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Thermal rehabilitation of residential buildings or efficiency vs effectiveness in envelope of existing buildings

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Abstract. Starting from the definition of the terms, efficiency generally refers to the management of resources in order to achieve a goal, while effectiveness represents the ability / effective quantification of the achievement of a goal. In other words, efficiency is a process while effectiveness is an outcome. Having said that, the question rises (rhetorical, after all): was the process of thermal rehabilitation of the residential building stock efficient? Was it effective? Efficient it probably was: with the resources at the disposal of the town halls, with funds attracted and with the contribution of owners' associations (when the situation demanded their participation), a huge number of residential buildings were covered in thermal-insulating blankets. Was the expected result achieved? In other words, was it effective? The question may have many answers, considering the angles, the nuances and perspectives from where the intervention is evaluated, from the very basis of the approach – the hypothesis and the concept - to the architecture of the buildings and their relationship with the urban space of which they are a part.
The paper proposes a critical analysis of the results of the approach to the thermal "wrapping" of residential buildings in Romania as well as in the European research and practice.

Keywords: thermal rehabilitation, housing, architecture.

1. Historical context

The concept of building rehabilitation is not new; in each era it is found that the built fund no longer corresponds to the contemporary requirements of the users, as functions disappear or new functions appear. It is ineffective (today we say "unsustainable") to demolish buildings whose physical condition is good just because they can no longer accommodate the functions for which they were designed; they are rethought, adapted and

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equipped for a new life cycle with a new function.
In recent decades, another requirement has been added to the existing ones regarding the functional conversion and modernization of buildings: that of reducing energy consumption in the context where the requirements regarding comfort and the development of technology have, as a consequence, the precise increasement of these consumptions. Of course, the idea of thermal comfort in indoor spaces can be nuanced a little and also related to the fact that the life expectancy of the population has doubled from the beginning of the 20th century until now [1], which has as a direct consequence the need to ensure higher temperatures in the interior spaces as well as a higher level of the artificial light. Technological development on the other hand, having as a result the huge expansion of domestic equipment, inevitably led to an unprecedented increase in energy consumption, especially electricity; if only a generation ago an urban dwelling had electric light, telephone, television, radio, refrigerator, iron, washing machine, the list of electrical household appliances and electronic devices has grown exponentially (not to mention that air conditioners visually "pollute" almost any building, including some historic buildings where they would have no business to exist). One of the "tips of the spear" in the modernization process of existing buildings was represented by Germany, which, after reunification, intervened massively and majorly on the buildings in the eastern part of the country, analyzing, changing, improving and modernizing [2]. And where it seemed that the price of interventions would be too high in relation to the result, demolishing.
Germany represented a model of intervention in many countries, the principles on the basis of which it acted being adapted / improved over the decade. Thus, if in the first stage, carried out in the ’90s [3] the rehabilitation program had as main objectives

- the complex rehabilitation of the building envelope by the integral, unitary and coordinated replacement of the windows but also by restoring the finishes of the opaque part, with the improvement of its thermal insulation
- replacement of thermal and sanitary installations both physically and morally outdated [4], [5]
- modernization of common parts of collective housing
- replacement of old elevators

In 1996, the foundations of the CO_2-Minderungsprogramm (CO_2 Minimization Program) were laid, which began to operate in 2001, through loans and financial advantages granted by the federal government to owners, developers of public institutions that took measures to reduce carbon emissions to the level homes. The program still works today, and has been taken as an example by other countries. Obviously, its objectives have changed compared to the ’90s (as well as the models of financing [2]), folding on the first form of the European Directive on the Energy Performance of Buildings [5] that appeared at the end of 2002. With the changes in the Directive, the targets in the German program were also changed/updated.
Great Britain also represented a model regarding the policies of intervention for the USA (through The American Council for an Energy Efficient Economy) or for The International Energy Agency (IEA).
As far as the buildings in Great Britain are concerned, the policy is not so much to preserve the massive built stock of the degraded buildings or of those that do not correspond to contemporary requirements; it is estimated that by 2050 one third of the buildings that will exist, will have been built after 2006 [6]. The intention is to reduce carbon emissions from buildings by 60%, so the biggest focus is on new buildings and how to achieve high energy performance in new buildings. As a result, all aspects are taken into account, from the thermal insulation of the envelope components (opaque and glazed) to ventilation systems,

equipment and alternative energy systems. It can be noted that, in less than two decades, the idea of complex rehabilitation of residential buildings that also included the improvement of living conditions under the aspect of spatial comfort, has abandoned the latter aspect, focusing almost exclusively on efficiency energy: of the construction, of the rehabilitation process, all the more so since the successive editions of the Directive also imposed new thresholds and concepts. If the first form of the Directive [7] introduced the certification of buildings based on energy performance, the version of 2010 – the revised Directive [8] – introduces the concept of Nearly Zero Energy Buildings (nZEB) and the subsequent ones (the one from 2016 [9] and the one proposed in 2021 [10]) extend the obligations of member countries to establish financing and intervention strategies for the existing building stock.

The new (most recent) modification of the Directive is part of the Fit for 55% Package [11] which aims to reduce carbon emissions by 55% by 2030 compared to 1990.

This new edition of the Directive also establishes – or nuances – previous definitions [11]:

- "Zero emission building": a building with very high energy performance, where the low amount of energy required is covered by renewable sources generated on site, by an energy community or by district heating and cooling. This will be the standard for new buildings and the level to be reached through deep renovations from 2030;
- "Near Zero Energy Building": a building that meets the above standards with a performance that is not less than a cost-optimal level
- "Deep renovation": in example the transformation of a building into a nearly zero-emission building (by 2030) or a "zero-emission building" (after 2030).

2. The national program for thermal rehabilitation of buildings

The program, launched in 2009, has some elements of similarity with the first stage of the program in Germany, but it does not go to the level of a holistic approach in terms of heating and hot water production, limiting itself to interventions on the common parts; the rehabilitation of the elevators was not taken into account.

If the thermal rehabilitation works of the envelope presuppose, at the declarative level [11] "the thermal insulation of the external walls of the block, the replacement of the existing external carpentry, including the one related to the access to the residential block, the thermo-hydro-insulation of the terrace, respectively the thermal insulation of the floor above the last level in the case the existence of the framework, the closing of balconies and/or loggias with heat-insulating carpentry, including the thermal insulation of the parapets, the thermal insulation of the floor over the basement" and, if necessary, "the repair of the building elements of the facade that present a potential danger of detachment and/or affect the functionality of the housing block", "repair of the terrace/slope type roof, including the repair of the meteor water collection system at the level of the terrace/slope type cover", "repair of protective sidewalks, in order to eliminate infiltrations to the infrastructure of the housing block", the way in what were these objectives were accomplished – or not - is debatable. The funding was, however, important, coming mainly from the state and local budget, there also existing (in the legislation) a share of contribution from the part of the owners' association.

3. Effectiveness of the works performed

The monitoring of the quality of the works was not (really) carried out in Romania, tt least not at a scientific, organized level, the efforts focusing on covering, from the allocated

funds, as many interventions as possible.
However, European research has been sounding the alarm since a decade ago, regarding the very principles from which it started. Thus, [12] Jan Rosenow and Ray Galvin point out, based on case studies from Germany and England carried out a decade ago [12] that "most evaluations of home energy efficiency programs depend on calculated levels, rather than measured, of energy consumption. This does not take into account the discrepancies that have been observed in practice, between the calculated and the actual energy consumption, both before and after the rehabilitation". Moreover, research carried out in the same period in other European countries (France, Holland, Switzerland, Denmark, Austria) confirms the findings of researchers Minna Sunikka-Blank and Ray Galvin [13]:
1. the consumption of energy used for heating differs by up to 600%, for buildings in the same energy class;
2. there are large differences (on average 30%) between the calculated consumption of thermal energy for heating - which leads to the establishment of the energy class - and the actual measured energy consumption; as a result, the energy savings appear higher, considering that the reporting is done to two different reference systems;
3. the difference between the values calculated for the annual energy requirement and those actually measured increases with the increase of the former, both because the occupants of buildings with low energy performance tend to save resources more, and as a result of a poor quality execution of the works improving the energy performance of the building in question; for example: for a calculated energy requirement of 150 kWh/m^{2}a the difference between calculation and measurements is 17% and it increases up to 60% in buildings where the calculated requirement, per m^2 and year is 500 kWh/m^{2}a
4. in new buildings designed for low energy consumption, a rebound effect was identified. The percentage in which the rebound effect influences real energy consumption is around 30%, both in Germany and in the other European countries presented in the cited study [12].
More recent research [14] attests to the idea that "if policies are based on the use of theoretical normative calculations, there is a risk that the assessment of this potential and the speed of its realization could be overestimated. More extensive research is needed to confirm (or not) this risk. Evaluations [of interventions tr.n.] should be carried out on a national scale with appropriate models and statistical analyzes in order to define correction factors adapted to the national level and to the profile of the users." The authors also draw attention to the fact that these interventions are not automatically cost-effective; profitability is also related to the behavioral habits of the occupants and suggests that expanding the empirical data base taken from the market will lead to finding regulation mechanisms targeted to the type of building users/occupants. Also, not only the efficiency of the interventions but also the way they affect the lives of the occupants are discussed: they are carried out "to save energy and reduce CO2 emissions, but also to improve the health of the people in the household and to preserve the valuable characteristics of the buildings, being at the same time accessible to all." [15]
In Romania, over the last 15 years, an impressive number of homes have been repaired, most of them being in collective housing buildings. We do not know if effective research and measurements has been carried out, but we had the opportunity to carry out technical reports or a significant number of buildings that have had such thermal performance improvement works. If we cannot say anything about energy saving after the interventions (but we note what has been studied by others, observing that the range of household products has increased exponentially and therefore the actual consumption of energy within the residential buildings has also increased), the effectiveness of the measures thermal

rehabilitation (?!) taken at the national level poses several problems of economic, technical, social and cultural nature:

a. tenders where the most important criterion is represented by the lowest price are almost a guarantee of failure: numerous works have been abandoned by the builder, over the years

b. tendering of "packs of housing blocks" and not individual buildings for the design phase; some original blueprints were found - or not - in the archives of the institutes that designed them. Not infrequently what was in the project had significant differences from the situation on the ground. Being awarded as packages, they were treated as such, as packs, not as independent building projects with their own characteristics and personality. The same solution, the same finishes, regardless of the physical condition and appearance of each building;

c. denial of architecture: in terms of collective housing in Romania, the last century was marked by an almost decade-long style change: the 30s of are characteristic of the modernist style, the 40s were unfortunately occupied by war, the 50s have benefited from the import of Soviet residential architecture, with neoclassical elements, the 60s stylistically made the connection with modernist architecture (the same architects or their disciples), the 70s represented the introduction of large prefabricated systems (large panels, spatial elements of reinforced concrete), the 80s brought, on the main trunks, interpretations – better or poor - of the post-modern style (which resonates, through excessive decorativism, with the taste of the decision-makers of the era in Romania). In all cases, from the 1930s to the 1990s, precious materials were used for the facades: elegant decorative plasters (terrace, travertine, mosaic), natural stone veneers (marble, travertine), ceramic veneers (brick, kleinmosaik). Moreover, there was an obvious structuring on levels of importance of the typology and composition of the facades: facades with elaborate volumetrics and precious finishes on the great boulevards, neutral facades towards enclosures or inner courtyards. The interventions financed by the national program promoted the same solution – thermal insulation with a thin film finish – regardless of the building's position in the city. As a result, it can be said that in the case of the rehabilitation of collective residential buildings, we have only one type of facade, differently colored. In order to achieve this objective - enveloping the buildings - the precious facades were effectively destroyed;

d. the lack of a holistic approach to building facades: unlike Germany in the 1990s, in Romania the replacement of the existing windows was uncoordinated. As a result, on the same facade there are windows made of different materials, with different panels, there are closed balconies with different panels, the facade becoming a multitude of self-contained housing units, not a coherent volumetric, stylistic and material composition;

e. the elimination of the need to obtain firemen's approval for rehabilitation / thermal cladding works allowed the use of solutions that do not ensure coherent behavior in case of fire (at the level of detail)

f. a significant number of rehabilitation projects were carried out with a minimum of execution details - almost none - taking over the schemes of the system providers; there is a huge difference between the catalog details and the actual details adopted for a sub-assembly (and in a building there are many sub-assemblies that need to be detailed); in the case of buildings from the 60s to 90s - and especially those completed in the last decade of the socialist period - there are numerous changes compared to the project, both in terms of detailed solutions and accuracy of execution, caused mainly by the speed of execution: crooked balconies, inefficient solutions, significant lack of vertically etc. In such a situation, it would have been necessary to pay more attention to the concrete situation, not to adopt a well-designed solution but whose relation to reality is questionable

g. the abolition of vocational schools, of trade schools led to the de-professionalization of performers: the lack of specialists - carpenters, painters, insulators, etc. - and learning "on the go" of a trade that requires more than a 2-week internship (in the best cases) leads to unacceptable improvisations on the construction site (but which can be seen with the naked eye); in these cases the "school of life" is not indicated and experience without knowledge leads to serious defects that others must remedy. Poor quality work has in many cases led to the appearance of fungus and mold in areas where moisture has become persistent;

h. the lack of responsibility for the works carried out unfortunately led to the destruction of some pre-existing works or, worse, required their repair / restoration by other teams, often at the tenants' expense. Most often, the waterproofing of the terraces, or the restoration of the coverings of the buildings provided with coverings made of scales or panels, in complete ignorance of the role of the elements that cross them, leads to water infiltration in the level / levels below it, including short-circuiting the electrical installation. Plaster repairs seem benign by comparison. The assembly of the doors and windows exclusively by means of polymer foam (without mechanical fastening elements), ad hoc inventions on the site for local solutions (in the absence of detailing the subassemblies, as stated in point "f") represent authentic "time bombs" in a country with high seismic risk. We refer to the adoption of solutions with improper materials, with improper fasteners, whose durability and behavior over time are untested and unknown;

i. the wrapping in thermal blankets as well as changing the windows with leakproof products induced a new pathology on the buildings as too often the hygro-thermal conditions of the indoor climate changes for the worse.

Corroborated with all these real aspects, identified within existing buildings undergoing the thermal rehabilitation process, we recall that simple, economic, available solutions were not taken into account at all: passive measures, such as ventilation, solar control, use of vegetation were excluded from the start.

So:

- at the level of the roofing, extensive green terraces could have been foreseen, with minimal investment, their existence contributing to the reduction of the urban heat island;
- where glazing is concerned, at least solar control glass could have been provided, on the facades on which it would have had an impact (South and West), or glass with low emissivity, on the Northern facades
- providing shutter-type elements would have represented both protection against excessive sunlight and a thermal input
- closed balconies (which were also imposed on people who didn't want them) are one of the causes of sultriness in rehabilitated apartments: for economic reasons (the cost of fixed windows is lower than the one of casements; as a result, the projects proposed the cheap variant); better ventilation was also ensured by the greater number of movable leaves
- closing of the ventilation ducts of the apartments is another source of air stagnation and therefore of increasing the risk of contacting specific diseases (sick buildings syndrome); this change occurred independently of the rehabilitation of the buildings, but the solutions adopted in the national program, by providing super-tight windows, increase the degree of discomfort and change the hygro-thermal conditions of the interior space.

4. Conclusions

The idea of providing better living conditions with lower energy consumption is a global trend and the state's intention to bear these costs in the vast majority of cases is a generous idea. In other European countries, the state intervenes through tax reductions or low-interest loans. In Romania, they opted for cheap solutions for finishing residential buildings, which replaced finishes that had a remarkable behavior over time (where they were correctly put into operation), not needing maintenance over time; it is unlikely that the tenants will obtain a permit to occupy the sidewalk, for the installation of scaffolding, that they will be able to financially afford to rent scaffolding to restore some fragile finishes, which - for example - hail damages; or a stray ball.

The questionable - or downright bad - quality of the execution led in some cases (not a few) to the termination of the execution contracts and the "freezing" of the construction site for years, with scaffolding in front of the windows, with quality materials that -they degraded, being directly exposed to the weather, with tenants who tried, on their own, to find compromise ways to bring the interior space back to livable quality and, in the end, with the dismantling of the works and restarting from scratch the whole process. With the corresponding discomfort and disturbance Even if theoretically the damage could be recovered (the cost of the materials), the disturbance, dust, dirt, damage in the interior spaces represent additional mental and financial expenses that divert the good intention of the program.

As a conclusion, we consider that too often the result of this type of intervention brought more problems than solutions and the prevailing economic factor canceled the idea of people's comfort at the level of housing unit, building, neighborhood, city.

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