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# ENERGY PROSPECTS IN WESTERN BALKAN REGION – MONTENEGRO CASE

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**Abstract:** To meet new energy demands and climate targets for 2030, the EU member states and West Balkans countries are requested to introduce the National Energy and Climate Plans (NECP) for the period from 2021 to 2030. That implies implementing clean, affordable and renewable energies to reach a climate-neutral economy by 2050. This will require moving towards the long-term goals set by Power agreements, which means to perform economic transformations to reach broader sustainable development goals.

To achieve those goals national long-term strategies in Western Balkan countries jointly with EU strategies have to cover, at least, the following in the coming 30 years: total greenhouse emission reduction, even elimination, to extend feasible socio-economic effects of the decarburization measures, to enable links to other national long-term objectives, to make progress on a low greenhouse gas emission economy by encouraging the use of renewable energy sources to approach the European green plan.

All those measures will lead the energy sector in the Western Balkans (WB6) to be organized to function with diversified sources of energy, secure fully functional integrated energy market, the free flow of energy, improve efficiency by reducing needs for energy imports; move to low carbon economy by promoting research and innovations in low carbon and clean energy technologies, which will all lead to extensive implantation of renewable energy sources and control of climate change in the region.

**Keywords:** Green plan, energy agenda, climate changes, sustainable development goals, energy prospects, Western Balkans, Montenegro.

## 1. INTRODUCTION

Most of the energy we capture for use on Earth comes from the nuclear reactions on the Sun. Historically, changes in energy systems have resulted due to different periods of technological, economic, and social advancements taking place by many actors at diverse locations. The scale of changes of the energy systems over the next 10 to 20 years will be considerable and fully different in many issues from what they have been up today. The energy system of the future will not look like it does today. Energy transitions occur at different speeds in different places. The old way of simply sending electrons and gas molecules down the wires and pipes will be replaced by better, much more sophisticated ways of meeting people's need to reach sustainability.

Energy systems are structured by many resources, technologies, end-users, and infrastructure. They are driven by economics, resource availability, public policies, and social behaviors. The relationships between those actors are very complex.

At present, fossil fuels like coal, oil and natural gas provide around 80 % of the world's Energy Mix which warms homes, charges devices and power transportation. It is, at the same time, the primary human source causing greenhouse gas emissions while resulting in climate change [1–4].

At the beginning of the twenty-first century, energy systems are changing fast due to the costs and availability of specific energy resources, technological advancements, environmental considerations, and the need to provide energy services to billions of people in developing countries. Energy consumption will increase drastically in the coming decades, which will result in many environmental problems.

Energy transitions that occur at different places with different speeds, aiming to fulfill specific social functions, represent complex socio-technical transformations.

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The EU has made significant moves towards the inclusion of the Western Balkan (WB6) into its energy sphere. The 2005 Energy Community Treaty was signed creating unique rules for power and gas markets in the region that would prepare it for joining the EU. At present, the Western Balkans region is extremely dependent on oil and gas imports since 90% of the necessary volume comes from imports.

Countries of Western Balkans have made a deliberate move to favor coal (lignite) as primary energy fuel in their national energy strategies because of its domestic availability while being cheaper than imported gas, oil, or renewable energy (RE). To be able to keep up with an energy demand growth (~2% on average by 2030) individual Western Balkans countries' policymakers have to address the large uncertainties related to the investment needed to modernize the national and regional energy sector [2–8].

The region's low efficiency in energy transformation and high dependency on lignite result in significant emissions of carbon dioxide ($CO_2$), sulphur dioxide ($SO_2$), nitrogen oxides (NOx) and small particles (PM). There is significant potential for improving energy efficiency in Western Balkans countries so as to decrease heavy dependence on fossil fuels, and generation of greenhouse gases, thus improving the quality of local air.

The WB6 countries should encourage energy policies by reforms in domestic markets to facilitate investments (either public or private) in sustainable energy solutions, implementing supply-mix diversification policies by increasing the use of lower-carbon-content fuels such as renewable energy (RE) and natural gas, deepening regional cooperation and electricity-market integration, and scaling up energy efficiency investments. This would help countries to realize the benefits of regional cooperation.

Despite the adoption of binding targets and incentive support schemes, RE development in the Western Balkans countries has lagged behind expectations. The overall cost of meeting renewable energy targets for WB6 countries can be significantly reduced if the countries establish coordination mechanisms.

A common feature of the Western Balkans region is the high share of fossil fuels in the supply mix (coal in particular) and the high import dependency on oil, petroleum products, and natural gas. Coal is expected to continue to dominate the region's Energy Mix, although its share is expected to decline from 50 % today to about 45 % by 2030. The Energy Mix means the specific combination of different energy sources used to meet energy consumption needs, generally, on the country level. Almost two-thirds of annual heat demand in the Western Balkans is met using firewood (42%) and electricity (21%), while other fuels account for the remaining 37%. The overall efficiency and quality of decentralized heating services are low and result in high indoor emissions.

Energy markets in the Western Balkan region are characterized by two main features:

– They all are net energy importers**,**

– Energy subsidies are rooted in the energy systems of all countries, characterizing the overall political energy strategy in the region.

All WB6 countries made significant progress in harmonizing their energy environment with the EU Internal Energy Market by adopting the Energy Community Treaty and establishing the regional Energy Community. They have taken important steps to strengthen their legislative and regulatory frameworks by transposing the relevant EU directives, passing important secondary legislation, and adopting National Energy Efficiency Action Plans (NEEAPs) [4–26].

## 2. ENERGY DEMAND

Since commercial oil drilling began (in 1850s) it has been drawn more than 135 billion tons of crude oil. At the same time, around 1.2 billion people in the regions like Asia, Latin America and parts of Africa still do not have access to modern energy services. Today, most of the world is dependent on electricity. It has radically influenced and changed human life. It has been the main power in industrialization as well. It must not be neglected that electricity in its raw form can also be fatal to humans and animals.

It is forecasted that the world's energy consumption/demand will increase by almost 50% by 2050. The growth or decline in energy demand, as well as its efficient use, is primarily the result of the state policies. The energy demand is mostly affected by a need for better, and more sophisticated ways of meeting people's needs [1–6].

The energy can be treated as a service activity since consumers must buy warmth, lighting and power. Energy needs to become part of the circular economy, keeping resources in use for as long as possible by recovering, regenerating and re-using them whenever possible. This will result in a shift away from buying energy in kWh or BTU towards buying energy as a service, which means that consumers have to pay a company for energy at the best price, while actively improving the efficiency of their homes by using less energy [4–16].

With energy being a service, consumers have a bigger influence and more choice in its production and use. To accomplish this effect in many situations, a proper solution might be reached by generating and using energy locally instead of having centralized energy systems.

At present, around 80% of the world's energy demand to warm and cool homes, charge devices and provide transport comes from fossil fuels, which has become the primary human source of greenhouse gas emissions. It is forecasted that the global energy demand will grow on average by about 0.7 % per year through 2050 (versus an average of more than 2 % from 2000 to 2015). It has been registered that global GDP doubles over the period whereas energy demand increases only by 30%. Lower global energy demand growth in the future will be the result of many factors like new technologies, greater efficiency, fall of energy intensity (the energy used for each unit of gross domestic product – GDP), the global economic shift toward services, slower population and economic growth, lower demand in Europe and North America, digitalization and possible pandemics. This decrease in demand will be followed by lower „global energy intensity”. It was suggested that around 1 kW per capita can provide „basic needs” for energy demand, while, recently, it was proposed a „2000-watt society”. Modern technologies allow much greater well-being at lower levels of energy consumption. In the contemporary world, 13% of the global population still lacks access to modern electricity. By 2050, the electricity demand will reach a quarter of all energy demand (18 % in the twenties). Electricity demand will grow twice as fast as that for transport. Oil, gas and coal will remain the dominant sources, accounting for more than 75% of energy supplies in 2035 (down from 85% in 2015). More than three-quarters of new capacity (77 per cent), according to research, will come from wind and solar energy, 13 per cent from natural gas, and the rest from everything else. By 2050, non-hydro renewables will account for more than a third of global power generation—a huge increase from the 2014 level of 6%. The share of nuclear and hydropower is also expected to grow, albeit modestly [4–28].

The climate change and energy security issues will determine the Energy Mix in the future.

The main factors that affect energy demand include:

– economic structure and its effect on industrial and commercial energy,

– residential energy in electricity and natural gas affected by state policies, and,

– energy used in transportation, as the result of total miles traveled and vehicle efficiency.

Market trends suggest that the demand for new energy resources will rise dramatically over the next 25 years since it is expected that:

– Global demand for all energy sources will grow by 57 %.

– By 2030, 56% of the world’s energy use will be in Asia.

– Nearly new 300 power plants (1,000 MW) will be needed.

– Currently, most greenhouse gas emissions come from electricity generation which relies on coal and fossil fuel.

Due to increased demand and limited supply in the coming time, energy prices should rise dramatically, which will result in business impacts like

– Drop in profits due to high operating costs.

– Reduction of sales of energy, and disruption of supply chains.

– Loss of competitiveness in energy-intensive businesses.

– Disruption in the supply chain since suppliers cannot meet the cost obligations.

The demand is related to Energy Mix. It should not be mixed up with the power generation mix (the electricity mix), which describes the breakdown of energy sources used specifically to generate electricity. The Energy Mix depends on the energy resources being national or import available to a country, standards of living and level of development. The adjustment of energy demand to Energy Mix, as well as integrating storage and demand flexibility within the country, requires automation, machine learning and real-time price signals, which results in the energy market becoming largely digital [13–27].

The key concept for energy demand is Energy Security, which means the ability of a country to secure sufficient, affordable and consistent energy supplies for its domestic, industrial, transport and military requirements. It has to be met regardless of economic or political conditions. It should include a high level of governmental control, and a number of geopolitical concerns. On the global level, it is often a need for stability and security in the country's oil production and export. Equally, this might be affected by the diplomatic relations within a certain country. Thus, the energy-secure country can be considered to be the one having accessible use of a variety of energy sources.

Energy Security can be achieved by a variety of strategies, such as:

– Exploiting own resources to achieve full self-competence.

– Less dependency on imports.

– Supplementing own energy resources with reliable imports from a wide range of suppliers.

– Reducing domestic demand for energy while increasing efficiency.

Energy Security has become the main force in the geopolitical landscape in the world. The countries with large oil reserves are still largely dictating Energy Security. With new technologies developed there will be a shift in the geopolitics of Energy Security.

Energy Security is related to Energy Dependency, an issue that takes into consideration the consumption dependent upon imported energy. A low Energy Dependency results in higher Energy Security.

One of the biggest changes that will take place is that consumers will become the most important part of the energy sector, ensuring that the energy does not have a destructive impact on the Earth. In that sense, the Internet of Things will be used to provide a greener approach to energy use. Furthermore, the „Internet of Energy" will make use of connected digital systems to control how we satisfy demand, use and storage of energy [12–31].

## 3. ENERGY AND ENVIRONMENT

Today, most of the world is dependent on electricity and petrol. Those energy sources have radically changed human life affecting it in houses, at work, architecture, communication etc. while being the main power of prosperity. The increase in global energy production and consumption has also resulted in massive environmental degradation. Thus, burning coal, oil and gas (3 billion people rely on wood, coal, charcoal or animal waste for cooking and heating), accounting for around 60% of global greenhouse gas emissions, has been manifested in the rising levels of greenhouse gases in the Earth's atmosphere. Energy-related greenhouse-gas emissions will rise by 14 % in the next 20 years. Around 2035, the emissions will flatten and then fall for two main reasons. First, cars and trucks will be cleaner. Second, there will be a shift in the power industry toward gas and renewables.

Thus, the problem is how to use energy efficiently to improve human well-being, while controlling the environment and consequently public health impacts. This will depend on the human ability to identify and control the consequences of technological and economic developments, public policy, cultural preferences, and many environmental impacts resulting in climate change.

Energy is one of the examples of geopolitical issues. The Paris Agreement (signed by 186 countries in December 2015) means having global warming „well below" 2 degrees Celsius, preferably to 1.5 degrees Celsius compared to pre-industrial levels. This is accepted to be the way of reaching a sustainable future for mankind. It implies fundamental transformations of the Energy Mix by 2050, i.e., how much hydrogen, biomass or renewables-based synthetic fuels can substitute fossil fuels. Thus, energy transformations will be followed by many technical issues. On top of that, the cost of this transformation will be one of the most crucial problems. The Paris Agreement understands that, by 2030, universal access to affordable, reliable and modern energy will be ensured. This should be achieved by a significant increase in the share of renewable energy in the global Energy Mix and doubling the global rate in energy efficiency. It understands implementing more international cooperation to facilitate access to clean energy and technology. That will be equally important all around the world, in particular in developing countries, as well as in small island developing states [2–13].

Energy generation and consumption, particularly from fossil fuels, influence the environment by threatening public health and affecting wildlife habitat and biodiversity. To accomplish this, we have to come up with new ways to tackle the energy challenge. However, due to the superior energy intensity and reliability of fossil fuels, they will play a significant role in Energy Mix through 2050, which will result, as forecasted, in the rise of energy-related greenhouse-gas emissions, as stated earlier, by 14 % over the next period.

The trends which can provide the flexibility of energy systems allowing for a higher, cost-effective, environmentally efficient use of energy are electrification, decentralization and digitalization. By decentralization of energy production – locally produced energy – a more flexible management of the energy and technologies in the system is enabled, which will result in consumers having more choices in how energy is produced and how it affects the environment. By decentralization, the losses in transmission are minimized while the production of wasted heat in power stations is reduced. Decentralization of energy production by renewable energy sources is a challenge for the security of the global energy supply.

Energy is the most important in preventing diseases and fighting pandemics. It enables tools for healthcare facilities such as clean water, communications and IT services, social distancing, and many more. At present, the access to energy is essential to respond to the COVID-19 crises. The energy industry these days is experiencing problems due to the COVID-19. There are disruptions on oil and other markets as the result of a collapse in demand while having a surplus of supply [4–18].

It has to be noted that democracy does not improve sustainability, although it does not do worse than non-democracies. Democratization can reduce environmental damage. In fact, democratization can spread without reducing sustainability. At the same time, democracy does not have to result in more efficient energy consumption while promoting well-being. It is expected that democracies would encourage more effective use of energy such as improving well-being [4–37].

Environmental sustainability also significantly influences the energy industry. Thus, it is very important to move the focus from selling electricity to selling grid infrastructure and energy services, while providing Energy Security, which is in line with a free market of energy.

When it comes to climate change, the most important actions are to facilitate with the EU Climate Law, appreciating inclusion of the Western Balkans countries in the EU Emissions Trading Scheme (EU ETS). The clean energy transition includes support in the alignment with the EU *acquis* related to decarbonization in the content of the Energy Community, as well as the development of National Energy and Climate Plans (NECPs). As far as reduction of air pollution is considered, it means helping the Western Balkans countries to develop and implement Air Quality Strategies. These activities include more investments in sustainable transportation, clean energy, the environment and climate, a digital future, human capital, and the private sector. The Plan identifies ten investment flagships, among which it includes: FLAGSHIP 4 – Renewable energy (The rehabilitation of HPP Fierza and the construction of HPP Skavica (Albania); the expansion of HPP Piva; the construction of HPP Komarnica (Montenegro); and the construction of the Ibër-Lepenc Hydro System Phase II (Kosovo)

The European Green Deal (EUR 9 billion Economic and Investment Plan for the Western Balkans), a plan to make the EU climate neutral by 2050, should provide that „the ecological transition for Europe can only be fully effective if the EU’s immediate actions have effective action in the Balkans as well”. Experts are now forecasting that green energy harnessed with the power of ICT will drive the next wave of economic development [29–30].

The Western Balkans is one of the regions in Europe which has been the most heavily affected by the impact of climate change, which is projected to continue, with estimates of temperature increases of 1.7 – 4.0°C, and even exceeding 5.0°C by the end of the 21th century, depending on the global efforts in greenhouse gas emission reduction. The leaders of the Western Balkans countries signed a Declaration on the Green Agenda, expressing their intention to join the path set out by the EU. The Green Agenda for the Western Balkans (a EUR 9 billion economic and investment plan for the Western Balkans) is a new growth strategy for the region, leaping from a traditional economic model to a sustainable economy in line with the European Green Deal [29]. The Declaration is in line with the EU’s efforts to combat climate change, protect the environment and unlock the economic potential of the region’s green, low-carbon and circular economy. The majority of this support would be directed towards key productive investments and sustainable infrastructure in the region. By this deal, the Western Balkans countries are committed to actions in decarbonization, water and soil, economy, farming and food production, protecting biodiversity and air pollution which are included in the main guidelines for implementing the Green Agenda for the Western Balkans:

– climate action, including decarburization, energy, and mobility,
– circular economy, in particular addressing waste, recycling, sustainable production, and efficient use of resources,
– biodiversity, aiming to protect and restore the natural wealth of the region,
– fighting air, water, and soil pollution, and
– sustainable food systems and rural areas.

The advancement of new technologies with digital possibilities will make energy systems of the future cleaner and more efficient. The core areas for investments to achieve mentioned targets should be sustainable transportation, clean energy, the environment and climate, a digital future, human capital, and the private sector.

Digitalization will be a key enabler for these pillars.

IRENA's 2019 Innovation Landscape study outlines 11 solutions to create reliable, efficient future power systems using large shares of solar and wind power by having to solve: RE generation uncertainty using advanced weather forecasting, flexible generation to accommodate complexity, interconnections and regional markets to provide flexibility, using super grids to allow for RE, large-scale storage, providing services to the main grid by distributed RE resources, demand on side management, optimizing distribution system operation with distributed energy resources, utility-scale battery solution and power-to-X solution [18–30].

## 4. SOLUTION FOR RENEWABLE POWER

The greatest challenge in the energy sector is to reduce, or even eliminate, the use of fossil fuels from many activities such as aviation, freight and long-range transportation, as well as from certain industrial processes, and substitute them with carbon-free energy sources, i.e. by renewable energy sources.

Around a fifth of the world’s primary energy supply already comes from renewable energy sources (wind, solar, biomass, hydro and geothermal), which is expected to grow by 2.6% each year until 2050. Traditionally, hydropower used to be the main source of renewable energy. However, biomass, wind and sun are becoming the fastest growing renewable energy sources today. Research into renewable energy sources, batteries, carbon capture and storage are helping to move the world to a more sustainable future. Wind power and solar radiation are increasingly popular sources of energy, but the sun neither always shine, nor the wind always blow. Batteries to store their intermittent energy are not yet cheap and powerful enough to fill the gaps.

Many energy scenarios predict growth in renewable energy installations, especially an expansion of offshore wind capacities, photovoltaic (PV) installations, and a widespread uptake in domestic electric vehicles. Biogas and biofuels are often seen as the most viable alternatives to fossil fuels. Some of them are the most promising alternative energy sources which may play a crucial role in the Energy Mix of the near future.

It is possible to list many promising new technologies when considering alternative energy sources of the future and the environment. They might happen on the market in different periods. Some of them look like science fiction from today's point of view, while some may play a crucial role in the Energy Mix very soon. In that respect, listed are some of the most promising alternative energy solutions of the future:

– Space-based solar, which requires a satellite to orbit, and the conversion of electricity into microwaves to transmit energy to the Earth’s surface.

– Human power, which uses the energy generated by the movement of people to power devices.

– Tidal power, which has very high potential already in use in some cases.

– Hydrogen power, which is one of the cleanest energy sources, accounting for 74% of the mass of the entire nuclear fuel, or around 5% of the universe.

– Magma power, already used in Iceland.

– Nuclear waste, which means better use of nuclear fuel.

– Embeddable solar power, such as solar windows harvesting the part of the invisible light spectrum.

– Algae power, with the potential of up to 9,000 gallons of biofuel per acre.

– Flying wind power, harvesting wind power at a higher elevation.

– Fusion power might be the solution to all problems.

Tidal power, space-based solar, human power, algae power, flying wind power, fusion power and many others are still in the development stage. The problem with hydrogen, the most needed power source, is that there are no natural reservoirs of pure hydrogen. It is an energy carrier but not a primary source of energy. Although its extraction from natural gas or water requires a significant amount of energy, hydrogen fuel cells might be an important power source in the near future. Another promising energy source – biofuel – is currently predominantly in use in the form of grain-based ethanol, the production of which is energy-intensive and requires a large amount of land and water.

At present, wind and solar are increasingly popular sources of energy, although they have only made a fractional part in the Energy Mix so far. With the costs going down, they are pushing on green technologies. In the last decades, wind and solar power had „explosive average annual growth” (23% and 50% respectively) resulting in renewable sources of power now representing around 30 per cent of the world's total capacity and 23 per cent of total global electricity production [32–35]. By 2030, investments in renewables will be over USD 1.2 trillion. On the global level, this is annually more than five times the investments into fossil fuels. Nuclear energy today provides over a third of the world's low-carbon electricity. Nuclear energy requires technical and institutional innovations, which includes a new generation of reactors such as small modular reactors, fast reactors, and fusion energy.

Some authors suggest that new energy capacity in the future will come from wind and solar (77 per cent), natural gas (13 per cent), and the rest from everything else. In particular, wind and solar are expected to grow four to five times faster than any other source of power up to 2050. Renewable energy is going to be the fastest-growing source of energy – at 7.6% per year by 2035. It accounts for 40% of the growth in power generation, causing its share of global power to increase from 7% in 2015 to nearly 20% by 2035. This transition in energy supply and demand will result in a new global Energy Mix and security order.

Storing carbon dioxide underground or turning it into clean fuel is still far from the commercial solution. Storing energy to satisfy demand is not yet cheap and powerful enough. Batteries to store energy are still expensive and not much efficient [32–40].

Achieving reliable, efficient power systems using large shares of renewables (solar and wind) should imply the following [18]:

– More flexible generation, including interconnections and regional markets.

– Energy production using advanced weather forecasting.

– Renewable energy generation and demand over large distances using super grids.

– Optimization of operation between the distribution system and distributed energy sources to provide demand on-site management.

The significant decarburization of the Fuel Mix will happen since new renewables, nuclear and hydroelectric power will reach half of the growth in energy supplies in 2030.

Still, there is no rational and efficient way to store the electricity produced by renewables. Capacitors and flywheels can store/provide energy for a few minutes or hours. Using new hydroelectric dams for that purpose has become a controversial issue. The solution for storing energy might come in the form of fuel. However, due to the superior energy intensity and reliability of fossil fuels, they will still play a significant role in Energy Mix through 2050, which will, as forecasted, result in the rise of energy-related greenhouse-gas emissions in the next period, as stated earlier. The major advantage of fossil fuels over renewable energy sources is that they are very easy to store and transport [18–32].

Global energy consumption will increase drastically in the coming decades, creating immense environmental stress. Using energy resources more efficiently to improve human well-being while limiting environmental and public health impacts will be a significant global development challenge. Decentralization of energy through the development of wind, solar, biofuels and geothermal results in the possibility to locally control environmental issues, which could mean that communities no longer need to be centralized.

EU will remain the leader in the application of renewables, with the share of renewables in its power sector doubling to reach almost 40% by 2035. However, China will be the largest overall source of growth in renewables over the next 20 years, planning more renewable power than the EU and US combined. The high growth in renewable energy is because both solar and wind power will become significantly more competitive in the coming future.

The shift towards renewable energy sources is resulting in reshaping the energy industry. This shift is also affected by the convergence of the energy and power industries [29–48].

## 5. RENEWABLES IN MONTENEGRO

Montenegro has the potential to improve its energy systems by further developing additional hydropower plants on major rivers and their streams, by using its thermal potential (coal), as well as by using biomass, solar and wind energy. The portion of renewables in the final gross energy consumption, defined by the national program (2012/04/ MC-EnC from 18 October 2012) forced Montenegro to implement Directive 2009/28/EC in its legislative system to try to reach 33% of renewables in its energy system in 2020. To fully develop this sector, Montenegro also needs to upgrade its transmission and distribution network.

Since 2011, demand for electricity in Montenegro has generally decreased (mainly due to the reduction of production in aluminium and iron plants). In the last decade, Montenegro’s ability to meet its domestic electricity demand has varied depending on the hydrological situations. In certain periods of the last decade, the country was forced to import relatively large amounts of electricity.

Montenegro's energy intensity has been falling slightly in the recent years, although there is a great potential for reducing demand through more efficient energy use. In particular, there is a need for the development and enforcement of relevant regulatory frameworks to increase environmentally friendly use of renewable energy and take energy efficiency actions such as encouraging the use of sustainable energy.

The Western Balkans governments have committed to pursuing a clean energy transition and sustainable development in the Ministerial Meeting held in Podgorica in February 2019. This transition means reducing energy imports, developing renewable energy sources, strengthening regional energy security, and addressing air and related health pollution challenges. At present, the renewable energy already makes a significant proportion of the electricity mix in some economies of the Western Balkans countries, predominantly hydropower and bioenergy.

The connectivity between the Western Balkans countries and the regional energy market has to be improved significantly, while energy efficiency, a prerequisite for achieving decarbonization, has to be strongly considered in the future energy-related policy. The option for decarbonization in Western Balkan countries may be seen to be natural gas, especially in the countries with heavy coal consumption. Transformation of energy-intensive industries towards climate-neutrality should include markets characterized by climate-neutral products reached by developing new technologies while speeding up competitive prices [37–40].

Renewable energy sources already make a significant proportion of the electricity mix in some economies of the region. With hydropower and bioenergy dominating the picture, it is important to diversify these sources and tap into solar and wind potential. In the Western Balkans countries, there is some variation in RE penetration and resource mix. Renewables account for about 20% of total final energy consumption in Bosnia and Herzegovina, Kosovo, FYR Macedonia and Serbia, 40% in Albania, and 50% in Montenegro, which derives most of its RE from hydropower. However, coal is still fundamental in the energy sector in the Western Balkans, on average accounting for around 70% of electricity produced and, in some countries, even 97% [32–47].

In 2005, the Energy Community proclaimed that the European Union should be a crucial promoter of clean energy transition rules and standards in the Western Balkans region. Montenegro signed the Agreement on the Electro-Energetic Community for South Eastern Europe on 1 January 2015, which resulted in opening its energy market to competitors. The EU should extend all its dimensions to the Western Balkan countries by supporting energy security, market integration and energy transition, energy efficiency and renewable energies. Many important international agreements related to the renewable energy sector have been ratified under the Constitution of Montenegro as well. (The Law on Ratification of the Treaty establishing the Energy Community between the European Community and Montenegro and the Law on Ratification of the Kyoto Protocol to the United Nations Framework Convention on Climate Change). The new Energy Law is in significant compliance with the relevant Directives of the European Union and significantly encourages the production of energy from renewable sources, and high-efficiency cogeneration [30–47].

The first calculations of the energy potential of sun, wind and biomass in Montenegro were done in 2007 by CETMA company from Italy. The project has been treating the dynamics of the development of renewable energy sources by 2025. The aim defined by the project was to reach 20% of renewables in total energy consumption of primary energy in Montenegro by 2015. It is planned that one-fifth of energy be produced from renewable energy sources by 2022. [39–49].

With around 620,000 inhabitants and only 396,000 customers, Montenegro’s electricity needs are mainly met by the 225 MW lignite power plant at Pljevlja, the 307 MW Perucica and 342 MW Piva hydropower plants. In 2017, the 72 MW EBRD (European Bank for Reconstruction and Development) financed the commissioning of the Krnovo wind farm – the first in the country. It was followed in 2019 by the 46 MW Možura wind farm. The highest value of renewable energy consumption (renewable energy consumption is the share of renewables energy in total final energy consumption) in Montenegro over the past 10 years was 49.38 in 2013, while its lowest value was 38.76 in 2008 [43–51].

Only 20% of the hydropower potential had been used in Montenegro by 2020. The energy produced by hydropower plants, wind parks and solar power was around 750 GWh. Montenegro's majority state-owned utility company, EPCG, plans to invest by 2022 a total of 700 million euros in three facilities of renewable energy (the Briska Gora photovoltaic plant, the Gvozd wind farm and the Komarnica hydropower plant) with a total capacity of 500 MW. The most important development project in the transmission system was the construction of a one-way underwater electricity cable (a 433-kilometer-long tunnel below the Adriatic Sea surface) to export power to Italy. It came into operation in December 2019, but in 2018 it was announced that its capacity had been halved to 500 MW [43–52].

From 24 May until 2 June 2019, Montenegro for the first time produced enough energy from renewable sources to meet all needs, thus joining it to a small number of countries that produced all the necessary energy from domestic renewable energy sources (Montenegro consumed 43,490,743,000 BTU of energy in 2017. This represents 0.01% of the global energy consumption. Montenegro produced 23,339,006,000 BTU of energy, covering 54% of its annual energy consumption needs) [47–48]. During this period, around 82 million kWh of energy was produced. That happened due to the production of two leading hydropower plants Piva and Perucica, which are state-owned utility companies, and wind farms Krnovo, the largest attitude wind park in Europe, and the Mozura, which in the mentioned period produced 12% of the energy consumed in Montenegro. A record part of wind energy was also recorded on May 28 the same year when production from wind farms accounted for 28% of total electricity consumption in the country. This ten-day experience confirmed that good operational readiness, adequate prognostic tools, high-quality power reserve and good connectivity with neighboring power systems could guarantee reliable power supply to consumers in Montenegro, which will be based exclusively on renewable energy sources [47–53].

The implementation of projects in the field of renewable energy has been treated in accordance with the Energy Law of Montenegro which deals with:

– The tariff system for incentive prices for electricity produced in power plants using renewable energy sources and high-efficiency cogeneration power plants;

– The level of a fee required to encourage the production of electricity from renewable energy sources and cogeneration.

The scope of use of energy from renewable sources is determined by the “Action Plan for the Use of Energy from Renewable Sources” [43–51].

### 5. 1. Hydropotential

Under plans being considered by governments, a network of nearly 3,000 hydro plants could be built across the Western Balkans with about a third of them being located in „protected” areas. Recent research shows that Montenegro has a high hydro-energy potential with a noteworthy index of cost-effectiveness of investments and favorable ecological and social environment. Authorities and investors view hydropower as a green alternative to other sources of energy that could help the country reach the renewable energy targets needed to join the European Union. Montenegro drives approximately three-quarters of domestic power supply by domestically produced electricity from hydropower. The hydropower potential of Montenegro comes from two confluences: the Adriatic Sea and the Black Sea. Two large hydropower plants, Perucica (307 MW) on the river Zeta, and Piva (363 MW) on the river Piva use only 18% of total hydropower potential. Besides those two existing hydro plants (HE Perucica, HE Piva), there is potential for new hydropower plants on rivers Morača, Komarnica, Lim, Ćehotina and Tara. It is not allowed to use the river Tara for building hydropower plants. Extensive geotechnical and hydrological research has already been performed on the Komarnica River (2 x 170MW) for the development of a multipurpose water reservoir. On the confluence of these rivers, there is also significant potential for building small hydropower plants. The estimated theoretical hydro potential on the main watercourses totals 9,846 GWh/year. Out of this capacity, less than 1,800 GWh, or only 18%, has been harnessed so far [46–52].

Between 2009 and 2018, at least 380 small hydropower plants were built in the Western Balkans region, bringing the total from 108 to 488. Due to a lack of regulation, experts estimate there may be many more of them. Across the Balkans, only 3.6% of energy was produced by small hydro plants. Technical (net) useful potential for small hydro plants in Montenegro (up to 1 – 10 MW) is estimated to be 400 GWh/year. The measurements have been performed by the Montenegro Institute of Hydrometeorology and Seismology in 38 locations. The register for small watercourses based on annual measurements has been done for 13 communities. There are currently 27 projects (34 concession contracts were signed for the construction of 53 small hydropower plants by 2018) for small hydro plants being implemented on some 25 watercourses, totaling 83 MW. Most planned small hydropower plants in Montenegro are not in line with EU conventions. There are currently 13 small hydro plants operating and a few more under construction. In 2018, they generated just 2.8% of Montenegro’s electricity.

Small hydropower plants are planned to increase their production from 109 GWh to 255 GWh in 2022. Although Montenegro has pledged to gradually change feed-in tariffs for renewable energy sources starting in 2020, the existing tariff contracts for small plants are still valid for many years (the price of kWh is estimated to be between 4 and 11 euro cents). As in other Western Balkans countries, the construction of small hydropower plants has caused widespread public protests in recent years.

In due course, more than 35 concessions given for small hydro plants were withdrawn, and in 2021, the Montenegro government has decided to stop issuing permits for the construction of small hydropower plants and reconsider those awarded so far.

### 5. 2. Biomass

The biomass accumulates energy by using photosynthesis. Energy from biomass is renewable and practically does not have negative effects on the environment. The biomass is found in all sorts of wood and its products, agriculture products, animal residuals and municipal and industrial waste. Among these, the wood has the greatest use. Thus, 35% to 40% of wood, while treated, remains as waste. In certain cases, this figure is even 65% (production of parquet). This waste presents great energy potential, especially when used for producing heat and electric energy, recently even in transport. Montenegro has significant biomass potential, primarily concentrated in woods, and then in agriculture that can be used for energy generation. Montenegro should focus on technology transfer for biomass technology to create conditions for the best use of current potential and future development.

Estimation of the energy potential of biomass is focused on the most important resources: forestry, wood-processing industry residual, and agriculture. The main biomass potential in Montenegro for generation can be represented with the following proportion: forests and forested land is 52.2% of the total Montenegro area – agricultural land 37.4%, and excluded from biomass potential is 10.4% of its total area. Forests and forested land represent the most significant energy potential for Montenegro, whose present use is two times lower than its natural potential [50–59].

The total potential of the biomass resources in Montenegro has been estimated to be 4.200 GWh, out of which 36% is wood, 28% agriculture and 33% are not precisely identified. This bioenergy potential is 1.5 times greater than the current electrical energy production, which shows that this green energy is a very important part of the Energy Mix in Montenegro. Urban areas have not been included in this estimation. The estimated reliable capacity of wood in Montenegro, on a yearly basis, is 2.6 $m^3$/ha/year, while only 1m3/ha/year is used. The capacity of wood has increased to 850.000 $m^3$/year, and 1.050.000 $m^3$/year including waste. The forest status is balanced in the range of 60-70 % from annual growth. The wood waste used for energy is estimated to be 30.000 $m^3$/year. Based on data obtained from all sites, the total wood waste is estimated to be even 57.000 $m^3$/year [49–59].

The cutting residuals from vineyards are traditionally burnt in Montenegro. These are a by-product of the company's main operation. Those residuals have low moisture content and high calorific value. The study shows that one kilogram of residuals from grape trees equals the energy value of one kilogram of fossil fuel. Thus, the cutting residuals from vineyards can be used for energy generation. Company Plantaže AD plans to install a 2 MW, 3t/h steam boiler to use locally produced wine cuts as the new biomass fuel. Montenegro has a large number of olive trees, and specifically residuals from the oil making process, a significant amount of mass can be used for energy value. There are a few more projects based on biogas from agriculture and food industry on the locations of Mozura, Becici, Budva, Mrtinici, and Mataguzi. [50–51]

The wood fuels currently produced in Montenegro are firewood, wood briquettes, and charcoal, with currently two lines for wood pellets production. In households in Montenegro, the total firewood consumption (both urban and rural households) ranges from 700.000 $m^3$ to 800.000 $m^3$, while average wood consumption per household ranges from 3.79 $m^3$ to 6.74 $m^3$ (the average of 5.49 $m^3$) per year, being relatively low consumption level in the coastal zone and high consumption level on the north of Montenegro. It has been shown that real total consumption of wood biomass for energy purposes in Montenegro is a few (~5) times higher than that officially statistically recorded!

From economic and environmental aspects, wood energy has a significant contribution to the reduction of the energy dependence of Montenegro, reduction of fossil fuels imports and reduction of $CO_2$ emission [51–54].

### 5.3. Wind energy

Wind is the result of the movement of air, which appears due to the difference in its density produced by temperature differences. Naturally, it presents the movement of air from places of higher density towards places of lower air density. The most important parameter for building windmills is the speed of the wind and its stability. Wind energy started to be used commercially in Europe as early as 1980s. The European Union plans that wind energy covers 10% of all its today's energy needs until 2030. The windmills have been installed both onshore and offshore.

The energy obtained from the wind depends on the cube of its speed, and the generation begins when the speed is 2.5 m/s and stops, due to security reasons, when wind speed is 25 m/s. It is considered that economic production of energy is obtained when the mean speed of the wind, during the year, is higher than 6 m/s. The investments in building windmills are falling and it is reasonable for them to be, depending on the size of the windmill, from EUR 700 (small) to EUR 2500 (large) per kW, typically being around EUR 1.3 million per 1 MW.

The analysis of wing potential has been done in Montenegro based on an average speed at a reference height of 50 m. This analysis has shown that in the largest part of Montenegro the average speed of wind is below 5 m/s, which is also typical for North Italy and Central Europe. Going towards the coast, the average speed reaches 5-7 m/s, even at the same places, it reaches 7-8 m/s. The region around the city of Niksic has a mean wind speed 5.5-6.5 m/s. A typical value of wind potential in Montenegro is between 100÷300 W/m$^2$. Most of the attractive locations related to wind speed are in the inlet of Montenegro, but they are not attractive for use due to their height, none of them having available roads and other infrastructure [51].

The most attractive locations concerning the use of the wind for the production of electricity are the region of the Mount Rumija along the seaside, as well as in the hinterland of Petrovac, Herceg Novi and Orahovac. All those locations have an average wind speed of more than 6 m/s. Mountains surrounding the city of Niksic are attractive too, having a mean wind speed of 5.5-6.5 m/s.

It has been concluded that Montenegro has a wind potential of 100 MW, only taking into account sites where mean speed is over 7 m/s. If sites with a lower mean speed are taken into account, this potential comes to 400 MW. If this energy is used, it will make 20% – 25% of the annual energy consumption of Montenegro. To encourage investments, the price of kWh from windmills is estimated to be 9.6-euro cent per kWh for the period of the next 12 years after the construction.

Two locations have been selected for the construction of windmills:

– Site Možura, between Bar and Ulcinj with the annual mean speed of 5.6-5.8 m/s at the height of 40-60-68 m,

– Site Krnovo, between Nikšić and Šavnik with an annual mean speed of 6.2 m/s at the height of 60 m.

The constructed wind capacities on those two sites should produce 313 GWh/year of electricity (Mozura 46.000 kW with 23 turbines and Krnovo 71.500 kW with 26 turbines). The highest energy production from wind farms accounted for as much as 28% of total electricity consumption in the country. The production from the existing 313 GWh will increase to 398 GWh since it is expected that, in 2022, windmill capacity at Gvozd, near Niksic, comes into full operation. Mitsubishi Heavy Industries Ltd. has signed the contract with the Montenegro government for building new 50 MW of wind installation as well as investigating the possibility of adding new 22 MW to the Krnovo wind farm. In addition, the agreement with Fersa energy (Spain) has been signed for building a 46 MW wind farm at the coast.

In addition to the investments mentioned above, the start of the project for the construction of two more wind farms is planned. All these investments do not imply any financial incentives for investors [51–59].

5.4. Solar energy

Estimated global solar radiation for Montenegro has been done using global radiation on daily basis, which shows the following:

– an average daily value of solar radiation on an annual level,

– an average daily value on a monthly level.

The territory of Montenegro is exposed to direct solar radiation of 1.5 to 2.0 thousand hours per year, which results in 3,5 kWh/m$^2$ to 4,5 kWh/m$^2$ and even 8 kWh/m$^2$ per day during the summer period. The sun shines 2460 hours/year, with over 200 hours in July and 104 hours of solar radiation in December. The average solar insolation in Montenegro is 1.450 kWh/m$^2$ [51].

The city of Podgorica has higher solar energy per year compared with other cities of Southeast Europe; it is estimated to be 1602 kWh/m$^2$ per year, which is the highest potential in Southeast Europe. Regarding the relatively small territory of Montenegro, there are no significant differences in average values of solar radiation. There is a great potential for use of solar energy in Montenegro.

Montenegro has so far made little use of its solar potential. However, in 2018, a tender for the construction of a 200 MW PV solar farm was completed. Photovoltaic capacities at Briska Gora are expected to be in the system in 2021, with the production of 10 GWh, reaching 100 GWh in 2022. The construction of the solar plant is to be carried out in phases, with Phase 1 including a facility of at least 50 MW of capacity within 18 months from signing the land lease agreement, and Phase 2, the remaining capacity, within 36 months of the signature.

Furthermore, the Ministry of Economy has issued over 20 permits for the installation of rooftop PV plants with an installed power of up to 1 MW. Their combined installed power is around 10.5 MW, while the planned annual production should be around 13.8 GWh.

115 PV installations have been constructed in high mountain locations for use during the summer by cattlemen, mainly for illumination. Alliance company has installed a 202.8 kW PV facility near Podgorica [51–59].

Due to solar potential along the coastal and in central areas of Montenegro, the use of solar energy, based on passive solar architecture, is recommended for heating, as well as the use of solar collectors for heating of service water. It has resulted in installing many solar heat collectors in Montenegro. Many hotels, especially along the coast, as well as many offices and private houses, use such collectors for heating service water. For example, a 130-kW unit is installed on the UN building in Podgorica and an electric vehicle charging station in Perast.

Even until the 1990s, there was a factory in Podgorica producing photovoltaic panels based on amorphous silicon [50–51].

### 5.5. Geothermal

In most cases, the use of geothermal energy is performed using hot water or a mixture of hot water and steam. This energy is used for heating and the production of electrical energy. The use of this energy requires higher initial cost while having lower cost during the operation. The hot water has been used only in Montenegro for recreation in some hotels along the seaside. There are no significant plans for building new capacities. The geothermal electricity net generation in Montenegro still does not exist.

The 2014 Montenegrin Energy Development Strategy estimates that, by 2030, up to 7 billion barrels of oil and 425 billion cubic meters of natural gas could be discovered along the coast. Further research regarding these resources is necessary to confirm these capacity levels. Montenegro does not currently have the necessary technology to produce oil or gas.

There are few places in Montenegro where the gas is generated from waste. There is a sanitary landfill in Podgorica of the capacity of ~1.1 MW, generating electricity of ~7 GWh/year and heat of 10 GWh in 2020.

The country has no infrastructure for natural gas distribution and does not currently extract oil, though the government is interested in oil and gas production in the Adriatic Sea [43–51].

## 6. CONCLUSIONS

Energy systems are dynamic and always in transition. They function within the laws of nature and the cultural norms of the societies in which they exist, being composed of diverse resources, technologies, and end-users, connected by infrastructure and driven by economics, resource access, public policies, and social behaviors. At the beginning of the twenty-first century, energy systems are changing in response to (a) the shifting costs and availability of specific energy resources, (b) technological innovations, (c) public concerns about the environmental consequences of specific energy practices, (d) the fact that billions of people in developing nations are gaining access to modern forms of energy, and (e) recent pandemics. The causes and speed of energy transitions are extremely complex.

Achieving climate neutrality by 2050, i.e. cutting greenhouse gas emissions by 55% by 2030, means making changes to the way we live today. Thus, an increased level of ambition for the next decade will put the EU on a balanced pathway to climate neutrality by 2050. Undoubtedly, reaching a 100% renewable energy system will improve our future wellbeing in many ways. It will slash air pollution, give millions of more people access to energy, grow employment, reduce future energy costs, and advance sustainable development.

When it comes to energy, there is one matter everyone agrees on. For the near future, at least, the world will need more of it, and how it is produced and used will be a critical factor of the global economy, geopolitics, and the environment. It is important to remember that we live in a business-as-usual scenario. The energy consumption in the countries at lower levels of economic development is linked to well-being, which is not the case with high-income nations. The level of development also affects human wellbeing via negative externalities. Thus, the crucial question is how to minimize energy consumption while maximizing well-being? The solution might be in connecting the energy grids of several countries (thus creating „super grids"), which will result in sharing Energy Mix and services over a wide area.

The most important energy issue is: will there be enough available energy in the near future, having in mind an increase in population and an increase in the standard of living? These problems have to be solved by technologies that are still in research or under development. Furthermore, having in mind that by 2050 we will, still, be getting most of the energy from fossil fuels, the question is how it will be possible to obtain carbon capture storage and its utilization. It cannot be achieved only by a new Energy Mix or by developing new technologies, but it also needs a shift of the geopolitics.

Montenegro has great potential for reducing demand through more efficient energy use. According to IEA statistics, Montenegro's energy intensity has been falling slightly in recent years but it is still more than twice that of the EU-28. Inefficient practices such as using electrical heaters and air conditioning for heating are, at present, widespread and should be reduced in the future.

In solving these problems energy companies may control more precisely the use of home appliances by turning them on and off depending on fluctuations in the weather or the time of a day. It would mean a move from the "power-on-demand" way of consuming energy. Thus, it is certain that in the future the biggest change in the area of energy market and services will take place, i.e. in consumers control over energy sources, and energy consumption, as well as in control of its cost, which will enlarge management activity.

One of the biggest problems is how to cope with the rise in energy demand. In that sense, it should be controlled where we get our energy to cope with the immediate rise in energy demands expected in the coming decades.

The new supply chain technologies are emerging, which significantly improves the visibility across the end-to-end supply chain. The traditional linear supply chain model is transforming into digital supply networks (DSNs). In such a way, end-to-end visibility, collaboration, agility, and optimization are enabled. Thus, whether there are events like COVID-19, trade wars, terrorism, regulatory change, labor dispute, sudden changes in demand, or supplier bankruptcy, organizations that deploy DSNs will be able to deal with the unexpected.

The future landscape of the energy industry will be transformed by technological innovations that drive towards a more convenient, efficient and ecological infrastructure. Transition to the new energy ecosystem will be dominated by digital technologies from “visualization, analytics and machine learning to cloud-based technologies, artificial intelligence and digital twins”.

Energy is one of the clearest examples of a geopolitical issue. Whilst intended to hurt the economies of the embargoed countries, this also forces importing countries to look elsewhere for their energy supplies. Thus, it is certain that in the future the biggest change in the area of energy market and services, i.e. in consumers control over energy sources, and energy consumption, as well as in control of its cost will take place, which will enlarge management activity.

New energy technologies with digital possibilities will enable the energy systems of the future to be cleaner, cheaper and more efficient. Undoubtedly, implementing a shift in where we get energy with new technologies is the greatest challenge facing our planet. It is very important how we will cope with energy demand in the coming decades to provide a more convenient, efficient and ecological infrastructure. Electrification, decentralization and digitalization are leading innovation trends that unlock system flexibility for more variable renewables.

The application of renewable energy sources presents a priority in the energy policy of Montenegro. It is needed to create an appropriate ambient for development and usage of renewables, further investigations of their potentials, and increase of their share in transport, in order to reach, by valorizing the existing potential of renewable energy in line with the Green Energy Plan, the national targets stated by the Law on Energy. This means that the hydropower plants, windmills, wood biomass-based facilities, solar systems, and gas from waste are priority projects with which should reach the national targets on renewables.

Owing to the continuing reduction in costs of renewable energy technologies like, particularly, wind and solar power, the old scale of economies would be turned upside down so that generating and using energy locally will represent better value than generating power in relatively few, large centralized systems.

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ЕНЕРГЕТСКЕ ПЕРСПЕКТИВЕ ЗАПАДНОГ БАЛКАНА – СЛУЧАЈ ЦРНЕ ГОРЕ

**Сажетак:** Како би се ишло у сусрет новим енергтским захтјевима и климатским циљевима за 2030 годину, од чланица Европске уније, као и оних Западног Балкана, захтијева се да усвоје националне енергетске и климатске планове за период 2021–2030. година. То значи примјену чисте, повољне и обновљиве енергије како би се досегла климатски неутрална економија до 2050. године. Ово ће захтијевати кретање ка дугорочним циљевима који су постављени енергетским уговорима, што значи да треба извршити економске трансформације како би се постигли шири циљеви одрживог развоја.

Да би се постигли ови циљеви, националне дугорочне стратегије у земљама Западног Балкана, заједно са стратегијама Европске уније, морају да покрију, најмање, сљедеће у наредних 30 година: укупно смањење емисије стаклене баште, па чак и елиминацију, проширење изведивих друштвено-економских ефеката мјера декарбонизације, повезивање са другим дугорочним циљевима, напредовање економије са ниском емисијом гасова стаклене баште подстицањем употребе обновљивих извора енергије ради приближавања Европском зеленом плану.

Све ове мјере довешће до тога да енергетски сектор Западног Балкана (WB6) буде организован да функционише са: диверсификацијом извора енергије, сигурним потпуно функционалним и интегрисаним енергетским тржиштем, преласком на економију са ниским степеном карбонизације, промовисање истраживања и иновација употребе технологија са ниским карбоном и чистом енергијом, што ће довести до широке примјене обновљивих извора енергије и контроле климатских промјена у региону.

**Кључне ријечи:** Зелени план, енергетска агенда, климатске промјене, циљеви одрживог развоја, енергетска перспектива, Западни Балкан, Црна Гора.

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