COMPARATIVE STUDIES AND RESEARCH ON ENERGY OPTIMIZATION OF NON-RESIDENTIAL BUILDINGS

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ABSTRACT:

Statistics confirm that in the EU, buildings consume approx. 40% of final energy, which accounts for 36% of total European greenhouse gas production after energy consumption. Energy efficiency measures are urgently needed to effectively reduce greenhouse gas emissions. Decreasing fossil fuel consumption would have a major impact on declining energy demand per unit of gross domestic product. In 2014, European leaders adopted the ambitious Climate and Energy Framework 2030, in which the three key targets were raised: a 40% reduction in greenhouse gas emissions by 2030, a 27% reduction in RES and a 27% increase in energy efficiency. Then, in November 2016, the European Commission (EC) proposed the Clean Energy for All Europeans package, designed to support and accelerates the transition to a carbon-free energy system. This paper comprises a case study of the current situation of these matters in Romania and focuses on steps and methodology of what actions are reliable and available to be put into practice on this matter.

1. INTRODUCTION

The quality of life depends on the quality of living conditions.
Statistics show that over 2 billion people worldwide are currently living in precarious housing. On the other hand, in Europe, about 50 million people live in houses that are insufficiently or improperly heated and/or lit. A recent study (2017) by Ecofys, Fraunhofer IPB and Copehangen Economics found that 2.16% of Europeans who report health problems live in a damp house, compared to 11% of those who live in homes without moisture; 15% live in dark homes, compared to 10% of those living in well-lit homes. Those in homes with moisture and dampness have a 40% higher risk of developing asthma. The same study found that 2.2 million people in Europe now suffer from asthma as a result of living conditions. The (direct) medical and social (indirect) costs of treating asthma and chronic lung disease in the EU are € 82 billion (World Bank, 2015; INCD URBAN - INCERC, 2012).

In Romania, taking into account buildings that were built before 1985, almost a third of the total housing stock needs major repairs and technical modernization. Most rural homes - almost half of the total housing stock - are heated with firewood, in conditions of low efficiency and with negative effects on air quality.
The process of rehabilitating buildings, as shown in this report, is an essential necessity in combating the energy poverty that a significant percentage of Romanians face.

Both building energy efficiency promotion policies and public rehabilitation support programs are part of a broader effort to reduce greenhouse gas (GHG) emissions in the sector considered to be the largest emitter of carbon dioxide, ie the energy one, which is also the biggest contributor to the phenomenon of global warming. It is proven that the building sector is one of the sectors with the highest energy consumption, thus taking responsibility for a large part of GHG emissions.

Statistics confirm that in the EU, buildings consume approx. 40% of final energy, which accounts for 36% of total European GHG consumption (Gheorghe – Constantin Ionescu et. al., 2021).

Energy efficiency measures are urgently needed to effectively reduce GHG emissions. An extensive analysis by the International Energy Agency (IEA, 2017) has shown that energy efficiency can make the most of the "emissions budget" corresponding to an average 2° C increase in atmospheric temperature compared to the pre-industrial era - objective established by the 2015 Paris Agreement on Climate Change. To achieve the goal of limiting global warming to 2° C (called the 2DS scenario by the IEA), both the energy intensity of the global economy (i.e. the energy needed to produce a unit of global gross domestic product) and the carbon intensity decrease by about 60 % between 2015 and 2050 (IEA, 2017).

Thus, the weighted average energy intensity would decrease in 2015 to 3.2 PJ/billion $ 2014, adjusted with purchasing power (PPP) from 5.4 PJ/billion 2014 PPP. The weighted average carbon intensity in the supplied energy, measured by the ESCII (Energy Sector Carbon Intensity Index) in the same scenario, would decrease to 43 kilotons/PJ.

Decreasing fossil fuel consumption would have a major impact on declining energy demand per unit of GDP. In the IEA modelling, in the 2DS scenario, the final energy consumption increases up to 663 EJ, a value that is 42% lower than in the business as usual (6DS) scenario - 940 EJ.

In 2050, the total difference in final energy produced from fossil fuels between scenarios 2DS and 6DS is estimated at about 400 EJ, of which more than half is due to the decrease in final energy demand through ambitious energy efficiency measures.
Since 2007, the EU Council has adopted a set of directives on energy and the prevention of climate change, which were incorporated into European law in 2009. These include: achieving a reduction in greenhouse gas emissions by 20% by 2020, when compared to 1990 emissions, increase renewable energy sources (RES) to 20% of the energy mix and increase energy efficiency by 20% (i.e. 20% reduction in energy consumption primary school) compared to 2005 (European Commission, 2014; BPIE, 2012; German Green Building Council, 2015).

The primary energy consumption target (CEP) assumed by Romania was 43 million tons of equivalent oil (Mtep) in 2020, representing a 19% reduction compared to the forecasted CEP (nn. PRIMES Scenario, 2007).

The quantitative estimate of the energy savings to be achieved as a result of the measures provided by a NAPA by 2020 has been developed on the basis of two economic development scenarios (Directive 2010/31/EU, 2010; Passiv Haus Institut, 2015; R. S. Balota et.al., 2012).

Taking into account the scenario of moderate economic growth of 2% per year of GDP, in the absence of energy efficiency measures, in 2020 the CEP was exceeded by 0.8 Mtep of the assumed limit of 43 Mtep. In contrast, in the scenario of high economic growth of 5% per year of GDP, the target could have been exceeded by 10.0 Mtep (figure 1).

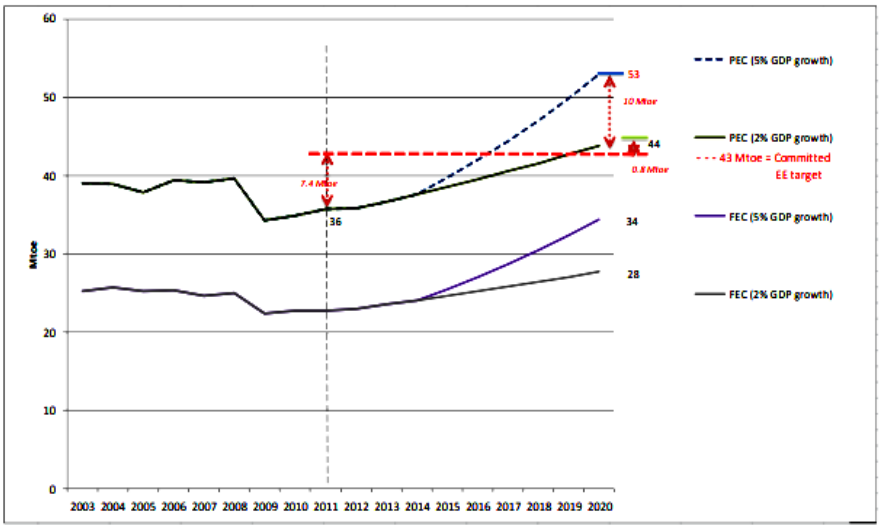


Figure 1. Projection of Primary Energy Consumption - CEP (in Mtep) for scenarios moderate and high GDP growth and relative to the 2020 energy efficiency target (Source: https://www.anre.ro)

In October 2014, European leaders adopted the ambitious Climate and Energy Framework 2030, in which the three key targets were raised: a 40% reduction in GHG emissions by 2030, a 27% reduction in RES and a 27% increase in energy efficiency. Then, in November 2016, the European Commission (EC) proposed the Clean Energy for All Europeans package, designed to support and accelerates the transition to a carbon-free energy system while maintaining the EU's economic competitiveness. Indeed, the three main objectives of this new package of energy and climate legislation, also known as the Winter Package, are: to put energy efficiency first, the EU to gain global leadership in RES and to provide correct terms for final energy consumers (BPIE, 2012; European Commission, 2010).

2. CASE STUDY - THE SITUATION IN ROMANIA

2.1 Identifying stakeholders and sources of information

The following ministries were identified as having a key role to play in developing and implementing the strategy:

- Ministry of Regional Development and Public Administration (MRDPA) - general responsibility for EPBD and main ministry in the elaboration of the national strategy;
- Ministry of European Affairs - supervision of European funds;
- Ministry of Economy, Trade and Business Environment (MECMA) - implementation of renewable energy sources in and on buildings;
- Ministry of Environment and Forests (MMP) - Kyoto financing mechanisms;
- National Energy Regulatory Authority (ANRE) - implications for energy service companies, including the role of energy efficiency obligations. ANRE now

includes former Romanian Agency for Energy Conservation (ARCE);

- National Institute for Research in Construction (INCERC) - management of the registration of energy performance certificates (EPC) (all EPCs are reported to this institute).

In addition, the following organizations were invited to the consultation process and they have made an important contribution to the development of the strategy:

- Association of Manufacturers of Construction Materials in Romania (APMCR);
- Romanian Association of Construction Contractors (ARACO);
- Board of Trustees of Construction Companies (PSC);
- Romanian Chamber of Commerce and Industry (CC IR);
- Romania Green Building Council (RoGBC);
- Romanian Association of Installation Engineers (AIIR);
- Construction Energy Auditors Association (AAEC);
- Liga Asociațiilor de Proprietari Habitat – League of Habitat Owners Associations);
- Federation of Owners Associations in Romania;
- Renewable Sources Producers Association (SUNE);
- Romanian Association for the Promotion of Energy Efficiency (Arpee);
- Association of Romanian Municipalities;
- Romanian Cities Association;
- The Confederation of Industrial Producers in Romania (CONPIROM);
- Romanian Geoexchange Company - representing users of geothermal energy in buildings.

It is important that these organizations continue to be involved both in the implementation phase of the strategy and in its review and updating every three years.

The main sources of information used in this strategy are:

- BPIE data platform which includes data collected by BPIE during the 2011 survey;
- ENTRANZE, an Intelligent Energy Europe project in which BPIE is a partner. The objective of the ENTRANZE project is to actively support the development of policies for a rapid and solid implementation of nZEB and the use of energy from renewable sources in existing building funds at national level.;
- Implementation of buildings with almost zero energy consumption (nZEB) in Romania - definition and roadmap, BPIE 2012;
- "Build Up Skills Romania - Current Status Analysis Report", National Institute for Research and Development in Constructions, Urbanism and Sustainable Territorial Development (URBAN-INCERC);
- Romania's Second National Action Plan for Energy Efficiency;
- Statistical Yearbook of Romania;
- Census data.

2.2 Presentation of the renovation model

For the analysis of scenarios illustrating the impact on energy consumption and CO_2 emissions at different levels (i.e., percentage of buildings renovated annually), as well as the extent of renovation (i.e., energy level reached) in the residential and non-residential building sector, up to and until 2050, a renovation model was developed. This model has allowed the development of several scenarios illustrating the financial, economic and environmental impact on employment and energy consumption for the different levels of assimilation and scale of building renovation. In particular, these scenarios evaluate the following results, both annually and in total:

- Energy savings;
- Reducing CO_2 emissions;
- Total investments required for the implementation of renovation measures;
- Energy cost savings;
- Impact on employment - the equivalent number of full-time jobs created by 2050;
- Profitability indicators:
  - ✓ **Internal rate of return (IRR)** - based on net savings made annually (ie cost savings minus the investments required in a given year);
  - ✓ **Net savings for consumers** - the difference between lifetime energy cost savings and lifetime investment. Both figures are discounted to their net present value;
  - ✓ **Net savings for society, including the value of externalities** - the sum of energy cost savings over a lifetime and the value of externalities, minus investments over a lifetime. Both figures are discounted at the social discount rate;
  - ✓ **Cost of reducing carbon dioxide emissions** - net social savings over a lifetime divided by savings in carbon dioxide over a lifetime. A negative figure indicates a net profit per ton of CO_2 saved.

The model allowed the introduction of different input data for four types of buildings:

- ✓ single-family homes (SFH),
- ✓ multi-family homes (MFH),
- ✓ public buildings (administrative buildings represent 6% of all non-residential buildings),
- ✓ commercial and industrial buildings.

There are about 1 million abandoned homes in Romania (Source: Second NAPEE - Action Plan for Energy Efficiency in Romania RO - Annex 2.4 p. 122), a consequence of strong migration and emigration trends in recent years.

The model allows the following variations of the real estate fund:

- **Demolished and abandoned buildings:** the total real estate fund decreases by 0.2% annually; half of this share corresponds to the average demolition rate from 2005-2012, and the other half corresponds to abandoned buildings.
- **Heritage buildings:** many buildings have historical, aesthetic and/or cultural value. Therefore, town planning authorities or other bodies may restrict the extent and type of renovations that may be carried out. In practice, these buildings are not excluded, as there will always be some energy-saving measures that can be applied, even if it is not a complete renovation. Minor and moderate renovations can often be feasible for heritage buildings.
- **Recent renovations:** Some buildings may have undergone renovations in the recent past, which would make future renovations less economically attractive. The number of buildings renovated to a level that would prevent the application of additional energy saving measures is most likely very small, around 1% of the existing fund.
- **New buildings:** New buildings built between the initial time and the year 2020 will probably be renovated by 2050, even if only to replace the heating, ventilation or air conditioning (HVAC) installations. Also, as renovation standards become more stringent and new technologies become more widely available and affordable, they will be increasingly implemented in buildings built in this decade. The rate of new constructions is set at 0.85% based on the average usable area of homes completed in the period 1990-2012. After 2020, it is estimated that the nZEB requirements set out in the EPBD reform will result in buildings with a high level of energy performance that will not require additional renovation (except for the replacement of facilities) by 2050.

For the purpose of modeling, the following information and assumptions were used:

- The current activity rates will be taken as basic figures for 2013:
  - Current renovation rates are 1%, the same as the EU average;
  - The scale of the existing renovations is predominantly minor.
    - In estimating the benefits to society, the externalities associated with energy use are included, in accordance with the guidelines on the optimal nature of costs.
    - The fundamental discount rates used are:
  - Private sector - 8%
  - Public sector - 4%
    - Two rates of decarbonization of energy supply have been modeled.
  - The slow decarbonization rate is based on the one found at EU level since 1990 - about 0.5% per year and reflects the continuation of the current activity.
  - The fast rate takes into account the decarbonisation rate needed to achieve the estimated carbon dioxide reduction levels in the EU Roadmap 2050, i.e. 5% per year for electricity and 2% for other fuels, the latter reflecting the shift to fuel sources with a lower carbon footprint.
- The average annual rate of increase in prices is 3.9% for gas and 5% for electricity, in line with the EU average by 2050. As recommended by the European Commission's methodology for cost optimization, the average increase in prices in the EU is set at 2.8% per year.

Renovation costs have been estimated at 60% of average EU costs. Cost reduction factors have been applied, which reflect the impact of increased renovation activity from the breakdown in 2050. Larger factors have been applied for the wider renovation profiles, given the steeper learning curve as the volume of activity increases, and the costs of renewable energy technologies integrated in buildings, in particular, decrease with the gradual maturation of the market. As renovation costs are already very low for Romania, the reductions range from 0.5% per year for minor renovations to 3% per year for nZEB renovations - up to half the estimated cost reduction rate for the rest of the EU. Keep in mind that these are real cost reductions, not adjusted for inflation.

The agreed costs were indicated according to the metric standard €/m^2. The values are deliberately technology neutral, as the combination of measures (thermal insulation, HVAC, intelligent control, window fitting, lighting, renewable energy and demand control measures) will vary depending on the type of building, as well as over time, as technological solutions are developed (table 1).

Renovation workload	Initial Cost (€/m2) at current prices	Learning Curve	Cost in 2050 (€/m2) at current prices
Minor - 15%	25	0.5%	21
Moderate - 45%	90	1%	63
Extensive - 75%	200	2%	97
nZEB - 95%	350	3%	117

Table 1. Cost estimates for different levels of renovation extent

Taking into account the hypotheses mentioned above, this model proposed two main growth paths (figure 2): SLOW and MEDIUM. These are related to a BASIC LEVEL which assumes that the renovation rates remain unchanged from the current rate (assumed to be 1% per year).

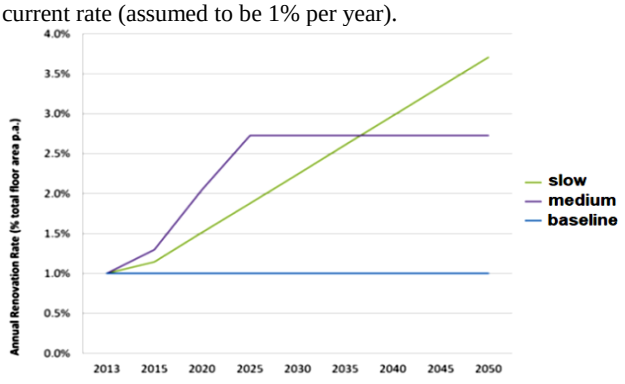


Figure 2. Modeled paths of renovation rates

The other key variable of the activity is the extent of the renovation, which means the proportion of energy savings achieved through a renovation.

Although it is not possible to estimate with certainty the current extent of the renovation undertaken in Europe, the existing

evidence shows an image in which the vast majority of the activity falls into the category of minor renovations.

Extensive renovations, where they exist, are often pilot or demonstration projects designed to assess the viability of achieving energy savings of 60% or more and provide an opportunity to learn.

There are three different scenarios for the extent of renovation (figure 3): superficial, intermediate, and extensive, reflecting the pace of a gradual transition to renovations that allow for greater average savings, as schematically illustrated below:

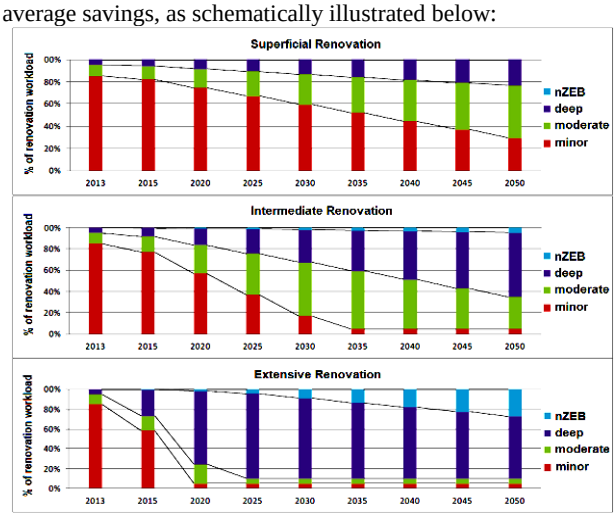


Figure 3. Breakdown of the type of renovation (extent) for three indicative renovation paths

3. CONCLUSIONS AND FUTURE RESEARCH DIRECTIONS

Through the energy renovation of buildings with the help of the ENTRANZE project, it is possible to achieve by 2030 energy savings in the final energy consumption for heating and hot water of about 20-25% and a preliminary energy saving estimated of up to 40% . The most ambitious **policy sets 2 and 3** (PS2 and PS3), also bring the greatest benefits in terms of energy savings achieved and the efficiency of public investment in programs to support the energy renovation of the building stock in Romania.

The elaboration of the policy sets took into account the achievement of a coherent and complex package of measures that could contribute to the sustainable renovation of buildings in Romania, starting from the current situation and aiming at the sustainable transformation of the building sector by 2030/2050.

The objectives that are expected to be achieved through the implementation of coherent sets of policies aimed at increasing the energy performance of existing buildings through renovation are:

Nationally:

- sustainable development of the building sector in the country by adopting ambitious regulations and policies to increase energy performance;
- increasing energy security by reducing the need for fossil fuels, potential imports and by increasing the use of local renewable energy resources;
- the development of an economic activity that generates a significant number of jobs, both in the construction sector and through the integration of horizontal industries that supply materials and equipment;
- reducing the impact of rising energy prices on citizens' budgets;
- combating energy poverty and increasing thermal comfort in buildings;
- increasing the quality of people's lives and combating related diseases;
- additional revenues to the national and local budget by creating new jobs and reducing unemployment.

At European and international level:

- fulfilling our obligations from the transposition and implementation of the European directives for energy performance of buildings (2010/31 / EU) and for energy efficiency (2012/27 / EU);
- Significant reduction of greenhouse gas emissions and energy consumption in buildings at the level indicated by the EU's long-term roadmaps (by 2050) for energy and the transition to a low greenhouse gas economy.

The sets of policies evaluated within the IEE ENTRANZE project were elaborated starting from the existing context in Romania, discussed with political factors and market actors and adjusted in terms of achieving the national and European development objectives for 2030.

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