Energy Sources for a Sustainable Future: Status and Perspectives of Application in the Republic of Srpska in Bosnia and Herzegovina

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Abstract

In order to provide a continuous supply of energy to consumers and ensure the standard of living of people in the transition period until 2050, it is necessary to develop improved or new technologies based on fossil fuels, with an increase in energy efficiency (saving and rational use of energy, reduction of distribution and other losses), as well as an increase in the share of production of useful forms of energy from renewable sources, with further encouragement of the development of co-generative and trigenerative systems. Strategic plans and programs for the use of renewable sources are being created, as well as directions for eliminating the main shortcomings of conventional power

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plants. The concept of planning "energy for the future" under the influence of various lobby groups can often lead to the creation of false perceptions or illusions. Some of them are analyzed within the framework of this paper. Within this paper, an analysis of the state and perspective of the use of some of these technologies in the territory of the Republic of Srpska as an entity within Bosnia and Herzegovina is given. Special emphasis is given to the segment of planning energy sources for a sustainable future in the light of the energy transition and liberalization of the energy market in Bosnia and Herzegovina. A special segment is devoted to the analysis of legal legislation in the field of energy in the Republic of Srpska and Bosnia and Herzegovina as a whole. At the end of the paper, a presentation of concrete goals until 2030 for the activity of electricity production at the level of MH Elektroprivreda Republika Srpska is given.

Keywords: Energy sources, state analysis, application perspectives, planning.

1 Introduction

Due to its easy transformation into other forms of energy, as well as the possible transport over longer distances through the transmission network (voltage levels 110 kV, 220 kV and 400 kV), electricity is extremely important for the economic development of every country. Empirically, it was established that electricity consumption per capita is one of the key parameters, which indicates the development of the national economy and the standard of living of the people of a certain country. Most forecasts today show that in half a century, the number of inhabitants on earth will double, before stopping at 12 billion, which requires the provision of additional energy.

All previous projections of energy sources in the future have shown that fossil fuels will continue to be a significant source of energy in the coming period. Forecasts from 2004 on the direction of world energy in the future showed that energy needs in the next two decades in developing countries will double, since the population and economy in developing countries are growing faster than in industrialized countries. Finding ways that will enable development and ways to meet the growing world energy needs should simultaneously mitigate the possible impacts of energy supply and use on the environment, while ensuring the long-term quality of life on earth [1].

Requirements for the continuous provision of energy needs in sufficient quantities for industrial plants, transportation and the standard of living of people require the development of new technologies based on fossil fuels (fluidized bed combustion plants, combined cycles with gasification, combined cycles with natural gas as fuel, fuel cells, technologies with external heat energy – Stirling machine, thermophotovoltaic conversion, thermal-electrical converters with alkali metals), as well as increasing energy efficiency. (saving and rational use of energy, reduction of distribution and other losses).

By analyzing today's current forms of conventional (thermal power plants, thermal power plants – heating plants, gas power plants, nuclear power plants and large hydroelectric power plants) and unconventional energy sources (such as small hydroelectric power plants, active thermal and photovoltaic use of solar radiation, wind, ambient heat, biomass and waste, geothermal energy), it can be determined that there are certain deviations from the general properties (in the form of certain improvements or deterioration) in each of them [2÷5]. The connection between the use of certain energy sources and savings and more efficient use has a double importance. On the one hand, the rational use of energy is a direct means of reducing the total energy consumption and thus the impact on the environment, and on the other hand, special designs of devices and plants for energy use increasingly enable the participation of non-conventional or new renewable energy sources.

The energy system in sustainable development is defined according to six compatibility criteria: compatibility with the environment, intergenerational compatibility, consumption compatibility, socio-political compatibility, geopolitical compatibility and economic compatibility. The goal of research on sustainable development is to integrate ecological, economic and social dimensions into the socio-ecological system, which is further managed, while maintaining the necessary state of balance (sustainability). Sustainable development is not limited to a clearly defined equilibrium situation, but corresponds to a more dynamic process, in which priorities and actions are continuously redefined in accordance with the needs and wishes of the observed energy consumption. The primary function of sustainable development indicators is the evaluation, assessment and state of the three dimensions of the socio-ecological system (society, economy and environment), in which sustainable development must be more strongly reflected in inter-dimensional relations than in intra-dimensional relations.

Starting from the main components of sustainable development in the field of energy, such as availability, accessibility, acceptable price, energy security, energy efficiency, environmental acceptability and possible risks, it is necessary to additionally stimulate the production of useful energy produced and used in a way that simultaneously helps the development of humanity over a longer period of time. Energy must be available and acceptable as a supply service, but also available and reliable as an energy service. On the other hand, there is no technology that is not risky, that has no waste and that does not affect the environment, so it does not make sense to talk in isolation about a single better or worse technology for transforming primary into useful forms of energy. It is better to compare the characteristics of one technology or energy service with possible alternative solutions.

Research and development of innovative energy technologies, as well as their promotion and use, rely on public funding and funding from the private sector. This cooperation should be deepened. Part of the funds to support research and innovation should be provided through European funds for development and research (Horizon Europ, Interreg Danube, Erasmus, WIBIF, Innovation Fund, IPA ...), through participation in projects, but also through the Innovation Fund from taxes on CO_2 emissions, by entering the EU Emissions Trading System (ETS system). The revision of the ETS Directive established a financial mechanism to support the modernization of the energy sector and industrial facilities for the period 2021–2030. The funds of the Innovation Fund are used for investments in: modernization of industrial production, production of electricity from renewable sources, improvement of energy efficiency, energy storage and modernization of energy networks, energy efficiency in transport, buildings, agriculture and waste management. In the initial phase, this fund is available only to EU members, and predominantly to those whose GDP is below 60% of the European average, Bosnia and Herzegovina needs to meet the conditions to enter the EU ETS, so that this fund is available to research and development institutions.

2 Basic Terms, Definitions and Concepts

Energy, as a property of the system, represents a scalar physical quantity measured in joules ($1\ J = 1\ kgm/s^2$). As such it is additive, and the total energy, whereby the sum of all energies of all systems in the universe, is a constant quantity. The connection of humanity and the projection of its destiny in the future is connected with energy. The basis that defines the growth of every society is the solution to the issue of energy production, transmission, accumulation and innovation. Any energy imbalance is reflected in growing differences between the rich and the poor [6, 7]. Electricity and electricity supply have a special status, followed by thermal energy and its distribution.

Most of the available energy comes from the Sun (thermonuclear reactions and solar radiation), followed by the energy accumulated in the Earth

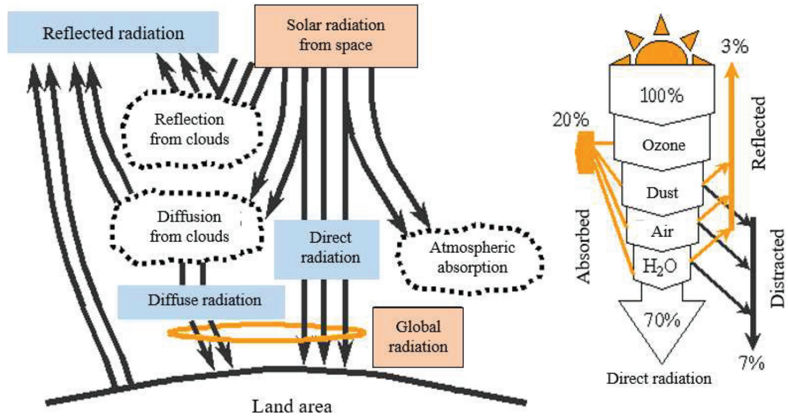

Figure 1 Mean radiation balance at the global level, [8].

(the temperature gradient of the Earth), as well as the energy that is the result of the mutual action of the gravitational forces of the Sun, Earth and Moon (the change in the potential energy of the sea due to gravitational forces). Of the total energy of solar radiation, only a small part reaches the Earth (1.05·109 TWh/year), Figure 1. It should be noted that even this annual energy contribution from the Sun is greater than the total known world reserves of coal and oil. The basic forms of indirect transformation of this energy are photosynthesis (the energy of solar radiation is transformed into the chemical energy of fossil fuels, and food for humans and animal life is provided by ongoing photosynthesis), evaporation of water from the surface of the sea, lakes and rivers, as well as from the soil and plants and the flow of air and water, and then condensation at a certain height leads to precipitation, which is a source of potential energy of water accumulations, while a smaller part serves for direct heating of the environment. Finally, as a consequence of the temperature differences of the air (wind) or water (sea currents), part of the kinetic energy can also be transformed into a useful form of energy.

As a consequence of the heat accumulated in the dry rocks and fluids of the Earth's crust, there is continuous heat radiation from the interior of the Earth (geothermal energy), either in the form of hydro geothermal (accumulated in fluids – water and gases) or petro geothermal energy (accumulated in solid rocks), Figure 2.

The temperature and pressure of the molten matter in the Earth's core is 5500 K and 345·109 Pa. Another important parameter for using the Earth's internal thermal energy is the so-called thermal gradient which for the Earth's

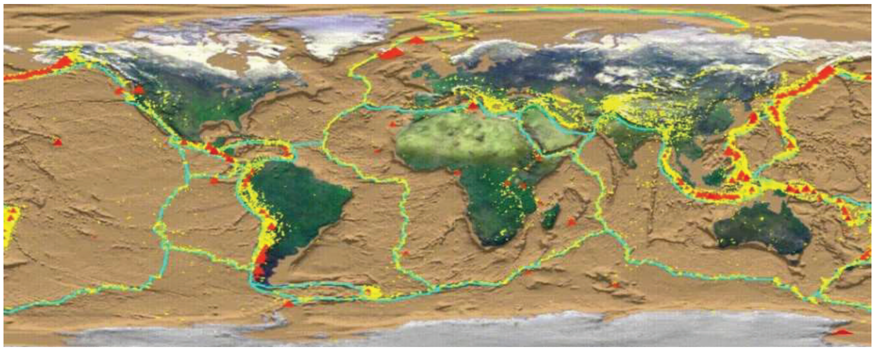

Figure 2 Temperature distribution inside the earth and surface effects of the earth's internal thermal energy, [8].

crust is 1 K for every 33 meters. The heat of the Earth can be used as a source of hot water and steam, as geothermal energy of dry rocks and by using heat pumps.

The consequence of the gravitational force between the Sun, the Moon and the Earth, which represents the energy of gravity that affects the water level in the sea, and the consequence of which is sea changes – tides, which carry kinetic energy. This third source of energy on Earth determines the change in the potential energy of the sea (tides), Figure 3. The variation in sea level is different and, depending on the geographical position, amounts from a few cm to 16 m. According to some estimates, the total tidal energy is about 23,000 TWh per year. It should be noted that today's level of technological development enables the technically and economically usable potential of sea level oscillations over one meter, which represents only a small part of the total energy.

Energy can take different forms, so it can be potential, kinetic, thermal, electromagnetic, chemical, nuclear, mass energy. Energy is a quantized quantity, so the change in energy cannot be less than some smallest amount (a quantum of energy). It is related to time, so it is less determined in a short time interval than in a long one. The energy of a technical system composed of a large number of particles is related to entropy, that is, to the number of different states it can take. The system will more often have energy that is realized in a number of different ways.

Reflections on the way energy reaches the Earth lead us to the conclusion that regardless of the form of energy in which it is stored, it is almost always about the same source: The Sun and its radiation. Solar energy is stored in

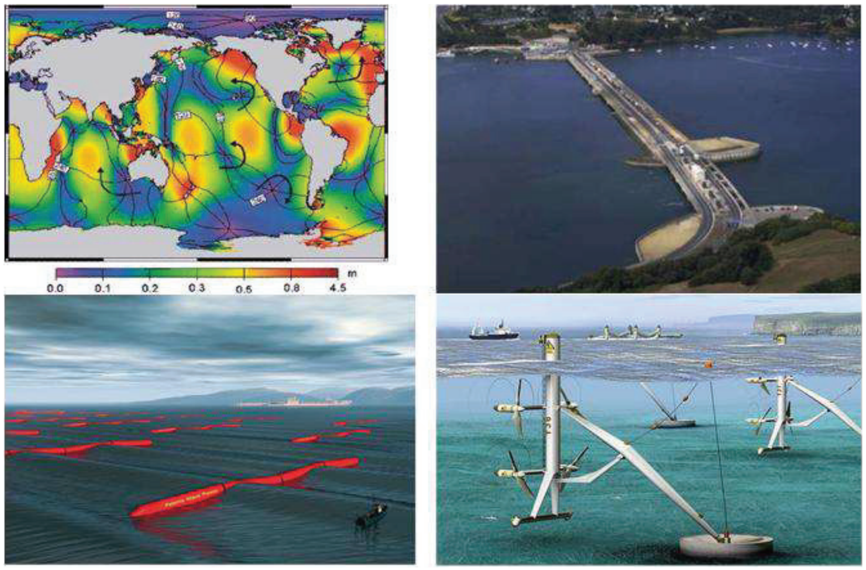

Figure 3 Energy of tides, sea currents and waves, [8].

coal, oil, natural gas, wood, food. On the other hand, it is the cause of the creation of water currents, sea currents, waves and winds, without talking about the direct radiation of heat, the benefits of which we use every day. From the point of view of human existence, solar energy is an infinite source of heat for the Earth. The main good properties of solar radiation on Earth represent a large renewable energy potential, fairly distributed over the Earth's surface, which creates a common basis for all non-conventional energy sources that are more widely used today (except for geothermal sources). The use of energy from solar radiation is characterized by the following: there are no costs of obtaining, nor costs of transporting the original form from the place of its capture to the place of transformation into a useful form, there is little or no emission of harmful substances at the place of transformation into a useful form and it is mostly CO_2-neutral. However, there are forms of energy on Earth that do not originate from the Sun. This is, for example, tidal energy, which is a consequence of gravitational forces primarily between the Earth and the Moon. Likewise, nuclear energy, regardless of which possible nuclear fuel it is, is not solar energy. The same applies to geothermal energy, which is assumed to compensate for the cooling energy over the outer surface of the Earth with the heat of the radioactive decay of the elements from which it was built, [8].

3 Overview of Previous Research

In the monograph [8], the authors analyze modern approaches and methods for solving the problem of sustainable energy planning from the aspect of available technologies and energy efficiency. The increased need for cheap and "clean" energy indicates the need for the introduction of modern fossil fuel combustion technologies (State of the Art), the use of renewable energy sources, and the introduction of energy saving measures in production and consumption, including the application of energy efficiency. One of the types of inclusion of renewable sources is represented by small systems for the production of electricity, which solve the issues of electricity supply to smaller consumers. In this context, small communities relatively far from the transmission and distribution network can be observed, as well as entities that have their own system for the production of energy from renewable sources, and which have the possibility of connecting to the distribution network with a two-way flow of energy. In areas where the electrical grid is unavailable, autonomous hybrid systems are being imposed as alternative solutions, including a system based on the use of solar energy and wind energy. Complementing the availability of these two sources in use solves the issue of limitations related to their individual availability. Namely, the intensity of the Sun's radiation is always higher during the summer months, while in the winter months wind energy can significantly contribute to the reliability of supply from the system (wind intensity is often stronger in winter than in summer). In the context of reducing the harmful effects on the environment and climate change and the possibility of depleting fossil fuel reserves, RES is clearly promoted as an important factor in energy supply. Due to their pronounced stochastic nature or uneven representation, they do not simultaneously represent a source that guarantees security of supply. In order to improve security of supply, they are combined with other technologies, including technologies for the combined production of heat and electricity (Combined Heating and Power Systems – CHP Systems), i. e., (Combined Cooling, Heating and Power Systems – CCHP Systems), when the heat from the cogeneration process is also used for cooling using cooling devices. Complex systems in which energy is produced from several different energy sources are known in professional and scientific literature as systems with distributed energy resources (Distributed Energy Resources Systems – DER Systems or Multi Energy Systems – MES), and often also as hybrid systems (e.g. Hybrid Photovoltaic-Trigeneration Systems, Hybrid Photovoltaic-Cogeneration Systems, etc.). Energy production from systems with distributed energy resources takes place in the immediate vicinity of consumers, so due to the absence of transmission losses and a high degree of heat utilization, their efficiency is higher compared to centralized systems. Within this monograph, an analysis of the possibility of applying modern fossil fuel combustion technologies (State of the Art), the use of renewable energy sources, with reference to the possible introduction of energy saving measures in the production and consumption of useful forms of energy in the Republic of Srpska is given.

In [9], the authors state that Bosnia and Herzegovina is one of the richest countries in the Balkans in terms of renewable energy sources. Although Bosnia and Herzegovina has energy sources such as geothermal, solar and wind, the primary sources of electricity supply are from hydro and thermal power plants. The share of these two sources in the total consumption is 62%. In this analysis, a prospective approach was made regarding renewable energy policy in Bosnia and Herzegovina, the country's economic approach to renewable energy and the government's renewable energy policy were considered.

In [10], the authors treat the development of the energy sector as one of the most critical issues in the Western Balkans region. Renewable energy is seen as a promising method for building sustainable and resilient energy systems that offer proven and affordable energy to fuel the region's economic development while reducing import dependency. A discussion was given on the current trends in renewable energy sources in the countries of the Western Balkans, with the aim of analyzing policies that promote and hinder the development of RES. Recommendations are given for the future growth of renewable energy in this region. Although these countries have defined targets for RES in their energy policies, there are gaps between targets and actual results, as national governments face different energy challenges. It was established that the main obstacles are common to all countries of the Western Balkans (regulatory uncertainty and low level of transparency, slow and unpredictable planning process and limited regional market integration). Therefore, it is necessary to take a more active approach through targeted renewable energy policies.

In [11], the authors provide an overview of the use of renewable energy sources in Bosnia and Herzegovina. Due to the reduction of pollution caused by the use of coal and fossil fuels for energy needs and harmful effects on people, the overview aims to provide insight into the current and future plans for renewable energy in Bosnia and Herzegovina. It has been established that the greatest potential for energy production lies in hydroelectric power plants.

On the other hand, of all the Balkan countries, it was determined that Bosnia and Herzegovina has one of the greatest potentials for the implementation of solar power plants, and the most suitable area is Herzegovina. A huge potential lies in the geothermal energy of Bosnia and Herzegovina, but without significant interest from the authorities responsible for development due to the initial investments in geothermal heating, which are significantly higher compared to other conventional heating systems. As far as bioenergy is concerned, wood residues have the greatest potential, because forests are one of the main natural resources of Bosnia and Herzegovina. There are currently two biogas power plants, but no data is available on the use of biofuels and other biowaste.

4 Unconventional, Improved and New Technologies for the Production of Useful Forms of Energy

4.1 Development of Technologies for the Production of Useful Forms of Energy

Energy needs are currently mostly met from conventional energy sources (fossil fuels: coal, oil, natural gas, hydropower of watercourses-hydropower plants, as well as nuclear fuels for fission processes). As fossil and nuclear fuels belong to the group of non-renewable energy sources, their reserves are limited, so it is necessary to reckon with the possibility of their exhaustion in the future. In order to ensure a safer energy future, research in the field of theoretical possibilities and realistic rational applications of energy sources flows in two directions – extending the life of the possible use of non-renewable energy sources and organizations on energy sources and technological procedures that minimally affect air pollution and the human environment as a whole, [7, 12]. Therefore, it is necessary to ensure the continuous growth of energy production in accordance with the growth of industrial production and social standards, while simultaneously finding suitable technological procedures for the rational use of renewable energy sources (an alternative to non-renewable sources) and improving the degree of utilization of non-renewable energy sources in plants with so-called low-waste technologies, with as little harmful impact on the environment as possible, [8].

Requirements for continuous provision of energy needs in sufficient quantities for industrial facilities, transportation and people's living standards require the development of new technologies based on fossil fuels (fluidized bed combustion plants, combined cycles with gasification, combined cycles with natural gas as fuel, fuel cells, technologies with external heat energy – Stirling machine, thermophotovoltaic conversion, thermal-electrical converters with alkali metals), then increasing energy efficiency (saving and rational use of energy, reduction of distribution and other losses), as well as increasing the share of production of useful forms of energy from renewable sources, with further encouragement of the development of cogenerative and trigenerative systems.

Recently, several influences have appeared, the combination of which has led to increased interest in distributed production from renewable energy sources (reduction of CO_2 emissions, programs for energy efficiency or rational use of energy, deregulation of the electricity market, diversification of energy sources, requirements for the self-sustainability of national energy systems, incentives from governments through the methodology for valuation and pricing of renewable sources, etc.).

Strategic plans and programs are being created for the use of renewable sources (wind power plants, small hydropower plants, photovoltaic sources, natural gas, energy from waste, energy from waves and tides, energy from biomass, etc.), as well as directions for eliminating the main shortcomings of conventional power plants (increasing the degree of utilization of the energy contained in the primary fuel from 33 to 45÷50%, choosing a different method for combustion, with a significant reduction of harmful pollutants contained in flue gases, which are released into the air, e. g., gasification of solid and liquid fuels into synthetic gas), [13–16].

The production of electricity in a conventional way takes place in large centralized plants. The electricity produced in this way is delivered to consumers through the power distribution network. The thermal energy generated in such a process is not fully utilized, so part of the heat is sent to the environment unused. Provision of the necessary energy for heating and cooling for remote consumers is simultaneously realized by the consumption of electricity, fossil fuels or the use of renewable energy sources), [17–20].

By the term new and renewable energy sources, most often only non-conventional renewable energy sources are understood, primarily solar energy, wind energy, geothermal energy and biomass energy. According to resolution N0 33/148 of the General Assembly of the UN, the following sources are included in new and renewable energy sources: hydropower (mini and micro hydropower plants also belong to the group of non-conventional energy sources), solar energy, geothermal energy, wind energy, tidal energy, sea wave energy, thermal gradient of the sea, biomass transformation energy,

energy obtained by burning wood, charcoal and peat, energy obtained by the draft cattle power, as and energy obtained by combustion of fuel shale and bituminized sandstones. For the area of the former Yugoslavia the use of solar and geothermal energy, as well as wind and biomass energy, is certainly of particular interest. However, their use is slowly being put into practice. Basically, the reasons are quite high specific investments in construction and the lower price of energy that is obtained in classic power plants. It should, however, be expected that the relative differences in investments will decrease even more in the coming period, and one should also expect significant increases in the construction costs of conventional and nuclear power plants due to additional investments in environmental protection facilities and increased operational safety of atomic reactors.

Another important direction of development in the energy sector is the conquest of technologies and energy plants in which non-renewable primary energy sources are used more rationally. In addition to a higher degree of beneficial effect, such plants should enable significantly less pollution of the environment. At the same time, this would extend the life of non-renewable fossil fuels, during which time an alternative replacement with other sources of energy should be found. Let's list some of those technological-energy procedures:

- conquest of highly efficient technologies in excavation methods, as well as in separation-flotation processes for the separation of mineral admixtures, in which greater utilization of the combustible mass of coal will be achieved (reduction of excavation losses and more efficient combustion in boiler furnaces);
- underground gasification of coal with obtaining gases as a carrier of thermal energy;
- gasification of solid fuels in high-power gas generators;
- conquest of gas-steam power plants with gas turbines with a power of 115÷200 MW and an initial temperature of gases over 1100°C, which significantly increases the SKD of the plant compared to classic steam-turbine plants;
- conquest of new constructions of steam boilers with a circulating fluidized bed and boilers with aero-fountain antechambers for coal combustion in which coal of lower quality can be burned with the regulation of SO2 in the ash (desulfurization in the process of low-temperature coal combustion – about 850°C);
- conquest of magneto-hydrodynamic (MHD – generators) direct transformation of heat into electricity, whereby the combination of MHD

generators and classic boiler turbine plants achieves a degree of fuel heat utilization of 50÷60%;

- incineration of city garbage and combustible industrial waste in special energy steam boilers in the block with heating functions;
- development of technical systems for the use of low-potential energy resources: waste heat of thermal power plants and nuclear power plants, industrial enterprises, heat of ventilation gases and the like;
- introduction of coal thermal briquetting procedures – as a result of rapid heating of coal and its thermal destruction, high-molecular liquid products are formed (but not separated!), which also serve as briquette binders (the SKD of the furnace increases by 20÷25%).

With the aim of improving energy efficiency and the global reduction of energy consumption, in addition to the centralized production of electricity, the concept of simultaneous production of two useful forms of energy was developed in the last few decades, with the application of plants for the combined production of heat and electricity (Combined Heating and Power Systems – CHP Systems), that is (Combined Cooling, Heating and Power Systems – CCHP Systems), [21, 22]. Such plants have a smaller capacity and are usually located near energy consumers. With the combined production of heat and electricity, significantly less heat is lost to the environment. It is used for heating or cooling purposes, which significantly increases the overall energy efficiency of the plant, [8]. In such plants, different technologies are used in which electricity production is based on the use of industrial steam turbines (ST), industrial gas turbines (IGT), reciprocating internal combustion engines (RICE), micro gas turbines (MGT), micro steam turbines (MST), Stirling engines (SE), or fuel cells, (Fuel Cell – FC). In combination with different heating and cooling systems, it is possible to functionally implement different types of CHP or CCHP plants, [17, 18].

4.2 Clean Technologies for the Production of Useful Forms of Energy

Coal is the energy source with the highest percentage of representation among estimated fossil fuels (over 65%), with more evenly distributed deposits in the world compared to oil and gas deposits. The largest coal reserves are located in Russia, USA, China, Australia, South Africa, and in Europe in Germany, Poland, Czech Republic and Great Britain. Coal is the most abundant and widespread fossil fuel in the world. About 23% of the needs for primary energy and 39% for electricity are obtained on the basis of

Figure 4 Forecast of the share of coal in energy consumption by sector until 2030, [8].

Source: (a) 2005 – EIA, International Energy Annual 2005, June-October 2007;
(b) 2015 and 2030 – EIA, World Energy Projections Plus, 2008.

coal. The International Energy Agency (IEA) expects a 43% increase in coal consumption between 2000 and 2020 [1]. Due to the decrease in oil and gas reserves, a significant increase in the use of coal is expected in the future. On the other hand, the representation of coal in meeting today's energy needs is lower than the representation of liquid and gaseous fuels combined, [8, 23, 24]. Today, about 40% of the total energy in the world is produced from coal, and it is expected, considering the energy projections, that this situation will remain in the coming period (during the 21st century), Figure 4.

Enacted regulations regarding environmental protection, along with increasing efficiency, require a reduction in CO_2 emissions per produced MW, which reduces the need to take other (more drastic) measures to reduce it. The high thermal efficiency of the process and achievable low levels of environmental pollution are just a few of the achievements of that development, which today represent an integral part of the commercial offer of energy equipment on the world market.

A large proportion of carbon and harmful ballast ingredients make the burning of coal the process with the largest polluter and producer of CO_2 emissions per unit of electricity produced. The answer to this problem is the development of "clean coal" technologies, which reduces this negative impact to an environmentally acceptable level. "Clean coal" technologies were initially aimed at reducing emissions of sulfur and nitrogen oxides and solid unburned particles, but due to growing concern about climate change, attention was increasingly directed towards reducing CO_2 emissions.

Technologies for producing electricity from fossil fuels with zero CO_2 emissions into the atmosphere have not yet been developed to maximum commercial profitability, but it is realistic to expect this in the coming period. For these reasons, achievements in the development of clean coal technologies should be considered in the strategic planning of the construction of production capacities in the power system of Republic of Srpska and Bosnia and Herzegovina as a whole, with the aim of ensuring long-term reliability of electricity supply. The following should be distinguished from "clean coal" technologies:

(a) coal washing technology, which involves cleaning the coal by "washing", which reduces ash and SOx emissions, and also has a favorable effect on the combustion process (coal is transported to the THP along with mineral content that is incombustible and may also contain harmful ingredients (such as mercury), is crushed and introduced into a slowly rotating drum in which there is a fluid of higher density, so that the coal floats as it weighs, the mineral material sinks and is drained from the bottom of the drum, to the purified coal would then be ground into a fine dust suitable for combustion);

(b) solid particle separation technology, with the use of electrostatic (alt. bag) filters and removal of up to 99% of ash from smoke gases (they work on the principle of an electrostatic field in which particles are electrically charged and collected on the anode);

(c) technologies with reducing sulfur oxides (desulfurization), most often with a wet desulfurization process, which removes up to 99% of SOx from smoke gases (smoke gases react with a dispersed mixture of calcium carbonate (limestone) and water, creating gypsum (calcium sulfate), which is removed and used in the construction industry);

(d) technologies with the reduction of nitrogen oxides (NOx), first through primary measures during the combustion process, which is achieved by the appropriate construction of the burner and the gradual supply of air and fuel, with a reduction in the maximum temperature in the flame core and a reduction in the oxygen concentration in the combustion zone (the amount of NOx produced can thus be reduced to a value of less than 300 mg/m^3 (up to 40%), and then through secondary measures to reduce NOx emissions, which are applied behind the combustion zone, and which includes selective non-catalytic reduction (SNCR) by which ammonia is introduced into the steam generator at the point where smoke gas temperatures of 850 to 900°C prevail, which achieves a change in emissions of about 70% (by introducing a catalyst, selective catalytic reduction (SCR) is achieved, which reduces NOx emissions by up to 90%);

(e) technologies with an increase in the thermal utilization of the plant, starting with today's coal-fired thermal power plants in operation, which in most cases represent structures 20÷40 years old years, with sub-critical steam parameters (530÷540°C and 14.0÷18.0 MPa) and with a degree of thermal utilization of 33 to 39% (the unrealized Lukovo Šugarje project predicted an SKD greater than 43%, while the last built German and Danish coal-fired power plants achieve a maximum SKD of 47%, with the latest constructions of coal-fired power plants with ultra-supercritical steam parameters (>600°C and >30.0 MPa) predict utilization rates higher than 50%, [25÷30];

(f) technologies with additional combustion (co-combustion) of biomass, which consists of various products of plant and animal life (such as branches, sawdust, residues of harvest or fruit picking, animal excrement, municipal and industrial waste), neutral from the point of view of CO_2 production (created by taking CO_2 from nature, although part of CO_2 is produced during the cultivation, harvesting and transport of biomass or the material from which it was created, whereby the process of burning biomass with coal is considered a transitional phase in the process of replacing fossil fuels and reducing CO_2), where experience so far shows that up to 10% of biomass can be burned with coal without undesirable effects, and further research aims to raise the proportion of biomass up to 50%, whereby the use of biomass with CO_2 extraction and storage technologies could ensure the cleaning of the atmosphere from CO_2;

(g) coal gasification (degasification) technology, which according to many has a great perspective to replace today's conventional coal burning technologies (it is used as part of a combined gas and steam turbine plant, where the coal is not burned completely but is gasified with a lack of oxygen, and in the reaction with water it creates hydrogen-rich synthetic gas, today there are only four plants in the world that use a combined cycle with integrated coal gasification for the production of electricity and an SKD of 37÷45 %, while some estimates say that future plants will achieve a degree of utilization of 50÷60%);

(h) technologies with combustion in a fluidized layer, with combustion chamber types: Fluidized Bed Combustion – FBC, which takes place at atmospheric pressure, and in the steam generator, steam suitable for driving a steam turbine is created, Pressurized Fluidized Bed Combustion – PFBC, with combustion at elevated pressure, which improves the operating characteristics of FBC (this group also includes Circulation Fluidized Bed Combustion – CFBC, where the fluidized layer due to high speed blowing air circulates, and the material and fuel are separated from the flue gases and returned to the combustion chamber), Gasification Fluidized Bed Combined Cycle – GFBCC, which is based on PFBC technology, to which a gasifier is added in which synthetic gas is created, and the gasification heat is used to produce steam for the steam turbine, while the synthetic gas is burned in the gas turbine (the plant has a very high SKD of 57 to 59%);

(i) smoke gas CO_2 extraction technologies, which have not yet been optimized for full application in coal-fired TPP, as their development has been more focused on obtaining clean CO_2 for industrial needs than on reducing CO_2 emissions from power plants (types: an integrated gasification combined cycle (IGCC) plant uses coal and water vapor to produce hydrogen and carbon monoxide (CO), which are then burned in the gas turbine of a combined plant with a steam turbine, for the production of electricity (if the IGCC plant is fed with oxygen instead of air, the smoke gases contain highly concentrated CO_2 in the smoke gases, which can be easily removed by the process of "washing" in an amine solution, for about half the price compared to a plant using combustion with air; the development of IGCC plants that use pure oxygen for combustion foresees the inclusion of a reactor for the oxidation of CO with water (Shift-reactor), so that the resulting gas will consist only of CO_2 and of hydrogen, where before the combustion of hydrogen comes to the separation of CO_2 from the mixture, so that only hydrogen will be used as a fuel for electricity production, while compressed CO_2 will be disposed of, combustion technology with pure oxygen (Oxy-fuel) could be used to renew existing coal dust plants that are the backbone of electricity production in many countries, thereby significantly contributing to the reduction of CO_2 emissions into the atmosphere), with the current SKD of IGCC plants of about 45%);

(j) CO_2 geological storage technology (sequestration), which implies the separation of CO_2, and various variants for its storage deep in the earth's interior with the aim of preventing penetration into the atmosphere (CO_2 is compressed in an abandoned coal mine from which it pushes CH4 (methane) which can be used as fuel, CO_2 is stored under pressure in a geological layer saturated with salt water, CO_2 is compressed in an oil well improving the depletion of oil), whereby previous research has shown that the presented carbon storage technologies are technically feasible, and efforts are needed to prove their commercial viability for the quantities produced in large energy and industrial plants, [8, 29, 30].

When it comes to increasing the efficiency of the conversion of the chemical energy of the fuel into thermal energy, while achieving the best possible environmental protection and more economical production, there are two main directions of development, namely: the improvement of the classic combustion technologies of pulverized coal (PC) and the development of new clean coal combustion technologies (New Clean Coal Combustion – NCCC). In parallel with the improvement of classic pulverized fuel combustion technologies and technologies for purifying smoke gases from particulate and gaseous influents from these plants, a number of new clean coal combustion technologies are being developed, which, compared to classic coal combustion technology, potentially offer greater energy efficiency, better environmental and economic effects. In addition to differences in the degree of efficiency, degree of emission of harmful substances, water consumption, amounts of waste solids, investment costs and maintenance costs, size, flexibility in exploitation, new technologies also differ in the degree of development and degree of commercial application. Atmospheric fluidized bed combustion, super atmospheric fluidized bed combustion (PFBC) or even with supercritical parameters and circulating fluidized bed combustion (CFBC) – today are considered commercially available technologies worldwide. Combustion technologies in a fluidized bed have an advantage as such, because they use solid fuels with lower heat power and larger grain granulations compared to combustion technologies in the form of coal dust. Also, with fluid technology, abrasive coals or coals with a high ash content can be used. Combustion of coal in a fluidized bed (floating bed) represents a transitional process between coal combustion in a bed and coal combustion in flight.

The technologies that are expected to be fully competitive with the classic coal combustion technology in the first half of the 21st century are: combustion in a fluidized bed (Fluidized Bed Combustion – FBC), and integrated gasification and combined cycles (Integrated Gasification Combined Cycle – IGCC).

Technologies, whose application is not expected in large-scale energy before 2020, include fuel cells and magneto-hydrodynamic generator (MHD). The IGCC technology is based on the gasification of coal and obtaining synthetic gas, which is burned in the gas turbine chamber. The basic components of the plant are a gasifier, a synthetic gas purification plant, a gas turbine with a combustion chamber, an utilizator boiler and a steam turbine plant. With today's achieved efficiency of the combined gas-steam cycle with natural gas of 52 to 58% and the efficiency of the gasification process of 75 to 90%, the commercially realized efficiency of IGCC plants is over 42%. IGCC technology with higher quality coal is in the phase of proving its potential at medium power plants (examples: Tampa Electric, USA, 260 MWe, 1996; SUV/EGT, Czech Republic, 250 MWe, 1996; Buggenum, Netherlands, 2x250 MWe, 1998; Puertolano, Spain, 300 MWe, 2000), while with lignite it is about small power (examples: Schwarze Pumpe, Germany, 40 MWe, 1996; IBIL/Sanghi, India, 60 MWe, 1998). Its introduction with commercial guarantees to the technology market is expected by 2020. Full competitiveness of IGCC technology with classical and other new technologies is expected in the third decade of the 21st century.

Sequestration ([31, 33]) or geological storage of CO_2 (Geological Storage of CO_2, [8]) is one of the clean coal technologies, which involves storing already separated CO_2 deep in the earth's interior, with the aim of preventing atmospheric pollution. Although these technologies are applicable, it is necessary to achieve their commercial profitability in the following period for the quantities produced in large energy-processing plants. Commerciality has already been proven in improving oil extraction (West Texas, Great Plains Synfuels Plant in North Dakota, etc.). Along with achieving commercial profitability, it is necessary to provide answers to the questions of achieving the necessary safety and durability of disposal in the following research.

4.3 New Technologies in the Production of Heat Energy in the Republic of Srpska

Most thermal energy in the Republic of Srpska is produced from biomass. The share of coal in heating fuels is still very significant. The total production of heat energy in 2022 was 1496 TJ, of which 62.9 percent was obtained from biomass, 29.6 percent from coal, 3.8 percent from natural gas and 3.7 percent from fuel oil. The largest consumers of thermal energy are households with a share of 78.5%, followed by other consumers with 21.2% and industry with 0.4%. The largest biomass heating plants are in Banja Luka, Gradiška and Prijedor, Table 1.

The impact of energy on sustainable development is most pronounced through the economic aspect of sustainability. Continuous economic growth is possible only when sufficiently secure electricity supply is achieved at acceptable prices for both households and industrial companies. Today's

Table 1 Biomass heating plants in the Republic of Srpska

Name of the Heating Plant	Quantity	Measuring Units	Note
KP Gradske toplane a.d. Pale	7500	t	Wood waste
Toplana a.d. Prijedor	23000	t	Wood
Eko-toplane a.d. Banja Luka	80000	m^3	Wood chips
IEE PJ Toplana a.d. Gradiška	9000	t	Wood chips

industry in Republic of Srpska, that is Bosnia and Herzegovina as a whole, depends a lot on fossil fuels, and mostly on coal. Increasing energy efficiency implies the use of total thermal energy within the energy system at different available temperature levels, for the production of useful mechanical work or steam heat for technological processes or heating, with minimal removal of heat to the environment as waste heat. This approach is most often implemented in the so-called combined cycles for the simultaneous production of useful mechanical work, i.e., electrical energy on the one hand and thermal energy on the other, i.e., in thermal power plants heating plants (TPP-THP), [34]. The use of combined production of heat and electricity enables saving of primary energy compared to separate production of heat and electricity. In the Republic of Srpska, a project was planned for the reconstruction of the heating plant in Doboj in TPP-THP Doboj with an installed capacity of 34.8 MWe and 27.5 MWt. This project has not yet been implemented. Bearing in mind the pronounced tendency to use renewable energy sources in the countries of the European Union, the potentially significant amount of wood industry waste available in Bosnia and Herzegovina and positive experiences in the use of biomass as a basic or supplementary fuel in combustion with boilers of lower power, there is also a need to analyze the possibility of using biomass as an additional fuel within thermal energy facilities.

The use of biomass as an additional fuel in the process of electricity production would provide the potential investor with obtaining a CO_2 certificate and the possibility of trading a certain quota of CO_2 emissions, in accordance with the provisions of the Kyoto Protocol and corresponding EU directives. Unfortunately, the current situation in Bosnia and Herzegovina as well as in Republic of Srpska is such that there are no systemic measures (state strategy for the use of renewable energy sources, legal regulations, favorable loans, promotion of positive experiences, etc.) to promote greater use of biomass as fuel. Accordingly, there is no interest of the wood processing industry to pay more attention to the proper collection of sawdust and other waste from the technological process, which could later be used in the process of producing wood chips, pallets or briquettes, which can be used as fuel. In other words, even if the annual amount of wood waste in Bosnia and Herzegovina, which can be used for further processing, is estimated at around 1785000 m^3, for now neither in Bosnia and Herzegovina nor in the surrounding countries there is a market that would accept this product. Namely, the multi-year average of firewood production in the Republic of Srpska is around 950,000 m^3. The majority of consumption in households refers to the consumption of firewood (primary solid biomass), while it is estimated that a smaller part is consumed as biomass (wood and plant waste), [35].

New investments related to investments in the construction of biomass power plants in the Republic of Srpska, in addition to the interest of public companies within the energy sector (MH Electric power company of Republic of Srpska, city heating plants), increasingly include private investors, who see their profits based on the achievement of a privileged status of electricity and heat producers with a preferential tariff for delivered electricity and heat (efficient cogeneration and trigeneration, hybrid systems, decentralized systems for electricity production). On the other hand, the opening of the energy market with the participation of renewable energy sources and efficient cogeneration creates conditions for the construction of new plants that are market-oriented. If the use of biomass for energy purposes (biomass as an energy source) is considered, several positive elements should be highlighted, such as:

- Increasing one's own energy supply and reducing energy dependence on the import of other (mostly fossil) fuels;
- Reduction of greenhouse gas emissions in relation to the use of fossil fuels (with mandatory consideration of emissions related to all stages of the production cycle, starting with collection, transportation and storage, and ending with obtaining useful forms of energy);
- Realization of additional income in agriculture, forestry and the wood industry resulting from the sale of biomass (an example of earlier burning of sawdust and wood chips in the wood industry and new use as semi-finished products for pellets and briquettes);
- Adoption of new technologies and opening of new production facilities in industry, process and energy technology (co-combustion, retrofit using bioenergy, cogeneration, trigeneration, etc.);
- Increase in activities related to the transport of biomass (transport of raw materials);
- Development of entrepreneurship, through the launch of new companies and new business structures;

- Initiation and more intensive development of research projects in science and technology, with the development of new or improved technologies;
- Increasing local and regional economic activity, with greater transfer of cash flows (investments – salaries – taxes), especially at the level of local communities (municipalities and cities), and
- Increasing the level of employment through the creation of new and retention of existing jobs (social aspect).

The previously mentioned characteristics of using biomass for energy purposes, along with the creation of prerequisites for the market model of valorization of biomass as a renewable energy source, also require supporting professional staff, who, on the basis of examples of good practice abroad and in neighboring countries, and on the basis of accompanying legislation for encouraging the production of useful forms of energy, will contribute to increasing the percentage participation of this energy source in covering the energy needs of the observed region.

5 Concept of Planning Energy Sources in the Future

The economic development of a country requires the consumption of appropriate energy resources. Any deviation from the time schedule for the result may have the appearance of limitations in the development of other economic activities, so it is necessary to continuously monitor the development of energy consumption. On the other hand, energy consumption itself is related to certain influential factors (population growth, development of science and technology, economic development, standards, etc.), the intensity of which changes over time. Choosing the optimal structure for covering consumption is very important for the development of energy.

All energy planning models have a simplified description of reality and are based on certain assumptions, which are more or less certain and reliable (stochastic character). Depending on the selected criterion, there are also ways of classifying energy models. Most often, energy models are classified according to eight criteria (general and specific model applications, analytical approach (top-down versus bottom-up), used methodology, available mathematical basis, coverage level – global, regional, national, local or project level, coverage of individual sectors, time coverage – short-term, medium-term, long-term, requirements related to the volume of required data).

Development planning in the field of energy is important both because of the dependence of society's development on safe, sufficient and appropriate amounts of necessary forms of energy, and because of the involvement of large financial resources in this area. When planning energy development, one should start from the following criteria: security of supply to consumers with minimal costs, rational use of domestic sources, with proper evaluation of imported forms of energy, maximum prevention of monopolistic and single forms of energy and achievement of satisfactory conditions for environmental protection and sustainable development.

The planning of the development of the electric power system includes all activities from the first assumptions about the possibility of building a facility to its commissioning, [1]. However, in the terminology, the term planning primarily refers to the planning of facilities for the production of electricity (hydro, nuclear and thermal power plants).

When planning the development of the electric power system (EPS), the goal and criteria are unambiguously determined: settlement of the expected electricity consumption with minimum costs and assuming that certain restrictions are met, such as, for example, financial, technical, environmental, limitations on the availability of primary forms of energy, etc. Constraint satisfaction is imposed as a primary task, regardless of the planning method, which is the reason that a certain constraint is often a decisive factor in deciding on the final development strategy. Although long-term plans carry a large amount of uncertainty, such planning is necessary primarily for two reasons: the first is the basic and extended life of production facilities (e.g., 25 to 30 basics plus 15 to 20 years of extended working life after revitalization, reconstruction and modernization of the thermal power plant), and the second is the time required for construction preparation and construction itself (3 to 6 years, not counting the possibility of project delays), [2].

When planning the construction of production plants, it is necessary to determine the necessary construction to satisfy future consumption (volume and capacity), the time of entry of each production plant into operation and the possibility of improving technologies for the production of electricity (improved and cleaner technologies, co-generative and trigenerative systems, hybrid systems, etc.). The preparation of development studies itself can be divided into two parts, which include the simulation of the legality of work in the system (system drive), as well as the economic evaluation of production facilities, i.e., entire development plans. The first part requires the creation of a system model, i.e., it is necessary to describe the system with mathematical equations, and to approximate it with inevitable neglects and simplifications. In the second part, the energy contribution of each plant should be evaluated and its valorization should be carried out using economic methods.

The methods used in planning the development of the power system differ with regard to: optimization technique (linear programming, non-linear programming, etc.), type of approximations (linear, non-linear) and economic valorization (with inflation, without inflation). None of these methods have so far proven to be absolutely acceptable for all problems, and that is why a large number of methods are being developed that are intended for solving partial problems, i.e., or they are used for the optimization of production plants only, or the optimization of only the transmission/distribution network, or else the optimization process refers to the entire energy sector (with very simplified relationships in the given system). The basic assumption of the application of optimization models is the high reliability of the parameters on which the calculation is based. Namely, if the parameters are not reliable enough, the question arises about the need to carry out optimization. Sometimes even sensitivity analyses, which are usually used in the final phase of each optimization model, cannot eliminate the effect of unreliability of input data. Furthermore, it is never possible to include all constraints within the model, so only an approximately objective picture of the state of the system is obtained. However, nowadays it is impossible to rely only on the intuition of planners when choosing the most favorable development option, so the application of models is inevitable (multi-criteria evaluation methods), [5].

Energy development planning is based on security of supply to consumers at minimal costs, with accompanying rational use of domestic resources, which includes proper evaluation of imported forms of energy, maximum prevention of monopolistic behavior (the only form of energy available) and achievement of satisfactory environmental protection conditions. When planning the development of the electric power sector of the Republic of Srpska, the goal and criteria are unambiguously determined through the settlement of the predicted electricity consumption, with minimum costs and assuming that certain financial, technical and environmental limitations of the availability of primary forms of energy are met. With the adoption of the revised Energy Strategy of the Republic of Srpska until 2035, as well as the Energy Efficiency Action Plan of the Republic of Srpska until 2018, prepared in accordance with the Law on Energy Efficiency (Official Gazette of the Republic of Srpska, number 59/13), as well as with the implementation of obligations from the Treaty on the Establishment of the Energy Community and obligations based on the requirements of Directive 2006/32/EC of the European Parliament on energy efficiency in final energy consumption and energy services, the starting points were created and for the introduction of the energy management system in companies that, as significant consumers of energy, have become obligees of this Act.

On the other hand, projects for achieving energy savings are very important for thermal energy facilities within the EPS of the Republic of Srpska, because, in addition to reducing costs and cleaner production, it enables an additional improvement of the company's competitiveness. The integration of these projects with the existing business plans of thermal energy companies within the EPS represents in a way the further direction of their development. The proposed measures and their priorities are given in accordance with the stated results, which does not mean that in practice, depending on the current needs and priorities of ZP RiTE Ugljevik and ZP RiTE Gacko within MH Electric Power Company of the Republic of Srpska, Trebinje, a slightly different ranking of individual measures would be carried out. When proposing energy efficiency measures, the current state of the equipment and the financial possibilities of ZP were considered, so that all proposed improvements in terms of reducing losses and increasing general energy efficiency are within realistic achievable limits. The new value of the thermal power plant's own consumption, which can be achieved by applying the proposed measures, is still above the reference values in relation to similar systems in the world, which means that serious work is still to be done on the analysis of possible savings and reduction of losses as a whole. It should be pointed out that it is expected that in the first period of implementation of the energy management system, more short-term measures will be recognized, which do not require financial investments and are more organizational in nature. After the introduction of the BAS ISO 50001 standard and the application of the corresponding standardized procedures in practice, the number of short-term measures will decrease, which also indicates an organized monitoring of the implementation of energy efficiency measures.

5.1 Energy Illusions and the Planning Concept "Energy for the Future"

The concept of planning "energy for the future" under the influence of various lobby groups can often lead to the creation of wrong perceptions or illusions, such as:

5.1.1 Illusion no. 1: Nuclear energy obtained from the process of nuclear fission in nuclear power plants is the solution to all problems related to the safe, reliable and cheap supply of the required amounts of energy

Third generation reactors were created by improving the design of second-generation reactors. Improvements in design resulted in lower investment costs and shorter construction time. Improvements are also visible in the stage of exploitation and management with accompanying maintenance, which is visible through the reduction of sensitivity to failures and the extension of the working life by 30 to 40 years. With the increased availability of the plant, the likelihood of nuclear reactor core meltdown is reduced and resistance to serious damage caused by even an aircraft strike is increased. The use of new combustible absorbers extends the length of the cycle, and the high resistance to fuel consumption reduces fuel requirements and the amount of radioactive waste generated. However, the biggest change from the previous generation is the installation of passive safety systems whose operation relies on gravity, natural convection and stored energy, and not on components dependent on external voltage sources. The development of the fourth generation of new reactors was initiated by the US government. An international forum was established in which the goals of the technological development of new nuclear reactors were defined. According to those goals, the new power plants should meet the requirements of sustainable development, and the impact on the environment should be reduced to a negligible level. Proliferation of nuclear material must be practically impossible at the technological level. The amount of nuclear waste should and must be reduced to the lowest level, and the long-term impact on the environment should also be reduced. The possibility of damage to the reactor core should be minimized. It is necessary to achieve excellence in safety and reliability. In addition to all these requirements, it is also necessary to eliminate the need for planning protective actions outside the plant area. In relation to other technologies, it is necessary to realize the economic advantage of the entire fuel cycle. As far as financial risk is concerned, it should be equal to other technologies. Reactors belonging to this generation should be built by 2030, so they are considered representatives of the future of nuclear energy. As one of the possible improvements in addition to the production of electricity lies in the possibility of using them for the production of hydrogen. The problems accompanying the implementation of the improvement of nuclear reactors are related to the storage of low, medium and highly radioactive nuclear waste, public perception due to possible nuclear accidents caused by force majeure (earthquakes, war events, floods, etc.) and relatively high investment costs per installed capacity. Most of the research into the reasons for the public's negative attitude towards nuclear power plants confirms that the disposal of radioactive waste is one of the two most important reasons AGAINST. Another reason is the fear of a possible catastrophic accident at the nuclear power plant. Statistics show that such accidents are unlikely. In the past

14,500 reactor-years, only three major nuclear accidents have occurred: Three Mile Island (equipment failure and human factor; no human casualties; no release of radioactivity), Chernobyl (human factor; 56 human casualties; large amount of radioactivity emitted into the environment, the wider area around the power plant site was abandoned) and Fukushima (natural disaster; there were no direct human casualties; 300 workers received large doses of radiation; estimates of an increase in cancer mortality in the area power plants vary from 0 to 100; a large amount of radioactivity emitted into the environment). The investment costs of building a nuclear power plant are about 3000 USD/kW of electric power. The cost of construction for a 1000 MW power plant is around 3 billion US dollars. The cost of building new nuclear power plants in Finland and France exceeds the stated costs. The initial estimates of the price of the Glossary Link EPR (European Pressurized Reactor) type nuclear power plant in Olkiluoto (Finland) were around 2500 USD/kW, but now the costs are estimated to be around 5000 USD/kW, a total of around 8 billion USD. This significant increase can be partly explained by the fact that these are the first power plants of this type to be built. Safety is a major concern when considering nuclear power. Given that it is extremely powerful, there is a chance for a potential leak, a terrorist attack, and even minimal carelessness that can lead to chaos. Therefore, it is essential that we take maximum care of security. Nuclear power plants, if damaged, pose a threat to civilization. Nuclear energy production does not release large amounts of greenhouse gases. Therefore, it is considered a safer alternative. But at the same time, there is radioactive waste that can be used to produce nuclear weapons. Plutonium is important for making nuclear bombs. While nuclear power is useful, it also raises major national security concerns.

5.1.2 Illusion no. 2: "The War for Oil"

Since the discovery of oil, it has dictated the entire development and progress of the world in the second phase of the industrial revolution (from the end of the 19th century), as well as international relations, geostrategic and geopolitical interests throughout the 20th century, including two world wars. In recent years, the inevitable power and strength of oil has been widely discussed in the context of climate change, global warming and global pollution of the atmosphere with greenhouse gases. Actually, for almost two and a half decades of the 21st century, oil is constantly on the black list of the biggest polluters of the planet Earth when it comes to the use of natural energy sources and consequently oil derivatives (gasoline, diesel fuel, fuel oil, plastic, bitumen, etc.). But regardless of the dark scenarios surrounding the role of oil in the energy future of developed and developing countries, oil still dictates the state of the world's stock markets, and it is impossible without it, no matter how many people point to oil being completely excluded from use tomorrow. In other words, oil was and remains the most tenacious element in the world's distribution of power, although it is increasingly and more spectacularly becoming the subject of confrontations in courtrooms due to the "trend" of denouncing fossil fuels, and finally oil, as the "black death", which is taking on global proportions.

5.1.3 Illusion no. 3: Energy transition from conventional energy sources, primarily fossil and nuclear, to an economy that would be based entirely on renewable energy sources

The global transition to 100% renewable energy is, under certain conditions, achievable, but probably not before 2050. Significant investments in the last 30 years have led to continuous improvements in technology, which have resulted in a drop in the cost of using solar energy and wind energy at a rate of almost 5 to 10 percent per year. The global transition to renewable energy sources in the main sectors that consume the most energy slowed down in 2023, primarily due to political uncertainties, but also due to regulatory ambiguities and insufficiently clearly set goals. Only 13 countries (including Greece, Portugal, Spain, Ireland, Great Britain, Italy, United States of America, Egypt, China, Vietnam, France, Germany and India) have implemented measures to switch to renewable energy sources in all sectors of consumption, 17 will continue the transition, while as many as 52 countries have abandoned their ambitions. In the analysis, among the reasons cited as to why the energy transition has slowed down are the drop-in fossil fuel prices, debates about the costs of switching to clean energy intensified as many countries approach elections, resistance from heavy industry companies who claim that RES cannot generate the heat needed to fire their blast furnaces. On the other hand, the decarbonization of heavy industry remains a big challenge, but it is not impossible to decarbonize that sector, while the transport transition is simpler. The withdrawal of the USA from the Paris Agreement in 2025 and the return to oil and other fossil fuels will result in a further slowdown in the implementation of the policy of increasing the share of renewable energy sources in all end uses (sectors: construction, industry, transport and agriculture). Plans for solving limitations related to the connection of power plants based on renewable sources to the transmission and distribution network, as well as problems in the regulation of the operation of power sectors with a significant participation of renewable energy resources, show the need for significant financial investments, as well as an additional price burden on end consumers from the aspect of the necessity of changing tariff systems. The analyzes carried out by the authors show that classic conventional energy plants will continue to play a significant role in the next 100 years, as well as that the transition period in the conditions of a liberalized energy market will last much longer than earlier projections, with a significant increase in investment and exploitation and maintenance costs of existing power systems.

5.1.4 Illusion no. 4: Nuclear energy obtained from the process of nuclear fusion in nuclear power plants is the solution to all problems related to the safe, reliable and cheap supply of the required amounts of energy

A nuclear fusion reaction is a reaction in which two light nuclei of an atom join into a heavier nucleus. This reaction releases enormous amounts of energy. Such a large amount of energy is released in the fusion process at the moment when two light nuclei come together. During this fusion, a nucleus is formed whose mass is smaller than the sum of the masses of the initial nuclei. Although fusion is an energetically suitable reaction for light nuclei, it cannot occur under normal conditions on Earth because it requires a large amount of energy. Because both nuclei, which enter the reaction, are positively charged, a strong electrostatic repulsion occurs when they come together. In order for two light nuclei that carry a positive electric charge to join, it is necessary to overcome their repulsive electric force. Only if one or both light nuclei have a high enough speed can they get close enough to each other for the strong attractive nuclear force to overcome the repulsive electric force. The medium in which light nuclei can achieve high speed, i.e., energy, is plasma. Plasma consists of positively charged free ions and free electrons of equal charge, so that medium is electrically neutral. By supplying energy to the plasma, the temperature of the plasma rises, and thus the energy of the ions becomes high enough for a fusion reaction to occur. The fusion reaction has been going on in space for billions of years. The most significant fusion process in nature is the one that powers stars. In man-made fusion, the primary fuel is not limited to protons and higher temperatures can be used, so high cross-section reactions are chosen. This implies a lower Lawson criterion, and therefore a lower initial effort. Lawson's criterion is an important measure of the system that defines the conditions required for fusion to reach ignition, when the heating of the plasma due to fusion is sufficient to maintain the temperature of the plasma, considering heating losses, without supplying external energy. Another problem is the generation of neutrons, which radiologically activate the reactor structure, but have the advantage of allowing the volumetric extraction of fusion energy and the creation ("fertilization") of tritium. Reactions in which no neutrons are released are called aneutronic reactions. In order to be useful as a source of energy, fusion reactions must meet several criteria. They are:

- exothermicity → limits the reactants to those on the side of the binding energy curve with a small number of protons. This makes helium-4 the most common product due to its extremely strong binding of nucleons in the nucleus, although helium-3 and tritium also appear.
- participation of low Z number nuclei → this is because electrostatic repulsion must be overcome before atomic nuclei can get close enough to fuse
- existence of two reactants → at any density less than the density of stars, three-body collisions are very unlikely. It should be noted that in internal retention both the density and temperature are much higher than in stars in order to compensate for the small value of the third parameter of Lawson's criterion, the very short retention time.
- the existence of two or more products → this enables conservation of both energy and momentum without dependence on the electromagnetic force
- conservation of both protons and neutrons → weak nuclear force cross sections are too small.

The high share of nuclear energy in the total electricity produced is a consequence of high technology and almost no greenhouse gas emissions. Well-designed nuclear power plants have proven to be reliable, safe, economically and environmentally acceptable. With the fusion reaction, however, there are a few difficulties. Numerous studies have been carried out, but none of them have provided an answer to the question "How to put the Sun in a box?" Since the beginning of fusion research, scientists have had to overcome a number of different challenges. So, among other things, they had to figure out how to heat the plasma to temperatures that are ten times higher than in the center of the Sun or how to isolate that hot plasma from the walls of the reactor chamber, without those walls melting. Thanks to the efforts of scientists in fusion research around the world, many of these problems have been successfully solved. However, numerous researches are still needed in order to successfully overcome the remaining problems that stand in the way of obtaining the cleanest source of energy. Most of the goals in the plan for obtaining energy through the fusion reaction are related to the successful implementation of the ITER thermonuclear experimental reactor project, which will enable the testing of the entire range of technologies required for the operation of the fusion power plant. The only problem that cannot be solved is radiation. Research has shown that people who live near nuclear power plants are more prone to disease than those who are not near them. That is why such types of power plants need to be built in uninhabited areas. In the same way that people who live nearby are exposed, workers who perform work in nuclear power plants are also exposed to radiation, only to a greater extent. During the construction of nuclear power plants, it is important to consider all protection measures, in order to minimize the risk of worker illness or any accident. Protection requires the application of many special measures, starting from the procedures for protecting the radiation source and ending with the removal of waste radioactive material. Personnel working with radiation sources must be under constant supervision, considering the size of the radiation doses received, as well as under regular medical supervision.

5.2 Alternatives to Energy Illusions and the Planning Concept "Energy for the Future"

The main resources for obtaining energy in the world are fossil fuels, but due to the decreasing supply of these resources and the negative impact of the products of their combustion on climate change and the environment, there are evident efforts to diversify energy sources in all areas.

During the last few decades, the concept of planning new energy capacities in the world has changed significantly, where through the increase of competition on the open energy market, centralized fossil fuel systems have partially lost their appeal. New concepts for energy supply are based on distributed energy production, which despite the complexity of fitting such systems into existing distribution systems, still have significant advantages. In this regard, the advantages related to the possibility of using renewable energy sources (hereinafter: RES), increasing energy efficiency and self-sustainability of energy systems are particularly highlighted. The combination of several energy sources, and also the comparative production of both electrical and thermal energy, can influence the improvement of the performance of the system for the production of useful energy, [8].

With the aim of improving energy efficiency and reducing the global consumption of energy sources, in addition to the centralized production of electricity, the concept of simultaneous production of two useful forms of energy was developed in the last few decades, with the application of plants for the combined production of heat and electricity (Combined Heating and Power Systems – CHP Systems), that is (Combined Cooling, Heating and Power Systems – CCHP Systems), [1]. Such plants have a smaller capacity and are usually located near energy consumers. With the combined production of heat and electricity, significantly less heat is lost to the environment. It is used for heating or cooling purposes, which significantly increases the overall energy efficiency of the plant, [2]. In such plants, various technologies are used in which the production of electricity is based on the use of industrial steam turbines (ST), industrial gas turbines (GT), reciprocating internal combustion engines (IC), micro-gas turbines (MGT), micro-steam turbines (MST), Stirling engines (STR) or fuel cells for cars, buildings, power plants and spacecraft (fuel cell – FC), which are the subject of intensive research in the last period of the twentieth century. Functionally, in combination with different heating and cooling systems, different types of CHP or CCHP plants are used, [1, 18].

It should be noted that the most developed micro-cogeneration technologies include systems with internal combustion engines (SUS engines), Stirling engines and fuel cells. Micro-cogenerative systems represent characteristic distributed sources of energy in the sense that their electricity production can be controlled-planned to a certain extent, [17, 18]. In the case when micro-cogeneration units are equipped with a heat storage tank, the flexibility in electricity production is significantly greater, so such plants with flexible electricity production can be a substitute for conventional production plants with significantly lower energy efficiency, and they can also be used to encourage a greater input of wind power plants into the power system as a whole. It is important to point out the fact that micro-cogeneration systems are being developed as one of the competitive technologies for heating residential and commercial buildings, which could lead to their mass production, [8].

5.2.1 The future of hydrogen energy, planning and trends

Jules Verne wrote back in 1874: "Water is the coal of the future". The world we know, the entire civilization, way of life, well-being, as well as scientific and technical development, currently still rest on existing fossil energy sources (coal, oil, natural gas). Without these sources, the entire humanity would instantly return to the time of the pre-industrial revolution. In order to preserve the way of life achieved so far, as well as civilizational achievements and at the same time ensure the further progress of humanity as a whole, certain changes must be implemented due to the limitation of existing resources of fossil energy sources, environmental problems caused by their use, as well as the increasing demand for energy (human population growth, growth in the trend of living standards in countries in transition and underdeveloped countries). Hydrogen appears as a potential solution to these problems. Currently, the biggest problems with hydrogen as an energy source are reflected in the production costs (the production of 1 kg of hydrogen requires an average of 55 KWh of electricity in the water electrolysis process, so it is not competitive with fossil energy sources in terms of price), as well as in the very nature of its production (the largest amounts of hydrogen are currently obtained using fossil energy sources). At the EU level, it is planned to build a new energy system by 2050, which would be completely independent of environmentally unacceptable energy sources, especially coal and oil, and which would rely entirely on renewable energy sources. On the other hand, the Government Regulation entitled "Plan for the development of the hydrogen economy in the Russian Federation until 2024" was adopted. and the adoption of a special Strategy that would define all plans in this area until 2050 was announced. In December 2017, a comprehensive Hydrogen Energy Strategy was published in Japan, which represents a joint platform of the public and private sectors and covers the period up to 2050, and in South Korea, a national Hydrogen Energy Utilization Strategy was presented in 2018. The draft of the new Energy Law in China promotes hydrogen as a very promising energy source in the future. Similarly, at the end of 2019, Australia presented its national strategy for the use of hydrogen energy, which covers the time period between 2020–2030. year. The USA, with between 12–16% of the total world production, is the world's largest producer and consumer of hydrogen after China. Competent federal institutions, such as the Federal Ministry of Energy, in their relevant research and public studies are increasingly mentioning hydrogen as a tool that would help solve problems related to current climate change, i.e., achieving zero greenhouse gas emissions. In addition to the mentioned countries, India, Canada, Morocco, South Africa, Saudi Arabia, as well as the United Arab Emirates, among others, are currently paying great attention to hydrogen and its application possibilities. It is evident that the perspective of using hydrogen energy in the future is very large (Figure 5), primarily because it goes hand in hand with the technologies of using renewable energy sources. At the same time, the basis for the further development of hydrogen energy technologies certainly exists, and the results achieved so far in these fields are positive and encouraging.

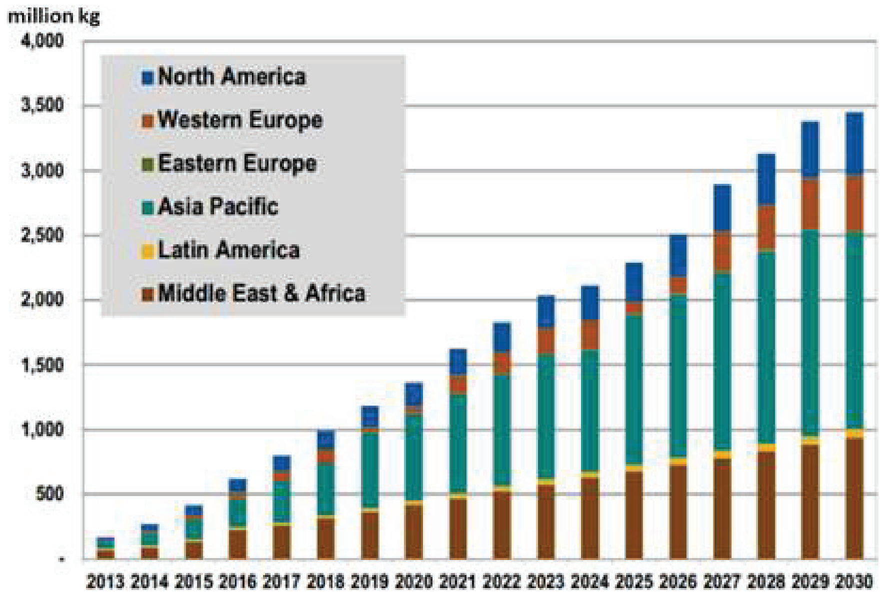

Figure 5 Hydrogen consumption by region of production, world markets: 2013–2030.

5.2.2 Combined production of useful forms of energy

The combined production of electricity and thermal energy (often also technological steam) is a consequence of the desire for the greatest possible use of fuel and savings in investments compared to the realization of individual plants, which are used only for the production of electricity or thermal energy. At the same time, in addition to the supply of electricity, it is necessary to fully cover the demands of consumers (urban environments, industrial zones, agriculture) for thermal energy and technological steam. Most often, the combined or coupled production of electricity and heat energy (CPEHE) is realized in existing thermal power plants-heating plants (TPP-HP).

Turbines for the combined production of electricity and heat work in parallel in two energy systems – the electric power system (EPS) and the thermal energy system (TES). At the same time, these systems have their own technological characteristics and specificities, which further result in certain technological conditions and requirements that steam turbines must meet. By using the main characteristics of the power system (annual diagram of load duration, daily diagram of electrical load), the main requirements are defined from a technological point of view (maximum electrical power, electrical power at the technical minimum, range of electrical power change, speed (time) of starting from hot, warm and cold conditions, gradient speed of electrical power change and sudden speed of electrical power change) and from a technical-economical point of view (specific heat consumption of the plant, heat consumption at start from hot, warm and cold conditions), which must be satisfied.

The thermal energy system is basically a system of urban energy consumers or a system of industrial heat consumers. It is also characterized by a load duration diagram or a daily load diagram. In the system of industrial consumers, the load changes very little over time (in the largest period it is close to the maximum load). Depending on the type of industrial consumers, the duration of these loads ranges from 8760 (8784) working hours (base chemistry plants) to 2500 working hours (process industry plants). The system of urban heat consumers includes heat consumers for room heating and sanitary hot water consumers.

Most often, all of them (maybe only one) are connected to the remote heat energy supply system. Heat consumption for heating depends on the ambient temperature (maximum in the coldest winter months, zero outside the heating period). Heat consumption for sanitary needs is usually constant throughout the year, with small and insignificant changes (depending on the number of users, standards and their habits). The total load duration of the district heating system depends on the climatic conditions and the extent of participation of certain types of thermal energy consumers.

Starting from the characteristics of thermal energy systems, the main technical and technological requirements are defined, which the used steam turbine in the composition of the CPEHE plant (plants for the combined production of electricity and heat energy) should satisfy. In addition to the above, the heat energy system should satisfy: the requirements for the thermal power of the turbine and specific heat consumption at maximum thermal power, specific reduction of electric power at maximum thermal power (heating operation mode), heat consumption at the start of the plant from a hot, warm and cold state, the range of pressure regulation for each of the consumers, the minimum electric power at maximum or nominal thermal power, as well as the maximum electric power at purely condensing mode of operation.

The fastest increase in the unit power of steam condensing turbines was recorded in the early fifties to the mid-seventies of the last century, when, under the influence of the first energy crisis, it slowed down significantly. At the same time, there is an increase in the unit power of steam turbines for CPEHE, so that at the end of the twentieth century, these powers are practically equal to the power of condensing turbines with two-pole generators. The result of combined energy production is a high level of utility of the steam turbo-plant and the unit as a whole.

Planning and development of energy systems is a complex activity, which includes development plans, design, construction, but also finding opportunities to use already built systems in the best possible way (optimization of exploitation mode, power balancing, etc.). Thermal energy plants within the EPS are gaining in importance every day, whether they are solid, liquid and gaseous fuel plants or nuclear plants. Their role is not diminished even by the more frequent use of renewable sources, as more environmentally friendly ways of obtaining energy. The most important factor for the future development of TPP (for fossil fuel thermal power plants) is the availability of fossil fuel reserves, which are of limited capacity. In addition, great importance is attached to the preservation of the environment and respect for the laws that treat this area. This is an issue that should be actively worked on in the future, with the aim of reducing emissions in combustion products and other harmful effects caused by thermal energy plants.

Bearing in mind the mentioned factors, which may eventually represent a brake on the smooth development of TPP, there is a need for the development of plants with the highest thermal efficiency and better energy indicators. The production of electricity in thermal power plants (TPP) and power plants is precisely characterized by greater economy and better energy indicators, because in such a process there are no losses in the cold source. In accordance with current requirements and efforts to increase energy efficiency, plants for combined energy production using gas and steam turbines have played a significant role. Their main advantage is the utilization of waste heat, which significantly increases thermal efficiency. The development of such thermal power plants represents one of the perspectives of the future development of energy plants.

5.2.3 Cogeneration and trigeneration (poly-generative energy systems)

Energy systems for the production of electricity and thermal energy are based on the process of simultaneous conversion of fuel energy into heat and electricity, Figure 6. This method of production represents energy technology with the first implemented systems dating back to the time of steam piston engines.

There are several ways to realize the simultaneous production of electricity and thermal energy, such as: energy systems based on the steam process,

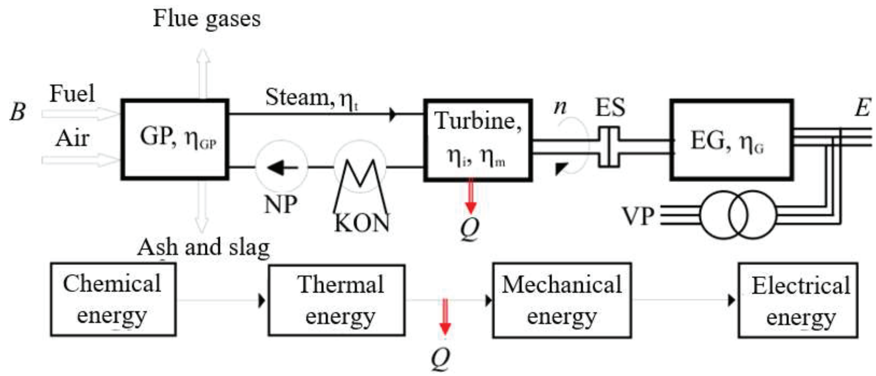

Figure 6 Representation of conversion of primary form (chemical) energy into final (useful) forms of energy.

energy systems based on the gas process, then energy systems based on the combined steam-gas process, as well as cogeneration energy systems. An electric generator is used for the production of electricity, which is usually driven by a steam or gas turbine or a gas or SUS engine. Cogeneration systems with fuel cells and cogeneration systems with magneto-hydrodynamic (MHD) generators represent systems that are less frequently used in practice and whose improvement in order to eliminate certain shortcomings is expected in the next period. The heat released during fuel combustion is used in the central heating system. At the same time, the fuel can be of fossil origin (natural gas, liquid petroleum gas, liquid fuels or solid fuels, i.e., coal) or a renewable source of energy (biomass, biogas, landfill gas, etc.). Modern systems for simultaneous production reach a very high overall efficiency (sometimes over 90%). In relation to systems with separate production of electricity, where approximately two-thirds of the input energy of the fuel is used to cover heat losses, systems with simultaneous production use that heat usefully, thus increasing the level of energy utilization of the input fuel (compared to separate production of electricity and heat, energy savings of between 20 and 40% are achieved).

Also, in most cases of simultaneous production of electricity and thermal energy, a lower load on the environment is achieved compared to separate production. On the other hand, as electricity is generally produced at the point of consumption, the safety of delivery to end users increases, and losses during the transmission and distribution of electricity are reduced, which has a positive effect on the reduction of total harmful gases in the production of electricity. Achieving lower costs, greater security of delivery and business flexibility, as well as stimulating measures by the state and local communities represent additional motives for faster development of cogeneration energy systems.

Combining a cogeneration plant with an absorption cooling system enables the use of seasonal surplus heat energy for cooling. Hot water from the cooling system of the cogeneration plant serves as the driving energy for the absorption chillers. The hot exhaust gas can be used as an energy source for highly efficient steam chillers. In this way, more than 80% of the thermal energy of the cogeneration plant can be converted into cooling water. In this way, the overall efficiency of the cogeneration plant is significantly increased.

Cogeneration contributes to a significantly better energy future, reducing environmental damage caused by classic energy activities, and the most important benefit is the reduction of carbon dioxide emissions (possible reduction of CO_2 emissions by 50%, compared to usual sources of heat and electricity). Another benefit is the reduction of sulfur dioxide and other harmful gases. A well-designed and well-managed cogeneration plant will improve energy efficiency and significantly reduce CO_2 emissions. With a typical energy efficiency of 70 to 95%, cogeneration is the best standard solution for the electricity and heat generation sectors. Cogeneration provides the most cost-effective option for electricity production, when savings from heat use are considered. In countries where the electricity market is liberalized, cogeneration can develop much more freely than in markets with managed tariffs. Bosnia and Herzegovina, with the already adopted legal legislation, has all the prerequisites for the freer development of cogeneration, and therefore also within the Republic of Srpska as its component entity. The economic efficiency of cogeneration depends on the characteristics of its specific application and the national legal framework. However, for many users of cogeneration, it is a significant investment, so it is necessary to define all initial possible options before starting the construction of the facility in terms of obtaining more favorable financial resources (e.g., with the participation of the funds of the RBI of the Republic of Srpska). Since the cogeneration plant operates for at least ten years, it is necessary to consider the costs of the entire working life of the plant.

In the best case of application, the cogeneration plant can sell its electricity to other consumers. Certainly, this way of working will enable the cogeneration system to work longer, increasing energy and financial savings, as well as earnings. The sale of electricity requires access to the electrical distribution (ED) network. The current relations between the co-generator and the operator of the ED network are such that it is not always allowed to sell electricity in a way that would enable the further development of cogeneration. This issue can be resolved in the future through the adoption of appropriate already prepared decisions and regulations by the Regulatory Commission for Electricity of Republic of Srpska, that is Bosnia and Herzegovina. In this way, the conditions for more significant stimulation for production would be provided, so that consumers would continue to use the economic benefits that cogeneration brings. Due to the nature of the technological process, the combined plant for the production of electrical and thermal energy should be energy efficient, with a significant saving of primary energy during its transformation into thermal and electrical energy. This, in turn, would lead to lower costs in energy production and contribute to a relative reduction in the emission of harmful substances, especially greenhouse gases. On the other hand, such plants have a good chance to ensure a favorable valuation of electricity in the coupled process of heat and electricity production ("green" energy) through the application of Directive 2004/8/EC, and to enable the use of incentive measures in the financing of construction, as well as benefits in the placement of such energy on the energy market. This could create good conditions for entering the energy market, regardless of relatively small amounts of energy and strong competition on the market. The European Parliament adopted the Directive on the promotion of cogeneration based on the demand for useful heat in the internal energy market. It obliges all EU members to adopt appropriate national regulations, which will achieve the set common goals in an optimal way for each member. In order to create conditions similar to those prevailing in the EU countries, it is necessary to adopt all secondary regulations in accordance with the current law on energy. As part of this process, we should also expect the adoption of regulations that would create conditions for the implementation of the EU Directive on the promotion of cogeneration in these areas in the near future. Also, the establishment of the Agency for Energy Efficiency is expected, which would prepare a draft of a multi-year program for promoting cogeneration in the Republic of Srpska, which could become national (at the Bosnia and Herzegovina level) after the harmonization of all relevant institutions. In the Republic of Srpska and Bosnia and Herzegovina as a whole, there is no necessary institutional organization to promote cogeneration. The launch of a national program for cogeneration and appropriate institutional organization would facilitate the application of cogeneration in the Republic of Srpska, that is, Bosnia and Herzegovina as a whole. The relatively high absolute temperature of the environment, in accordance with the second law of thermodynamics, prevents that in the known thermal cycles, slightly more than 40% of the input energy contained in the fuel is converted into useful mechanical work. The rest of the energy will, as an inevitable loss, be discharged into the natural heat reservoir, i.e., external environment.

The disadvantage of today's classic conventional thermal power plants is precisely the non-use of released low-temperature energy, which is irreversibly lost by cooling the working fluid in the condenser and additionally causes problems due to excessive heating of the river flow, reservoir or surrounding air (depending on the chosen concept for its cooling). Industrial process plants together with centralized heating systems provide the possibility of returning and using that energy in the form of heat by applying energy processes with coupled (linked or combined) production of electricity and heat. This is how one gets the application of the so-called cogeneration, which evaluates primary energy more efficiently and makes better use of fuel exergy. At the same time, thermal energy is used for technological needs in industry or for heating rooms in district heating systems (central heating). As steam or hot water produced by burning fuel in steam generators or hot water generators is used for this purpose, the parameters of such steam are relatively low (necessary temperatures from 50 to 200°C). Due to the large temperature differences between the temperature in the combustion chamber as a result of the combustion of the primary fuel (1500 to 1600°C) and the starting temperature of the working medium for district heating, i.e., heating (1300 to 1500°C), there will be large irreversibility losses (increase in entropy). Solutions with the production of steam of high parameters suitable for realizing the steam turbine circular process (temperature difference of 1000°C) and with heat removal from the process at temperatures suitable for the required heating of the working medium for heating (50 to 200°C), in the case where there is a simultaneous need for heat and electricity, represent a concept based on which better parameters of work and utilization of the input primary fuel are achieved, with reduced levels of impact on the environment. Types of plants for the associated production of heat and electricity use the most common backpressure or condensation turbine plant with regulated steam removal, then gas turbine plants with and without using waste heat from flue gases, as well as internal combustion engines with the use of waste heat.

Combining a cogeneration plant with an absorption cooling system enables the use of seasonal surplus heat energy for cooling. Hot water from the cooling system of the cogeneration plant serves as the driving energy for the absorption chillers. The hot exhaust gas can be used as an energy source for highly efficient steam chillers. In this way, more than 80% of the thermal energy of the cogeneration plant can be converted into cooling water. In this way, the overall efficiency of the cogeneration plant is significantly increased.

The calculation of the actual savings resulting from the application of cogeneration production of electricity and heat is based on the obtained difference between the annual costs of separate production and the costs of the cogeneration plant. How the costs of exploitation or regular operation depend on the needs of consumers in a specific location for electricity and thermal energy (energy needs), the state of the mechanical and electrical system (heat pipes, power system), the prices of selling and buying electricity on the market, the costs of obtaining primary fuel, the occupation of space, personnel work, contributions, taxes and fees, as well as on other operating requirements (variable seasonal parameters, unevenness in requirements for a particular form of obtained energy, concession compensation and similar).

The economic feasibility of building a cogeneration plant can be most easily determined by comparing the production price of energy obtained in a cogeneration plant and the production price of energy obtained in a conventional plant (classic power plant, power plant or heating plant). The cost of primary fuel, as well as the price of both electricity and thermal energy, has the greatest impact on the profitability of the cogeneration plant and the optimal return on investment and profit, especially if the owner of the cogeneration system will have to purchase larger amounts of electricity from the power system during peak loads, downtime or repairs. In such systems, fuel costs, depending on the type and its physical and chemical characteristics, represent the most significant operating costs (up to 80% of the total costs). Fossil fuels (natural gas, oil derivatives and coal) and alternative fuels (biomass, landfill gas, biogas, liquid biofuels, waste wood, waste, geothermal energy and hydrogen) can be used as fuel. The development and design of all technologies used in cogeneration systems schemes aims to achieve the lowest possible cost and emission of greenhouse gases with high efficiency. In addition, the choice of technology primarily depends on the available type of fuel, the required power, the availability of the cogeneration plant, the environmental effects achieved, as well as the accompanying economic and financial indicators of the operation of cogeneration plants: annual savings achieved by cogeneration, costs of operating cogeneration plants (fuel costs, maintenance costs, etc.).

Polygeneration could be described as a system or process of energy supply, which has the task of supplying the consumer with different forms of energy, such as, for example, electrical, thermal, cooling energy delivered from the same plant, i.e., polygeneration is an integrated process that has three or more different forms of energy output produced from one or more natural resources. They are implemented with the aim of improving the energy efficiency of the overall system. Polygeneration includes a combination of cogeneration (i.e., simultaneous production of electricity and thermal energy) and trigeneration (production of electricity, and the possibility of heating and cooling) power plants. For a polygeneration system, a wide range of fossil and renewable energy sources can be used, such as gas, coal, biomass, waste, wind, etc., using different transformation technologies to produce different products (forms) of energy.

5.2.4 Hybrid energy systems

A hybrid system is the name for a solution that involves obtaining or producing energy from two or more sources that complement each other. Electricity sources do not necessarily have to be renewable, but in the following we will talk exclusively about renewable sources. The most common combination is the one that includes wind and sun as energy sources, but other combinations are also possible, such as hydropower plants and reservoirs for storage or solar power plants and biomass.

The hybrid system is currently considered the most efficient technique for producing electricity from renewable sources. Considering the variability of resources or sources, i.e., considering, for example, the variable amount of sun, wind strength or water level, the storage of energy in so-called tanks makes this system safe for uninterrupted power supply. Tanks are considered the leading solution for cases of higher or lower consumption or production. A hybrid system can thus produce much more energy for use and thus ensure a continuous supply of the system or household. What makes it special is the fact that it does not depend on one natural resource, but two that complement each other.

The hybrid system can also function as one natural resource with the use of a storage tank, where the storage tank is considered another source that, due to the lack of a primary natural source, provides already produced additional amounts of natural resources that supply the power plant, i.e., the building or household. Hybrid systems will be used more often for the needs of industry, because for smaller power supplies, one natural source is often enough. Hybrid systems can power a variety of commercial and residential buildings and facilities, each not necessarily using the same source.

Hybrid systems are designed to reduce the use of a non-renewable source in addition to a renewable source to obtain the required amount of electricity. An example is the combination of sun and wind. However, currently the system itself is still insufficiently developed in order for some important institutions to switch to supply from exclusively renewable sources due to the possible instability of the network. That's why institutions like hospitals, banks or government institutions, which are powered by a hybrid system, are powered most often from one natural source and another non-natural source to make sure that they will not run out of electricity. Currently, most hybrid power systems are used by houses far from the center of the power grid, for example in the mountains, a small island, remote villages or some rural areas. Also, hybrid power systems from natural sources are suitable, for example, for ships, lighthouses or similar vessels or objects. However, by building additional energy storage tanks, it will be possible to power much larger systems.

The biggest increase in the use of the hybrid system will soon be visible in industrial plants, which are large consumers and often also energy producers. In addition to the industry, there are many advantages for others, so hybrid systems will lead to lower investment costs in facilities, less storage space will be needed, savings will lead to the possibility of investing in infrastructure, operating costs will also be reduced, energy will be produced locally, which is why each country or smaller area will depend on itself and on its own production, which will not lead to the instability of the energy network.

Various renewable sources can provide clean energy. Depending on where you are, certain resources may be abundant, and clean energy from these resources may be profitable. Warm and dry climate where open land is ideal for solar energy. For example, the US Southwest has some of the best solar radiation in the world. As a result, it is experiencing a rapid development of solar energy. Countries like Denmark and the Netherlands may not have the same sunny weather. However, they have access to the sea, where large offshore wind farms have been built to harness the power of the wind. One 15 MW wind turbine can produce enough energy to power a small city. Other top clean energy sources include nuclear, hydro, and geothermal.

Hydrogen energy will play a key role in the future energy landscape. Hydrogen can be produced in a renewable way by electrolysis of water using renewable energy. Hydrogen has a high energy density, which is why it is a sustainable alternative to fossil fuels for combustion. Just like natural gas, we can transport hydrogen through pipelines over long distances. By converting it into liquid ammonia, we can also ship hydrogen across the sea using tanker ships. However, there are challenges to establishing a hydrogen economy. These include reducing the cost of hydrogen production and expanding the storage and distribution infrastructure.

Renewable natural gas (RNG) is another fuel that can be low carbon or carbon neutral. It is produced from organic waste such as livestock, waste or food waste. RNG can serve as a substitute for natural gas in a number of applications. These include motor vehicles, domestic heating and industrial processes.

5.2.5 Energy storage

The requirement that the consumer be provided with electricity for all his needs is the main cause of the complexity of the power system. Namely, larger deviations of electricity consumption from its production call into question the stability of the entire system. As a consequence of the inequality of production and consumption of electricity, there are problems related to the deviation of voltage and frequency from their nominal values. The term "energy storage" refers to the transformation of some transient forms of energy (electrical energy, thermal energy, mechanical work or friction work), into a form suitable for storage (some form of internal energy) and back again. On the other hand, when using the RES system for autonomous coverage of a small (household) or large consumer (distributed sources for isolated villages, cities or island settlements), energy storage systems enable the matching of requirements with the possibility of supplying electricity to end consumers.

The problem of energy storage was previously solved using simple methodologies: piling up logs, building a dam for the needs of a mill, providing coal supplies, and the like. There are a number of reasons why electricity is stored, such as: achieving the energy balance (harmonizing the non-simultaneity of electricity consumption and production, reserve with the aim of preventing power losses), in the part of covering peak consumption and remediating the occasional unavailability of certain energy sources (compensating for variable production of renewable energy sources), managing changes in consumption, improving the reliability and security of energy supply, raising and ensuring the quality of delivered energy, off-grid power supply, reducing investments in peak energy plants, achieving a greater share of renewable sources in the production of useful forms of energy (solution to the problem of stochasticity, stronger integration of RES into the EES), i.e., production when the energy source is not available and storage when it is available. Energy storage represents an important segment of all physical processes and enables energy management. There is a need for an intermediary between energy sources and consumers, that is, the need for an energy storage system, [8].

The European Commission analyzed scenarios for the decarbonization of the energy system and in 2011 published the Energy Plan until 2050, with different scenarios. In order to achieve the decarbonization assumptions for 2050, the electricity sector would rely on a large share of energy from renewable sources (between 59 and 85%), the majority of which would come from variable renewable sources of electricity generation.

Every technology for electrical energy storage is based on the transformation of energy from one form to another, so one of the possible formal definitions of energy storage is that it is the transformation of a transient (process) into a permanent form of energy, suitable for reverse transformation. In order to store and save electrical energy for a certain period of time in alternating current systems, it is necessary to convert it into another form of energy, such as electromagnetic, electrochemical, kinetic or potential energy. Energy is stored at intervals when energy production exceeds its consumption, and stored reserves are used when energy consumption exceeds its production. In this way, electricity production should not be drastically increased or decreased according to consumption requirements, but maintained in an even ratio. Energy storage gained importance especially with the development and integration of renewable energy sources with the grid. Renewable energy sources are unpredictable by nature, because the amount of energy they produce changes significantly and depends on weather conditions. Energy storage represents the procedure of adjusting the produced electrical energy according to its consumption, which is variable over time, i.e., the so-called "ironing" the production diagram and the diagram of electricity consumption. A common feature of all energy storage technologies is the relatively high level of initial investment, but also their subsequent low operating cost. This is the reason why today much attention is paid to the development and use of such systems.

Starting from the basic features of the electric power system (EPS) related to the transmission and storage of the produced electricity (the most convenient and flexible power transmitters, the impossibility of storage), as an alternative to overcome these shortcomings, the so-called secondary energy storage. The system for secondary energy storage is a system specially designed to accept the produced energy in the EPS, to convert it into a form that is suitable for storage, to keep it for a certain time and to return as much energy as possible to the EPS by converting it into a form that is suitable for use. It consists of a power transformation system (PTS – Power Transformation System), a central store (CS – Central Store) and a charging and discharging control system (CDCS – Charge-Discharge Control System), [8].

Categorization of energy storage systems is done on the basis of different criteria for their categorization, such as their purpose, response time or capacity, then according to the form of internal energy (energy categorization) and corresponding applied technologies, their degree of development, the way of connection to the EPS, etc. Energy storage in the power system is defined as a system or procedure by which it is possible to store the energy that is generated in the power system, keep it stored and use it when needed. All energy-producing industries, including electricity generation, store significant amounts of energy. Energy storage can be done through combined and hybrid systems. Combined systems are systems with one primary source of energy at the input and two or more types of energy at the output. An example of such a system is the so-called CHP production, which represents the process of simultaneous production of electricity and heat in a single process. Hybrid systems are systems with two or more types of input energy and one type of energy at the output (e.g., wind-photovoltaic system). Active use of solar energy refers to the direct use of radiated energy for transformation into electrical energy, which can be used to power electrical devices or store it in solar batteries. There are a large number of different versions of these plants, depending on whether they are connected to the distribution or transmission network (on-grid) or work autonomously (off-grid). In the case of autonomous systems, an accumulator (battery) is necessary, which will serve as a reservoir of electricity (when it is necessary to supply electricity overnight or in a period with low intensity of solar radiation). By adding a regulator, the charging and discharging of the battery can be controlled, and by adding a DC-AC transformer, autonomous systems can satisfy all types of consumers (they are suitable for providing the necessary amounts of electricity for remote consumers). Hybrid systems most often connect the solar system with other alternative sources of electricity (wind turbines, hydrogen generators, auxiliary gas or diesel aggregates, etc.), providing greater security and availability of electricity supply, and also enable smaller capacities of accumulators as electricity storage. Dimensioning the system for solutions that use diesel and gas aggregates implies their exploitation in very few hours a year, which saves fuel, reduces maintenance costs and extends the service life. Passive grid photovoltaic systems use electricity only in periods when the modules cannot produce enough electricity, e.g., at night, when at the same time the batteries of electricity are discharged. In most cases, photovoltaic systems are cheaper to install than additional installation of transmission lines and transformers. Active, i.e., interactive network photovoltaic systems use the network interactively (in case of greater needs, they take electricity from the network or its delivery to the network in case of excess electricity produced in the modules in accordance with the signed contract on the delivery/reception of electricity with the competent distribution or transmission company).

The most commonly used method of dividing energy storage containers stems from its definition as a body (object) that stores (stores) some form of internal energy. According to this criterion, the following are distinguished: reservoirs of mechanical energy (gravitational or elastic potential energy and kinetic energy), reservoirs of electromagnetic potential energy, reservoirs of electrochemical energy, reservoirs of internal caloric (thermal) energy, chemical or electrochemical energy.

If appropriate technologies are added to the previously given criteria, it follows that (electrical) energy storage can be further divided into hydro pump systems PHS (Eng. Pumped Hydro Systems), flywheels (flywheels), compressed (compressed) air (air) storage CAES (Eng. Compressed Air Energy Storage), spiral springs, capacitive storage, inductive storage SMES (Eng. Super Magnetic Energy Storage), thermal energy storage, accumulators and batteries, hydrogen and solar fuels, Figure 7. Analyzing the given graphic representation from Figure 7, it can be seen that the transitional form of energy created in the energy production system undergoes a single or multiple transformation before its final stabilization in a permanent energy form.

The classification according to the degree of development of certain technologies used is also interesting. Conditional categorization implies a division into 4 categories (commercial, pre-commercial, demonstration and development), where the further development of these technologies will condition their new division according to this criterion.

At the same time, commercial plants included five plants in operation with ten years of work experience in exploitation per unit, as well as clearly defined financial investments and profit (time of return of invested funds), pre-commercial plants – one or more commercial plants, a without enough years of work to define experience in exploitation and financial structures, while for demonstration and development plants there were limited work experiences or only a laboratory plant, respectively. There are also some other divisions, e.g., into three categories: developing technologies, developed and mature technologies. The parts of the energy storage system are: power transformation system (PTS), central storage (CS) and charge and discharge control system (CDCS). The power transformation system is the

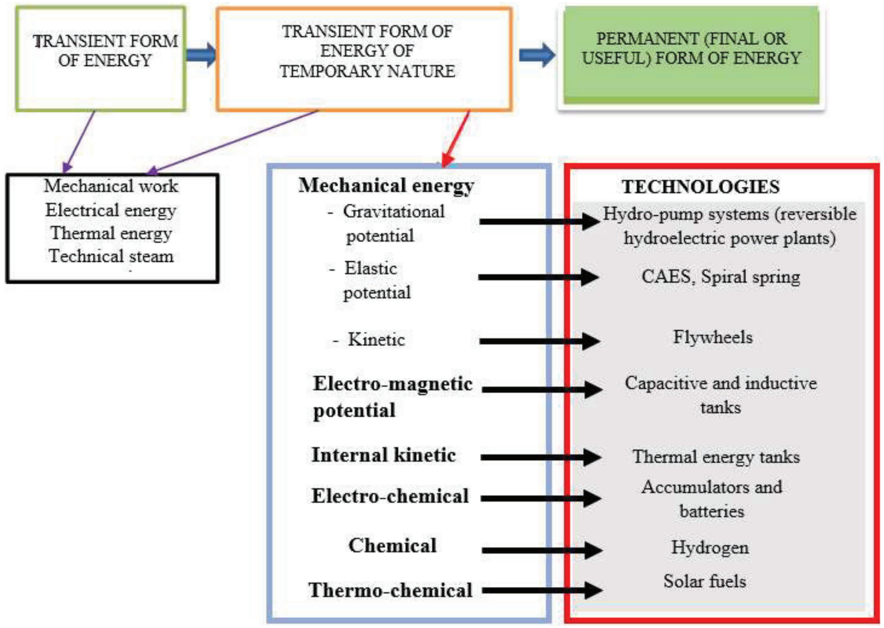

Figure 7 Energy categorization of energy storage, [8].

coupling between the power grid and the central storage. In addition to being used to manage the energy exchange process between the power system and the central storage, it is also often used for power adjustment. Power transformation systems can be: thermal, electromechanical and electrical. Such systems are connected to the power grid either in series or in parallel. In case of parallel connection, PTS is dimensioned according to the capacity of the central storage, while in serial connection, PTS is dimensioned according to the total energy. Central storage can be defined as an "energy store", from which energy can be taken, with a power that does not exceed the installed capacity of the power transformation system, until it is discharged. The central storage, which includes the energy storage medium and reservoir, must have the ability to charge and discharge, which are carried out up to the power level predetermined for these processes. Central storage can be implemented as mechanical (uses potential and kinetic energy), thermal (uses sensible and latent heat of the relevant medium), chemical (uses chemical energy for storage) and electrical (uses electromagnetic and electrostatic field energy). The management system for charging and discharging manages the processes of charging and discharging energy storage, in accordance with the mode of operation in the power system. The control system includes sensors placed in the power system, the power transformation system and the central system, [8].

When choosing the appropriate way to store energy, it is important to know the basic (general) characteristics (parameters) of the storage system, such as: energy storage capacity, maximum power and time constant, energy density and power density (energy and specific power), storage cycle duration, charging and discharging speed (power), energy losses and storage efficiency (cycle efficiency), aging of the system, response time, investment costs, durability, economy, compatibility, autonomy, reliability, impact on the environment (environment) and etc. These parameters serve to compare different energy storage methods.

Based on the results of the comparison, a final decision is made on the choice and commitment to the optimal energy storage method for each specific situation.

Storage efficiency is defined as the ratio of the energy leaving the storage during discharge to the energy entering the storage during charging.

The total efficiency of the energy storage cycle (ηs) is defined as the ratio of the energy that leaves the tank during discharge and the energy that enters the tank during charging.

5.2.6 Distributed energy sources

Distributed electricity production is a term used in the power industry for the production of electricity at the consumer's location, [8]. As a production system of electricity, it is connected directly to the medium-voltage or low-voltage distribution network or is connected in the installation from the consumer's side, whereby distributed sources include autonomous sources (stand-alone) and sources for backup power supply of consumers in the distribution system. The terms (synonyms) used in the literature are: Embedded Generation – EG (South America), Dispersed Generation – DPG (North America), Decentralized Generation – DCD (Europe and part of Asia) and Distributed Generation – DG (generally accepted term). The Electric Power Research Institute (EPRI) defines distributed generation as the generation of installed power from a few kW to 50 MW, while the Gas Research Institute defines distributed generation in the range of 25 MW to 50 MW. CIGRE defines distributed production as production whose installed power is less than 50 to 100 MW. The use of distributed energy sources (DES) reduces losses in the transmission system, with the use of heat losses. Apart from wind farms, distributed sources are most often connected near consumers in the distribution network, which in principle helps to reduce losses in the distribution system.

Decentralized production, as an alternative or supplement to centralized electricity production systems, results in an increase in supply reliability and a reduction in energy losses, along with a reduction in the emission of harmful substances, and represents a possible alternative or supplement to centralized production systems. Also, the drop in prices of equipment for distributed systems, the introduction of incentive measures or subsidies at the state level (which resulted in favorable purchase prices for 1 kWh of electricity produced from these sources) led to the uncontrolled mass installation of distributed sources of different power, where this development was usually not accompanied by adequate planning and alignment with the state and capabilities of the energy infrastructure, developed for centralized energy sources of large power, [8]. The result of this disparity was numerous problems related to the complexity of planning and running distribution networks (mass introduction of unregulated and unmanageable generators into the distribution network, selection of their optimal location and installed power, introduction of private investors as owners of distributed sources of electricity in addition to existing public production companies, technical problems related to the criterion of permitted power of small power plants, criterion of flicker, criterion of permitted currents of higher harmonics, criterion of currents of three-phase card connection, etc.). All these problems significantly complicated the work of distribution network planners in the process of planning and reconciling the demands on the one hand for quality delivery of electricity to end customers, and on the other hand the demands of investors for the largest possible production of electricity, with the aim of increasing their profits.

The problem of allocation of distributed sources of electricity comes down to defining the location of the DIE in the distribution network, optimal power and energy losses, whereby the aim is to optimize one or more objective functions, while satisfying a certain set of constraints. At the same time, the objective functions can be the reduction of operating power losses, the minimization of voltage drops, the maximization of savings in the form of postponing investment in the distribution network, the increase of voltage stability, etc. As there are a large number of combinations, it is necessary that the number of objective functions that can be directly mapped into financial parameters is relatively small.

Distributed energy sources include energy production and storage systems located close to the point of final consumption. Distributed energy sources are usually of low power, their operation can be island (autonomous), but they are most often connected to the distribution power network (less often to the heating network). Through strategic planning, the development of distributed energy sources is directed so that their role in energy supply is complementary to large energy systems, which in the event that it is justified from the point of view of sustainable development, the construction of distributed energy sources will be further stimulated. The use of distributed energy sources is expedient for energy-intensive facilities in the service sector, for larger residential or residential-business facilities, but increasingly also for smaller facilities (family and weekend homes).

It is expected that in the coming period the Republic of Srpska will continue to stimulate the construction of distributed energy sources (on the basis of OI), as complementary systems to large energy systems. Only the wider application and further technological development of the technologies of these systems can, with high energy prices and increased fees for CO_2 emissions, be competitive in terms of their economic parameters with the supply of energy from conventional energy systems. As investments in these technologies are mostly private, their application encourages an entrepreneurial climate and the development of energy services. At the same time, cogeneration/trigeneration units will continue to be used for heating, cooling and production of electrical and thermal energy, as well as cooling energy, while the application of heat pumps is expected more intensively in low-temperature heating systems (mostly not applicable to existing heating systems). At higher energy prices, heat pumps become competitive, so, with high-quality stimulation systems, their increasing application for heating and cooling residential and residential-business buildings is expected, [8].

5.3 Overview of the Consumption of Primary Forms of Energy in the Republic of Srpska for the Year 2023

The main carriers of heating in the Republic of Srpska are heating plants, mostly organized as public utility companies. Currently, in the Republic of Srpska, district heating services are provided by 14 heating plants with a total installed capacity of 457.7 MW, Figure 8.

In addition to 14 heating plants, the thermal energy supply system also includes TPP Ugljevik, which provides thermal energy for the city of Ugljevik, where the activity of distribution and supply of thermal energy is not separated from production.

An overview of energy consumption for the production of electricity and heat for the year 2023 is given in Table 2.

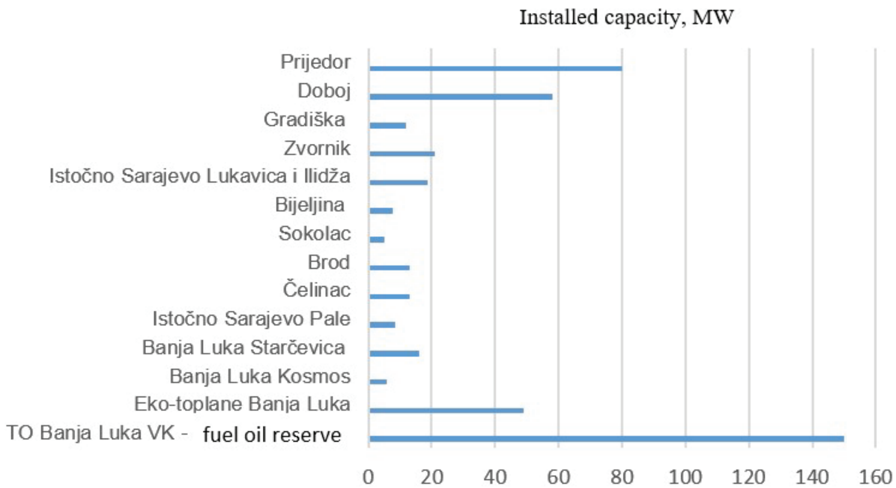

Figure 8 Installed capacities of heating plants in the Republic of Srpska.

Table 2 Consumption of energy commodities for the production of electricity and heat, 2023

	Energy Source									
	Coal		Fuel oil		Natural gas		Biomass		Biogas	
Heating Plants	t	TJ	t	TJ	$Sm^3 \cdot 10^3$	TJ	t	TJ	$Sm^3 \cdot 10^3$	TJ
Thermal power plants	6295529	54204	16673	670						
CHP plants							24019	247		
District heating plants	49345	471	1657	67	1809	60	90979	912		
Industrial power plants (Autoproducers)	17345	302					2184	22	1476	28
Total	6362219	54977	18330	737	1809	60	117182	1181	1476	28

6 Results and Discussion on the Adopted Policies for the Development Strategy of the Electricity Sector of the Republic of Srpska

6.1 Regulation for Energy Efficiency in the EU and Republic of Srpska and Bosnia and Herzegovina as a Whole

From the current regulations regarding energy efficiency in the EU, which affects the decisions of the Electric Power Company of the Republic of Srpska (as well as the electricity industry in the Federation of Bosnia and Herzegovina) in terms of long-term development, the following can be distinguished:

directives related to energy efficiency, EU standards/norms for energy efficiency, directives related to renewable energy sources and greenhouse gas emissions. As part of the obligations from the Agreement on the Energy Community, the transposition of the EU acquis for energy efficiency into the legislation of Republic of Srpska – Bosnia and Herzegovina is underway. On the basis of Directive 2006/32/EC on energy efficiency of end-use energy and energy services, the Law on Energy Efficiency of the Republic of Srpska was prepared. The First National Action Plan for Energy Efficiency was prepared, as well as a preliminary report on its implementation (prepared by the Energy Community). National plans for energy efficiency define quantitative goals for increasing energy efficiency in terms of savings in the final consumption of energy sources, considering households, traffic and industry. In November 2012, the new Energy Efficiency Directive 2012/27/EU entered into force in the EU, which replaced the Cogeneration Promotion Directive 2004/8/EC, as well as the Energy Efficiency Directive 2006/32/EC, and significantly tightened and expanded activities to increase energy efficiency and energy savings, and now in the entire chain from production, through distribution and supply, to final energy consumption. The directive mandated the allocation of public funds for such projects, predictions of the development of company plans for energy savings, the performance of energy audits as a regular activity in companies, the introduction of Energy Management systems in companies, the installation of smart meters, etc. For now, the EU member states are obliged to implement the directive, and the Energy Community countries will have to wait for reports on the effects of the directive in the member countries, before it becomes binding for the Energy Community countries as well. However, it is to be expected that this will happen in the near future, so this directive, and all that it carries in terms of plans, goals and obligations for energy efficiency, should be considered when defining the development plans of the EP of Republic of Srpska – Bosnia and Herzegovina.

6.2 Guidelines for Energy Efficiency in Production

Although significant progress has been made in recent years in the production of MH Electric Power Company of the Republic of Srpska to increase energy efficiency, the results still lag behind developed countries, primarily due to the obsolescence of the existing production park of power plants and related technologies. In this sense, MH Electric industry of the Republic of Srpska faces the challenge of introducing efficient and clean technologies into the production portfolio – power plants based on renewable energy sources and thermal blocks with clean coal technologies, in order to further increase energy efficiency and reduce emissions. When it comes to existing production facilities within the EES of the Republic of Srpska, the achieved value of specific heat consumption for the existing partially reconstructed and modernized units of TPP Gacko 1 and TPP Ugljevik 1 of about 30 to 33%, with planned maintenance and investment measures, will be maintained until they are decommissioned, with a proportional increase in energy efficiency with the planned entry of new, more efficient thermal units of the new generation into the company's production portfolio.

For the implementation of such determinations, it is necessary to develop detailed activity plans for the realization of projects such as operational plans for increasing energy savings through the reduction of own consumption in production units, which will be continuously implemented, with the implementation of energy audits and monitoring of effects in production facilities, then activities and projects with the aim of optimal load distribution of the production units of MH Electric Power Company of the Republic of Srpska, based on the real (on-line determined) specific heat consumption of thermal blocks, and all with the aim of managing production units (load schedule) in to the production efficiency objective function.

There is also the continuous implementation of energy audit activities at mines, with the aim of identifying and implementing measures to increase energy efficiency at mines and improve the quality of delivered coal (coal separation projects at mines to improve and standardize the quality of delivered coal – 1st degree of coal homogenization). We should also not forget the implementation of development activities and cogeneration expansion projects from TPP Ugljevik 1 and TPP Gacko 1: heating of the Gacko area from TPP Gacko 1 (cogeneration) – realization of the project in accordance with the recommendations of the done Study with conceptual solution and improvement of the heating level of Ugljevik from TPP Ugljevik 1.

To envisage the preparation of Studies on the implementation of a partial increase in energy efficiency at existing power generation facilities, as well as the implementation of development activities and projects that imply a reduction of CO_2 emissions. When it comes to new production facilities, from the aspect of the net efficiency of thermal energy facilities, the document of the European Commission from July 2006 is important: IPPC8 – Reference Document on Best Available Techniques for Large Combustion Plants (IPPC – Reference Document on Best Available Techniques for Large Combustion Plants), which lists the net efficiency of thermo-blocks according

Table 3 Efficiency levels according to BAT for thermal power plants

		Net Efficiency, %	
Fuel	Combustion	New TPP	Existing TPP
Lignite/Brown coal	Cogeneration (CHP)	75 – 90	75 – 90
Lignite	FBC	>40	• Specific to each power plant • Indicative: 26 – 40% or 3%
	PFBC	>42	
	PC (DBB)	42 – 50	
	FBC	>41	
Brown coal	PFBC	>42	
	PC (DBB and WBB)	43 – 47	

PC – Pulverised Combustion; DBB/WBB – Dry/Wet Bottom Boiler; FBC – Fluidised Bed Combustion; PFBC – Pressurised Fluidised Combustion

to the best available techniques in relation to the type of plant and type of fuel Table 3.

What is important for the production portfolio of MH Electric Power Company of the Republic of Srpska, i.e., the planned new thermal energy projects in the next planning period, can be seen from this document that: for lignite block 2 in TPP Gacko, for the planned FBC combustion technology, the minimum level of net efficiency is 40%, for block 3 in TPP Ugljevik, which will use brown coal, with in-flight combustion (PC) technology, the net efficiency would be at least 43%, and with combustion technology in fluidized bed (FBC) higher than 41%.

Furthermore, for cogeneration (CHP), a net efficiency of 75÷90% is stated for all types of coal, with the fact that the stated values for the net efficiency of cogeneration power plants (CHP) are conditioned by the share of thermal power in the total power of such plants, i.e., the net efficiency here also depends on the thermal consumption. Finally, for gas power plants with a combined plant with a gas and steam turbine (CCGT), the net efficiency in the condensation mode (mode of electricity production only) is 54÷58 %. In the aforementioned reference document, emission limit values are also given, and they are included in the Industrial Emissions Directive 2010/75/EU (IED) and thus became an integral part of the binding legislation in this area for EU member states, and in the future also for EC countries, when it comes to new thermal energy facilities. Unlike emissions, net efficiency values are not further regulated by appropriate directives or laws, and it is difficult to estimate when, if at all, this will happen. Nevertheless, Directive 2010/75/EU on industrial emissions includes energy efficiency among the criteria for determining BAT for achieving GVE, which is underlined in the preamble of the new Directive 2012/27/EU on energy efficiency.

In the new directive for energy efficiency, the promotion of efficient heating and cooling through cogeneration and trigeneration is carried out to the extent that the EU member states are obliged to identify the potential for highly efficient cogeneration and/or efficient district heating and cooling, and to realize such projects, and that in cases where the investment costs exceed the benefits of such projects, the member states are obliged to take adequate measures to realize such projects. Also, this directive distinguishes between high-efficiency cogeneration and cogeneration, in such a way that high-efficiency cogeneration should meet the criterion of achieving primary energy savings of at least 10%, whereby such plants have the possibility of appropriate incentives. This is important in the development of future cogeneration projects at MH Electric Power Company of the Republic of Srpska in the coming period, as well as in the design of the planned new thermo blocks for MH Electric Power Company of the Republic of Srpska (block 2 of TPP Gacko, solving the issue of block 2 in Ugljevik). Finally, in the EU 2020 strategy, Priority 1 – Energy efficiency, Activity 3 – which refers to power companies, it is mentioned that net efficiency should be among the criteria for issuing permits for power plants (authorization), which indicates that only thermal plants with appropriate net efficiency will be able to receive permits.

6.3 Defining Goals for 2030

Sustainable development based on the principles of economic growth with the imperative to preserve the environment and respect the social aspect is the essence of the European Union's energy and development policy. Rising energy prices and dependence on energy imports threaten the stability of energy supply, as well as the competitiveness of Europe. In addition, negative impacts on the environment and the gradual depletion of fossil fuel reserves are key problems in EU energy today. An additional problem is the imperative to reduce emissions, as well as the fight against climate change. Therefore, the central goals of EU energy policy are: supply stability (reduces dependence on energy imports), competitiveness (enables economic growth) and sustainability (enables environmental protection and social acceptability). The energy market in the European Union is liberalized for all consumers who can choose electricity suppliers that appear on the market. This means that all legal and administrative barriers to market entry for electricity and gas supply companies are removed. New suppliers have the ability to provide services to consumers at competitive prices. An open market should help to achieve real competitiveness on the European market and to improve security of supply. It should also help protect the environment as companies need to innovate in the field of renewable energy.

Climate protection policy assumes a radical reduction of CO_2 emissions and other environmental impacts. Therefore, in addition to the limitations used so far, which arise from the energy/technological/locational characteristics of the plant, a dominant limitation is also introduced – the cumulative right to greenhouse gas emissions, which has a descending character. It can be expected that by 2030, the rights to emit greenhouse gases will be at least halved compared to the initial year of 1990, which will affect structural changes in energy production and consumption. Obligations to radically reduce emissions of CO_2 and other greenhouse gases additionally require an increase in the use of non-fossil fuels, primarily renewable sources, such as water, wind, sun, biomass, and an increase in energy efficiency and the application of new technologies.

Energy efficiency is particularly emphasized as the most economically effective way to reduce emissions, improve energy stability and competitiveness, ensure the availability of energy for consumers, and increase employment. The energy sector in the Republic of Srpska and Bosnia and Herzegovina as a whole has significant development potential. The Republic of Srpska and Bosnia and Herzegovina are currently rare examples of entities in the region that have a positive electricity balance. Inadequate institutional and legal framework, political instability, undefined authorization procedures for construction and selection of investors, along with the well-known problem of complicated and lengthy procedures for obtaining a large number of permits and consents, represent an obstacle to significant investments in the energy sector in the Republic of Srpska and the Federation of Bosnia and Herzegovina, and thus Bosnia and Herzegovina as a whole. It should also be pointed out that Bosnia and Herzegovina is significantly late in fulfilling the obligations assumed by signing international treaties and agreements. The agreement on the energy community foresees the creation of a legal framework for the establishment of a free energy market, the promotion of investments in the energy sector, and assistance to the energy sector of countries in transition. The Stabilization and Association Agreement

(SAA) also requires the adoption of European energy-related directives and standards.

The development of MH Electric Power Company of the Republic of Srpska, with an emphasis on the future production portfolio of the company, should be traced considering the stated EU goals and the EU legal acquis, and considering the initial and future technological, economic, legal-regulatory and socio-political situation in the Republic of Srpska, as well as the framework positions related to Bosnia and Herzegovina. In doing so, it is particularly important to use the own energy resources and potentials available in the Republic of Srpska as a way to develop the economy, to increase employment and improve social conditions. Initial analyses, based on previous observations, suggest that the optimal and realistic development scenario for MH Electro industry of the Republic of Srpska includes a mix of renewable energy sources (RES: hydro, wind, sun, biomass, geothermal energy, etc.) and replacement and modernized domestic coal-fired power plants. Such a mix implies optimized shares of individual RES and coal-fired power plants in the function of the lowest costs of the power system, as well as in the function of other goals related to the ecological aspect (growth of renewables, growth of efficiency, reduction of emissions) and security of supply and energy independence.

Activities required to improve energy efficiency at existing production facilities are: expansion of cogeneration from TPP Ugljevik 1 and TPP Gacko 1 (heating of Gacko and Ugljevik), partial increase in energy efficiency of individual plants and processes in thermal power plants, reduction of own consumption, introduction of energy management, as well as introduction of energy efficiency management system. The new production facilities will have to meet the minimum level of efficiency according to the best available techniques (BAT) in relation to the type of plant and the type of fuel (depending on the technology, this level for the future blocks in Ugljevik and Gacko is 41 to 43%).

Projections of MH Eletric Power Company of the Republic of Srpska show that the average efficiency of the production park of thermal power plants could be increased by 2030 from the current 30 to 33% to at least 35 to 37%, and in the long term to over 40%. The Law on Electricity mandated the opening of the electricity market on the 1st of January, 2015, which is a significant influencing factor on the production activity of MH Electric Power Company of the Republic of Srpska. Customers should be able to choose the supplier from whom they will buy electricity on the unregulated open market, which has not yet been implemented in practice, and the responsibility rests solely with the energy regulatory agency. Given that all activities are moving, albeit at a somewhat slower pace, in that direction, the first determinant for the development of electricity production activities relates to competitiveness. Considering the obligations of transposition of EU regulations into domestic legislation related to the environment, renewable energy sources (RES) and energy efficiency, another determinant that directs the development of production activity is environmental acceptability. Therefore, the long-term general goal of MH Electric Power Company of the Republic of Srpska in the production activity can be formulated as follows: to be competitive and meet environmental standards. Competitiveness requires high productivity and cost reduction (highest impact of coal costs, operating costs due to redundant employees and costs related to CO_2 emissions). This determines the priority directions of action, such as: the growth of energy efficiency, which brings about a reduction of the required input raw materials and emissions, and thus costs, the restructuring of mines with the aim of obtaining coal at the lowest possible price, the realization of activities from the aspect of environmental impact, i.e., the realization, first of all, of the obligation to implement EU regulations on air emissions, energy efficiency and the participation of RES in the final energy consumption (the above can be realized with a strategy based on the use of domestic resources, both fossil fuels and renewables).

Activities and projects recommended through the long-term plan at the level of MH Electric Power Company of the Republic of Srpska relate to: planning and timing of activities related to the construction of new replacement thermal units that meet the criteria of limit emissions and minimum energy efficiency, continuation of reconstruction, modernization and revitalization of the existing units of TPP Gacko 1 and TPP Ugljevik 1, modernization of existing units from the aspect of meeting environmental standards, which implies the continuation of activities related to the construction of desulfurization and denitrification plants, especially at TPP Ugljevik 1 (obligation from environmental permit), construction of new power plants that use renewable sources (hydroelectric power plants, wind power plants, photovoltaic plants), use of biomass and cogeneration (production of thermal energy, including the construction of heat pipes to expand heat consumption). By optimizing these activities and individual projects, and considering the framework long-term energy and financial projections at the level of MH Electric Power Company of the Republic of Srpska, it is possible to achieve specific goals by 2030, as shown in Table 4 for the activity of electricity production.

In order to achieve the set goals in the field of energy efficiency, MH Electric Power Company of the Republic of Srpska needs to adopt, follow and implement its own energy efficiency policy, as part of integral activities within the Energy Management System (EMS), which needs to be introduced in the company, all according to EN 16001 and EN ISO 50001 Standards. The introduction of EMS and the implementation of energy efficiency activities based on EMS, is in accordance with the recommendations of current long-term EU strategies and guidelines, as well as new EU Directives 2012/27/EU on energy efficiency. Thus, MH Electric Power Company of the Republic of Srpska directs its activities in the field of energy efficiency in the long term in the direction of the latest developments in this area, that is, in the direction of the most developed countries.

The process of mastering new technology or the development and application of a specific innovative solution must be based on the upgrading of existing knowledge and experience in a specific area, the available personnel and their level of training and ethical awareness for the application of energy efficiency principles to energy plants within the EES of the Republic of Srpska. This implies that the technology of introducing the principle must be adopted beforehand, with the aim of integrating individual segments of energy efficiency into structured solutions. It also requires a certain level of technical equipment for implementation, as well as service ability. Interest in making money on the project, in order to be able to maintain its business and its further improvement in addition to the engagement of resources, requires knowledge of the key factors for the successful management of energy efficiency projects. Those projects include the possession of certain competencies in the field of energy efficiency technology, as well as the existence of domestic demand for certain energy efficiency technology, in order to achieve economies of scale and continue the further development of solutions and improvement of services. The demand for energy-efficient technologies is significantly influenced by the measures of domestic regulatory bodies, which include measures to raise standards and provide financial incentives for implementation.

The realization of the project also requires the possession of project management knowledge and skills, which include project management methods, from project planning, through risk management and change management, to cost and time management. Careful planning of the project and detailed definition of the offered solution results in the accuracy of the evaluation of the effects of the investment (calculated, considering not only the technical brochures of the manufacturer, but also comparisons with similar realized

Table 4 Presentation of specific goals until 2030 for the activity of electricity production at the level of MH Electric Power Company of the Republic of Srpska

Production Activity	Minimum Required Separation
– Production of electricity and thermal energy (and technological steam), – If it uses renewable sources or waste or engages in the combined production of heat and electricity, it can acquire the status of a qualified producer through the RERS solution	– Accounting and management separation from other activities (completed process), – Accounting separation between regulated (public service) and market production (completed process, established RERS Trebinje, FERC Mostar and SERC Tuzla)
Obligations of the manufacturer	
– Compliance with the conditions of the permit for the performance of electric power company activities, – Production of electricity that corresponds to the quality requirements according to technical regulations, network rules and General conditions for the delivery of electricity, – Possession of measuring devices and equipment with which it is possible to measure the energy and power that is transmitted/taken from the network, – Adherence to the prescribed rules of operation for the electricity market and the Network Code, – Satisfying and respecting the prescribed technical and operating conditions, as well as environmental protection conditions from the environmental permit	
General goal	**Key development areas**
To be competitive and to satisfy the ecological standards with the use of domestic resources	– Energy efficiency, – Reduction of SO2, NOx, PM and CO_2 emissions, – Increasing capacity based on RES, – Cogeneration of electricity and heat (trigeneration and hybrid systems), – Trigeneration (electrical and thermal energy, cooling energy)

systems, should provide an objective and reliable picture to the investor about the expected effects of the project). Before making an investment decision, the objective way is to arrive at these indicators through the preparation of a justification study, which will show the estimate of equipment and works, the costs of maintenance and use of the system, with the application of the sensitivity analysis method for determining the return on investment indicators in cases of deviations from the planned, the accessibility of financing conditions and access to financial institutions, as a prerequisite for the successful implementation of energy efficiency projects.

Energy development planning is based on the security of supply to consumers at minimal costs, with the accompanying rational use of domestic resources, which includes the correct evaluation of imported forms of energy, the maximum prevention of monopolistic behavior (the only form of energy available) and the achievement of satisfactory environmental protection conditions. When planning the development of the electric power sector of the Republic of Srpska, the goal and criteria are unambiguously determined through the settlement of the expected electricity consumption with minimum costs and assuming that certain financial, technical and environmental limitations of the availability of primary forms of energy are met. On the other hand, projects for achieving energy savings are very important for thermal energy facilities within the EES of the Republic of Srpska, because, in addition to reducing costs and cleaner production, it enables an additional improvement of the company's competitiveness. The integration of these projects with the existing business plans represents in some way the further development of this company. The proposed measures and their priority are given in accordance with the stated results, which does not mean that in practice, depending on the current needs and priorities of the subsidiaries (ZP) RiTE Ugljevik and RiTE Gacko within the MH Electric Power Company of the Republic of Srpska Trebinje, a slightly different ranking of individual measures would be carried out. When proposing energy efficiency measures, the current state of the equipment and the financial possibilities of ZP were considered, so that all proposed improvements in terms of reducing losses and increasing general energy efficiency are within realistic achievable limits. The new value of the thermal power plant's own consumption, which can be achieved by applying the proposed measures, is still above the reference values in relation to similar systems in the world, which means that serious work is still to be done on the analysis of possible savings and reduction of losses as a whole. It should be pointed out that it is expected that in the first period of implementation of the energy management system, more short-term measures will be recognized, which do not require financial investments and are more organizational in nature. After the introduction of the BAS ISO 50001 standard and the application of the corresponding standardized procedures in practice, the number of short-term measures will decrease, which also indicates an organized monitoring of the implementation of energy efficiency measures.

On the other hand, the increase in energy efficiency and the use of renewable sources and the protection of the environment will be realized through the following activities:

- Establishing a mechanism for determining responsibility for environmental damage based on the "polluter pays" principle;
- Development of a Strategy for encouraging investment in the energy rehabilitation of existing residential and commercial buildings;
- Improvement of energy efficiency in public buildings;
- Adoption of the National Emissions Reduction Plan for Bosnia and Herzegovina (NERP) in accordance with the Report on the Emissions Reduction Plan for the Republic of Srpska Electric Power Company.

Adoption and application of the Law on Amendments to the Law on Waste Management will create the basis for the provisions of the proposed changes to achieve their compliance with EU legislation, i.e., to establish a mechanism for determining responsibility for environmental damage, based on the "polluter pays" principle, i.e., for environmental polluters to be financially responsible for preventing environmental damage. Amendments to the Law on Waste Management created the conditions for the adoption of regulations that will regulate types of pollution, products that become special waste streams after use, criteria for calculating fees and payees, the amount and method of calculating fee payments, etc. When it comes to fiscal effects, there are no costs related to the activities of drafting and passing laws and by-laws. In relation to the impact on the business environment, the budget, the health and social status of citizens and the environment, this regulation has no impact on the aforementioned areas. With the correct application of the regulations and principles on which the EU legislation is based, there should be no increase in product prices since the financial instruments refer to imported products whose prices already include funds according to the "polluter pays" principle.

According to the obligations arising from the decisions of the Ministerial Council of the Energy Community (MC EC), Bosnia and Herzegovina must implement the Energy Efficiency Directive, which, among other things, implies that the Republic of Srpska establish a long-term strategy for encouraging investment in the renovation of residential and commercial buildings, public and private. This strategy should include an overview of the real estate stock, as appropriate based on statistical samples, the identification of cost-effective approaches to renovations depending on building type and climate zone, policies and measures to encourage cost-effective large-scale building renovations, including large-scale building renovations, a long-term perspective to guide investment decisions by individuals, the construction industry and financial institutions, and an evidence-based assessment of expected energy savings and wider benefits.

Implementation costs include the costs of developing the Strategy itself, which should be financed from the public revenues of the Republic of Srpska and from grant funds of international organizations that provide technical assistance for the implementation of regulations related to energy efficiency. In addition to the above, according to the preliminary estimates of the Energy Community in Bosnia and Herzegovina, 15 buildings should be rehabilitated annually, which is why about 7 million BAM is needed, of which the Republic of Srpska accounts for a proportional part. The main risk for implementation is reflected in the lack of funds in the Environmental Protection Fund, which would be directed under favorable and acceptable conditions for building owners to energy renovations and major reconstructions of existing buildings, and the disinterest of commercial banks in opening favorable credit lines in order to grant loans to owners and investors of existing buildings that need to carry out major reconstructions in order to implement energy efficiency measures. This measure stems from the Action Plan for Energy Efficiency of the Republic of Srpska, which is part of the Action Plan for Energy Efficiency in Bosnia and Herzegovina. This measure is in accordance with the Decision of the Ministerial Council on the implementation of the EU Directive on energy efficiency.

Improving energy efficiency in public buildings will reduce energy consumption in buildings, which will directly affect the reduction of energy costs in the budget of the Republic and local self-governments, start economic activities in the construction sector and increase the number of jobs, which will have a positive effect on GDP and public revenues. Work will be done on the development of financing mechanisms for the improvement of energy efficiency, which will enable the inclusion of the private sector in the financing of the mentioned projects. In 2017, the implementation of the World Bank project “Energy efficiency in Bosnia and Herzegovina” will continue, where investments of around 6 million KM are expected, and the “Green Economic Development” project, which is implemented by UNDP and the Fund for Environmental Protection and Energy Efficiency of the Republic of Srpska, where the planned investment value is 1 to 3 million BAM. It is planned that the reconstruction of public buildings will take place in the second and third quarters. In the period from 2018 to 2019, the realization of new projects that will be financed from credit and grant funds is planned, as well as the realization of pilot projects that will be financed through new models of energy efficiency financing. The implementation of the mentioned activities will be based mainly on the engagement of domestic companies, which will enable the strengthening of their capacities in the implementation of energy efficiency projects, especially in the field of design, rehabilitation, energy inspections, etc. Failure to provide additional credit and grant funds, and problems in the implementation of pilot projects considering the fact that it would be a novelty for the market, are potential risks for the implementation of activities.

The Government of the Republic of Srpska has accepted the Information on the Draft National Plan for Reducing Emissions for Bosnia and Herzegovina (NERP) in accordance with the Report on the Plan for Reducing Pollutant Emissions for the Electric Power Company of the Republic of Srpska, which was adopted by the Council of Ministers of Bosnia and Herzegovina and sent to the Secretariat of the Energy Community for consideration. The national plan was prepared according to the guidelines of the Secretariat of the Energy Community. This plan refers to the reduction of emissions of sulfur dioxide, nitrogen oxides and solid particles from large combustion plants in the Republic of Srpska. The report on the plan to reduce pollutant emissions for the Electric Power Company of the Republic of Srpska will begin on the 1st of January, 2018 and will last until 31st of December, 2027.

For the implementation of the adopted NERP, it is necessary to provide funds for the costs of financing the construction of a plant for the reduction of sulfur dioxide, nitrogen oxides and dust, which will represent a significant burden for TPP Ugljevik, due to which there will be an increase in total production costs and thus there is a risk of jeopardizing the future market position of the power plant, and to a lesser extent TPP Gacko, but it will contribute to the fulfillment of obligations under the Energy Community Agreement and the global reduction of air emissions from plants included in the Plan. Because of the above, ERS representatives appealed to the competent institutions to help find ways to finance the Plan.

The adopted National Emissions Reduction Plan for Bosnia and Herzegovina in accordance with the Report on the Emissions Reduction Plan for the Republic of Srpska Electric Power Company was prepared in accordance with the Policy Guidelines of the Secretariat of the Energy Community for the preparation of National Plans for the Reduction of Air Pollution in the Republic of Srpska and in accordance with the Rulebook on Measures to Prevent and Reduce Air Pollution.

It is important to point out that the Government of the Republic of Srpska in the field of energy efficiency will insist on an increased role of the Fund for Environmental Protection and Energy Efficiency of the Republic of Srpska in providing financial support to economic activities related to the field of energy efficiency and environmental protection.

7 Conclusions

Energy independence is an essential part of the independence and stability of a country, so it should be given special importance for each sector separately (natural gas sector, oil and oil derivatives sector, coal and electricity sector, and biofuel and biomass sector). Single market for electricity and gas, which was established in 33 European countries by signing the Treaty establishing the Energy Community, determines part of the energy policy between the European Union and the countries of Southeast Europe (Croatia, Bosnia and Herzegovina, Serbia, Montenegro, Macedonia, Bulgaria, Romania, Albania and the UN Provisional Administration in Kosovo). By signing the Treaty on the Energy Community, an obligation to comply with the European Union's legal regulations in the field of energy was created, and the ultimate goal of this arrangement is to create a legal and institutional framework for the free transfer and trading of energy products, as well as a greater obligation to protect the environment and the rights of the end customer, i.e., consumer. All this requires harmonization of regulations in accordance with good practice and directives of the European Union. Therefore, the energy policy in Bosnia and Herzegovina is primarily based on ensuring a safe, high-quality and reliable supply of energy and energy sources, ensuring the optimal development of energy infrastructure, introducing modern technologies, providing conditions for improving energy efficiency, creating conditions for stimulating the use of renewable energy sources and improving environmental protection. At the same time, it is necessary to first create the necessary legal prerequisites for the collection of more precise data on energy statistics in accordance with the EUROSTAT methodology (Law on Energy, Rulebook on Energy Balance, etc.). Reform of the electric power sector of Bosnia and Herzegovina through the implementation of strategic projects, which aim to provide high quality universal service of energy delivery and supply and protection of end customers, i.e., consumers, will create preconditions for regional cooperation on the energy market in accordance with the Agreement on the Energy Community of Southeastern Europe. Although the current advantage of the Republic of Srpska is the surplus of electricity, the gradual and planned liberalization of the energy market will abolish the privileges of the monopoly position of electricity companies in Bosnia and Herzegovina, and introduce fierce market competition, which will not tolerate static and inflexible systems, which will have to be considered in the future. There is also a determination to introduce alternative sources and energy obtained from renewable sources into the structure of production, such as: biodiesel, hydropower, biogas, biomass, solar energy, wind energy, etc. Since the most important renewable energy sources in the Republic of Srpska are biomass energy and hydropower, the stimulus measures should be focused to the greatest extent on these two types of renewable energy sources, while the increased use of biomass residues for the production of heat energy, as well as the production of liquid motor biofuel, should be encouraged. It goes without saying that an integral part of the energy management policy should be a mandatory environmental protection policy, as stipulated by the standards of the European Union. In this context, the most important mechanisms for achieving these energy policy goals are the constant increase in the share of renewable (non-fossil) energy sources, and the second, the increase in energy efficiency. This current and broad initiative gives special importance to the more detailed management of energy balances, through which the progress made in energy saving activities and the reduction of fossil fuel consumption is measured and recorded. In years of economic crisis, the philosophy of energy efficiency should be recognized and its potential, which can permanently achieve significant savings (without loss of standards) not only in the household budgets of citizens, but even in the public budget, if adequate education, programs and technical-technological measures are applied in administrative bodies, administrative and public institutions, municipalities, hospitals, judiciary, educational institutions, public heating plants, public transport, etc.

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