

Smart strategies for the transition in coal intensive regions

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Research & Innovation strategy in the field of energy for Kolubara region

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Executive summary

In order to implement the energy transition properly, a lot of knowledge and experience is needed. So, all available domestic experts and institutions should be involved in the transition process, trying to implement available research and innovation procedures in an aim to support the transition process. For the R&I on that and other hot subjects related to the energy future, more trust was gained by local experts and R&I institutes than by foreign consultants. Nevertheless, it was stated that there is a lack of continued education of energy professionals, resulting in a lack of ability to participate in the multidisciplinary research.

It should be noted that RES and nuclear power plants have a special place in the non-carbon strategy, and there should be planned more collaboration with international companies and research institutions. Concerning stronger implementation of RES, there are doubts among experts about the possibility of the intention to use renewables as a single backbone as promoted in. In the upcoming period, the complete draft version of the INECP will be prepared and presented during the public consultations expected to be organised at the beginning of 2022. This activity is expected to further strengthen the knowledge of all relevant participants of the project, as well as the strategic planning capacities of the Ministry of Mining and Energy, and provide in-house energy and climate planning tools.

1 Introduction

1.1 Development of the Strategy: Overview of the process

Faced with forthcoming international obligations related to climate change mitigation measures, primarily planned to be reflected through the Law on Climate Change and Action Plan on Low Carbon Development Strategy, as well as the Law on Renewable Energy, all of which are recently being defined and adopted, Serbia is facing a necessity to switch its coal-fired facilities to, environmentally more acceptable, alternatives. The related measures will have to be implemented much sooner than initially planned. Knowing that 80% of national GHG emissions originate from the energy sector, as well as that the dominant portion of those emissions results from the use of locally available coal, it is clear that the most efficient climate change mitigation measure would be a switch to alternative fuel options.

However, having in mind that such an energy transition process is coupled with significant technological, environmental, economic, social, and other difficulties, EU has initiated several projects, and one of them is TRACER, launched under the Horizon 2020 program, that strives to shed light on the best research and innovation strategies facilitating easier transition to the sustainable, low carbon energy system. The project addresses actions across nine coal-intensive European regions, including Kolubara coal region in Serbia. In the project TRACER technological, environmental, and social challenges are treated in the transition process, besides eight coal regions in Europe, and the coal region Kolubara.

Energy transition towards the non-carbon energy technologies is not an easy effort 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. 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.

Therefore, in order to be ready to enter the process of energy transition, it is necessary for Serbia to make a strategy of the transition itself, as well as all preparatory documents that support the energy transition. An important step is the process of staff training, as well as the engagement of all resources in the field of scientific research and development and support of innovation.

The document concerning the R&I strategy is based on the basic assumptions of the vision of energy development (2030 & 2050), starting from the current state, as well as the improvement of the environment due to new energy measures.

It starts from a short description of the current state of the Kolubara coal region, with reference to regional technological, social, environment and economic aspects. The status of energy production technologies in the Kolubara coal region for 2030 and 2050 is presented, as well as the plan regarding environmental protection/climate change, etc.

There is also given an overview of research and innovation activities, institutes and faculties, as well as all others active in the field of energy innovation. The SWOT analysis shows the region's strengths and weaknesses in terms of innovation and specialization.

The strategy is based on the requirements and needs of the energy and environment sectors, and R&I is aimed to support the energy transition and contribute to sustainability for these two sectors. The goal of the strategy is to strengthen R&D and through that help national competitiveness and development of some industries.

On the basis of national documents related to R&I as well as the NECP law, as well as on the basis of conclusions obtained from stakeholders, areas are defined and the implementation of RTDI policy defined. An overview of potential financial resources that can support the strategy is then described. By applying smart specialization, as well as based on the conclusions of stakeholders, priority areas for development are defined. Finally, the process of monitoring the progress of the implementation of the strategy is described, as well as the possibility of improvement, and based on the set goals for 2030.

In order to define the path for energy transition and the basic requirements to be met, the following documents are used for the reference basis for further elaboration:

1. Energy Development Strategy of the Republic of Serbia until 2025 with projections until 2030 (2015);
2. Low Carbon Development Strategy with Action Plan (revised September 2021);
3. Energy Development Strategy of the Republic of Serbia until 2040 with projections until 2050 (ongoing) with Strategy realization program (ongoing);
4. Integrated National Energy and Climate Plan (INECP) by 2030 (ongoing)
5. Strategic Environmental Impact Assessment of the new Energy Development Strategy (ongoing).

In order to better understand the role of the Kolubara coal region, in defining the roadmap for energy transition, the document Spatial Plan of the Exploitation Area of the Kolubara lignite basin, draft spatial plan (2016) is also considered. An overview and assessment of the state of spatial development is given, with special reference to the state of development of mining and energy, economic development, infrastructural systems, as well as basic characteristics in terms of population.

Energy transition Roadmap is based on R&I activities, and so following guidelines of the Strategic Energy Technology (SET) Plan, the R&I pillar of the EU's energy and climate policy. SET plan aims to implement new technologies and reduce costs by working with close-to-market technologies in developing renewable and low-carbon energy sources.

Also, Serbian energy strategy is based on the document Research for Innovation (Strategy on Scientific and Technological Development of the Republic of Serbia). In order to achieve the defined vision and mission, this Strategy defines six specific objectives, as follows:

1. Encouraging excellence and relevance of scientific research in the Republic of Serbia;
2. Strengthening the connection between science, economy and society to encourage innovation;
3. Establishing an effective management system for science and innovation in the Republic of Serbia;
4. Ensuring excellence and the availability of human resources for science and economy and social affairs;
5. Improving international cooperation in the field of science and innovation;
6. Increasing investment in research and development through public funding and encouraging the investments of the business sector in research and development.

The task of the ministry responsible for science and technological development (hereinafter: the Ministry of Science) is to prepare and implement a set of measures that will create conditions for the realization of these objectives. Measures that will support strengthening the link between science, economy and society are: Encouraging the application of scientific research results, Strengthening the work of the Innovation Fund, Further development of the Serbia Innovation Project, Establishment of joint innovation projects of the private sector and scientific research organisations, Improving the transfer of knowledge and technology, Encouraging the establishment of companies based on the scientific research work ("spin-off"), Establishing a public-private partnership, Science Technology Parks, Establishing research and development clusters and competitiveness networks.

Also, it should be considered the project: *Integrated National Energy and Climate Plan of the Republic of Serbia from 2021 to 2030 with the vision until 2050 (INECP)*, funded by European Union (IPA) and is implemented by LDK Consultants SA in consortium with the Centre of Renewable Energy Sources and Saving (CRES). INECP should provide an overview of the existing situation, key policies, and adequate measures for the consideration of five dimensions of Regulation (EU) 2018/199 on the governance of the Energy Union and Climate Action:

- Decarbonisation;
- Energy efficiency;
- Energy security;
- Internal energy market;
- Research, innovation and competitiveness.

SMART SPECIALIZATION - The development of the R&I strategy for the Kolubara Coal Region also takes into account the strategy of smart specialization of the Republic of Serbia (4S), which brings together the entire society by directing resources to areas with the greatest potential in terms of innovation and competitiveness. Smart specialization for Serbia is given in the document - STRATEGY of smart specialization in the Republic of Serbia for the period from 2020 to 2027.

Based on the Comprehensive Entrepreneurial Discovery Process (EDP), certain priority areas have been identified:

- Food for the future,
- Information - communication technologies (artificial intelligence included),
- Machines and production processes of the future,
- Creative industries.

The Serbian economy is projected to be largely based on knowledge and innovation by 2027. Measures are defined in accordance with the available financial resources, necessary for the implementation of the set goals; most measures are financed from the budget of the Republic

of Serbia, and all other available sources of financing will be included. The Smart Specialization Strategy is being implemented by an appropriate monitoring action plan (AP 2020-2023), evaluated to indicate each possibility for improvement.

1.2 Definitions

Tertiary education covers higher schools, faculties and art academies.

Non-financial sector includes business entities and organisations which primary activity is the market production of goods and services, and their sales at economically significant prices. The private non-profit organisations also belong to this sector, as well as R&D units in their composition

Government sector includes organisations, department offices and other bodies furnishing services, other than tertiary education, cannot be provided under market conditions and reflect the economical and social policy of the society. It also includes non-profit institutions, controlled and mainly financed by the State.

Non-profit sector includes non-market non-profit organisations serving households free of charge or at low cost. These organisations may be created by citizens' associations in order to provide goods and services to the members of the association or for general purposes. This sector includes professional associations, charitable organisations, humanitarian organisations, trade associations, consumers' associations, etc...

Tertiary education sector includes universities, faculties and academies, whatever their funding sources and legal status. This sector includes R&D institutes and clinics operating under the direct control of administered by the tertiary education organisation.

A **patent** is the right which protects an invention. Patent and patent rights are acquired after recognition and registration of a granted right in the corresponding register.

Innovation is the implementation of a new or significantly improved product, service or process, a new marketing method or a new organisational method in business practice, workplace organization or external relations of an enterprise with the environment.

Process innovation is the implementation of a new or significantly improved product or delivery method. This includes significant changes in techniques, equipment and/or software.

Product/service innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other function characteristics.

2 Setting the context

2.1 Kolubara region profile and specialisation

The Kolubara coal basin with its related sectors (mining supply chain) belongs to Šumadija and West Serbia region [RS21] (municipalities: Lajkovac, Ub and Aranđelovac) and Belgrade region [RS11] (municipalities: Obrenovac and Lazarevac). Depending on their availability, data for some economic and innovation performance indicators are given for the Republic of Serbia (RS) as a whole, while for some other categories data are given by regions.

GDP, total and per capita, is growing year by year, but is slowing down. As a consequence of the global pandemic caused by a coronavirus (COVID-19), the growth of GDP per capita in 2020 compared to 2019 is only 1.34%.

Belgrade region [RS11], with the GDP per capita amounting to 11,635 EUR (2020), has 71.5% higher per capita amount in relation to the level of the RS (6,783 EUR). GDP per capita level index for Šumadija and West Serbia region [RS21] is 65.8% (4,525 EUR), which is lower in relation to the level of the RS.

In accordance with accounting principle of place of work, Belgrade region [RS11] participates in GDP with 42.1% while Šumadija and West Serbia region [RS21] participates with 18.3%. The following activities have the largest share in GDP generation of the RS and Šumadija and West Serbia region [RS21]: Mining; Manufacturing; Electricity, Gas and steam supply and Water supply, Waste management and Remediation. On the other hand, the activities such as: Wholesale and Retail sale; Transportation and storage and Accommodation and food service have the largest share in GDP generation of Belgrade region [RS11].

In all the regions observed the unemployment rate declines year after year, as in the RS. Despite that, the unemployment rate in 2020 was very high in Šumadija and West Serbia region amounting to 10.7% and was higher than the rate of RS (9.5). The unemployment rate for Belgrade region amounted to 7.7%.

The percentage of R&D expenditures in the GDP is very small and amounts to 0.91%, particularly in the Šumadija and West Serbia region [RS21] (0.03%). The R&D expenditures are the highest in non-financial sector, particularly in natural sciences and engineering and technology.

Table 1: Expenditure for R&D by sectors and regions (2020)

Category	NUTS 2 regions: 1) Šumadija and West Serbia region [RS21] - Lajkovac, Ub and Arandelovac 2) Belgrade region [RS11]– Obrenovac and Lazarevac				
Sectors	Total	Non-financial sector	Government sector	Tertiary education	Non-profit sector
<i>Republic of Serbia</i>					
Thous. EUR	423,942	165,341	124,279	134,289	33
% of GDP	0.91	0.35	0.27	0.29	0.00
<i>Šumadija and West Serbia region [RS21]</i>					
Thous. EUR	14,618	3,2345	1,434	9,949	-
% of GDP	0.03	0.01	0.00	0.02	-
<i>Belgrade region [RS11]</i>					
Thous. EUR	308,620	131,280	99,548	77,764	28
% of GDP	0.29	0.28	0.21	0.17	0.00

Source: Statistical Yearbook of the RS, Statistical Office of the RS

A total of 241 patent applications were filed in 2019 (domestic and foreign) per million population.

The total number of innovative enterprises for the period 2016-2018 was 19,011. Innovation activities were more present in manufacturing enterprises, with more than a half-introduced innovation, while less than 50% innovations were introduced in service enterprises.

Referring to regional distribution (RS), product and process innovations almost kept the same percentage (about 40%), but were not equally distributed by regions. Regional distribution of

product and process innovations ranged from 50% (Belgrade region) to 10% (South and East Serbia region). The percentage of Šumadija and West Serbia region is about 17%.

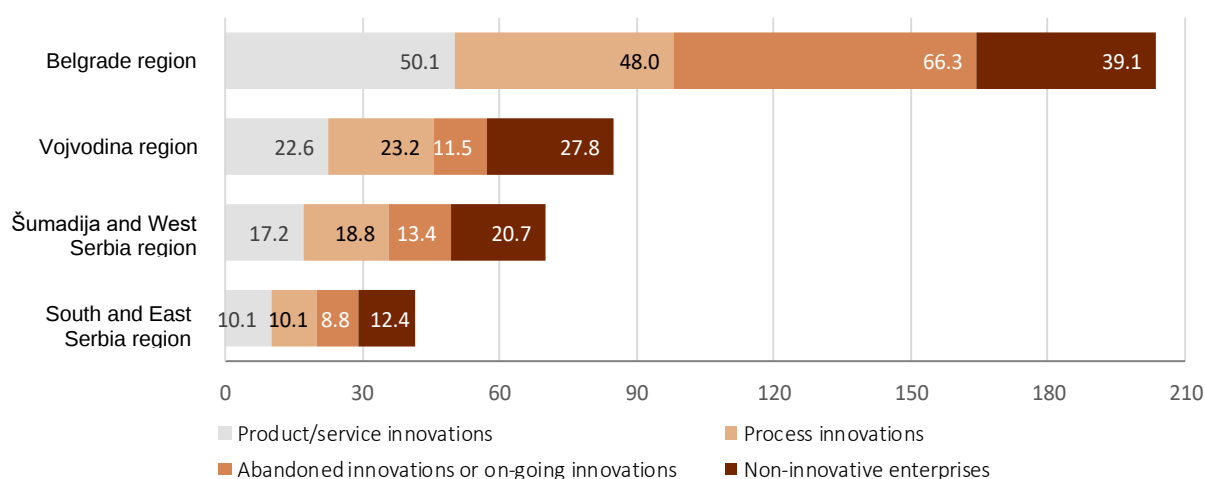


Figure 1: Percentage of types of innovations by territory for period 2016-2018 (%)

The development of Belgrade region and particularly Šumadija and West Serbia region is, to a large extent, related to the operation and development of the energy sector, primarily the Kolubara coal basin and thermal power plants. That is exactly why the transition process will have a great impact on the further development, not only on these regions but also on the Republic of Serbia, and it is therefore important that the process be well-thought-out and started on time.

2.2 Kolubara's region energy and environment outlook

Background

Serbia has ratified the United Nations Framework Convention (UNFCCC) on the 12th of March 2001, and the Paris Agreement on 25th of July 2017. Serbia has commitment, under the Paris Agreement, throughout its first Nationally Determined Contribution (NDC) submitted on June 30th, 2015, "to reduce GHG emissions by 9,8% until 2030 compared to emissions in 1990". However, under the Energy Community Treaty, Republic of Serbia does not have obligations in terms of GHG emission reduction.

Up to now, climate change related activities in the country were mostly analysed and described under the national communications and biannual updated reports, as the reporting obligations to the UNFCCC.

However, in aim to fulfil the undertaken requirements, as well as in the scope of process of the EU integration, the Law on Climate Change that has been adopted in March 2021. This Law transposes the EU relevant legislation providing, among else, a legal basis for development and updates of low-carbon development and adaptation strategies, monitoring, reporting and verification of the GHG emissions and implementation of a climate policies and measures.

The other relevant regulation and documents which will have significant impact on creating energy development policy in the forthcoming decade are as follows:

- Energy Law, which defines the long-term main goals of energy policy and Energy Strategy as the main document which define the energy policy.
- Law on efficient use of energy

- Energy Development Strategy of Republic of Serbia for the period up to 2025, with the projections up to 2030, which defines the three main priorities: improvement of energy security, development of energy market and sustainable development, and implement the obligations under the Energy Community Treaty.
- Decree on establishing Program for the Implementation Energy Sector Development Strategy of Republic of Serbia for the period up to 2025, with the projections up to 2030, for the period from 2017 to 2023., which defines all measures, activities and projects which should be done in all energy sectors.
- Treaty on Establishing Energy Community. Under this Treaty, the targets for RES and energy efficiency are defined for 2020 as well as the obligation for the preparation Integrated national energy and climate plans for the period up to 2030 (RECOMMENDATION of the Ministerial Council of the Energy Community 2018/01/MC-EnC on preparing for the development of integrated national energy and climate plans by the Contracting Parties of the Energy Community).

As for almost all countries in the world, the energy sector is the most important GHG emitting sector in Serbia, which represents about 80% of total GHG emissions.

Energy and Environment Outlook in Kolubara Region

Kolubara coal region is the largest coal basin in Serbia, producing more than 54% of total electricity production. The annual coal (lignite) production is about 30×10^6 tonnes, almost all used as fuel in power plants located within the basin. Because of the used technologies, both for coal mines exploitation and electricity generation, harmful environmental impacts are numerous.

Apart from mines and power plants, environmental impact issues recorded in the region are also related to associate industries and industrial activities (for example coal preparation facilities in the company “Kolubara Prerada”, as well as “Kolubara Metal”). The mining process affects soil degradation, while emissions of particulate matter SO_x, NO_x, and volatile organic compounds have harmful impacts on ambient air quality. Wastewaters from coal mines are discharged to the Kolubara River and its tributaries without proper treatment. All activities carried out during coal excavations also produces noise that affect life in the neighbouring settlements.

Present thermal power plants in the Region are significant sources of SO_x, NO_x and particulates emissions which negatively affect air quality in the near and far field. As these power plants are in operation for several decades, in the past years they are all faced with challenges to comply with new, more severe, requirements regarding reduction of environmental impacts. New national regulation, in line with EU guidelines and directives, imposes numerous actions to be performed to comply with the required emission limit values and other environmental protection measures, all in aim to provide conditions for future operation in a sustainable way. So far, new environmental protection installations comprise mainly particulates emissions reduction, as well as NO_x emission reduction, while flue gas desulphurization plants are still in the construction phases. According to the National Emissions Reduction Plan (NERP - approved by the Energy Community), deadline for introduction all necessary environmental protection measures regarding EU Industrial Emission Directive is 1st January 2028.

The other important environmental projects, currently implemented in the power plants and coal industry include construction of waste waters treatment plants, as well as introduction of ash and slag disposal in dance hydro-mixture (using much less water, in the ratio to solid 1:1). These measures will significantly reduce the existing impacts on the Sava River water quality and groundwater pollution in the vicinity of ash disposals.

Besides the implementation of the environmental regulations and standards and investments in technical and technological systems that reduce harmful impacts on the environment, special focus is also given to the climate change issues. EPS recognizes the importance of the energy transition as one of the most important actions within the climate change mitigation measures. It is clear that the decarbonization is the key word in the process of energy transition. However, bearing in mind the economic and social situation in Serbia, the energy transition process should be conducted carefully and slowly, over the next few decades, requiring broad consensus on the modalities of its implementation.

According to existing Energy Development Strategy of the Republic of Serbia [10], as well as in line with currently prepared documents as the baseline for the next Strategy [11], coal will remain the main electricity generation source for the next 15-20 years, so the main goal is to improve existing power plants operation. One of the first steps in this regard is increase of the existing power plants' efficiencies. In this sense during the past decade, nominal capacities of major power plants fired by lignite from the Kolubara coal basin (TPPs Nikola Tesla A and B) have been increased following an effort of Electric Power Industry of Serbia to extend the life and increase their rated power. As this power rate increase have been achieved without increase of boiler steam production and coal consumption, but as the result of turbine reconstruction, significant energy efficiency of the units is recorded, all in line with the relevant legal requirements.

On the other side, current European energy development insights strongly suggests new energy sources introduction in the countries' energy mix, based on much higher share of renewables (solar, wind and hydro). Also, new fossil fuel power plants should be based on natural gas or biomass.

In line with these guidelines, Serbian institutions, with the aid of European consultants, have conceived necessary activities to modify its energy generation facilities, in the way not to jeopardize the energy stability of the country, both in the economic, environmental and social manner.

Kolubara coal basin, as the biggest one in Serbia, shall follow nationally defined strategic decisions, in aim to fulfil the main goals of energy transition.

Given the above, the main actions in the field of technology development, including R&I for environment, shall include:

- Implementation of measures to improve energy efficiency in technologies applied in the existing power plants, in aim to reduce self-energy consumption and increase specific heat rate (kJ/kWh)
- Realization of planned and already started projects for environmental protection measures implementation (such as FGD and NO_x emission reduction measures, mainly secondary measures, based on SNCR technology, waste waters treatment systems, fly and bottom ash and gypsum disposal system improvement), designed to comply with the latest EU guidelines and regulation (BREF 2017).
- Research the possibilities to continue operation at the locations of the oldest coal power plants (TPP Morava and Kolubara A) by switching the fuel from coal to natural gas or communal waste.
- Research the possibilities to implement the newest technologies, based on hydrogen utilization, together with natural gas.
- Construction of solar power plants on the former ash disposal sites (TPP Morava and Kolubara A).

2.3 Kolubara's region current energy related R&I landscape

Energy related R&I landscape

The climate policy urges the power sector to accelerate its decarbonisation process to help meet the ambitious Paris climate goals to limit global temperature rise to $\leq 2^{\circ}\text{C}$ or even 1.5°C above its preindustrial level by the end of this century. The coal-based electricity generation is planned to be gradually replaced by renewable energy sources and natural gas as a transitional fuel. Longer-term alternatives include nuclear power to cover base load.

To fulfil this goal, without any doubt, renewable energy technologies are expected to take the leading role in the forthcoming energy generation portfolio in order to achieve sustainable energy generation. The vision for Serbia is to get at least 40% of energy from renewable energy sources by 2040¹.

The major constraints for increasing penetration of renewable energy sources are their availability and intermittency, the latter being addressed through energy storage when available and energy use when needed to make them readily accessible stable forms of energy like conventional ones. Otherwise, intermittent renewable energy sources, such as wind and solar, are unable to be stockpiled and must be used as available or, if not, they will be lost energy potentials.

The way to overcome this unfavourable characteristic of renewable sources is to provide the back-up of energy generation to ensure the stability of energy system and energy supply.

These tasks shall be followed by energy related research projects, some of which are already in process of realization. The following text elaborates these aspects of energy transition to renewable energy sources.

Using the biomass

EPS is piloting mixing biomass with coal in its thermal power plants. The project secures the reclamation of unused and degraded land in the former open pit mines areas in Kolubara basin on one side and production of energy from biomass on the other.

The fast-growing willows are planted on the edge of the Field G of the open-pit mines in mining basin Kolubara. It is a pilot phase of the SLLES Project (Sustainable Land, Livelihoods and Energy Initiative Serbia) in EPS.

Domestic white willow and Scandinavian Inger willow were planted on 3.17 hectares. These trees could give up to 112 tons of biomass per hectare.

It has been explored that there are 1.6 million hectares of unused and degraded land in Serbia, including mines and landfills. It should be examined if the implementation of the mentioned pilot project should be suitable in these areas as well, to secure its reclamation, but as well the production of energy from biomass. It can also create new jobs and enable an easier energy transition.

The willows, planted near an open-pit mine, can be cut 12 times within 25 years in order to be used in thermal power plants together with lignite for electricity production. Joint use of coal and biomass in power plants will result in cleaner air also. It is estimated that wood biomass from 75,000 ha of SRPs can substitute 10% of Serbia's coal-based energy through co-firing in coal-powered plants.

¹ Minister of Mining and Energy, Prof. Zorana Mihajlovic, PhD declared at the signment of the Agreement on Cooperation between the Ministry and the association "Renewable Energy Sources", 20th April, 2021.



Figure 2: Location on the edge of the mine where willows are planted

New conventional power plants

As the transition process in Kolubara coal basin should be slow, in aim to provide sustainable changes for the population and the economy, the first step should be change from coal to lower carbon fuel, such as natural gas. For this reason, EPS has launched the project on examination of the possibilities to install gas fired power plants on the locations of TPP Morava and Kolubara A. Various options should be evaluated, both from the techno-economic and the environmental aspects, with the aim to evaluate advantages and disadvantages of each location and to recommend optimal solution in terms of power rate and power plant concept.

Nuclear power plants

Serbia currently has no funds to build nuclear plant. As the consequence of adoption, the Law on nuclear power moratorium, Serbia has stopped education in this field, followed by the loss of any kind of qualified staff in this field. In the meantime, nuclear technologies have been developed rapidly, resulting in new generations of power plants, with more secure safety systems and producing less radioactive waste.

Faced with the necessity to increase the share of renewable energy sources, and being aware of the uncertainty of energy production from the same, it shall be necessary to have some kind of energy balance. For this reason, one of the solutions for Serbia is to become a minority shareholder of the planned nuclear power plant in some of the neighbouring countries (Hungary or Bulgaria). Although this matter is not strictly connected to Kolubara coal basin, it may help its transition process, in the way to switch from coal energy production to other, carbon free, source.

Renewable energy sources (solar and wind)

Specific features of energy produced in solar and wind power plants are already explained at the beginning of this chapter. However, in spite of limited natural resources in this field, plans to realize projects of construction solar and wind installations are on the priority list of actions in the transition pathway.

Solar power plants may be installed on the former ash disposal sites, as well as small ones on the roofs of the buildings and other suitable structures. One of the attractive locations for solar power plant installation is location of the recently halted coal-fired thermal power plant Kolubara B. Serbia's state-owned power producer EPS issued a call for research for this

purpose as well as for and for the preparation of the documentation and technical data necessary for the investment.

Wind power plants may be installed on the exhausted open pit mines, depending on the terrain characteristics (geology profile) and reclamation plans.

SWOT analyses

SWOT analysis is a technique frequently used in strategic planning and decision-making processes. For the needs of this Report, it will be used as a tool for better characterization of each proposed solution in the transition process realization. In the following SWOT analyses for the proposed innovation technologies in energy production to be implemented in the transition process are presented.

Using the biomass

Strength & Opportunities	Weakness & Threats
Usage of the existing potential for primary energy production Low investment costs for cultivation of biomass Application of international experiences Enable new continuous energy generation sources Application of new combustion technologies Usage of domestic fuel New job opportunities Diversification of energy production	Possible environmental impacts, particularly near field air pollution from small applications Investments in modernization of existing facilities using the biomass and in new modern facilities to improve efficiency and minimize environmental impacts

New conventional power plants

Strength & Opportunities	Weakness & Threats
Collaboration with international companies and research institutions New energy generation sources Application of new technologies Use of existing auxiliary facilities (balance of plant) of the former coal power plants Existing power plant's staff may be employed in the new facilities	Use of imported fuel High fuel cost and uncertainties in fuel cost changes on international market Shortage of imported fuel

Renewable energy sources (wind and solar)

Strength & Opportunities	Weakness & Threats
Existing potentials of primary energy resource should be used Enable green energy generation Application of new technologies New job opportunities Diversification of energy production	Renewable energy sources are unstable and intermittent Effective capacity factor is low Back-up energy generation capacities should be provided to ensure continuous energy supply

Nuclear power plants

Strength & Opportunities	Weakness & Threats
Collaboration with international companies and research institutions New guaranteed amount of energy Gain of new knowledge in nuclear power technologies	High power plant investment cost Possible environmental impacts Possible opposition of the population and fear from risks Nuclear power plants phase-out in EU Increase of power production price because of operation safety improvements

3 R&I in Energy and Environment: Vision for 2030 & 2050

3.1 Objectives and outcomes

The common conclusion of all discussions related to the survival of Kolubara basin as the energy generation region in the future² was that transition in Kolubara target region to coal phase-out should be planned well in advance, bearing in mind all issues that may appear during implementation of this process.

This and the next decade shall be essential in defining strategies for energy sustainable transition worldwide, which foremost means leaving fossil fuels, especially coal, in energy generation. Developed European countries' governments were the leaders in promotion energy generation based on renewable sources, defining ambitious energy transition plans even for 2030, while 2050 is defined as the deadline for zero carbon emission from energy sector.

For the countries like Serbia, where coal has been the primary energy production source for decades before, transition to new sources shall be postponed comparing to European countries, due to economy which is strongly dependent on electricity price. However, Serbia is obliged to follow European decarbonization roadmap, adjusting it to its own needs and possibilities, ensuring stability and sustainability of the country.

In this situation, the Strategy for Kolubara coal basin transition (the Strategy) should address of the following main objectives that should be achieved

- Regional and local policies in the Kolubara target region are currently guided almost exclusively by the national energy policy, but with due regard to the wellbeing of the local population.
- However, this transition should be gradual and supported by additional hydro pumped storage facilities with the aim to keep the electricity supply stable and minimize dependence on imports. Actually, about 12,000 employees are working in Kolubara coal basin, both in mining and associated industries, and for the majority of them this is the main source of income.
- Besides new RES facilities, the potentials of the Kolubara coal region are basically in the field of agriculture, forestry, and tourism, but this will require a long-term reclamation period.

² Report D 5.3: Report setting out a vision and future-oriented priorities in Kolubara

For this reason, transition and reclamation activities should be well prepared before and developed immediately after each mine field closure.

- The development of a new economy needs the creation of new perspectives for employment and careers, as well as the willingness of people to keep their households, re-skill, and stay living in this region. As re-skilling the workforce is a rather complex and time-consuming process, there is a fear that many former mining employees would feel discouraged to search for new jobs, as they have limited to inexistent opportunities in the community they belong to after coal mines are closed down.

In an aim to support the transition process, the new energy-related research and innovation (R&I) activities need to be developed, focused on the application of innovative technologies in line with the resources present in the Kolubara target region. For the R&I on that and other hot subjects related to the energy future local experts and R&I institutes should make collaboration with foreign consultants when application of new technologies are proposed.

Special attention should be paid on the improvement of environmental protection measures, both regarding existing power plants, as well as coal mines, which will continue operation, and the new facilities of all kinds. The main objective is to improve quality of life for the population living in already threatened environment.

Of particular concern is also the improvement of energy efficiency both in generation (to keep environmental and climate impacts as low as possible) and in consumption (to prevent losses and reduce the energy intensity of goods and services).

In addition to the above said and bearing in mind that in the post-coal period the existing and in the meantime added infrastructure will remain fully operational, it should be smart to ensure a continuous use of both the transmission networks and the remaining infrastructure at the sites of the existing and new coal fired power plants, with no option/technology being left aside.

3.2 Key guiding principles

The key guiding principles in implementation of the Strategy are:

- Keeping the coal power plants as strategic reserve.

The strategic reserve mechanism will be established by the conservation of all power plants that finished their regular operation, in the way that they would be ready to go online in case of an energy crisis.

This strategic reserve mechanism is similar to the capacity mechanism applied in the EU, where it includes old gas or coal power plants.

In times of market disruption, when prices are high, like happened in the autumn 2021 in Western Europe countries, or in case of emergency, such power plants go online. In times when there is no market disruption or emergency, they do not produce energy. Of course, the government must pay their owners to play the role. Also, power plants under the strategic reserve mechanism must meet environmental standards.

- Ensuring energy security, solidarity and trust

One of the major guiding principles of the national strategy is keeping the energy import dependence on the lowest acceptable level. To achieve this goal energy mix in the future period should be projected in such a way to make balance to the renewable sources in the highest possible level.

For Kolubara basin, the following examinations should be conducted:

- Installation of solar power plants at different sites, such as

- (i) the site that was envisaged for coal TPP Kolubara B, i.e., in the villages of Kalenić, Poljane, Stepojevac, Mali Borak, Veliki Crljeni and Cvetovac.
 - (ii) on the roofs of existing buildings, like warehouses and workshops, as well as examine of the possibilities for ground-mounted facilities as well.
 - (iii) at coal power plant ash and slag disposal sites, as well as on the exhausted open pit mines areas.
- Ensuring coordination and cooperation between public, private and research entities

As in the past mining and plants' operation caused the number of problems in the area of environmental protection in the neighbouring villages, future energy transition plans should carefully address these aspects as well. Although Kolubara mines and power plants are in public energy sector, private entities should also be included in future projects, particularly those considering small photovoltaic plants mounted on the roofs of buildings and auxiliary structures (stables, workshops, etc.) on their properties. The policy of subsidies for realization of these projects should be applied in aim to enhance the interest for implementation of this kind of innovations in the households where coal and/or electricity were used for heating.

4 Support framework for R&I in Energy and Environment

4.1 Multi-level governance structure for R&I policies in the Kolubara region

Transition process in the Kolubara target region is closely connected to already adopted national Low carbon strategy, as GHG emissions from this region presents the large share in total countries' GHG emissions. Given that, the specific objectives defined in the Low carbon strategy are also the guidelines for actions to be researched and implemented in the target region.

The main Strategy objectives are:

1. Reduction of GHG emissions covered by the EU-ETS by 15.0% in 2030 and between 66.4% and 76.8% by 2050 compared to 2010.
2. Reduction of GHG emissions not covered by the EU-ETS by 9.7% in 2030 and between 33.5% and 54.5% by 2050 compared to 2010.
3. Increase of the carbon sink in the Serbian forest by 17% by 2030 and between 22% and 132% by 2050, compared to 2010.
4. Preservation of the potential of mitigation measures, determined for 2030 and 2050, by increasing the resilience to climate change of the priority sectors.
5. Promotion of transition to climate neutral and climate resilient economy and society.

To achieve the defined objectives, the following measures should be implemented:

Strategy objective 1:

- Increasing the use of RES in electricity production
- Improving energy efficiency and increasing use of CHP and RES in district heating systems
- transition to emission trading

Strategy objective 2:

- Improving the energy efficiency and increasing use of RES in industrial sector
- Improving the efficiency in electrical appliances for households and tertiary sector
- Improving the thermal integrity of households and tertiary sector

- Carbon pricing and excise duties on final energy consumption
- Energy efficiency improvement of heating and cooling infrastructure and promotion of use of RES in households and tertiary sector
- Transport sector: Efficiency improvements of vehicle stock and usage of vehicles. Promotion of public transport and non-motorized transport; Promotion of usage of alternative fuels and biofuels)
- Agriculture: Winter cover crops. Increase legume share in fodder area. Breeding for higher milk yields.
- Waste sector: Waste separation and construction of material recovery facilities. Construction of biological treatment facilities (composting plants). Construction of thermal treatment (incineration) plants.

Strategy objective 3:

- Research, training and awareness raising programme for the enhancement of the carbon sink and of the resilience of the Serbian forest to climate change
- Afforestation using site mapping and tree species adapted to climate change (integrated with the mitigation measure on afforestation)
- Adaptation of cultivation technologies to a changing climate (selection of species and agrotechnical measures)
- Increase the area with forests by conversion of coppice to high forest
- Implementation of short rotation plantations

Strategy objective 4:

- Construction of water structures for protection against floods, erosion and torrents and additional protection measures in the basin
- Improvement of the system for observation, data collection and early warning systems
- Increase in water storage capacity: construction of multipurpose small reservoirs and stagnant water (lakes, ponds) and multipurpose reservoirs for water supply, irrigation, erosion control, ecosystem services
- Construction of new irrigation systems and increased efficiency in the use of existing ones

Strategy objective 5:

- Climate change education, training for new skills and awareness raising.

Apart from the Public Utility Companies in the target region (such as coal mines and power plants and coal treatment and preparation company “Prerada”), stakeholders affected by the strategy are other industrial companies, municipalities, local self-government units, stakeholders in biomass supply chain, final energy consumers of fossil fuels in industrial, household and tertiary sectors, farmers, agriculture and livestock producers, forest public enterprises (State Enterprises for Forest Management “Srbijašume”); private forest owners, as well as education and training centres.

The way to successful transition process development is to adopt a cohesive plan of actions which considers engagement of all stakeholders, particularly those with high degree of influence. The following should be considered as the most important in the interaction with the stakeholders:

- Different interests, resources and capacities of stakeholders
- Provision of sufficient, transparent information. This enables informed stakeholder involvement and prevents negative perceptions (such as secrecy or corporatism)
- Implementation of follow-up mechanisms to ensure that stakeholders’ views are taken on board, and can be fed back into the decision - making process

- Efforts should be made to work with authorities that are less aware of the issues or more hesitant to take action e.g., you could collect their feedback by questionnaire
- Remember that stakeholders must become involved at the right moment i.e., when their views can provide added value and can be taken into account. Stakeholders do not need to be involved in each step of decision-making process.

The following scheme, presented on Fig.3, shows the common structure of the decision-making process development. The higher you go up the pyramid, the more engaging the method is – but the process involves less people.

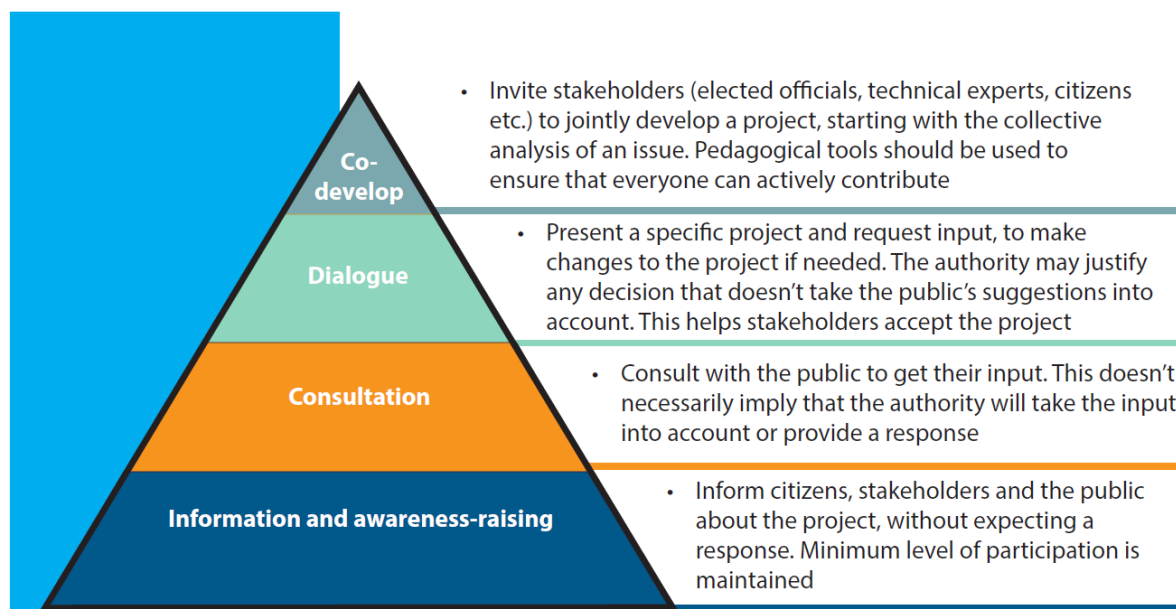


Figure 3 [12]

In Kolubara Target region, the stakeholders which are mostly affected by the transition process are coal mines with associated industrial plants and power plants. On the other hand, farmers, agriculture and livestock producers, private and public forest owners expect significant benefits of this process. However, the sustainability of the same requires some R&I to be conducted before setting up precise strategy goals.

4.2 Funding opportunities

The Republic of Serbia is one of the countries with relatively low budget allocated for research and development, and is therefore making significant efforts to approach the developed countries with respect to investments made into this field. These efforts are reflected in the improvement of regulatory framework through the adoption of new laws, implementation of structural reforms and the creation of institutional framework. In accordance with such policy, a number of laws have been adopted, such as the Law on the Science and Research, the Law on the Science Fund, the Law on Innovation Activity, Innovation Fund and Science Fund of the Republic of Serbia were established. Due attention is paid to balanced regional development by establishing new institutes (Institute of Information Technology in Kragujevac and Bio Sense Institute in Novi Sad), and creating a network of science and technology parks (Niš, Čačak, Novi Sad, Beograd) with a tendency to further expand it.

The model of financing science, technology and innovation applied in the Republic of Serbia includes:

- direct budget funds,
- investments of tertiary education
- investments of private and public companies

- investments of non-profit organizations
- use of international funding sources.

International sources include European Union funds (pre-accession funds), World Bank and International Bank for Reconstruction and Development loans and participation in research and development programs.

The Republic of Serbia is included in the European Union research and development programs such as:

- COST programme – European Cooperation in Science and Technology
- EUREKA programs out of which 6 programs in the field of energy and 11 in the field of environment have been implemented so far.
- Program for Funding Multilateral Scientific and Technological Cooperation in the Danube Region
- Bilateral cooperation programs with many countries (Slovenia, France, Portugal, Germany, China, Italy, Austria, Croatia, Montenegro, Belarus, Hungary and Slovakia),
- Horizon Europe – one of the EU's key funding programmes for research and innovation.
- Western Balkans Regional R&D Strategy for Innovation.

It is estimated that in the future, the Republic of Serbia, with the realization of goals set by the Strategy, will have less need for borrowing and that the investment of the economy in science and development will increase. To this end, it is planned to provide financial and fiscal support to companies

In addition, it is necessary to work on the development of human resources, strengthening scientific research infrastructure and digital infrastructure.

Bringing the economy and science closer to each other and stimulating greater application of scientific achievements, innovations and research results in companies can have a positive impact on employees in the Kolubara mining basin. Namely, after cessation of mining operations, certain number of employees will decide to start business activities by using some innovation. On the other hand, a certain number of employees will decide to start some research themselves.

In addition to the mentioned methods of financing, companies have at their disposal other, alternative forms of fundraising, which include: Crowdfunding, Business angels, Venture capital, Leasing, etc.

In order to successfully complete the process of closing the Kolubara basin, it is necessary to start the transition process in time and, with the education and retraining of employees, introduce them to various models and forms of financial support. In addition, it is necessary to provide organizational and legal assistance, as well as assistance in drafting business plans and financial projections with the aim of successfully applying for the use of certain programs implemented by the Republic of Serbia and the EU.

4.3 Priority areas for Research and Innovation

The basis for defining the priority areas for R&I in aim to support implementation of transition Strategy is Clean Energy for all Europeans package adopted by the Energy Community Ministerial Council in 2017. The package covers legislation in the area of energy efficiency, renewables, governance, electricity market design and electricity security of supply rules.

The main task of this energy package is to boost the clean energy transition and modernize energy systems. The new legislative acts will help the Energy Community to gradually

transition away from fossil fuels and contribute to the achievement of a carbon neutrality by 2050. It is important that cutting emissions does not result in cutting jobs and this package will help us achieve that by unlocking opportunities of the clean energy revolution.

The Council also adopted the Decarbonization Roadmap for the contracting parties of the Energy Community, a political document outlining the sequence of adoption, transposition and implementation of decarbonization-focused rules in order to put the contracting parties on a path towards achieving 2030 and mid-century decarbonization targets.

This Roadmap, that may be been used in the mining, construction and industrials sectors, consists in several steps, as presented in the figure 4, below:

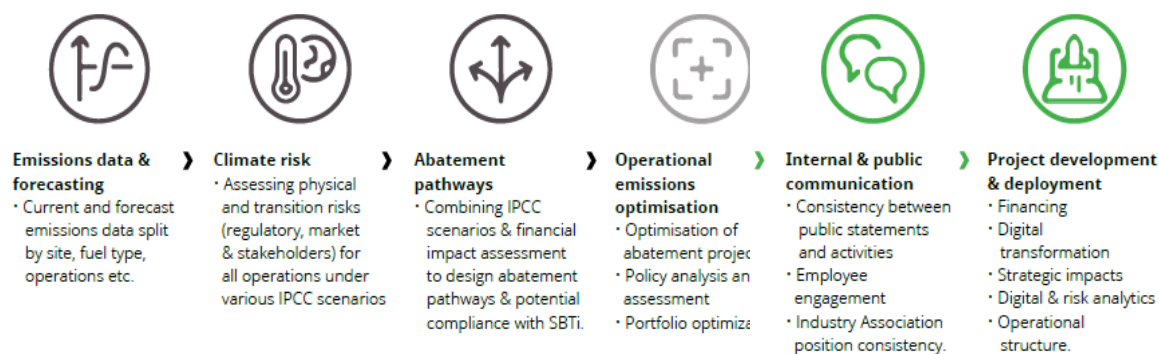


Figure 4: Steps in Decarbonization Roadmap [13]

Compile emissions data and forecasting

Emissions data establishes the baseline from which the organization can forecast, measure and monitor progress against targets, as well as critically evaluate the areas of the business with the highest potential for decarbonization.

This step comprise compilation and assess current and forecast emissions data, delineated by site, fuel type and operations.

Assessing climate risk

Climate-related risks include transition risks and physical risks.

Transition risks are those arising from the changes needed to achieve a low-carbon economy. These changes may occur in the areas of policies, legal frameworks, technologies, and markets, and depending on their nature and speed, they may pose varying degrees of financial and reputational risk to oil and gas organizations. A key aspect of transition risk is understanding how different stakeholder groups are likely to react over the next period.

Physical risks include direct damage to assets and indirect impacts from supply chain disruptions. In addition to fires, floods, and more frequent and severe hurricanes, such damages may be caused by changes in water availability, sourcing, and quality; food insecurity; and extreme temperature swings that affect physical structures, operations, supply chains, transport needs and employee safety.

Abatement pathway options

Before the companies set targets, they should examine the costs or other implications that future emissions trajectories might have for their business. They should also consider if the proposed targets meet societal expectations.

Different stakeholders (NGOs and others) are asking companies to prove that their targets are science-based and that they meet the set goals.

Key tasks for this step are:

- Determining emissions pathways under a well-below set target (2°C future).
- Understanding historical, current and future emissions profiles.
- Ascertaining the “abatement challenge,” which is the gap between forecast emissions and abatement pathway options.
- Establishing science-based targets by selecting an appropriate abatement pathway and assessing the reduction goals across timeframes such as 2030 and 2050.

Operational emissions abatement:

Operational emissions abatement is essential in emissions reductions, but it has financial consequences to the company, which may be vital to the success of the project.

Key tasks in this step are:

- Assessing the costs, benefits and implementation risks of abatement projects across all assets and operations.
- Reviewing the value chain for each product line to assess if competitive advantage can be gained from decarbonizing some operations ahead of others.
- Prioritizing project development to maintain optionality and deliver the greatest benefit for the least cost.

Internal and external communication

Both internal and external stakeholders are becoming increasingly vocal in expressing their expectations for companies to contribute to a financially efficient transition to a low-carbon economy.

To be effective, this communication needs to be transparent, authentic and consistent with the company’s demonstrable actions. Without transparency and authenticity in communications, stakeholders may begin to lose faith.

Key tasks for this step are:

- Devising engagement plans for employees, customers and shareholders, tailoring them as the company progresses on the journey to net-zero.
- Reviewing the public positioning of industry associations to which the company belongs.
- Determining if publicly stated targets are consistent with action plans, executive incentive schemes, and budget allocations.
- Mapping stakeholders to understand their interactions and intentions, identifying warning signs of harmful activity.
- Engaging and empowering employees to develop internal emissions-abatement projects.

Project development

To preserve credibility, decarbonization goals and communications must be backed up by the activities across three horizons:

- Short-term tactical projects that can be delivered immediately.
- Development and preparation for medium-term projects.
- Research and collaboration for long-term solutions.

Key activities for this step are:

- Embedding quantified emissions criteria into the organization's operating resource planning systems, upgrading them if necessary, to capture accurate performance data in real-time.
- Developing project feasibility analyses to attract the required financing.
- Integrating the emissions-abatement projects with other strategic activities, such as process automation and optimization.
- Examining potential deployment barriers to ensure strategic priorities of the project.
- Avoiding any projects that will make the challenge of decarbonizing harder in the future.

8. Targeted incentives to boost research, development and deployment of key low-or zero-carbon technologies should be focused to the following topics:

- *Large-scale energy storage*: Research and development in the area of energy storage appear as very important step in reaching targets.
- *Carbon capture*: In order to make carbon capture an attractive option for power generators in the future, it should be useful to be informed about the efforts made in aim to scale up the technology and develop pipeline infrastructure needed to. National possibilities to store carbon should be examined.
- *Renewables*. Renewables should be benefitted from the state production tax credit and investment tax credit.
- *Advanced nuclear*. Insight in the research and development in the area of advanced nuclear is important in aim to be informed about the current results in technologies and their applications in this field.

4.4 Evaluation and Monitoring

Transition process in the target region requires some changes in the existing energy system, which is a long-term project, determined by the Strategy realization schedule. Development and progress of this process should be monitored in aim to measure the degree to which significant targets are attained and studies the economic cost and benefit from proposed measures. The result should be timely intervention, if needed, in the case of undesirable developments. The legal bases for the monitoring procedure should be provided in the national legislation, namely in the by-laws of the regulation mentioned in Chapter 2.2 of this Report.

The following indicators should be monitored:

The current Monitoring Report for 2020 (abridged version, most data stem from before and up to 2019)¹, deals first with selected indicators and contains a descriptive part containing the seven topics mentioned below derived from Energy Strategy 2050, the Energy Act and other State bills (which include the Electricity Grid Strategy, climate policy, and Swiss Coordinated Energy Research):

1. Energy consumption and production

Reduction of energy and electricity consumption by enhancing efficiency measures is one of the main objectives of Transition Strategy by 2030/2050 and therefore an important pillar of energy legislation. The same applies to the expansion of electricity production from renewable sources, which will have to partially compensate for the gradual loss of capacity from fossil fuel power plants.

The following parameters should be monitored:

- Development of per capita final energy consumption

- Development of per capita electricity consumption
- Development of electricity production from renewable energies, namely from: photovoltaic plants, wind energy plants, biogas plants, waste incineration plants and renewable wastes, furnaces burning wood and proportions of wood.
- Energy efficiency parameters according to the template defined by the Authorities. Annual Report shall be submitted to the Authorities.

2. Grid development

The reorganisation of the energy system place new demands on the energy grid. Development of the electricity grid is crucial because it is the link between production and consumption.

3. Security of supply

The monitoring process should observe indicators which characterise significant aspects of development in the field of security of supply from the overall energy perspective.

With the phasing out of coal power plants, the expansion of use of renewable energies, increased energy efficiency, and the fairly long-term decarbonisation of the energy system, the electricity sector is also categorized as a very important from this point of view.

The recommended parameter to be monitored is share of energy carriers in final energy consumption.

4. Expenditure and prices

In addition to safety and environmental compatibility, significant dimension for a sustainable energy supply is economic viability. Taking into account social status of the region, the focus in this area is on final consumer expenditure for energy and energy prices.

5. CO₂ emissions

There is a close relationship between energy policy and climate policy because major part of all greenhouse gas emissions in the Region are caused by the use of fossil energy carriers. The main goal of the Strategy is contribution toward lowering the consumption of fossil energy as well as greenhouse gas emissions from energy sources.

According to the Law on Climate Changes, National GHG emissions inventory should be established as the database on all important information related to this matter, such as details on the activities that are sources of GHG emissions, emission factors applied in GHG emission calculations, data on GHG emissions and sinks. National Report on the GHG inventory should be prepared by the Serbian Environmental Protection Agency every year, by the 15th of March for the previous year.

The following parameters should be analysed, based on the information gathered in the Monitoring Reports:

- Per capita CO₂ emissions from energy sources
- CO₂ emissions from energy sources in total and by sector (industry, transport, households, services, agriculture).
- Trends of CO₂ parameters in relation to defined targets.

6. Research + Technology

It can be assumed that, in relation to short-term Strategy time schedule, tasks could be attained with the technology available today. However, attaining the long-term goals will require new developments in the technology sector, particularly in relation to new energy technologies. It

is not expected that these technologies will be developed in the Region/Serbia, but their compilation and applicability in the Region should be examined.

For this reason, the annual monitoring process focuses on public expenditure for energy research as an indicator for efforts being made in energy research.

7. National/international environment

Because of the location of the Target Region, its harmful impact on the environment has been in the focus over the years of coal exploitation in the past, both on national and trans-boundary (regional) level. Apart from its main goal to contribute climate change mitigation, actions connected with transition process will significantly affect environmental pollution reduction. Although the obvious results in this field will not be seen immediately, but on long-term basis, monitoring of environmental quality indicators shall be defined, including air, water and soil quality, vegetation and fauna diversity and the state of material goods (buildings and structures).

5 Concluding note

The inevitable transitional process of the energy sector in Serbia would result in a **significant shift** of the current energy development strategy of Serbia towards the low-carbon development strategy. This would imply a shift towards climate adaptable economy in the Kolubara target region. According to the current position of the stakeholders in the region, stepwise energy transition towards an efficient carbon-free energy sector should be provided.

In order to implement the energy transition properly, to take care of all employees, as well as especially taking into account the energy security of the system, a lot of knowledge and experience is needed. So, all available domestic experts and institutions should be involved in the transition process, trying to implement available research and innovation procedures in an aim to support the transition process. The new energy-related research and innovation (R&I) activities need to be developed, focused on the application of innovative technologies in line with the resources present in the Kolubara target region.

For the R&I on that and other hot subjects related to the energy future, more trust was gained by local experts and R&I institutes than by foreign consultants. The idea of the need to form a specialized multidisciplinary institute for national energy matters was proposed. Nevertheless, it was stated that there is a lack of continued education of energy professionals, resulting in a lack of ability to participate in the multidisciplinary research required to support or direct and monitor transitional processes.

It should be noted that RES and nuclear power plants have a special place in the non-carbon strategy, and there should be planned more collaboration with international companies and research institutions. Concerning stronger implementation of RES, there are doubts among experts about the possibility of the intention to use renewables as a single backbone as promoted in.

Energy Development Strategy of the Republic of Serbia until 2040 with projections until 2050 with Strategy realization program and Strategic Environmental Impact Assessment of the new Energy Development Strategy are planned to be completed soon, so some directions and ways of action will be clearer.

In the upcoming period, the complete draft version of the INECP will be prepared and presented during the public consultations expected to be organised at the beginning of 2022.

After the drafting of the INECP, an extensive training and capacity building programme for further development of the capacity for energy and climate planning is planned as a second part of the project, in order for Serbia to fulfill its obligations as per the recommendation adopted by the EnC.

This activity is expected to further strengthen the knowledge of all relevant participants of the project, as well as the strategic planning capacities of the Ministry of Mining and Energy, and provide in-house energy and climate planning tools.

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