Literature Review Analysis

Literature Review Analysis on Energy Performance and Sustainable Buildings in Romania

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Forward and Acknowledgements

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Report Information

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The information provided by the list of publications reviewed in this work has been cited.

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Abbreviations

ARDL: Autoregressive-Distributed Lag
CUSUM: Cumulative Sum
CUSUMSQ: Cumulative Sum of Squares
GDP: Gross Domestic Product
GFP: Gas Filled Panel
GP: Glass Powder
LRM: Literature Review Matrix
MVHR: Mechanical Ventilation Heat Recovery
nZEB: nearly Zero Energy Buildings
PCM: Phase Change Material
PH: Passive House
PHPP: Passive House Package Protocol
PHTT: Passive House Thermal Transient
VIP: Vacuum Insulation Panel
WSE: Wasted/Saved Energy
ZEB: Zero Energy Buildings

1. Introduction

In order to review the state-of-the-art of the energy performance of the buildings in Romania, a number of publications were analyzed. The purpose of the literature analysis was to study the available information regarding the implementation of the passive house, nZEB and ZEB in Romania. By studying the available information, I created the foundation of the research for the Master Thesis.

At first, a Resources Screening List was elaborated which contains the resources from where the following information was distilled:

1. The publications related to energy performance in buildings from Romania.
2. Romanian design codes for energy performance
3. The energy consumption in Romania
4. The price of energy in Romania
5. The climate of Romania.

The Resources Screening List can be found in the Appendix I where are shown all the resources from where the publications were taken. After establishing the list of resources, publications were searched using the following keywords: “Romania”, “nZEB”, “implementing”, “passive buildings”, “passive house”, “thermal comfort”, “building stock”, “Romanian house”. The found publications were gathered all in the Literature Survey List where we can find information about the title, authors and publisher of the paper, the number of citations and observations which contain the classification of the publication. The Literature Survey List contains 80 publications related to sustainable buildings design in Romania. These publications were classified as following:

- **No new information.** This means that the publication doesn’t bring anything new.
- **Not related to my subject.** This means that the publication is not related to the subject of the Master Thesis, even though the title might appear like it is. The reason might be because the title may contain one of the keywords used to search for publications.
- **Not clear.** The publication which was classified as not being clear and had gaps that made the understanding difficult or it was too detailed and the information was poorly systemized to be easily understood.
- **Should be cited in the LRM.** This classification means that the publication will be included in the Literature Review Matrix (LRM) because the information contained is new or original, but the number of citations is 0. Therefore the publication included in the Literature Review Matrix that doesn’t have any citations should be cited in the future.
- **In the LRM.** This means that the publication will be included in the Literature Review Matrix because it has new or original content.

The Literature Survey List can be found in the Appendix II. After establishing the Literature Survey List and after sorting the publications by the originality of the content, the Literature Review Matrix was elaborated. The Literature Review Matrix, which can be found in the Appendix III, contains 35 publications which were selected according to their study parameters, focus, gaps and findings which represent the main ideas of the publications.

2. An overview of the publications from the Literature Review Matrix

Based on occurrence of major topics in the LRM, the publications are divided into the following four categories: policy, governments, technology and feasibility. In this paragraph, the publications classified in each of the four categories are summarized. The concluding remarks from each category are grouped in Section 3.

2.1. Policy

In this category are the findings from the Romanian standards for energy efficiency C107 – 2005, Mc001 – 2006, C107/6-02 and C107/7-02, the European standards for energy efficiency and documents about the implementation of the nZEB policy in Romania. (See references [1], [2], [3], [4], [5], [10], [34] and [35] from the Literature Review Matrix, Appendix III).

From the standard C107 – 2005 [1], it was found that there are two different formulae for calculating the global thermal insulation coefficient for residential, respectively non-residential buildings and that it influences the result of the annual heating demand. Also, in the analysis of the building elements in contact with the ground, there are new parameters such as the temperature of the ground at the invariable layer level, the thermal conductivity of the soil and the influence of the ground water table. It was found that the steps of the analysis of the energy performance of the buildings in heating from C107 – 2005 are quite simple which might put in doubt the accuracy of the final results. Mc001/1 – 2006 [2] has similar content with C107 – 2005 with upgraded information. The second part of Mc001 – 2006 [2] presents the evaluation of the energy performance of the building services using advanced methods of calculation such as iterative methods or step by step integration and the third part contains templates for energy audit and energy performance certificate.

C107/6-02 [34] states that in order to satisfy the requirements for hygiene and interior comfort and also for the performance of the building envelope, the building must fulfill the following conditions: the increase of mass relative humidity of the materials from the building envelope's structure due to water vapor condensation should not exceed a maximum value and to avoid the progressive accumulation of water inside the building envelope every year due to condensation phenomenon. C107/7-02 [35] states that the thermal stability during summer and winter is evaluated for the room positioned in the most unfavorable direction and it will be considered by the designer as a reference room, by analyzing different parameters such as the thermal stability of the boundary element. According to the limitations imposed by the thermal stability, the rooms or the building sectors are divided into 3 groups ("a", "b" and "c") taking into account the endowment or necessity of the ventilation and air conditioning system.

Reference [4] from the Literature Review Matrix established the rules for selecting the reference buildings and the packages of measures in order to apply the Cost – Optimal Methodology and it presents three case studies made for building stocks from Germany, Austria and Poland, in which this methodology was applied. The differences between the three case studies are based on the reference building, weather conditions, design codes and energy prices typical for each analyzed country. The Cost – Optimal Methodology was applied in case of Romania by using 3 different reference buildings and at least 10 variants [3]. Reference [5] emphasizes the key changes that have to be done to the Energy Performance of Buildings Directive and it explains the Cost – Optimal Methodology in a simple and easily understanding manner.

In September 2012 – April 2014 was developed the project called ENTRANZE where Romania, along with other 8 countries from the European Union, was analyzed for the implementation of nZEB and RES&H/C. This was done by establishing three policy sets based on the pace of implementing the nZEB regulations until 2030, with special focus on year 2020. Two energy price scenarios and three renovation packages were analyzed. The policy scenarios, along with the energy price scenarios and the renovation packages were modeled in the software named Invert/EE-Lab [10].

After analyzing the publications related to policy we find out that the Romanian standards regarding the energy efficiency have a clear structure and are easy to use by the specialist, but they haven't been updated since 2011. The Romanian standards need to be aligned with the European standards so that Romania could reach the 2020 target. Besides the Romanian regulations for energy performance, there are also reports about implementing the nZEB concept in Romania and both of the reports conclude that Romania has potential for designing sustainable buildings and for using energy from renewable sources.

2.2. Governments

Reference [8] and reference [11] from the Literature Review Matrix (See Appendix 3) reflect the implications of the Romanian Government into the implementation of the energy saving and climate change policies. The energy efficiency and CO2 emission reduction target imposed by EPBD must be achieved by all Member States, including Romania, by year 2020. Reference [8] from the LRM gives information about the variation of the Romanian standards in the field of energetic efficiency between the years 1973 – 2009 and the structure of the Romanian building stock according to the age of the buildings.

Regarding the reduction of greenhouse gas emission in Romania, a large number of intelligent measures could be used and the fact that the majority of towns are not properly developed in connection with greenhouse gas emissions reduction is, at the same time, a challenge and an opportunity. The barriers in combating the climate change in Romania are the lack of information regarding the package requirements, the lack of coherent development plans and the lack of financial means. The lack of financial means is not an excuse since there are a lot of EU instruments that could be used in Romania [11].

2.3. Technology

The findings in the technology of passive houses, nZEB and ZEB are reflected in the references [6], [7], [9], [13], [16], [17], [18], [22], [23], [24], [25], [27], [28], [29], [30], [31], [32], [33] from the Literature Review Matrix (See Appendix III). References [6], [7], [9], [13], [29] and [30] concentrate on the passive houses, references [18], [22], [27], [32] and [33] present the traditional, innovative and the future thermal insulation materials, simulations of the building's thermal behavior are described in the references [23], [24], [25], [28] and [31] and other technologies related to building sustainability are found in references [16] and [17].

2.3.1. Passive houses

In Romania there are 5 passive houses, one of them being the AMVIC office building from Bragadiru and a house which is a part of a duplex from Timișoara [9]. The passive office building AMVIC was simulated using the building thermal load model, the model of the ventilation/heating system, the thermal target and the operation control. The simulation was done using PHTT (Passive House Thermal Transient) model with a time lag of 10 minutes and the PHPP (Passive House Package Protocol) model with the monthly method, resulting the fact that the office building fulfills the passive building standard [6]. The largest problem of the passive office building is overheating and that's why PHPP recommends additional cooling measures if the overheating exceeds 10%. The internal heat sources and solar radiation have significant influence in the summer months on the cooling load [7]. For the passive house from Timișoara was installed a monitoring system that registers and collects data which is uploaded to a web server where diagrams are created for online visualisation [9]. In Bucharest, two passive houses located in the campus of the University Politechnica of Bucharest were tested for energy efficiency using the software TRNSYS. The designers created two models to use in the simulation with TRNSYS: one model is the building provided with simple flux ventilation system and the second model represents the building provided with MVHR system [13].

Another passive house that has gone through simulation was Pirmasens Passive House from Germany in which was used a one dimensional time dependent heat transfer equation solved numerically by using Netlib. The model used on the house from Germany can be applied to any passive house with arbitrary number of rooms and arbitrary space orientation [30].

The four passive houses built in Romania are the following: AMVIC office building from Bragadiru, near Bucharest, the passive house from Timișoara which is a part of a duplex and the two passive houses belonging to the campus of University Politechnica of Bucharest. Reference [9] mentions that in Romania are 5 passive houses, but it doesn't mention the location and the function of the other four passive houses besides the one from Timișoara. The results of the monitoring system installed on the passive house from Timișoara show that the house doesn't fulfill the passive house standard because the annual heat demand exceeds $15\ kWh/m^2 \cdot yr$ [9]. So technically, the house from Timișoara can not be classified as passive house. The information about the 5th passive house built in Romania is currently unknown, because there hasn't been found any information about it in the literature.

2.3.2. Thermal insulation materials

In order to design a building that fulfills the passive house standard, the choice of materials is important. Besides the traditional building materials, there are also advanced technologies for building envelope such as advanced wall systems: passive solar walls, lightweight concrete walls, ventilated or double skin walls and walls with latent heat storage, advanced glazing: aerogel glazing, vacuum glazing, switchable reflective glazing, suspended particle devices film, holographic optical elements and roof systems: ventilated and micro-ventilated roofs, solar reflective/cool roofs, green roofs, photovoltaic roofs [29].

The traditional thermal insulation materials are vulnerable to humidity and perforations. Their high thermal conductivity lead to very thick building elements in cold climate areas in order to achieve the passive house and ZEB standard. The Polyurethane foam has the smallest thermal conductivity among the traditional thermal insulation materials, but it has the disadvantage of being very toxic in case of fire, because Polyurethane releases hydrogen cyanide [32]. That's why designers try to find thermal insulating materials that have low thermal conductivity, do not allow air leakages, ensure thermal comfort and thermal stability and are not harmful to the indwellers' health.

An example of thermal insulating material is the active thermal insulating system composed of a cellulose honey comb, made from recycled carton and paper placed inside the panel, a glazed panel and a layer of passive thermal insulation positioned on the existent wall's side. Between the glazed panel and the cellulose honeycomb is a layer of ventilated air which stimulates convection and avoids the overheating of the panel during summer season [18]. Another thermal insulating material which may be suitable for a passive building is the Phase Change Material (PCM) which reduces fluctuations in air temperature, shifts cooling loads to off-peak periods and have the ability to store energy which is characterized by its latent heat of fusion. The PCM can be made of organic compounds, inorganic compounds or eutectic mixtures and on buildings can be applied by direct impregnation into building materials or by encapsulation [27].

Another example of thermal insulating materials which might be suitable for the passive buildings or nZEB are the state-of-the-art materials. The most promising state-of-the-art thermal insulation materials are the vacuum insulation panels (VIP) and the aerogels due to their very low thermal conductivity, but VIP's drawback is the fact that it's thermal conductivity increases with age because of the water vapors and humidity penetration into the pores. The gas filled panels (GFP) are doubtful solution because their thermal conductivity is higher than of the VIP whose thermal conductivity is low due to the vacuum from the pores. There are also conceptual thermal insulation materials which have been designed to have very low thermal conductivity and to be robust with respect to aging, perforation, building site adaptations [32]. One of the conceptual thermal insulation material is the PCM with waste glass powder which is made of n-octadecane, because its phase transition temperature is in the human comfort zone and has high latent heat of fusion, and soda-lime glass which represents 80% by weight of waste glass. The composite PCM was prepared by using vacuum impregnation method and was tested for surface morphology, chemical compatibility, phase change behavior, thermal properties, thermal stability and thermal performance. The results of the tests show that the melting and freezing temperatures are for n-octadecane 27.4°C and 25.15°C and for n-octadecane-GP (glass powder) are 26.93°C and 25.03°C, which are close to the range of human comfort zone and the thermal conductivity of the n-octadecane-GP is 0.62 $W/m \cdot K$ [33].

The application of an adequate thermal insulation to improve building energy performance in summer has only been analyzed in few studies. The study presented in the reference [22] was applied in 3 phases: the first phase of the study involved the effect of the whole building envelope on the building's thermal behavior in summer, in the second phase the effect of the opaque building envelope was analyzed and in the third phase was studied the effect of the thermal insulation level of the opaque envelope. Two case studies were analyzed: a residential building and an office building, both of them being located in Rome, Italy. The residential building, respectively the office building went through 5 simulations where the model is subjected to the same conditions, but has a different driving force each time. The detailed numerical simulation was done by EnergyPlus [22].

The efficiency of the PCM in ensuring thermal comfort in the building was studied on a duplex house from Portland, Oregon, in the USA. The model was analyzed by the following three scenarios: simulation of the building with no PCM installed, simulation of the building with PCM having different melt temperatures and simulation of the building with PCM layer at the interior surface of the interior wall. The results of the simulations show that using PCM with 25°C melting point may reduce the zone hours overheated by 50% and reducing the melting point of the PCM below 25°C may have an adverse effect on thermal comfort [27].

In order to design a house with low energy consumption, the designers are trying to develop thermal insulation materials which have very lower thermal conductivity than the traditional materials such that they do not require large thicknesses. Also designers try to develop thermal insulation materials which ensure air tightness and which are not sensible to humidity or perforations. Because the problem of the passive houses is overheating due to the high air tightness, designers try to study the effect of thermal insulation on the building in summer conditions in order to find solutions for thermal comfort and low cooling demand. Even though the case studies from reference [22], respectively reference [27] were done in Italy, respectively in the USA, the methods of thermal analysis during summer applied on the three case studies (the residential and office building from Rome, the duplex from Portland, Oregon) can also be applied in Romania. In the reference [7] from Section 2.3.1 is mentioned the fact that the largest problem of the passive houses in Romania is overheating and this is the reason why the analysis methods applied in the case studies from Italy, respectively from the USA could be useful in Romania.

2.3.3. The simulation of the thermal behavior of the building

The thermal behavior of the building was studied in many reviewed papers by simulations using different models. One of the simulations was done on the building's interior comfort using the following models: the mathematical model for the analysis of thermal comfort in buildings based on the energy balance equation and the simulation model of indoor air quality based on the general equation for the time evolution of a contaminant concentration, on the equilibrium concentration and on the computation of the metabolic CO2. The numerical application was done on a room with the dimensions 4.4x6x2.7 meters and with the indoor air temperature 24°C [23].

Another simulation was done for the evaluation of the building's permeability using 4 models in case of large buildings: model I, the calculation of the permeability as the air flow divided by the volume, model II, the calculation of the permeability as the air flow divided by the façade surface, model III, the calculation of the permeability as the air flow divided by the wind surface and model IV, the calculation of the permeability as the air flow divided by the joint length. The experimental study was done on a single family residential building, built in 1998, located in the village Homoraciu, Prahova county, in Romania. The method used in the experimental study was the Blower Door [24].

The building went through exergy analysis which allows a complete thermodynamic assessment of a building's energy use by taking into account the potential of energy carriers that cross the system boundary and their degradation in addition to the energy conservation equations. The building is an open thermodynamic and transient system which exchanges energy and material flow with the environment and it is modeled as a "black box" that needs exergy, while the surrounding is a closed system and the environment is a closed system in thermodynamic equilibrium with the surrounding. The building model used in the exergy analysis was a multi-family residential building located near Florence, in Italy [31].

Reference [25] proposes a methodology for the calculation of the optimal thermal load of intermittently heated buildings which aims to transform heating load calculation into a control problem. The current procedures of the heat load calculation have the following problems: the non-physical variation of the heat load temperature, the dependence on the peak load value on sampling time and the non-optimal control. The intermittently heated building was also modeled using the state-space modeling in which is applied the principle of analogy between two different physical domains that can be described by the same mathematical equations. The building's thermal behavior is modeled as a linear electric circuit and the state-space equations, in which it can be applied the superposition theorem of the electric circuits, are obtained by solving the circuit. The methodology for the calculation of the optimal thermal load of intermittently heated buildings was applied on a detached house located in France [28].

The experimental analysis using Blower Door method is hard to apply in a multi-family residential building because it requires the cooperation of the indwellers. The experiment made on the single family house from Homoraciu village had limitations because of the size of the house and the large number of rooms, of the low probability of having favorable weather conditions on a long duration necessary during a large number of measurements and of the similarity between the ground floor area and a common Romanian apartment [24]. Even though the thermal exergy analysis was done on a residential building from Italy, the same building exergy model could be applied on a residential building from Romania. For Romanian residential buildings it would be useful to have an exergy analysis in order to find out how much of the building's exergy is destroyed and how much is lost. This way can be established the impact of the building on the surrounding environment. Also the methodology of the calculation of optimal thermal load of intermittently heated buildings could also be applied on Romanian residential buildings, especially on multi-family residential buildings connected to the district heating plant.

2.3.4. Other technologies for improving the energy efficiency of buildings

There are other ways of improving the building's energy performance found in the reviewed literature. For example, on the building can be applied architecturally integrated multifunctional solar thermal facades. The concepts of integrating solar energy conversion systems are the following: hiding the components in the façade, mounting the components of the façade without drawing attention and outlining the solar components in the building design. The vertical implementation of the solar collectors having the shapes as equilateral triangle and isosceles trapeze, will lead to increased surface available for mounting and a better distribution of the heat production [16]. The first practical application of the multifunctional solar thermal facades was done on the Research and Development Institute of Transylvania University of Brasov. The solar thermal facades were applied experimentally on the building mentioned previously [16]. The same multifunctional solar thermal facades can be applied experimentally on a residential building from Romania.

The energy performance of the building can also be improved by taking into account the bioclimatic elements, as in the traditional Romanian houses which are characterized by the orientation relative to the shining of the sun and to the direction of the dominant winds, solar energy collection for heating by greenhouse effect, minimizing the quantity of conventional fuels used through a proper design of the house and of the stoves and the use of shading elements in the warm season [17].

2.4. Feasibility

In this category are classified the references [12], [13], [14], [15], [19], [20], [21] and [26] from the Literature Review Matrix (See Appendix III) which reflect cost analysis on the energy performance and energy consumption of the buildings and on the potential of renewable energy in Romania and reduction of CO2 and greenhouse gas emissions.

2.4.1. The analysis of cost and energy efficiency in buildings

Different methods can be used to analyze the cost of the building from the energy point of view. Reference [12] presents a methodology for the real estate appraisal of green value which uses the sales comparison approach applied if similar properties have recently been sold or are currently on sale in the subject property's market. The element of comparison between the buildings is the wasted/saved energy (WSE). The methodology must be applied on at least 3 comparable buildings, one of them being the reference building and leads to good results if the subject property and comparable buildings are built on the same standards. The passive house belonging to University Politechnica of Bucharest was analyzed using the general model of the life cycle cost which involves the variability of the bank interest rates, inflation and price escalation. The utilities, the staff, tax, the residual value and the cost of the decommissioning at the end of the life cycle are not taken into consideration in the analysis because they tend to have the same value throughout the change of the design of the house involved [21].

Some buildings were simulated with softwares in order to determine their energy efficiency. For example, the passive house Politechnica was simulated in TRNSYS using two models: the building provided with simple flux ventilation system, where the fresh air had the outdoor temperature and the thickness of the thermal insulation of the walls was reduced to half from the initial value and the building provided with MVHR system. Two functions of the building were simulated: the house as laboratory and the house used for a family composed of 4 members [13]. An office building from Transylvania University of Brasov was simulated in TRNSYS to determine the most effective methods to improve the energy performance of a building and to have optimal energy costs. In the simulation the office building was modeled using 6 building variants. The building variants had 3 types of insulation materials with different thickness for the exterior walls, with different types of windows and with 2 types of thermal insulation for the roof [15].

A building having PCM as thermal insulation went through a simulation in order to determine its energy efficiency and the energy costs. The analysis was run on a test room with the dimensions 6.5x4.5x2.5 meters, having the walls exposed to heat transfer and 1 window with the opening area 2 m^2. In the analysis were used 4 occupancy patterns which were denoted with A, B, C, respectively D. Each occupancy pattern was analyzed for two cases: when the room doesn't have mechanical ventilation and when the room has mechanical ventilation. The energy demand for heating was calculated for several values of the PCM melting point in the case of each occupancy pattern and ventilation situation considered and the results show that the PCM with the melting point 19°C has the highest potential for energy savings [20].

There was also a comparison of the same passive house built in different climate zones from Germany and Romania, where the heating demand was computed by the means of PHPP. The results state that for the same passive house constructive structure, the heating demand in Romania is latitude dependent and more reduced comparative to Germany. In the same climate zone, but at different latitudes, the variation of the specific heat demand is higher in Romania than in Germany [19].

The methodology for the real estate appraisal of green value is important to apply for Romanian residential buildings that go under energy audit. Based on the results of the real estate appraisal of green value and on the energy certificate of the residential building is established the price of the apartment, respectively of the house according to its energy efficiency. Therefore a house with the energy class D will have a smaller price than a house with the energy class B. In the study presented in reference [20] is not specified which exactly are the four occupancy patterns used in the simulation. Therefore the information stated in reference [20] is incomplete since we don't know exactly what kind of occupancy pattern leads to the result mentioned above. The comparison of the heat demand between a passive house built in Romania and the same one built in Germany was made for the office building AMVIC from Bragadiru, near Bucharest [19]. The study would have been more accurate if the same comparison would have been made between a residential passive building from Romania and the same one from Germany.

2.4.2. The renewable energy potential and CO2 emissions

In the references which fall in the feasibility category there were also information about renewable energy in Romania and CO2 and greenhouse gas emissions reduction. Reference [14] from the Literature Review Matrix states that Romania is the 14th most attractive country regarding renewable energy markets in the top 40 made by Ernst and Young in 2012, because the country has very good potential mix of solar energy, hydropower, biomass and geothermal energy. Using the Environmental Kuznets Curve, which shows the relationship between per capita GDP and measures of environmental degradation as inverted U-shape, the CO2 and greenhouse gas emissions from Romania were evaluated using the time reference data between 1980-2010. The existence of the Environmental Kuznets Curve in Romania, in the presence of energy consumption, was tested by using a series having natural logarithm form which is superior and provides consistent empirical findings. Also, for the analysis was used the ARDL (Autoregressive-Distributed Lag) bounds testing approach. [26].

The results of the Environmental Kuznets Curve from Romania are shown in table form in reference [26]. In Figure II.1 is represented the plot of the cumulative sum of recursive residuals (CUSUM). The plot is not consistent after the 4th quarter of year 2005 because of the structural break in the Romanian economy. In 2005, the Romanian Government made a major tax correction by introducing the flat tax rate of 16%, for almost all revenues of companies and individuals. This change led to higher imports of manufactured goods, with negative effects on the current account balance [26]. In Figure II.2 is represented the cumulative sum of squares of recursive residuals (CUSUMSQ). The curves of the cumulative sums are taken from reference [26].

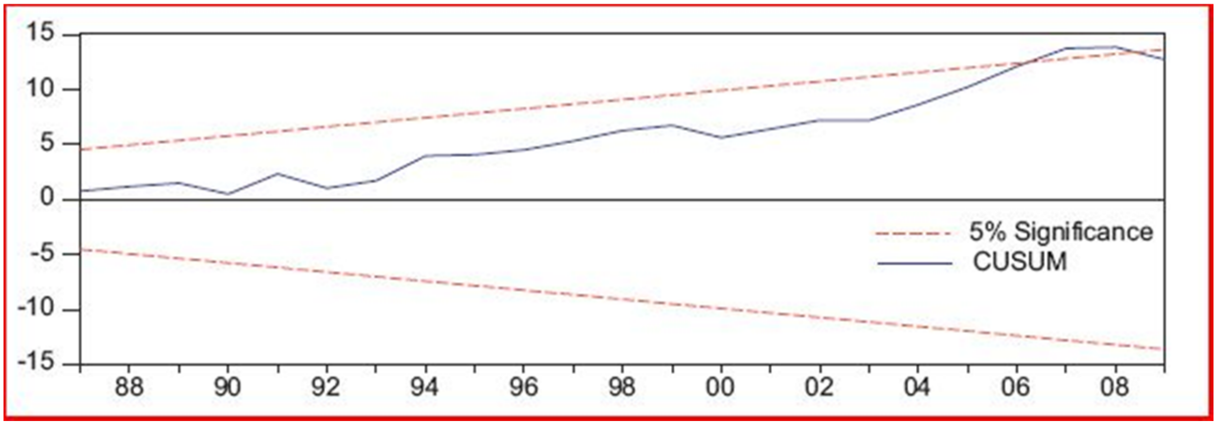

Figure II.1 – The plot of the cumulative sum of recursive residuals in Romania, between 1980 – 2010. The plot is not consistent after the 4th quarter of 2005. This indicates structural break in the Romanian economy [26].

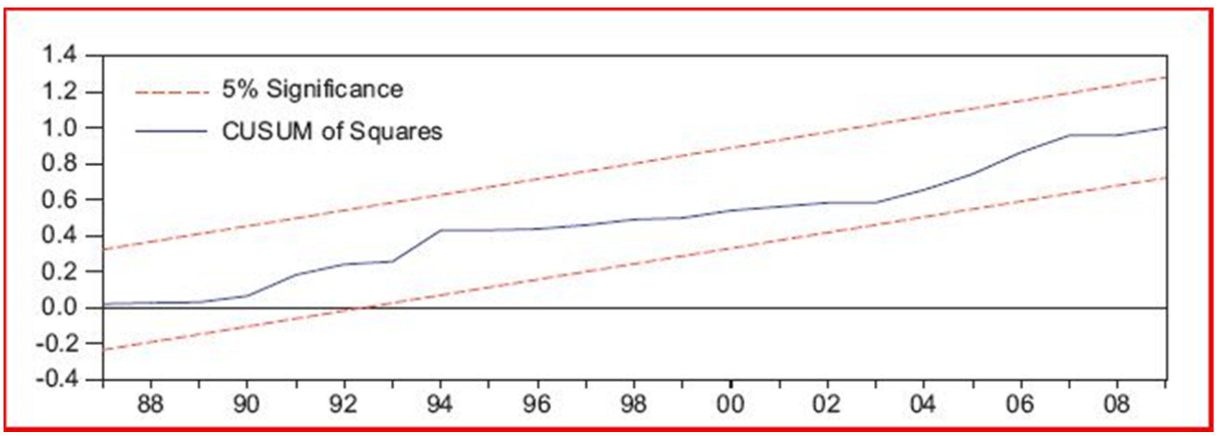

Figure II.2 – The plot of the cumulative sum of squares of recursive residuals in Romania, between 1980 – 2010. The plot shows that the ARDL parameters are stable [26].

3. Literature review analysis: findings and gaps

The publications suitable for the Literature Review Matrix (See Appendix III) were selected from the Literature Survey List (See Appendix II). The publications included in the LRM were reviewed on their study parameters, focuses, gaps and findings. In the following paragraphs are presented the concluding summaries of the findings, respectively of the gaps from the reviewed publications.

3.1. Findings

The most important findings from the publications included in the Literature Review Matrix are the following:

- The traditional Romanian houses are built using bioclimatic elements which take into account the amount of solar radiation with respect the cardinal points, the direction of the dominant winds and the microclimate of the area (i.e. the annual average rainfall, the annual average temperature in summer, respectively in winter, the local wind produced by the orographic conditions of the landscape, the climatic influences).
- Currently designers develop innovative thermal insulation materials, such as the Phase Change Materials (PCM), in order to reach the passive house, nZEB, respectively ZEB standard without being necessary to use large thicknesses for the thermal insulating layer of the building envelope.
- Romania has very good potential mix of renewable energy sources: there is solar energy potential, geothermal energy, biomass potential due to the large agricultural activity and hydro energy potential which is also the dominant renewable energy source in the country.
- The buildings from the Romanian housing stock have relatively young age, 37% of the buildings have between 20 – 40 years.
- Romania has the potential to integrate multifunctional solar panels into facades, the first practical application being done on the Research and Development Institute of Transylvania University of Brasov.
- In Romania was determined the Environmental Kuznets Curve, which shows the relationship between per capita GDP and measures of environmental degradation as inverted U-shape, for the time reference date 1980 – 2010. The same time reference shows how the CO2 and greenhouse gas emissions decreased in Romania.
- In Romania there were 3 case studies of passive houses: the AMVIC office building from Bragadiru, the passive house from Timisoara which is a part of a duplex and the two passive houses from the campus of University Politechnica of Bucharest.
- In Romania there is a potential application of the PHTT (Passive House Thermal Transient) model for new residential buildings located in different Romanian climate areas. The PHTT model was already applied on an office building (i.e. the AMVIC building from Bragadiru) located in the Bucharest climate area. Therefore the PHTT algorithm can be used for residential buildings too.

3.2. Gaps

The major gaps found in the publications reviewed in the Literature Review Matrix are as follows:

- The bioclimatic strategies on urban planning level and on the buildings level are not applied in Romanian modern buildings.
- There is uncertainty of using innovative thermal insulating materials, such as PCM, because of their availability on the market and of their high costs.
- There is no balance between the heating and cooling estimation regarding the passive house requirements and its impact on the seasonal interior comfort.
- In Romania there is no climatic variation in implementing nZEB and the application is done in only one climatic area out of four.
- Most of the case studies from Romania were done for office buildings, other case studies were analyzed outside Romania.

4. Research proposal

Based on the findings and gaps from the publications reviewed in the Literature Review Matrix, the current state of sustainable buildings design and energy performance in Romania was established. Therefore, the research proposal can finally be formulated in order to fill the major gaps and improve the current state-of-the art of the sustainable buildings design in the Romanian context. This research proposal aims to give designers innovative technical solutions so that residential buildings could achieve the passive house, nZEB or ZEB standards. Also, the technical solutions presented in this section are studied in order to find a balance between the heating demand during winter and cooling demand during summer in passive buildings, nZEB, respectively ZEB. So some of the technical solutions are studied to avoid overheating during summer.

One of the research proposals would be to create a new house model that uses the bioclimatic elements of the traditional Romanian house mentioned in Section 2.3.4. The new house will be provided with a porch which is a part of the main structure of the house. The porch’s depth will be designed such that the sun rays penetrate the rooms under different incident angles at winter solstice, summer solstice, respectively spring and fall equinox. In front of the house could be planted deciduous trees to be used as natural shading elements. Therefore, the overheating of the house is avoided naturally. The house model designed by using bioclimatic elements will be combined with the passive house, nZEB, respectively ZEB standards.

The energy efficiency of the house model will be analyzed by parametric study. The house will be tested for different types of thermal insulating materials (i.e. traditional thermal insulating materials, PCM) with different thicknesses. The house model will also be provided with different types of glazed surfaces used for fenestration. The parametric study will be done for each climate area from Romania. Therefore, the impact of the passive house, nZEB, respectively, ZEB requirements on cooling, heating, interior comfort and energy efficiency can be investigated accurately. The accurate investigation of the model for all the Romanian climate areas leads to more varied results. The variety of results will bring particular solutions for residential buildings on energy efficiency level for each Romanian climate area.

In the Table II.1 is the short summary of the concluding findings and gaps from the reviewed publications and the summary of the research proposal.

Findings	Gaps	Research Proposal
Traditional Romanian houses use bioclimate elements in their design.	The new buildings from Romania don't use bioclimatic elements.	Create a new house that integrates in its design the bioclimatic elements of the Romanian traditional house combined with the passive house, nZEB and ZEB requirements.
Innovative thermal insulation materials are tested (i.e. PCM).	The lack of bioclimatic elements is also observed at urban level.	By using bioclimatic elements, the balance between heating demand and cooling demand may be achieved because overheating is avoided naturally.
Romania has potential of mixed renewable energy sources (i.e. geothermal, biomass, solar, hydro).	The practical application innovative thermal insulation materials (i.e. PCM) on new or existing building is uncertain due to their availability and costs.	In the parametric study of the model, test the energy efficiency of the innovative thermal insulation materials (i.e. PCM) for each Romanian climate area.

Most of the buildings from the Romanian housing stock have relatively young age.	In Romania, the application of passive house and nZEB requirements is done for one climate area.	The impact of the passive house, nZEB, respectively ZEB requirements on heating, cooling, thermal comfort, energy consumption and cost should be investigated for all the climate areas from Romania.
The Environmental Kuznets Curve from Romania shows the evolution of CO2 and greenhouse gas emissions reduction, along with the environmental measures.	There is no climatic variation in implementing these requirements.	This parametric study will establish whether the innovative materials are feasable.
In the Romanian literature are 3 case studies of passive house simulation.		Because the Romanian climate is different for each area, to implement the PH, nZEB and ZEB requirements we need a variety of results.
The PHTT model can be applied for new residential buildings because in Romania it was already applied on an office building. Therefore the literature on PHTT algorithm is available.		The variety of results of parametric study applied in all the climate areas will lead to solutions particular for each climate area from Romania.

Table II.1 – The concluding findings and gaps from the reviewed publications and the summary of the research proposal.

5. The list of publications included in the Literature Review Matrix

This section presents the list of the publications included in the Literature Review Matrix which are in the same order as they appear in the matrix. For more details about the publications, see Appendix III. The publications included in the LRM and cited in this chapter are as follows:

[1] C107 – 2005: Normativ privind calculul termotehnic al elementelor de construcție ale clădirilor. Partea 1-5.vol. I. 2005

[2] Mc001 – 2006: Metodologie de calcul al performanței energetice ale clădirilor. Partea I-III. 2006

[3] I. Nolte, N. Griffiths, O. Rapf, and A. Potcoava, Eds., “Implementing Nearly Zero-Energy Buildings (nZEB) in Romania – Towards a definition and roadmap.” The Building Performance Institute Europe (BPIE), Aug-2012.

[4] I. Nolte, O. Rapf, D. Staniaszek, and M. Faber, Eds., “Implementing the Cost – Optimal Methodology in EU countries. Lessons learned from three case studies.” The Buildings Performance Institute Europe (BPIE), Mar-2013.

[5] T. Boermans, K. Bettgenhäuser, R. de Vos, and T. Constantinescu, Cost Optimality. Discussing methodology and challenges within the recast Energy Performance of Buildings Directive. 2010.

[6] V. Badescu, N. Laaser, R. Crutescu, M. Crutescu, A. Dobrovicescu, and G. Tsatsaronis, “Modeling, validation and time-dependent simulation of the first large passive building in Romania,” Renewable Energy, vol. 36, no. 1, pp. 142–157, Jan. 2011.

[7] V. Badescu, N. Laaser, and R. Crutescu, “Warm season cooling requirements for passive buildings in Southeastern Europe (Romania),” Energy, vol. 35, no. 8, pp. 3284–3300, Aug. 2010.

[8] M. F. Prada, S. Brata, D. F. Tudor, and D. E. Popescu, “Energy saving in Europe and in the World – a desideratum at the beginning of the millennium case study for existing buildings in Romania,” Proceedings of the 11th WSEAS International Conference on Sustainability in Science Engineering, pp. 246–251.

[9] C. Tanasa, C. Sabău, D. Dan, and V. Stoian, “Energy consumption and thermal comfort in a passive house built in Romania,” Portugal SB13 - Contribution of Sustainable Building to Meet EU 20-20-20 Targets, pp. 161–166.

[10] B. Atanasiu, L. Kranzl, and A. Toleikyte, “Policy scenarios and recommendations on nZEB, deep renovation and RES-H/C diffusion: the case of Romania. Deliverables D4.3 and D5.6 from Entranze Project.” EntraNZE, Sep-2014.

[11] V. Musatescu and M. Comănescu, “Energy – Climate change package impact on Romanian urban areas,” CCASP TERUM, vol. 4, no. 13, pp. 194–213, Nov. 2009.

[12] D. Popescu, E. Cerna Mladin, R. Boazu, and S. Bienert, “Methodology for real estate appraisal of green value,” Environmental Engineering and Management Journal, vol. 8, no. 3, pp. 601–606, Jun. 2009.

[13] V. G.E. Ionescu and H. Necula, “Simulation and energy efficiency evaluation of a low-energy building,” JSE, vol. 3, no. 4, Dec. 2012.

[14] M. Păcesilă, “Analysis of the Balkan countries policy on renewable energy sources: the case of Bulgaria, Romania and Greece,” Management Research and Practice, vol. 5, no. 1, pp. 49–66, Mar. 2013.

[15] E. Eftimie, “Costing energy efficiency improvements in buildings. Case study: Brașov, Romania,” IJEE, vol. 6, no. 1, pp. 47–60, 2015.

[16] M. Comsit, L. Isac, and M. D. Moldovan, “Architecturally Integrated Multifunctional Solar-Thermal Façades,” Springer Proceedings in Energy, pp. 47–65, 2014.

[17] N. Petrasincu and L. Fara, “Bioclimatic Elements for Traditional Romanian Houses,” PLEA2006 - The 23rd Conference on Passive and Low Energy Architecture, Geneva, Switzerland, 6-8 September 2006.

[18] A. R. Vasiu, “Sistem inovativ de „termoizolare activă” a clădirilor vechi,” A XI-a Conferință Națională Multidisciplinară-cu participare internațională ”Profesorul Dorin Pavel - fondatorul hidroenergeticii românești”, Sebeș, pp. 247–252, 2011.

[19] N. Rotar and V. Badescu, “Romanian climate data impact on passive buildings design,” U.P.B. Sci. Bull., vol. 73, no. 3, pp. 287–290, 2011.

[20] B. Diaconu M. and M. Cruceru, “Building envelope with phase change materials inclusions: factors influencing thermal energy savings,” Annals of the „Constantin Brâncuşi” University of Târgu Jiu, no. 3, pp. 76–84, 2010.

[21] A. Badea, T. Baracu, C. Dinca, D. Tutica, R. Grigore, and M. Anastasiu, “A life-cycle cost analysis of the passive house ‘POLITEHNICA’ from Bucharest,” Energy and Buildings, vol. 80, pp. 542–555, Sep. 2014.

[22] I. Ballarini and V. Corrado, “Analysis of the building energy balance to investigate the effect of thermal insulation in summer conditions,” Energy and Buildings, vol. 52, pp. 168–180, Sep. 2012.

[23] I. Sarbu and C. Sebarchievici, “Aspects of indoor environmental quality assessment in buildings,” Energy and Buildings, vol. 60, pp. 410–419, May 2013.

[24] V. Iordache, I. Nastase, A. Damian, and I. Colda, “Average permeability measurements for an individual dwelling in Romania,” Building and Environment, vol. 46, no. 5, pp. 1115–1124, May 2011.

[25] C. Ghiaus and I. Hazyuk, “Calculation of optimal thermal load of intermittently heated buildings,” Energy and Buildings, vol. 42, no. 8, pp. 1248–1258, Aug. 2010.

[26] M. Shahbaz, M. Mutascu, and P. Azim, “Environmental Kuznets curve in Romania and the role of energy consumption,” Renewable and Sustainable Energy Reviews, vol. 18, pp. 165–173, Feb. 2013.

[27] J. S. Sage-Lauck and D. J. Sailor, “Evaluation of phase change materials for improving thermal comfort in a super-insulated residential building,” Energy and Buildings, vol. 79, pp. 32–40, Aug. 2014.

[28] I. Hazyuk, C. Ghiaus, and D. Penhouet, “Optimal temperature control of intermittently heated buildings using Model Predictive Control: Part I – Building modeling,” Building and Environment, vol. 51, pp. 379–387, May 2012.

[29] S. B. Sadineni, S. Madala, and R. F. Boehm, “Passive building energy savings: A review of building envelope components,” Renewable and Sustainable Energy Reviews, vol. 15, no. 8, pp. 3617–3631, Oct. 2011.

[30] V. Badescu and B. Sicre, “Renewable energy for passive house heating: II. Model,” Energy and Buildings, vol. 35, no. 11, pp. 1085–1096, Dec. 2003.

[31] M. G. Baldi and L. Leoncini, “Thermal Exergy Analysis of a Building,” Energy Procedia, vol. 62, pp. 723–732, 2014.

[32] B. P. Jelle, “Traditional, state-of-the-art and future thermal building insulation materials and solutions – Properties, requirements and possibilities,” Energy and Buildings, vol. 43, no. 10, pp. 2549–2563, Oct. 2011.

[33] S. A. Memon, T. Y. Lo, and H. Cui, “Utilization of waste glass powder for latent heat storage application in buildings,” Energy and Buildings, vol. 66, pp. 405–414, Nov. 2013.

[34] Normativ general privind calculul transferului de masă (umiditate) prin elementele de construcție. 2002. C107/6-02

[35] Normativ pentru proiectarea la stabilitate termica a elementelor de inchidere ale clădirilor. 2002. C017/7-02

SBD

Sustainable Buildings Design Lab

APPENDIX 1 : RESOURCES SCREENING LIST

No.	Source	Link	Address
1	Universitatea de Arhitectură şi Urbanism „Ion Mincu” – Bucureşti (University of Architecture and Urban Planning “Ion Mincu” – Bucharest)	https://www.uauim.ro/	Str. Academiei nr. 18-20, 010014, Bucuresti, Romania, Tel: 0040 21 307 71 12, Fax: 0040 21 307 71 09
2	Institutul de Cercetări în Construcții şi Economia Construcților INCERC – Bucureşti (The Institute for Research in Civil Engineering and Economy of Constructions – Bucharest)	http://www.incerc.ro/	Şos. Pantelimon, 266, 021652, Sector 2, Bucureşti, România, Tel: 0040 21 255 00 62
3	Universitatea Tehnică de Construcţii – Bucureşti (Technical University of Civil Engineering – Bucharest)	http://utcb.ro/	Bd. Lacul Tei, nr. 122 - 124, cod 020396, Sector 2, Bucuresti, Romania, Tel.: +40 21 242.12.08, Fax: +40 21 242.07.81
4	Ministerul Transporturilor, Construcţiilor şi Turismului (The Ministry of Transport, Constructions and Tourism)	http://www.mt.ro/	Bulevardul Dinicu Golescu nr. 38, Sector 1, Bucuresti, Romania, Cod poştal 010873, Romania
5	Buildings Performance Institute Europe	http://www.bpie.eu/	Rue de la Science 23, 1040 Brussels, Belgium
6	Scopus	http://www.scopus.com/	N/A

7	SC Electrica Furnizare SA (Romanian electricity supply provider – data on energy consumption and energy price)	http://www.electricafurnizare.ro/	The main headquarters: Bucureşti, str. Grigore Alexandrescu nr. 9, Sector 1, Tel. 021.208.59.99, Fax. 021.208.59.98
8	Google Scholar	https://scholar.google.com/	N/A
9	Science Direct	http://www.sciencedirect.com/	N/A
10	CES Working Papers	http://ceswp.uaic.ro/	N/A
11	WSEAS	http://www.wseas.us/	N/A
12	Central and East European Online Library	www.ceeol.com	N/A
13	ENTRANZE project	http://www.entranze.eu/	N/A
14	Scribd	https://www.scribd.com/	N/A
15	Administrația Națională de Meteorologie (The National Meteorology Administration from Romania – for weather data)	http://www.meteoromania.ro/	Sos. Bucuresti-Ploiesti nr.97, Sector 1, Cod postal: 013686 Bucuresti Romania /Tel: +40 21 318 32 40; Fax: +40 21 316 31 43
16	E.ON Energie România (Romanian natural gas supply provider – data energy price for residential buildings)	http://www.eon-energie-romania.ro/	Sediul social: Mureş, Tîrgu Mureş, Justiţiei nr.12, 540069, Romania
17	Banca Națională Română (The National Bank of Romania – Information about the euro-RON exchange price)	http://www.cursbnr.ro/	Main headquarters: Strada Lipscani nr. 25, sector 3, Bucureşti, cod 030031, Romania, Telefon: 021 313 04 10, 021 315 27 50

APPENDIX 2: LITERATURE SURVEY LIST

Research keywords: *Romania, nZEB, ZEB, implementing, passive buildings, passive house, thermal comfort, thermal insulation, building stock, Romanian house*

No.	The Name of the Publication	Citations	Observations
1	S. Pescari, V. Stoian, D. Dan, and D. Stoian, "Achieving the nearly zero energy building concept - A study based on practical experience," *Recent Advances in Urban Planning, Sustainable Development and Green Energy*, pp. 117–122.	0	No new information.
2	C. Romilă, "A comparative analysis of the building stock in EU and Romania," *CES Working Papers (CES Working Papers)*, no. 1, pp. 89–99, 2013.	0	No new information.
3	A. Badea, T. Baracu, C. Dinca, D. Tutica, R. Grigore, and M. Anastasiu, "A life-cycle cost analysis of the passive house 'POLITEHNICA' from Bucharest," *Energy and Buildings*, vol. 80, pp. 542–555, Sep. 2014.	0	Should be cited in the LRM.
4	M. Păcesilă, "Analysis of the Balkan countries policy on renewable energy sources: the case of Bulgaria, Romania and Greece," *Management Research and Practice*, vol. 5, no. 1, pp. 49–66, Mar. 2013.	1	In the LRM.
5	I. Ballarini and V. Corrado, "Analysis of the building energy balance to investigate the effect of thermal insulation in summer conditions," *Energy and Buildings*, vol. 52, pp. 168–180, Sep. 2012.	10	In the LRM.
6	M. Comsit, L. Isac, and M. D. Moldovan, "Architecturally Integrated Multifunctional Solar-Thermal Façades," *Springer Proceedings in Energy*, pp. 47–65, 2014.	0	Should be cited in the LRM.
7	I. Sarbu and C. Sebarchievici, "Aspects of indoor environmental quality assessment in buildings," *Energy and Buildings*, vol. 60, pp. 410–419, May 2013.	9	In the LRM.
8	R. Săulescu, O. Climescu, and C. Jaliu, "Assessment of Wind Energy Resources in Communities. Case Study: Brasov, Romania," *Springer Proceedings in Energy*, pp. 151–166, 2014.	0	Not related to my subject.
9	V. Iordache, I. Nastase, A. Damian, and I. Colda, "Average permeability measurements for an individual dwelling in Romania," *Building and Environment*, vol. 46, no. 5, pp. 1115–1124, May 2011.	0	Should be cited in the LRM.

10	N. Petrasincu and L. Fara, "Bioclimatic Elements for Traditional Romanian Houses," *PLEA2006 - The 23rd Conference on Passive and Low Energy Architecture, Geneva, Switzerland, 6-8 September 2006*.	3	In the LRM.
11	B. Diaconu M. and M. Cruceru, "Building envelope with phase change materials inclusions: factors influencing thermal energy savings," *Annals of the „Constantin Brâncuşi" University of Târgu Jiu*, no. 3, pp. 76–84, 2010.	0	Should be cited in the LRM.
12	R. Crutescu, "Buildings without energy bills," *Mathematics and Computers in Biology, Business and Acoustics*, pp. 128–132.	0	No new information.
13	*C107 – 2005: Normativ privind calculul termotehnic al elementelor de construcție ale clădirilor. Partea 1 – Normativ privind calculul coeficienților globali de izolare termică la clădirile de locuit*, vol. I. 2005, pp. 2–46, C107/1	0	Should be cited in the LRM.
14	*C107 – 2005: Normativ privind calculul termotehnic al elementelor de construcție ale clădirilor. Partea a 2-a – Normativ privind calculul coeficienților globali de izolare termică la clădire cu altă destinație decât cea de locuire*, vol. I. 2005, pp. 47–72, C107/2	0	Should be cited in the LRM.
15	*C107 – 2005: Normativ privind calculul termotehnic al elementelor de construcție ale clădirilor. Partea a 3-a – Normativ privind calculul performanțelor termotehnice ale elementelor de construcție ale clădirilor*, vol. I. 2005, pp. 73–192, C107/3	0	Should be cited in the LRM.
16	*C107 – 2005: Normativ privind calculul termotehnic al elementelor de construcție ale clădirilor. Partea a 4-a – Ghid privind calculul performanțelor termotehnice ale clădirilor de locuit*, vol. I. 2005, pp. 193–217, C107/4.	0	Should be cited in the LRM.
17	*C107 – 2005: Normativ privind calculul termotehnic al elementelor de construcție ale clădirilor. Partea a 5-a – Normativ privind calculul termotehnic al elementelor de construcție în contact cu solul*, vol. I. 2005, pp. 218–310, C107/5.	0	Should be cited in the LRM.
18	C. Ghiaus and I. Hazyuk, "Calculation of optimal thermal load of intermittently heated buildings," *Energy and Buildings*, vol. 42, no. 8, pp. 1248–1258, Aug. 2010.	34	In the LRM.
19	*Catalog cu punți termice specifice clădirilor*. 2012, p. 836.	0	It should be cited.
20	R. Crutescu, "Chapter 15 - Architectural Buildings in Romania," in *Sustainability, Energy and Architecture*, A. Sayigh, Ed. Boston: Academic Press, 2013, pp. 401–419.	4	No new information.

21	G. Teodorescu, “Climate change impact on urban ecosystems and sustainable development of cities in Romania,” *WSEAS TRANSACTIONS on ENVIRONMENT and DEVELOPMENT*, vol. 6, no. 2, pp. 103–112, Feb. 2010.	12	Not related to my subject.
22	D. Marusciac and S. Pleșa, “Confortul higrotermic şi economia de energie la clădirile civile existente,” *A XI-a Conferință Națională Multidisciplinară-cu participare internațională ”Profesorul Dorin Pavel - fondatorul hidroenergeticii românești”, Sebeș*, pp. 283–290, 2011.	0	No new information.
23	R. Grigore, “Considerations about the influence of the thermal insulation layer on the energy performance of a building,” *PROCEEDINGS OF PLUMEE 2014*, pp. 38–41.	0	No new information.
24	E. Eftimie, “Costing energy efficiency improvements in buildings. Case study: Brașov, Romania,” *IJEE*, vol. 6, no. 1, pp. 47–60, 2015.	0	Should be cited in the LRM.
25	G. Teodoriu, M. Balan, I. Şerbănoiu, and M. Verdeş, “Cost-optimal Analysis of Performance Relation Thermal Insulation – Hydronic Heating System Applied to Romanian Residential Buildings,” *Procedia Technology*, vol. 12, pp. 583–590, 2014.	0	No new information.
26	T. Boermans, K. Bettgenhäuser, R. de Vos, and T. Constantinescu, *Cost Optimality. Discussing methodology and challenges within the recast Energy Performance of Buildings Directive*. 2010.	2	In the LRM.
27	M. Baritz, D. Cotoros, and D. Barbu, “Criteria Analysis for Optimal Choice of Efficient Energy Use in Residential Buildings,” *Springer Proceedings in Energy*, pp. 39–45, 2014.	0	Not clear.
28	D. Stoian, D. Dan, V. Stoian, T. Nagy-György, and C. Tanasa, “Economic impacts of a passive house compared to a traditional house,” *Journal of Applied Engineering Sciences*, vol. 1(16), no. 1, pp. 135–140, 2013.	0	No new information.
29	V. Musatescu and M. Comănescu, “Eenergy – Climate change package impact on Romanian urban areas,” *CCASP TERUM*, vol. 4, no. 13, pp. 194–213, Nov. 2009.	7	In the LRM.
30	C. Tanasa, C. Sabău, D. Dan, and V. Stoian, “Energy consumption and thermal comfort in a passive house built in Romania,” *Portugal SB13 - Contribution of Sustainable Building to Meet EU 20-20-20 Targets*, pp. 161–166.	0	Should be cited in the LRM.
31	S. A. Ghita and T. Catalina, “Energy efficiency versus indoor environmental quality in different Romanian countryside schools,” *Energy and Buildings*, vol. 92, pp. 140–154, Apr. 2015.	0	Not related to my subject.

32	M. F. Prada, S. Brata, D. F. Tudor, and D. E. Popescu, “Energy saving in Europe and in the World – a desideratum at the beginning of the millenium case study for existing buildings in Romania,” *Proceedings of the 11th WSEAS International Conference on Sustainability in Science Engineering*, pp. 246–251.	2	In the LRM.
33	M. Shahbaz, M. Mutascu, and P. Azim, “Environmental Kuznets curve in Romania and the role of energy consumption,” *Renewable and Sustainable Energy Reviews*, vol. 18, pp. 165–173, Feb. 2013.	47	In the LRM.
34	J. S. Sage-Lauck and D. J. Sailor, “Evaluation of phase change materials for improving thermal comfort in a super-insulated residential building,” *Energy and Buildings*, vol. 79, pp. 32–40, Aug. 2014.	2	In the LRM.
35	D. Popescu, S. Bienert, C. Schützenhofer, and R. Boazu, “Impact of energy efficiency measures on the economic value of buildings,” *Applied Energy*, vol. 89, no. 1, pp. 454–463, Jan. 2012	53	No new information.
36	I. Nolte, O. Rapf, N. Griffiths, and A. Potcoava, Eds., “Implementarea clădirilor cu consum de energie aproape zero (nZEB) în România. Definire și foaie de parcurs.” Institutul European pentru Performanţa Clădirilor (BPIE), Aug-2012.	0	Should be cited in the LRM.
37	I. Nolte, N. Griffiths, O. Rapf, and A. Potcoava, Eds., “Implementing Nearly Zero-Energy Buildings (nZEB) in Romania – Towards a definition and roadmap.” The Building Performance Institute Europe (BPIE), Aug-2012.	0	Should be cited in the LRM.
38	I. Nolte, O. Rapf, D. Staniaszek, and M. Faber, Eds., “Implementing the Cost – Optimal Methodology in EU countries. Lessons learned from three case studies.” The Buildings Performance Institute Europe (BPIE), Mar-2013.	2	In the LRM.
39	B. Nicolae and B. George-Vlad, “Life cycle analysis in refurbishment of the buildings as intervention practices in energy saving,” *Energy and Buildings*, vol. 86, pp. 74–85, Jan. 2015.	0	No new information.
40	*Mc001 – 2006: Metodologie de calcul al performanței energetice ale clădirilor. Partea a II-a – Performanța energetică a instalațiilor din clădiri*. 2006, pp. 167–481, Mc001/2-2006.	0	Should be cited in the LRM.
41	*Mc001 – 2006: Metodologie de calcul al performanței energetice ale clădirilor. Partea a III-a – Auditul și certificatul de performanță a clădirii*. 2006, pp. 482–577, Mc001/3-2006.	0	Should be cited in the LRM.
42	*Mc001 – 2006: Metodologie de calcul al performanței energetice ale clădirilor. Partea I – Anvelopa clădirii*. 2006, pp. 2–162, Mc001/1-2006.	0	Should be cited in the LRM.
43	D. Popescu, E. Cerna Mladin, R. Boazu, and S. Bienert, “Methodology for real estate appraisal of green value,” *Environmental Engineering and Management Journal*, vol. 8, no. 3, pp. 601–606, Jun. 2009.	11	In the LRM.

44	V. Badescu, N. Laaser, R. Crutescu, M. Crutescu, A. Dobrovicescu, and G. Tsatsaronis, “Modeling, validation and time-dependent simulation of the first large passive building in Romania,” *Renewable Energy*, vol. 36, no. 1, pp. 142–157, Jan. 2011.	12	In the LRM.
45	*Normativ general privind calculul transferului de masă (umiditate) prin elementele de construcție*. 2002. C107/6-02	0	Should be cited in the LRM.
46	*Normativ general privind calculul transferului de masă (umiditate) prin elementele de construcție. 2002.* C107/7-02	0	Should be cited in the LRM.
47	I. Hazyuk, C. Ghiaus, and D. Penhouet, “Optimal temperature control of intermittently heated buildings using Model Predictive Control: Part I – Building modeling,” *Building and Environment*, vol. 51, pp. 379–387, May 2012.	43	In the LRM.
48	I. Hazyuk, C. Ghiaus, and D. Penhouet, “Optimal temperature control of intermittently heated buildings using Model Predictive Control: Part II – Control algorithm,” *Building and Environment*, vol. 51, pp. 388–394, May 2012.	32	Not related to my subject.
49	*Ordin pentru modificarea reglementării tehnice ”Normativ privind calculul termotehnic al elementelor de construcție ale clădirilor” indicativ C107 – 2005, aprobată prin Ordinul ministrului transporturilor, construcțiilor și turismului nr. 2.055/2005*, vol. Partea I. 2010, pp. 7–11.	0	It should be cited.
50	S. B. Sadineni, S. Madala, and R. F. Boehm, “Passive building energy savings: A review of building envelope components,” *Renewable and Sustainable Energy Reviews*, vol. 15, no. 8, pp. 3617–3631, Oct. 2011.	127	In the LRM.
51	B. Atanasiu, L. Kranzl, and A. Toleikyte, “Policy scenarios and recommendations on nZEB, deep renovation and RES-H/C diffusion: the case of Romania. Deliverables D4.3 and D5.6 from Entranze Project.” EntraNZE, Sep-2014.	0	Should be cited in the LRM.
52	D. Constantinescu, “Proposition of updating the method used in calculating the heat demand based on a new concept of design outdoor temperature and of building – soil boundary heat transfer,” *Construcții*, no. 1, pp. 27–52, 2010.	0	Not in my subject.
53	C.-A. Bojan and D. Petric, “Reabilitarea termică a blocurilor vechi de locuințe,” *A XI-a Conferință Națională Multidisciplinară-cu participare internațională ”Profesorul Dorin Pavel - fondatorul hidroenergeticii românești”, Sebeș*, 2010.	0	No new information.
54	V. Badescu and B. Sicre, “Renewable energy for passive house heating: II. Model,” *Energy and Buildings*, vol. 35, no. 11, pp. 1085–1096, Dec. 2003.	54	In the LRM.

55	V. Badescu and M. D. Staicovici, "Renewable energy for passive house heating: Model of the active solar heating system," *Energy and Buildings*, vol. 38, no. 2, pp. 129–141, Feb. 2006.	41	Not related to my subject.
56	V. Badescu and B. Sicre, "Renewable energy for passive house heating: Part I. Building description," *Energy and Buildings*, vol. 35, no. 11, pp. 1077–1084, Dec. 2003.	69	No new information.
57	N. Rotar and V. Badescu, "Romanian climate data impact on passive buildings design," *U.P.B. Sci. Bull.*, vol. 73, no. 3, pp. 287–290, 2011.	0	Should be cited in the LRM.
58	R. Crutescu, "Save the environment by building ecological passive houses," *Recent Advances in Environment, Energy Systems and Naval Science*, pp. 124–129.	0	No new information.
59	V. Badescu, "Simulation analysis for the active solar heating system of a passive house," *Applied Thermal Engineering*, vol. 25, no. 17–18, pp. 2754–2763, Dec. 2005.	16	No new information.
60	V. G.E. Ionescu and H. Necula, "Simulation and energy efficiency evaluation of a low-energy building," *JSE*, vol. 3, no. 4, Dec. 2012.	0	Should be cited in the LRM.
61	R. Frunzulică, A. Damian, and I. Colda, "Simulation model in TRNSYS of a small substation from Romania," *U.P.B. Sci. Bull.*, vol. 72, no. 1, pp. 17–24, 2010.	0	Not in my subject.
62	A. R. Vasiu, "Sistem inovativ de „termoizolare activă" a clădirilor vechi," *A XI-a Conferință Națională Multidisciplinară-cu participare internațională "Profesorul Dorin Pavel - fondatorul hidroenergeticii românești", Sebeș*, pp. 247–252, 2011.	0	Should be cited in the LRM.
63	R. Grigore, "Some aspects about low energy buildings," *PROCEEDINGS OF PLUMEE 2014*, pp. 34–37.	0	No new information.
64	*SR1907-1: Instalații de încălzire. Necesarul de căldură de calcul. Prescripții de calcul*. 1997.	0	It should be cited.
65	M. C. Dascălu, "Studiul de caz privind posibilitatea de transformare a unei cladiri existente intr-o casa pasiva energetic."	0	Not related to my subject.
66	C. Tanasa, C. Maduta, V. Stoian, D. Dan, and S. Pescari, "Study on energy efficiency requirements in buildings," *Recent Advances in Urban Planning, Sustainable Development and Green Energy*, pp. 80–86.	0	No new information.
67	R. C. Dinu, I. Mircea, L. Ruieneanu, and N. Popescu, "The evaluation of thermal comfort indices in households," *JSE*, vol. II, no. 3, pp. 36–41, Sep. 2011.	0	Not clear.
68	R. Miron, "The implementation of European energy policies in Romania in the context of the global financial crisis," *Bulletin of the Transilvania University of Brașov*, vol. 3 (52), pp. 407–412, 2010.	0	No new information.

69	D. Ciobanu, E. Eftimie, and C. Jaliu, “The Influence of Measured/simulated Weather Data on Evaluating the Energy Need in Buildings,” *Energy Procedia*, vol. 48, pp. 796–805, 2014.	0	Not related to my subject.
70	F. Iacobescu and V. Badescu, “The potential of the local administration as driving force for the implementation of the National PV systems Strategy in Romania,” *Renewable Energy*, vol. 38, no. 1, pp. 117–125, Feb. 2012	11	Not related to my subject.
71	I. Udrea, C. Croitoru, I. Năstase, A. Dogeanu, and V. Bădescu, “Thermal comfort analyses in naturally ventilated buildings,” *Mathematical Modelling in Civil Engineering*, vol. 10, no. 3, 2014.	0	Not related to my subject.
72	C. Croitoru, I. Nastase, F. Bode, A. Meslem, and A. Dogeanu, “Thermal comfort models for indoor spaces and vehicles—Current capabilities and future perspectives,” *Renewable and Sustainable Energy Reviews*, vol. 44, pp. 304–318, Apr. 2015.	0	Not related to my subject.
73	M. G. Baldi and L. Leoncini, “Thermal Exergy Analysis of a Building,” *Energy Procedia*, vol. 62, pp. 723–732, 2014.	0	Should be cited in the LRM.
74	M. Moldovan and D. Ciobanu, “Towards nZEB—Sustainable Solutions to Meet Thermal Energy Demand in Office Buildings,” *Springer Proceedings in Energy*, pp. 115–133.	0	Not related to my subject.No new information.
75	B. P. Jelle, “Traditional, state-of-the-art and future thermal building insulation materials and solutions – Properties, requirements and possibilities,” *Energy and Buildings*, vol. 43, no. 10, pp. 2549–2563, Oct. 2011.	105	In the LRM.
76	M. Baritz, D. Cotoros, and D. Barbu, “Use of Thermo-Vision for Early Detection of Heat Losses, Inside and Outside Buildings with Mixed Heating,” *Springer Proceedings in Energy*, pp. 31–37, 2014.	0	No new information.
77	S. A. Memon, T. Y. Lo, and H. Cui, “Utilization of waste glass powder for latent heat storage application in buildings,” *Energy and Buildings*, vol. 66, pp. 405–414, Nov. 2013.	2	In the LRM.
78	D. Constantinescu, C.-P. Stamatiade, H. Petran, and G. Caracas, “Validation of the software used in determining the energy performance of buildings (EPB),” *Construcții*, no. 2, pp. 3–26, 2010.	0	Not clear.
79	V. Badescu, N. Laaser, and R. Crutescu, “Warm season cooling requirements for passive buildings in Southeastern Europe (Romania),” *Energy*, vol. 35, no. 8, pp. 3284–3300, Aug. 2010.	17	In the LRM.
80	F. Schärf, M. Vasilache, and I. Olteanu, “Ways of reducing the impact of residential buildings on the environment,” *Bul. Inst. Polit. Iaşi*, vol. LX (LXIV), no. 2, pp. 51–59, May 2014.	0	No new information.

APPENDIX 3: LITERATURE REVIEW MATRIX

No.	REFERENCE	STUDY PARAMETERS	FOCUS	GAP	FINDINGS
1	*C107 – 2005: Normativ privind calculul termotehnic al elementelor de construcție ale clădirilor. Partea 1-5.* vol. I. 2005	The global thermal insulation coefficient of residential and non-residential buildings The standard global thermal insulation coefficient of residential and non-residential buildings The annual heat demand The standard annual heat demand The thermal resistances of the building elements The thermal bridges The elements of the building envelope	Calculation of the thermal characteristics of the building envelope Analysis of the thermal bridges in the building envelope Special analysis of building elements in contact with ground The thermal inertia of non-residential buildings The temperatures balance sheet The calculation of the annual heat demand and of the global insulation coefficient	The energy performance design code concentrates only on the heating of residential and non-residential buildings. The mechanical ventilation, domestic hot water or artificial lighting are not included. Very few mentions about the interior climate of the building.	There are 2 different formulae for establishing the global thermal insulation coefficient for the residential, respectively non-residential buildings. In the analysis of the building elements in contact with the ground, new parameters appear: the temperature of the ground at the invariable layer level, the thermal conductivity of soil and the influence of the ground water table. The steps of the analysis of the energy performance of the building in heating are quite simple which might put in doubt the precision of the final results. The annual heat demand is influenced by the global thermal insulation coefficient, which means that in case the condition G<GN is not fulfilled, then the modifications should be done in the initial calculations.

2	*Mc001 – 2006: Metodologie de calcul al performanței energetice ale clădirilor. Partea I-III* . 2006	Thermal performance, energy performance and air permeability analysis of the building envelope and its elements. Functions of the buildings and their influence on their energy performance. Performance requirements and thermal, energy and air permeability performance levels of the building envelope and its elements. The energy performance of the building services: heating, domestic hot water, mechanical ventilation, lighting. The energy audit and energy performance certificate of buildings.	The calculation of the parameters of thermal and energy performance and air permeability of the building envelope. The calculation of the parameters of the elements of building envelope in contact with ground. The architectural and constructive design of the building for energy efficiency Calculation of the energy performance of the building services: heating, domestic hot water, mechanical ventilation, lighting. Alternative methods for the evaluation of the energy performances of building services. The energy audit of residential and non-residential buildings. The energy grading and energy certificate of buildings.	There aren't so many details regarding the interior comfort of the buildings. Some of the calculation methods described in the code lead to results with errors. (i.e. monthly method for energy demand for cooling) Some of the formulae seem to be unclear. (i.e. the number of degree - days for the evaluation of the annual energy demand for the AC systems) Few information regarding the energy certification of the new buildings.	Mc001/1 has similar content with C107-2005, Parts 1-5 with upgraded information. In the evaluation of the energy performance of the building services are used advanced methods of calculation such as iterative methods or step by step integration. Contains templates for energy audit and energy performance certificate.
3	I. Nolte, N. Griffiths, O. Rapf, and A. Potcoava, Eds., "Implementing Nearly Zero-Energy Buildings (nZEB) in Romania – Towards a definition and roadmap." The Building Performance Institute Europe (BPIE), Aug-2012.	Implementing the concept of Nearly Zero Energy Buildings in Romania for the existing and new buildings State of the art Gaps in the Romanian design codes Financial analysis of nZEB solutions.	The building stock of Romania. The roadmap of implementing the nZEB concept for Romanian buildings. Current regulations and practice for new buildings Current support schemes for buidlings	The report about Romanian building stock concentrates only on the urban areas and not on rural areas too. There isn't a detail report about the areas with renewable energy. The cities are only mentioned. The cities: Beius, Huedin, Giurgiu are mentioned as having renewable energy, but don't have certain facts or data to prove its implementation.	The Cost-Optimal Methodology was applied for 3 different reference buildings from Romania: a single family house, a multi family house and an office building. In the application of the Cost-Optimal Methodology, for each reference building were chosen at least 10 variants.
4	I. Nolte, O. Rapf, D. Staniaszek, and M. Faber, Eds., "Implementing the Cost – Optimal Methodology in EU countries. Lessons learned from three case studies." The Buildings Performance Institute Europe (BPIE), Mar-2013.	The energy performance of buildings Cost - Optimal calculations	Implementing the Cost - Optimal Methodology in the EU countries. The algorithm of the Cost - Optimal Methodology applied for 3 case studies: Germany, Austria and Poland. Rules for applying the Cost - Optimal Methodology.	The publication states that at the moment there is no data base about the price of energy at EU level.	The publication establishes the rules for selecting the reference buildings and for the packages of measures (variants). The three case studies presented emphasize the mistakes in the application of the Cost - Optimal Methodology. The three case studies made for the building stock from Germany, Austria and Poland emphasize the difference in choosing the optimal solution between the three countries. The differences between the 3 studied cases are based on the reference buildings typical for the studied country, weather conditions, design codes and energy price.

5	T. Boermans, K. Bettgenhäuser, R. de Vos, and T. Constantinescu, *Cost Optimality. Discussing methodology and challenges within the recast Energy Performance of Buildings Directive* . 2010.	The Cost - Optimal Methodology The recast Energy Performance of Buildings Directive.	The challenges of the Cost - Optimal Methodology. Requirements of the Cost - Optimal Methodology. Measures to improve the energy performance of the buildings. The steps of the Cost - Optimal calculations. Changes to be done in the Energy Performance of Buildings Directive.	As the publication states, the Cost - Optimal Methodology needs further development The Cost - Optimal Methodology is fully developed if all the Member States and other stakeholders such as industries or scientific organisations are actively involved.	The publication emphasizes the key changes that have to be done to the Energy Performance of Buildings Directive. The calculations using Cost - Optimal Methodology are explained in a simple and easily understanding manner. The steps of the calculations are listed in a manner such that the Cost - Optimal calculations can be applied easily.
6	V. Badescu, N. Laaser, R. Crutescu, M. Crutescu, A. Dobrovicescu, and G. Tsatsaronis, “Modeling, validation and time-dependent simulation of the first large passive building in Romania,” *Renewable Energy* , vol. 36, no. 1, pp. 142–157, Jan. 2011.	The first Romanian passive office building. The time depending simulation of the first Romanian passive house building using the model Passive House Thermal Transient (PHTT).	The description of the passive office building, the headquarters of SC AMVIC SRL from Bragadiru town, near Bucharest. The description of the Passive House Thermal Transient model applied on the building. The description of the heating and ventilation system with which the building is provided. The meteorological data base of the climate zone near Bucharest. The time dependent models used. The analysis of the results of the PHTT simulation.	The simulation was done on an office building. This type of analysis can be applied also to a passive residential building.	In the simulation of the passive office building were used the following models: building thermal load model, the model of the ventilation/heating system, the thermal target, the operation control. The simulation using PHTT was done with a time lag of 10 minutes leading to more accurate results than the PHPP model using monthly method. In order to compare the results from the PHPP and from the PHTT, the monthly average of the results from PHTT was computed. According to the results given by PHTT, PHPP monthly method and PHPP annual method, the passive office building fulfills the passive house standard imposed by Passivhaus Insitute from Darmstadt, Germany.

7	V. Badescu, N. Laaser, and R. Crutescu, “Warm season cooling requirements for passive buildings in Southeastern Europe (Romania),” *Energy* , vol. 35, no. 8, pp. 3284–3300, Aug. 2010.	The analysis of cooling requirements of a passive building in Romania during summer season. The analyzed passive building is the headquarters of SC AMVIC SRL from Bragadiru, near Bucharest.	The description of the passive office building, the headquarters of SC AMVIC SRL from Bragadiru town, near Bucharest. The meteorological data base of the climate zone near Bucharest. The steady state analysis for cooling requirements during summer season. The time dependent models used. The analysis of the results of the time dependent models used.	The analysis of the cooling requirements during summer season was done on a passive office building. Opening the windows to decrease the rate of overheating can be done in a standard building too. It is nothing new here. Even though the analysis was done on a passive office building, the problem of overheating in the summer can occur also in passive residential buildings.	PHPP recommends additional cooling measures in passive buildings if the overheating exceeds 10%. A common technique to decrease the rate of overheating is opening the windows at night during summer time and this technique was not inculded in the anlaysis. Opening the windows to decrease the rate of overheating can be done in a standard building too. It is nothing new here. The cooling requirements for a passive house are larger than in a standard building. Changing the thickness of thermal insulation in the range of -20% to +20% has no influence on the cooling load. The internal heat sources have significant influence in the summer months on the cooling load. In the design of a passive building in Romania, it is important to take into consideration the overheating during summer season and the heat demand during winter season. These two aspects are equally important when it comes to energy performance and fulfilling the passive house standard.

8	M. F. Prada, S. Brata, D. F. Tudor, and D. E. Popescu, “Energy saving in Europe and in the World – a desideratum at the beginning of the millenium case study for existing buildings in Romania,” *Proceedings of the 11th WSEAS International Conference on Sustainability in Science Engineering* , pp. 246–251.	The problem of the energy saving in the existing buildings from Romania.	The thermal insulation and energy saving problem in Europe and in the world. The thermal insulation and energy saving problem in Romania. Case study for existing buildings in Romania.	The buildings from the case study are not residential buildings, they are schools.	The article states at the beginning the energy efficiency and CO2 emission reduction target imposed by EPBD and which must be achieved by all Member States by year 2020. The variation of the Romanian standards in the field of energetic efficiency between the year 1973 - 2009. The structure of the Romanian building stock according to the age of the buildings. The case study presents 6 buildings from Romania which were expertized, have energy performance certificates and a part of them have been rehabilitated from the thermal point of view. None of the buildings from the case study have renewable energy sources.

9	C. Tanasa, C. Sabău, D. Dan, and V. Stoian, “Energy consumption and thermal comfort in a passive house built in Romania,” *Portugal SB13 - Contribution of Sustainable Building to Meet EU 20-20-20 Targets* , pp. 161–166.	The measure of energy consumption and the variation of the comfort parameters of the passive house built in the city of Timisoara in Romania.	The characteristics of the passive house built in Timisoara, Romania. Implementation of the monitoring system and measured energy consumption. Analysis of the thermal comfort parameters. Analysis of the final results.	The results of the monitoring system show that the passive house from Timisoara doesn't fulfill the passive house standard. The paper states that in Romania there are 5 passive houses. One of the passive houses is the one from Timisoara which, according to the analysis results, doesn't fulfill the PH standard. The paper doesn't give information about which are the other 4 passive buildings from Romania, which are their functions and where they are located on the Romanian territory.	In Romania there are 5 passive houses. A monitoring system was used on the house from Timisoara that registers and collects data which is uploaded to a web server. On the web server diagrams are created for online visualization.
10	B. Atanasiu, L. Kranzl, and A. Toleikyte, “Policy scenarios and recommendations on nZEB, deep renovation and RES-H/C diffusion: the case of Romania. Deliverables D4.3 and D5.6 from Entranze Project.” EntraNZE, Sep-2014.	The objective of the ENTRANZE project is to provide the required data, analysis and guidelines to achive a fast and strong penetration of nZEB and RES-H&C within the national building stocks. Dynamic building regulations. Longer term predictability of support programmes. Quality of works in construction. Information and technical advice. Measures in primary energy and support Research, Technology & Development and supply chain industry.	The document focuses on the building stocks from Romania. The methodology of the analysis. The policy set description. Analysis of the results of the model. Recommendations for implementing the nZEB and RES-H&C in Romania.	-	3 policy sets were used in case of Romania: "BaU+" (smooth but continous tightening of building regulations until 2030), "Growing-up" (a consistent tightening of the building regulations introducing nZEB for both new and existing buildings undertaking major renovations) and "Market transformation" (supporting a fast adoption of strict nZEB requirements for new and existing buildings undertaking renovations). 2 energy price scenarios were used: the reference scenario (only on going and already planned climate policies are taken into account and that no consensus is reached at the international level) and the ambitious climate scenario (the implications of more stringent policies and reinforced support for renewables at world level driven by succesful negotiations between advanced and emerging economies on climate change). For modeling it was used Invert/EE-Lab, a simulation tool of different scenarios: price, insulation, consumer behavior and their impact on future trends of energy demand and mix of renewable and conventional energy sources on national and regional level. 3 renovation packages were defined: the standard package (current practice of thermal building renovation), the good package (set of measures near the cost-optimality point), the ambitious package (level of renovation near the minimum primary energy level).

11	V. Musatescu and M. Comănescu, "Eenergy – Climate change package impact on Romanian urban areas," *CCASP TERUM* , vol. 4, no. 13, pp. 194–213, Nov. 2009.	The problem of energy consumption and climate change in Europe. The problem of climate change in Romanian urban areas.	The renewables target impact. The possible barriers in energy - climate change package implementation in Romania. Greenhouse gases emission reduction. Energy consumption reduction.	-	Romania's proposed target for renewable energy is 24% by year 2020. Regarding the reduction of GHG emissions, in Romania a large number of intelligent measures could be used. The fact that the majority of towns are not properly developed in connection with GHG emissions reduction is at the same time a challenge and an oportunity. In 2006 Romania used for the residential sector around 30% of its total energy consumption. The barriers in combating the climate change: lack of information regarding the package requirements, lack of coherent development plans and lack of financial means. The lack of financial means is not an excuse since there are a lot of EU instruments that could be used in Romania. 11 towns from Romania are members of Convenant of Mayors, established in 2007 as a part of EU's energy and climate protection package.
12	D. Popescu, E. Cerna Mladin, R. Boazu, and S. Bienert, "Methodology for real estate appraisal of green value," *Environmental Engineering and Management Journal* , vol. 8, no. 3, pp. 601–606, Jun. 2009.	A new methodology to be considered in the sales comparison approach of real estate valuation.	The building energy efficiency linkage to its market value. The building valuation methodology including energy efficiency input. Case study on a residential building from Romania built in 1992 which suffered only current maintenance since then. Perspectives of the methodology.	-	The procedures of real estate appraisal: cost approach, income capitalization approach and sales comparison approach. In the case study was used the sales comparison approach. The sales comparison approach is applied if similar properties have recently been sold or are currently on sale in the subject property's market. In the sales comparison approach, the wasted/saved energy (WSE) is the element of comparison between the buildings. If WSE is postive, then the building is highly efficient. If WSE is negative, then energy is wasted when opposed to the current legal standards. The methodology must be applied on at leasr 3 comparable buildings, one of them being the reference building. The method leads to good results if the subject property and comparable buildings are built on the same standards.

13	V. G.E. Ionescu and H. Necula, “Simulation and energy efficiency evaluation of a low-energy building,” *JSE* , vol. 3, no. 4, Dec. 2012.	Promote the energy efficiency of buildings in Romania. Simulation in TRNSYS of two houses located in the campus of University Politechnica of Bucharest.	The description of the two houses from the campus of University Politechnica of Bucharest. The simulation of the houses in TRNSYS. The analysis of the simulation results.	-	2 models were simulated in TRNSYS: the building provided with simple flux ventilation system and the building provided with MVHR system. In the first model, the fresh air had the outdoor temperature and the thickness of the thermal insulation of the walls was reduced to half from the initial value. In the second model, two functions of the building were simulated: the house as laboratory and the house used for a family made of 4 members. The results of the first simulation: energy consumption of the building decreases with the increase of the thermal insulation layer and the efficiency of windows have influence on the thermal load. Result of the second simulation: the power consumption of the building used as lab is greater than of the building used as a 4 member family house. Also energy consumption decreases if MVHR system is combined with EAHX system. The two analyzed houses fulfill the passive house standard.
14	M. Păcesilă, “Analysis of the Balkan countries policy on renewable energy sources: the case of Bulgaria, Romania and Greece,” *Management Research and Practice* , vol. 5, no. 1, pp. 49–66, Mar. 2013.	Describes different types of renewable energy sources. Reveals the importance given by Romania, Bulgaria and Greece regarding the investment and technologies in the field.	The renewable energy potential maps for Bulgaria, Greece and Romania. The analysis of the current situation of renewables in Bulgaria, Greece and Romania.	-	Romania is the 14th most atractive country regarding renewable energy markets in the top 40 made by Ernst and Young in 2012. Romania has very good potential for solar energy, hydropower, biomass and geothermal energy. Romania has almost reached the 2020 target of renewables production. In 2010 the production of renewables was 23.4%. The target set is 24%.

15	E. Eftimie, "Costing energy efficiency improvements in buildings. Case study: Brașov, Romania," *IJEE* , vol. 6, no. 1, pp. 47–60, 2015.	The analysis of the most effective methods to improve the energy performance of a building. Case study on a multi-zone building from Brasov, in Romania.	Possibilities to increase the energy efficiency of a building. The thermal insulation of the exterior walls and roof. Providing windows with triple pane insulation glass. The computation methods. Energetic simulation of the building. Analysis of the results of the simulation.	The analysis was done for an office building from Transilvania University of Brasov.	The advantages and disadvantages of the following thermal insulation materials are presented: expanded polystyrene, extruded polystyrene and polyurethane foam. These also apply to residential buildings. The simulation was done using TRNSYS with the weather data file from Brasov. In the simulation were used 6 building variants having 3 types of insulation materials with different thickness for the exterior walls, different types of windows and 2 types of thermal insulation for the roof. The polyurethane foam has the best insulation during cold season, but increased demand for space cooling. If the thickness of the layer increases from 10 to 15 cm, the heating demand decreases by 3.4% and the colling demand decreases by 1.3%. The expanded polystyrene has the worst insulation during the cold season. If the thickness of the layer increases from 10 to 20 cm, the heating demand decreases by 6.1%, but the cooling demand increases by 2.1%. The extruded polystyrene has the lowest values of space cooling demand.
16	M. Comsit, L. Isac, and M. D. Moldovan, "Architecturally Integrated Multifunctional Solar-Thermal Façades," *Springer Proceedings in Energy* , pp. 47–65, 2014.	Relevant issue related to the architectural integration of active solar technologies in the facades. Concepts of interest for architects, engineers and designers working on the implementation and integration of solar energy conversion systems in the built environment.	The problem of the solar technology integration into the building facades. The solar collector and the array units. The multifunctional solar thermal facades.	The article shows the implementation of the solar thermal façade on a non-residential building: The Research and Development Institute of Transilvania University of Brasov. The solar thermal façade has not been applied practically on a residantial building yet.	The problems of the solar technology integration into the building's façade are shape, aesthetics and functional demand The vertical implementation of the solar colectors will lead to increased surface available for mounting and a better distribution of the heat production. The suggested shapes of the solar collectors are the equilateral triangle and the isosceles trapeze. The equilateral triangle has great flexibility in development of various patterns with direct applications for small and medium facades, with various openings and volumetric structures. The isosceles trapeze offers cost effective larger arrays and facilitates an easier connection and mounting. The concepts of integrating solar energy conversion systems are the following: hiding the components in the façade, mounting the components of the façade without drawing attention and outlining the solar components in the building design.

17	N. Petrasincu and L. Fara, “Bioclimatic Elements for Traditional Romanian Houses,” *PLEA2006 - The 23rd Conference on Passive and Low Energy Architecture, Geneva, Switzerland, 6-8 September 2006* .	The analysis of the bioclimatic elements from traditional Romanian houses. The analysis is ment to emphasize the characteristics of the traditional Romanian houses in order to adjust them to the new social and economic conditions.	The analysis of the bioclimatic elements of traditional Romanian houses from the rural environment. The analysis of the bioclimatic elements of the traditional Romanian houses from the urban environment.	-	The Romanian houses are characterized by the following: the orientation relative to the shining of the sun and to the direction of the dominant winds, solar energy collection for heating by greenhouse effect, minimizing the quantity of conventional fuels used through a proper design of the house and of the stoves and the use of shading elements in the warm season. The main factors that influence traditional Romanian houses are the natural environment with an excessive continental climate and the human creative nature.
18	A. R. Vasiu, “Sistem inovativ de „termoizolare activă” a clădirilor vechi,” *A XI-a Conferință Națională Multidisciplinară-cu participare internațională ”Profesorul Dorin Pavel - fondatorul hidroenergeticii românești”, Sebeș* , pp. 247–252, 2011.	Active thermal insulation solution for the rehabilitation of the old buildings.	The description of the active thermal insulation solution.	There is no information regarding practical application of the active thermal insulation system on residential or non-residential buildings.	The active thermal insulation system has the following components: the celulose honeycomb, glazed panel and a layer of passive thermal insulation positioned on the existent wall's side. The celulose honeycomb is made of recycled carton and paper placed inside the panel. Between the glazed panel and the celulose honeycomb is a layer of ventilated air which stimulates convection and avoids the overheating of the panel during summer season.
19	N. Rotar and V. Badescu, “Romanian climate data impact on passive buildings design,” *U.P.B. Sci. Bull.,* vol. 73, no. 3, pp. 287–290, 2011.	The comparison of the same passive house built in different climate zones from Germany and Romania.	The passive house energetic requirements and the European climate. The passive house energetic variation in the European climate. The analysis of the final results.	The analysis was done using the geometrical data of the office building SC AMVIC SRL from Bragadiru, near Bucharest.	11 towns from Romania and Germany which are considered representative for the development of the passive house were chosen for the study. The towns are almost evenly distributed on the two territories between the limits of the longitude and latitude. The heating demand was computed by the means of PHPP. For the same PH constructive structure, the heating demand in Romania is latitude dependent and more reduced comparative to Germany. In the towns situated in the same climate zone, but at different latitudes, the variation of the specific heat demand is higher in Romania than in Germany.

20	B. Diaconu M. and M. Cruceru, “Building envelope with phase change materials inclusions: factors influencing thermal energy savings,” *Annals of the „Constantin Brâncuşi” University of Târgu Jiu* , no. 3, pp. 76–84, 2010.	Proposal of a Phase Change Material (PCM) enhanced wall system. The development of a model for the heat exchange between the indoor heated environment and ambient. Assess the effect of occupancy pattern and ventilation on energy savings for heating that the Phase Change Material wall system is capable of achieving.	The description of the PCM wall system. The analysis of the effect of occupancy pattern and ventilation on energy efficiency of a room with PCM walls. The analysis of the results.	The article doesn't describe which exactly are the occupancy patterns used in the model. All it is known that the patterns were denoted as A, B, C, D.	The wall system is composed of 3 layers: the inner layer is the one that contains the PCM which stores thermal energy attenuating the indoor temperature fluctuations, the middle layer which is brick structural wall and the external layer made of expanded polystyrene thermal insulation. The analysis was run on a test room with the dimensions 6.5x4.5x2.5 meters, having the walls exposed to heat transfer and 1 window with the opening area 2 sqm. The floor and ceiling are not considered into the analysis. The energy demand for heating was calculated for several values of the PCM melting point in the case of each occupancy pattern and ventilation situation considered. The results show that the PCM having the melting point 19°C offers the highest potential for energy savings.
21	A. Badea, T. Baracu, C. Dinca, D. Tutica, R. Grigore, and M. Anastasiu, “A life-cycle cost analysis of the passive house ‘POLITEHNICA’ from Bucharest,” *Energy and Buildings* , vol. 80, pp. 542–555, Sep. 2014.	The analysis of the life cycle cost of a passive house including its technical design variations. The analyzed passive house is located in the campus of the University Politechnica of Bucharest.	Literature reviews of the life cycle cost analysis. The description of the method. The description of the passive house "Politehnica". The model of analysis. Discussion of the obtained results.	-	The general model of the life cycle cost involves the variability of the bank interest rates, inflation and price escalation. The utilities, the staff, tax, the residual value and the cost of the decommisioning at the end of the life cycle are not taken into consideration in the analysis because they tend to have the same value throughout the change of the design of the house involved. In the study presented in the article the rate of inflation was not considered and for analyzing the variable economic environment was used the deterministic approach which involves the variation of one or of a combination of variables around the predicted point. The houses used in the model have the same layer of thermal insulation and air tightness, but the equipment is different. The thermal loads of the passive house were evaluated using the PHPP software and the thermal balances were determined by creating a VBA programming code in order to achieve a conservative balance of the thermal loads supplied by the PHPP by using conditional Boolean functions and threshold functions. The results of the life cycle cost analysis show that the payback time in case the passive house uses for heating gas fuel is 16-26 years, in case it uses electricity is 9-16 years and in case the house is connected to the District Distribution is 16-28 years.

22	I. Ballarini and V. Corrado, “Analysis of the building energy balance to investigate the effect of thermal insulation in summer conditions,” *Energy and Buildings* , vol. 52, pp. 168–180, Sep. 2012.	The thermal characteristics of a building for summer performance with the focus on thermal insulation. A new methodology for the analysis of the parameters which influence space cooling energy performance.	The methodology of the building's thermal analysis. The ways of representing obtained results. Potential applications of the proposed methodology. The methodology applied using parametric analysis for case studies. Sensitivity analysis and discussion of results.	The residential building and the office building used in the case study were located in Rome. The same methodology could be used on buildings located in Romania since they also experience the same problem with energy performance in cooling because of the climate.	The application of an adequate thermal insulation to improve building energy performance in summer has only been analysed in few studies. The study presented in the article was applied in 3 phases. The first phase of the study involved the effect of the whole building envelope on the building's thermal behavior in summer which is assessed as a function of boundary conditions of the indoor and outdoor environment, of the building's typology and of the building's geometry In the second phase, the effect of the opaque building envelope was analyzied which is influenced by the size of the transparent surfaces, the glazing thermo-physical parameters and the solar properties of the external opaque surfaces. In the third phase was studied the effect of the thermal insulation level of the opaque envelope which depends on the dynamic thermal properties of the structure. There were 2 cases studies: a residential building and an office building. The detailed numerical simulation was provided by Energy Plus. There were 5 simulations for the same model subjected to the same conditions and they were done by adding a different driving force each time. The proposed methodology can be applied for the energy design of a new building, the energy audit of an existing building or for the validation of simplified calculation models of building energy performance through a comparison with a detailed dynamic model.

23	I. Sarbu and C. Sebarchievici, "Aspects of indoor environmental quality assessment in buildings," *Energy and Buildings* , vol. 60, pp. 410–419, May 2013.	The numerical prediction of thermal comfort in closed spaces on the basis of PMV–PPD model. Computation and testing model of thermal comfort in buildings. A computational model for indoor air quality numerical simulation.	The prediction of the thermal comfort. The thermal comfort criteria used for the design of the heating system. The relationship between thermal environment and human performance. The evaluation of the olfactory comfort. The indoor quality simulation model. The computation of the outside air flow rate and indoor air quality control. The influence of CO_2 concentration on human performance and productivity.	-	The costs of poor indoor environment for employer, the building owner and for the society as a whole are often considerably higher than the cost of the energy used in the same building. The mathematical model for the analysis of thermal comfort in buildings is based on the energy balance equation. The numerical application was done on a room with the dimensions 4.4x6x2.7 meters and with the indoor air temperature 24°C. The criteria for the general thermal comfort are the PMV and PPD indexes and the standard ISO 7730. The simulation model of indoor air quality is based on the general equation for the time evolution of a contaminant concentration, on the equilibrium concentration and on the computation of the metabolic CO_2. The air is considered contaminated if the concentration of CO_2 is 0.1-0.15% and is considered to be harmful for indwellers at a concentration of 2.5%.

24	V. Iordache, I. Nastase, A. Damian, and I. Colda, “Average permeability measurements for an individual dwelling in Romania,” *Building and Environment* , vol. 46, no. 5, pp. 1115–1124, May 2011.	Mathematical models and the adapted experimental protocol for four different parameters that describes the permeability.	The proposed mathematical model for permeability. The adjusted experimental protocol. The experimental study on a Romanian residential building. The analysis of the results.	As the publication states, the experimental study of the air permeability in the individual dwelling was limited because of the following reasons: the size of the house and the large number of rooms, the low probability of having favourable weather conditions on a long duration necessary during a large number of measurements and the similarity between the ground floor area and a common Romanian apartment. There were errors of measurements for the wooden first level because of the numerous joints and of the felxibility of the wood during the measurements under the action of the indoor-outdoor pressure difference. The experimental study could not be done on a multifamily residential building because it required the cooperation of the indwellers and optaining the approval of the indwellers is a difficult task.	The air inflitration uses in general 2 models: the single zone models (predicts the air inflitration rate for the whole building represented as a single and well mixed zone) and the multizone model (allows the division of the building into a number of distinct pressure regions). The multizone model has more user inputs, requires more computation time, but it provides detailed results about the leakage rates through all leakage paths. For the evaluation of the permeability of large buildings there are 4 models. The model I is about the calculation of the permeability as the air flow divided by the volume. In this case, the permeability is the air change rate. Model II is about the calculation of the permeability as the air flow divided by the façade surface. Model III is the calculation of the permeability as the air flow divided by the wind surface. Model IV is the calculation of the permeability as the air flow divided by the joint length. The experimental study was done on an individual dwelling built in 1998, in the Subcarpathian village Homoraciu from Prahova county. In the experimental study was used the Blower Door method. The Blower Door consists in the following equipment: false door, radial fan with variable speed, variable voltage device, dual differential micromanometer, computer and software.
25	C. Ghiaus and I. Hazyuk, “Calculation of optimal thermal load of intermittently heated buildings,” *Energy and Buildings* , vol. 42, no. 8, pp. 1248–1258, Aug. 2010.	Methodology for estimating the heating load of buildings with variable zone temperature set-point.	The outline of the proposed methodology. A possible thermal model for a building. The compensation of the weather conditions. Set point tracking. Methodology for heat load calculations based on model predictive programming. Case studies and the analysis of results.	The article could be provided with the summary of the method for better understanding.	The problems of the current procedures of the heat load calculation are the non-physical variation of the heat load temperature, the dependence on the peak load value on sampling time and the non-optimal control. The methodology aims to transform heating load calculation into a control problem.

26	M. Shahbaz, M. Mutascu, and P. Azim, “Environmental Kuznets curve in Romania and the role of energy consumption,” *Renewable and Sustainable Energy Reviews* , vol. 18, pp. 165–173, Feb. 2013.	The relationship between energy consumption, economic growth and CO2 emissions, in case of Romania. The existence in Romania of the environmental Kuznets curve’s effects over the period of 1980–2010.	The Literature Review on Environmental Kuznets Curve. The economic specifications and methodology. Empirical results and discussions.	-	Kuznets Curve expresses the relationship between per capita income and income inequality as inverted U-shape. The hypothesis is that if per capita income increases, the income inequality increases too, but starts declining after a turning point. The Environmental Kuznets Curve shows the relationship between per capita GDP and measures of environmental degradation as inverted U-shape. The determinants of the Environmental Kuznets Curve are: the financial development, the energy consumption, economic growth and CO2 emissions. The hypothesis of the Environmental Kuznets Curve is that the economic growth increases the energy emissions initially, but after a certain level of per capita income, the economy starts to adopt environment friendly techonology due to the rising demand of cleaner environment. To test the existance of the Environmental Kuznets Curve in the presence of energy consumption it is used a series having natural logaritm form which is superior and provides consistent empirical findings. The time reference data used for Romania was 1980-2010. It was used the ARDL bounds testing approach.

27	J. S. Sage-Lauck and D. J. Sailor, "Evaluation of phase change materials for improving thermal comfort in a super-insulated residential building," *Energy and Buildings* , vol. 79, pp. 32–40, Aug. 2014.	A newly constructed passive house duplex was thoroughly instrumented to monitor indoor environmental quality metrics and building energy use. The use of phase change materials (PCMs), which store heat as they melt and release heat as the solidify.	Motivation and background. Overview of the phase change materials (PCM). PCM applications in buildings. The goals of the study. The methods used in the study. The analysis of the result.	The case study was made on a duplex house located in Portland, Oregon, in the USA. The standard used for the evaluation was ASHRAE.	The PCM reduce fluctuations in air temperature and shift cooling loads to off-peak periods and they have the ability to store energy which is characterized by its latent heat of fusion. PCM can be made of organic compounds, inorganic compounds or eutectic mixtures. The PCM properties desired in a passive house are: high thermal conductivity, high latent heat fusion, non-flammable and a melting point that is approximatevly equal to room temperature. On buildings, the PCM can be applied by direct impregnation into building materials or by encapsulation. The 3 scenarios used to evaluated the behavior of the house with PCM material were: simulation of the bulding with no PCM installed, simulation of the building with PCM having different melt temperatures and simulation of the building with PCM layer at the interior surface of the interior wall. Results state that using PCM with 25°C melting point may reduce the zone hours overheated by 50%. Reducing the melting point of the PCM below 25°C may have an adverse effect on thermal comfort. Placing the PCM on the interior surfaces of the interior wall will result in a reduction of the zone hours overheated by 60%.

28	I. Hazyuk, C. Ghiaus, and D. Penhouet, "Optimal temperature control of intermittently heated buildings using Model Predictive Control: Part I – Building modeling," *Building and Environment* , vol. 51, pp. 379–387, May 2012.	A possible way to obtain a low order model of the building's thermal behavior. Generate input/output data records by simulating a detailed model of the building instead of measuring them on a real building.	The dynamic modeling of a building. The model inputs characterization. The model parameter identification.	The chosen reference building was a detached house located in France.	In the state-space modelling is applied the principle of analogy between two different physical domains that can be described by the same mathematical equations. The building's thermal behavior is modeled as a linear electric circuit and the state-space equations are obtained by solving the circuit. In the state-space equations it can be applied the superposition theorem of the electric circuits. In the parametrical identification method used for the reference building, the model is represented as a nonlinear correlation between its parametes. To guarantee the optimality of the solution, the initial values need to be close to the optimal solution and the constrains need to be included in the algorithm in order to bound the physical values of the parameters. The representation of the model is obtained by time discretization of the continous transfer function model. To identify the transfer function model, the system must be in stationary initial conditions before applying the excitation.
29	S. B. Sadineni, S. Madala, and R. F. Boehm, "Passive building energy savings: A review of building envelope components," *Renewable and Sustainable Energy Reviews* , vol. 15, no. 8, pp. 3617–3631, Oct. 2011.	The most important building envelope elements and their latest development.	Walls, fenestration and roofs. Thermal insulation, thermal mass and phase change materials. Infiltration and air tightness. Building simulation software programs. Building envelope diagnosis. Building envelope maintenance.	-	The advanced wall technologies presented are: passive solar walls,lightweight concrete walls, ventilated or double skin walls and walls with latent heat storage. The types of glazing for fenestrations are presented: aerogel glazing, vacuum glazing, switchable reflective glazing, suspended particle devices film and holographic optical elements. The types of roofs discussed are: masonry roofs, lightweight roofs, ventilated and micro-ventilated roofs, solar reflective/cool roofs, green roofs, vaulted and domed roofs and photovoltaic roofs. There are methods for building envelope diagnosis like infrared termography, fenestration diagnosis, inflitration and air tightness diagnosis and envelope moisture diagnosis.

30	V. Badescu and B. Sicre, “Renewable energy for passive house heating: II. Model,” *Energy and Buildings* , vol. 35, no. 11, pp. 1085–1096, Dec. 2003.	Model to compute the heating demand for a three-zone passive house. The model is time dependent in order to take into account properly the thermal inertia of the very thick walls of the passive house's envelope.	The building's thermal load model. The thermal model for the ventilation/heating system. The thermal model for the solar collectors. Thermal targets and operation control. Preliminary results and discussions.	The analyzed building is Pirmasens Passive House from Rhineland Palatinate, Germany. As the article states, the detailed information about the meteorological parameters at Pirmasens PH location were missing. For the research it was used the meteorological data from Chemnitz, Saxony, containing information measured in year 2000. The paper states that there are 2 ideal hypothesis regarding interconnection between various elements of the heating/ventilation system which turn out to be 3. The 3rd ideal hypothesis refers to the heat providided by the solar collector to the heating/ventilation system.	The zones of the house similar in terms of temperature and relative humidity are the kitchen, the bathroom and the rest of the rooms. The definition of the space heating/cooling demand depends on the following parameters: the heat flux escaping the building envelope, the heat loss due to air circulating through the walls, the heat gain due to solar irradiation passing through the windows and the heat released by the building occupans or by household appliances. The time dependend heat transfer through walls was modeled by 1 dimensional time dependend heat transfer equation which was solved numerically by using a standard Netlib solver. In the model for the heat transfer through doors the thermal inertia of the doors was neglected. The heat transfer through windows has two components: the solar energy flux transmitted inside the building and absorbed there and the heat flux transferred by conduction through the window. The energy balance of the room takes into account the following: the heat fluxes transferred through separating elements of high thermal inertia, the heat fluxes through windows and doors, the thermal fluxes associated with internal heat sources and the energy fluxes entering and escaping the room through the air moved by the ventilation system. The model can be used to analyze the space heating demand for passive houses with arbitrary number of rooms and arbitrary space orientation.

31	M. G. Baldi and L. Leoncini, “Thermal Exergy Analysis of a Building,” *Energy Procedia* , vol. 62, pp. 723–732, 2014.	The description of the thermal exergy model of a building. The application of the exergy model on a real building.	Exergy as environmental impact value. Building impact on the environment. Equations. The thermal exergy model. The computational model. Discussion of the obtained results.	The analyzed building was a multi-unit residential building located near Florence, Italy.	Exergy represents the thermodynamic potential measure of energy or material flux with respect to an equilibrium state assumed as the reference state. The exergy analysis application as an evaluation parameter allows a complete thermodynamic assessment of a building energy use because it accounts the potential of energy carriers that cross the system boundary and their degradation in addition to the energy conservation equations. Each of the sectors of the energy flow receives an exergy input from the sector placed upstream and provides an exergy output to the sector placed downstream. The irreversibility due to energy conversion and transport or temperature differences leads to exergy destruction of each sector and of the corresponding exergy efficiency. The building is an open thermodynamic system which exchanges energy and material flow with the environment and it is modeled as a "black box" that needs exergy. The building is a transient open system, while the surrounding is a closed system and the environment is a closed system in thermodynamic equilibrium with the surrounding. The results of the building exergy analysis performed in the article state that 95% of the building's exergy is destroyed while 5% of the exergy is lost.

32	B. P. Jelle, "Traditional, state-of-the-art and future thermal building insulation materials and solutions – Properties, requirements and possibilities," *Energy and Buildings* , vol. 43, no. 10, pp. 2549–2563, Oct. 2011.	Investigate and compare the various properties, requirements and possibilities for traditional, state-of-the-art and possible future thermal building insulation, materials and solutions, their weaknesses and strengths, disadvantages and advantages.	Traditional thermal building insulation. State-of-the-art thermal building insulation. Nanotechnology and thermal insulation. Possible future building thermal insulation. Comparison of weaknesses and strengths.	-	The Polyurethane foam has the smallest thermal conductivity among the traditional thermal insulation materials, but it has the disadvantage of being very toxic in case of fire, because Polyurethane releases HCN (hydrogen cyanide). The most promising state-of-the-art thermal insulation materials are the vacuum insulation panels (VIP) and the aerogels due to their very low thermal conductivity. VIP's drawback is the fact that it's thermal conductivity increases with age because of the water vapours and humidity penetration into the pores. The gas filled panels (GFP) are a doubtful solution because their thermal conductivity is higher than of the VIP whose thermal conductivity is low due to the vacuum from the pores. The high thermal conductivity of the traditional thermal insulation materials lead to very thick building elements in cold climate areas in order to achieve the passive house and ZEB standard. The traditional thermal insulation materials are vulnerable to humidity and perforations. The conceptual thermal insulation materials have been designed to have very low thermal conductivity and to be robust with respect to aging, perforation, building site adaptions.

33	S. A. Memon, T. Y. Lo, and H. Cui, "Utilization of waste glass powder for latent heat storage application in buildings," *Energy and Buildings* , vol. 66, pp. 405–414, Nov. 2013.	Form-stable composite PCM was developed by utilizing waste glass powder as container for n-octadecane.	Experimental program. Results and discussion.	-	The ideal PCM has the following properties: high storage density, good heat transfer, small volume change, low vapour presence, no super cooling, long term chemical stability, non-toxic, non-flammable, self nucleating behavior and should have phase change temperatures in the human comfort zone. The selected PCM was n-octadecane because its phase transition temperature is in the human comfort zone and has high latent heat of fusion. The container of the PCM was soda-lime glass which represents 80% by weight of waste glass. The composite PCM was prepared by using vacuum impregnation method. The form stable composite PCM was tested for surface morphology, chemical compatibility, phase change behavior, thermal properties, thermal stability and thermal performance. The results show that the melting and freezing temperatures are for n-octadecane 27.4°C and 25.15°C and for n-octadecane-GP are 26.93°C and 25.03°C, which are close to the range of human comfort zone. The latent heat for melting and freezing for unit weight are for n-octadecane 229.9 J/g and 228.5 J/g and n-octadecane-GP 18.97 J/g and 18.95 J/g. The thermal conductivity of the cement paste with n-octadecane-GP is 0.62 W/mK and without n-octadecane-GP is 0.90 W/mK. The PCM with n-octadecane-GP is effective in reducing the indoor temperature and the temperature fluctuations, improving the indoor thermal environment. This material can be used in buildings for thermal energy storage purpose to reduce energy cost, scale air-conditioning and flatten the fluctuation of indoor temperature.

34	*Normativ general privind calculul transferului de masă (umiditate) prin elementele de construcție* . 2002. C107/6-02	Methods for calculation of the water vapors diffusion in the building elements in order to choose the optimal solution to ensure normal relative humidity of the building elements during the life cycle of the building.	Technical conditions and performance level of building elements in case of humidity. Calculation of the diffusion of the water vapors through the building elements. Constructive measures in order to avoid increasing the humidity inside the building elements.	The standard C107/6 was released in year 2002 and since then there is no knowledge of being upgraded. Some of the formulae presented in the standard seem to have mistakes at indexes leading to confusion of the designer who uses it.	The calculation method is based on the following hypothesis: 1. The thermal transfer takes place in a steady regime and is unidirectional. 2. All the thermal and physical properties of the materials are independent from temperature and humidity. 3. The air flow inside the building element or from the indoor environment to outdoor environment through the building element is not taken into consideration. 4. The superficial air layer from the building elements is taken into consideration as stated in the standard C107/3. In order to satisfy the requirements for hygiene and interior comfort in the building and to ensure the performance of the exterior and interior building elements, they should satisfy the following technical and performance conditions: the increase of mass relative humidity of the materials from the building envelope's structure due to water vapors condensation and avoid the progressive accumulation of water inside the building envelope every year due to condensation phenomenon.

35	*Normativ pentru proiectarea la stabilitate termica a elementelor de inchidere ale clădirilor* . 2002. C017/7-02	Prescriptions regarding the design of the opaque elements of the building envelope and of the separation elements in the residential buildings for thermal stability taking into account their thermal inertia and the thermal stability of the rooms.	Criteria and performance levels for apreciating the thermal stability in the building. The calculation of the thermal stability of the building. Constructive measures in order to ensure thermal stability in the room.	The standard C107/7 was released in year 2002 and since then there is no knowledge of being upgraded. Mistake in the unit of measurment: there is no such thing as "degree Kelvin". In the International System the temperature is measured in Kelvin. No performance levels during warm season in case of the thermal stability coefficient, respectively for cold season for the dephasing coefficient of the outdoor temperature oscillation.	The thermal stability during summer and winter is evaluated in the room which has the most unfavorable direction and which is considered by the designer as a reference room inside the building. According to the limitations imposed by the thermal stability, buildings are classified into 3 groups as following: "a", "b", "c", depending on the endowment or necessity of the ventilation and air conditioning system. In the calculation of the thermal stability of the building, the following parameters are analyzed: the damping coefficient of the amplitude of the outdoor, the dephasing coefficient of the outdoor temperature oscillation temperature oscillation and the thermal stability coefficient of the boundary element .