Market research of innovative technologies for EE and climate protection in historic buildings and areas throughout the BSB countries (Romania)

Introduction

1. Legislation in the field of energy efficient technologies in Romania (partner country)

The law 121/2014, modified and updated by the 160/2016 law regarding the energetic efficiency states that energetic efficiency is a strategic objective of the national energy policy and defines the objectives regarding the improvement of energy efficiency, the measures of improvement of energy efficiency in all the economic sectors, such as introduction of the energy efficient technologies, of modern systems of measure, the application of modern principals of energetic management, modern systems of measure and control, management of energy systems.

2. Analysis of the market of energy-efficient technologies in Romania (partner country)

An analysis of residential buildings, based on the survey conducted for the BPIE, revealed that heating energy represents approximately 55% of the total energy consumption of flats and up to 80% in the case of individual houses, and, depending on the climatic zone, a single-family dwelling consumes on average 24% more energy per square meter compared to an apartment within a multi-family building. Having this data, the types of improvements, technologies and techniques presented below, and many others, are part of the Romanian strategy for renovation to create and improve houses to be energy efficiency. It was chosen to prioritise the residential buildings constructed before 1960 and a large part of these buildings are or will be renovated between now and 2030.

2.1 Building scale (Energy efficiency)

- Building shell improvement – at least 3 methods to be surveyed by each partner (insulation placement, window replacement, the construction of vestibules etc.)

Building Shell Improvements refers to building improvements, constructed or to be constructed, by the landlord, at landlords' sole cost and it usually refers to the outside improvements of the building.

The thermal insulation has a significant effect on heating and cooling loads. The insulation can reduce the energy consummation, placed correctly. The most popular building thermal insulation materials include expanded polystyrene, extruded polystyrene, polyisocyanurates, polyurethane and mineral wool. But there are also hybrid isolation that uses ecological insulating materials like sawdust, cellulose (recycled newspapers) and wool. The materials for the insulation depends on where the insulation is placed. The external insulation consists in attaching the materials on the external walls of the building, for this type of isolation it is usually used polystyrene. Internal insulation consists in attaching materials on the internal walls of the building, but it is not recommended because it doesn't protect the walls from the cold, it is usually used the mineral wool.

Windows are an important source of heat transfer because of their relatively poor energy performance. When replacing the windows it needs to be taken into account the balance between admission of daylight and thermal issues such as wintertime heat loss and summertime heat gain. For an efficient window replacement, are recommended windows with warm edge thermoplastic spacer (TPS) and/or technology featuring polyisobutylene (PIB) that can make a significant contribution to a high-performance building envelope. Warm edge TPS technology can improve the energy performance the window. At the same time TPS is flexible so that the windows are able to accommodate stress from wind and impact, and there is a lower risk for windows to shatter or to lose their seal and insulating interior gasses. Windows with high-performance glazing system will admit more light, but less heat than a typical window, allowing for natural light without negatively impacting the building cooling load in the summer. Another thing that we must consider when replacing the windows is the proportions and character of the buildings and historic streetscapes.

Roofs are also a component that is important factor to consider when trying to build an energy efficient house. Depending on the material, the roofs can absorb more heat. Metals roof can be made from materials like copper, steel, or aluminum that are thin and don't absorb and retain the heat. It is also advised to use a light-colored roof. Tile roofs holds heat during the cold seasons and keep the house interior cool during the summer. There is also isolation of the roof that uses usually mineral wool.

- Natural cooling techniques - at least 2 techniques to be surveyed by each partner (air movement control, cross ventilation techniques, etc.)

Natural ventilation or passive ventilation, uses outside air movement and pressure differences to cool and ventilate a building, it provides and move fresh air without the use of mechanical methods to maintain a comfortable indoor temperature. In other words it cools the building by carrying warmed air out and replacing it with cooler external air. Passive cooling techniques uses openings like windows, doors, solar chimneys, wind towers and trickle ventilators and it depends on climate, building design and human behavior.

Cross ventilation or wind effect ventilation is a natural technique of cooling. This system relies on wind to force cool exterior air into the building through an opening, like a window, and it forces warm interior air outside through a roof vent or higher window. In other words, this technique helps increasing the flow of cool air coming in and assist the hot air going out. When wind flows into the building, each side of the building is hit with different amounts of pressure that forces the air toward the lower pressure side of the building in the attempt to reach equilibrium. Below, in figure 1 is it presented how this technique works.

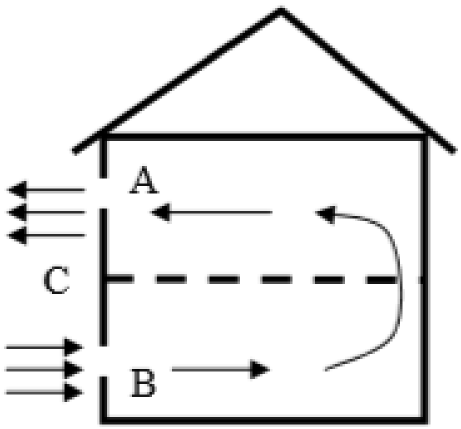

Figure 1

There is also the ventilation through devices located on the roof. This type of natural cooling consists in ventilation chimneys or any other opening in the roof. It is based on the accessional air movement principle due to the differences between indoor and outdoor temperature. In order to control the intake of the air, these chimneys are equipped with adjustable shutters. In figure 2 we have different examples of chimneys and the movement of the air through them.

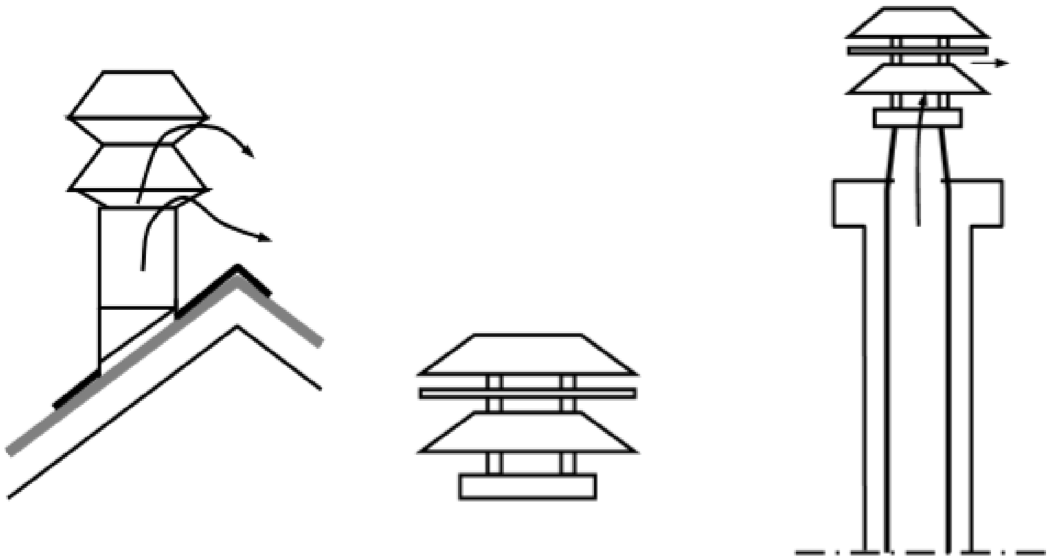

Figure 2

- Natural lighting techniques - at least 3 techniques to be surveyed by each partner (side lighting, overhead lighting, combined)

Natural lighting techniques consists of systems, technologies, and architecture to ensure that the building has a large amount of daylight and to reduce energy consumption.

Overhead lighting technique, also called top lighting, consists in illuminating the building from above. Skylights is such a design, allowing the daylight into the building through an opening in the roof. This type of skylights is passive. Active skylights use a mirror system within the skylight that tracks the sun and are designed to increase the performance of the skylight by channeling the sunlight down into the skylight well. Another type of overhead lighting are the tubular daylight devices that employ a highly reflective film on the interior of a tube to channel light from a lens at the roof, to a lens at the ceiling plane. Roof monitor (figure 3) and saw tooth systems consist of vertical or sloping openings in the roof used to capture light. These kinds of openings are designed to reflect natural light at certain moments of the day or year. The roof monitor system allows natural light in the building during winter, but not during summer.

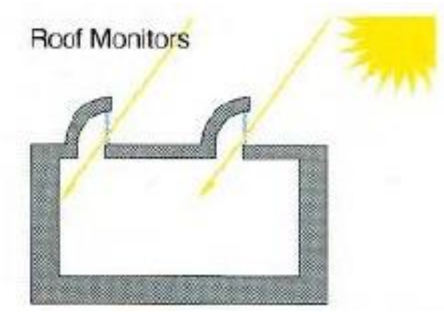

Figure 3

Side lighting techniques, or light shelves, are designed to distribute the daylight equally in the building by using the traditional windows. These types of systems reduce the light near the windows and increasing the light in areas far from the windows, generally onto the ceiling. The devices of such a system are placed horizontally in a window above eye level (figure 4). Mirrors, holographic sheets or Holographic Optical Elements (HOEs) redirect the natural light, improving the distribution of light inside building. Figure 5 represents the performance of the redirection devices during seasons. The optical holograms separate the majority of light visible from the infrared part of the solar spectrum, they are an efficient means of both controlling natural light and optimizing natural light gain. Louvres and blinds are also systems designed to capture the sunlight entering into the front part of a room and redirect it towards the back. They are made from numerous horizontal, vertical or sloping slats that have on impact on glare and visibility, but also on effective transmittance, absorption and reflectance of a window-blind, but it depends on the rotation angle, shape, size, configuration and color of the slats. Also, louvres can reduce the cooling loads in the building. Figure 5 represents the performance of such devices during different seasons.

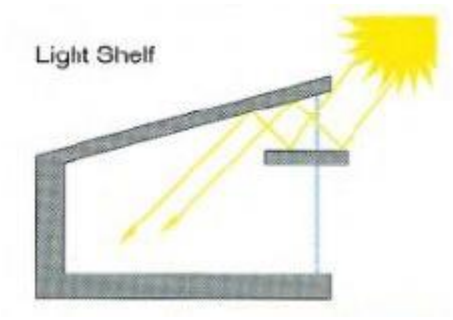

Figure 4

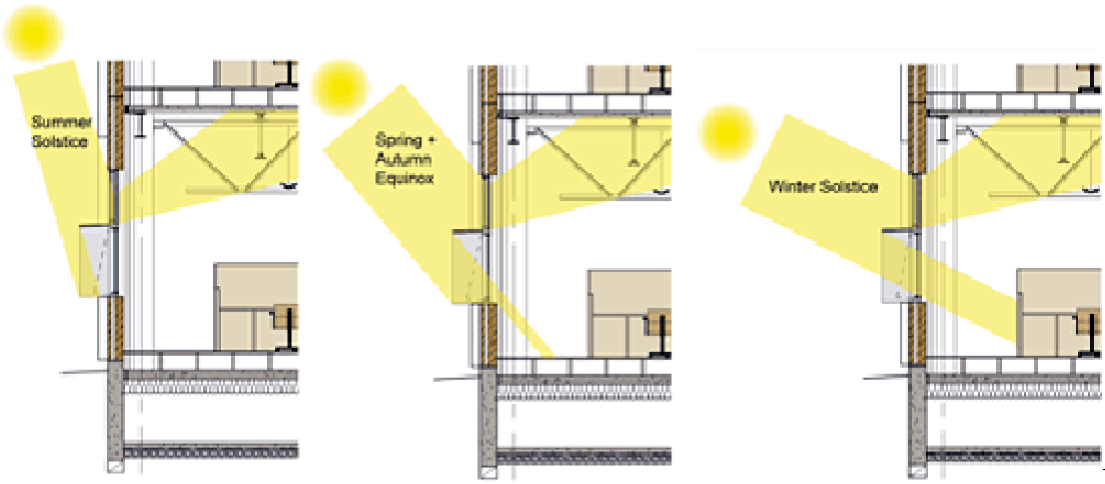

Figure 5

Overhead lighting and side lighting techniques can be combined for an efficient illumination of the building.

- Energy efficient heating and cooling systems – at least 1 system to be surveyed by each partner (such as micro-CHP and other)

Micro combined heat and power or micro-CHP is a technology that generated heat and energy, from the same energy source for individual buildings or houses, as presented in figure 6. The advantage of this kind if technology is that the energy in the fuel is almost fully utilized. Currently micro-CHP systems are currently powered by mains gas or LPG, that are fossil fuels, not renewable energy sources, still this technology is considered a low carbon technology because it is more efficient than just burning a fossil fuel for heat. There are three main micro-CHP technologies depending on the way in which they generate electricity. Stirling engine micro-CHP is a new technology in which the electrical output is small relative to the heat output. Internal combustion engine CHP consist in a truck diesel engine that is modified to run on natural gas or heating oil, connected directly to an electrical generator. Heat is then taken from the engine’s cooling water and exhaust manifold. Fuel cell CHP technology is not widely available to consumers and it works through fuel cells that work by taking energy from fuel at a chemical level, not burning it.

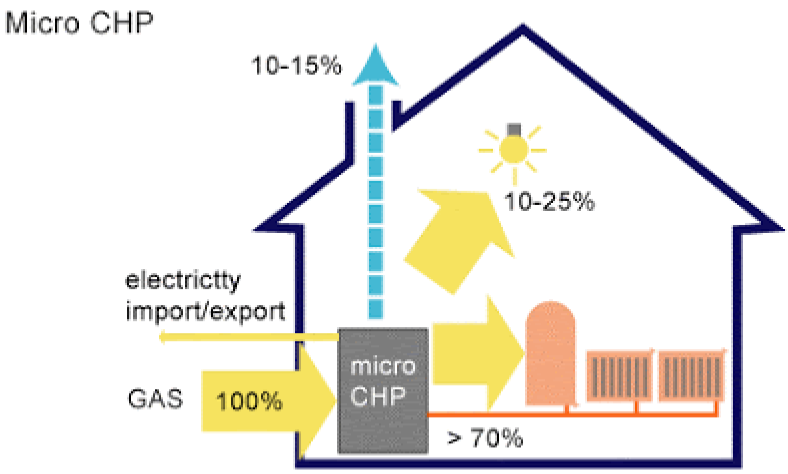

Figure 6

- Rational use of energy - at least 2 systems to be surveyed by each partner (Building Energy Management Systems (BEMS) and building automations, weather control)

Building Energy Management Systems or BEMS is a technology that monitors and controls the building’s energy needs, like energy management, heating, ventilation and air conditioning (HVAC), lighting, fire alarm system, or security measures. BEMS can be used in residential or commercial buildings. The components of this technology are a central station and a connection, commonly provided through the internet, of the principal operator position to remote outstations or controllers. The controller has an interface with the remote outstations and can control various functions of these outstations depending on the client's requirements.

Building Energy Management Systems (BEMS) can also refer to Building Automation (BA), Building Automated Control Systems (BACS) and Building Automation Technologies (BAT).

There are three main areas of transition can be identified in these different systems: model-based controls, semantic tagging and smart building applications. The model-based control system is an automated building-control software that predicts the necessary behavior of a building based on the predicted occupancy, weather forecast, etc. In other words, this system is able to look further ahead and adapt the building systems in anticipation to the forecast. Semantic tagging system is the labelling of all components in an entire building's technical system, allowing them to be integrated in a system and communicate with each other.

2.2 RES (building scale)

At the moment the renewable energy in Romania is around 25%, reaching our goal for the 2020 renewable energy. The country has a potential of energetic resources like biomass, hydro or wind energy. We should also mention that the production of renewable energy in Romania is significant, ranking the country second in Southeast Europe, after Poland. With an increase of only 3.1% between 2000 and 2016, the average established in Europe was not exceeded, but an increase of 7.8% between 2015 and 2016 can be observed, which suggests an active involvement in the use of renewable energy in Romania the in recent years.

- Solar Energy Systems - at least 3 techniques to be surveyed by each partner (from multicrystalline silicon, from polycrystalline silicon, based on cadmium telluride)

Photovoltaic (PV) solar cells based on cadmium telluride (CdTe) represent the largest segment of commercial thin-film module production worldwide. This type of Solar Energy System is considered a thin-film technology because the active layers are just a few microns thick. Transparent conducting oxide (TCO) layers such as SnO_2 or Cd_2SnO_4 are transparent to visible light and highly conductive to transport current efficiently. Intermediate layers, such as CdS, helps the growth and electrical properties between the TCO and CdTe. The CdTe film acts as the primary photo conversion layer and absorbs most visible light within the first micron of material. Together, the CdTe, intermediate, and TCO layers form an electric field that converts light absorbed in the CdTe layer into current and voltage. Metal is placed on the back to form electrical contacts. In production, all these layers are deposited on incoming glass and processed into complete solar panels in just a few hours.

Monocrystalline solar cells are made out of silicon ingots, which are cylindrical in shape and the solar panels have the highest efficiency rates since they are made out of the highest-grade silicon. This type of solar panels produces up to four times the amount of electricity as thin-film solar panels.

The polycrystalline silicon, which also is known as polysilicon (p-Si) and the solar panels tend to have slightly lower heat tolerance than monocrystalline solar panels, but it also means that they perform slightly worse than monocrystalline solar panels in high temperatures. The process used to make polycrystalline silicon is simpler and cost less, raw silicon is melted and poured into a square mold, which is cooled and cut into square wafers.

- Solar thermal/PV systems - at least 2 systems to be surveyed by each partner (flat and tubular)

Photovoltaic systems or PV systems are a renewable energy technology which transforms the energy from the sun into electricity using photovoltaics solar cells. The solar panels made from PV cells provide a reliable green energy source by collecting solar energy from the sunlight and converting it into electricity. The reflection of the sunlight will create an electric field across photovoltaic systems, causing electricity, direct current (DC) to flow and the electricity will be transported to an inverter, which will convert DC into alternating current (AC) is used for the household appliances, as shown in figure 7.

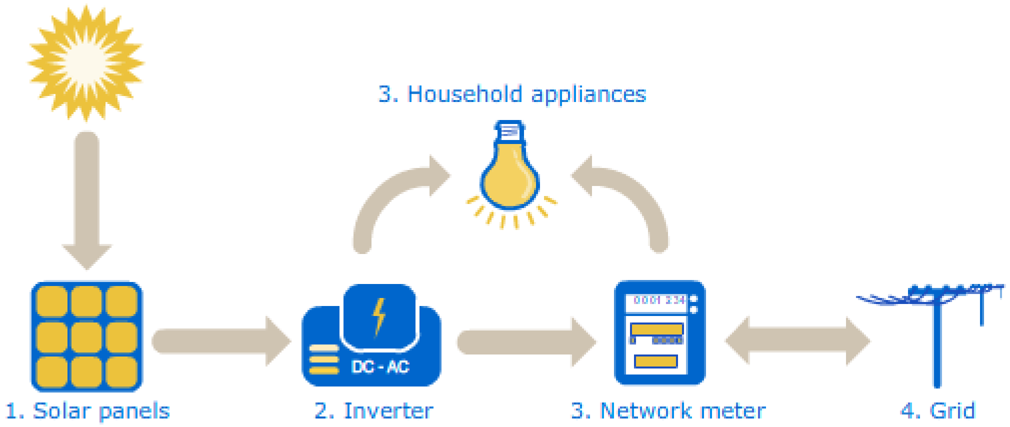

Figure 7

The solar thermal panels use the sun only to heat up water. Solar thermal uses renewable energy from the sun, absorbing its heat with panels that are called collectors. The heated water then runs from the collectors to the hot water cylinder. There are two types of solar thermal panels, tubular and flat, that looks like a PV system. The flat panels (figure 8) includes an absorber panel attached to multiple copper pipes through which the water passes. These copper pipes are encased in a metal frame that is surrounded by insulation to support the retainment of the collected heat. However, the tubular panels or evacuated tube collectors (figure 9) are more efficient because the tubes are designed to avoid heat loss. This type of solar thermal panel is made of a heat pipe surrounded by a glass tube. These are under a vacuum and having something under vacuum is a better heat retention than air space. In addition, the heat pipe is pressurized, which allows the fluid to boil rapidly.

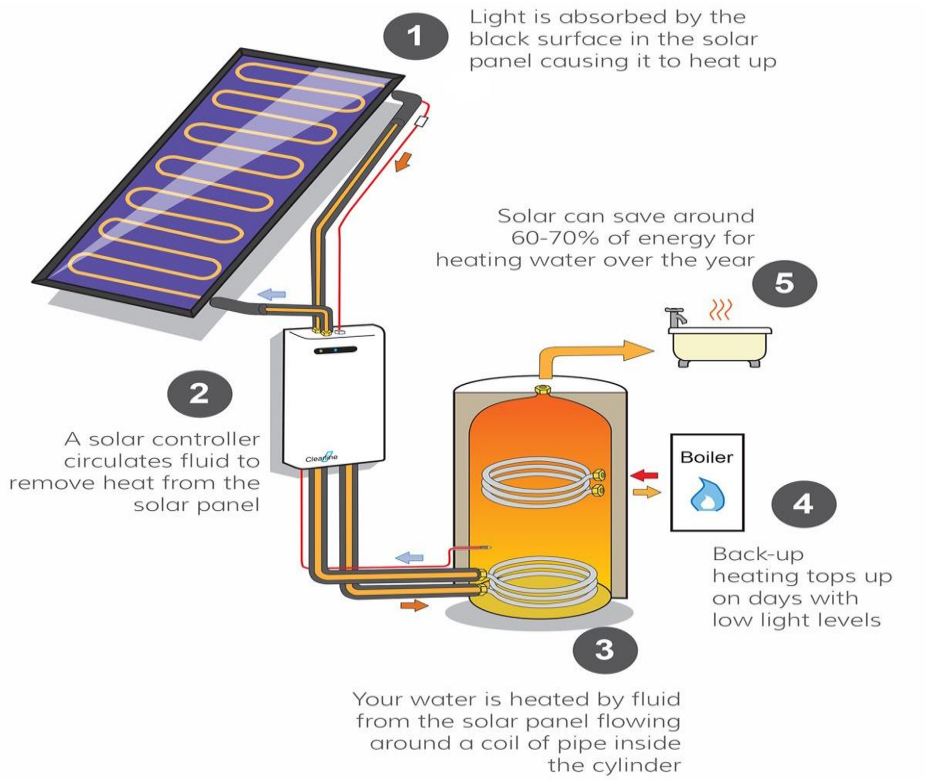

Figure 8

Figure 9

- Small scale building-mounted wind turbines

Small wind turbines, also called urban wind turbines, are turbines that are specially designed for built environment, and can be located on buildings or on the ground next to buildings. The turbines have been adapted for the wind regime in the built environment and have various designs.

Horizontal axis wind turbines or HAWTs (figure 10) are designed for open areas with smooth air flow and few obstacles. The propeller-type rotor is mounted on a horizontal axis and the rotor needs to be positioned into the wind direction by means of a tail or active yawing by a yaw motor.

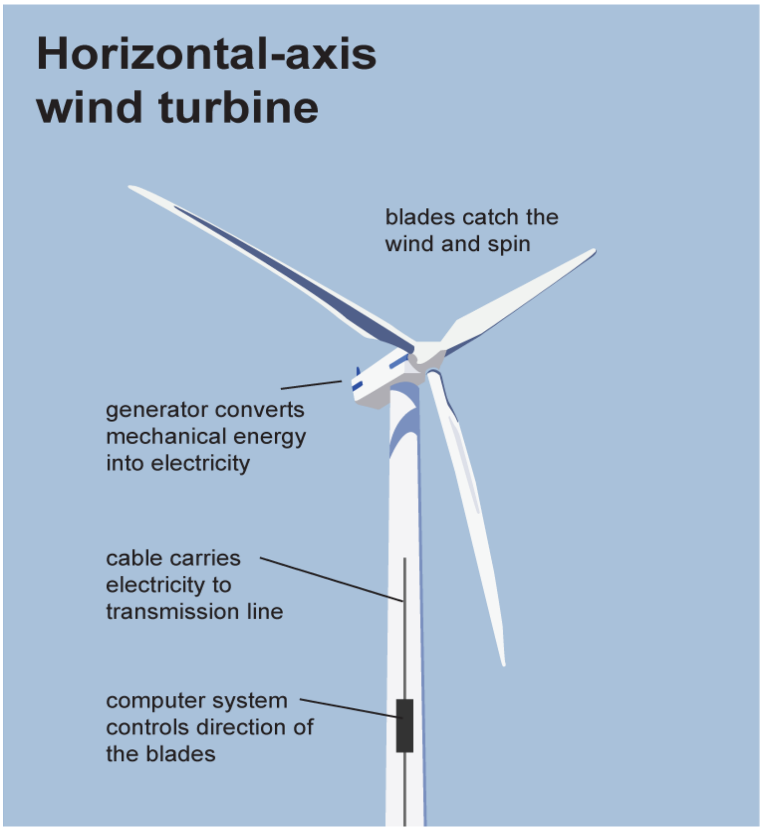

Figure 10

Vertical axis wind turbines, or VAWTs (figure 11) are typically developed only for the urban deployment. It does not need to be positioned into the wind direction and the changes of the wind direction have fewer negative effects, but the production of electricity is lower than HAWTs.

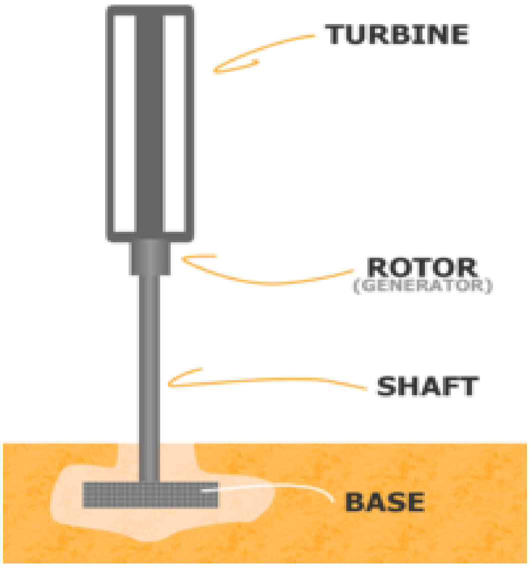

Figure 11

Energy Ball, or Venturi (figure 12), is horizontal axis turbine with the tail but with an innovative rotor construction and it has six half-circular blades forming a spherical construction.


Figure 12

Wind Wall is also a horizontal axis turbine suitable only for locations were the wind from one direction strongly prevails because the axis is fixed to the roof so that it can catch the wind from just one direction.

- Heat pumps - at least 2 types to be surveyed by each partner ("Air — water", "air — air")

The air to air heat pumps extracts the heat from the outside masses of air and transfer it to the pump's indoor unit compressor. This process is based on the principle of heat transfer, which is supported by the pump's refrigerant property to lower the temperature of the air that is passed through the device. The thermal value of the incoming air is below the ambient temperature level, which leads to the thermal isolation of the air heat. The system can be reversed during the summer to enable cooling.

Air to water heat pump (figure 13) takes the heat from the outside air and transfer it to a water-based system. The created heat can be used for space heating or as a hot water supply for the house. Air to water heat pumps are among the most efficient air source heat pumps on the market. Although this type of pump runs on electricity, it mainly uses replenishing green energy. It captures low grade air, which is then transferred within the system, and generates optimal heating and hot water for your home.

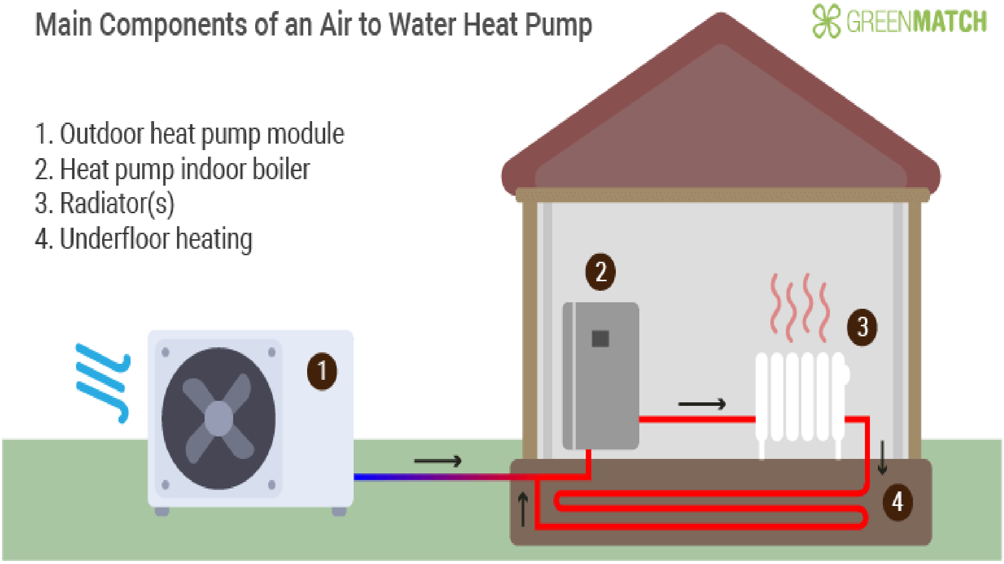

Figure 13

Water to water heat pumps (figure 14) use the solar energy stored by water from the groundwater or from water from rivers, lakes, to heat the buildings and provides hot water for the household. From all the types of heat pumps this type, at the moment, has the best performance. However, for this type of heat pump it is important the location, the composition and the quality of the water. To implement this system, we need two wells. One will serve as a water source, and the other can be used to discharge water from the heat pump. From experience it is found that where we find the quantity of water with enough ease, there are problems with the discharge, due to the high levels of water from the soil. In these cases, we need to drill several wells of smaller depth to be able to discharge the amount of water used by the heat pump. Also, water to water heat pumps use the solar energy

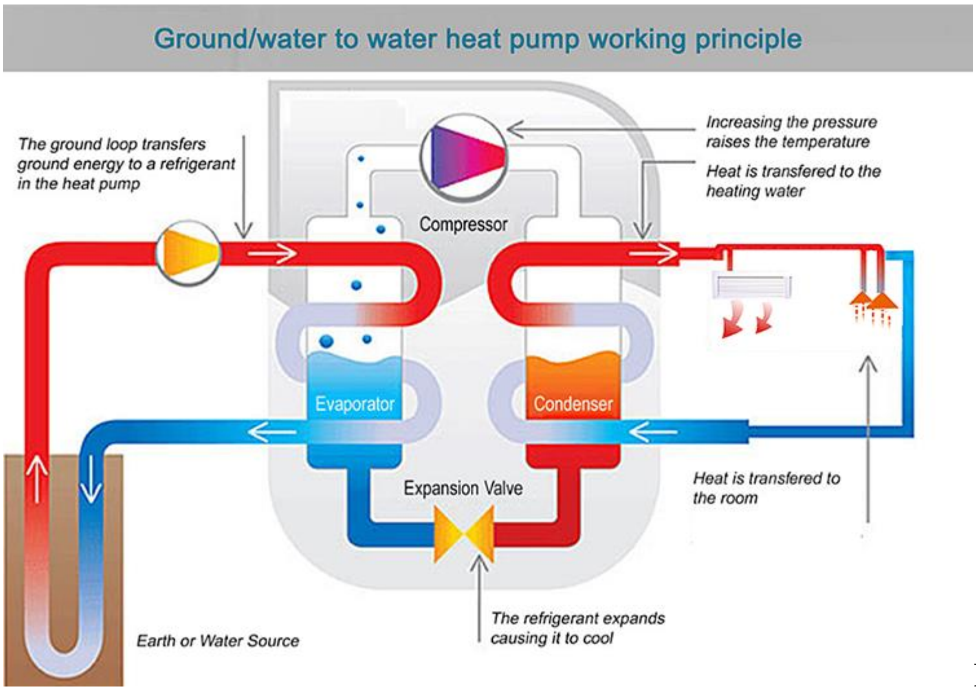

Figure 14

There are two types of soil water heat pumps. The soil water heat pump with horizontal collectors has pipe coils (figure 15) placed at a depth of 1.3-3.3 meters through which a working agent circulates, which takes the solar energy accumulated in the ground and transports it to the heat pump. Ideally, the pipes should be buried in sand or humus, such systems cannot be placed on rocky soil. The other type has vertical collectors (figure 16) in one or more parallel wells with a depth of 100 meters, a probe is inserted through which a working agent (of the water type with antifreeze) circulates. This type of collector occupies a small space. The functioning of the system is based on the fact that at a depth of 15 m the geothermal temperature is constant throughout the year; as the depth increases, the soil temperature is higher. In the case of heat pumps with the collection of energy from wells at depth (closed circuit), it is necessary to drill a well in the ground, using as a transport agent of energy at the heat pump a mixture of circulating water and glycol through a hose inserted into the drilled well.

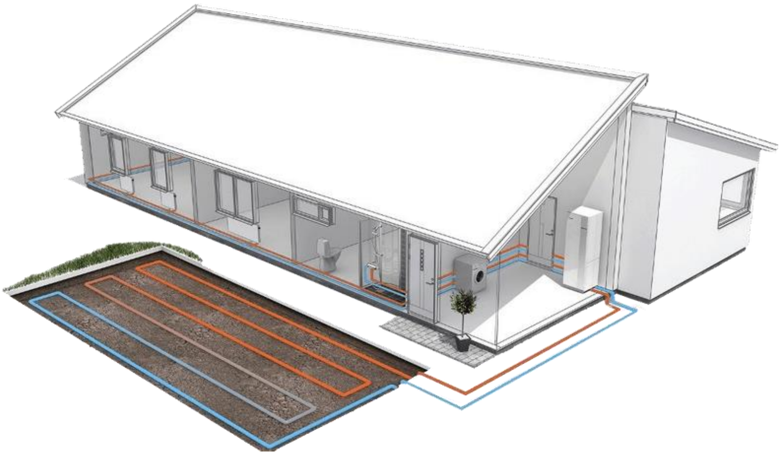

Figure 15

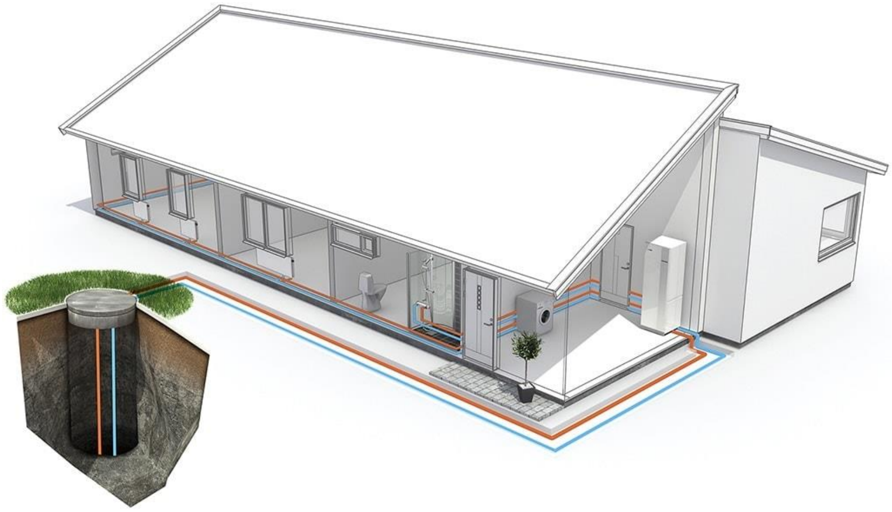

Figure 16

- Biomass

Biomass is an organic material that comes from plants and animals that can be turned into fuel, biofuel, to supply heat and electricity and transport fuels. Bioenergy can be obtained from many forms of biofuels. Biomass comes from many sources like harvest residues, trees killed by disturbances such as fire, diseases or insects, trees that are grown specifically to provide biomass for conversion to bioenergy.

2.3 Community scale

- Sustainable transport – car clubs, travel reduction measures, public transport improvements

Car clubs provide vehicles to hire on a short-term and allow people who do not own a vehicle, but to use one at their convenience. There are two models of car club. The

Fixed-Point car club means that each car has its own designated bay and has to be returned to that bay by the end of the hire period. While the in the Free-Floating model the car doesn't have a designated bay and can be returned to any other bay permitted by a participating local authority.

Regarding the travel reduction measures, people are encouraged to travel in a suitable way to work, school, or any other place by public transportation, cycling and walking a part of the route. For children there are measures like school bus or pedestrian and cycle training.

To improve and encourage public transport there were takes measures like having better vehicles, better seats, Wi-Fi in the public transport. Having more roots and making them more frequent. Making vehicles accessible for the elderly, disabled, and mothers with children by having low-floor vehicles.

4. Proposals on the use of energy efficient technologies on examples of historical objects of the Black Sea Basin

Many buildings have historical and/or cultural value. As a consequence, there must be taken care on how these kinds of buildings are renovated because there are restriction on the type of renovation that can be undertaken. Still, minor and moderate renovations may often be feasible in case of heritage buildings.

Through an EU funded project, a historical building in Iasi was restored that was intended to be the ***Municipal Museum*** https://www.interregeurope.eu/policylearning/good-practices/item/2084/energy-efficient-consolidation-restoration-of-a-historical-building-city-museum-of-iasi/. In the restoration process was taken into account the building elements, which were kept as much as possible like the original. The energy efficiency was another element considered in the restoration process. Because the building was intended to be a museum it had two elements that had to be considered: the conservation of the museums exhibits and the comfort of the visitors. There were used techniques to control the daylight, energy efficient windows to increase the natural heat.

Another building in Iasi that was restored is a monument of the city, the Palace of Culture under the governmental project ***"The rehabilitation of historic monuments in Romania,"*** - https://www.interregeurope.eu/policylearning/good-practices/item/2723/the-rehabilitation-of-historic-monuments-in-romania-palace-of-culture-iasi/ funded by the Council of Europe Development Bank and implemented by a project management unit with the Ministry of Culture. The building respects the historical and modern requirements, providing quality spaces from the energy efficiency point of view. Some of the measures regarding the energy efficiency that were used are: the insulation of the entire building and the materials used for insulation were natural, wool for example, installing a cooling air station activated with sensor technologies to prevent losses, techniques to control the daylight.

5. List of technologies, producers and distributors available and operating in Romania

Code CAEN 4329 – isolation

Code CAEN 4332 – for works of carpentry – replacing windows

Code CAEN 4391 – roof building

Code CAEN 4322 – ventilation chimneys, solar panels, micro – CHP systems

Code CAEN 2811 – wind turbines

Code CAEN 2813 – fabrication of aer pumps

Code CAEN 2912- montaging of heat pumps

Conclusions

As addressed in the European Portal for Energy Efficiency in buildings https://www.buildup.eu/ "*the historic buildings can be considered the symbol of European cities, towns and villages; entire districts are a unique proof of the European cultural heritage. Currently, about 35% of the EU's buildings are over 50 years old and almost 75% of the building stock is energy inefficient*". According to the Methodology-Gonzalez-Bouillard- "*many countries perceived the fact that historic buildings, particularly those with special protection, should be exempt from having to be equipped with new energy efficient technologies*."

Therefore, there is an increased effort in identifying not only new technologies but also new approaches in addressing not only the preservation but also the improvement of the energy efficiency of the historical buildings as an integrated part of reaching the goals of sustainability. Although "*the renovation of existing buildings has the potential to lead to significant energy savings, possibly reducing the EU's total energy consumption by 5-6% and lowering CO_2 emissions by about 5%*" the efforts of implementing the EE sollutions should also be coordinated with the innovation tools that are designed by the academia that can be transformed in new business for the private sector.
The historic buildings are an integrated part of our heritage hence the improving the energy performance of those buildings is a first step in providing users with current standards of comfort, as a crucial requirement to ensure the continued use of historic buildings over time.