ	%	50				

Psychometric chart



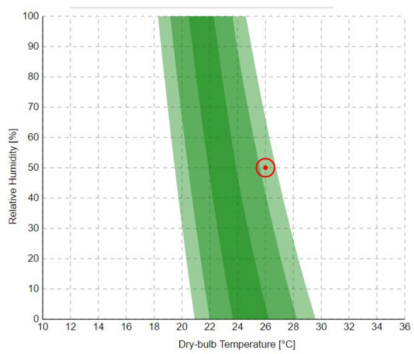
PMV [%]	1.09		
	Cat. I	Cat. II	Cat. III
	-0,2<PMV<+0,2	-0,5<PMV<+0,5	-0,7<PMV<+0,7
PPD [%]	30		
	<6	<10	<15
Category			IV
	Does not comply with EN-15251		

Psychometric chart



PMV [%]	0.53		
	Cat. I	Cat. II	Cat. III
	-0,2<PMV<+0,2	-0,5<PMV<+0,5	-0,7<PMV<+0,7
PPD [%]	11		
	<6	<10	<15
Category			III

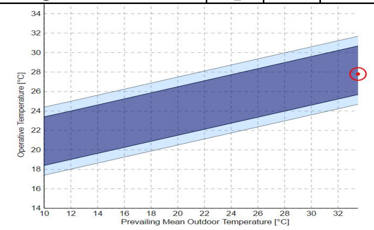
Temperature –Relative humidity cart



PMV [%]	1.09		
	Cat. I	Cat. II	Cat. III
	-0,2<PMV<+0,2	-0,5<PMV<+0,5	-0,7<PMV<+0,7
PPD [%]	30		
	<6	<10	<15
Category			IV
	Does not comply with EN-15251		

Note: Indicators comfort set for regulated interior comfort parameters not remains constants in different functional external conditions; operating point is established outside the comfort zone

Table 4
Adaptive chart

<table>
<tr><th colspan="9">**a.** Adaptive method: ASHRAE-55</th></tr>
<tr><th colspan="5">Indoor environment parameters</th><th colspan="4">Human parameters</th></tr>
<tr><td colspan="2">Air temperature</td><td>t_a</td><td>^{0}C</td><td>26</td><td>Metabolic rate</td><td>R_m</td><td>met</td><td>1.1-1.3</td></tr>
<tr><td colspan="2">Mean radiant temperature</td><td>T_{mr}</td><td>^{0}C</td><td></td><td>Clothing level (Typical summer indoor</td><td>$N_î$</td><td>clo</td><td>0.5-1.0</td></tr>
<tr><td colspan="2">Air speed</td><td>v_a</td><td>m/s</td><td>0.3</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Prevailing mean outdoor</td><td>T_{m_ae}</td><td>^{0}C</td><td>33.5</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">Adaptive chart</td><td colspan="4" rowspan="5">
</td><td>acceptability limits: 80%</td><td colspan="3">Operative temperature: 24.7-31.7 °C</td></tr>
<tr><td>⇒ Status</td><td colspan="3">Comfortable</td></tr>
<tr><td>90% acceptability limits</td><td colspan="3">Operative temperature: 25.7-30.7 °C</td></tr>
<tr><td rowspan="2">⇒ Status</td><td colspan="3">Comfortable</td></tr>
<tr><td colspan="3">Complies with ASHRAE Standard 55-2013</td></tr>
<tr><th colspan="5">Indoor environment parameters</th><th colspan="4">Human parameters</th></tr>
<tr><td colspan="2">Air temperature</td><td>t_a</td><td>^{0}C</td><td>27</td><td>Metabolic rate</td><td>R_m</td><td>met</td><td>1.1-1.3</td></tr>
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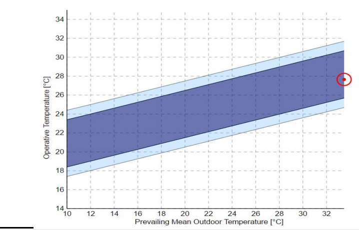
<tr><td colspan="2">Air speed</td><td>v_a</td><td>m/s</td><td>0.3</td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Prevailing mean outdoor</td><td>T_{m_ae}</td><td>^{0}C</td><td>33.5</td><td></td><td></td><td></td><td></td></tr>
<tr><td rowspan="5">Adaptive chart</td><td colspan="4" rowspan="5">
</td><td>80% acceptability limits</td><td colspan="3">Operative temperature: 24.7 to 31.7 °C</td></tr>
<tr><td>⇒ Status</td><td colspan="3">Comfortable</td></tr>
<tr><td>90% acceptability limits</td><td colspan="3">Operative temperature: 25.7 to 30.7 °C</td></tr>
<tr><td rowspan="2">⇒ Status</td><td colspan="3">Comfortable</td></tr>
<tr><td colspan="3">Complies with ASHRAE Standard 55-2013</td></tr>
<tr><th colspan="5">Indoor environment parameters</th><th colspan="4">Human parameters</th></tr>
<tr><td colspan="2">Air temperature</td><td>t_a</td><td>^{0}C</td><td>27</td><td>Metabolic rate</td><td>R_m</td><td>met</td><td>1.1-1.3</td></tr>
<tr><td colspan="2">Mean radiant temperature</td><td>T_{mr}</td><td>^{0}C</td><td>30.4</td><td>Clothing level (Typical summer indoor clothing)</td><td>$N_î$</td><td>clo</td><td>0.5-1.0</td></tr>
<tr><td colspan="2">Air speed</td><td>v_a</td><td>m/s</td><td>0.3</td><td></td><td></td><td></td><td></td></tr>
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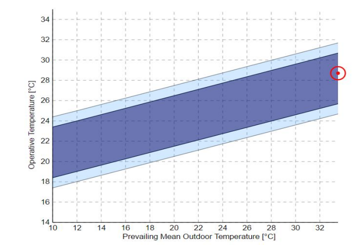
<tr><td rowspan="5">Adaptive chart</td><td colspan="4" rowspan="5">
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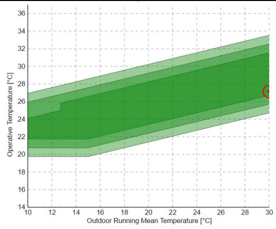
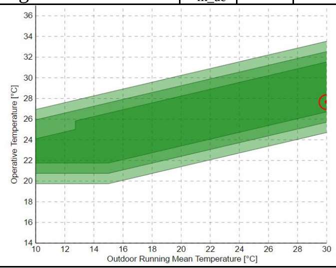
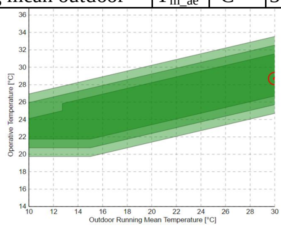
<tr><td>⇒ Status</td><td colspan="3">Comfortable</td></tr>
<tr><td>90% acceptability limits</td><td colspan="3">Operative temperature: 25.7 to 30.7 °C</td></tr>
<tr><td rowspan="2">⇒ Status</td><td colspan="3">Comfortable</td></tr>
<tr><td colspan="3">Complies with ASHRAE Standard 55-2013</td></tr>
<tr><td colspan="9">**Note:** *Method is applicable only for occupant-controlled naturally conditioned spaces that meet all of the following criteria:*
(a) There is no mechanical cooling system installed. No heating system is in operation;
(b) Metabolic rates ranging from 1.0 to 1.3 met; and
(c) Occupants are free to adapt their clothing to the indoor and/or outdoor thermal conditions within a range at least as wide as 0.5-1.0 clo.</td></tr>
</table>

Table 4

b. Adaptive method: SR EN 12521							
Indoor environment parameters				Human parameters			
Air temperature	t_a	^0C	26	Metabolic rate	R_m	met	1.1-1.3
Mean radiant temperature	T_{mr}	^0C	28.3	Clothing level	$N_î$	clo	adaptable
Air speed	v_a	m/s	0.3				
Prevailing mean outdoor	T_{m_ae}	^0C	30				
Adaptive chart				Acceptability limits: Class III	*Operative temperature: 24.7 to 33.5 °C*		
				Status	*Comfortable*		
				Class II acceptability limits	*Operative temperature: 25.7 to 32.5 °C*		
				Status	*Comfortable*		
				Class I acceptability limits	*Operative temperature: 26.7 to 31.5 °C*		
				Status	*Comfortable*		
				Complies with EN-15251			
Indoor environment parameters				Human parameters			
Air temperature	t_a	^0C	27	Metabolic rate	R_m	met	1.1-1.3
Mean radiant temperature	T_{mr}	^0C	28.3	Clothing level	$N_î$	clo	adaptable
Air speed	v_a	m/s	0.3				
Prevailing mean outdoor	T_{m_ae}	^0C	30				
Adaptive chart				Class III acceptability limits	*Operative temperature: 24.7 to 33.5 °C*		
				Status	*Comfortable*		
				Class II acceptability limits	*Operative temperature: 25.7 to 32.5 °C*		
				Status	*Comfortable*		
				Class I acceptability limits	*Operative temperature: 26.7 to 31.5 °C*		
				Status	*Comfortable*		
				Complies with EN-15251			
Indoor environment parameters				Human parameters			
Air temperature	t_a	^0C	27	Metabolic rate	R_m	met	1.1-1.3
Mean radiant temperature	T_{mr}	^0C	30.4	Clothing level	$N_î$	clo	adaptable
Air speed	v_a	m/s	0.3				
Prevailing mean outdoor	T_{m_ae}	^0C	30				
Adaptive chart				Class III acceptability limits	*Operative temperature: 24.7 to 33.5 °C*		
				Status	*Comfortable*		
				Class II acceptability limits	*Operative temperature: 25.7 to 32.5 °C*		
				Status	*Comfortable*		
				Class I acceptability limits	*Operative temperature: 26.7 to 31.5 °C*		
				Status	*Comfortable*		
				Complies with EN-15251			

Note: *Method is applicable only for buildings without mechanical cooling systems and where there is easy access to operable windows and occupants may freely adapt their clothing to the indoor and/or outdoor thermal conditions. The criteria for the spaces are the following:*
(a) There is no mechanical cooling or heating system in operation;
(b) Metabolic rates ranging from 1.0 to 1.3 met;
c) Occupants are allowed to freely adapt their clothing insulation.

3.2. Research Results

The results are presented in Tables 2, ..., 4. Are represented:

- Psychrometers graphs $t_a = f(T_{Tbu})$ $T_o = f(T_{Tbu})$, and $\varphi = f(T_{Tbu})$ and comfort zones in standard climatic conditions and extreme weather conditions in summer, conformement:
  - the PMV method for standard ASHRAE 55 and (Tables 2a and 3a);
  - EN 12051 (Tables 2b and 3b).
- Adaptive diagrams obtained using adaptive comfort method, established under the same rules and that the same conditions (Table 4).

4. Discussion.

The analysis of diagrams can be drawn the following conclusions:

1º Design of the housing building with active systems to ensure comfort parameters indicated in the rules EN 12521 and ASHRAE-55, in accord with the PMV method does not guarantee maintaining an indoor environment comfortable, in climate conditions much different from those considered in the design, in the absence of control strategies effective internal parameters (Tables 2 and 3).

2º Design of the housing building according with the two rules by using method ”adaptive comfort” and by considering only strategies passive ensuring hygro-thermal comfort during the summer ensure the maintaining a comfortable atmosphere and under periods hot (Table 4).

There are different passive strategies for the control of the hygro-thermal indicators/parameters of the comfort (Fig. 2) for the cold and the warm sezon. But these strategies must be carefully balanced with quality assurance strategies indoor air. In the climatic conditions of Romania, to ensuring Hygro-thermal comfort during winter is necessary the use of active systems.

5. Conclusions

Hygro-thermal comfort parameters for design of buildings NZBE, in the climatic zones with large variations of temperature winter-summer and with the sultry important periods, must consider differently, for the winter period, the warm period and the hot periods. The strategies comfort control must be correlate to specific of each climatic periods.

Maintaining comfort indicators considered in the design of buildings NZBE lifespan can be provided if designed:

a) after standard passive buildings to operate in winter but with appropriate technologies that favour the reduction of inputs sun in summer.

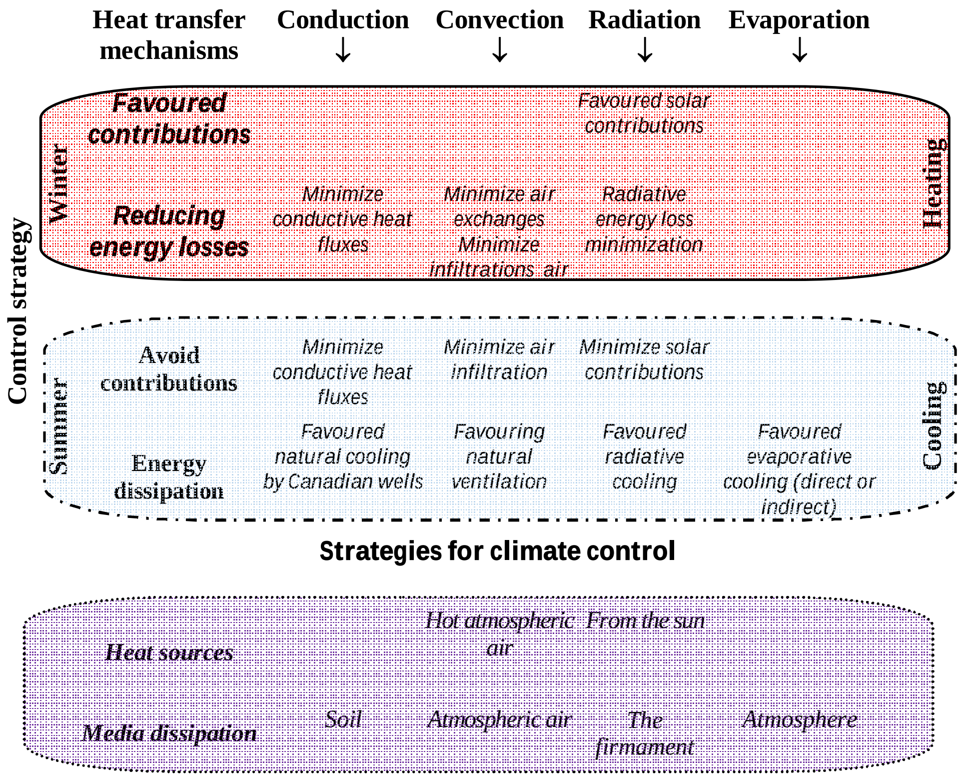


Fig. 2 – Hygrothermal comfort control strategies.

Are possible such technologies: heliotrope or thermotropic glass windows showing the possibility of controlling thermal and optical radiation transmitted to and from the interior and exploitation of solar radiation in excess of the requirements to ensure visual comfort and indoor environment; south wall cladding with glass bricks intelligent, dynamically adaptive radiation and solar thermal devices; north wall cladding panels finishing with thermo-active; use possible strategies coupled with the ground elements to increase the thermal inertia and thermoregulation (MSF), ...

b) after standard passive buildings during the summer but punctual provision of indoor climate control strategies for hot periods (natural ventilation strategy) ...

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CONSIDERAȚII ASUPRA INDICATORILOR DE CONFORT DIN CLĂDIRILE CU CONSUM REDUS DE ENERGIE ÎN REGIM DINAMIC

(Rezumat)

Impunerea noilor exigențe energetice pentru clădirile viitorului necesită revizuirea tuturor normelor referitoare la parametrii de proiectare ai acestora. Normele referitoare la confortul higro-termic al clădirilor pot avea un impact important asupra consumului de energie în exploatare. Adaptarea acestora la noile exigențe impuse clădirilor şi previzionarea unui comportament al clădirilor cât mai aproape de cel real este absolut necesară în acest context. Pe de altă parte, strategiile de asigurare a confortului în aceste clădiri trebuiesc atent analizate şi corect considerate în cadrul normelor deoarece confortul higro-termic este influențat de climatul exterior, performanțele clădirii şi exigențele utilizatorilor. În cadrul lucrării se prezintă o analiză a impactului variațiilor climatice estivale asupra indicatorilor de confort din clădirile NZBE, prin evaluarea acestora conform normelor EN 15251 şi ASHRAE -55. Analiza vizează evidențierea dinamicii indicatorilor de confort în condițiile reale de funcționare şi identificarea unor strategii de control.