nZEB Energy Atlas - TOOL FOR ENERGY RECONFIGURATION AT THE LEVEL OF URBAN AREA

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Abstract: *Urban issues related to energy performance are a top priority of the European Agenda, as a significant share of the intense effort to reach climate-neutrality by 2050 (European Commission, 2019). The European” Green Deal” set the target of 55% greenhouse gas emissions reduction by 2030, which requires new buildings to meet energy and environmental performance thresholds of the Nearly Zero-Energy Buildings (nZEB) (Directive 2010/31/EU) and also increase in deep renovations of existing buildings stock by giving priority to energy efficiency in order to achieve nZEB performances (Directive EU 2018/ 844).*

Sustainable planning plays an important role in the process of transformative urban adaptation (EEA Report 2016) by promoting the nZEB concept as an energy reconfiguration strategy of buildings, urban areas and settlements, having as goals of minimizing the impact on the quality of natural environment and ensuring normal indoor living conditions. It is proposed to submit a decision-making tool for energy assessment at the urban area level, called nZEB Urban Energy Atlas, which describes the methodological path from the current state assessment until the adoption of optimal scenarios for deep renovation of existing buildings stock.

Keywords*: nZEB- nearly zero energy building, Energy Atlas, energy efficiency, urban retrofitting, integrated solutions*

1. Introduction

European smart retrofitting programs include software applications for zonal energy assessment and planning based on the creation of a workable virtual urban model starting from a three-dimensional mapping of the built area, this representing the geometric conformation given to which various energy conformations are attributed (attributes of energy performance).

Virtual City Systems is an example of this, practically a tool that recreates a digital city starting from the three-dimensional model of the city and offers the possibility of successive energy modelling in order to establish energy planning strategies, resulting in the “Virtual city Database” virtual model. Similar applications such as Accompany cities in energy strategy - ACCENT have been used in major renovation programs in pilot projects for cities such as Paris, Valencia, etc., or CEA City Energy Analyst - used in Switzerland to provide diagnoses of the current energy situation, automatic collection of geospatial data, assessments of the potential for renewable energy production, or economic analysis of the proposed renovation scenarios.

It is important to note that this type of tool can support 3D public applications, such as the "Energy and Climate Atlas of Helsinki" which allow easy understanding of major renovation projects and thus help mediate between authorities and residents, having given that the success of renovation projects is largely conditioned by the co-participation of residents especially in the case of collective residential buildings where the decision belongs to a large number of owners. Moreover, information and participatory approach in the "relationship" of the inhabitants with the project through active involvement in decision-making and during the implementation of renovation works, is one of the integrated solutions in the approach of Smarter Together projects (EU Smart Cities) European Horizon 2020 program which offers "smart" -intelligent solutions in a systemic approach to improving the quality of life of the inhabitants with reference to the creation of energy efficient urban areas through the major renovation of existing buildings.

2. Materials and Methods

The nZEB Energy Atlas analysis tool proposed for use in urban design and planning is based on two major components, namely the method of graphical modelling associated with numerical values and the calculation algorithm that allows quantification of energy simulation results. The graphical representation is therefore the interface of numerical determinations, a representation in synthesized form with a high degree of information that can be used in order to develop strategies for major renovation of existing buildings in the area. The graphical interface offers the possibility of integration in the GIS geographic information system by placing the analysed model in a 3D geospatial context, resulting in a three-dimensional virtual replica.

The nZEB target, buildings with nearly zero energy consumption, set as a target for the energy performance to be achieved in existing buildings in major renovated urban areas, involves determining, through detailed analysis, the specific numerical values of Primary Energy (kWh / sqm per year) and CO_2 emissions (kg / sqm per year), and comparing them with the minimum values required by law depending on the location of the buildings and their function. Given the need for detailed numerical analysis it is necessary to choose based on the specialty literature, a calculation model appropriate to the energy analysis at the urban area level. It is proposed to use the method developed in the paper (Constantinescu D. - Tratat de Inginerie Termică, Termotehnica în construcții, vol.2, 2020). It is based on the evaluation of the Natural Thermal Regime as well as the Energy Response in conditions of achieving the microclimate characterized by thermal comfort, based on the dynamic modelling algorithm with hourly time step. The energy syllogism described in the cited paper, allows the use of the Reference Housing Unit (ULR) of the analysed building characterized by "maximum energy vulnerability" as a unique support for energy simulations on modernization solutions that allow the transition from the current state to nZEB performance.

This method facilitates the practical analysis at the level of urban areas by using the calculation tool at the level of ULR representative for the typologies of buildings inside the analysed area and the determination of the average zonal values.

3. Results and Discussion

The graphical results of the use of the nZEB Energy Atlas planning tool for the analysis of the energy and environmental performance of a representative Urban Area regarding the area of existing buildings with reference to the collective residential dwellings in Bucharest (Figure 1, 2- Marin Lazăr I.,"Atlas Verde al României aplicații în arhitectura clădirilor cu consum de energie aproape de zero" 2021) are presented.

Figure 1 Three-dimensional virtual urban model current energy situation analysed area (scale of energy consumption MWh / year)

The model in the image illustrates the current energy situation of a number of 283 block stairs in Sector 2 of the Capital which are located inside the delimited area and which from an energy point of view can be grouped into two representative typologies: CRA type buildings - buildings in the current initial state "not thermally rehabilitated" and those of CRR type - renovated buildings "thermally rehabilitated". Table one shows for example, the average values of Primary Energy (MWh/ year) for two types of representative blocks in the area, respectively a block staircase with 8 floors height regime - 52 apartments and a block staircase with 10 floors height regime - 44 apartments. It is specified that the specific values of primary energy and CO_2 emissions specific to the existing and proposed typologies of buildings analysed are based on the results of dynamic simulations with hourly time step on the support of the typical climate year described in the paper Constantinescu D. „Reziliența climatică și performanța energetică și de mediu a clădirilor de locuit" and the work cited above.

Collective residential building	Energetic type	Primary Energy (MWh/ year)
Ground floor +8 Floors	CRA	636
	CRR	482
Ground floor +10 Floors	CRA	554
	CRR	389

Table 1 Values of Primary Energy for representative types of analysed buildings (Marin Lazăr I., 2021).

The analysis of the current situation has highlighted relatively high values of specific heat energy associated with the efficiencies of current technical systems lead to increased energy values at the final consumer and thus high values for net specific primary energy and associated CO_2 emissions. The average values resulting from the analyzed area about 183 kWh / sqm specific primary energy and 41 kg / sqm per year CO_2 emissions (Marin Lazăr I., 2021). This leads, compared to the required energy thresholds required for nZEB classification (maximum values of specific primary energy 43 kWh / sqm per year and CO_2 emissions 9 kg / sqm per year for the time horizon 2050- Constantinescu D. 2020), to the need to use the nZEB Energy Atlas decision-making tool for successive energy simulations to determine the results of various in-depth renovation solutions and to establish optimal (applicable) intervention scenarios.

The following image graphically transposes the energy performance achieved in the analysed area following the application of the solution package that led to an energy saving of about 58% for current CRR type buildings and over 88% by renovating CRA type buildings (including a high-level thermal insulation).

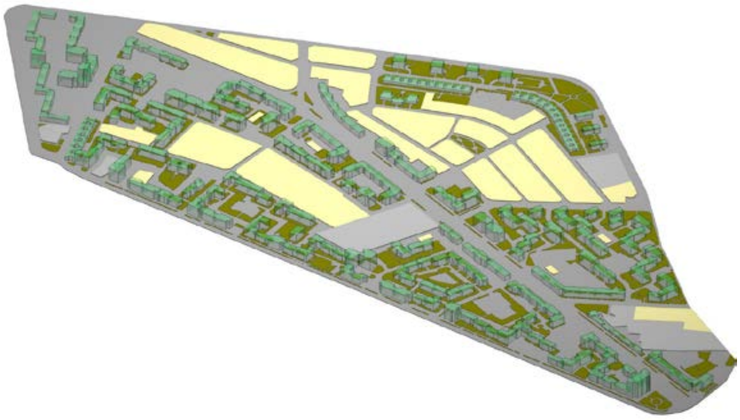

Figure 2 Proposed three-dimensional virtual urban model energy situation analysed area - nZEB time horizon 2050 (scale of MWh / year energy consumption)

4. Conclusions

The analysis of the renovation scenarios highlighted the fact that in order to ensure the inclusion in the nZEB 2050 class it is recommended to apply integrated solutions at urban level by combining passive architectural solutions applicable to buildings (thermal insulation, use of shading systems, use of finishes having a low coefficient of absorbance of solar radiation, etc.) with the recovery of energy from exhaust air, and capitalization of the potential for energy production from renewable sources and last but not least the achievement of these values is conditioned by the modernization of district heating and the use of a system cogeneration, high efficiency trigeneration in combination with the rest of the proposed solutions in buildings.

The conclusions of the analysis substantiate the application of the nZEB Energy Atlas decision-making tool for creating applicable scenarios of real urban energy reconfiguration that can be implemented in the medium or long term and can be used by both specialists involved in building design and by authorities in order to establish urban planning strategies. The essential quality derives from the reproducibility of this instrument for the energy analysis of any urban settlement depending on specific climatic conditions and the characteristics of the analysed buildings.

5. References

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