



## Integration of Renewable Energy Generation in the Power System of Bosnia and Herzegovina

Vincenzo Bianco<sup>1\*</sup>, Furio Cascetta<sup>2</sup>, Luigi Caserta<sup>1</sup>, Mario Gallo<sup>1</sup>, Sergio Nardini<sup>2</sup>

<sup>1</sup> Dipartimento di Ingegneria Università degli Studi di Napoli Parthenope, Naples 80133, Italy

<sup>2</sup> Dipartimento di Ingegneria Università degli Studi della Campania "L. Vanvitelli", Aversa (CE) 81031, Italy

Corresponding Author Email: [vincenzo.bianco@uniparthenope.it](mailto:vincenzo.bianco@uniparthenope.it)

Copyright: ©2025 The authors. This article is published by IETA and is licensed under the CC BY 4.0 license (<http://creativecommons.org/licenses/by/4.0/>).

<https://doi.org/10.18280/jesa.580911>

### ABSTRACT

**Received:** 10 August 2025

**Revised:** 15 September 2025

**Accepted:** 21 September 2025

**Available online:** 30 September 2025

#### **Keywords:**

*energy planning, renewables, Bosnia and Herzegovina, Plexos, energy systems*

The present paper proposes a comprehensive analysis of the Bosnian power system, with a particular focus on the transition towards sustainable energy sources. This study examines a scenario that involves the phase-out of lignite power plants, which are known for their high carbon emissions and environmental impact. In place of lignite, the scenario emphasizes a significant increase in renewable energy generation, specifically hydro, solar, and wind power. The model used for this analysis is developed in Plexos, a sophisticated energy modeling software, and operates with an hourly resolution to capture the nuances of energy production and consumption throughout the day. Key outputs from the model include detailed data on generation capacity, emissions levels, and electricity prices. The findings of the analysis indicate that the proposed scenario not only supports environmental sustainability but also offers economic benefits. The positive cost-benefit ratio suggests that investing in renewable energy infrastructure can lead to long-term savings and reduced reliance on fossil fuels. The paper provides valuable insights for policymakers and stakeholders in the energy sector, highlighting the potential for a greener and more resilient power system.

## 1. INTRODUCTION

Bosnia and Herzegovina (BiH) is a European country located in the Western Balkans area. It is not a member of the European Union, but it applied for EU membership in February 2016, and in December 2022 EU granted Bosnia and Herzegovina the status of candidate country.

Politically, the country is constituted by two entities, namely the Bosnia and Herzegovina Federation and the Republic of Srpska. The country is characterized by mineral, forestry, and hydro resources.

Bosnia and Herzegovina has a population of about 3 million. people with a power demand of about 10 TWh/year and a power generation fleet of 4000 MW installed, mostly lignite and hydro power plants with a generation capacity of 16/17 TWh/year.

Power generation increased 50% between 2001 and 2013, and the average power generation per capita aligned with the average value of Eastern Europe. Also, distribution losses decreased by half in the period 2007-2010. These results can be ascribed to the post-war reconstruction that the country experienced after 1995. However, power demand increased 1%/year in the last ten years due to the limited economic development of the country in the same period.

BiH is characterized by one of the highest energy intensities in Europe, determined by a very low energy efficiency level. For example, most of the power plants are old, many of them were built in the '60s or '70s, and are characterized by a low

level of thermal efficiency. Existing power capacity is in need of investments to support its modernization and to reach an adequate standard in terms of efficiency.

The sector of renewable energy is progressing slowly. Most of the development is linked to projects in the field of solid biomass, whereas expansion of the solar and wind sector is very slow. Furthermore, BiH is characterized by a relevant hydroelectric potential, but the exploitation rate is low, and investments are necessary to develop new hydro power plants.

Substantial investments are necessary to increase the penetration of renewable energy in BiH.

Currently, 60% of power generation is provided by lignite power plants characterized by a very high carbon intensity, whereas 37% is provided by hydro power plants, 2% by wind power plants, and less than 1% by oil power plants. It can be noted that the contribution of sources other than lignite and hydro is minimal.

Another issue hampering the development of the BiH energy sector is represented by the misaligned policies developed by the Bosnia and Herzegovina Federation and the Republic of Srpska. This determines a dispersion of financial resources and, sometimes, the pursuit of opposite goals.

Despite this conflicting situation and lack of investments, as part of the EU candidate country status, the BiH government released an energy policy aimed at achieving by 2035 the 85% energy generation from hydroelectric power plants, 9% from wind power plants, 2% from solar power plants, and 4% from biomass power plants.

Due to these substantial challenges and to the peculiar energy mix, BiH has been analyzed in previous studies openly available in literature.

Renewable energy potential in BiH is assessed by Sher et al. [1]. They developed a review analysis of the literature to highlight the potential for renewable generation from the new planned power plants. In particular, they estimate that hydro generation could rise by 22 TWh of generation, whereas wind planned projects could achieve a generation of 1 TWh. Furthermore, BiH is supposed to have one of the largest solar generation potentials in the area.

The assessment of the development of renewable energy progress in the Western Balkans, i.e., Serbia and Bosnia Herzegovina, is proposed in literature [2]. Karakosta et al. [2] analyze the renewable development progress in relation to the economic, political, and institutional dimensions. Their comparative analysis between the two countries shows that in BiH the progression is slower, because the institutional framework is less developed with respect to Serbia.

The development of small hydropower in BiH is discussed by Novikau et al. [3]. They focus on the evolution of the small hydropower industry in Bosnia. In particular, they analyze the governmental schemes that supported the development of this technology and the consequent social impact. This technology had a relevant development in the period 2010-2020, supported by attractive feed-in tariffs. The aim was to align Bosnia RES generation to the EU targets in order to support the accession procedure. However, negative environmental impacts are detected as a result of these massive installations, which determined public dissatisfaction, resulting in stopping the small hydro installations. The paper points out the need to align policy with social acceptance and environmental sustainability.

A multi-criteria assessment model for analyzing different options to modernize power generation in BiH is proposed by Begić and Afgan [4], who investigated different options compared with the refurbishment and rehabilitation of 110 MW lignite power plants. They consider hydro power plants, solar PV power plants, wind power plants, and biomass power plants as alternative options. The assessment is developed by using a stochastic approach to include the impact of uncertainty. A sustainability indicator is defined as a driver for the choice.

An investment strategy to modernize the overall BiH power sector is proposed by Nikolakakis et al. [5], who developed a power market model of BiH and evaluated the impact of different capacity development scenarios. Different demand scenarios were also considered. The model is bottom-up, and the power plants are modeled individually. Each plant is characterized by its power, fuel cost, and efficiency. The investment costs for the different scenarios are estimated, and the impact of each scenario on the expected power prices is expected.

Based on the reviewed literature, the present work attempts to extend the previous work by developing a comprehensive power market model of BiH. The proposed model is bottom-up and consists of a techno-economic model based on the System Marginal Price concept.

The proposed model considers the division of the country into different zones to consider the impact of the connections on the transmission of energy flows from one area to another. This is fundamental to estimating the impact of renewables. Renewables will be installed in specific areas identified according to suitable climatic conditions (e.g., solar radiation,

wind availability, etc.). Thus, this renewable generation is to be conveyed from one area to another, and the evaluation of available connections is critical for increasing the RES share in the power mix.

Finally, the present work provides an assessment of the impact of a likely scenario of thermal capacity development, RES development, and demand on the BiH power market. The time horizon of the analysis is up to 2050, and intermediate years, i.e., 2030 and 2040, are explicitly simulated. Energy balances, fuel consumption, emissions, externality costs, and power prices are estimated in the considered scenario.

## 2. METHODOLOGY

The BiH power market model is developed by using the Plexos power market simulator, which was used and reviewed in previous studies [6, 7].

Power plants are modeled individually. In particular, thermal power plants are modeled by considering their maximum power, the minimum stable level, the heat rate, and the number of units. More features, such as minimum up time, minimum down time, and ramp-up can be set in Plexos, but there is no available information on this. All the data used in the analysis comes from public sources, including previous papers.

All the thermal power plants are fueled with lignite, which is abundant in BiH. In practical terms, each lignite thermal power plant is attached to a lignite mine; thus, each plant is characterized by different lignite costs (differences are slight), which depend on the cost of extraction characterizing each mine.

| Parent Object | Generator | Property         | Value | Data File | Units  | Band | Action | Expression           | Category |
|---------------|-----------|------------------|-------|-----------|--------|------|--------|----------------------|----------|
| System        | Gacko     | Units            | 1     |           | -      | 1    | =      |                      | TPP      |
| System        | Gacko     | Max Capacity     | 276   |           | MW     | 1    | =      |                      | TPP      |
| System        | Gacko     | Min Stable Level | 138   |           | MW     | 1    | =      |                      | TPP      |
| System        | Gacko     | Fuel Price       | 2.07  |           | \$/GJ  | 1    | =      |                      | TPP      |
| System        | Gacko     | Heat Rate        | 11,61 |           | GJ/MWh | 1    | *      | Escalator Fuel Price | TPP      |
| System        | Kakanj 5  | Units            | 1     |           | -      | 1    | =      |                      | TPP      |
| System        | Kakanj 5  | Max Capacity     | 100   |           | MW     | 1    | =      |                      | TPP      |
| System        | Kakanj 5  | Min Stable Level | 50    |           | MW     | 1    | =      |                      | TPP      |
| System        | Kakanj 5  | Fuel Price       | 2.53  |           | \$/GJ  | 1    | *      | Escalator Fuel Price | TPP      |
| System        | Kakanj 5  | Heat Rate        | 11,61 |           | GJ/MWh | 1    | =      |                      | TPP      |
| System        | Kakanj 6  | Units            | 1     |           | -      | 1    | =      |                      | TPP      |
| System        | Kakanj 6  | Max Capacity     | 100   |           | MW     | 1    | =      |                      | TPP      |
| System        | Kakanj 6  | Min Stable Level | 50    |           | MW     | 1    | =      |                      | TPP      |
| System        | Kakanj 6  | Fuel Price       | 2.53  |           | \$/GJ  | 1    | *      | Escalator Fuel Price | TPP      |
| System        | Kakanj 6  | Heat Rate        | 11,61 |           | GJ/MWh | 1    | =      |                      | TPP      |
| System        | Kakanj 7  | Units            | 1     |           | -      | 1    | =      |                      | TPP      |
| System        | Kakanj 7  | Max Capacity     | 208   |           | MW     | 1    | =      |                      | TPP      |
| System        | Kakanj 7  | Min Stable Level | 104   |           | MW     | 1    | =      |                      | TPP      |
| System        | Kakanj 7  | Fuel Price       | 2.53  |           | \$/GJ  | 1    | *      | Escalator Fuel Price | TPP      |
| System        | Kakanj 7  | Heat Rate        | 11,25 |           | GJ/MWh | 1    | =      |                      | TPP      |
| System        | Stanari   | Units            | 1     |           | -      | 1    | =      |                      | TPP      |
| System        | Stanari   | Max Capacity     | 263   |           | MW     | 1    | =      |                      | TPP      |
| System        | Stanari   | Min Stable Level | 132   |           | MW     | 1    | =      |                      | TPP      |
| System        | Stanari   | Fuel Price       | 2.07  |           | \$/GJ  | 1    | *      | Escalator Fuel Price | TPP      |
| System        | Stanari   | Heat Rate        | 9,23  |           | GJ/MWh | 1    | =      |                      | TPP      |
| System        | Tudla 5   | Units            | 1     |           | -      | 1    | =      |                      | TPP      |
| System        | Tudla 5   | Max Capacity     | 180   |           | MW     | 1    | =      |                      | TPP      |
| System        | Tudla 5   | Min Stable Level | 90    |           | MW     | 1    | =      |                      | TPP      |
| System        | Tudla 5   | Fuel Price       | 2.55  |           | \$/GJ  | 1    | *      | Escalator Fuel Price | TPP      |
| System        | Tudla 5   | Heat Rate        | 12,41 |           | GJ/MWh | 1    | =      |                      | TPP      |
| System        | Tudla 6   | Units            | 1     |           | -      | 1    | =      |                      | TPP      |
| System        | Tudla 6   | Max Capacity     | 200   |           | MW     | 1    | =      |                      | TPP      |
| System        | Tudla 6   | Min Stable Level | 100   |           | MW     | 1    | =      |                      | TPP      |
| System        | Tudla 6   | Fuel Price       | 2.55  |           | \$/GJ  | 1    | *      | Escalator Fuel Price | TPP      |
| System        | Tudla 6   | Heat Rate        | 10,58 |           | GJ/MWh | 1    | =      |                      | TPP      |
| System        | Ugljevik  | Units            | 1     |           | -      | 1    | =      |                      | TPP      |
| System        | Ugljevik  | Max Capacity     | 279   |           | MW     | 1    | =      |                      | TPP      |
| System        | Ugljevik  | Min Stable Level | 140   |           | MW     | 1    | =      |                      | TPP      |
| System        | Ugljevik  | Fuel Price       | 1.98  |           | \$/GJ  | 1    | *      | Escalator Fuel Price | TPP      |
| System        | Ugljevik  | Heat Rate        | 11,61 |           | GJ/MWh | 1    | =      |                      | TPP      |

**Figure 1.** List of thermal power plants and corresponding features considered in the Plexos model

Figure 1 illustrates the thermal power plants modeled in Plexos, where it is possible to notice which are the modeled technical features as well as the associated lignite cost. The lignite cost evolves over time based on an escalator, which models the effect of the inflation rate. Since lignite is a local fuel, its cost is independent of the international market, and its

evolution is mainly related to the manpower necessary for its extraction. This is the reason why it is escalated based on the inflation rate.

Other aspects which are taken into account in the modeling are the maintenance frequency, the mean time to repair, and Variable, Operating, and Maintenance costs.

Hydro power plants are simulated with different strategies depending on whether they are run-of-river or dammed. In the case of run-of-rivers, monthly rated power is imposed. If they are dams, a monthly energy constraint is imposed. Namely, the maximum amount of energy generated monthly by the plant is imposed as a constraint. This energy is then dispatched at the most convenient hours (i.e., those with higher market prices).

Similarly, wind and solar power plants are modeled individually, and the generation profile is determined through a rated power and an assigned profile based on weather data. Data to estimate the generation profile are retrieved from the site Renewable Ninja.

As for the internal connecting lines, four nodes are considered, i.e., Sarajevo, Mostar, Banja Luka, and Tuzla. Power demand is distributed among these four nodes. In particular, the total power is attributed to each node proportionally to the population of each region.

Based on these four nodes, the following lines are defined:  
**L1-2:** Banja Luka (node 1) → Tuzla (node 2) with a Max Flow of 624 MW. This is a high-capacity line which connects two important points of the network.

**L1-3:** Banja Luka (node 1) → Sarajevo (node 3) with a maximum capacity of 343 MW.

**L1-4:** Banja Luka (node 1) → Mostar (node 4) with a maximum capacity of 343 MW.

**L2-3:** Tuzla (node 2) → Sarajevo (node 3) with a maximum capacity of 1934 MW. It is the line with the maximum available capacity, and it has a crucial role in the BiH network.

**L3-4:** Sarajevo (node 3) → Mostar (node 4) with a maximum capacity of 1322 MW.

Furthermore, the following three lines are added to model the cross-border flow with Serbia, Croatia, and Montenegro:

**L2-5:** Tuzla (node 2) → Ernestinovo, Croatia (node 5) with a maximum power of 624 MW and a loss base of 0.1.

**L2-6:** Tuzla (node 2) → Sremska Mitrovica, Serbia (node 6) with a maximum power of 624 MW and a loss base of 0.1.

**L4-7:** Mostar (node 4) → Podgorica, Montenegro (node 7) with a maximum power of 947 MW and a loss base of 0.1.

The loss-based coefficient models the energy loss on the lines.

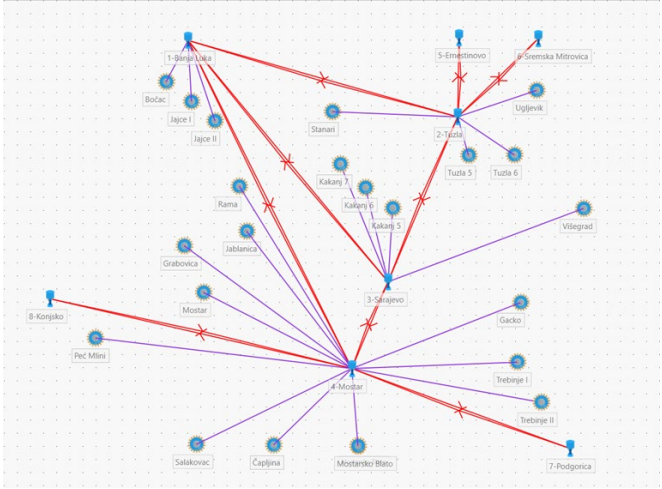
As for the demand, it is uploaded with an hourly profile determined based on historical data. This profile is applied to the yearly demand taken from the forecasting scenario.

Figure 2 illustrates the connection among the different nodes and the allocation of each power plant to its corresponding node.

If connecting lines are saturated, energy cannot be exchanged among nodes. This is relevant to understanding how energy can flow among the different regions, and it is fundamental information to define any capacity expansion plan.

The simulation is run with an hourly time step. The objective function consists of minimizing the total system cost by respecting all the imposed constraints.

An hourly power price curve is obtained based on the concept of the Short Run Marginal Cost (SRMC).



**Figure 2.** Connection among nodes and attribution of considered power plants to each node

All the results are available with an hourly resolution.

3. RESULTS AND DISCUSSION

Simulations are executed according to the data reported in Figure 3.

|                        |              | 2023  | 2030  | 2040  | 2050  |
|------------------------|--------------|-------|-------|-------|-------|
| Installed Capacity, MW | Coal/Lignite | 1606  | 1264  | 922   | 580   |
|                        | Hydro        | 1948  | 2863  | 3778  | 4000  |
|                        | Wind         | 135   | 905   | 2005  | 3115  |
|                        | Solar        | 97    | 622   | 1372  | 2122  |
| Gross Consumption, GWh |              | 10752 | 13329 | 15619 | 17805 |

**Figure 3.** Data used in simulations.

It is foreseen a decrease in lignite power plants from the current 1600 MW up to 580 MW; thus, different units are phased out beginning from the oldest ones.

Then it is assumed an increase in renewables with hydro increasing from 1950 MW in 2023 to 4000 MW in 2050, wind from 135 MW in 2023 to 3115 MW in 2050, and solar PV from 97 MW in 2023 to 2122 MW in 2050.

Furthermore, power demand is supposed to increase from 11 TWh in 2023 up to 18 TWh in 2050.

All these data are taken from the SEERMAP (South East European Roadmap) report for Bosnia and Herzegovina.

By running the simulation with these data, the results shown in Figure 4 are obtained.

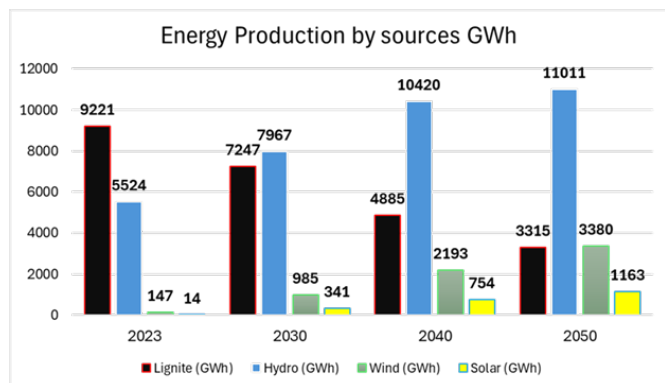
| Scenari PLEXOS   | 2023  | 2030  | 2040  | 2050  |
|------------------|-------|-------|-------|-------|
| Total Generation | 14906 | 16540 | 18252 | 18869 |
| Load             | 10752 | 13329 | 15619 | 17805 |
| Netflow          | 4153  | 3210  | 2633  | 1063  |
| Bilancio         | 0     | 0     | 0     | 0     |

**Figure 4.** Energy balance in GWh

Figure 4 illustrates how total generation, consumption, and net flow evolve in the period 2023-2050. First of all, it is important to note that 2023 simulated values are aligned with the historical data. This demonstrates that the model is capable of reproducing historical data and it can be considered validated.

Then, it can be observed that total generation increases in the considered period to follow the demand profile. At the same time, a decrease in energy exports is determined (e.g., a reduction in the positive net flow). Overall, the balance is zero in each simulated year. This means that the conservation of energy is satisfied; thus, the model is coherent and works properly.

Figure 5 reports the generation per source, namely lignite, hydro, wind, and solar.

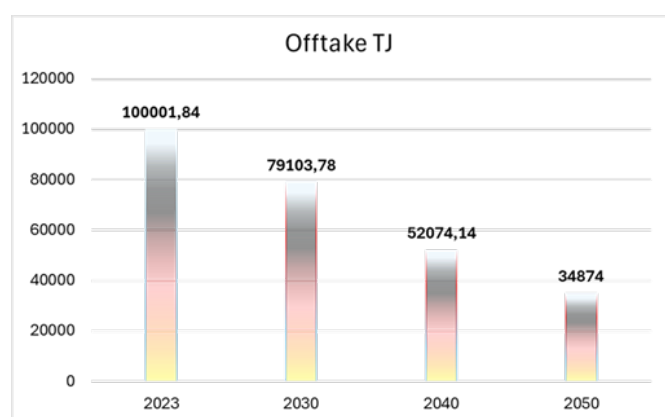


**Figure 5.** Energy generation by source

Figure 5 highlights a relevant decrease in lignite generation because of the phase-out of the corresponding power plants. In 2050, the lignite generation is supposed to decrease by two-thirds with respect to the value of 2023. Oppositely, a substantial increase in renewables, primarily hydro, is foreseen from 2023 to 20250.

In 2023, both wind and solar energy provided a negligible contribution to the power system, whereas a noticeable contribution is expected in the following years. In 2050, wind and solar generation will exceed that of the lignite.

According to the simulated scenario, a relevant effort to decarbonize the BiH power system is to be pursued.

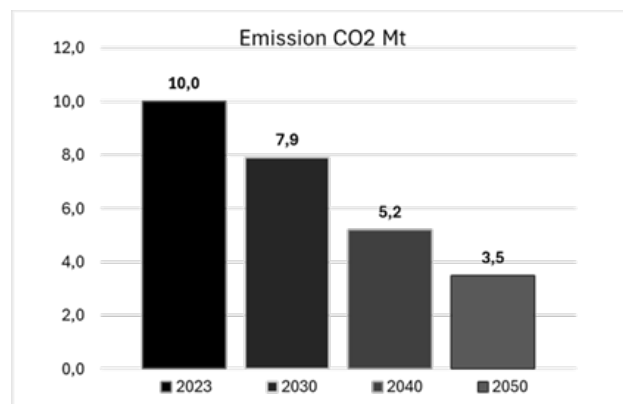


**Figure 6.** Trend of the lignite consumption in the simulated scenario

Figure 6 reports the fuel offtake, i.e., the lignite consumption, in the simulated scenario. It can be noted that there is a sharp decrease in consumption, which is quite aligned with the decrease in power generation of the lignite power plants. However, the slight differences can be ascribed to the different efficiencies of the considered power plants.

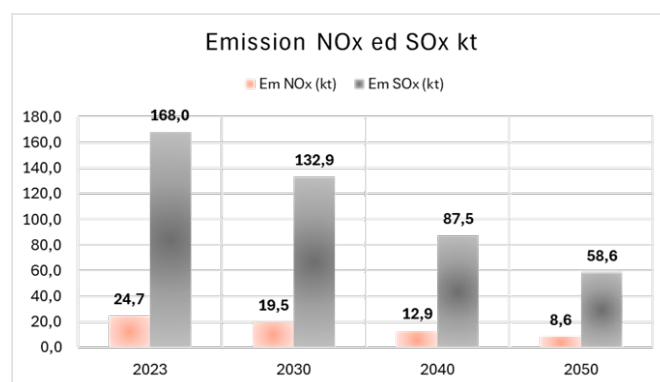
The decrease in coal consumption is positive from the point of view of the environmental impact, but it poses a relevant social issue. The mining sector employs a relevant number of

people, and the reduced activity of the mines or their closure can determine substantial unemployment issues. Thus, the Bosnian government should carefully consider this impact and manage the problem by including all the different perspectives.

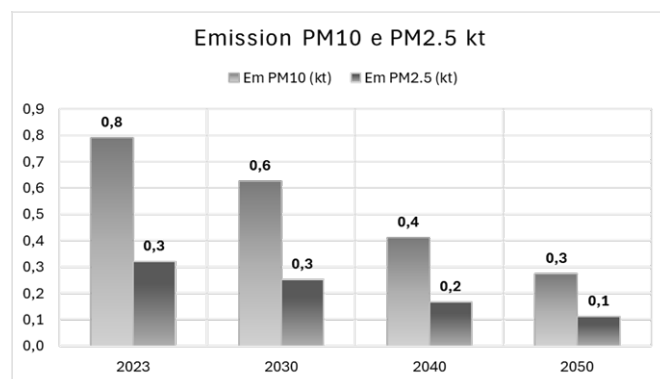


**Figure 7.** Trend of carbon emissions in the simulated scenario

Figure 7 illustrates the trend in carbon emissions for the simulated scenario. Carbon emissions in 2050 represent approximately one-third of those in 2023. The reduction can be attributed to the phase-out of lignite power plants. The proposed scenario determines a substantial reduction of the carbon intensity of the Bosnian power sector.



**Figure 8.** Trend of NO<sub>x</sub> and SO<sub>x</sub> emissions in the simulated scenario



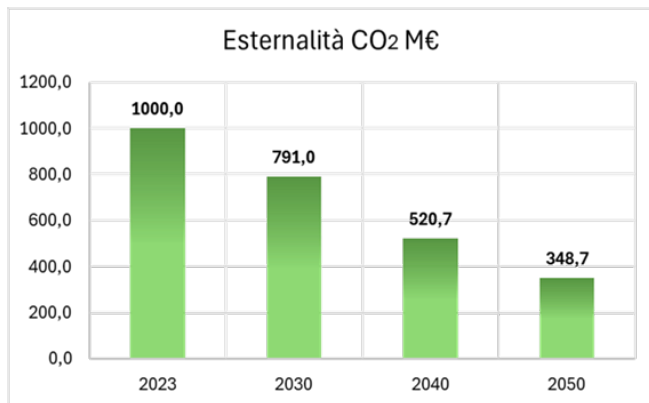
**Figure 9.** Trend of PM emissions in the simulated scenario

The reduction of lignite power generation also determines a decrease in pollutant emissions, as shown in Figure 8 and Figure 9, where NO<sub>x</sub>, SO<sub>x</sub>, and PM emission trends are

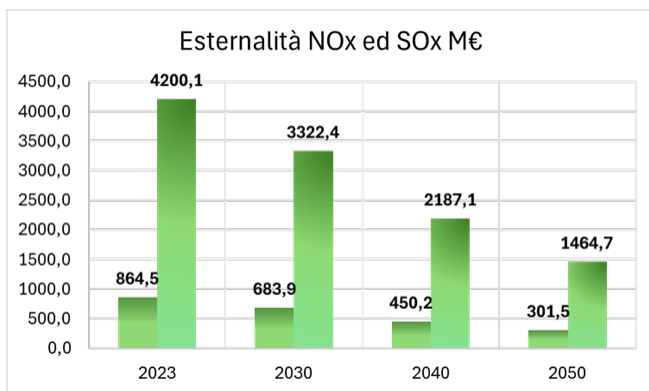
illustrated.

Pollutant emissions are very dangerous because they have a direct impact on people's health and on the living conditions in the areas where the power plants are located. Lignite is characterized by high levels of emissions; therefore, its phase-out determines a strong reduction in emissions.

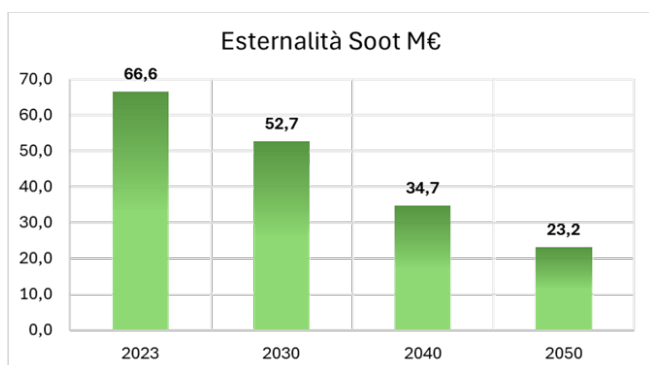
The reduction in both greenhouse gas emissions (e.g., CO<sub>2</sub>) and pollutant emissions (e.g., NO<sub>x</sub>, SO<sub>x</sub>, and PM) provides economic benefits in terms of reduction of negative externalities as shown in Figures 10-12.



**Figure 10.** Reduction in negative externalities due to a decrease in CO<sub>2</sub> emissions



**Figure 11.** Reduction in negative externalities due to decrease in NO<sub>x</sub> and SO<sub>x</sub> emissions



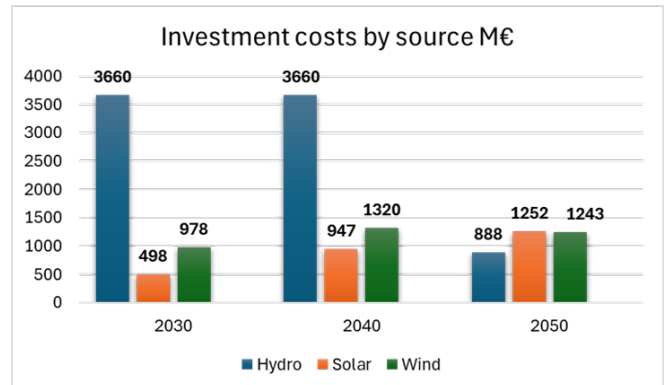
**Figure 12.** Reduction in negative externalities due to decrease in Soot (PM) emissions

The reduction in externality cost is relevant. It is mainly due to the decrease of the negative effect on public health, environment, productivity, etc., given by greenhouse and pollutant emissions. The most relevant saving, as shown in

Figure 11, is due to the reduction in SO<sub>x</sub> emissions. The saving can be estimated at 2735 M€.

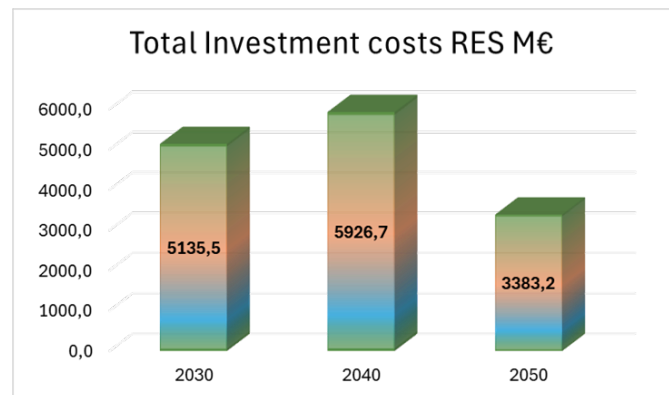
The savings in negative externalities are to be considered when the cost-benefit ratio of the decrease in lignite power plant generation and the increase in renewables is estimated.

To estimate the feasibility of the proposed scenario, it is necessary to consider the reduction of negative externalities, as previously discussed, the investment costs in renewable sources, and the effect on the power market in terms of price.



**Figure 13.** Investment cost per renewable energy source to implement the simulated scenario

Figure 13 reports on the investment cost in renewable energy for the three simulated years. The total investment cost to achieve in each of these years is shown in Figure 14.



**Figure 14.** Total investment cost in renewable energy sources to implement the simulated scenario

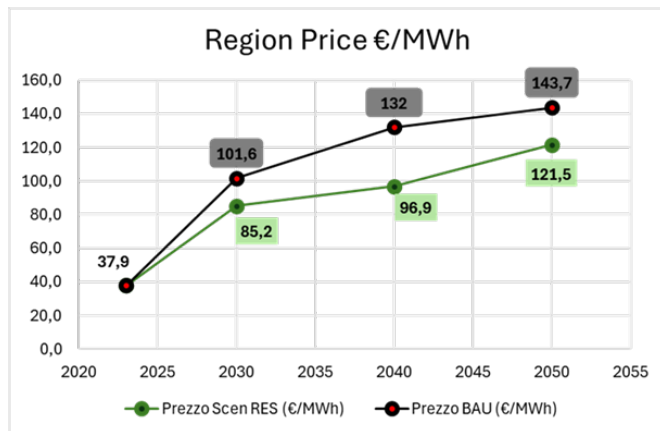
In 2030, 5 Bill. € are necessary to support the deployment of the foreseen RES capacity. In 2040, almost 6 Bill. € are necessary to support the plan. Whereas, in 2050, a little more than 3 Bill. € will be necessary. These amounts represent the cost for the scenarios considered.

The variation of the power capacity mix (e.g., more RES and less lignite) will determine a change in the power price on the market, because the variable costs of generation are different; thus, according to the System Marginal Price theory, the price will change as well.

The Business-as-Usual case simply considers that lignite power plants are all active and that RES development is limited.

It can be noted that when RES penetration is high, the expected power market price is lower, Figure 15, and this determines relevant savings for the users. This can be considered as another benefit of the simulated scenario. In

particular, the market savings can be estimated at 219 M€ in 2030, 548 M€ in 2040, and 396 M€ in 2050.



**Figure 15.** Power price in the considered scenario and in the Business-as-Usual case

To estimate the benefits, it is necessary that the effect of the investment lasts for a number of years. Fifteen years are considered to estimate the benefits, which means that savings in negative externalities and power price effect will be cumulated during these years, and a discount rate of 7% is considered. This assumption leads to the estimation of a Cost Benefit Ratio (CBR) of 2.5 in 2030, 2.4 in 2040, and 3.0 in 2050. This means that, in 2050, for each euro of investment there will be a return of 3.

#### 4. CONCLUSIONS

The present paper proposes the implementation of a scenario to increase the penetration of RES in Bosnia Herzegovina power sector.

The analysis is based on a detailed simulation of the Bosnian power market developed by implementing a bottom-up techno-economic model within the market simulation tool Plexos. The proposed model is multiregional, and four zones are considered, namely Sarajevo, Mostar, Tuzla, and Banja Luka.

The proposed analysis focused on energy, environmental, and financial aspects. It allows for determining the change in the energy mix, variation of the emissions, and impact on power prices.

The study shows that it is possible to substitute most of the lignite generation with renewables. In particular, BiH has a relevant hydro potential; thus, hydro power plants can be further developed to supply green power to the country.

Furthermore, solar PV and wind power also have a good potential in some areas of the country [8], and so they can be exploited, provided that the necessary connecting lines are available.

The analysis highlights and estimates the relevant savings in pollutant and greenhouse emissions that can be achieved.

Despite the significant amount of investment required by the implementation of the proposed scenario, a positive cost-benefit ratio can be obtained, equal to 3.0 from 2050 onwards.

Even if the proposed scenario is feasible from the economic point of view, it is necessary to assess its financial feasibility. Namely, if the country is able to provide the necessary financial resources to develop the investments within the

proposed timeline.

The main weaknesses of the proposed scenarios can be linked to social and environmental aspects. The main social issue is the possible unemployment resulting from reduced mining activity. Mining is one of the main sectors of the country, and a relevant decrease in the use of lignite would determine the decrease in the manpower, as also discussed in [9].

The second weakness is linked to the development of hydro power plants. They may have a substantial environmental impact as highlighted in literature [3], but also, their production can be reduced over the years due to the water scarcity deriving from climate change, as also discussed in literature [10].

Further development for the proposed study could consist of the testing of more scenarios to compare different alternatives. Also, different demand scenarios should be assessed, because, according to the foreseen economic development of the country, the power demand may substantially change. A change in power demand will modify the market equilibrium with an impact on the market price and power generation.

#### ACKNOWLEDGEMENT

Vincenzo Bianco, Luigi Caserta, and Mario Gallo acknowledge Energy Exemplar for the support in providing a free academic license of the software Plexos.

#### REFERENCES

- [1] Sher, F., Smječanin, N., Hrnjić, H., Bakunić, E., Sulejmanović, J. (2024). Prospects of renewable energy potentials and development in Bosnia and Herzegovina—A review. *Renewable and Sustainable Energy Reviews*, 189: 113929. <https://doi.org/10.1016/j.rser.2023.113929>
- [2] Karakosta, C., Flouri, M., Dimopoulou, S., Psarras, J. (2012). Analysis of renewable energy progress in the western Balkan countries: Bosnia–Herzegovina and Serbia. *Renewable and Sustainable Energy Reviews*, 16(7): 5166–5175. <https://doi.org/10.1016/j.rser.2012.04.040>
- [3] Novikau, A., Veljović, E., Krupalija, M. (2025). Big trouble with small hydro: Why renewable energy policies in Bosnia and Herzegovina have been revamped. *International Journal of Energy Sector Management*. <https://doi.org/10.1108/IJESM-01-2025-0014>
- [4] Begić, F., Afgan, N.H. (2007). Sustainability assessment tool for the decision making in selection of energy system—Bosnian case. *Energy*, 32(10): 1979–1985. <https://doi.org/10.1016/j.energy.2007.02.006>
- [5] Nikolakakis, T., Chattopadhyay, D., Malovic, D., Väyrynen, J., Bazilian, M. (2019). Analysis of electricity investment strategy for Bosnia and Herzegovina. *Energy Strategy Reviews*, 23: 47–56. <https://doi.org/10.1016/j.esr.2018.12.002>
- [6] Bianco, V., Scarpa, F., Tagliafico, L.A. (2015). Long term outlook of primary energy consumption of the Italian thermoelectric sector: Impact of fuel and carbon prices. *Energy*, 87: 153–164. <https://doi.org/10.1016/j.energy.2015.04.097>
- [7] Hampton, H., Foley, A. (2022). A review of current

- analytical methods, modelling tools and development frameworks applicable for future retail electricity market design. *Energy*, 260: 124861. <https://doi.org/10.1016/j.energy.2022.124861>
- [8] Begić, F., Kazagić, A. (2005). Potential utilization of renewable energy resources for electricity generation in Bosnia and Herzegovina. *Thermal Science*, 9(3): 15-23. <https://doi.org/10.2298/TSCI0503015B>
- [9] Baran, J., Szpor, A., Witajewski-Baltvilks, J. (2020). Low-carbon transition in a coal-producing country: A labour market perspective. *Energy Policy*, 147: 111878. <https://doi.org/10.1016/j.enpol.2020.111878>
- [10] Teotónio, C., Fortes, P., Roebeling, P., Rodriguez, M., Robaina-Alves, M. (2017). Assessing the impacts of climate change on hydropower generation and the power sector in Portugal: A partial equilibrium approach. *Renewable and Sustainable Energy Reviews*, 74: 788-799. <https://doi.org/10.1016/j.rser.2017.03.002>