Smart strategies for the transition in coal intensive regions

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Roadmap for the Kolubara region

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1 Introduction

It is evident that the planet's climate is significantly changing. Human activities are the primary driver of those changes, so to slow the pace of global warming and to cut the emissions of CO_2 different activities are undertaken. Europe is very heterogeneous, and so is the energy system of European countries, but the European Union has nevertheless agreed on common goals (e.g., the UN Framework Convention on Climate Change (United Nations)) on COP (Conference of the Parties) 21 in Paris 2015, to reach net zero emission by 2050.

The necessity of energy transition is indisputable, the only question is how to implement it, as the goals are the same all over the world, especially in Europe, but the paths for realization are different. The main goal is the replacement of fossil energy with different forms of renewable energy sources, including bioenergy, geothermal, hydropower, ocean, solar and wind energy. Such energy transition is very complex, financially demanding and time consuming. Also, it should be a "just" transition. The new energy system must be sustainable, secure and able to provide low-carbon growth and prosperity.

The energy transition in Serbia is due to be in line with the country's obligations regarding climate change mitigation policy, defined according to the Paris Agreement and the UN Framework Convention on Climate Change (UNFCCC). Serbia is also signatory country to the Kyoto Protocol as a Non-Annex I Party of the UNFCCC. In this respect, Serbia is actively contributing to the global efforts to prevent climate change beyond repair, based on the principle of common but differentiated responsibilities.

The Serbian National Determined Contribution (NDC) to the climate change mitigation submitted to the UN provides reduction in emissions of greenhouse gases (GHGs) by 9.8% until 2030 relative to the 1990 emissions. However, it seems not sufficient, and a new target is expected to be defined for Serbia, in line with the EU energy and climate policy, under the framework of the Energy Community (EnC) Treaty of the Contracting Parties with the EU.

Energy transition towards the non-carbon energy technologies is not an easy endeavour for Serbia due to the fact that its major primary energy source is the indigenous coal-lignite, which is used to generate three quarters of the country's electricity. With an aim to ensure security of energy supply, especially of electricity and heat, the transition away from coal will mean closure of the coal fired thermal power plants before the expiration of their (and of coal mines) lifetime. The share of lignite in the primary consumption will decline, but it will still be dominant. Beside the coal, the share of oil will also decline, and the share of hydropower and renewables will rise.

For an expected country's economic growth and continuous raise of power demand, adequate measures and activities should be undertaken to ensure that a substitute with the low-carbon generation could be realized in the meantime.

To ensure high level of energy independence as long as possible, Serbia has foreseen gradual carbon dioxide emission decrease to be achieved by step-by-step phase out of the oldest coal fired power plants. In the meantime, renewable power plants, wind and solar, will be commissioned and connected to the grid. So far, the intermittence challenges related to power production from already built RES plants is balanced by hydro power, but it is clear that introduction of higher RES capacities in the future should be followed by construction of new flexible power plants and/or other solutions which will provide sufficient balance. Apart from hydropower, natural gas is considered as "a possible transitional solution", but to a lesser extent than originally planned, in the period until Serbia decides whether to turn to nuclear power as a solution for base load and in case that issues with renewables can't be overcome in some other way.

The Republic of Serbia has joined the EU Platform of the regions and countries that have entered into development of the Smart Specialization Strategy. By targeting resources in areas that have the most competitive and innovative potential, the *Smart Specialization Strategy of the Republic of Serbia (4S) for the period 2020-2027* aims to help the domestic economy of the Republic of Serbia to more effectively utilize its potential and better position itself in global markets. Developing

innovation in identified priority areas (4S) creates the preconditions for sustainable development in different areas. Many among these areas are found to be useful in the coal region and present excellent opportunities for regional development in the post-coal period.

Bearing in mind that the Kolubara target region, with intensive coal exploitation, provides more than a half of the total electricity and about 70% of coal production in Serbia, the transition away from coal is seen as an extremely complex task. Kolubara open-pit coal mine is located over two NUTS regions – Belgrade city region (3,234 km^2 of surface area and the population of 1,687,132) and Sumadija and Western Serbia region (26,492 km^2 of surface and a population of 1,941,130).

Moreover, the energy transition must be viewed as a development opportunity, which it really is. The interviews with stakeholders have shown a great deal of consistency across major aspects of transition. However, there are slight differences on what is in focus of particular Helices. The Helix A (Government) expressed particular interest for regulatory matters and international obligations that Serbia has taken concerning the transition process. For the Helix B (Academy) the focus was on the organization and funding of the R&I services, as well as environmental protection and climate change issues. Helix C (Industry) paid major attention on security of supply, employment, energy efficiency and import dependence. For the Helix D (Citizens), the major concern were economy, employment and environmental protection issues of the transition. Interestingly, although a hot topic worldwide, the impact of corona pandemic on the energy transition has not been taken into serious consideration by the interviewees. The reason might be their belief that the long-term dimension of the energy transition does not necessarily take account of the short-term disturbances like this one could possibly be.

Section 2 of this document (*Roadmap for the Kolubara region*) starts from a short description of the strategic approach for the development of the roadmap, based on R&I and reskilling / retraining activities for the selected energy technologies. A brief description of what has been identified in the TRACER document D6.2, i.e. the "*R&I Strategy of the Kolubara coal region*", is also provided. Then, the agreed strategies for the reskilling and the retraining of the local workforce that currently works in coal mining and/or power generation through coal, according to the TRACER document D6.3, are described. There is also an overview of a number of significant barriers in the achievement of the regional strategy.

Section 3 deals with recommendations for measures. It starts with the formulation of the major axes which are necessary for implementation of the roadmap in relation to the specified R&I activities of priority. Also, the needed activities in relation to the strategies for reskilling and retraining of the local workforce in the Kolubara coal region are described. Finally, the set of measures - as defined above - and how they can be supported and accepted by stakeholders are analysed in detail.

In section 4, an action plan of the roadmap is presented, according to the categorization of the measures identified in the previous section, with explanation of how this categorization has been made. Different discussions and consultations among working groups were implemented and their outputs are also presented in this section. For the different proposed actions their timeline, the necessary participants for their execution, funding opportunities, etc. are given.

2 Strategic approach for the development of the Roadmap

2.1 Prioritization of R&I activities for the selected energy technologies

The Republic of Serbia has begun drafting an Integrated National Energy and Climate Plan (INECP) for 2021-2030, with a vision until 2050, which will define measures to reduce greenhouse gas emissions and set targets for increasing the share of RES, as well as increasing energy efficiency until 2030 (with projections until 2050). The drafting has kicked-off after the adoption of three energy

laws which are expected to initiate the energy transition in Serbia. The laws also create a legal basis for the NECP's preparation.

The National Energy and Climate Plans (NECPs) have been introduced as an obligation for EU members under the "Clean Energy for All Europeans" package, which was adopted to help the EU achieve its 2030 energy and climate targets – reducing greenhouse gas emissions by at least 40%, increasing the share of renewables in energy consumption to 32%, and improving energy efficiency by 32.5%. EU members have already adopted their NECPs (the deadline for submitting the final plans was set for the 31st of December 2019).

Serbia, as an EnC contracting party, has no deadline for adoption a NECP, but all EnC contracting parties are currently in the process of adopting NECPs (in line with the *Recommendation of the Ministerial Council of EnC 2018l1IMC-EnC*, on preparing for the development of INECPs by the contracting parties of the EnC). The process of preparation of the Integrated National Energy and Climate Plan (INECP) of the Republic of Serbia from 2021 to 2030, with the vision until 2050, is underway and is being developed within the IPA project implemented by LDK Consultants SA and the Centre of Renewable Energy Sources and Saving (CRES).

Within the process of the INECP preparation, a wide range of consultations has been conducted with the Working Group members and other interested parties. A particular challenge encountered during the work on the INECP was to define new targets in the area of energy efficiency, renewable energy sources, and reduction of GHG emissions for 2030 with the vision until 2050. In the upcoming period, the complete draft version of the INECP will be prepared and presented during the public consultations expected to be organized at the beginning of 2022.

Drafting of a new Strategy for the development of the energy sector until 2040, with projections until 2050, is also underway, with the accompanying program of strategy implementation. The main objectives drafted in the strategy are:

- to provide secure electricity supply to the domestic market;
- to accomplish decarbonization of the energy sector and minimize impacts of energy generation to the environment and people's health;
- to provide maximum possible level of independence in the energy sector;
- to improve the electricity market on the national and regional level.

In aim to realize the said, the following activities are planned:

- Construction of new power plants' capacities, mainly based on gas fuel.
- Construction of power plants capacities based on renewable energy sources (wind, solar and hydro).
- Construction of plants and facilities for energy balancing (as pumped hydro, batteries, etc.).
- Capacity building in the field of new technologies (such as nuclear power, hydrogen, etc.).
- Improvement and reconstruction of energy transmission and distribution systems on national and regional level.

As the Kolubara Region is one of the most important energy providers in Serbia, the Kolubara Basin roadmap development shall follow the energy and overall economy development strategies foreseen for the state as a whole. It must be mentioned that, as the above-mentioned documents are not yet clearly defined and adopted, all considerations presented in this Report will be based on the available background information gathered from the relevant sources (drafted documents, authorities' reports, papers presented on the national and/or international meetings, etc.).

Beside the above said, in the past decade the country was facing with the fact that plans set up in the previous Energy sector development strategy (for the period up to 2025 with the vision to 2030) had to be modified in line with the actual energy and climatic considerations, primarily due to the

necessity for more radical reduction of carbon dioxide emissions from energy sector. Based on the experience already got from the developing countries, it is clear that impacts of climate change on the overall country's economy and society may lead to a number of new negative consequences, leading to the necessity to adapt to new climatic conditions along with the efforts to reduce greenhouse gases emissions.

However, a sustainable energy mix design needs to consider the balance between available energy resources and consumption rate. Currently, approximately 75% of energy in Serbia comes from fossil fuels. Combustion of fossil fuels releases CO_2, which is the main cause of the greenhouse effect. The use of fossil fuels, as well as their extraction from the ground, contribute to air pollution and cause serious damage to people's health and the environment. The national CO_2 emissions in Serbia is approximately 62 million tons annually, from which about 22 million tons come from the energy production in Kolubara coal basin. This is why the comprehensiveness in defining plans and ways to reduce emissions, while enabling the economy to develop, is one of the most important tasks that the strategy developers are currently facing.

The primary task that should be considered when defining the future Serbia's energy system development still remains the provision of safe and continuous access to energy resources at sustainable prices, respecting all the principles of a healthy environment. The same objective stands for Kolubara region. In this sense, in the past decade, the Republic of Serbia has accepted and ratified over the years a number of acts at the international level (in 2015 - Paris Agreement, 2019 - Green Deal EC, 2019 - Podgorica, joint statement on the transition to clean energy, 2020 - Sofia Declaration on the Green Agenda of the Western Balkans), proving its intention to follow general EU policy in climate change combat.

Further harmonization of domestic regulations with the regulations of the EU has been achieved in 2021, by adoption of the Law on Amendments to the Law on Energy (Off. Gazette No. 40/2021). Some of the novelties brought by the new Law in the field of electricity are:

- The obligation to develop and monitor the implementation of the INECP, in accordance with the obligations under the Energy Community Treaty, which defines national targets in the field of decarbonization in terms of greenhouse gas emissions from renewable sources, energy efficiency, energy security, internal energy market, research, innovation and competitiveness.
- Arrange the merging of the organized electricity market with neighboring markets - appointment of the Nominated Electricity Market Operator.
- Introduction of new participants in the electricity market: prosumer, electricity storage, and aggregator.
- Extension of the authority of the Energy Agency of the Republic of Serbia (AERS) to issue ex officio a decision on temporary revocation of a license in cases provided by law.
- Expansion of the scope of the Security of Supply Statement, which provides a complete picture of the supply of the market of the Republic of Serbia with energy and energy sources, as well as of measures taken to ensure the security of supply.
- Amendment of provisions related to guaranteed and regular supply, unauthorized consumption, disconnection and suspension of electricity, protection of electric power facilities.
- More precise definition of the energy endangered electricity costumer.

In line with the above said, it is clear that all policies defined for the period until 2050 must contain the principles of a new growth model based on "green development", which entails concrete actions, such as:

- gradual reduction in energy production from fossil fuels, mainly coal (lignite);
- increase the transition to energy generation from coal to natural gas;
- increase investments in renewable energy sources;

- energy efficiency improvement;
- introduction of carbon taxes on GHG emissions;
- examination of possibilities for new technologies applications in energy generation and storage (hydrogen, nuclear energy, batteries, etc.);
- diversification in energy supply, based on creating local, self-supply networks on one side, as well as better connection with the surrounding electricity markets, on another.

The listed actions will constitute the basis for considering Kolubara coal region's transition roadmap.

2.2 Prioritization of local workforce reskilling / retraining needs

Developing a strategy for re-skilling and re-training is a complex task that requires the involvement and cooperation and coordination of a large number of participants, including:

- Public Enterprize "Elecrtic Power Industry of Serbia" (PE EPS) and Trade Union of the workers of PE EPS (EPS Trade Union),
- Local government,
- National Employment Service,
- Qualification Agency,
- Ministry of Mining and Energy,
- Ministry of Education, Science and Technological Development,
- Ministry of Labour, Employment, Veterans and Social Affair,
- Private sector and other stakeholders.

PE EPS, in cooperation with the EPS Trade Union, should take the first step in developing a strategy for re-skilling and re-training of personnel. This step implies the adoption of the development strategy of production capacities, including the closure of mines and power plants. In that sense, it is necessary to analyse the possibilities of using alternative fuels at the locations of existing thermal power plants, as well as the possibilities of building renewable energy sources plants at the location of the Kolubara coal basin. In addition, it is necessary to consider the possibility of using the land on which the basin is located, for some other purposes (construction of artificial lakes, afforestation, construction of sports fields, etc.).

On the other hand, state institutions, both at the national and local levels, should jointly approach the development strategy. This strategy should include, among others, the economic development of the Kolubara coal basin area and thermal power plants. The PE EPS Development Strategy and the RS Economic Growth and Development Strategy should serve as a basis.

Based on its development strategy, PE EPS should conduct a staff analysis that would include:

- the qualification and age structure of employees,
- the necessary staff in accordance with the planned capacity development.

The analysis of the age structure shows the number of employees who will fulfil the condition for retirement at the time of the basin's closure. In addition, it will be possible to identify the number of employees over the age of 50, who represent the age group that finds it most difficult to find a new job and to retrain. Consideration of the qualification structure is also important for making strategies and plans for re-skilling and re-training.

The analysis of the required staff should be performed in accordance with the jobs that will appear according to the strategy of development of EPS production capacities, as well as according to the qualifications that will be required for their execution. Based on the performed analyses, PE EPS can conclude whether it possesses staff that, according to their qualifications, knowledge and skills,

can meet the requirements of the jobs that will be created during the transition period. It can also be seen whether and to what extent retraining should be carried out for these new jobs (as well as in which topics it should be focused).

The development strategies of regions covered by the transition are the starting point for defining the employment strategy and the action plan for the implementation of that strategy. In addition, it is necessary to take into account EPS's analysis of the personnel structure, as well as the results of the employers' survey. The survey of employers is conducted by the National Employment Service every year and, on the basis of it, it makes a forecast of employment needs. Based on all these activities, the local self-government dealing with employment should adopt an employment strategy for the Kolubara basin region and thermal power plants.

In order for this process to be successful, it is necessary to provide guidance to the representatives of local self-government and members of local employment councils, who participate in the creation of local employment policy. This training is conducted by the Qualification Agency. In addition to active participation in the adopted strategy of employment and retraining, local self-government, with the support of national branches and institutions, should actively promote adult education and retraining by informing the public and business entities about the conditions, benefits and importance of retraining. The promotion should point out the importance of improving knowledge, skills and abilities, given that it also improves the quality of life.

At the same time, a campaign should be conducted to encourage private initiative. Thus, if e.g. one of the goals of development is the development of agriculture, with a special emphasis on organic production, it is necessary to organize a series of lectures in this area. In that way, those interested would get acquainted with the possibilities that open up by engaging in this activity. They should also be shown problems they may encounter, as well as be referred to institutions that can help them overcome these problems.

If, for example, the goal of development is tourism, whether rural or sports, it is necessary to acquaint them with the conditions they need to provide in order to develop accommodation facilities. Then, the relevant stakeholders should be acquainted with the regulations and procedures according to which certain business activities take place. It is especially important to consider the financial resources needed for the implementation of the retraining process, as well as the sources of these resources.

To conclude, it is important that all necessary activities are undertaken after the closure of the Kolubara basin in order to employ as many people as possible from those that will lose their jobs on that occasion, and in the shortest possible period of time. One should keep in mind the fact that the longer people have to wait for a job, the less chance they have of finding it. Namely, if people do not work, their working abilities decline, and due to technological progress, their skills and knowledge become obsolete and outdated. In addition, a long stay in the labour market gives employers a negative signal in terms of skills and knowledge, and sends the message that these people are not a quality workforce.

2.3 Barriers analysis

The energy sector is always the main pillar in the country’s economic development and in everyday life of all citizens, so that the security of energy supply is a vital condition for all aspects of living. The second important factor is the price of energy, mainly electricity and heat for industrial and household consumption.

As any crucial change in the already established ways of energy supply is connected with a number of barriers in the process of its acceptance and implementation, it is obvious that the above listed activities, aimed to enable the energy transition to a new (more ‘clean’) era in the target region, will be faced with significant difficulties during their development. The main expected barriers are listed and evaluated in the below paragraphs.

Gradual reduction in energy production from fossil fuels, mainly coal (lignite)

Switching from coal to renewable energy may cause serious socio-economic challenges which, if not timely prevented, may cause unwanted consequences, such as unemployment, migration of workforce, economic disruption, etc. Coal mining and energy generation are the main economic activities in the Kolubara basin. Currently, there are about 14.000 employees in the energy sector, from which 11.600 are engaged in coal mines, and the rest are employed in thermal power plants. As the coal mines phase out will cause the gradual closure of numerous working positions, serious disapprovals are expected from the people living and earning money in the region. This should be the main barrier in the transition process.

The second group of barriers related to coal fired power plants phase-out are social impacts, raised as the consequence of significantly higher price of energy expected after change in energy mix. Actually, people are not yet aware of the fact that energy price from fossil fuels, mainly lignite, will be even higher after the introduction of carbon emission taxes and that actual low energy prices shall not anymore be sustainable in the near future.

Apart from the above presented barriers related to social issues, the main barrier, arising from the change of the main source of energy supply, is the provision of new safe and secure sources to generate the necessary electricity and heat. Introduction of the new sources shall be scheduled to start operation on time, in aim to avoid significant shortage in energy supply.

Increase the transition to energy generation from coal to natural gas

The main barrier connected to this activity may arise from the lack of predicted quantity of gas fuel supply, as well as the fuel price forecast, which may cause these investments unfeasible.

Increase investments in renewable energy sources

Energy generation from RES are in expansion in the Republic of Serbia. The main recognized RES in Serbia are wind and solar energy. Unfortunately, the potentials of these energy sources are not high in Kolubara coal region, so that significant capacities of such facilities should not be expected. This may be the main barrier in the exploitation of RES energy generation in the region. The consequence is also the lack of interest to invest in this kind projects, so they will be left to local individual investors, which are usually very limited in number or funding capacity.

In addition, the potentials of the use of RES based on biomass and biofuels are still not examined seriously, so that this kind of renewable energy is still poorly applied, both for industrial and domestic needs.

Energy efficiency improvement

Energy efficiency improvement is closely connected to energy savings and is often mentioned as the first step in energy consumption reduction, as this measure does not cause any change in the main energy generation process. On the other hand, it is connected to some system and equipment modernizations, which is sometimes time and money consuming. Besides systems and equipment improvements, important and effective rise in energy efficiency in energy production can come up from the combined generation of electricity/power and heat (CHP). For this reason, activities related to implementation of CHP Plants, instead of heating boilers, should be mandatory for new heating consumers, as well as in the projects of old heating plants reconstruction.

Since in the field of district heating natural gas is a dominant fuel, another step should be the provision of incentives to use renewable energy resources, such as biomass and/or waste, instead of fossil fuels. When considering energy consumption in households, high energy consumption is almost always connected to poor heat insulation of buildings and houses, but also with the low level of people’s awareness of the real “worth” of energy sources. This is something that needs to be fixed asap.

Introduction of carbon taxes on GHG emissions

In the EU countries, introduction of carbon taxes on GHG emissions has been recognized as the main measure to combat the climate changes. Also, the EU announced carbon border tax from 2026 to the Western Balkan countries. More precisely, the Carbon Border Adjustment Mechanism (CBAM) is a CO_2 tax that the EU is preparing to impose on imports of cement, iron, steel, fertilizer, aluminum and electricity from countries without a national carbon pricing scheme. CBAM is aimed to prevent "carbon leakage", the situation where businesses move from the EU to countries where there is no CO_2 taxation, as well as to discourage imports of carbon-intensive goods by making them more expensive. The above said mean that carbon pricing will make a power system based on renewables cheaper than a coal-based system. However, the EU leaves the option of a delayed implementation of the CBAM for power exports until 2030, so that Western Balkan countries will be in position to delay implementation of carbon pricing for power exports until that time.

One should be aware of the fact that implementation of any kind of taxes will impact the overall energy price on national level, which will reflect the rise of almost all products' prices. The result is that carbon taxes should impact both population and economy of the country. In addition, as energy intensity in Serbia is high (amounting to 400grCO_2/1€GDP), the social cost of CO_2 emissions will also be of special concern. In poor economies, like Serbia, significant rise of energy prices should even more decline standard of living and may result in wide range of complaints to the government and various institutions. The same will reflect Kolubara region.

As a mitigation transition measure, the Energy Community proposes introducing carbon taxation by developing national systems from 2025 in the member states, and combining them into a single regional system by 2030, and reaching the EU's carbon price by 2040. The funds got from carbon taxes will stay in state's budget and should be used for projects related to climate change and environmental protection improvements.

Application of new technologies

As the energy transition is a long-lasting process, it will include relevant new technologies development. Each country/region may have different appreciation regarding their applicability. In this sense, application of new technologies is often the subject to be examined and considered on the level of the country rather than on the level of the region. This even more relates to small countries like Serbia. The main barrier in the new technologies' considerations is the lack of relevant staff educated to evaluate and decide about the applicability of new technologies, and assess their feasibility in the local conditions. The next barrier is the lack of funds for the realization of projects of this kind.

In the case of nuclear power, it is expected that the most serious barrier will be public opposition, caused by the fear of the possible consequences in case of nuclear accidents. Also, due to moratorium on nuclear energy use (adopted in 1989 after nuclear accident in Chernobyl), there are no scientific or expert human resources that would monitor the construction and operation of these plants, as educating human resources needed for nuclear energy has been terminated since that time. Similar situation is expected in the administrative & regulatory and scientific & expert terms, as well as with the treatment of highly radioactive waste and spent nuclear fuel. Also, it should be noted that this is the case of energy based on import fuels.

In the case of hydrogen production and use, the main barrier is the lack of educated stuff who is able to deal with these issues, as well as lack of funds for the related research and minor cooperation with international institutions.

Diversification of energy supply

So far, electricity is supplied by the public company (PE EPS), while heat is supplied both from the public heating plants (district heating systems) and from individual systems. Diversification of energy supply means radical changes in primary energy sources, mainly transition to RES usage instead of electricity from coal combustion. As this transition includes the installation of new equipment, it is

connected with certain investments. Bearing in mind the social status of people living in the region, this could be one of the barriers in the realization of this activity.

3 Recommendations for Measures

3.1 Major axes needed to accomplish the objectives of the R&I Strategy

Gradual reduction in energy production from fossil fuels, mainly coal (lignite)

Current electricity (and heat) production in lignite fired thermal power units in Kolubara basin can be considered as insufficiently efficient due to the units' age and old technology. In spite of that, this way of energy production covers almost half of the national electricity production and represents the major pillar of electric power industry. However, actual agreement signed between Serbia and the Energy Community (in line with Decision D/2013/05/MC-EnC and Decision D/2013/06/MC-EnC) have defined the schedule for future operation of the thermal power plants in Kolubara basin. According to this agreement, the National Emission Reduction Plan (NERP) has been adopted, which specified the timing for introduction of environmental protection measures for the units that will continue operation after 2023. In addition, the TPPs that will be shut down until this target date (end of 2023) are TPP Morava and TPP Kolubara A. This shall be the first step in energy production reduction from fossil fuel power plants.

For the TPPs that will continue operation, the following measures that may contribute to carbon dioxide emissions reduction are envisaged:

- The homogenization of coal quality, which will result in TPP units' operation under optimal conditions, achieving higher overall efficiency and lower coal consumption.
- Modernization of the main technological process (water-steam cycle), as well as turbine reconstruction to achieve higher steam utilization and lower specific heat rate (kJ/kWh).
- Modernization of I&C systems in TPPs.
- Optimization of TPPs operation in the electric power system, bearing in mind introduction of new RES sources, including hydro power plants.
- Gradual withdrawal of existing coal fired units in the period up to 2040, as well as gradual reduction of their operating hours.
- Gradual reduction of coal consumption in applications other than electricity production (industry, heat generation, consumption in households, etc.) by realization of various R&I activities (described below).

Increase the transition to energy generation from coal to natural gas

As already mentioned, natural gas usage instead of coal is considered as one of the optimal movements in the transition process. In order to increase use of natural gas in energy production, the following activities are foreseen:

- Evaluation of the potential of existing TPPs to realize transition from coal to natural gas and/or to modernize existing gas fired units; in this sense, EPS has recently launched a project which includes examination of the feasibility to use natural gas at six locations in Serbia, of which two are in Kolubara basin (TPP Kolubara A and TPP Morava).
- Use for combined generation of electricity and heat in industry and agglomerations.
- Expansion of the district heating network to smaller settlements
- Augmentation of the gas supply network for industrial power production needs.

- Augmentation of the gas supply network for households' supply, as replacement of electricity consumption for heating needs.
- Increase the popularization of gas use versus coal among the population living in small settlements, in spite of higher gas fuel price and necessary investments.
- Establishment of favourable financing mechanisms for realization of projects related to gas fuel applications (state loans with low interest, partial state participation in financing, …).

Increase the investments in renewable energy sources

The main purposes of increasing the energy production from RES are:

- increasing and diversifying the share of renewable energy in the gross final energy consumption;
- reducing of imports and improving energy security;
- carbon dioxide emissions decline.

Production of energy from renewable sources has the potential to affect energy security, especially in remote areas, and to ensure supply independence in case of electricity shortages and rising prices, thus contributing to reducing dependence on electricity imports.

Up to now, Serbia has built a number of RES power plants, with a total capacity of approximately 2.91 GW, which include 13 large and medium hydropower plants (HPPs) with a total capacity of 2.35 GW, and approximately 0.56 GW are other technologies of RES. It should be noted that the replacement of fossil fuel power plants with RES plants is a comprehensive process, bearing in mind the availability of RES, as well as the variability of power production in RES power plants. It is estimated that in order to replace 4.4 GW of Serbian coal-fired TPPs in the coming decades, it will be necessary to build a total of around 21-22 GW of RES capacity (hydro, wind and solar).

Kolubara coal region will contribute to the set goal, in line with the availability of RES resources. Strategic actions in this sense should be the following:

- Actualization of the existing National Action Plan for RES (dated back to 2013), defining national objectives for using RES per sectors.
- Using RES for electricity generation.
- Using RES in heating plants (biomass in small applications).
- Using RES for the production of sanitary hot water instead of electricity (in small applications – mainly households and public institutions).
- Using RES in transportation (stimulate the production of biofuels in the country and usage of biofuels instead of fossil fuels).
- Development of distribution network for the connection of smaller electricity generators.
- Production and application of equipment and technologies that shall provide more efficient use of energy from RES.
- Informing and educating the general public.

Energy efficiency improvement

Existing indicators of energy consumption compared to the GDP in Serbia have values comparable to countries in the region, but significantly above average values for EU countries, regardless of the fact that the consumption of energy per capita is lower than the EU average (figure 2.1).

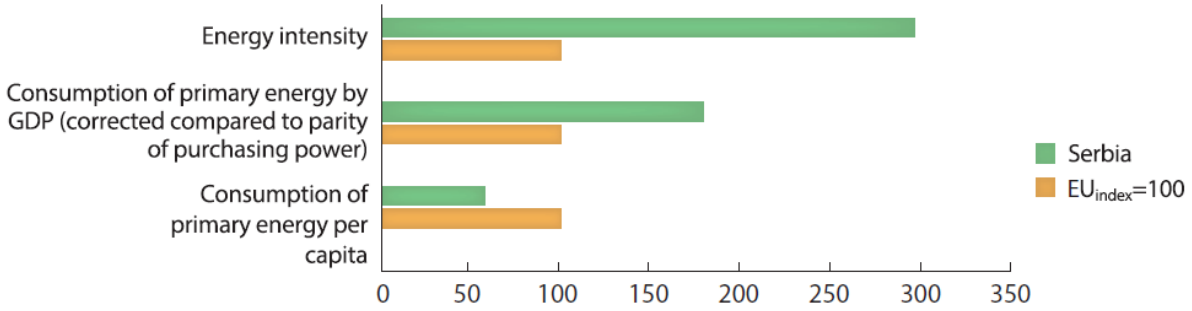

Figure 2.1: Comparison of energy indicators for the Republic of Serbia and the EU

The experiences of the EU counties indicate that strong support of the State is necessary for achieving significant results in the implementation of measures and technologies for the increase of energy efficiency. As energy efficiency improvement requires multidisciplinary activities, coordinated work of different state and local institutions and various types of organizations is necessary, including different companies, but citizens as well. Although the leading role in the activities related to the increase of energy efficiency and rationalization of energy consumption will have the Ministry of Mining and Energy, capacity rise will be necessary for different fields and sectors.

Measures foreseen on the country level shall be applied in the target region as well, and will include the following strategic actions:

- Continuous application of the Law on Efficient Use of the Energy.
- Adoption and implementation of National Action Plans for Energy Efficiency tailored for the target region.
- Defining the saving goals (in total and per sectors) for the target region and monitoring of implementation.
- Use of combined production of electricity and heat in industry.
- Reduction of losses in the district heating systems
- Introduction of payment based to heat consumption instead of existing price based on heated surface.
- Introduction of energy management systems within the overall management systems in the companies which are significant energy consumers (industry, public institutions).
- Capacity building on the level of local institutions/authorities in aim to contribute to energy policy on the local level.
- Increase of capacity of energy consumption monitoring (e.g., including the type and level of energy consumption per different groups of consumers).
- Continuous informing and educating the general public.

Introduction of carbon taxes on GHG emissions

The Republic of Serbia has not yet introduced a mechanism for GHG emissions trading (ETS), as is the practice in the European Union, and has not yet introduced mechanisms for setting the price for CO_2 nor has it introduced the CO_2 tax. It is expected that, shortly, Serbia will be forced by EU, i.e. the Energy Community, to introduce carbon taxes on GHG emissions. For the reasons mentioned above, the starting date for this measure should be postponed as much possible, or the taxes should be applied gradually, in certain percentages over the longer period. This should be the subject of negotiations of Balkan countries with the European Commission.

Application of new technologies

New technologies are considered within the scope of “Strategic directions of development” (within the document “Energy Security of the Republic of Serbia”, prepared by the Ministry of Mining and Energy of the Republic of Serbia in 2021), as long-term solutions, as most of them are still in the phase of research and development and are not yet commercially available. The main role of new technologies shall be to provide RES capacity balancing and increase of system flexibility. Apart from pumped storage hydro power plants, the possible solution is nuclear power, hydrogen as a fuel, and storage facilities.

As for hydrogen use for energy production, it should be noted that Serbia has prepared “Draft of the Hydrogen Strategy” as the initial document dealing with this issue. The Working Group, formed on the Faculty of Mechanical Engineering in the University of Belgrade, who was the creator of this document, has already proposed action plan for the related regulatory acts preparation as well as for the provision of necessary conditions for drafted Strategy implementation.

As for the possibility to use nuclear energy, for which the Law that prohibits the construction of nuclear power plants is still valid, currently there is no regulatory or administrative framework which would regulate the construction and operation of nuclear power plants. Also, there are no scientific or expert human resources that would monitor the construction and operation of these plants, and the education process for the human resources needed for nuclear energy was terminated. However, the construction of nuclear power plants should not be excluded as an option. According to estimations, the minimum period to overcome all listed problems and deficiencies, until the beginning of possible operation of such a plant in the Republic of Serbia, would be at least 10-15 years from the moment of abolishing the Law that prohibits the construction of nuclear power plants.

Generally speaking, the main actions to prepare the country/region for implementation of new technologies should be:

- Strengthening scientific and technological capacities, by modernization of universities’ education programs, and the establishment of funds for stimulating research in energy innovations.
- Participation of the Serbian scientific community in projects related to hydrogen, nuclear energy, batteries etc., through interstate agreements, contracts and cooperation.
- Better communication with the scientists in diaspora and transposition of their experiences to domestic needs
- Greater involvement in EU research funds in energy, especially in areas that may be suitable for the development of equipment production and IT in Serbia.
- Establishment of regional/wider international connections on the development of innovations, with special emphasis on hydrogen generation and usage, CO_2 savings, nuclear power and other innovative technologies.

Diversification in energy supply

Diversification in energy supply means energy generation in smaller, individual facilities, which are not necessarily connected to the grid. This may help the increase of energy supply availability to the remote consumers, as well as in small and medium enterprises in aim to reduce consumption of energy from the grid and/or become the “prosumer” category. This way of energy supply is mostly based on solar and wind power.

Photovoltaic technology has been used in Serbia for several decade ago, but its limited applications were caused by the high capital costs. Recently, the price of photovoltaic modules rapidly declines, thus offering electricity production of acceptable price. This kind of small-scale energy generation, using renewable sources is promoted by introduction of “producer - consumer” concept, defined in the recently adopted Law on renewable energy sources and Law on energy and the related by-laws.

3.2 Major axes needed to fulfill the needs for workforce retraining

The main axes needed to accomplish the objective of the Roadmap as regards the agreed strategies for re-skilling and re-training of the local workforce in the target region are the following:

1. Involvement of the wider community, various institutions, business and research entrepreneurs
2. Encouraging the employment of certain categories of those able to work
3. Stimulating private entrepreneurship
4. Provision of financial resources for the implementation of the retraining process

Involvement of the wider community, various institutions, business and research entrepreneurs

In order for the transition process to be successful in terms of retraining and employment, the wider community needs to be involved, not just local government. There needs to be good cooperation and coordination between all participants and at all levels from national, through the State, and local, to the level of economic entity. The termination of the Kolubara basin's activities will represent a great loss, not only for the employees, but also for the local self-government, since it largely depends on the tax revenues it collects from economic entities. Less funding also means less investment in education and other public services. All these further jeopardize potential employment opportunities. In addition, it should be borne in mind that, in coal-intensive regions the population develops a cultural identity associated with coal exploitation. The close down of coal mines not only affects the economy, but also individuals' identity and self-esteem, which are linked to their professional activity.

Another possible negative consequence of shutting down coal mines is the necessity to re-locate to other regions in the country, as new job opportunities are not provided in coal-intensive regions in transition. Hence, in many families one or even more members would need to leave home to find a new job, with impact from both social and psychological perspectives on all family members. In the case of older workers, unemployment is the most likely scenario, as they are prone to refusing re-location. Longer commuting distance to work may be another drawback that leads to declining job searches. That is why it is crucial to start the transition process on time, and within it the retraining process, and it is even more important that a large number of entities are involved and that their support lasts as long as the transition lasts.

Precisely for all the above-mentioned reasons, it is necessary to stimulate the attraction of new investors, to actively work on creating a positive atmosphere for the development of new economic areas. Special emphasis should be placed on the ecological aspects of the region's development: deforestation, agricultural development, primarily through the development of organic production, as well as the development of eco-tourism.

Encouraging the employment of certain categories of those able to work

The following categories of employees will be particularly affected by the termination of the coal mining and power production activity in the Kolubara basin:

- employees over the age of 50;
- employees who's the first and only job was working in the basin or thermal power plants.

Practice has shown that people over the age of 50, after losing their job, find it difficult to find other jobs or it takes a long period of time. The reasons may be on the side of the workers themselves, who find it difficult to accept the changes, or on the side of the employers, who prefer to hire a younger workforce. Therefore, it is necessary to stimulate employers to employ this category of labour force more often. This may include providing tax breaks, reducing payroll contributions and other similar cash incentives. In addition, it is necessary to create such an atmosphere in society, in which the importance of the experience that this workforce has, which can be passed on to younger colleagues, will be pointed out.

It should be borne in mind that for a large number of employees in the basin and the power plants, this was the first and only employment, which means that the number of those who changed companies in their working career is rather small. For many, especially those that are older than 50, it is difficult to change not only the company, but also the job they did, after a long working life spent in one company. That is why special attention should be paid to this category of workers. It should be pointed out to them that retraining has a number of advantages and that it opens up new possibilities. The employer will rather hire persons who have shown that they want to learn and to spread their knowledge, rather than persons who do not show interest in changing their position, for advancement and/or improvement.

Stimulating private entrepreneurship

In addition, it is necessary to provide organizational, legal and advisory assistance and support to employees who decide to start a company or start a new activity. This includes assisting in the development of business plans and financial projections, in contact with potential investors, whether they are banks or alternative sources (institutions) of financing. It is necessary to encourage potential entrepreneurs to start developing their business ideas and to be actively involved in the fundraising process. Also, to enable them easier access to financial resources, whether they are credit funds or funds from the RS and/or EU funds.

Provision of financial resources for the implementation of the retraining process

A very important issue for the successful transition process is the provision of financial resources necessary not only for retraining, but also for providing assistance in starting own businesses. The Republic of Serbia received significant funds to support the transition process through several different EU instruments and funds. Support from EU funds is intended for the necessary legal, institutional, administrative, economic and social reforms in various areas - from justice, public administration, public finance to education, employment, transport, agriculture and environmental protection. The Republic of Serbia is a beneficiary of instruments for pre-accession assistance, i.e. IPA funds. In addition, the Republic of Serbia has signed the Framework Agreement on Participation in EU Programs, which includes, among others: Horizon 2020, Program for the Competitiveness of Enterprises and Small and Medium-sized Enterprises - COSME, Erasmus and others.

Moreover, the Republic of Serbia is a beneficiary of the Western Balkans Investment Framework (WBIF). Its funds are intended for financing and providing technical assistance in the implementation of strategic investments in the field of: energy, environmental protection, social protection, transport sector and private sector development. Also, the Republic of Serbia has at its disposal the funds of the European Investment Bank (EIB) for projects in the field of climate change mitigation.

In addition to conducting the retraining process, it is necessary to acquaint potential entrepreneurs with the possibilities and ways in which they can obtain the necessary funds to start their own business. Financing from external sources is especially problematic for start-ups and very young companies, as well as for innovative companies whose business ventures are extremely risky. There are a number of alternative sources of funding: crowdfunding, business angels, venture capital, peer to peer, factoring, leasing, etc. Since these are alternative and relatively new sources of funding, it is necessary to acquaint potential entrepreneurs with the possibilities and conditions of their use.

3.3 Measures proposed under each one of main axes to overcome the barriers

Gradual reduction in energy production from fossil fuels, mainly coal (lignite)

Bearing in mind the social situation in Kolubara region (as described in the report D3.1 of this Project), most of the employed population in the region are working in the fields of mining and energy generation and in connected businesses. They will be strongly against the reduction of coal exploitation and closure of existing coal fired TPPs, which was already manifested after EPS decision to terminate the project of TPP Kolubara B construction.

In order to prevent this kind of reactions, the state government should adopt a clear plan for transition for the Kolubara coal region, defining:

- an action plan for establishing the new production activities that will create new jobs;
- new employment structure plan;
- requalification plan for the ex-employees in the mining and energy sector;
- establishment of the action plan for implementation of subventions for consumed electricity for the vulnerable groups;
- public hearing of all plans before their final adoption.

Increase the transition to energy generation from coal to natural gas

Serbia is highly dependent on natural gas imports, as domestic production covers only 10% of its needs. Currently, the whole quantity of imported gas fuel is from the Russian Federation. The division by final consumers is 10% population whereas 90% are large consumers, industry and plants for the production of thermal energy in district heating systems all over the country.

The main activities aiming to increase the security of gas supply are:

- Increase the level of connection with neighbouring markets and countries: connecting with the countries of the region via gas interconnectors would enable the formation of regional cooperation for the supply of markets of the Republic of Serbia and the region on the basis of cooperation in case of crisis situations.
- Expansion of the existing underground storage facilities and construction of new ones.
- Development of new main network for natural gas supply: until January 2021, the Republic of Serbia had only one direction of gas inflow, i.e. Russia-Ukraine-Hungary-Serbia, making it dependent on the energy-political relations between Russia and Ukraine. As of 1st January 2021, Serbia has diversified its natural gas supply routes and is additionally supplied from Bulgaria by the Balkan Stream gas pipeline. On February 2022, began the construction of the gas interconnector Serbia-Bulgaria (Nis-Dimitrovgrad), which will be operational in 2024.
- Development of distribution network within the country, in order to enable gas supply to the local consumers.

Increase the investments in renewable energy sources

Construction of energy plants based on renewable energy sources in the Kolubara target region should be intensified by the following actions:

- Detailed identification of renewable energy sources potentials in the region (wind, solar and biomass/biofuel).
- Development of a detailed structure of the energy needs in the region and current ways of supply.
- Industrial and public/social development plan survey and preparation of the relevant energy balances.
- Promoting higher use of biomass (possible co-combustion in existing coal-fired heating plants, as well as in individual houses heating systems).
- Use of municipal waste as fuel for heat generation.
- Promoting the ways of implementation of new energy sources (biomass, solar) in small applications (households and small industrial).
- Organization of tendering process on regional level for funding the projects in the field of RES applications.
- Provision of subsidies and/or funds for realization of projects related to RES applications.
- Stakeholders' motivation to participate in realization of the projects in the field of RES applications.

Energy efficiency improvement

Energy efficiency improvement is a multilevel task and needs actions in all activities connected to energy use. The best way to enhance energy efficiency is to make detailed review of the highest energy consumers in the region, including examination of the applied technologies and possibilities for modernizations, in aim to reduce energy consumption. It is also important to consider small consumers which, as numerous, may have considerable contribution to total energy consumption.

For successful energy efficiency improvement, the following actions should be realized:

- Identification of the main energy consumers in the region
- Assessment of the potentials in modernizations in the main sectors (industry, mining, energy production, traffic, public and individual consumption)
- Promotion of energy efficient technologies (heat pumps, heat insolation of buildings, energy saving light bulbs, etc)
- Organization of the open competition on regional level for funding the projects in the field of energy efficiency improvements
- Provision of subsidies and/or funds for realization of projects related to energy efficiency improvements
- Stakeholders' motivation to participate in realization of the projects in the field of energy efficiency improvements.

Application of new technologies

The main barrier in the application of new technologies is the fear rising from unacknowledged that generates negative opinion regarding their application. To overcome this barrier the following actions are proposed:

- Wide promotion of the new technologies, with the clear highlight of their advantages and disadvantages, as well as possible applications in the target region.
- Timely staff education in the field of new technologies.
- Provision of subsidies and/or funds for realization of projects related to new technologies application.
- Stakeholders' motivation to participate in the realization of projects in the field of new energy technologies.

4 Action Plan of the Roadmap

4.1 Assessment and prioritization of the proposed measures

The transition period in Kolubara coal region has to start in the next few years, parallel to the gradual change of the energy mix in Serbia. In line with this, the main measures aimed to fulfil the prescribed goals were identified and described in the previous chapters. Following the dynamics of Kolubara region's transition, as well as the fact that coal exploitation will continue in the next 15 years, at least, the prioritization of the proposed measures will be done primarily in order to create conditions for the proposed transition process realization. The measures evaluation is performed based on the current knowledge related to national energy and climate strategy, as the reference documents on the state level are not yet adopted (Energy sector development strategy up to 2050, NECP,…).

It should be noted that the strategic directions for the future energy development of the region should ensure:

1. **Energy security** - as a basic priority of the country's development, achieving national and economic security, through maximizing independence from energy and minimizing energy imports, with sufficient quantities of energy and energy-generating products, in accordance with future energy needs.
2. **Energy safety** - continuous supply of energy in various forms and at sufficient quantities, as well as at acceptable prices.
3. **Energy efficiency of buildings** - reduction of energy intensity per unit of gross domestic product.
4. **Energy transition** - transition from a system in which non-renewable sources (fossil fuels) are mainly used for energy production, to a system based on the use of renewable energy sources, as well as the energy resources with minimal impact to the environment, together with changes in production technologies and the management of energy production, distribution and consumption.
5. **Decarbonisation** - carbon neutrality by 2050, reducing net emissions to zero.

The measures proposed to achieve the conceived goals include actions at different domains and require organizational, technical and financial capabilities of the whole society. As their realization will be long term, it is advisable to perform priority analyses in advance. In this sense, measures are evaluated regarding three dimensions (contribution to national targets, economic, social) and the related criteria, as shown in Figure 4.1.

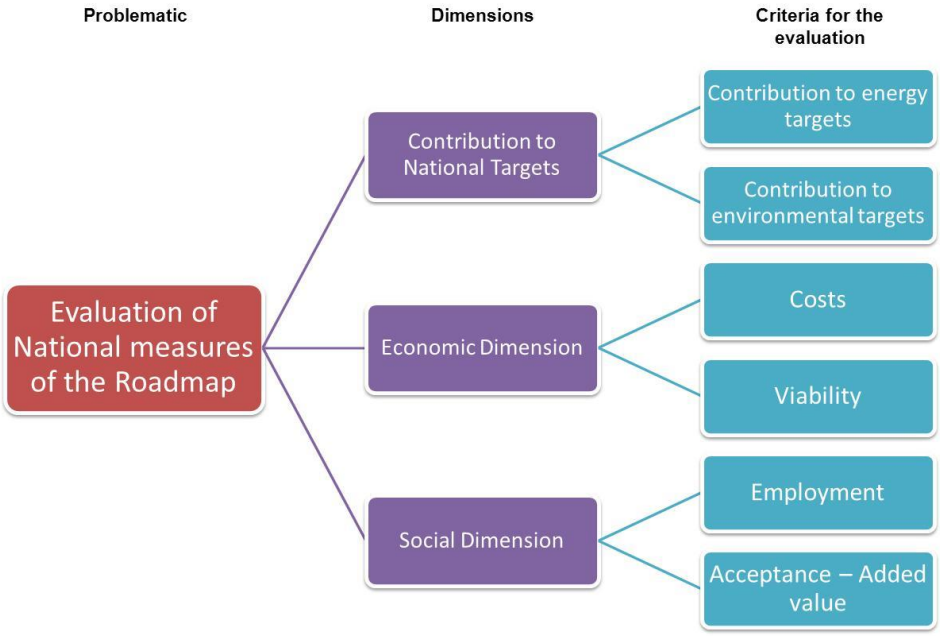

Figure 4.1: Dimensions and evaluation criteria of the Roadmap's measures

The contribution of each measure over any defined criterion and dimension is expressed qualitatively in a three-stage distinct and ordered scale as is shown in Table 4.1. The evaluation results are presented in Tables 4.2 and 4.3 below.

Table 4.1: Rating scale of the measures to export priorities

Rating	Contribution
+	Low
++	Medium
+++	High

Table 4.2: Qualitative contribution of the proposed measures to evaluation criteria

Measure	Contribution to National Targets		Economic		Social	
	Energy targets	Environmental targets	Costs	Viability	Employment	Added value
Gradual reduction in energy production from fossil fuels, mainly coal (lignite)	low	high	high	high	low	low
Intensify the transition to energy generation from coal to natural gas	medium	medium	high	medium	medium	low
Increase the investments in renewable energy sources	medium	high	high	medium	medium	medium
Energy efficiency improvement	medium	medium	low	high	low	medium
Introduction of carbon taxes on GHG emissions	low	high	high	medium	low	low
Examination of possibilities for new technologies applications	medium	medium	low	low	medium	low
Diversification in energy supply	low	medium	low	medium	low	low

Table 4.3: Priority analyses for the proposed measures

Measure	Priority
Gradual reduction in energy production from fossil fuels, mainly coal (lignite)	high
Intensify the transition to energy generation from coal to natural gas	medium
Increase the investments in renewable energy sources	high
Energy efficiency improvement	high
Introduction of carbon taxes on GHG emissions	low
Examination of possibilities for new technologies applications	low
Diversification in energy supply	medium

4.2 Specification of the set of actions required to implement the Roadmap

High priority measures derived from the analyses carried out in the Section 4.1 are:

- Intensify the transition to energy generation from coal to natural gas.
- Increase the investments in renewable energy sources.
- Energy efficiency improvement
- Planning of the reskilling/retraining process and start its realization on time.

The main activities aimed to realize the priority measures are discussed in the following text.

Intensify the transition to energy generation from coal to natural gas

Transition to energy generation from coal to natural gas shall be supported by the following actions:

- Initiation of projects for the construction of gas CHP plants as a transitional solution for the production of electricity and heat. The possibilities to use existing locations of gas fuel plants for construction of new plants or reconstruction/modernization of the existing units should be examined.
- Establishing strategic gas reserves in the amount necessary to meet the needs of 30 days of supply in the coldest winter period, which would be used as strategic reserves only in emergency situations. Strategic reserves ensure energy security and security of supply in cases of disruption and interruption of natural gas supply. This should be provided by initiation of the expansion of Banatski Dvor gas storage to the maximum capacity (1 billion m^3 of storage capacity),
- Improving regional cooperation in the field of natural gas supply and mutual response in emergency situations in the supply of this energy source.
- It is necessary to further diversify supply routes through interconnectors with neighbouring countries and fully open the natural gas market in the Republic of Serbia, which would result in the natural gas supply stability to the market of the Republic of Serbia, leading to more favourable conditions, and the Republic of Serbia becoming a gas hub.
- Acceleration of gasification of the entire territory of the Republic of Serbia, construction of a gas distribution network in all settlements and substitution of solid fuels with natural gas by large consumers.

Increase of investments in renewable energy sources

- Detailed consideration of renewable sources potentials in the target region (wind, solar, biomass).
- Due to the limited natural and spatial resources, but also to limited access to the transmission and distribution network, it is necessary to timely take measures of strategic planning in aim to define the optimal locations and enough space for RES plants, especially the larger ones.
- To enhance national electricity production, examine the way to increase the state company's share in RES projects, particularly for large ones, as well as to build RES plants in the state company's ownership.
- As a precondition for high RES integration is the improvement of the transmission network, replacement of obsolete transmission lines and substations, but also the construction of new internal and inter-connective transmission infrastructure should be provided.
- Ensure enough power and energy for balancing electricity production from wind and solar plants with the electricity production in natural gas and/or biomass TPPs, together with pumped-storage facilities and HPPs.
- Popularization of individual production (wider “prosumer” concept implementation, i.e., installation of photovoltaic panels in households, public buildings and industrial facilities).

Energy efficiency improvement

- Provide incentives for improving energy efficiency in households for energy reconstruction of buildings, family houses and apartments in order to increase energy efficiency of these structures and reduce excess energy consumption.
- Promote the significance of energy savings in every-day life and activities

- Provide funds from the state budget, international financial institutions and donations for energy rehabilitation programs in buildings, whereby energy efficiency will be achieved through the rehabilitation of residential buildings, apartments and family houses, as well as through the exploitation of renewable energy resources.
- Launch projects related to the examination of energy efficiency improvements in industry and provide funds for their realization.

Planning of the reskilling/retraining process and start its realization on time

- Develop a strategy for reskilling and retraining, based on the EPS Development Strategy, the RS Economic Growth and Development Strategy and analysis of the qualification and age structure of EPS employees.
- Involvement of the wider community, various institutions, business and research entrepreneurs; There needs to be good cooperation and coordination between all participants and at all levels from national, through the State, and local, to the level of economic entity.
- Stimulate private entrepreneurships through providing organizational, legal and advisory assistance and support to employees to start a business.
- Provide the financial resources using several different EU instruments and funds and alternative sources of funding.

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