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Energy sizing of nZEB buildings (I)

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Abstract. The nZEB-type building has the ability to minimize the impact of climatic parameters intensity on the microclimate of the inhabited spaces and implicitly to reduce the heat and cold needs of the buildings. This concept implies the update of the energy dimensioning methodology of the existing buildings (which are being renovated) and of the new ones located in urban area. The extension of the numerical modeling method through dynamic simulation with an hourly time step is possible at the level of an urban area by adopting the own calculation support of the Representative Building. The work presents examples of numerical solutions aimed at both the Energy Dimensioning of buildings in the nZEB (the *necessary condition*) and their Climatic Resilience in conditions of excessive impact of climatic parameters (the *sufficient condition*).

Key words: nZEB, heat flow rate, annual Energy Performance of Building value (PEC_0). Environmental Performance of Building value (PMC_0). energy syllogism method, hourly simulation, Representative Building, Climatic Resilience.

Note: The author makes the statement that he maintained in the paper the abbreviations resulting from the Romanian language of some indicators currently used in the practical activity of major renovation of the existing building stock and the geometric, energetic and architectural configuration of the new buildings included in the nZEB energy class.

1. Introduction

In the context of global climate change, a new approach to energy and architectural configuration solutions for existing buildings and new buildings is required. This approach involves design procedures and methodologies aimed in particular at reducing the heat and cold needs of a building, associated with the adoption of high-performance technical systems. Technical systems include heat and electricity sources, heat recoveries, mobile shutters fitted to the glazed envelope, free cooling systems. The opaque surface of envelope benefits from high albedo finishes. The author makes the point that the adoption of the concept of near Zero Energy Building nZEB is not correlated with global climate change by

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causal relationship but is correlated in terms of the impact of these changes on the urban environment [1]. It is aimed at minimizing the dramatic consequences generated by the impact of violent climate events, specific to global climate change, on the population of urban settlements (the summer heat wave in 2003 caused more than 60000 victims in countries of Europe and on the US East Coast, [2], [3], [4], [5], [6]) and minimizing of emissions from building operations, in order to maintain a healthy environment in urban settlements. Equally important is the minimization of the impact of Urban Heat Island [7], [8], [9], [10], [11], [12] on the climate inside urban settlements during the summer season. The European Environment Agency (EEA) report No 2 (2012) attests that Romania is one of the countries most exposed to significant future climate change, especially in terms of significant increase in average outdoor temperature during summer days and expansion of the summer season (Fig. 1).

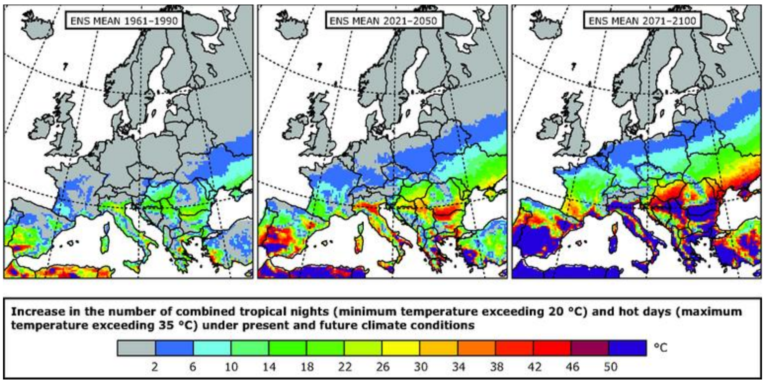

Fig. 1. The increase in the number of days characterized by tropical nights (outdoor temp. minim. over 20°C) and tropical days (maxim. outdoor temp. above 35°C), 1961-2100
Source: EEA <http://www.eea.europa.eu/data-and-maps/figures/

This concept, nearly Zero Energy Building (nZEB) involves changing the methodology of energy sizing existing buildings (which are undergoing major renovation) and new ones located in urban settlements. The energy sizing of a building currently refers strictly to the sizing of technical systems (in order to ensure thermal comfort with coverage of 98% of all hours of the year) and of the envelope elements (opaque and transparent) in order to ensure the hygrothermal behavior by which condensation is avoided on the internal surface and inside the envelope elements (opaque multilayer and single-phase type). *The transition to nZEB solution is in the foreground to reach a maximum allowable value of the annual energy performance index of Energy Performance of Building (PEC_0) (maximum permissible primary energy consumption) [kWh/m^2 y] associated with an environmental performance index value (emissions of CO_2 in the natural environment) maximum allowed Environment Performance of Building (PMC_0) [kg/m^2y]*. At this stage of energy modernization, both values are strictly aimed at *the exploitation of the building*. With reference to the criteria for included building into those characterized by near Zero Energy Buildings (nZEB), a study, developed by the author within a Research project in 2013 [13], [15] led to the determination of energy performance indicators of nZEB buildings, at the level of Romania. The official document, which takes over the study in full, is the Annex to the Government Decision no. 122 of 25 February 2015, published in the Oficial Buletin of Romania, part I, no. 169 bis, 11.III. 2015 (pg. 265-377), Annex C, Table II.1, p. 14. 208-

209. The paper presents elements that allow the correct quantification of the energy and environmental performance of the application of technical solutions packages at the level of buildings in urban areas.

2. Energy and environmental dimensioning method

The specific performance of nZEB buildings is determined on the climatic support of the type climatic year (statistically representative for a climatic zone) (order no. 2210/2013, M.of. 561 of 04.09.2013, SR EN ISO 15927-4:2006 "Hygrothermal performance of buildings. Calculation and presentation of climate data. Part 4: Hourly data for the assessment of the annual energy consumption for heating and cooling"), by applying a *method of modeling and dynamic simulation of energy and environmental performance (empirically and numerically validated)* [15]. Energy and environmental dimensioning involves two stages, the *necessary* stage and the *sufficient* stage.

The ***necessary*** energetic dimensioning stage of buildings nZEB refers to the determination of geometric, architectural and structural characteristics of opaque and transparent envelopes of the building (exterior walls, external windows, lower borders, building - ground and upper, building - roof, passive equipment, albedo of opaque external facades, the presence of mobile window shutters, active heat recovery equipment, free cooling systems and technical building systems, related to both conventional energy sources and renewable energy sources). The purpose is to determine the energy performance index of the building whose value is Energy Performance of the Building (PEC_0) and which implicitly leads to a value of the Environmental Performance of the Building (PMC_0). The PEC_0 values [kWh/m^{2}y] and PMC_0 [kg/m^{2}y] are the primary energy related to energy consumption of fossil origin and to the intervention of renewable energy sources, respectively the CO_2 releases associated with the processes of ensuring housing conditions specific to the purpose of buildings, the occupancy regime and the energy profile. Basically, performance indicators vary depending on the *climate zone*, the destination of the building and the time horizon that targets the major renovation of existing buildings and/or the design of new buildings. A customization with the value of specifying the final solution is based on the ordering of the resolution priorities. Basically, a nZEB building is characterized by the minimum value of energy consumption based on conventional energy sources and the intervention of renewable energy sources in order to reach the PEC and PMC indicators. This step in the methodology of energy sizing of buildings nZEB is designated as the necessary step to achieve the proposed objectives. The principle „**a good ZEB definition should first encourage energy efficiency and then use renewable energy sources available on site**" results from the efficiency analysis of the concept of energy design of nZEB buildings [14].

The ***sufficient*** stage involves ensuring the *climate resilience* of nZEB buildings. The quality of the building to provide a tolerable microclimate in case of extreme climatic stress over probable durations in which the energy sources and the technical system can no longer supply the energy needed to maintain thermal comfort is called *climate resilience*. Basically, we have in view the periods of production of frozen rain for maximum 5 consecutive days (in the cold season) and the manifestation of heat waves in the summer season. In both cases, the power supply to the technical systems of the buildings is affected.

3. Models for calculating the heat requirement for heating / sensitive cooling inhabited spaces

The building energy calculation methodologies currently in use DO NOT target the nZEB building standard; this is why it is admitted simplifications of the calculation model in relation to the physical processes and implicitly of the method of solving the thermal balance equations. The current simplification consists in the adoption of the *one month step calculation interval and implicitly of the steady state conduction heat transfer model through the building's envelope elements*. The appropriate calculation model that is the subject of this work is addressed to the buildings included in the nZEB class. The calculation model includes the thermal balance equations of the building elements that define the inhabited spaces and the annex spaces. Opaque elements are characterized by Dirichlet boundary conditions (of first type), in the definition of Unitary Thermal Response (UTR), [8], to Dirac function and convolution type requests based on boundary conditions of third type – of the surfaces adjacent to the living environment and external environments. The thermal balance of the Housing Units (UL) in the form of the energy response of the occupied spaces is materialized by determining the hourly values of the heat needs (cold season) and sensitive cold (summer season) based on the indoor thermal conditions (proper to the occupied spaces without interruptions, or to the spaces whose occupation is discontinuous over predetermined periods of time). In the time periods when the variation in indoor temperatures (air and resultant) is associated with the lack of intervention of technical systems and the modification of the energy profile of the dwelling units, the characteristics of the natural thermal regime are determined. The thermal capacity of the interior construction elements ensures the "massiveness" of the building. The thermal balance equations of Housing Unit (UL_k) (k – order number) include the values of UTR and the massiveness of opaque interior elements in the corrected form of the intensity of the thermal flux specific to the surfaces that delimit the building elements. The correction factor is generated by the comparative analysis of the thermal flux resulting from the application of the UTR method and the resulting flux by applying the temporal variation of the heat accumulated in the mass of the building element. In relation to the current dimensioning methods (targeting the technical systems and hygrothermal properties of the envelope) by applying the calculation methods presented in specialized standards (on the basis of the calculation climate), energy sizing is a relatively new activity involving the approach of demanding numerical analyzes. The climatic support of the modeling of heat and mass transfer processes (with reference to the hygrothermal analysis of opaque envelopes adjacent to the outside environment and the vapor content in the indoor air [15]) is represented by the type climatic year. The purpose of analyzing heat and mass transfer processes inside the opaque envelop elements of existing (old) buildings is to determine the correction coefficients of thermal resistances, on the one hand and to numerically test the risk of producing water vapor condensation in the opaque structure, on the other hand. In the major renovation activity of the existing building stock for inclusion in the nZEB building class, the necessary and sufficient steps are taken on the geometric support of the Representative Building (C.R.) [15], [16]. The *numerical validation* of the calculation method involves two steps. A first stage involves determining the natural thermal response of the housing unit. The dynamic thermal response simulation model of an occupied space benefits from validation carried out in accordance with European standards EN 13791 : 2004, EN 13792 : 2006 – precursor of ISO DIS 52017- 1 and EN 15255 : 2007, EN 15265 : 2007. The second stage aims to determine the Energy response of Housing Unit (UL) on the basis of the geometric configurations included in the European standard ISO DIS 52017-1 – Energy performance of buildings – calculation of the dynamic thermal balance in a building or building zone. Part 1: Generic calculation procedure (ISO/TC 163/SC 2). The result of the validation is the subject of the Treatise [15]. The *empirical validation* of the dynamic simulation model of the thermal response of an experimental room is also subject of [15]. The final result of empirical validation is presented in Fig. 2. ($\theta_{am}(\tau)$ – indoor measured temperature, $\theta_{ac}(\tau)$ – indoor calculated temperature)

Equation of the regression line of data calculated using the *dynamic hourly step simulation* model according to the measured data (referring to the indoor air temperature)

$$\theta_{ac}^{(INV)}(\tau) = 1{,}0206 \cdot \theta_{am}(\tau) - 0{,}6361 \qquad (1)$$

Along with the Pearson correlation coefficient R^2 = 0.9523, very close to the correlation coefficient of the first bisector, R^2 = 1, *attests to the correctness of dynamic simulation* model INVAR–SID.

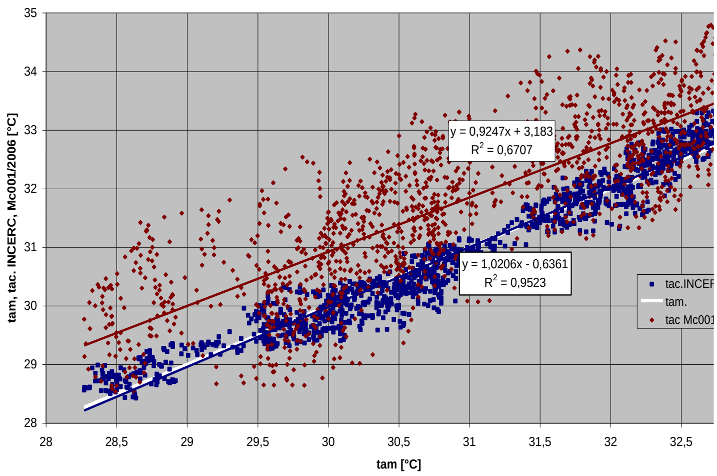

Fig. 2. Correlation of the measured hourly values of the indoor air temperature with the values calculated by dynamic simulation with the INVAR - SID method and with the Mc 001: 2006.

Similar regression was generated by data calculated on the basis of Mc 001 / 2006 (Romanian official document – simplified monthly step calculation) , with the equation:

$$\theta_{ac}^{(Mc001)}(\tau) = 0{,}9247 \cdot \theta_{am}(\tau) + 3{,}183 \qquad (2)$$

Along with the correlation coefficient value R^2 = 0.6707, it attests a significant deviation of the calculation model (Mc 001 / 2006) from physical reality (Fig. 2).

The detailed presentation is the subject of the work [15]. Based on the presented methods (hourly step simulation and simplified), a comparative analysis of the extreme values of the heat requirements proper to January of the typical climatic year, Bucharest Municipality (the analysis is similar in case of any locality) was made, referring to the each type of building. Two completely different types of buildings were chosen, namely type Current Representative Building (CRA) which does not include any energy modernization and type nZEB, Renovated Representative Building (CRR – nZEB) characterized by efficient thermal protection, equipped with Heat Recovery (R.C.) from the exhaust air and equipped with mobile insulating shutters used during the night hours in the cold season and during

the day hours in the summer season (partially open positioning that minimizes the impact of the direct component of the incident solar radiation). In both cases the same energy profile (internal heat sources) of the building was used. The synthetic characteristics of the structural solution, in the form of the thermal resistance of the envelope, and the values of the ventilation rate specific to each type of building are presented in Tab.1.
The first analysis concerns buildings of type CRR – NZEB (Fig.3.1, Fig.3.2 simulation with hourly step - non-stationary heat transfer, and monthly time step – stationary heat transfer).

Table 1

Building Type	CRA	CRR – nZEB
Thermal Resistance, Ext.Wall [m^2K/W]	0,57	6
Thermal Resistance, Terrace [m^2K/W]	0,89	7,2
Thermal Resistance, Windows [m^2K/W]	0,40	0,79
n_a [h^{-1}]	1,24	0,103 based on heat recovery efficiency

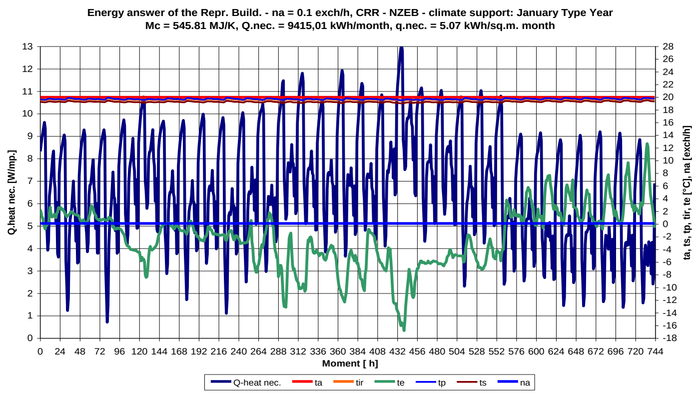

Fig. 3.1 The energy response of the CRR – nZEB – January, year climatic type Bucharest

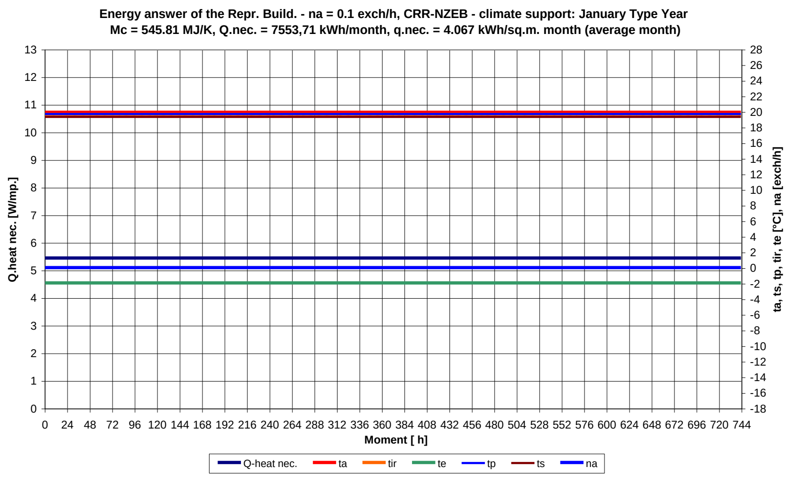

Fig.3.2 The energy response of the CRR – nZEB – January, year climatic type Bucharest

Evaluation error (CRR-NZEB):

$$\varepsilon = \frac{5{,}07 - 4{,}07}{4{,}07} \cdot 100\% = 24{,}57\%$$

The second analysis concerns buildings of type CRA (Fig.4.1, Fig.4.2 simulation with hourly step - non-stationary heat transfer, and monthly time step – stationary heat transfer)

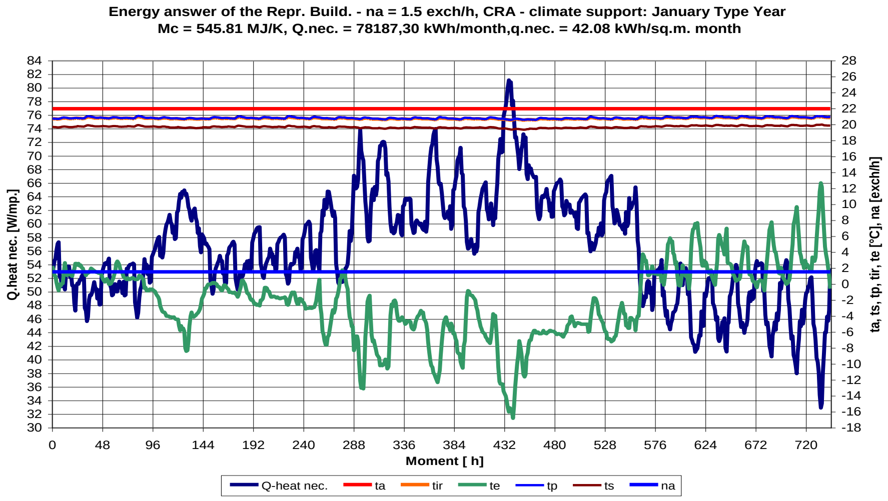

Fig.4.1 The energy response of the CRA– January, year climatic type Bucharest

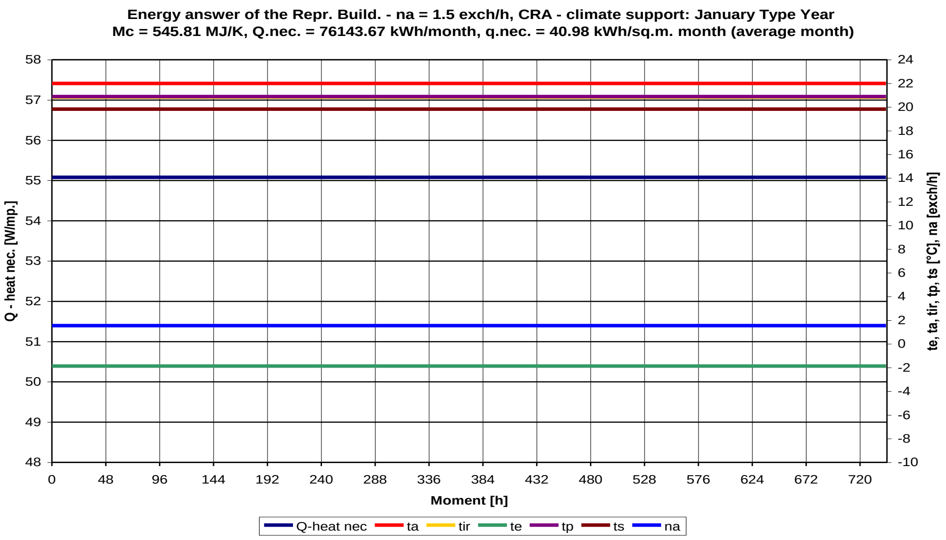

Fig.4.2 The energy response of the CRR – nZEB – January, year climatic type Bucharest

Evaluation error (CRA):

$$\varepsilon = \frac{42{,}08 - 40{,}98}{42{,}08} \cdot 100\% = 2{,}61\%$$

The two error values signify the differences between the two models that mathematically describe the physical heat transfer processes in the two types of buildings analyzed.
It is necessary to specify that the model that approaches the most to the temporal evolution of physical processes is associated with solving dynamic simulation type with hourly time step. Therefore, this model represents the reference against which the degree of accuracy (error) associated with the simplified model that benefits from the average monthly climate support and the quantified heat transfer steady state regime through the building's envelopes. The following conclusions are drawn:
1) in the case of the CRR building – NZEB the difference between the quality of the descriptive models (January of the type climatic year, Bucharest) is represented quantitatively by the value 24.57%. This value eliminates the possibility to use for the purpose of sizing existing and new energy efficient NZEB buildings by using the simplified model. Therefore, the energy dimension of NZEB class buildings requires *only the use of dynamic time-based simulation*;
2) in the case of existing non-modernized buildings CRA the difference between the energy performance determined by the use of the two calculation models is only 2.61%, value that numerically validates the simplified model for assessing the energy performance of a CRA class building. It is the case of the issuance of energy performance certificates of an un - renovated building either for the purpose of real estate transactions (subject of CRA types of Housing Unit (UL)) or as an element included in the technical expertise prior to the major renovation,
The comparison of heat flows values determined by simulation with hourly step on the support of CRA and CRR – n ZEB buildings and type year as climatic support for Bucharest, demonstrates the consistency of the above conclusions. The correlation Pearson coefficient R^2 = 0.887 (Fig. 5 - diagram of correlation of heat flows with outside temperature – source Fig. 7), characteristic of the CRA building envelope, determined by dynamic simulation with hourly step, demonstrates that the use of *calculation relations specific to the stationary heat regime* leads to physically *acceptable results*. In the case of similar simulation of the CRR – n ZEB, the degree of correlation of the coordinate points P ($\theta_e(\tau)$, $q(\tau)$), R^2= 0.234 (Fig. 6 - diagram of correlation of heat flows with outside temperature – source Fig.9) demonstrates that the *energy performance will be correctly determined exclusively by dynamic simulation with hourly time step (INVAR – SID).*

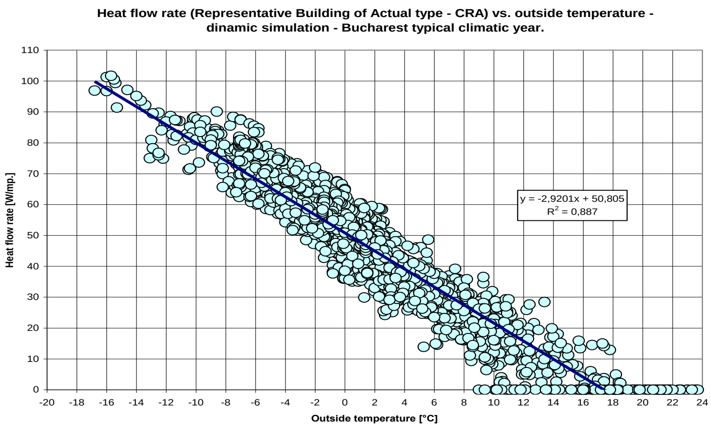

Fig.5 Heat flow rate vs. outside hourly temperatures – CRA dynamic simulation, Bucharest typical climatic year.

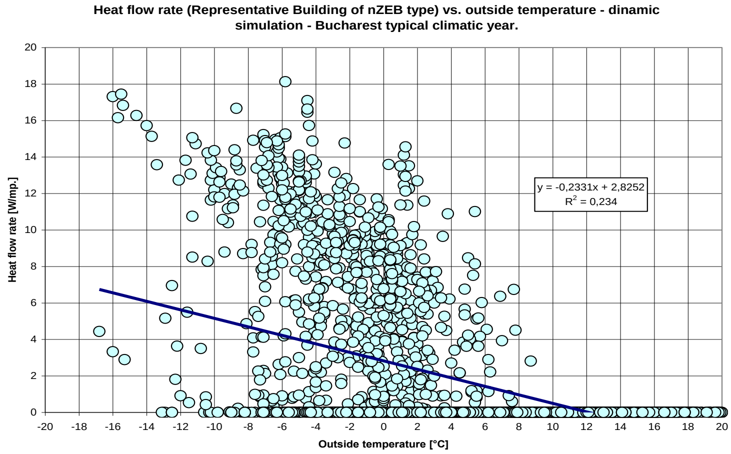

Fig.6. Heat flow rate vs. outside hourly temperatures – CRR- nZEB dynamic simulation, Bucharest typical climatic year.

The above results attest that the energy sizing of *existing* and *new buildings* within the energy efficiency class and implicitly environmental (CRR – NZEB) is achieved exclusively by using a dynamic calculation method by simulation with one hour time step. The error of adopting the simplified method with a monthly time step (on the support of the collective housing building) of 24,57% attests the incompatibility of using the simplified model with a monthly time step in the case of energy efficient buildings.

The results of the comparative analysis targeting buildings classified in the CRA class (buildings in current state, not renovated) attest that the energy performance assessment can also be performed by applying the simplified calculation method with a monthly step. The situations included in this category concern the elaboration of the Energy Performance Certificates (CPE) of buildings of type CRA (*real estate* activity or technical expertise *before* to major energy renovation)

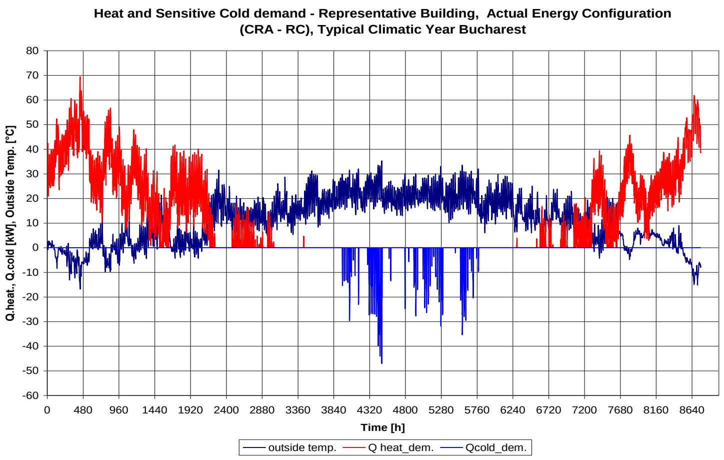

Fig. 7**.** The heat demand for heating and the sensitive cold demand – CRA Dynamic simulation with hourly time step (INVAR – SID)

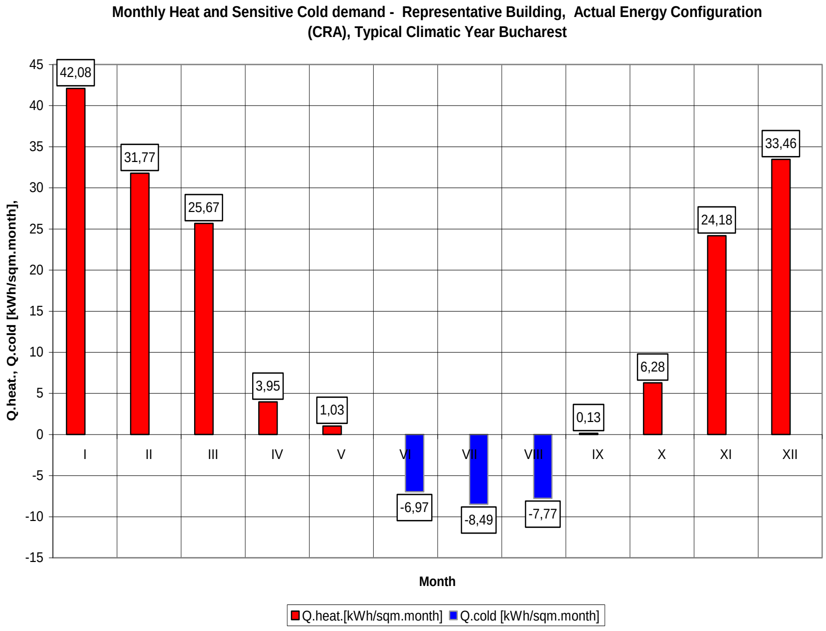

Fig. 8**.** The value of the monthly heat and cold needs– CRA

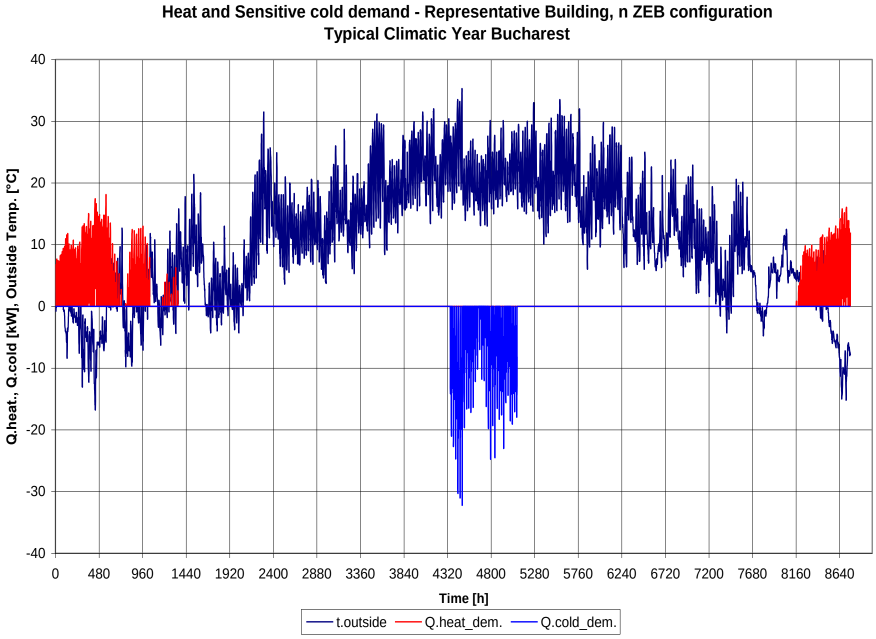

Fig. 9. The heat demand for heating and the sensitive cold demand – CRR n ZEB
Dynamic simulation with hourly time step (INVAR – SID)

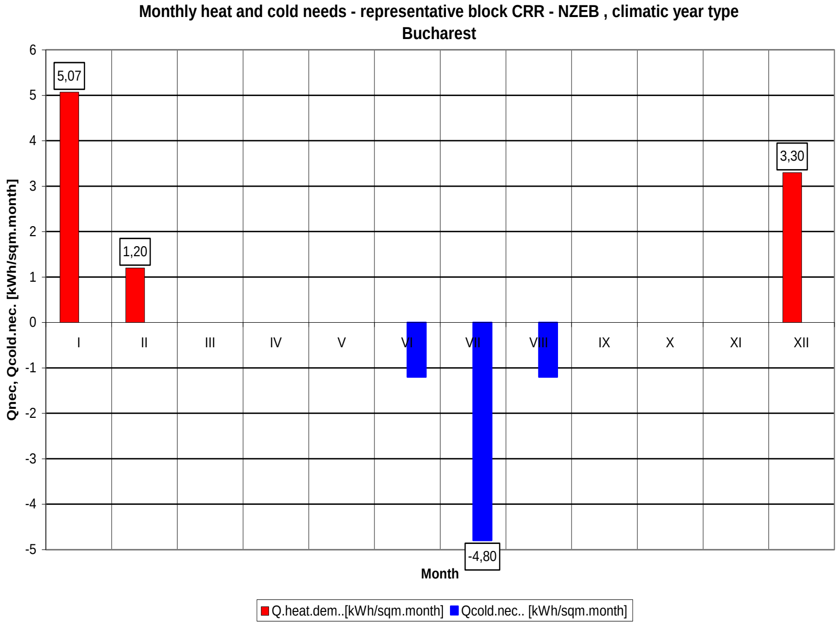

Fig. 10**.** The value of the monthly heat and cold needs – CRR – nZEB

4. Impact of the technical system on the energy performance of the building

In addition to the analysis of the energy performance of the condominium building, the final results are presented regarding the Representative Building (useful area 1858 m^2) located in Bucharest in different energy resolution options (construction, internal technical system, local heat / sensitive cold sources and centralized sources). The use of the High-Efficiency Cogeneration -Trigeneration (CCTIE) power source was considered. Even more so, the current buildings and the major renovated ones connected to the current sources of energy the Apartment Thermal Power Plants (CTA) or Zone Thermal Power Plants (CTZ) DO NOT reach acceptable values of PEC and PMC. The results are presented in Tab.2. It follows that the major renovation associated with the connection of the thermal installations of the building to the High-Efficiency Cogeneration -Trigeneration (CCTIE) type source is the solution to minimize the primary energy, in the absence of renewable energy sources. Any other current type of building connected to CCTIE does not benefit from the capacity of major renovated buildings (CRR – RC and CR – nZEB) connected to CCTIE, to reduce the thermal component of primary energy. If (reduced to absurd) the minimum mathematical value of the heat required index for space heating $q_{heating} = 0$, and (Apartment Thermal Power Plants) CTA or Zone Thermal Power Plants (CTZ) energy sources is admitted, the result is primary energy with the value of 97.8 kWh/m^2y, with 32% higher than the value associated with CRR - nZEB connected to CCTIE. Therefore, the major renovation of existing buildings is recommended to be associated with the connection of interior heating installations to High-Efficiency Cogeneration -Trigeneration CCTIE.

Table 2

Building Type	CRA	CRA & RC heat recovery insulating window.	CRR mobile shutter insulating window.	CRR & RC heat recovery	**CRR - nZEB**	U.M.
Q_{HEAT}	160,55	61,7	52,76	30,14	9,57	kWh/m²y
$Q_{WARM\ WATER}$	26,6	26,6	26,6	26,6	26,6	kWh/m²y
$Q_{COOLING}$	-21,23	-12,5	-3,13	-3,13	-7,01	kWh/m²y
Split COP	2,7	2,7	3	3	3,6	
$q_{EL.\ COOLING}$	7,86	4,63	1,04	1,04	1,94	kWh/m²y
$q_{EL.HOSEHOLD}$	13,06	16,76	12,4	16,1	16,35	kWh/m²y
Vector THERM. UL	187,15	88,30	79,36	56,74	36,25	kWh/m²y
Efficiency	0,96	0,96	0,96	0,96	0,96	
Vector ELECTRIC	20,92	21,39	13,44	17,14	18,29	kWh/m²y
Vector THERM Build.	194,95	91,78	82,70	59,11	37,04	kWh/m²y
Efficiency CCTIE	0,79	0,79	0,79	0,79	0,79	
y - cogen. coef.	0,11	0,24	0,16	0,30	0,49	
Conversion coef. of Heat in Primary Energy	1,24	1,01	1,11	0,78	0,60	
Primary En. T	284,32	92,75	91,43	56,10	23,15	kWh/m²y
Primary En. El.	54,81	56,04	35,21	44,91	47,92	kWh/m²y
PRIMARY EN.	339,13	148,79	126,64	101,00	**71,06**	kWh/m²y

Therefore, the major renovation of existing buildings is recommended to be associated with the connection of interior heating installations to CCTIE. The major renovation solutions CRR – RC and CRR – nZEB connected to CCTIE are solutions that ensure the quality of nZEB building. It is a conclusion that must be included in the major renovation strategy of the housing fund in urban settlements in Romania.

Table 2 shows that changing technical solutions associated with buildings and energy sources leads to reduced primary energy values. It follows that the method of identifying solutions, by application, fit buildings in class nZEB, is based on achieving a maximum permissible value of the primary energy that is characteristic of a nZEB building.

The analysis and identification of the nZEB class areas of building classification involves the analysis of the energy response of buildings correlated with the operating costs and primary energy associated exclusively with the operation of buildings. The application of the optimal cost method (Delegated Regulation 244/2012/EU) and the designation of the maximum allowed values of primary energy are subject to work [13], [15]. The support of buildings representing the types of buildings depending on the destination and the location in the climatic zones of Romania is the so-called representative building. Representative buildings for administrative buildings, education, hospitals, collective housing and individual buildings were determined by statistical processing of data from the 2002 census. For each type of building results a representative building that becomes geometrical energy and architectural support for the application of the method of determining the energy response during the typical climatic year associated to the localities located in the winter climatic zones of Romania. The result is the operating cost variation curves and the minimum cost values by using the Hessian matrix method [15, Chapter 3.2]. The value of the maximum allowed primary energy results from the increase by maximum 15% the resulting minimum cost. The result is a suite of primary energy values such as those presented in Tab.3 referring to collective housing buildings and winter Climatic zone II.

Table 3

Climatic Zone	Time horizon	COLLECTIVE HOUSING BUILDINGS	
		Primary energy [kWh/m^{2}y]	CO_2 emissions [kg/m^{2}an]
II	Before 2005	270	70
	2005 - 2010	132	36
	2015	112	30
	2020	100	28
	2030	**74**	**19**
	2050	43	9

The condition of the maximum allowed value of the primary energy of the representative building below the criterion value of 74 kWh/m^{2}year is met by the solutions of the renovated major Representative building, equipped with heat recoveries and major renovated representative building according to the nZEB type energy configuration, both connected to the high efficiency cogeneration/trigeneration plant (CCTIE). By default, the indicator that targets the maximum permissible CO2 emissions associated with the operation of the building is also provided.

5.Building climate resilience

The graph in Fig.11 demonstrates the quality of the nZEB type building *climate resilience* [17], which is the demonstration of the *condition of sufficiency* associated with the *necessary condition* imposed by the methodology of energy dimensioning of the nZEB type buildings.

The selected time interval for numerical testing of the climate resilience quality is 8 days in January Type climate Year, when no heat is provided (simulating a frozen rain impact in which no electricity is supplied and implicitly no heat). It is observed that during 6 days (12.01 – 18.01) the inside temperature drops from 20^{0}C to 15,4^{0}C. The minimum temperature resilience criterion = 15^{0}C is observed.

It should be noted that in the case of the summer heat waves the presence of photovoltaic panels in the building equipment replaces, during the hours with sun, the possible lack of electricity from the urban network (affected by the high degree of simultaneity of electricity demand for the purpose of operating split cooling equipment). The value of the endowment index of a nZEB class building located in Bucharest (and generally in winter climatic area 2) with photovoltaic solar panels (PV) is 0.10 – 0.12 m^2 PV/ m^2 usable area. The Representative Building can have a PV surface of approx. 220 m^2 easy to place on the terrace and equipped with batteries and inverter (for compatibility with the building's electrical equipment). The selected time interval for numerical testing of the climate resilience quality is 8 days in January Type climate Year, when no heat is provided (simulating a frozen rain impact in which no electricity is supplied and implicitly no heat). It is observed that during 6 days (12.01 – 18.01) the inside temperature drops from 20^0C to 15.4^0C. The minimum temperature resilience criterion = 15^0C is observed.

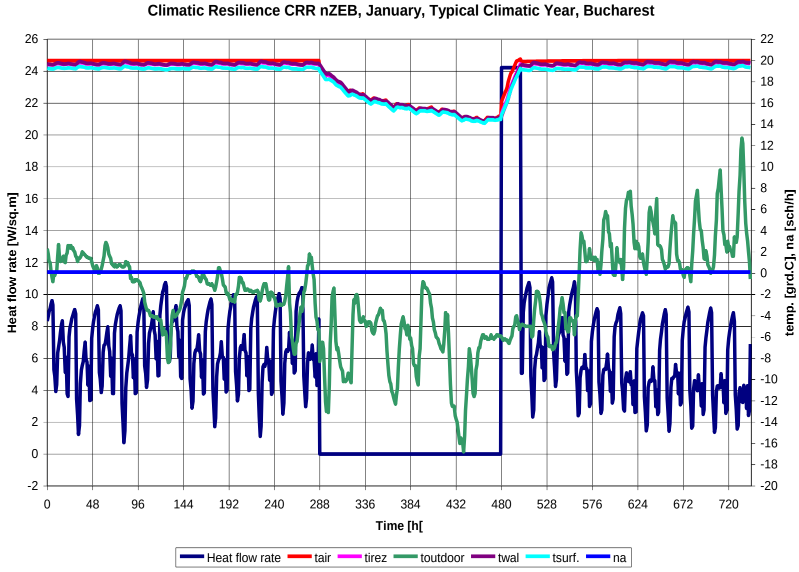

Fig. 11. Climatic resilience of the residential building CRR nZEB, January Typical climatic Year.

It should be noted that in the case of the summer heat waves the presence of photovoltaic panels in the building equipment replaces, during the hours with sun, the possible lack of electricity from the urban network (affected by the high degree of simultaneity of electricity demand for the purpose of operating split cooling equipment). The value of the endowment index of a nZEB class building located in Bucharest (and generally in winter climatic area 2) with photovoltaic solar panels (PV) is 0.10 – 0.12 m^2 PV/ m^2 usable area. The Representative Building can have a PV surface of approx. 220 m^2 easy to place on the terrace and equipped with batteries and inverter (for compatibility with the building's electrical equipment).

6. Energy syllogism

The method of energy syllogism allows the identification of the Housing Support Unit (ULS) for the energetic sizing of the entire building. The final ULS solution applied to the entire building has the certainty of achieving the PEC_0 and PMC_0 performances at the level of the entire building and implicitly at the level of any housing unit “k”. The dynamic simulation method used has high fidelity (hourly time step) and benefits from *numerical and empirical validation* [15]. The energy modernization of some urban areas involves the application of energy syllogism on the support of Representative Buildings (CR). This results in reproducible energy configurations in urban areas. In the case of the design of a

new building, the application of the energy syllogism is applied to the support of the architectural configuration of the building. The determination of ULS leads to the identification of the geometric support of UL_k which becomes support for the application of the dynamic simulation method with hourly step during the type climatic year.
The ULS choice indicator is the *thermal dissipation index*, [15] associated with UL_k located at different levels of the building. The maximum value of the dissipation index designates the ULS characterized by the property of ensuring the quality of nZEB building for the entire building, without going through the path of UL_k sizing. The solutions developed by using the method of energy syllogism consist in the *certainty* of achieving the performance parameters proper to the energy efficiency class nZEB both in the case of housing units within a building and within an urban area (the calculation support is the Representative Building)

7. Conclusions

- Energy and environmental sizing of *existing and new buildings* involves two stages, the *necessary* stage and the *sufficient* stage.
-The *necessary* energetic sizing stage of buildings nZEB refers to the characteristics of envelopes of the building and technical building systems, related to both conventional energy sources and renewable energy sources. The purpose is to determine the maximum acceptable primary energy performance index of the building whose value is PEC_0 [kWh/m^{2}year] and which implicitly leads to a value of the environmental performance of the building PMC_0 [kg/m^2 year].The thermal balance of the Housing Units (UL) in the form of the energy response of the occupied spaces is materialized by determining the hourly values of the heat (cold season) and sensitive cold (summer season) requirements based on the indoor thermal conditions. Mathematical solution is *exclusively* dynamic hourly simulation based on Type Year for each climatic Zone;
- *Sufficient* stage involves ensuring the *climate resilience* of nZEB buildings. The quality of the building to provide a tolerable microclimate in case of extreme climatic stress over probable durations in which the energy sources and the technical system can no longer supply the energy needed to maintain thermal comfort is called climate resilience.
- The synthesis of the energy regime modeling of the Representative Buildings are highlighted by applying appropriate technical solutions packages resulting from *numerically* and *empirically* validated numerical modeling.

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