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Research Article

Carbon Capture and Storage Technology Ccs in the Production of Electricity by Combustion of Coal, an Opportunity for a Just Energy Transition on the Example of the Western Balkan Countries

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Abstract

This paper does not deal with the development, challenges or any new findings related to carbon capture and storage technology (CCS) in the production of electricity by burning coal in thermal power plants, it aims to show how important this technology is and how much it promises the conditions for a fair and successful energy transition, especially for countries still rich in quality coal reserves, which include some of the countries of the Western Balkans. All the countries of the Western Balkans have entered the energy transition process, the level of transition is different. The rapid increase in capacity in the production of electricity from renewable sources also causes an accelerated abandonment of coal and a reduction in the production of electricity from its combustion. This again means even greater challenges in maintaining and balancing the electrical energy system, especially in conditions of high consumption or reduced production from renewable sources, putting energy system operators on additional challenges. In the last year, the region has already experienced one significant outage in the supply of electricity, the first time recorded, and more importantly, each of the listed countries had periods when they had a deficit of electricity. For example, Bosnia and Herzegovina was considered a significant exporter of electricity, but in January of this year, for the first time in its history, electricity production was lower than consumption. In order to overcome this, the countries of the Western Balkans, at least according to what we know today, are basing their energy transition on natural or liquefied gas, several projects are in the planning and implementation phase. The development and application of CCS in the production of electricity by burning coal significantly changes these plans and relations, especially since the use and introduction of this technology is necessary at some stage in gas burning as well. Simplified, why use imported gas instead of own coal resources during the energy transition, at least for the maintenance and ballasting of the electrical energy system. Of course, this does not mean giving up and stopping investment in the production of electricity from renewable sources, it should be continued wherever possible and justified, but the part necessary for balancing the system should be provided from one source that can be managed.

Keywords

Decarbonization, CO_2 Capture Technology, Coal, Electricity, Energy Transition

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1. Introduction

Decarbonization as a global trend has already affected almost all countries and economic regions of the world to a greater or lesser extent. It includes the application of new technologies in almost all areas of human activity, which aim to reduce or completely eliminate carbon dioxide (CO_2) emissions as a product of human activity. Today, decarbonization is spoken of as a civilizational norm. Even if it is accepted like this, its implementation and application is different from country to country. It is logical that, as with the promotion of any other new technology, developed countries have an advantage in its application, and in fact they are the ones who promote it, force it and eventually impose it. Today, the most economically and technologically developed countries in the world, the EU member states, the USA and Canada, China, South Korea, Japan and Australia have made the most progress in decarbonization.

Today, we can find decarbonization in a certain level of realization in electricity production, transport and traffic, construction and housing, agriculture. The only place where it is still not mentioned is the military industry and wars. Numerous declarations and agreements have been adopted that deal with this area, such as the Kyoto Agreement, the Paris Agreement, the Sofia Declaration and some others.

The production of electricity by burning fossil fuels was the first to be attacked and it is actually the area where decarbonization has gone the farthest [1], as the area where CO_2 emissions are high and new technologies have made the most progress. It refers to the accelerated reduction and eventually the complete cessation of the use of coal, natural gas and oil in the production of electricity. This especially applies to coal, so that today in a significant part of the world, mainly the developed part, there has been no construction of new plants, thermal blocks, for the production of electricity by burning coal for several years. Of course, the replacement technology here also had the biggest step forward, drastically cheapening the production of electrical energy using solar panels and wind. The use of natural gas in the production of electricity, although in the beginning it should have the same fate as coal, today is significantly spared, even more so in the last few years, it has undergone a transformation where instead of natural gas transported by gas pipelines, liquefied gas, LNG, is increasingly used. It is true that during combustion it emits twice as much CO_2 as coal. It is also noticeable that investments in the use of LNG are increasing significantly, creating a dilemma about when to end its use, wherever possible today they are replacing the use of coal [2].

According to announcements, CCS technology in electricity production could be used in the early thirties of this century [3], in the next five to ten years. They would enable the successful capture and storage of CO_2 produced by burning coal in a percentage of more than 95% [4]. Captured CO_2 as a product of coal combustion would be stored in underground spaces and rock massifs, basalt rocks, shale or old mining works, as one of the possible variants [5]. As a negative side, it can be mentioned the reduction of the degree of utilization of the energy plant during the production of electricity, since the CCS system itself uses 20 to 25% of the total electricity produced [6], all depending on the method and location of the storage of the captured carbon. Also, the announced percentage of CO_2 capture using this technology is disputed by some, it is not 100%.

Decarbonization in the field of traffic and transport (auto industry), especially agriculture, and in the most developed countries, is not carried out energetically, as is the case with the production of electricity, mostly due to the lack of preparation or sovereignty over the necessary technologies for its implementation. Some industrial branches and activities, such as the cement industry, require the introduction of new technologies and their application, considering that this industry is impossible without CO_2 emissions [7]. Also, according to data from the International Energy Agency (IEA), even after 2050, the STEPS scenario, electricity production by burning coal with the application of carbon capture technology will have its application [8].

Currently, the greatest focus on decarbonization is directed towards reducing the use of coal in electricity production, and countries that are still rich in this energy source are under the greatest pressure, having to give up the energy source that they have in significant quantities. Developing and mastering technologies that will enable the continued use of coal in electricity production with acceptably low or insignificant CO_2 emissions as a necessary measure to stop climate change, is certainly of great importance for such countries.

2. Current Situation and Assumptions for the Future

The region of the Western Balkans, which consists of the countries of Bosnia and Herzegovina, Serbia, Montenegro, Kosovo, North Macedonia and Albania, in terms of energy, today represents a less complicated mix in the production of electricity. Of all the countries listed, only Bosnia and Herzegovina has a surplus of electricity and in fact is, or was until recently, a significant exporter of electricity. Bosnia and Herzegovina bases its energy independence on coal, and along with Kosovo, it is the only country out of the list that does not import other energy sources for its needs, and the burning of which produces electricity.

In addition to Bosnia and Herzegovina, coal is still used for electricity production in Serbia, Montenegro and Kosovo. Gas, imported, for the production of electricity is used in North Macedonia and Albania.

In all the listed countries, the energy transition is significantly represented, plants for the production of electricity using solar and wind energy are being rapidly built, replacing

conventional sources of electricity. In relation to the percentage participation of renewable sources of electricity in the total production of electricity, Albania has gone the farthest.

The rapid investment in renewable sources of electricity caused major problems in the balancing of the electrical energy system, causing a large outage of the electrical energy system at the beginning of the summer of 2024, which affected Albania, Montenegro, Bosnia and Herzegovina and partially Croatia [9]. This outage also opened up the question of how to balance and preserve a stable electrical energy system, first of each country individually, and then of the Western Balkans, but also of Southeastern Europe as a region.

The question is how it will be done and whether the countries of this region will be able to do it at all in the future at a time when the production of electricity from renewable sources is small. There are indications that some of them will increase investment in facilities for the use of imported gas, Albania, North Macedonia and Serbia.

Bosnia and Herzegovina still has significant reserves of coal and it would be illogical to replace its use with another fossil fuel, imported gas, although there are such ideas.

3. Bosnia and Herzegovina, Energy Challenges but also an Opportunity

Bosnia and Herzegovina has five active coal-fired thermal power plants, the youngest of which was commissioned in 2016 and is the only one managed by a private company. The other four are much older, from the 1980s and are managed by state-owned companies. Their work is based on already outdated technology, with a low degree of utilization and no desulfurization plant. Several thermal blocks in them have already been permanently shut down in the recent past. The coal burned in them is of different qualities, lignite and subbituminous coal. Lignite has a calorific value of 7 to 13 MJ/kg and subbituminous coal up to 23 MJ/kg [10]. Interestingly, the newest thermal power plant burns coal with the worst calorific value of up to 8 MJ/kg.

Bosnia and Herzegovina has large coal reserves. Geological reserves exceed 5 billion tons, while the exploitation ones are much smaller and amount to about 500 million tons, of which 300 million tons are lignite and 200 million tons are subbituminous coal [11]. Intensive exploitation of coal in Bosnia and Herzegovina began after the Second World War and reached its peak at the end of the twentieth century.

Bosnia and Herzegovina, like other countries of the Western Balkans, is under strong pressure to speed up the abandonment of coal in the production of electricity. Until just ten years ago, Bosnia and Herzegovina produced over 17,000 GWh of electricity per year, of which in some years 75% was from coal-fired thermal power plants. About 40% of the produced electricity was exported. Today, data for 2024 (figure 1), Bosnia and Herzegovina has produced 14,550 GWh of electricity, of which 63% is from coal-fired thermal power plants. A significant part of electricity is obtained from large hydroelectric power plants, sometimes up to 40%, all depending on hydrological conditions. In the last ten years, the construction of wind power plants and solar power plants has been intensified, so that in 2024, 4% of electricity was produced in this way [12]. The privately owned thermal power plant exports its entire production, and it was built with this goal in mind.

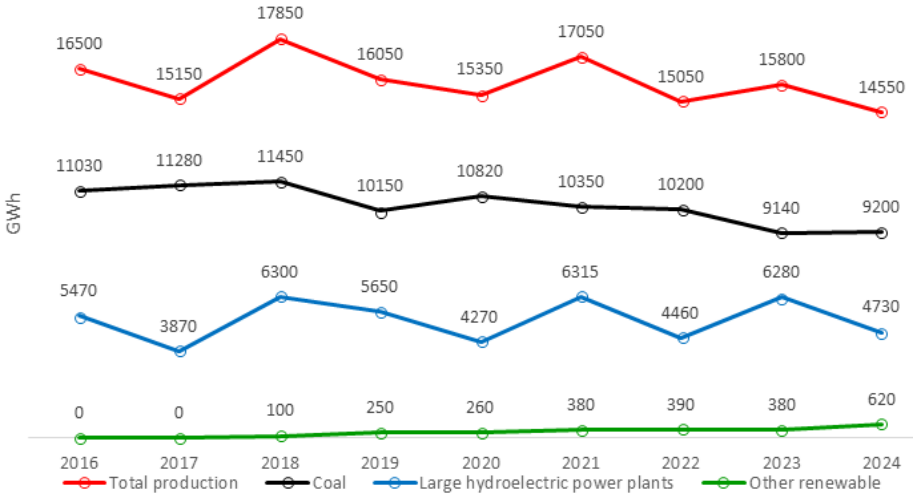

Figure 1. *Electricity production in Bosnia and Herzegovina.*

Today, electricity production is organized in such a way that large hydroelectric power plants are used to the maximum. If the hydrological situation in the year is favorable, then the production from these hydropower plants will be significant, creating conditions for reduced production from thermal power plants. The problem arises at the moment when, due to the bad hydrological situation, hydropower plants significantly reduce production, sometimes up to 40% on an annual

level, and thermal power plants do not have the possibility to increase production due to the lack of coal or low reliability in operation. That is, due to the imposition of accelerated decarbonization, the maintenance of part of the energy system based on coal is left to itself without strategies and clear goals. This was especially pronounced for the years 2023 and 2024, when the decrease in production from large hydroelectric power plants is accompanied by a decrease in total electricity production, that is, when the lack of electricity must be compensated by imports.

The production price of one MW of electricity in thermal power plants in Bosnia and Herzegovina today ranges from 40 EUR in a private thermal power plant to 60 EUR in state-owned thermal power plants and is significantly lower than it is currently on the reference stock exchange [13].

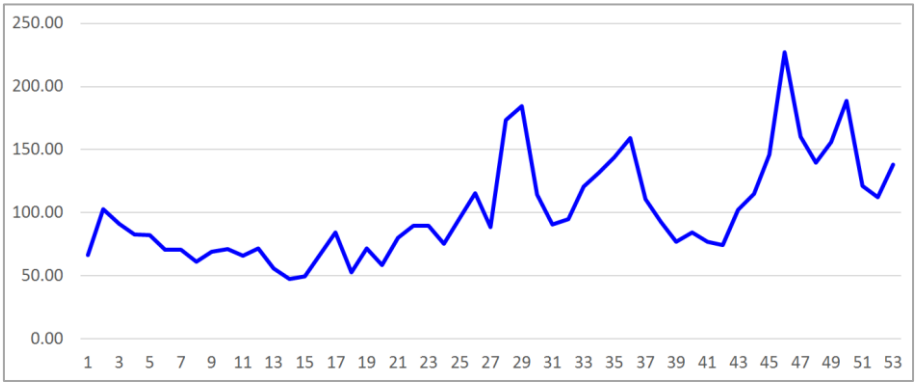

Figure 2. *Weekly price of electricity on the reference Hupx stock exchange for the year 2024 (EUR/MWh).*

The price includes all costs, coal and labor as the most important, then maintenance costs, raw materials and taxes related to environmental protection. Taxes on CO_2 emissions have not yet been introduced in Bosnia and Herzegovina and are not paid, their introduction is expected soon. If CO_2 capture technology were to be applied at one of the listed thermal power plants, then the costs of electricity production would increase due to the increased own consumption of electricity to a maximum of 80 EUR per one MW of electricity produced, along with the costs of installing the necessary equipment necessary for capturing, transporting and storing carbon. Bosnia and Herzegovina, as well as the remaining countries of the Western Balkans, follow the decisions of the EU member states through the directives they pass in the legislation, which will also be the case with regard to possible fees for CO_2 storage. This area has not yet been treated in the EU countries, regardless of the fact that it is rapidly emerging, especially in the cement industry. The announcements are that, if there are fees, they will not be for the storage of CO_2 at the level of fees as for their release into the atmosphere. Considering that there would be no CO_2 emissions into the atmosphere, the complete emission or a larger part of it would be captured and stored, the price of electricity would be acceptable [14], and certainly it would be much lower than it is at the time of already known peaks, at the end of summer and during winter when hydrological conditions are bad [13]. The most important thing in all of this is that it is coal from our own mines, the price of which cannot be influenced by external factors.

Bosnia and Herzegovina has relatively favorable conditions for the production of electricity from renewable sources, primarily solar and wind energy. On average, from 1300 to 2200 hours a year are the hours with favorable conditions for the production of electricity using sunlight, depending on which part of the territory is observed [15]. The use of wind has similar conditions of use, up to 1400 hours during the year are those with favorable wind for the production of electrical energy. The use of biomass in the production of electricity is still only being considered. Also, the mention of gas as an alternative in the production of electricity is increasingly being imposed, regardless of the still significant reserves of coal.

In Bosnia and Herzegovina, for the first time, in the month of January 2025, a deficit of electricity appeared. Production was lower than consumption, so Bosnia and Herzegovina once turned from a significant exporter of electricity into an importer, and in fact is only at the beginning of the decarbonization process in electricity production. The reason for this can be found in the accelerated reduction of electricity production from coal-fired thermal power plants, but also in the significant increase in consumption on an annual basis, growing by around 3% every year.

The emergence of a deficit of electricity caused the need for faster construction of new plants for its production from renewable sources, but also the need to review the speed of shutting down coal-fired thermal power plants, as is the case with some other countries [16], among which are economically and economically developed ones [17].

4. Projects of Regional Significance

All the countries of the Western Balkans, as well as the re-

gions of Southeastern Europe, have already made significant progress in the process of decarbonization and the development of facilities for the production of electricity from renewable sources. These processes have already caused problems in the safe and reliable supply of electricity to each of the countries, but also the appearance of large changes in the price of electricity at which it can be purchased on the market at the time of its lack from own production [13]. In order to avoid this, each of the listed countries is considering their own plans to have a reliable supply of electricity. Some of them will turn to imported gas, some to nuclear energy. Countries that still have coal reserves, mostly low-caloric coal, are trying to extend the life of its use.

Bosnia and Herzegovina is one of the rare countries in Europe that has significant reserves of high-calorie coal, extremely favorable for burning in thermal blocks, with the existing knowledge and tradition of coal mining. For this reason, the construction and commissioning of a new facility for the production of electricity by burning coal with the application of CO_2 capture and storage technology would ensure the stability of the energy system and, in particular, the possibility of providing electricity to neighboring countries in crisis situations.

5. Conclusion

Solutions that will ensure a safe and reliable supply of electricity to citizens and consumers at the time of the energy transition are of great importance. How this will be ensured depends on the obligations undertaken, own resources, technological solutions, but also the influence of global trends and attitudes.

It is clear to everyone today that renewable sources alone, no matter how many are built, are not sufficient for the functioning and maintenance of the electrical energy system. Today, battery warehouses are already being used significantly, which should provide storage of electricity for at least a few hours, due to high costs, they are currently reconditioned only for developed and rich countries.

The development of technologies and the possibility of their application to capture CO_2 produced during the combustion of coal in thermal power plants and its storage significantly change relations in the future when it comes to the production of electricity and the energy transition. This is especially interesting for countries still rich in high-quality coal deposits, such as Bosnia and Herzegovina. Today, Bosnia and Herzegovina is being proposed, and secretly imposed, as are some other countries, to use liquefied gas as a transitional energy source and to replace part of its electricity production from coal with gas, at some stage with CCS technology [18].

The possibility of using CO_2 capture technology in the production of electricity by burning coal will provide conditions for a fair energy transition in countries such as Bosnia and Herzegovina. This especially applies to periods of balancing the electrical energy system and during periods of high electricity prices on the stock market. Bosnia and Herzegovina, like some other countries, still has significant quantities of quality coal, has a tradition of coal mining and experience in the production of electricity from coal. In addition to these advantages, imposing on it that it has to switch to the use of gas, build large facilities for battery storage or eventually be an importer of electricity, all with the existence of CCS technology, cannot be called a fair transition.

Abbreviations

CCS	Carbon Capture and Storage Technology
CO_2	Carbon Dioxide
LNG	Liquefied Gas

Conflicts of Interest

The authors declare no conflicts of interest.

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