URBAN CLIMATE CERTIFICATION – CONDITION OF MITIGATION THE URBAN HEAT ISLAND ON THERMAL COMFORT IN BUILDINGS IN SUMMER

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Rezumat. Lucrarea prezintă scopul şi obiectivele activității de modernizare energetică a clădirilor existente, precum şi de proiectare şi realizare a unor clădiri noi, caracterizate de Performanța Energetică şi de Mediu ridicată. Referirea la Strategia europeană (Europe 2020) şi la Directivele europene, preluate în legislația națională, constituie reperul de necesitate, iar soluțiile tehnice şi economice ale obiectivelor care derivă din scopul menționat, completează dimensiunea de suficiență a structurii logice a procedurii de rezolvare a obiectivelor. Importanța economică şi în special socială a domeniului locuirii în condiții de confort şi igienă, fără costuri excesive şi fără afectarea climatului, rezidă şi din impactul climatic asupra actualului sistem de locuire şi de utilizare a resurselor energetice. Vara anului 2003 s-a încheiat cu un bilanț tragic la nivel european şi internațional, reprezentat de peste 50.000 de victime ale valului de căldură şi al incapacității de adaptare a clădirilor la extreme de tip hazard climatic de intensitate excepțională. S-a evidențiat vulnerabilitatea mediului construit în raport hazardul climatic care se caracterizează printr-o evoluție ascendentă, inclusiv la nivelul României. Sistemul de evaluare cantitativă a Performanței Energetice şi de Mediu a clădirii, parte a procedurii de Configurare Energetică şi de Mediu, implică etape distincte de expertiză şi diagnostic care permit elaborarea scenariilor şi strategiei de modernizare energetică. Pe baza diagnosticului clădirii se elaborează scenariile de modernizare, diferențiate prin indicatori tehnici şi economici. Scenariile permit elaborarea strategiei de modernizare. Strategia de modernizare energetică/ proiectare a clădirilor noi, performante energetic, se bazează pe *configurarea energetică a clădirii*, care reprezintă modelarea detaliată a proceselor de transfer de proprietate şi evaluarea eficienței economice a soluțiilor de proiectare / exploatare.

Cuvinte cheie: vulnerabilitatea mediului construit; configurația energetică a clădirilor; metode de calcul validate; analiză de sensibilitate.

Abstract. The paper presents the aim and objectives of modernizing the energy system of current buildings as well as of designing and executing new buildings with a high Energy and Environmental Performance. It is necessary to refer to the European Strategy (Europe 2020) and to the European Directives, transposed into the national legislation, while the technical and economic solutions to the objectives resulting from the above mentioned purpose complete the dimension of the logical structure of this procedure for reaching the objectives. The economic and especially social importance of comfortable and hygienic living conditions, without excessive costs and without affecting the climate also stems from the climate impact on the current living conditions and use of energy sources. The summer of 2003 had a tragic aftermath at the European and international level, consisting in over 50,000 victims of the heat wave and of the buildings' incapacity to adapt to extremes such as exceptionally intense climate hazards. This highlighted the vulnerability of the built environment compared to climate hazards characterized through an ascending evolution, Romania included. The system of quantitative assessment of the building's Energy and Environmental Performance, part of the procedure for Energy and Environmental Configuration, entails separate expertise and diagnosis phases which allow elaborating scenarios and strategies for energy modernization. The modernization scenarios are elaborated based on the diagnosis of the building, scenarios differentiated through technical and economic indicators. Scenarios allow the modernization strategy to be elaborated. The energy modernization strategy / designing of new, energy performance buildings is based on the *energy configuration of buildings* which is the detailed modelling of ownership transfer processes and the assessment of economic efficiency of design / exploitation solutions.

Keywords: vulnerability of the built environment; Energy Configuration of Buildings; calculation methods validation; sensitivity analysis.

1. OVERVIEW

One of the major targets at the global level is to protect the natural environment and to improve the quality of living in the spirit of the Sustainable Development concept. Buildings are one of the major factors that disturb the quality of the natural environment and, consequent to this disturbance, they have a major impact on the built environment.

At the world level, over 40 % of the energy consumption goes to building related processes. At the national level, Romania's National Strategy of Sustainable Development certifies that Romania falls in the specific parameters for living with over 32 % power consumption from the national consumption. The European Directive 2010 / 31 / EU sets very ambitious targets regarding the reduction of power consumption pertaining to constructions, targets which are included in the provisions of the European strategy Europe 2020, known as 20 / 20 / 20 and which sets the benchmarks for reducing energy consumption, reducing NO_x emissions and increasing the participation of renewable energy sources in the energy balance of the buildings by 20 % compared to the current similar parameters. This work presents the objectives of the energy modernization of existing buildings as well as activities of designing and building new buildings characterized by a High Energy and Environmental Performance. This activity is the object of the Energy Configuration of new buildings and of the reconfiguration of existing buildings so that the Buildings Energy Performance reaches the target set in Art. 9 of Directive 2010 / 31 / EU, that is nearly zero energy consumption (regarding the primary energy pertaining to achieving thermal comfort and living hygiene). This paper presents the current values of the synthetic parameters of thermal processes with a major impact in determining the Building Energy Performance indicator at the level of the climate areas in Romania. It also presents the dynamic of the climate parameters on two significant periods from a statistical point of view (1961-1994 and 1994-2008) (Constantinescu D. et al, 2009) as well as an analysis of the effects of climate change at the European and international level. The focus is on processes that affect the thermal regime of the buildings and which highlight the vulnerability of buildings compared to thermal climate hazards. Building vulnerability appears depending on the transfer between the climate requests and indoor living environment. On the other hand, the high vulnerability of buildings determine the increased intensity of climate hazards by using systems and equipment which reduce vulnerability on the short term but amplify the impact of hazards through the anthropogenic component. This is the typical form of accelerating the disorder of an environment, respectively to increase environment entropy. At the same time with highlighting the vulnerability of the living environment, the periods of thermal discomfort present the dramatic effects of vulnerability in the form of deaths among those that live in so-called social housings. This refers to rather recent events with over 50,000 victims in European countries. One of the causes that amplifies the climate impact on the buildings consists in the accelerated dynamic of the urbanism process correlated strictly with an economic efficiency on a short and medium term, without observing minimum criteria for protecting the natural outdoor environment. The occurrence of heat islands above built areas is an effect type of event which feeds through a feedback process and turns into a man-made type of hazard. The increase of the outdoor temperature in highly populated areas generates changes with respect to the buildings' energy configuration both at the level of selecting the covers and technical systems and as global energy management strategies for the built environment. The urban environment, which has become an aggressive environment by neglecting the accelerated increase processes of entropy, may benefit from a systemic approach targeting to minimize the destruction of the natural environment. In this process, executing buildings – as structural entities of the built environment – is important both for the population living in the buildings and for the impact that buildings have on the natural environment. From the point of view of the built environment, this paper sees the building as an element of the said. The paper is focused on two fundamental coordinates of building energy configuration, i.e. the accuracy of estimating the Energy Performance and of the intensive and extensive thermodynamic parameters of the occupied spaces during the design phase by using the simulation of the buildings' thermal response to dynamic climate efforts, on the one hand, and the association of economic efficiency criteria determined for the building's economic lifespan, on the other hand. A third coordinate of the building energy configuration, which appears after commissioning the building, is the empirical monitoring and validation of Energy Performance, activities associated with reporting at the local, regional and national level of the building's Energy and Environmental Performance. The accurate building energy configuration leads to a significant reduction of NO_x emissions pertaining to burning processes as well as of the thermal flow transferred through convection and radiation to the adjacent areas of the building (traffic spaces). This will implicitly reduce the intensity of the manifestation of urban heat islands. One must highlight that the presence of heat islands is largely a consequence of the built environment and of solutions found by the urbanism activity. These are joined by urban transport with its double effect of NO_x and heat emissions.

2. CLIMATE PARAMETERS CHARACTERISTIC OF ROMANIA – COMPARATIVE ANALYSIS

The paper (Constantinescu D. et all, 2009) presents the method of defining the typical climate year necessary to assess the Buildings Energy Performance (BEP). In order to determine the calculus climate necessary for sizing the systems of reaching thermal comfort, the time values for 41 localities representative for Romania's counties were selected. The data were determined both for the winter and summer period. The criterion for creating the database was to have representative values for one locality in the urban area in every county, for the timeframe amounting to 48 consecutive years (1961-2008) and 15 consecutive years (1994-2008) respectively. For the cold season, the data were time values appearing as 164 rows of 120 consecutive hours. The pentad groups allow the analysis of the thermal response of the premises studied in the simulation, the only answer based on which one can take a useful decision for designing the buildings' heating systems. This paper refers to the results yielded by the analysis on the dynamic model for reference buildings located in Bucharest, Constanta, Iaşi and Miercurea Ciuc. The average values of the outside temperature over the coldest pentads belonging to Climate 1 (1961-1994) are below the counterpart values belonging to Climate 2 (1994-2008). Except for the size of the two sets (48 years Climate 1, 15 years Climate 2 respectively), one can notice a warming process in most localities. The chart with the occurring frequency of average temperature differences in the coldest pentads (Fig. 1):

$$\Delta t_e = \bar{t}_{e\,\min\,Cl.2}^{(5)} - \bar{t}_{e\,\min\,Cl.1}^{(5)} \tag{1}$$

presents that in 37% of the cases $\Delta\, t_e > 3.25$°C, which is proof of the increase of the minimum values of $t_e\,(\tau)$.

The warm season highlighted that all pentads with maximum values of the average temperature are found, for all the 41 cities, exclusively in the period 1994-2008, specific to Climate 2. Based on the primary data, the pentadic average climate characteristic for every city from the overall 41 cities analyzed was generated. The conclusions of the primary climate data analysis prove that for the *cold season* the values of daily average temperatures of extreme pentads, specific for Climate 2 (1994-2008) exceed in average by 2.28°C the similar values specific for Climate 2 (1961-1994). Basically, this difference leads to a reduction by circa 17.5 % of the buildings' thermal load. At the level of the season average, the temperature difference is 2.78°C which leads to a reduction by 18.04 % of the heat consumption. Figure 2 presents the variation curves t_a (τ), t_i (τ) for Current Floor space, in Bucharest, requested for climate 1 (1961- 1994).

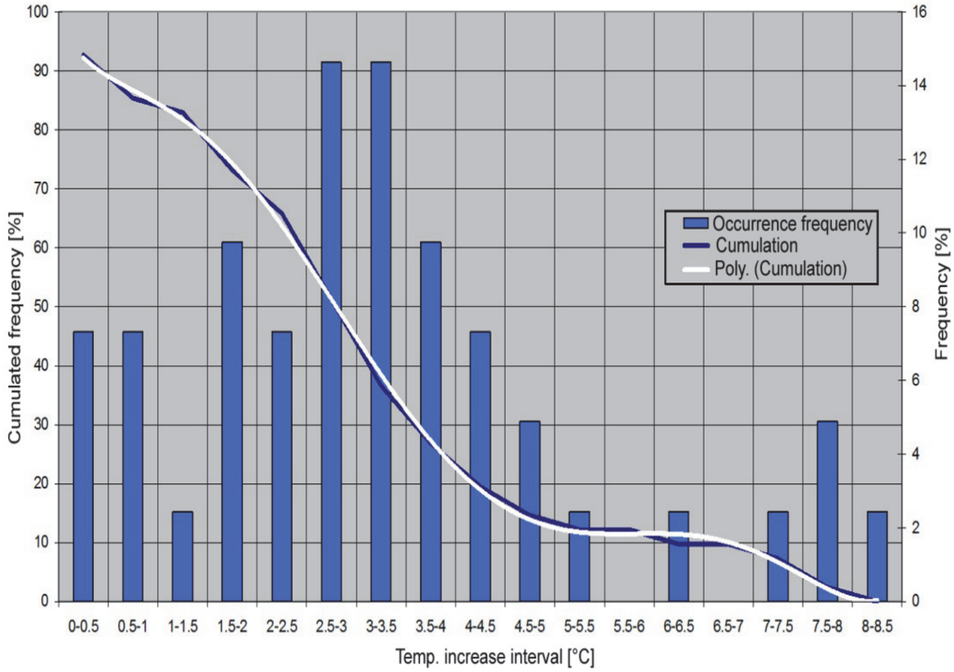

Fig. 1. Statistics of the increase in average outdoor temperature of the coldest pentad in 41 localities in Romania during 1994-2008, compared with the period 1961-1994 (Climate 2 compared to Climate 1).

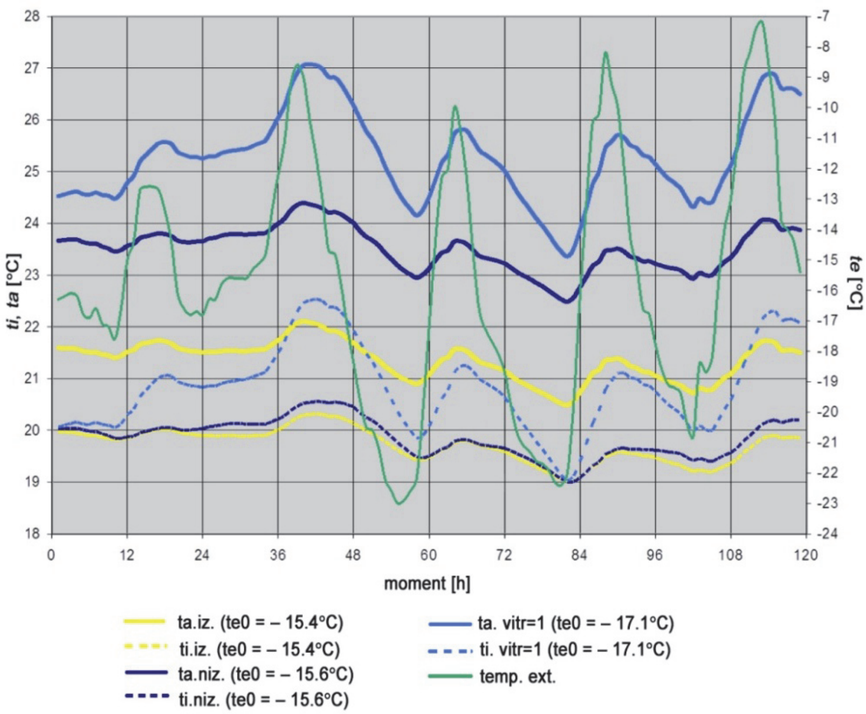

Fig. 2. Case study – Bucharest, calculus climate 1 (1961-1994) (non-isolated cover / thermally isolated cover and double / thermo-isolating windows) – corner premises

Apart from the significant differences of values t_a (τ) and t_i (τ) depending on the energy configuration of the analyzed premises, one can see that the thermal isolation has a major influence on the necessary indoor temperatures of the air for reducing by 2.1°C in case of buildings with an average glazing (glazing ratio below 0.40). In case of highly glazed buildings, achieving the thermal comfort entails an increase in indoor air temperature by 4.72°C compared to buildings with an average glazing level. The main conclusion of this finding (maintained throughout all the analyzed cases, not just for Bucharest) is that the proper energy configuration of buildings entails the minimization of the necessary heat both by means of thermally protected covers and by optimizing the glazing ratio.

Figure 3 presents the variation curves t_a (τ), t_i (τ) for Current Floor space, in Bucharest, requested for climate 2 (1994-2008). Apart from the fact that outdoor calculus temperatures increase significantly compared to the previous case (increases between 2.6°C and 3.2°C), the oscillation scale of hourly values also increases. The analysis of the variance indicator highlights an increase $CV_{(2)} > CV_{(1)}$:

$$\left(\frac{\sigma}{\mu}\right)_{(2)} > \left(\frac{\sigma}{\mu}\right)_{(1)} \tag{2}$$

where σ and μ are the standard deviation, respectively the average of outdoor temperatures.

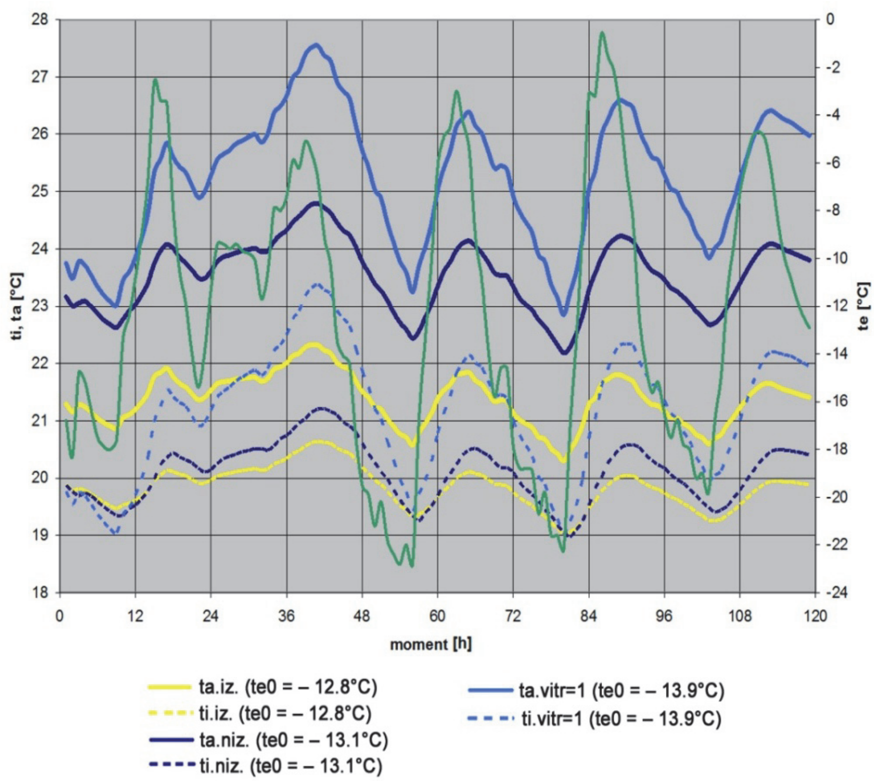

Fig. 3. Case study – Bucharest, extreme calculus climate 2 (1994-2008) (non-isolated cover / thermally isolated cover and double / thermo-isolating windows) – corner premises.

The calculus model for dynamic simulation that was used is implemented in the Calculation Programme INVAR 2 based on the Unitary Thermal Response (UTR) (Constantinescu D., 2008) applied to composite structures affected by thermal bridges and on the thermal balance of premises that make up the multi-area system. With respect to the *summer season*, the average increase of average temperatures in the calculation pentads is 3.58°C with unfavorable consequences both on the thermal comfort and on the cooling load necessary for reaching the thermal comfort in buildings.

3. URBAN HEAT ISLANDS (UHI) – CLIMATE VULNERABILITY OF BUILDINGS

Highly populated areas in the urban environment are characterized by an increased outdoor air temperature compared to the rural / periurban environment temperature. This phenomenon, known as urban heat islands (UHI), is the consequence of replacing vegetation with building and paved roads (Akbari H., 2001). The exterior surfaces of the buildings and the paved roads absorb the solar radiation which than they transfer back, segmented and slowly, to the natural environment through convection and radiation. The increase of the outdoor temperature leads to a significant increase of the cooling load and, implicitly, to increased emissions resulting from the thermodynamic processes of generating electricity as well as to increased thermal pollution of the natural environment, as a consequence of the energy configuration of buildings. In US, the heat islands are responsible for the increase by circa 10 % of the cooling load and circa 20 % of the emission concentration in highly populated urban areas. The dynamic of the increase in heat islands expressed in degrees/ decade appears in the chart in Figure 4 (Akbari H., 2001).

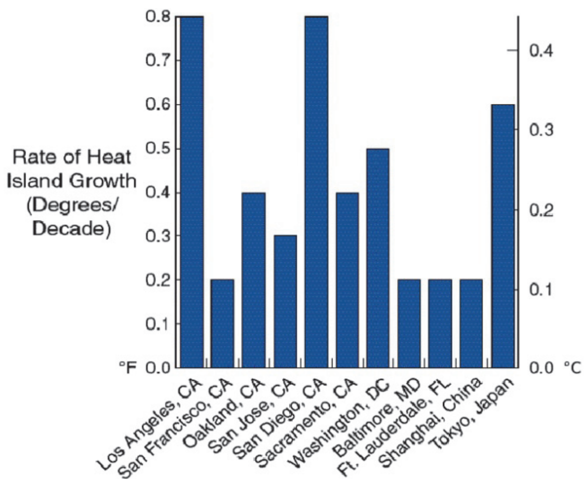

Fig. 4. Dynamic of the increase in urban heat islands.

The effects of heat islands during summer are impressive in large metropolises. In Tokyo, an increase by 1°C of the air temperature leads to an increase of the cooling load by 1.8 GW, value equal to the power of two nuclear power plants of average capacity (Murakami S., 2006). In Europe, in western Athens, there is an increase of the energy consumption by 180 GWh / year compared to the peri-urban area of Athens (Hasid S., 2000, Santamouris M., 2001). For London, we notice an increase in the cooling load by 25 % and a reduction of the necessary heat by 22 % in the last decade (Desmie, 2007). As far as the energy landscape in US is concerned, one can notice significant variations of the values of the indicator for cooling and heating degree days (Santamouris M., 2001) (Table 1).

The thermal profile representative for a metropolis is presented in Figure 5 (Oke T.R., 1982).

The difference between extreme temperature values is the *intensity of the urban heat island.* Figure 6 (Oke T.R., 1982) presents the correlation of the intensity of urban heat islands with the size of the population in the urban area. One can notice that most urban settlements in Romania can be characterized by intensities between 5°C and 8.1°C.

A climate parameter which determines the intensity of urban heat islands is wind speed. Oke (Oke T.R., 1987) suggests an empirically determined computing relation for urban areas in the U.S.A.:

$$\Delta\vartheta_{u-r} = 2 \cdot P^{0,25} \cdot \sqrt{w_{10}} \qquad (3)$$

where: P is the number of inhabitants of the city, w_{10} [m / s] – the wind speed in the peri-urban (rural) area at 10 m above ground level; $\Delta\vartheta_{u-r}$ [°C] – the intensity of the urban heat island at sunset.

Table 1

Effect of heat islands on urban energy consumption

Locality	Urban – heating degree [days]	Airport – heating degree [days]	Difference [%]	Urban – cooling degree [days]	Airport – cooling degree [days]	Difference [%]
Los Angeles	384	562	-32	368	191	92
Washington DC	1300	1379	-6	440	361	21
St. Louis	1384	1466	-6	510	459	11
New York	1496	1600	-7	333	268	24
Seattle	2493	2881	-13	111	72	54
Detroit	3460	3556	-3	416	366	14
Chicago	3371	3609	-7	463	372	24
Denver	3058	3342	-8	416	350	19

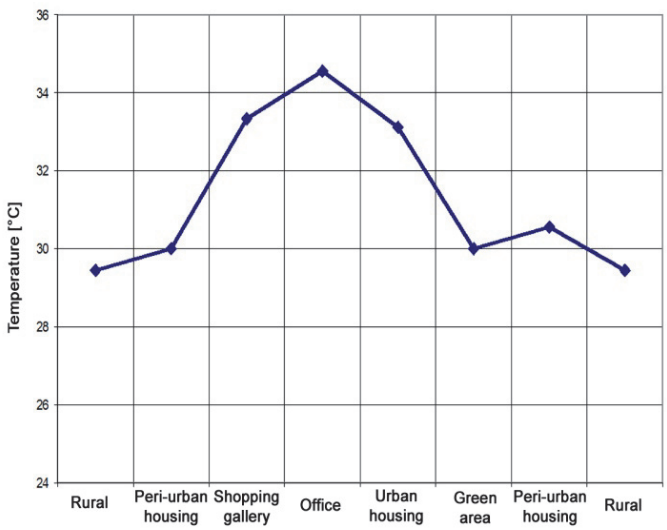

Fig. 5. Profile of an urban heat island.

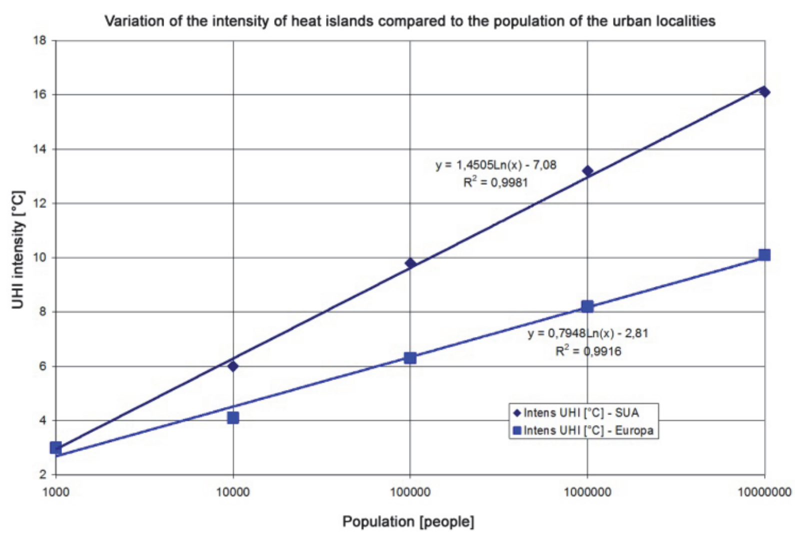

Fig. 6. Intensity of urban heat islands versus the population.

For Bucharest, with a population of circa 1.8 mil. inhabitants, for July and August wind speed at the ground level has average values of 1.7 m / s, respectively 1.18 m / s. By adjusting depending on the height, we get values w_{10} with the following relation:

$$w_{10} = w_{sol} \frac{\ln\left(\frac{h}{z_0}\right)}{\ln\left(\frac{h_0}{z_0}\right)} \tag{4}$$

where z_0 is the height of the roughness of the upper layer at the ground level. This leads to w_{10} values of 7.3 m / s respectively 5.1 m / s for July and August, leading to the values of heat island intensity of 6.8°C and 8.2°C respectively, values close to the ones provided in the chart in Figure 6.

Basically, if in the rural area, at sunset, the air temperature is 32°C, in the urban area the air temperature is 39-40°C, which means an extremely serious heat impact. From this point of view, the climate data used during the summer season for analyzing Building Energy Performance and for determining the cooling load (both in local regulation and in European standards EN 15927-2 and EN 15927-4) must be reconsidered by taking into account the impact of the urban heat island. During the cold season, the intensity of the heat island is circa 4-5°C which, from the viewpoint of the heating load, is a favorable impact. Consequently, the impact of the urban heat island is one of translation combined with increasing amplitude, temperature curves, with contrary energy effects between the cold season and the warm season and with major effect on the climate risk during the summer season. Depending on the geometrical characteristics of buildings and streets, Oke (Oke T.R., 1982) proposes a correlation between the intensity of the urban heat island and the ratio between the building average height and the street openness presented in the chart in Figure 7. This chart is useful for elaborating urbanizing strategies for localities.

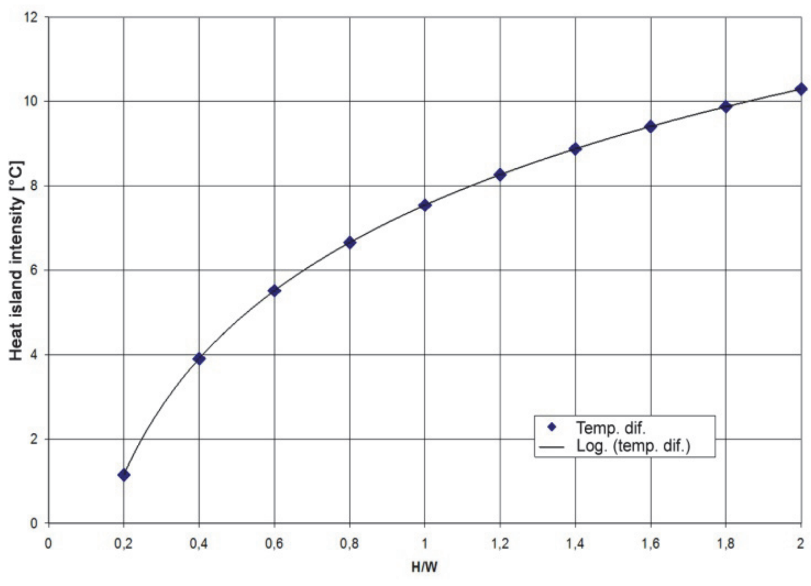

Fig. 7. Correlation of the intensity of urban heat islands with the geometrical characteristics of the urban environment.

According to International Panel of Climate Change IPCC – 2001, vulnerability is defined as the level in which a system is sensitive or cannot cope with the side effects caused by climate change, including the climate variation and extreme values. In order to use this definition, one needs to assess either:

– the level in which a system is sensitive to the impact of the climate parameter's variation and of extreme vales;

– or the system's lack to cope with the climate requests.

The abovementioned statements refer basically to the thermal comfort, living hygiene and to energy consumption. Thermal vulnerability compared to the climate change is a component of the living vulnerability associated with the sick building syndrome. The author proposes the PPD synthetic indicator, by means of the daily average value of PPD_m as an appropriate parameter for assessing the vulnerability of an occupied building, subject to the impact of climate parameters. The thermal vulnerability of buildings / premises and the risk of living can be determined depending on the daily average indexes of thermal comfort PPD_m, with the following relations:

$$V = 0{,}125 \cdot PPD_m - 1 \tag{5}$$

$$\begin{gathered} R = 1{,}92 \cdot 10^{-4} \cdot V^6 - 4{,}5964 \cdot 10^{-3} \cdot V^5 + \\ + 4{,}3727 \cdot 10^{-2} \cdot V^4 - 0{,}19897 \cdot V^3 + \\ + 0{,}30039 \cdot V^2 + 1{,}4469 \cdot V - 0{,}048758 \end{gathered} \tag{6}$$

PPD_m indexes [%] can be determined from the chart in Figure 8, depending on the average indoor air and cover temperature. E.g., a space with the daily average temperatures of $\overline{\vartheta}_a$ = 28°C and $\overline{\vartheta}_r$ = 32 °C has the PPD_m value of 56 %, the thermal vulnerability level V = 6.0 and the living risk R = 6.2 (high risk, deep discomfort).

The living risk scale in Table 2 is suggested.

The chart in Figure 9 can be used to assess the vulnerability of a building and the risk of living in building in the urban area.

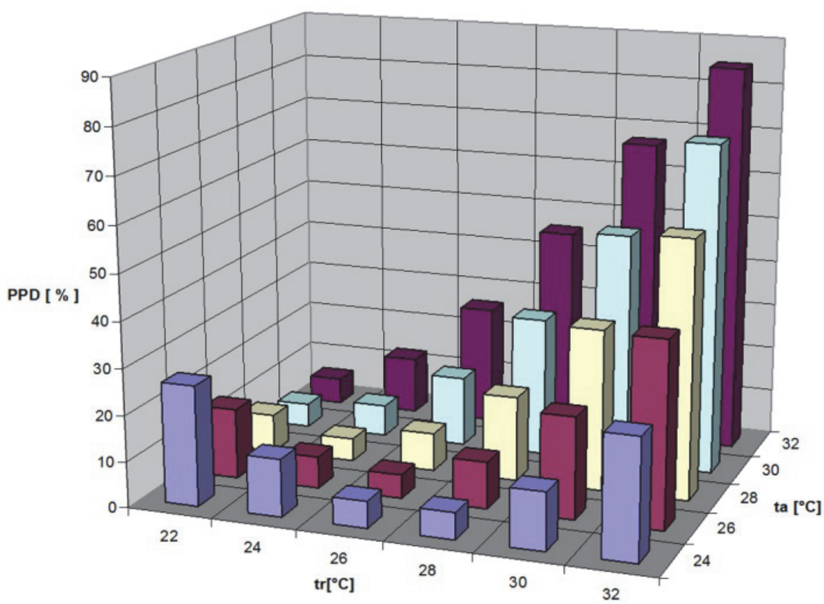

Fig. 8. Variation of the PPD index depending on the indoor air and radiant mean temperature.

Table 2

Daily average *PPD* value [%]	**Risk index, *R***	**Risk class**
$PPD_m \leq 30$	$R \leq 3.90$	Low risk
$30 < PPD_m \leq 45$	$3.90 < R \leq 5.55$	Medium risk
$45 < PPD_m \leq 60$	$5.55 < R$ v 6.70	High risk
$60 < PPD_m \leq 73$	$6.70 < R \leq 8.00$	Major risk
$73 < PPD_m$	$8.00 < R$	Danger (death)

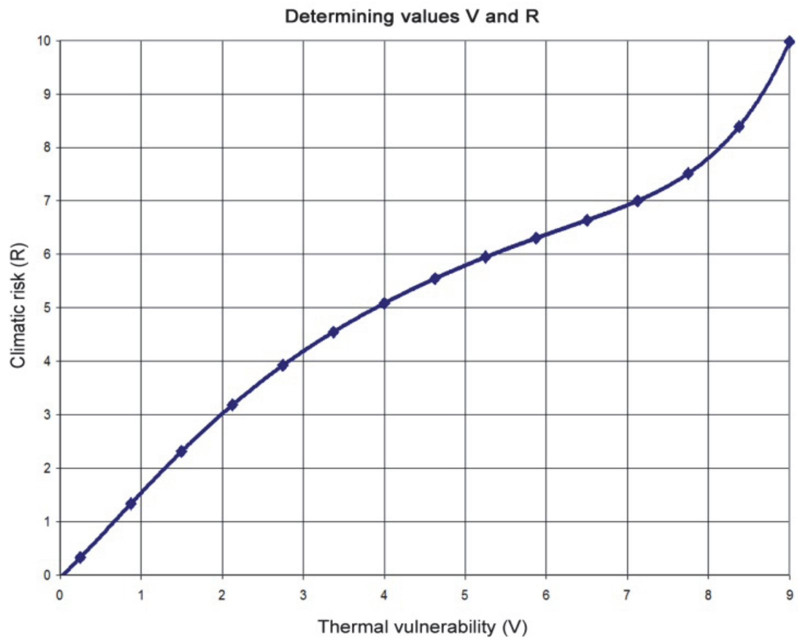

Fig. 9. Variation of climatic risk (*R*) depending on the thermal vulnerability (*V*) of the buildings.

Figure 10 presents a simple solution which can be applied both at the level of existing buildings and street solutions (Akbari H., 2001).

According to the aforementioned statements (see tab. 1), we conclude that the summer season is expanding compared to the cold season and the thermal discomfort in occupied area is intensified given the incapacity of the current buildings to take over the heat request peaks, except for cases in which buildings are equipped with air condition systems. The paradox of this type of „solution" is that it reduces the vulnerability of occupied spaces on the short term, but on the medium and long term it amplifies the aggressive effects of urban heat islands.

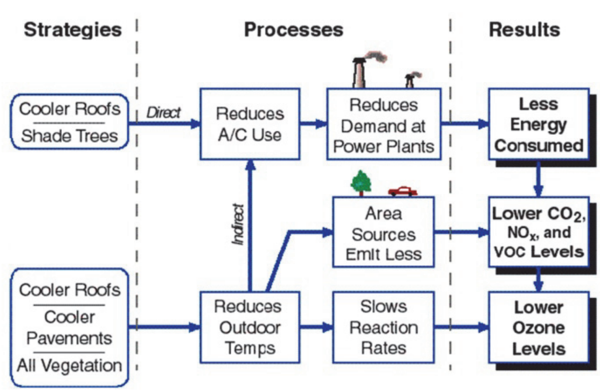

Fig. 10. Solutions to diminish the impact of urban heat islands.

This is the consequence of releasing into the atmosphere the thermal flow of the condensers in cooling systems. Consequently, increasing the intensity of heat islands will affect at some point the entire community by means of the incapacity of the systems to take over cooling load peaks. This is a situation that the urban areas in Romania are also experiencing significantly starting with 2000. Unfortunately, at the present moment the only „solutions" are to mount cooling equipment. Not adjusting at the level of the urban community solutions like those presented in the chart in fig. 10 can lead to dramatic phenomena such as those registered in the summer of 2003 in Western Europe when over 50,000 people lost their lives and another couple thousand victims throughout USA. Therefore, climate risk can be defined in correlation with the climate hazard (urban heat islands) in which the anthropogenic component is obvious and with the vulnerability of buildings which are built nowadays and which basically lack the capacity to face climate aggressiveness. With respect to the occurrence of heat islands in the vicinity of the cities in Romania, studies have little visibility in the consulted literature.

4. QUANTIFICATION AND MONITORING OF THERMODYNAMIC PARAMETERS CHARACTERISTIC OF LIVING PREMISES

Promoting the European directives with an impact on the activity to reduce NOx emissions in the natural environment leads to reducing the intensity of climate hazards especially with respect to the anthropic component and increasing the capacity to adjust the buildings to the climate change impact, respectively to reduce the vulnerability of the built environment. Unfortunately, the energy design of buildings by means of configuring / reconfiguring the energy characteristics is, in Romania, only a dire desire limited to the current system of building energy certification whose sole pragmatic result is to thermally isolate condominium buildings. The solutions adopted by the body of energy auditors and agreed upon or imposed even, due to economic reasons, by the central and local authorities only contribute to a small extent to the increase of the thermal comfort during the summer season and to reducing the economic and financial risk associated to climate change. There are two causes that favor maintaining a high climate risk for buildings, as follows:

– the lack of elements from the National Strategy for Sustainable Development that promote Sustainable Development in the construction's sector as a fundamental coordinate of urban development;

– the lack of computing tools, validated empirically and in figures, and of monitoring system of the built environment regarding the thermal comfort and living hygiene components.

The energy referential associated with thermal processes (premises heating and ventilation) are self-evident for the Buildings Energy Performance in Romania, presented in Figures 11 and 12. The energy consumptions for heating for 8 representative structures were determined. The values obtained per type of building and per representative climate area were averaged taking into account the number of buildings per type in each county, taking into account the climate area where the city capital is located, as per the census of population and housing dated March 18th-27th 2002. Finally, the average values of the energy consumptions were calculated depending on their weigh per climate area, as per the data in the abovementioned census. The energy classification scale [kWh / m^2 year] for heating is generated by applying the non-linear grading system as per the computing methodology of the buildings energy performance, Mc 001/3 -2006.

In order to determine the referential for space air conditioning, the dynamic computing method was used for the necessary sensitive heat / cold (Constantinescu D., 2008). The simulation included the reference buildings with the following uses: condominiums, offices, commercial centers, hospital, public building and hotel. For the buildings in the category condominiums and hotel, we took into account the night time ventilation of spaces in all of the analyzed situations. Another element that was taken into account upon determining energy referential was the significant dispersion of Building

Energy Performance (BEP) values between the building units located differently compared to the orientation of the building cover. Basically unfavorable and advantageous locations are highlighted, the limits being set by building units located at the penthouse under the terrace oriented toward west – the most exposed location, respectively at the ground floor, above the technical basement or on the ground, oriented toward North – the least affected by summer climate.

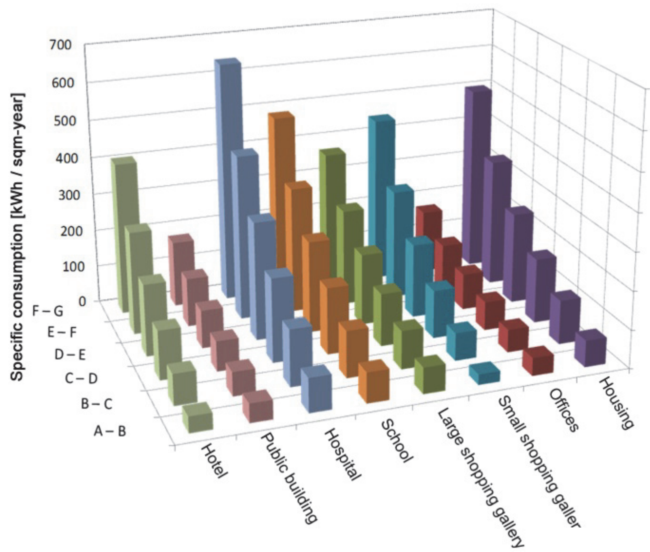

Fig. 11. Energy classes for heating.

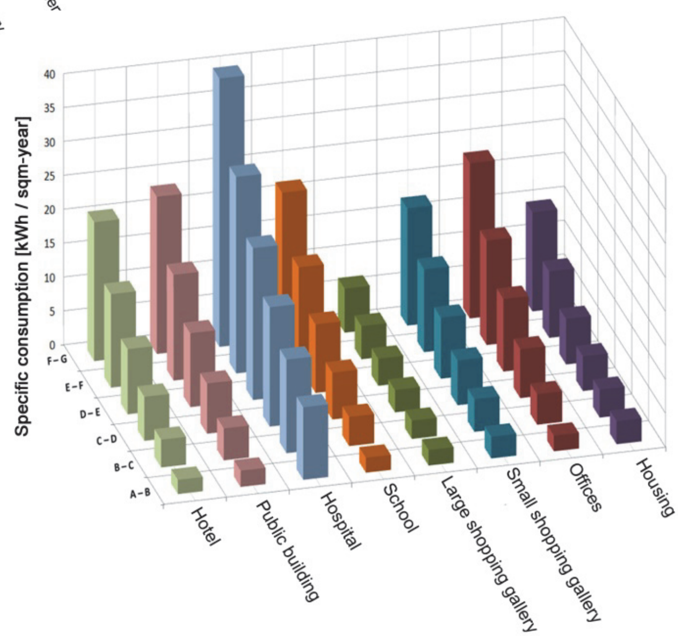

Fig. 12. Energy classes for space air conditioning.

The presented values refer to the average location representative for the entire building. The aforementioned statements are a very useful observation in case of assessing the BEP of condominium buildings (whether the reference is to living buildings or public buildings) regarding their manner of energy certification. The current Romanian methodology of calculating the BEP, as well as the European standards from which most computing relations were taken (EN ISO 13790:2008), make no differentiation between the computing for the entire building or at an individual level, per building units. One can argue against this with the mode of computing at the building level for the BEP assessment during the cold season. The difference of approach comes from the manner of using the thermodynamic potential of the natural outdoor environment (enthalpy of the outdoor air) in the warm season, both by using natural ventilation during night time and by using mechanical ventilation during night time, process which is not used during the cold season. Basically, during the warm season, every building unit with the net area A_j is characterized by BEP_j.

The average *BEP* at the level of the building comes from the weigh mediation compared to the net surface of the building units:

$$BEP = \sum_{j=1}^{j=n} \left(BEP_j \cdot \beta_j \right) \tag{7}$$

where:

$$\beta_j = \frac{A_j}{\sum_{j=1}^{j=n} A_j} \tag{8}$$

The presented computing relation offers two pieces of information:

1) *BEP* for the entire building, as representative value per building;

2) BEP_j for every building unit, useful in elaborating technical solutions of increasing the building's energy efficiency. The results under fig. 13 were determined taking into account the abovementioned details.

It is important that most buildings fall under the energy classes C-D for both utilities. If we add up the values, BEP is between 160 kWh / m^2 year and 220 kWh / m^2 year, significantly different from the building standard with nearly zero energy consumption (NZEB). Regarding the chart in Figure 13, one can notice four building categories with climate vulnerability, i.e. hospitals, offices, public buildings and housing which can also possibly cause the highest number of victims. The required solutions which must exceed in quality the approach of designing buildings presently refer to elaborating technical solutions that generate *solution packages.* These are virtually applied to the existing/new building and are simulated based on dynamic computing models with maximum hourly time step, building energy response as BEP [kWh / m^2 day, kWh / m^2 month, kWh / m^2 season, kWh / m^{2}year] as well as thermal response in the sense of thermal regime if there is no air conditioning system (free running temperatures – hourly values of indoor temperatures and thermal comfort indicators). One would eliminate solution packages that lead to high values of the BEP index, similar to those in the energy referential charts. The second component is the economic component represented by determining the best consumption for the building's economic lifespan (as per the European Directive 2010 / 31 / EU, Art. 4 and 5), but also on the period of recovering the investment cost by means of energy savings. These criteria encourage promoting passive air conditioning solutions, solutions which are numerically tested in the specific conditions of the summer computing pentad. It consists in the test on the need to equip the building with artificial cooling systems associated to the sufficiency test represented by the minimum BEP value during the summer season (a value as close to zero as possible). These elements allow the accurate configuration of the building and are the result of a multidiscipline cooperation, completely different from specific cooperation applied during the current approach when designing a building. Basically, one defines an iterative – innovating type of design, essentially different from the linear – deterministic type of design (as per the Cartesian system) currently used. It is essential that the calculus method used be a dynamic double validated calculus method. We insist on the type of calculus model, detailed and dynamic, the only method which can carry out the requested assessments through the definition for vulnerability set by the IPCC group. Empirical validation is carried out by modelling a controlled experiment at a large scale, while the numerical validation is carried out through the cross-validation procedure, based on already solved cases, components of the numerical validation standards (e.g. IEA BESTEST). The authors used calculus programme with both empirical and numerical validation INVAR 2 for analyzing certain case studies. The following details present briefly the results of the cross-validation method based on the European standards EN 13971, EN 13792, EN 15255, EN 15265. The results of the empirical validation method to which the calculus programme was subject are presented in the works (Constantinescu D. et all, 2010, Constantinescu D., 2010).

5. NUMERICAL VALIDATION OF THE CALCULUS PROGRAMME INVAR 2

The maximum value of the resulting indoor temperature, $t_{i.\max.}$ (as per the software) with the maximum value of the operational temperature [°C].

The maximum value of the heat flow rate pertaining to the cooling process, $Q_{R.\text{Max.}}$, necessary for ensuring the selected thermal comfort condition [W].

The daily average value of the heat flow rate pertaining to the cooling process, $Q_{R.\text{med.}}$ [W].

There were 12 tests carried out and the results compared between the reference values (IEA BESTEST and INVAR 2) were centralized.

Legend of the sample cases:

Case 1 – low thermal capacity (Fig. 13):

– internal contribution 20 W / m^2 – convective, 30 W / m^2 – radiant (compared to the floor surface), between 08:00-18:00;

– n_a = 0 ach;

– air conditioning with continuous functioning set at $t_{a,0}$ = 26°C;

– window with outdoor shading.

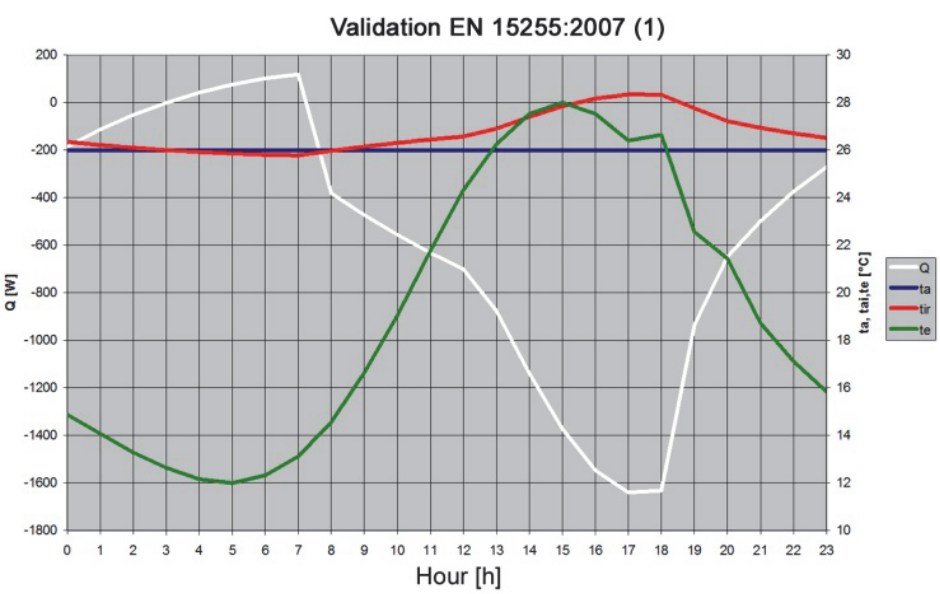

Fig. 13. Test 1.

Case 11 (fig. 14) – test 6 (test 1 with disengaging functioning of the cold source: internal contribution 20 W / m^2 convective, 30 W / m^2 radiant (based on the floor surface), between 08:00-18:00; n_a = 0 ach) with disengaging functioning of the cold source and limitation of the maximum power (14 W):

– internal contribution 20 W / m^2 – convective, 30 W / m^2 – radiant (compared to the floor surface), between 08:00-18:00;

– n_a = 0 ach;

– air conditioning with continuous functioning set at $t_{a,0}$ = 26°C between 08:00-18:00; $Q_{R\,\max.}$ = 1400 W;

– window with outdoor shading.

Case 12 (fig. 15) – test 1 with disengaging functioning of the cold source:

– internal contribution 20 W / m^2 – convective, 30 W / m^2 – radiant (compared to the floor surface), between 08:00-18:00;

– n_a = 0 ach;

– air conditioning with continuous functioning set at $t_{a,0}$ = 26°C (operational temperature) between 08:00 – 18:00;

– window with outdoor shading.

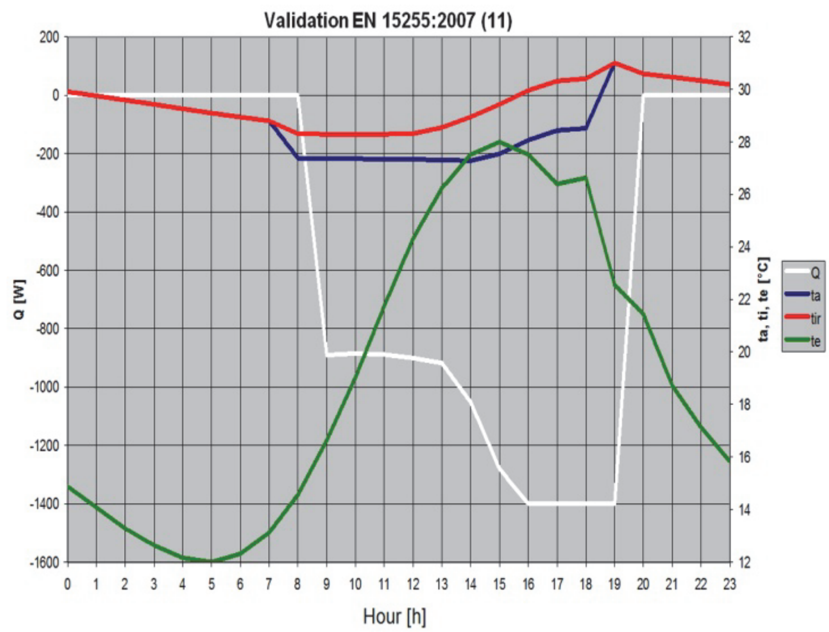

Fig. 14. Test 11.

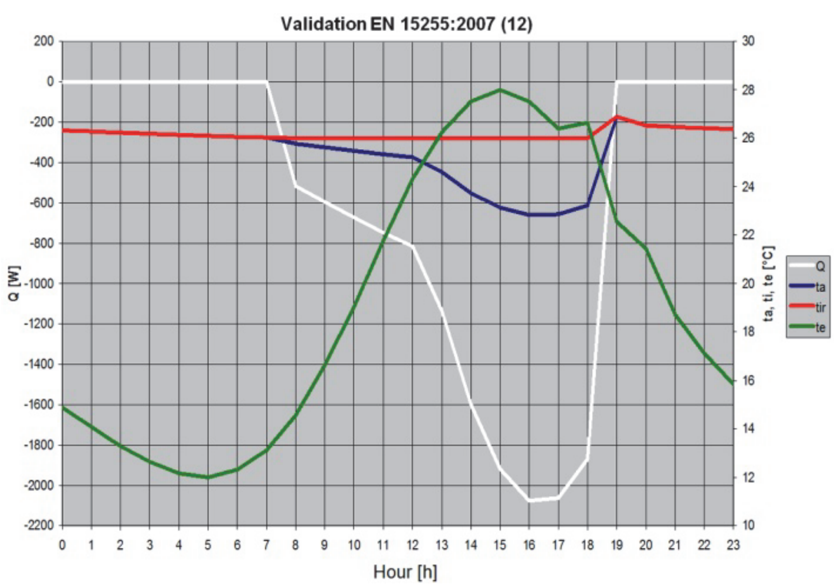

Fig. 15. Test 12.

Results of the validation:

1) Three compliance classes were taken into account (EN 15265:2007, chap. 9) regarding the thermal flow analysis:

$$rQ \leq 0.05 \text{ – class A}$$
$$rQ \leq 0.10 \text{ – class B}$$
$$rQ \leq 0.15 \text{ – class C}$$

where: $rQ = \left|\left(Q_{EN15255} - Q_{INVAR2}\right)/Q_{EN15255}\right|$.

2) As far as the maximum operational temperature is concerned, the criteria are:

$$r\,t_i \leq 0.5°\,\text{C – class A}$$
$$r\,t_i \leq 1.0°\,\text{C – class B}$$
$$r\,t_i \leq 1.5°\,\text{C – class C}$$

where: $rt_i = \left|t_{i,EN15255} - t_{i,INVAR2}\right|$.

3) Criterion rQ:

3.1) as far as the *maximum cooling load* is concerned. From 12 tests carried out, 9 fall under class A and 3 in class B;

3.2) as far as the *average cooling load* is concerned. From 12 tests carried out, 9 fall under class A and 3 in class B.

4) Criterion rt_i. From 12 tests carried out, 11 fall under class A and 1 in class B.

5) From the overall 36 tests, 29 results fall under class A and 7 under class B.

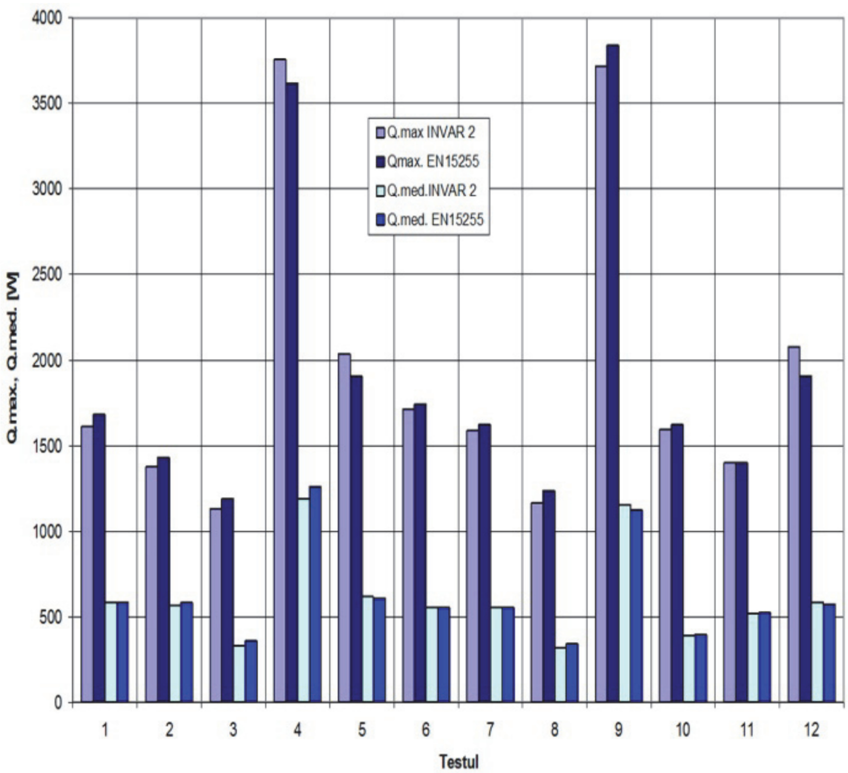

Fig. 16. *rQ* indicator, test synthesis 1...12.

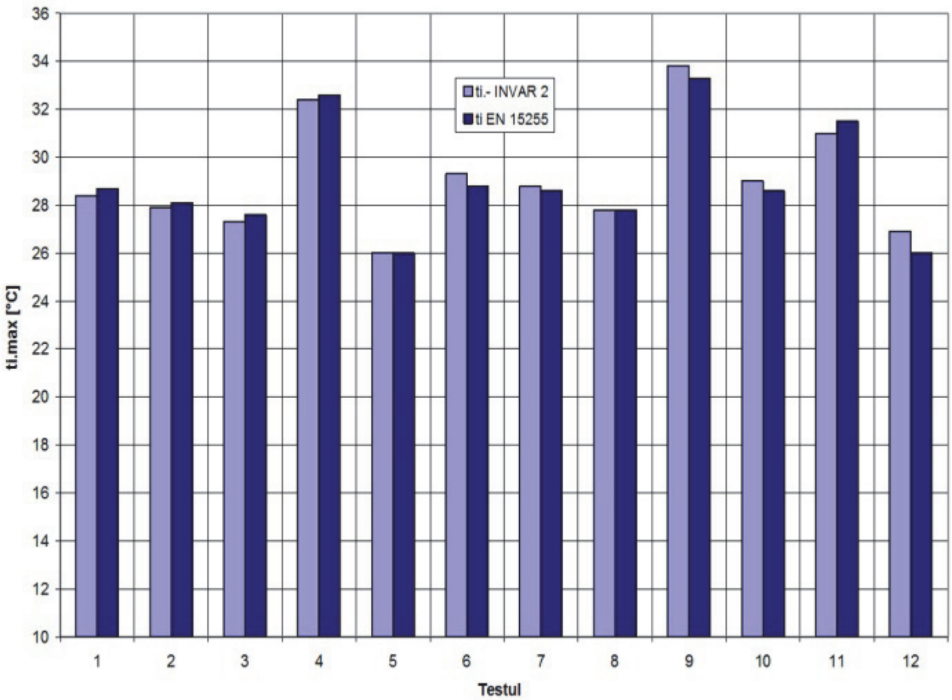

Fig. 17. rt_i indicator, test synthesis 1...12.

6. CONCLUSIONS

One can conclude the following from the abovementioned facts:

– urban heat islands are a consequence of the expansion of the urban environment and their intensity is directly proportional with the increase of the urbanism ratio. Urban heat islands set the tone of the aggressiveness of urban areas on the environment and their intensity is directly proportional with the increase of energy of the natural environment and, implicitly, of entropy;

– it is mandatory that measures be taken for the energy reconfiguration of the built environment in order to diminish the intensity of urban heat islands and their impact on life and safe living conditions;

– correlating the Building Energy Performance for current and new buildings with the impact of climate and anthropogenic hazards by adopting a Design through Energy and Environ-mental Reconfiguration / Configuration.

It is essential to elaborate the national system for numerical validation of the dynamic calculus programs for using computing tools harmonized at the level of acceptable minimum performance.

Promoting the European directives with an impact on the activity to reduce NO_x emissions in the natural environment leads to reducing the intensity of climate hazards especially with respect to the anthropogenic component and increasing the capacity to adjust the buildings to the climate change impact, respectively to reduce the vulnerability of the built environment. Unfortunately, the energy design of buildings by means of configuring / reconfiguring the energy characteristics is, in Romania, only a dire desire limited to the current system of building energy certification whose sole pragmatic result is to thermally isolate condominium buildings. The solutions adopted by the body of energy auditors and agreed upon or imposed even, due to economic reasons, by the central and local authorities, only contribute to a small extent to the increase of the thermal comfort during the summer season and to reducing the economic and financial risk associated to climate change. There are two causes that favor maintaining a high climate risk for buildings, as follows:

– the lack of elements from the National Strategy for Sustainable Development that promote Sustainable Development in the construction's sector as a fundamental coordinate of urban development;

– the lack of computing tools, empirically and numerically validated, and of monitoring system of the built environment regarding the thermal comfort and living hygiene components;

– the Strategy for Sustainable Development must include Roadmap Measure Plans for controlling urban solutions and building quality by quantifying the vulnerability and climate risk indicators (during summer).

The case study proves that the *passive* measures of variant (d) implemented in the project for building energy modernization (energy reconfiguration) eliminates the climate vulnerability of the building and contributes implicitly to reducing the intensity of the urban heat island. It also eliminates the power consumption necessary for artificially cooling the building.

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