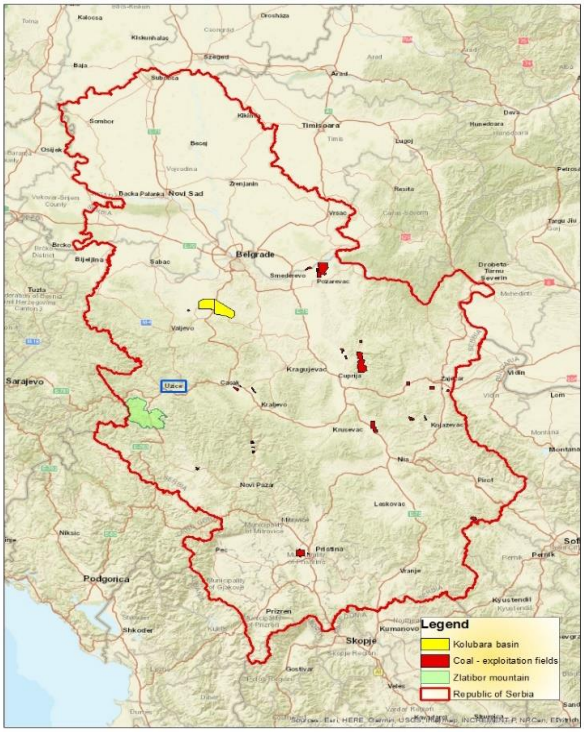
Author: Mr. Radoslav Vukas

Contract No: 2500228576

Fund: 64ROA SFSA Supp Dev Act

Fund Centre: 13824 ECE Sustainable Energy Division

CASE STUDY
"INTEGRATED ENERGY AND WATER RESOURCES MANAGEMENT IN SERBIA USING UNFC SYSTEM"



(source: www.mre.gov.rs)

Belgrade, July 2020.

ACKNOWLEDGEMENTS

This Case Study is part of the UNDP project "Integrated Energy and Water Resources Management in Support of Sustainable Development in South-East Europe and Central Asia "(2018-2021). The study is performed by the National Consultant, Radoslav Vukas, Graduate Engineer of Geology, Economic Geologist. The author is grateful to his colleagues for suggestions and advice. Special gratitude goes to Dr. Miloje Ilić, Professor of Geology, UN Expert in Mineral Exploration (Project UNDP: MLW/88/030) for the suggestions to improve the case study.

TABLE OF CONTENT

Table (in text):

Annex:

The List of Abbreviations

UNECE	United Nations Economic Commission for Europe
UNDP	United Nations Development Program
UNFC	United Nations Framework Classification for Resources (Update 2019)
SDGs	The Sustainable Development Goals
WFD	Water Framework Directive
RS	Republic of Serbia
RSD	Republic of Serbia Dinar
€	Euro
CRIRSCO	Committee for Mineral Reserves International Reporting Standards
JORC code	Australasian Joint Ore Reserves Committee- Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves
Measurement units	
Mt	Million tone
kJ/kg	Kilo joule per kilogram
l/s	Liter per second
kW	Kilowatt
MW	Megawatt
GWh/y	Gigawatt per year
Mtoe	Millions of tons of oil equivalent

Case Study Report

Executive summary

In accordance with the project "Integrated Energy and Water Resources Management in Support of Sustainable Development in South-East Europe and Central Asia", strategic plan of the UNDP (2018-2021) and Sustainable Development Goals (SDG), **"Integrated Energy and Water Resources Management in Serbia Using UNFC System"** project is defined and with its realization, through subject **Case Study** a transparent and sound basis is created towards the integrated manner of energy and water resources management of the Republic of Serbia.

The Republic of Serbia owns significant natural hydro-energy potential, which is of high value for national, economic and social development. Utilization of hydro-energy potential in Serbia is conducted under the legal-administrative legislative that today, according to the author, given the absence of formal harmonization with UNFC resources classification system, does not reflect the fully integrated manner of energy and water resources management. This is especially noticeable from the comparison of current Serbian legal-administrative regulations in the energy and water resources sector, with the conditions of the United Nations Framework Classification for Resources (Update 2019) and the UN Sustainable Development Goals Agenda that is based on careful, reasonable, rational, transparent and uniformed classification and unique integrated manner of energy and water resources management.

Adjustment to the subject UNFC-Update 2019, through the application on particular examples of projects for energy (coal) and water resources (groundwater) by the suggested map of conversion, available data on energy and water resources of the Republic of Serbia shall be recognized in a transparent manner, given that the Aligned System and Bridging Document are not developed. Energy and water resources classified at the national level and harmonized with UNFC system become completely comparable at international level and SDG, under which is implied the integrated, sustainable resources management that is of the utmost significance for all parties (Government, industry, investors, social community…). In accordance with all above mentioned, codified energy and water resources of Serbia, according to the project goal, become the sound basis for creation of national mineral, energy and water policy, for sustainable integrated energy and water resources, for investing, for meritorious comparison and connecting of available statistic data on resources with international statistics (current Eurostat and others).

The goal of the "Integrated Energy and Water Resources Management in Serbia in Using UNFC System" project is to get, through harmonization of UNFC Framework system for classification of resources and projects, quality and harmonized expert-legal-administrative tool for the sustainable and integrated management and monitoring of energy and water resources in the legal-administrative system of the Republic of Serbia. Besides the need for fully integrated management of these resources in accordance with the current Serbian regulations, it is necessary to establish and specify appropriate guidelines (Classify-according to UNFC, Harmonization of Classification Systems, Mapping through an Aligned System, Use UNFC as a Harmonizing Tool) and ensure legal support in the management of the impact that the production of electricity, heating and cooling energy (based on energy and water resources) has on the state of energy and water resources, and on the environment system of Serbia and neighbouring countries (EU Directive).

Project is based on the facts that energy and water are integrally connected, that are mutually strongly codependent and that, as is already mentioned, Serbia has significant energy and hydro-energy potential. All this is included into the legal framework, i.e. current legal-

administrative regulations of the Republic of Serbia, directed towards the aim of full accomplishment of the Goals 6 and 7 of the sustainable development, according to the adopted United Nations Sustainable Development Goals Agenda. There are also deficiencies in the current system of the classification of the resources in comparison to the UNFC. This includes the recording of the current state of resources, defining and introduction of necessary measures into the classification system, all towards achieving the fully integrated energy and water resources management of the Republic of Serbia. Application of the UNFC system - United Nations Framework Classification for Resources, Update 2019 (Series 61) through the application of suggested, informal map of conversion (as the author's personal opinion) to here particularly given resources, is just a starting, initial step in that direction.

Energy resource – coal, in the project, i.e. Case Study, is processed on the example of active coal deposit "Tamnava – West field"in Kolubara basin (Central Serbia) from which the thermal power plants "Nikola Tesla – A" and "Nikola Tesla – B" are supplied with coal for the production of electric energy. The water resource is processed on the example of a *karst aquifer* (karst aquifers are water-bearing, soluble rock layers at or near the earth's surface in which groundwater flow is concentrated along secondarily enlarged, and other interconnected openings) and *fracture aquifers* (aquifer formed in fractured rocks with porosity; fissure porosity) fracture aquifers in the area of mountain Zlatibor (Western Serbia) for the water supply, bottling, production of heat and cooling energy from these resources for the needs of heating and cooling of facilities of Zlatibor urban area.

Subject adjustment of data was conducted with due respect to the relation: water – energy – food from the system of the Convention on protection and utilization of cross-border watercourses and international lakes (Water Convention) of the UNFC, that was created in Helsinki on March 17th 1992, in order to achieve integrated energy resources management (energy mineral raw materials: coal, uranium, oil shale, oil and natural gas), and water resources (groundwater). The case study enables, through the realization of the project, the complete perception of possibilities and conditions of UNFC system application for the classification of energy and water resources of Serbia. Key parties or holders of national policies and strategies on energy and water resources development of Serbia are public sectors, as well as the private sector. Herein, it is to be expected that the private sector plays an active role in investments in the development and utilization of advanced technologies, which is connected with all the benefits.

Generally speaking, it is to be expected that the "Integrated Energy and Water Resources Management in Serbia Based of the UNFC System" project, in its initial sense, can help the state economy, through identification and implementation of the best practices towards fully integrated management of national energy and water resources as a public good, which is, per author's opinion, not yet the case.

The case study is authored by Mr. Radoslav Vukas, independent consultant, with the participation of Mr. Đuro Milanković in the section related to the groundwater's of Zlatibor, a hydrogeologist from the company "Hidromeridijan" – Belgrade. Expert consultant participation in reviewing and finalization of the Report, or subject case study, had Miss Ana Dajović, economic geologist, Ministry of Mining and Energy of the Republic of Serbia, and Mr. Ilija Radović, MSc Geology from the company "Georad-Ing" – Belgrade. Expert revision of the subject Report was conducted by Professor emeritus Mr. Miloje Ilić, UN Expert for Geology exploration of ore deposit of mineral raw material.

Translation of the text into the English language was done by Ms. Dina Hrecak, professional translator from Murasaki Translation Agency from Belgrade. Final case study Report was done in the period of May – July 2020, in Belgrade, during the Covid19 pandemic.

1. Introduction

The project *Integrated Energy and Water Resources Management in Serbia in Using UNFC System* is sub-project of the UNDP project *Integrated Energy and Water Resources Management in Support of Sustainable Development in South-East Europe and Central Asia* from strategic plan and framework from 2018 to 2020. Project is based on facts that the energy and water are integrally connected, mutually causally dependent and that the Republic of Serbia has significant energy and hydro-energy potential, which requires efficient management that is unique and integrated. Project is in accordance with the legal-administrative regulations of the Republic of Serbia and UN Sustainable Development Goals Agenda (17) until 2030. Subject Project provides assistance in the realization of Goals 6 and 7 of the sustainable development (Goal 6 – to provide availability and sustainable management of water and sanitation for all; Goal 7 – to ensure the access to available, reliable, sustainable and modern energy for all). Therefore, it is intended, by the realization of the Project through adjustment of data within UNFC classification of resources (Update 2019), to recognize the need and, through guidelines on the application of key instructions from UNFC, create the initial basis for an integrated manner of energy and water resources management in the Republic of Serbia.

Basic data on energy and water resources, the water potential of the Republic of Serbia that are classified in accordance with the legal-administrative regulations of Serbia, as well as the manner of their management are shown in this Project according to the proper valid, publicly available strategic and planning documents. Data on resources and mineral raw materials reserves (solid, liquid and gas), or energy (coal, uranium, oil shale, oil and natural gas) and water resources (surface and groundwater) of the Republic of Serbia are processed in the Spatial Plan of the Republic of Serbia from 2010 to 2020 (2010); Spatial Plan of the Republic of Serbia 2021-2035 (conceptual approach, 2020); National Strategy on Sustainable Development until 2025 with projections until 2030 (2010), National Strategy on Sustainable Usage of Natural Resources and Goods (2015), Energy Strategy (2015), Energy Balance for 2020 (2019), National Strategy on Water Resources Management (2015), Spatial Plan for the Area of Exploitation of Kolubara Lignite Basin – Draft, Book II (2016) and other planning documents.

In the sector for energy in Serbia, i.e. sector for energy resources (coal) and water resources (river waters) a number of "projects" is active (Kolubara coal basin, Kostolac coal basin, Kovin, hydro-potential of the rivers the Danube, Drina, etc.) and they are the basis for electric energy production.

According to the goal and performance of the *Integrated Energy and Water Resources Management in Serbia Based of the UNFC-SEEA System* Project, the energy resources (coal, uranium, oil and natural gas, renewable resources) and water resources (groundwater), from the aspect of integration, are reviewed on particular examples and shown in the Final Report of this Case Study. Subject energy (coal) and water resources (groundwater), shown in categories A, B, C_1, C_2, D_1 and D_2 of geological reserves (A, B, C_1, C_2, D_1 and D_2) and categories A, B and C_1 of the balance reserves, here are generally adjusted to the categories, codes of UNFC-2009 system, with the application of suggested *map of conversion*. The goal was to get the national system for classification of energy and water resources of Serbia, in the absence of Guidelines, Aligned System and Bridging Document, connected in the expertly qualified and transparent manner to the global system for resource classification, that is to the INFC-2019 classification. Management of subject resources of Serbia is currently at an insufficiently integrated level, because of which the adjustment of the classification system to the UNFC system and SDG was suggested.

2. National classification system for energy (coal, oil shale, uranium) and water resources (groundwater) and their correlation to the UNFC classification of resources

2.1. National classification system and energy and water resources management

Classification of energy (solid, liquid and gas) and water resources, groundwater and petro-geothermal resources are defined on the basis of the Law on Mining and Geology Exploration of the Republic of Serbia (2015), current Rulebook on the classification and categorization of solid raw material reserves and their records-keeping (1979), Rulebook on classification and categorization reserves of groundwater's and their records-keeping (1979) and the Rulebook on classification and categorization of oil, condensates and natural gases reserves and their records-keeping (1987) from former Yugoslavia. Petro-geothermal resources, as a separate energy resource, are classified according to the regulations of the Rulebook on conditions, criteria, content and manner of classification of petro-geothermal resources and manner of their presentation in the elaborate of the Republic of Serbia (2018), [56,56,58,59,60,61]. System for classification, management, usage and control of the state of energy and water resources is also regulated by the Law on Energy (2014), Law on Efficient Usage of Energy (2013), Law on Waters (2010, 2012, 2016, 2018), Law on Environment Protection (2005), Law on Spatial Planning of the Republic of Serbia (2010) and others [48,49,53,54,63,72].

Law on Mining and Geology Exploration of the Republic of Serbia (both 2011 and 2015) contains the terms *mineral resources and reserves of mineral raw materials and renewable geological resources* that include *groundwater and geothermal resources*. The Law does not state the manner of proving and classification of resource and reserves.

The draft of the new Rulebook on reporting and classification of mineral resources and reserves (2012) includes the *map of conversion* per which the categories A, B, C_1, C_2, D_1 and D_2 of geological and balance reserves of solid mineral raw materials (also oil and gas) are generally adjusted to the categories and classes of generally known reporting standards JORC code (2012), Ni 43-101, PRMS (2007) and codes UNFC – 2009. However, the subject draft is not yet adopted, and current regulations (with perceived deficiencies) is the basis for creation of strategic and planning documents in Serbia, that define the energy and water resources management of Serbia [53,64,65].

2.1.1. Categorization and classification of *energy resources (coal, uranium, oil shale, oil and natural gas)*

Per the Rulebook on the classification and categorization of reserves of solid mineral raw materials and their records-keeping of former Yugoslavia from 1979, it is stipulated that the deposits, or ore bodies of solid mineral raw materials, and therefore energy resources, are divided into groups and sub-groups (based on several elements). Classification of the deposit, or ore bodies, into a certain group and sub-group, determines the optimal type and density of exploration work (maximum allowed mutual distance), by which the degree of exploration and knowledge of the deposit (i.e. ore body) is determined, which is the basis of the categorization of reserves.

Geology reserves od solid mineral raw materials deposits, that is, their quantities *in situ*, are sorted into categories A, B, C_1, C_2, D_1 and D_2 (Annex: Figure 10). Geology reserves of categories A, B and C_1 are classified into balance (masses of mineral raw materials in the deposit

that can be used profitably by existing technique and technology of exploitation and processing) and outbalance reserves (masses of mineral raw materials in the deposit that cannot be used profitably by existing technique and technology of exploitation and processing). Categories of geology reserves of coal, uranium, metal and non-metal are separated based on the *degree of research and knowledge of the mineral raw material quality.* Reserve balancing is performed by the analysis and evaluation of factors and indicators of technical-economy evaluation in the "Elaborate on resources and reserves". Balance reserves, with the state of balance reserves on a particular date, are certified by the state authority, Commission / Workgroup for verification and certification of the reserves…, [53]. Deposits of ***coal***, according to the current Rulebook (1979), are divided into three groups and three sub-groups. Quality of coal reserves of A, B and C_1 categories in the deposit is determined by examining physical-chemical and technological properties of coal substance on samples obtained by systematic testing of coal layer and density of testing depending on the manner of exploration and on the variability of coal layer (test length cannot be more than 5m). Barren interlayers in the layer that cannot be removed during mass exploitation are tested for their volume, weight and lithological composition. Taken samples of coal are appropriately chemically tested. For ascertaining the A category, on the representative sample of coal, besides immediate analysis, the following properties are determined: coal grinding, the content of xylitol, ignition point, the elementary composition of ash, the petrographic composition of coal, etc. Based on parameters from technical analysis, or data on total humidity, the caloric value of coal without humidity and ash, per vaporizing matter, appearance and property of cox residue, the coal is sorted into lignite, brown lignite, brown coal hard coal and anthracite, [46,57].

Identically, the categories of geological and balance reserves of oil and natural gas deposits are sorted, proven and certified. [16, 53,58].

As separate renewable, geological, energy resource, in accordance with the Rulebook on conditions, criteria, content and manner of classification of petro-geothermal resources and manner of their presentation in the elaborate (2018), petro-geothermal resources are classified as *proposed and perceived* resources. [61].

Decision-certificate on certified balance reserves is the basis for creation of project mining and technical documentation and is prerequisite for obtaining the necessary approvals and consents for reserve exploitation. [56].

2.1.2. Categorization and classification of water resources (groundwater)

Groundwaters are a specific natural treasure and one of the most significant geology resources that the Republic of Serbia has, but in no instance can it be treated as a resource, or a gift of nature that can be disposed of freely. Water is under special protection and is used according to the Law and EU Directive (2000/60/EC), based on integrated environmental management.

Groundwater reserves (potable, mineral and thermal) of A, B, C_1, C_2, D_1 and D_2 categories in the natural deposit are classified into balance reserves (A, B, C_1 categories), and that when their quality corresponds to determining conditions for utilization purpose and when they can be profitably used through existing exploitation technique and technology, and processing technology, [60].

Balance reserves of groundwaters of A, B, C_1 categories are certified by authorized Commission / Work Group for determination and certification of groundwater reserves, [56]. The Decision that determines that the balance reserves of water resources (groundwater sites), hydrothermal resources are certified is issued, according to the Law, by authorized Ministry of

the Republic of Serbia and Provincial Secretariat of AP Vojvodina. The subject decision is the basis for creation of technical documentation and acquisition of necessary approvals and consents for utilization from authorities, [56]

2.2. Relationship between the categorization system for solid mineral raw materials reserves in Serbia and the UNFC system

Formally speaking, there is no official Decision or appropriate Guidelines on the application of key instructions for implementation of the UNFC system for resources classification in the Republic of Serbia. This means that there are no appropriate Aligned System and Bridging Document or instructions that could explain the relationship between national classification of resources and UNFC system codes, in three-component system E, F and G axis (categories).

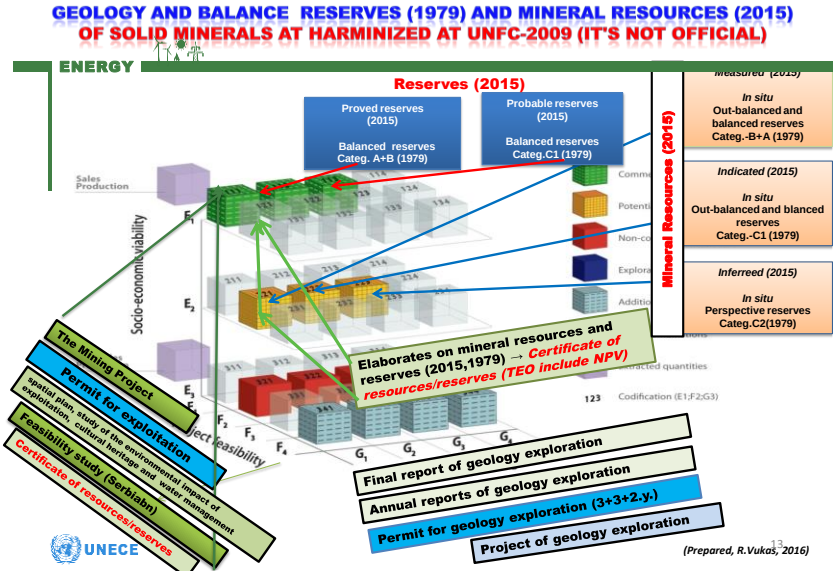
For harmonization of data on categories of geological and balance reserves (mineral resources and reserves) of Serbia with categories and classes of mineral resources and reserves from well-known reporting standards (JORC Code, Ni 43-101, PERC) and UNFC system codes, the *map of conversion* is applied (Table 1), proposed by a smaller group of authors in the past ten years, [5,6,7,9,41,42,43].

Table 1: Proposed *map of conversion* for categories of solid mineral raw materials reserves of Serbia for comparison with mineral resources and reserves (JORC Code, Ni 43-101; CRIRSCO) and UNFC system [5,6,7,9,41,42,43].

Law (2015) and Proposed New Book of Regulations for Solid Mineral Raw Materials	**Results of Geological Exploration**	**Mineral Resources**			**Mineral Reserves**	
		Inferred	**Indicated**	**Measured**	**Probable**	**Proved**
Official Book of Regulations for Solid Mineral Raw Materials (1979)	**Mineral Reserves**					
	Potential	**Potential**	**Established** (*in situ* – Geological: *Out-of-Balance and Balance)*		**Exploitation** *(inclusive of dilutions and losses during mining)*	
	D_2, D_1	**C_2**	**C_1**	**B,A**	**C_1**	**B,A**
UNFC			**Mineral Resources**		**Mineral Reserves**	
	334	**223**	**222**	**221**	**112**	**111**

Author of this Case Study Report proposed the *map of conversion* in 2014 (Table 2), for the purposes of harmonization of A, B, C_1, C_2, D_1 and D_2 categories of geological and balance reserves of solid mineral raw materials (mineral resources and reserves) with framework classification UNFC. The same was modified in 2015, in accordance with the provisions of the Law on Mining and Geology Exploration (2015), [43].

Table 2: Categories A, B, C_1, C_2, D_1 and D_2 of geology and balance reserves of solid mineral raw materials (mineral resources and reserves) of Serbia in framework classification UNFC-2009, [R. Vukas; 43].



2.2.1. Energy resources - coal

Framework harmonization of A, B, C_1, C_2, D_1 and D_2 – categories of geological reserves and A, B and C_1 categories of balance and out-balance classes of reserves for the subject coal project (uranium and oil shale), according to the codification of UNFC-2019 framework classification of resources is performed in accordance with the proposed *map of conversion*, Table 1 and 2, [5,6,7,43].

2.2.2. Water resources – groundwater

Categorization of *groundwater* reserves of A, B, C_1, C_2, D_1 and D_2 categories and their classification is performed per Rulebook on classification and categorization of groundwater reserves and their record-keeping (1979), [59]. The Law on Mining and Geology Exploration (2015) provides the adoption of a number of by-laws that should regulate the area of reserves categorization. So far, the only adopted by-law is the Rulebook on the content of the elaborate on the conditions for groundwater or hydrothermal resources exploitation, i.e. petro-geothermal resources exploitation, and conditions and manner of elaborate technical control (2018), and it does not deal with the categorization of groundwater reserves.

Therefore, the authorities made no steps towards the implementation of the UNFC framework for resource classification concerning the groundwater. There are no necessary Guidelines, Aligned System, Bridging Document or instructions based on which a procedure for UNFC (Update-2019) application could be developed. For the necessities of the groundwater Project in Zlatibor area, and in accordance with the author's personal understanding and knowledge of issues concerning categorization and classification of groundwater of Serbia, *map of conversion* shown in Table 3 is prepared.

Table 3: Proposed map of conversion for groundwater reserves in Serbia in the UNFC system, (Update 2019); [B. Jolović, R.Vukas, Dj.Milanković, 2020, unpublished]

<table>
<tr><th colspan="6">RULEBOOK ON CATEGORIZATION AND CLASSIFICATION OF GROUNDWATER ... (1979)</th></tr>
<tr><th colspan="6">Groundwater reserves</th></tr>
<tr><th colspan="2">Explored</th><th>Partially explored</th><th>Orientationally explored</th><th colspan="2">Not explored - prognosis</th></tr>
<tr><th>A-category</th><th>B- category</th><th>C1- category</th><th>C2- category</th><th>D1- category</th><th>D2 category</th></tr>
<tr><td colspan="3">Economic evaluation of exploitation profitability</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="3"></td></tr>
<tr><td colspan="3">Balance reserves</td></tr>
<tr><td>A- category</td><td>B- category</td><td>C1- category</td></tr>
<tr><td colspan="6">UNFC</td></tr>
<tr><td rowspan="3"></td><td></td><td>223</td><td>333</td><td colspan="2">334</td></tr>
<tr><td>212</td><td>213</td><td rowspan="2"></td><td colspan="2" rowspan="2"></td></tr>
<tr><td>111</td><td>112</td><td></td></tr>
</table>

3. Basic information on the project – coal deposit "Tamnava – West Field" and project – groundwater's (karst and fracture aquifers; see page 8) formed in the area of Mt. Zlatibor

3.1 Previous work on energy (coal) and water (groundwater) resources

Energy and water resources (*coal and groundwater*) as energy potential of the Republic of Serbia (Annex: Figure 1, 2 and 3) are subject to several decades of complex geological exploration and exploitation, usage, management, quality monitoring and protection. All previous geology and other exploration, geological exploring, exploiting and other works, are performed in accordance with the strategic documents of the Republic of Serbia and legal regulations that were valid, in the aspect of categorization and classification of energy and water resources, even in former SFR Yugoslavia, [57,59].

3.1.1. Energy resource – coal (soft brown coal – lignite)

The total energy potential of the Republic of Serbia consists of solid, fossil and liquid-gaseous fuels (coal, uranium, oil shale, oil and natural gas), as well as renewable energy sources, [52].

Coal – lignite with the share of 93 per cent is the most significant energy resource – potential that is naturally found in 8 coal-lignite basins, [51,52,55,]. Another 15 basins of hard coal and 37 of brown coal are known to exist in Serbia, (Annex: Figure 2). By underground manner of exploitation, the coal is mined in 13 basins (2 of hard coal and 11 of brown coals), [1].

Certain coal deposits with the underground manner of exploitation are exhausted or are in the phase of additional exploration, while Aleksinac coal deposit is not in exploitation since 1989, due to a mining accident in which 90 miners lost their lives. (Annex: Figure 2)

In Aleksinac basin, the oils shale reserves are determined in the scope of around 2x109 tons, that are balanced for Dubrava deposit (around 200 Mt). The middle content of organic substance is determined at 16.6 volume per cent and oil yield of 8.95 mass per cent. Energy balance for 2020 (www.mre.gov.rs), consists of the production of hard coal, brown coal (within public company Mining with underground coal exploitation – "Resavica") and lignite (within

open pit Kolubara and Kostolac), that are part of the public company EPS (Elektroprivreda Srbije). Besides this, lignite production by underwater exploitation is active in Kovin mine (AP Vojvodina), [55].

Geological reserves of lignite (Table 4) in comparison to geological reserves of all types of coal in the Republic of Serbia make for 93 per cent.

Table 4: Total coal reserves of the Republic of Serbia, on the date of Dec. 31st, 2010, [55].

Type of coal	Republic of Serbia without Autonomous provinces (AP) (t)	AP Kosovo and Metohija* (t)	AP Vojvodina (t)	TOTAL Republic of Serbia (t)
Hard	**8,214,000.00**			**8,214,000.00**
Brown	**111,293,000.00**			**111,293,000.00**
Brown-lignite	**536,678,000.00**		**8,729,000.00**	**545,407,000.00**
Lignite	**3,989,333,000.00**	**15,746,000,000.00**	**275,000,000.00**	**20,010,333,000.00**

From estimated quantities of coal, around $4x10^9$ t is in the central part of the Republic of Serbia, i.e. Kolubara and Kostolac basin, while around $15,7x10^9$ t is on the territory of AP Kosovo and Metohija* (Note: Kosovo and Metohija is an Autonomous Province (AP) within the borders of the Republic of Serbia and based on the United Nations Security Council Resolution No. 1244 from June 10th 1999, it is under temporary civilian and military administration of the United Nations).

Other types of coal (hard, brown, brown-lignite or hard brown coals) make only 7 per cent of the total quantity of geological reserves in Serbia. Exploitable coal reserves are quite respectable and significant and therefore represent a realistic basis for further, long-term development of the energy sector based on conventional sources. In Kolubara coal basin, with deposit "Tamnava – West Field", there is a plan to excavate 29,1 Mt of coal in 2020 (approx. 3 per cent more than in 2019).

Total available quantities of coal from domestic coal production and net export in 2020 are planned in the scope of 7,766 Mtoe, while from total domestic coal production 94 per cent of coal is planned to be used for electric energy production in thermal power plants.

Data on quantities are shown in accordance with the methodology of International Agency for Energy and Eurostat, so all values are shown in physical units and that: solid fuels in thousands of tons, liquid fuels in millions of tons, gas fuels in millions of m^3 (reduced cubic litre of gas), electric energy in GWh, heat energy in TJ.

Oil and natural gas, as an energy resource, can be found in the biggest scope in the area of Pannonia basin, which is in the area of AP Vojvodina. In a lesser scope, it can be found in Central Serbia. The total scope and potential of this energy resource, i.e. geological and balance reserves in Serbia are small. According to the available data, at the end of 2010, remaining balance reserves of crude oil it the Republic of Serbia were approx. 10,14 Mt, or $4,23x10^9$ m^3 of natural gas, [47,51,55].

Renewable energy sources or energy from renewable sources is energy produced from non-fossil renewable sources such as water resources, biomass, wind, sun, biogas, landfill gas, gas from sewer water processing plants and geothermal energy sources. According to the Directive 2009/28/EZ, energy from renewable sources implies energy from non-fossil renewable sources (energy of wind, solar, aero-thermal, geothermal, hydrothermal, the energy of the ocean, hydro-energy, biomass, landfill gas, gas from garbage processing plants and biogas). The

estimated technical potential of renewable energy sources, according to the document National action plan for utilization of renewable energy sources of the Republic of Serbia, Belgrade, 2013, is approx. 5,6 Mtoe per year, [69,71].

Summary energy balance is shown in millions of tons of oil equivalent (Mtoe), and one ton of oil equivalent is 41,868 GJ or 11,630 MWh of electric energy or two tons of hard coal or 5,586 t of crude lignite, [55].

3.1.1.1. Project: Coal deposit "Tamnava – West field"

Kolubara coal basin, with coal deposit (of soft brown-lignite) "Tamnava – West field", is located at approx. 50 km southwest from Belgrade, (Annex: Figure 2 and 8). Total basin surface is approx. 600 km^2, while productive, the coal-bearing part is approx. 167 km^2. Kolubara basin is divided by river Kolubara into east and west part. In the eastern part of the basin, there are nine separate geological-mining-economic units (deposits, open pits – coal production systems), and they are "A", "B", "C", "D"," E", "F", "G", „Veliki Crljeni" and "Šopić - Lazarevac". In the western part of the basin (between rivers Kolubara, Tamnava and Ub), there are following deposits: "Tamnava – East field", "Tamnava – West field", "Radljevo", "Zvizdar", "Ruklade" and "Trlić". Coal exploitation is done in deposits "Field B and D", "Tamnava – East field" and "Tamnava – West field", while it is finished at "Field A" (Annex: Figure 7 and 8), [13,40].

According to petrographic composition, coal from all three layers of Kolubara coal basin belongs to texto-ulminite type. Quality parameters are as follows: moisture 46.2 per cent, ash 19.4 per cent, total sulfur 0.57 per cent, volatile matter 60.2 per cent and DTE 7400 KJ/kg, [11,12,13]. Total geological reserves of the Kolubara basin of $A+B+C_1$ category on the date of Dec. 31st 2019 are $2{,}54 \times 10^9$ tons, of which balance $1{,}98 \times 10^9$ tons and exploitable reserves $1{,}84 \times 10^9$. Estimated potential reserves (resources) of coal in Kolubara basin were 307 million tons, [11,12,13,77].

3.1.1.1.1. Utilization of coal from the deposit "Tamnava – West field"

Coal deposit "Tamnava – West field" is in the energy system of the Republic of Serbia since 1995/96, (Annex: Fig. 8 and 9), [11,12,13,40]. The deposit "Tamnava – West field" supplies coal to existing thermo capacities – thermal power plants "Nikola Tesla – A" and "Nikola Tesla – B" (at the distance of 6 to 25 km), for electric energy production, [40]. By surface manner of exploitation, there is approx. 12-13 Mt of coal excavated annually, and from the entire Kolubara basin (in the system of water drainage and protection) there is approx. 30 Mt of coal excavated or produced. The total of excavated coal is used to produce 52-55 per cent of totally produced electric energy in the Republic of Serbia, [11,12,13,40].

3.1.2. Water resources - Groundwater

Groundwater is part of the unique water cycle and balance (connected with atmospheric and surface waters) and geological resource of special significance. Waters, accumulated in different aquifers systems (inter-granular, karst and fracture) at the explored area are also sufficiently abundant that can secure the continuity of capturing and usage, and even to enable the opening of new sources, including the regional water supply (Annex: Figure 3). According to that, generally speaking, there are favourable natural prerequisites for, with rational exploitation and eventual regulation measures (where it's possible), ensuring long-term and reliable usage of groundwater resources, first of all in the water supply system, as well as in thermal, mineral and table potable waters usage.

Certificate on sufficient quantities of groundwater, necessary for the future development of the Republic of Serbia, can be found in the strategic document – *National Strategy on sustainable development*, that states: "The Republic of Serbia has sufficient quantities of water for satisfying its needs, but only if they are used rationally and protected from accidental and deliberate pollution," [30,52,64].

All groundwater, according to the conditions of forming and structural type of porosity can be divided into the following units: groundwater formed within the rock with inter-granular porosity type, then groundwater formed within carbonate rocks with karst porosity type and groundwater formed within rocks with fracture porosity type.

Table 5, according to the data from *Vodoprivredna Osnova Srbije* (VOS – Water management basis of Serbia), represents the review of groundwater sources abundance in Serbia [66].

Table 5: Abundance of groundwater sources in Serbia according to the aquifer structure type [66].

Hydrogeological unit	Alluvial flats	Basic aquifer complex (Vojvodina)	Neogene sediment	Karst environment	Fracture environment	Total
Bačka and Banat	1.454	3.570	431	0	-	5.455
Srem/Mačva, Sava/Tamnava	6.974	340	506	30	-	7.850
Central Serbia	2.585	-	845	430	-	3.860
East Serbia	620	-	60	1.711	-	2.391
Southwest Serbia	242	-	140	1.614	-	1.996
West Serbia	1.051	-	60	397	17	1.525
Total	12.926	3.910	2.042	4.182	17	23.077

Based on these and other data from VOS, current groundwater capturing is approx. 19 m^3/s. More than half of these quantities of groundwater are captured from alluvial sources. Basic aquifer complex (BAC) stretches almost across all territory of Vojvodina. Waters from BAC are captured via deep wells, at springs significantly distanced from the feeding zones (aquifer recharge). Long-term exploitation of groundwater of this complex shall result in declining levels of groundwater, which is a direct consequence of slowed and difficult water substitution (turnover). Around one-sixth of the total quantity of groundwater captured in the Republic of Serbia comes from basic aquifer complex in Vojvodina.

Groundwater formed within the Neogene aquifer is used for the water supply of population in the area of Central and South Serbia. Neogene aquifer is characterized by significant reserves of groundwater with partial renewal in conditions of continuous exploitation, [29].

Waters of karst aquifer have significant oscillations of abundance and level of groundwater. The groundwater of karst aquifer is used for water supply to the population in the area of East and West Serbia. Groundwaters formed within the fractured aquifer are used mostly locally.

The most common type of use of groundwater formed within the fractured aquifer is balneotherapy, bottling, local water supply and, lately, as a resource for heating and cooling energy.

Theoretically, total available hydro-energy potential of waters that flow in watercourses on the territory of the Republic of Serbia is approx. 25,000 GWh/year [4,52,55]. The biggest part of hydro-potential (over 70 per cent) is concentrated on just a few watercourses with potential

above 1,000 GWh/year: Danube, Drina, Velika Morava, Lim and Ibar. On the other hand, on a number of rivers in Serbia, hydro-energy potential can be used only partially, due to water management prioritizing of the water utilization because some rivers are planned as sources for regional water supply systems: Toplica, Crni Timok, Rasina, Studenica, Veliki Rzav, Mlava, Lepenac, etc. The technically usable potential is approx. 19.5 TWh/year, of which approx. 17.7 TWh/year on facilities larger than 10 MW.

So far, there are 16 hydroelectric power plants built that produce approx. 10.5 TWh annually. The total technical potential of hydroelectric power plants of up to 10 MW is estimated at around 1,800 GWh annually. Remaining technical hydro-potential and the possibility of its utilization shall be determined in accordance with the non-energy criteria related to multi-purpose utilization of waters and issues regarding the environment protection, as well as based on the agreements on the distribution of hydro-potential with neighbouring countries. Given the fact that the estimated potential of small hydroelectric power plants is based on Cadaster of small hydroelectric power plants from 1987, detailed revision of locations is needed, in order to create a valid list of viable locations and create better planning basis for the utilization of these renewable sources, with respect to all negative impact of building and justified opposition, [68].

For assessment of the entire hydro-energy sector, it is necessary to perceive the impact of climate change on the availability of watercourses utilization for electric energy production. This is important both for perceiving the expected electric energy production from existing hydroelectric power plants, and possible hydro-energy potential for construction of new hydroelectric power plants, [55].

Big hydroelectric power plants (HE) have the power at the threshold of 2969 MW, while the power of small hydroelectric power plants is 114,30 MW. Installed power of hydroelectric power plants that shall use the incentive measures for electric energy production in 2020 is 77.50 MW, [55,70,71]. In the last decade, there is a growing trend of groundwater utilization as an energy resource, through heating and cooling energy production that is used mostly for the needs of individual users.

So far, there is no appropriate strategic document that could be directly linked to the assessment and classification of water resources – groundwater, regarding the subject usage of heating and cooling energy, [55,68,69]. State Balance of annual groundwater utilization is kept by the Ministry of Mining and Energy through updating and creation of Book on Balance of groundwater, in accordance with the Law on Mining and Geology Exploration (2015) and the Rulebook on classification and categorization of groundwater and their record-keeping (1979), [56,59].

3.1.2.1. Project – Development and utilization of groundwater at Mt. Zlatibor

Groundwater in the area of mountain Zlatibor is formed within the karst aquifer and fracture aquifer (Annex: Figure 10). Karst aquifer is formed within the carbonate package of Triassic age sediments, while the fracture type of aquifer is formed within the ultramafic rock complex. Waters of karst aquifer are used mostly for centralized water supply in the rural area of Zlatibor and for the needs of bottling of water, while the waters of the fracture type of aquifer, besides for local water supply, are also used for industrial bottling of water, as well as for the necessities of heat and cooling energy production for infrastructural facilities, [2,17,18,19,20,21,22,23,24,25].

Balance reserves of groundwater of the *karst aquifer* at the level B and C_1 categories (Table 6) and balance reserves of groundwater formed within the *fractured aquifer*, at the level of

B category (Table 7), in the area of Zlatibor, are shown in the following Tables 6 and 7, (Annex: Fig.10).

Table 6: Balance reserves of groundwater in the area of Mt. Zlatibor formed within the karst type of aquifer, [2].

Deposit: Appearance/object	B-category (l/s)	C_1- category (l/s)
Sušičko vrelo	108,7	-
Dobroselička vrela	21,7	35,0
Zlatibor voda (BSG-1/09)	7,5	-
TOTAL	137,9	35,0

Table 7. Balance reserves of groundwater formed within the fracture type of aquifer in the area of Mt. Zlatibor, [25]

Deposit: Appearance/object	B- category (l/s)	C_1- category (l/s)
IEBO-1/09	10,0	-
Hemel-1	4,0	-
IEBT-1/11	6,0	-
Kraljeva voda	0,6	-
TOTAL	20,6	-

3.2. Current status of the energy and water resource project

3.2.1. Current status of the Project – coal deposit "Tamnava – West Field"

Deposit of coal (soft brown-lignite) "Tamnava – West field" in the Kolubara basin, as was mentioned, was introduced into the process of production and surface excavation of coal-based on the coal reserves of 670 Mt. In accordance with the average annual exploitation capacity, dynamics, applied method and excavation conditions (in the system of groundwater protection and drainage), there is 12-13 Mt of coal excavated on an annual level. At the end of 2010, remaining coal reserves in the deposit "Tamnava – West Field" were 375 Mt (in categories: A=22 Mt or 6 per cent; B=107Mt or 29 per cent; and C_1=245 Mt or 65 per cent), [11,12,13,40,].

By further excavation coal reserves were reduced, by the end of 2019, to approx. 250 Mt, [77]. By exploitation of reserves of A and B categories (reserves with a high degree of determination probability; 85 per cent and 70 per cent) in the part of the deposit remaining for excavation, starting mutual shares of particular categories of reserves in total quantities of current coal reserves are completely changed. Reserves of A category are excavated in full (remaining share 0 per cent), reserves of B category are significantly reduced (remaining share is only 2 per cent), and reserves of C category were not excavated at all so that their current share in remaining quantities of coal reserves is 98 per cent, [77].

Above-mentioned data on categories A, B and C_1 of coal reserves are of utmost significance for understanding and approaching to the UNFC-2019 framework for resource classification, [5,33,39,43].

Exploitation, transport and processing of coal from "Tamnava – West Field" deposit is progressing with strict adherence to measures of security and health at the workplace, as well as environment protection, that is harmonized with the adopted sustainable development goals (6 and 7), [8,10,14,31,34,35,36,38,45].

3.2.2. Current status of the project: Water resources in the area of Mt. Zlatibor

From the groundwater resources in the area of Mt. Zlatibor, the current energy production for heating and cooling, performed mostly at the expense of the exploitation of groundwater formed within the fractured aquifer (Annex: Figure 10). Installed power of heating pumps water-water and potential annual production in facilities that use groundwater, as a result, is given in Table 8.

Table 8: Review of potential heating and cooling energy production from hydrothermal resources in the area of Mt. Zlatibor, [17,21].

Deposit: Object	Balance reserves of groundwater determined and in the process of determination (l/s)	Installed heating capacity (kW)	Potential annual energy production for heating and cooling (MWh)
IEBO-1/09	**10,0**	**156**	**1.300**
IEBT-1/11	**6,0**	**112**	**980**
IEBHB-1/17	**1,8**	**45**	**390**
IEBHB-2/17	**1,2**	**45**	**390**
IEBZ-1/19	**6,0**	**90**	**780**
TOTAL	**25,0**	**448**	**3.840**

3.3. Prospects

3.3.1. Project: Coal deposit "Tamnava – West field"

Regarding the prospects and development of coal deposit "Tamnava – West field" as *energy resource – project*, it can be spoken of based on the remaining reserves in the quantities of 250 Mt ($B+C_1$ category) [9,11,15,25,27,28,59].

These coal quantities limit the development of this resource, given the fact that the coal comprises 8 per cent of total quantities of geological reserves of coal in Kolubara basin (of $2{,}9x10^9$ t). Project development is conditioned by enforcement of adopted planning and strategic documents on the general development of energy resources of Serbia (Energy strategy, 2015; Strategy on the management of mineral resources of coal in Kolubara and Kostolac basin, 2013; National strategy for the accession of Serbia to EU and Sustainable Development Goals, etc.).

In accordance with all above-mentioned, several decades of coal production from deposit "Tamnava – West field" gradually comes to an end, and in that sense, the further significant developing perspective of this project does not exist. The only thing that is practically certain is re-categorization of C_1 category reserves based on additional exploration.

3.3.2. Project: Water resources –groundwater resources in Zlatibor area

Strategic development of *water resources*, i.e. subject groundwater in Zlatibor area, generally arises from *Vodoprivredna osnova Srbije* (VOS), which states – maintenance and development of water regime that provides the most favourable and purposeful technical, economic and environmental solutions for uniform water management, protection from harmful effects of waters and water utilization, [4,30,37,62,64,67].

Groundwater resources in Zlatibor area as an energy resource are used for the needs of heating and cooling energy production. Significant reserves of Zlatibor groundwater, formed within the karst type of aquifer that is drained mostly on the rims of the mountain massif, provide

the possibility of exploitation of these resources for the needs of electric energy production, also, [68].

So far, exploration determined the reserves of groundwater of B category in the quantities of about 25 l/s within the fractured aquifer and 13 l/s within karst aquifer, and C_1 category in quantities of 35 l/s (Tables 5 and 6). In addition to this, hydrogeology exploration is performed at several other exploration fields, which require additional defining of balance reserves quantities of groundwater's within the karst and fractured aquifer in this area.

4. Environmental-social-economic aspects of the project

4.1. Environmental and socio-economic aspects of energy resource – project: coal deposit "Tamnava – West field"

Environmental-social-economic aspects of the *project: energy resource* – coal deposit "Tamnava – West field", that is social and environmental aspects, are recognized and available in strategic development plans, planning documents and sustainable development goals, [50,51,53].

Detailed information on socio-economic and environmental aspects can be found in technical documents: "Elaborate of Resources and Reserves", "Feasibility Study of Exploitation" and "Mining Project", that are, particularly speaking (in accordance with the obtained consents), reflecting the appropriate degree of project feasibility, or maturity (70-90 per cent), [5,6,51,53,55,56,77].

The project has an intensive impact on water resources; that is, it affects the state, quality and balance of surface and groundwater's of this area, [31,50]. From the environmental protection aspect, the following can be seen: mining operations in surface exploitation of coal harms local sources of water supply, and waters are continuously treated, drained from the open surface pit and purified (in accordance with issued permits), [8].

Surface and groundwater are exposed to pollution by a high concentration of different pollutants (suspended and organic matter, coliform germs, a small percentage of dissolved oxygen, dangerous and harmful matter: nitrite nitrogen, phenols and manganese). In the area of ash landfill, groundwater contains dangerous and harmful matter (elevated presence of sulfites and suspended particles of arsenic) and has variable pH value, [50].

In the conditions of surface exploitation of coal, for the purposefully determined electric energy production based on coal, aspects of social protection and environment protection imply the facts that groundwater sources have to be protected, that is, it has to be ensured they are not lost and that it is necessary to implement the groundwater protection in accordance with the regulations. All of this is ensured by adequate planning and finding substitute solutions for water supply, or utilization of sources that are not endangered by exploitation, and by reducing the negative impacts of exploitation on the environmental status of water factor of the environment. This is achieved through a setup system of already mentioned drainage and water purification (purification, channelling, separation, harmonization of water regulation, etc.) and established monitoring, [75]. Basically, it is necessary to provide quality and classes of water in accordance with the *Vodoprivredna osnova Srbije* (VOS), which can be achieved by the established manner of energy and water resources management and their monitoring, [74,75].

General management of waters in Kolubara basin or in Zlatibor area (as subject water resource of this case study), is conducted in accordance with the Law, through the institutional connection of scope and manner of appropriate funding, all towards the purposeful insurance of sufficient quantities of surface and groundwater of the required quality, i.e. environmental and chemical status.

4.2 Social aspects of energy production and groundwater utilization

Social aspects of energy production and groundwater utilization are reviewed in detail through basic goals in the area of social development shown in Spatial Plan, [49,50].

Above all, that covers the production aspects that imply: unhindered realization of economic, social and cultural rights of the population; ensuring the better availability and conditions of basic content utilization from social standard and public services for population; improvement of living and accommodation conditions for sensitive social groups (elderlies and ill people, handicapped, etc.); timely planning and moving of populace from projected zones of expansion for surface open pits and accompanying mining works; rural demographic development; local infrastructure functioning, development of agriculture; development of economic subjects and public services, etc. [49,50].

Additionally, urban development, the function and content of towns is directed towards the spaces outside the borders of influence of current mining-energy, hydro-energy-economic complex of Kolubara basin and subject energy project "Tamnava – West field" and accompanying water facilities, groundwater for water supply. The same can be applied to subject hydro-facilities in Zlatibor area and others, [31, 50].

Basically, social aspects can be seen in the influence on current migratory paths of young people from rural canters into cities for the purposes of education, general knowledge, employment probability, etc. [76,78].

4.3. General environmental question in relation to energy production and groundwater utilization

For insight into the state of the environment, i.e. environmental factors, during the energy production, and from the aspect of groundwater utilization, the relevant data comes from state authorities and institutions, which Environment Protection Agency acquires in accordance with the national list of environment protection indicators, [78]. According to these, basic data, the pollution of waters of Serbia is dominant, by nitrogen and phosphorus from communal and industrial capacities (sources). In most cases, the pollution comes from the energy sector, mineral and chemical industry, and from public communal services, which is stated here, [50,75,76].

Groundwater (water resource), as one of the main environmental factors, is a factor on which the subject exploitation of coal from the deposit "Tamnava – West field" has an extensive impact. It affects the quality of water and, per that quality, the possibility of its further use (water supply, etc.).

In this case, the basic goals and special principles of environmental factor, i.e. environment protection, are adopted, and they imply controlled conditions and preventive approach to coal exploitation, as an energy resource. This means protection and improvement of quality of air, soil, *surface and groundwater*, by application of adequate measures for pollutant emission reduction, especially sulfur dioxide, nitrogen dioxide, ash, and others, [50].

4.4. Aspects of energy resource – coal depletion

By exploitation of mineral raw material reserves from the deposit (coal) and its further processing and utilization, physically speaking, the mineral raw material is permanently reduced, or permanently lost form the deposit. From that aspect, the deposit "Tamnava – West field" is absolutely *exhaustive and not renewable*.

In the past several decades of coal excavation from Kolubara basin, for the energy requirements in Serbia, electric energy production, $1{,}9 \times 10^9$ tons of coal (lignite) was spent and

permanently lost, [40]. Considering the exploitation of coal deposit "Tamnava – West field" and annual "depletion" of coal reserves (approx. 12-13 Mt), as well as remaining reserves (around 250 Mt), and expected rise of reserves spending, the subject project is certainly not promising in the long run.

In the area of energy resource – coal project "Tamnava – West field" and the entire Kolubara basin, water supply is based on the utilization of local sources. Missing quantities of water for water supply are provided from protected springs of ground and surface waters of the state significance, [31,50].

4.5. Depletion or contamination of groundwater

With water resources, the entire hydro-energy and geothermal potential of Serbia, the situation is different. This resource is *renewable*.

The oldest renewable sources of electric energy are hydroelectric power plants, and based on the conducted assessment (in mid-'80's previous century), the Cadaster of small hydroelectric power plants with a power range from 100 kW to 10 MW was created, [79]. Total *theoretical* available hydro-energy potential of waters that flow through watercourses is approx. 25,000 GWh/year, [79]. The biggest part of hydro-potential (over 70 per cent) is concentrated on just several watercourses (Danube, Drina, Velika Morava, Lim and Ibar), with potential above 1,000 GWh/year. *Technically* usable potential in the Republic of Serbia is approx. 19.5 TWh/year, of which around 17.7 TWh/year is in facilities larger than 10 MW, [79].

Utilization of hydro-potential, environmentally the cleanest renewable energy source, is of high priority and is renewed within the integral river systems, on higher national and international levels. Modern technology enables the rational setup of these potentials, meaning that those systems can be planned at alluvial river levels, in accordance with the environment protection projects, and others.

One of the main tasks in proving the groundwater resources balance, given that this is a renewable geological resource, is determining the viability of exploitation, i.e. prevention of over-exploitation. Taking this fact into consideration, it is clear that the significance of research related to the determination of groundwater reserves is of high value.

Issues concerning the groundwater protection are defined by Law on Waters (2010, 2012, 2016, 2018) and by the Rulebook on the manner of determination and maintenance of sanitary protection zones for water supply sources (2008). According to said regulations, groundwater that is used as a geothermal resource does not fall under the provisions of the Law on Waters (2010, 2012, 2016, 2018). Inadequate utilization of groundwater as a geothermal resource can result in a change of natural temperature regime of groundwater and geological environment, and it is, therefore, necessary to pay special attention to these phenomena during the creation of by-laws related to the determining of groundwater reserves. It is necessary to mention that the issue of disposition (return) of "energetically used" groundwater into the geological environment is not adequately covered by legal regulation – the Law on Mining and Geology Exploration (2015), and accordingly there is no uniform set rules related to this issue.

4.5.1. Review of the aspect of depleting and contamination of groundwater in Kolubara basin – coal deposit "Tamnava – West field"

Springs of groundwater in the area of subject Kolubara coal basin that serve as potable water supply to population, in accordance with the planning documents and measures, are protected from pollution and endangering of their quality by particular destruction and by the introduction of inappropriate and polluting materials and content. Groundwater of the highest

quality can be used only for supply to the urban environments and those industries that require potable quality grade water.

Spending and contamination of groundwater are from the subject coal project from Kolubara basin implies the application of adequate and particular measures for the reduction of pollutant emission, especially sulfur dioxide, nitrogen oxide, ash and other toxic materials, [50].

Groundwater source "Peštan", used for the requirements of water supply to the town of Lazarevac, is located within the exploitation filed of the mining basin Kolubara. Spring management was entrusted to public communal service from Lazarevac, that by the current provisions of the Law on Mining and Geology Exploration (2015) is not able to get, without the consent from coal exploitation holder – public communal service *Elektroprivreda Srbije*, that is Mining basin Kolubara, the appropriate approval for hydrogeological exploration with the aim to prove the groundwater balance reserves (that are captured in said spring).

Besides this, the subject area on which the source "Peštan" is located will be fully liquidated in the following phases of exploitation, by expanding mining operations. Thus, the establishing of the sanitary protection zone for the spring per provisions of the Law on Waters (2010, 2012, 2016, 2018), in the long term, would not give appropriate effects in the sense of establishing conditions for the prevention of contamination of the groundwater from this spring.

4.6. Other remarks

It has been shown that the production-economic sector for energy that is dominantly based on the production of electric energy from conventional energy sources, such as coal and oil, has the biggest negative impact on the environment, [79]. The energy sector, as such, represents a more real threat to environmental sustainability and industry movements. However, the characteristic of deposits of hard energy resources – coal that is exhaustive and non-renewable, is that at the same time they are the most commercial deposits in Serbia, with the ultimate goal of producing electric energy. These facts, on the one hand, provide the possibility for generations of today to achieve social-economic growth and development by utilization of said resources, while, on the other hand, future generations certainly are limited or even denied such opportunity, which is not in accordance with the Sustainable Development Goals (society), [https://www.rs.undp.org/content/serbia/sr/home/sustainable-development-goals.html].

Taking into consideration the entire state of the energy sector that is the "backbone" of Serbia, it is to be expected that the spending of the energy resource-coal in Serbia will be on the rise in the following period.

The environmental-social-economic aspect of the development of the energy project – coal deposit "Tamnava – West field" and water resources – groundwater in the area of Mount Zlatibor, have been considered from the aspect of their validity evaluation, and are fully in accordance with the currently valid legal frame, [73]. Besides, they contain the necessary level of information according to the planning and strategic documents and obligations for harmonization with the EU legislature (EU Directive on waters 2000/60/EC and Directive 2009/2009/E3), [49,50,65].

5. Field feasibility and status (maturity) of the project for energy production and groundwater utilization

5.1 Energy resource – coal

Technical-technological feasibility of the energy resource, coal project (and accompanying groundwater's) from the aspect of status and field feasibility, includes the conditions of surface mining exploitation and production of coal, the process of transport, coal quality control, grinding and burning, for the needs of production of electric (and heating) energy. Entire (field) technical-technological process is supported by existing infrastructure, engineering and other facilities, as well as technical and expert services. Everything is conducted in accordance with the legal regulations, consents, contracts and expert-scientific solutions for the field production process.

In accordance with the geological structure of the deposit, engineering and natural hydrogeological conditions of the deposit, per depth of dip of the coal layers and their quality, for the energy resource, coal deposit "Tamnava – West field", the surface exploitation is predisposed.

Annually produced, excavated coal (around 12-13 Mt), along with the coal excavated from other basins, supplies the existing blocks of thermal power plants (TE "Nikola Tesla" A and B in Obrenovac and TE "Kolubara" in Veliki Crljeni), [www.eps.rs]. The annual demand for thermal power plants is around 29-30 $x10^6$ t of coal, which implies the coal production of 31-32 $x10^6$ t annually from the entire Kolubara basin, [www.eps.rs]. For the requirements of the industry and mass consumption, it is necessary to have appropriate previous preparation in the existing facilities for wet and dry separation, and drying, where produced commercial assortments are made by classing, washing, cleaning and drying of coal. For the requirements of burning in thermal power plants, the coal has to meet the demand for Lower Heat Value (LHV) of 5,230 kJ/kg, that is subject to constant quality control, [76; (www.eps.rs)].

Technical-technological feasibility of the said project is based on technical documentation, created in accordance with the legal regulation and based on which appropriate approvals and consents are obtained. All of this is the basis for "Strategy on the development of energy in the Republic of Serbia until 2025, with perspective for development until 2030" and other strategic and planning documents, [49,50].

Based on all above-mentioned and several decades of experience in the area of mining exploitation of coal in Kolubara basin and subject coal deposit, under the conditions of open-pit drainage and water supply from current groundwater sources, technical-technological feasibility of the project in the system for connecting all technological sub-systems, *in the aspect of viability is not under question, that is, there are no obstacles for project viability.*

For water supply requirements, there are solutions found in a manner that utilizes *groundwater springs* away from the reach of mining operations, or from the open pit surface, [50;(www.eps.rs)].

5.1.1 Water resource – groundwater in Zlatibor area

Public water supply to rural towns in Zlatibor area is done by the exploitation of karst groundwater's (Spring Zmajevac, spring in Golovo, Spring Međe, etc.), while for the area of central towns (Čajetina and Zlatibor), it is done at the expense of surface water exploitation from water accumulation "Zlatibor" built on the river of Rzav in the town of Ribnica.

Lately, significant urbanistic and tourist development of Zlatibor as a mountain centre induced the hydrogeological exploration related to the determination of groundwater to balance reserves that could, in the foreseeable future, be used for various purposes (public water supply, individual water supply, production of heating and cooling energy, etc.).

In the last ten years, there is a rise in the number of individual users of groundwater that open their own groundwater springs. Among individual users, the hotel owners are topping the list, using the determined balance reserves of groundwater (Table 7) mostly for the needs of heating and cooling energy production and secondary for water supply requirements.

The growing degree of fullness (filling degree) of "Zlatibor" accumulation in Ribnica, and relatively poor quality of raw water that is conditioned by the elevated concentration of heavy metals, requires a significant degree of treatment of raw water before distribution to end-users.

The alternative solution to the question of population water supply in Zlatibor area, public communal service solves by opening groundwater springs that have better quality. In this aspect, hydrogeological exploration had started and resulted in determining of groundwater balance reserves of B and C_1 category at sources Sušičko Spring and Dobroselička Springs (Table 5). At this moment, hydrogeological exploration related to determining groundwater reserves that could eventually be used for the requirements of centralized water supply, are done at 3 other exploration areas (karst sources – Ljubiško spring and spring in Golovo) and at spring of groundwater formed within fracture aquifer – Zlatibor centre, [www.mre.gov.rs; WebGis)].

5.2 Finished detailed studies and their results

Main aspects of surface exploitation of coal are taking up of huge expanses of land and change to the land purpose; degradation and change of relief-landscape; disruption of the natural soil drainage; disruption of regional hydrogeological balance, etc.

For energy resource – coal deposit "Tamnava – West field" in Kolubara basin, environment protection was considered through the Study on the environmental impact assessment (EIA), initiated by European agency for reconstruction (EBRD). EIA study was initiated in order to provide obligatory data required by the national legislative process, as well as possible international investors. The study analyzes the main aspects of the environment and social aspects of the project during coal exploitation. Environmental and social aspects of the project feasibility came to light particularly during 2017, after the devastating floods of 2014, caused by the cyclone "Tamara". During 2017, through annual, maximally achieved production of coal of 17 Mt, there was a significant impact on the environment and social aspects, [www.eps.rs]. Mining project for the 5-year period of exploitation was conducted, and it deals with the issues of advancing of mining operations by the end of the exploitation lifecycle (according to the remaining quantities of coal reserves), [www.eps.rs; New project EBRD].

The subject study considers the negative effects of the surface exploitation on the watercourses and water supply, through a set system of drainage and purification of surface and groundwater, water, soil and air protection, as well as other elements of the environment. Manners of drainage, channelling and purification of waters, as well as prevention of dust settling (by wetting for example front of the excavation – exploitation head and roads that are used by machinery, etc.) are considered in order to mitigate unfavourable effects. Study shows the need for better characterization of some social and environmental aspects. Likewise, for the development of the better system for protection, it is important to implement corrective measures of mitigation before existing, during and after the surface mining operations, that is, in the physical sense, existing of the coal deposit "Tamnava – West field", [50].

The study proposes measures for mitigation of environmental impact through the implementation of the action plan for environment protection. Mentioned future activities are separated into four categories: (1) communication and transparency of EPS and local population, (2) detailed plan and reviews of mining activities, (3) development of environment protection management system (EMS) and (4) environment protection monitoring (during the mining operations in order to document and survey the mine impact on the environment), [www.eps.rs]. Accordingly, the Project for improvement of the environment in the Kolubara basin was created [www.eps.rs]. Project is conceived in accordance with the Spatial Plan of the Republic of Serbia, Spatial Plan of the Kolubara coal basin, Spatial Plan of the area of Kolubara lignite basin exploitation (2008) and Evaluation of environmental impact for surface mining in Tamnava – West field, as well as others.

5.3 Planned detailed studies

Based on the conditions from the *EPS Strategy and Long-term development program for Kolubara coal basin*, Program for population relocation was also created. There are activities foreseen for the end of the investment program on surface mine "Tamnava – West field", i.e. subject industrial energy resource – coal deposit, [www.eps.rs].

6. Level of confidence/reliability in estimates

6.1 Geological and other relevant aspects – coal deposit "Tamnava – West field"

Geological structure of Kolubara basin, and with it the subject coal deposit "Tamnava – West field" has been studied since the end of the XIX century, [12,40]. Structural-geological composition of coal-bearing basin is explored in great detail. Shown geological data in geological and other technical documentation (projects, elaborates, studies, etc.) and in expert publications are of a high level of confidence and reliability, which is confirmed by verification of coal reserves, on several occasions, [11,12,13,28,40].

Geological-structural elements and properties of the coal-bearing basin and its layers of coal are completely known, which was enough for mining projections and conducting of mining operations in coal exploitation (partly in the underground manner of mining). The entire surface of Kolubara basin is around 600 km^2, of which around 150 km^2 (25 per cent) is scheduled for the exploitation of coal layers with depth from 20 to 120 m, [12].

In the geological composition of Kolubara coal-bearing basin are included Paleozoic (Devonian, Carboniferous and Permian), Mesozoic (Triassic and Cretaceous) and tertiary formations (Miocene and Pliocene) and quarter sediments. There are the most of tertiary clay-sand sediments that are simultaneously bearers of powerful, thick layers of coal – lignite. The biggest part of the basin is covered by horizontal Neogene and quarter formations that are slightly dislocated. Complex tectonic, the structural set is seen only in certain peripheral parts of the explored terrain and wider area of Kolubara coal-bearing basin, that is basically still quite simple tectonic set. For Kolubara basin, during 2015, the synthetic geology map was created (R. Stojaković, M. Kezović, unpublished), that includes the overview of separate surface open pits (coal deposits). Also, illustrative geological profiles are created throughout the Kolubara basin, with a precise display of the vertical distribution of coal layers. This map and geological profiles have become indispensable parts of entire geological, mining and other technical documentation (studies, plans, etc.) and various expert publications. Based on said geology map, for the requirements of environmental study (EBRD), there is also a map of Kolubara basin with the

display of active and non-active mining facilities – fields, that includes positions of deposits – open surface pit "Tamnava – West field" (Annex: Figure 4), [www.eps.rs].

Engineering-geological and hydrogeological data, *data on surface and groundwater* of the Kolubara basin, was successively processed by qualified experts. In the deposit "Tamnava – West field" three types of aquifers are determined, with a total income of water from 0,66 to 0,74 m^3 per ton of excavated coal. In the zone of intensive stratification of complex coal layer, engineering-geological conditions are not favourable, [13].

Stated data on the coal deposit "Tamnava – West field" is on a *reliable and valid basis, with a high degree of confidence* for all geological, hydrogeological, mining, technological, energy, environmental and economic considerations and specific planning in Kolubara basin. The same is included in all geological, hydrogeological, engineering-geological, mining and other technical documents. In that sense, they are completely relevant, reliable and with a high degree of confidence for all types of evaluations (and comparison to UNFC-2019), which is *proven by technically feasible, economically viable and environmentally acceptable coal exploitation for several decades*.

6.2. Geological and other relevant aspects – for groundwater in Zlatibor area

During the hydrogeological exploration in the area of mountain Zlatibor, the principle that implies "evenness in conducting the exploration" was not uniform. Given the conditions and requirements of the exploration (Basic geology map, 1:100 000, etc.), this is understandable and acceptable, [62].

Accordingly, certain parts of the deposit of groundwater formed within the karst and fracture aquifer are explored at the level that enables determination and proving of balance reserves of groundwater ($B+C_1$ categories), while certain parts of explored terrain are left at the level of prognostic reserves (D_1 and D_2 categories).

6.3 Quantity and volume assessment for subject energy resources (coal) and water resources (groundwater) at national level

6.3.1. Coal deposit "Tamnava – West field"

At the end of 2012 in the entire *Kolubara basin*, there was a total of $2{,}75x10^9$ tons of geological reserves of coal, that is $2{,}13x10^9$ tons of balance reserves, $0{,}62x10^9$ t of outbalance, and $1{,}98x10^9$ tons of exploitation coal. Potential geological reserves of categories C_2, D_1 and D_2 are estimated at $0{,}32x10^9$ t of coal, [12]. During the 60 years of exploitation, about $1{,}98x10^9$ tons of coal has been excavated. Accordingly, at the end of 2013, there remain $2{,}9x10^9$ tons of geological coal reserves, [40]. Coal quality is defined by its content: ash 17.00 per cent, moisture 46.00 per cent and Lower Caloric Value (LCV) 7500 kJ7kg.

In the deposit "Tamnava – West field", at the end of 2009, quantity and volume of proven balance reserves of coal in categories $A+B+C_1$ was 374 Mt (A=22 Mt, B=107Mt, C_1=245Mt of coal), [12,77]. By administrative-technical expansion of the open surface pit (parts of other open pits were captured), at the end of 2012, in the deposit "Tamnava – West field" there was 420 Mt of coal reserves (categories $A+B+C_1$). Exploitation reserves of coal (categories $A+B+C_1$) that include losses and dilutions during exploitation were 315 Mt. Coal quality is shown through the lower caloric value of 7 200 kJ/kg, an ash content of 17.92 per cent, and moisture of 47.17 per cent, [12].

According to the data from Geology service MB Kolubara (Baroševac), at the end of 2019, in the coal deposit "Tamnava – West field" there remains 242 Mt of coal reserves (B =3,9 Mt or 2 per cent and C_1 = 238,6 Mt or 98 per cent), [77].

During the long exploitation of coal in the deposit "Tamnava – West field", the mutual share of particular geological reserves of coal in total quantities was fluctuating in the following scope: A = 6-11-0 per cent, B = 26-29-2 per cent and C_1= 63-65-98 per cent. The shares of categories A and B were reduced, while the C_1 category share (of low degree of determination probability, of 50 per cent) was increased and the category was not moved to a higher degree.

Thus, the process of earlier geology exploration of deposits of energy and other solid mineral raw materials was taking place in accordance with the determined and expertly justified condition, that the mutual projected share of the category of geological reserves in total quantities in the deposit (*in situ*) is to be: A=15 per cent, B=35 per cent and C_1=50 per cent. Such relation of explored categories of reserves was the basis for mining projections, which were based on A+B categories. Today that is not the case, because the Law allows mining projections on the C_1 category of (balance) reserves, as well. Practice shows that in the exploration of coal and metal deposits (predisposed for underground exploitation) this condition was significantly infringed and that in the most cases there was an enlargement of A category share in the total reserves quantities (up to 40 per cent), [41]. The shown ratio of categories of explored and proven balance reserves of A, B and C_1, for deposit "Tamnava – West field", basically, reflects, it could be said, unfavourable degree of deposit exploration, which is particularly shown by the state and share of categories B and C_1 at the end of 2013, [13].

In the Kolubara basin, there is approx. 30 Mt of coal and approx. 70 Mm^3 of overburden produced annually. For industry and mass consumption, 1,2 Mt of lignite is delivered annually, [40]. Feasibility of the entire project is observed through energy-environmental-economic effects of coal exploitation and their acceptability, as well as for coal consumption for electric energy production, [55].

Presented data on A, B and C_1 categories of coal reserves from deposit "Tamnava – West field" is very important for their adequate representation within UNFC – United Nations Framework Classification for Resources (Update 2019).

6.3.2. Groundwater in the area of mountain Zlatibor

In planning or strategic documents of the Republic of Serbia, the assessment of resources of *groundwater of mountain Zlatibor* was not considered in full. It is possible to perceive water resources – groundwater through the analysis of the fund documentation and published data that are related to various types of groundwater exploration.

For parts of the deposit formed within the karst and fractured aquifer in Zlatibor area, it is possible to show entire reserves and "share percentage" of certain categories of balance reserves (Tables 5 and 6). In the total balance of groundwater formed in the Zlatibor area, that share represents the scope of below 50 per cent when it comes to karst deposit, and below 20 per cent when it comes to groundwater deposit formed within the fractured aquifer, related to the prognosticated quantities of groundwater that could be exploited in Zlatibor area in a sustainable manner.

7. Classification of energy and water resource projects by using UNFC

Classification of subject projects of energy-coal and water resources-groundwater of Serbia (with categories A, B, C_1, C_2, D_1 and D_2 of geological and balance reserves), within three-

component system UNFC (United Nations Framework Classification for Resources; Update 2019), was conducted based on unofficial, ***proposed map of conversion*** by mutual comparison, analysis and harmonization of data on categories and on projects maturity.

7.1. Energy resource – Coal deposit "Tamnava – West field"

7.1.1. Review of environmental-social-economic data (E-axis)

Socio-economic and environment data from the project – coal deposit "Tamnava – West field", i.e. environmental-social-economic data (E-axis UNFC; Update 2019) were processed with respect to conditions of the legal regulations of Serbia according to which they were gathered. They are shown through categories A, B and C_1 of balance reserves.

In order to harmonize the subject categories A, B and C_1 with E-axis from UNFC system, the basic data from technical documentation created in accordance with the regulations of the Republic of Serbia and permits from the line Ministry were considered. In initial (starting or early) phase of the project, *socio-economic and environment data* have been processed for the first time through assessment of socio-economic factors in regard to the coal exploitation impact on the (social) environment. This is done in the section of factor analysis and technical-economic mark assessment of the "Elaborate on resources and reserves", thus the subject data, by verification of balance reserves, become legally verified (on a certain date). Environmental-social-economic data (values) are again processed in the "Study on the assessment of project impact on the environment", "Feasibility study…" and "Main mining project of exploitation". Therefore, subject data are shown in the documentation, based on which and according to the law, appropriate permits and consents can be acquired from the authorities.

In subject technical documentation, the impact of the exploitation of reserves (A, B and C_1 categories) on the social community is considered. There is also a review of the impact on the social structure of the population, on the state of the (social) environment, on public and other facilities in the zone of mining operations impact, as well as on the expropriation and change of the soil structure, on infrastructure, and others. The impact of the mining operations of coal excavation in all technical and technological phases of exploitation, and the impact of preparations and processing of coal on the environment are determined, and they define control measures and their implementation for environment protection and remediation requirements.

Coal project "Tamnava – West field", i.e. coal exploitation, has indubitable socio-economic significance and social impact, given that coal is, almost entirely, used for electric energy production. The economic prosperity of the area, in this case, is considered through the number of permanently employed workers, their material-financial income, but also through the development of other accompanying activities and new employment requirements. For normal functioning, economic development of rural and urban areas is achieved, the economy and industry, culture, health services, education, sports and other accompanying activities are developing.

For the socio-economic significance of this resource – coal, it is important to know that coal, as an energy resource in the deposit is exhaustible and non-renewable. By physical exhaustion of coal from the deposit, the end of exploitation will inevitably happen, and coal exploitation, in this case, is a matter of *public interest*, which will certainly have a negative effect on the environmental-social-economic significance, i.e. on the entire social flow of this area.

The impact of surface exploitation, preparation and processing of coal, and transport to thermal facilities, *on the environment (environmental status)* is obvious and clearly visible. It is seen primarily in the degradation of large swaths of land. Mining operations deteriorate the main elements of the environment, that is, they contaminate the surface and groundwater, air (by

suspended particles of mineral dust, gases, etc.), above-mentioned soil, etc. Coal exploitation from the deposit "Tamnava – West field" has completely positively confirmed the *environmental-social-economic data (values), through complete feasibility, cost-effectiveness and acceptability of the project.*

In accordance with all above mentioned, the subject categories of balance and exploitation reserves A+B+C$_1$, are codified with the class of commercial projects into E category, UNFC-United Nations Framework Classification for Resources (Update 2019), as E1, while categories of A+B+C$_1$ of outbalance reserves, as E2, [6,7,43], (Annex: Figure 8).

National Classification	Category	UNFC definition	Reasoning for the classification
Balance A+B+C1	E1	Development and operation are confirmed to be environmentally-socially-economically viable.	• Environmental-socio-economic data (E-axis) are in accordance with the legislation, considered at several levels of projects • On the basis of positive assessments, the necessary approvals and consents were obtained • They have been proven by successful exploitation over decades
Outbalance A+B+C1	E2	Development and operation are expected to become environmentally-socially-economically viable in the foreseeable future	• At this moment, due to the spatial distribution of reserve categories, the existing technique and technology cannot be excavated profitably • Development and operation are expected to become environmentally-socially-*economically viable* in the foreseeable future

7.1.2. The assessment of information on project feasibility and maturity (F-axis)

The assessment of information on project feasibility and maturity for the coal deposit "Tamnava – West field", for the purposes of harmonization with F-axis of UNFC-2019, is considered in accordance with the period of several decades of coal exploitation.

Exploitation is conducted in accordance with the legal approvals from the authorities, and based on approved mining projects and feasibility study, that are sufficiently detailed. Available information on project feasibility shows that *the feasibility is proven* by several decades of exploitation of balance, i.e. exploitation reserves of A+B+C$_1$ categories (that include losses and dilutions). Feasibility assessment through additional Feasibility study is not necessary and should not be asked for. This means that the active production, coal excavation, has been successfully underway since 1995/96, and is in its entirety in accordance with conditions and technical solutions from the approved, Main and Auxiliary mining project and Feasibility study of exploitation, that contains sufficient valid evidence.

According to the dynamic of reserves mining from the coal deposit "Tamnava – West field", ***categories A+B+C$_1$ of balance and exploitation reserves are positioned in the F-axis of UNFC, as F$_1$. At the time of assessment, the quantity of outbalance reserves is not profitable for mining, without additional data, and is therefore classified into sub-category F$_2$,*** [6,7,43], (Annex, Figure 8).

National Classification	Category	UNFC definition	The reasoning for the classification
Balance $A+B+C_1$	F1	Technical feasibility of a development project has been confirmed	• Exploitation is performed, in accordance with the legal approvals of the competent authority, and on the basis of approved mining projects and feasibility studies, which are sufficient details • They have been proven by successful exploitation over decades
Outbalance $A+B+C_1$	F2	Technical feasibility of a development projects is subject to further evaluation	• At this moment, due to the spatial distribution of reserve categories, the existing technique and technology cannot be excavated profitably • Technical feasibility of a development projects *is subject to further evaluation*

7.1.3. Review of (geological) knowledge, reliability and confidence in the assessments (G-axis)

For the assessment of geological study and reliability, according to the condition of G-axis of UNFC framework, for subject deposit "Tamnava – West field", the structure of ($A+B+C_1$, $A+B$, $B+C_1$…) categories of geological and balance reserves (A+B+C1, A+B, B+C, …) in total quantities and their mutual shares are of particular interest. For coal deposit "Tamnava – West field", in the previous period, several "Elaborates on resources and reserves of coal" (previously "Elaborate on coal reserves…") have been created, and they prove the balance of geological coal reserves. The initial quantity of reserves was 670 Mt of coal in categories $A+B+C_1$. By active exploitation of coal, the quantity of coal is reduced to current 250 Mt of coal approx. (242 Mt exactly). The share of A category of balance reserves in total quantities was decreased with time, from previous 25 per cent to 11 per cent, 6 per cent and 4 per cent and is currently 0 per cent. In the deposit, there is, according to the technical conditions of exploitation, a class of outbalance reserves of A category (that is classified within the UNFC framework). The share of B category was, by intensive exploitation, changing – reducing from 34 per cent to 29 per cent and 28 per cent, and is now 2 per cent. Category C_1, had a share of 40 per cent, then it increased to 65 per cent and 68 per cent, and is currently at 98 per cent [calculated by R. Vukas, 2020].

For data comparison, it is important to mention that the reserves of A category are the ones with the highest certainty, or with the highest degree of probability of reserves determining (of 85 per cent) and allowed margin for error of 15 per cent. B category is determined – proving with the degree of probability of 70 per cent, that is, with the margin for error of 30 per cent. For C_1 category, degree of probability is low, only 50 per cent, with the same margin for error in determining reserves (50 per cent). Therefore, the structure of category and mutual share in total quantity reflect different *degrees of exploration (unequal level of risk) of the deposit*, i.e. the level of knowledge (of particular resource), [41].

Shown data, manner and conditions of determining of subject reserves A, B and C_1 are highly important for the creation of technical documentation (Feasibility studies, etc. in accordance with the generally known standards), which reflect the degree of advancement (maturity) of the mineral project. Often these data are neglected in further mining and other technical projections (because of the scope of C_1 categories of geological reserves, that is of the low level of reliability, which makes all types of data comparison difficult).

From above mentioned it is visible that, during the exploitation of the coal deposit there was no significant geological exploration, given that the C_1 category of reserves (with a low degree of reliability, or a high degree of risk, 50 per cent) was not moved to categories of higher

degree of probability (B category). B category (70 per cent), also, was not further explored and re-categorized into the A category, which in a certain way, reduced the degree of confidence.

Based on all above mentioned, harmonization of subject coal reserves A, B and C_1 with G-axis of UNFC framework (Update 2019), in data comparison, categories A and B of balance/exploitation reserves are recognized in G-axis, as category G_1, and category C_1 as G_2, [6,7,43], (Annex: Figure 8).

National Classification	Category	UNFC definition	The reasoning for the classification
Balance A+B	G1	Product quantity associated with a project that can be estimated with high level of confidence	• Product quantity of A+B category balance/exploitation reserves associated with a project that can be estimated with high level of confidence (85 per cent and 70 per cent by law regulation) • Exploitation is performed, in accordance with the legal approvals of the competent authority • They have been proven by successful exploitation over decades
Balance C_1	G2	Product quantity associated with a project that can be estimated with a moderate level of confidence	• Product quantity of C_1 category of balance reserves associated with a project that can be estimated with moderate level of confidence (50 per cent by law regulation) • Exploitation is performed, in accordance with the legal approvals of the competent authority

7.2. Other relevant observations

According to the legal regulations of Serbia, basic geological document in which the categories of geological reserves (A, B and C_1) are separated and balanced is the "Elaborate on resources and reserves…" The document is of synthetic character, and its content (per the opinion of some qualified, competent individuals) "corresponds" to the level and content of the document *Pre-Feasibility Study*, i.e. in lesser part to the *Feasibility Study*, from generally known standards JORC code, Ni 43-101, etc. (Per this author's opinion, the subject issue is for further consideration).

7.3 Water resource – groundwater in Zlatibor area

Exploration and exploitation of groundwater in Serbia are primarily regulated by current Law on Mining and Geology Exploration (2015). According to the provisions of the Law, legal entities that use groundwater as a resource for heating and cooling energy production are obliged to acquire three levels of permits: (I) *Approval for conducting applied geothermal exploration* which is issued based on the project for applied geothermal exploration created in full in accordance with the Rulebook on conditions, criteria and content of the project for all types of geology exploration, (*Official Gazette RS, 45/2019*); (II) *Decision on balance reserves of groundwater* that is issued based on the Elaborate on groundwater reserves created in full in accordance with the Rulebook on classification and categorization of groundwater and their record-keeping (*Off. Gaz. SFRY, 34/79*) and (III) *Decision on exploitation area* that is issued based on the Elaborate on the conditions of groundwater exploitation created in full in accordance with the Rulebook on the content of the elaborate on the conditions of groundwater or

hydro-geothermal resources or petro-geothermal resources exploitation, and conditions and manner of the technical control of the Elaborate (*Official Gazette RS, 7/18*).

In the following Tables 9 and 10, there is the overview of issued permits and consents for the exploitation of the groundwater, in accordance with the Law on Mining and Geology Exploration (2015), Law on Waters (2010,2012,2016,2018), Law on Nature Protection (2001).

Table 9: Overview of the permits and consents for the exploitation of groundwater formed within the karst type of aquifer in the area of mountain Zlatibor [http://www.rdvode.gov.rs/lat/vodna-akta-vodna-knjiga.php, http://geoliss.mre.gov.rs/geoliep/].

Deposit: Appearance/object	Law on Mining and Geology Exploration	Law on Waters	Law on Nature Protection
	The decision on exploitation area/field	Water permit	Consent to the project for sustainable utilization of natural resource
Sušičko vrelo	NO	NO	YES
Dobroselička vrela	NO	NO	NO
Zlatibor voda (BSG-1/09)	NO	NO	NO

Table 10: Overview of the permits and consents for the exploitation of groundwater formed within the fracture type of aquifer in the area of mountain Zlatibor [http://www.rdvode.gov.rs/lat/vodna-akta-vodna-knjiga.php, http://geoliss.mre.gov.rs/geoliep/].

Deposit: Appearance/object	Law on Mining and Geology Exploration	Law on Waters	Law on Nature Protection
	The decision on exploitation area/field	Water permit	Consent to the project for sustainable utilization of natural resource
IEBO-1/09	No	No	Yes
Hemel-1	No	No	Yes
IEBT-1/11	No	No	Yes
Kraljeva voda	Yes	Yes	No

7.3.1 Review of environmental-social-economic data (E-axis)

Explorations of groundwater of karst aquifer are mostly performed to the level of determining groundwater balance reserves. Further activities, related to the acquisition of permits and consents for the exploitation of the groundwater are partially realized only on the groundwater source Sušičko vrelo. The reason for this is that the groundwater of karst aquifer for which the groundwater reserves are determined is not currently exploited (with the exception of source Sušičko vrelo that is connected to the water supply system for the city of Užice).

Groundwater formed within the fracture type of aquifer is mostly used for the requirements of heating and cooling energy production. The exception is groundwater from the spring Kraljeva voda that is used for bottling.

Groundwater used as a geothermal resource is not subject to the provisions of Law on Waters, and accordingly springs IEBO-1/19, Hemel-1 and IEBT-/11 do not have water permit. These springs are opened in the period when the Law on Mining and Geology Exploration from 2011 was in force, and approval holders were not under obligation to obtain the decision on exploitation area/field, but only the consent for groundwater utilization. Accordingly, groundwater users (formed within the fracture type of aquifer) have the above-mentioned consent

only, for the spring Kraljeva voda, the approval on exploitation field was obtained (Law on Mining, 1995), as well as water permit in accordance with the Law on Waters, which makes the source completely legalized.

National Classification	Category	UNFC -definition	The reasoning for the classification
A+B cat. Groundwater Project-fissure type: Kraljeva voda	E1	Development and operation are confirmed to be environmentally-socially-economically viable.	• The data were confirmed by all obtained permits and decades of project work
A+B cat. Groundwater Project-fissure type: IEBO-1/19, Hemel-1 and IEBT-/11	E1.1	Development is environmentally-socially-economically viable on the basis of current conditions and realistic assumptions of future conditions.	• Development is environmentally-socially-economically viable on the basis of current conditions and realistic assumptions of future conditions • At this moment, the projects do not have a water permit, but only consent as an intermediate phase

7.3.2. Assessment of information on feasibility and maturity of the project (F-axis)

Sources of groundwater formed within the karst type of aquifer in Zlatibor area are intended mainly for public water supply to the population. The degree of exploration of karst type of aquifer is still in the early phase of the project, i.e. at the level of determining and proving of groundwater reserves. In the following period, according to the users' requirements, subject sources shall be included in the water supply system for the population.

Analyzed sources of groundwater formed within the fracture type of aquifer are already into commercial exploitation. Given that the exploitation of the groundwater on analyzed springs started before the Law on Mining and Geology Exploration came into force (Official Gazette RS 101/2015 and 95/2018, other law), in the following period, users/owners of said springs will start the harmonization process for groundwater exploitation with the provisions of this Law.

National Classification	Category	UNFC-definition	The reasoning for the classification
A+B cat. Groundwater Project-fracture aquifer: Kraljeva voda	F1	Technical feasibility of a development project has been confirmed.	• Feasibility has been confirmed in production
A+B cat. Groundwater Project-fracture aquifer: IEBO-1/19, Hemel-1 and IEBT-/11	F1.1	Production is currently taking place	• Feasibility is confirmed by current exploitation, but all types of permits have been not obtained

7.3.3. Overview of geological reliability and confidence in assessment (G-axis)

Users of groundwater formed within karst aquifer have mostly reached the level of determination of reserves for groundwater of B and C_1 categories. Further activities are related to the obtaining of water permit and exploitation area before spring inclusion into commercial exploitation (which is possible even without A category of reserves).

Users of groundwater formed within fracture aquifer have reached the level of defining sustainable utilization of natural resource – groundwater. In the following period, it is necessary to conduct the indispensable scope of hydro-geological exploration related to the defining of the exploitation area.

In each case, it is desirable that the level of exploration of analyzed groundwater formed within the karst and fractured aquifer, during the period of exploitation, be brought to the level of reserves of A category.

National Classification	Category	UNFC -definition	The reasoning for the classification
A cat. Project karst aquifer: Sušičko vrelo and Dobroselička vrela	G1	Product quantity associated with a project that can be estimated with a high level of confidence.	• Product quantity associated with a project that can be estimated with a high level of confidence (B-category)
A cat. Project karst aquifer: Bobroselička vrela	G1	Product quantity associated with a project that can be estimated with a moderate level of confidence	• Product quantity associated with a project that can be estimated with a high level of confidence (C_1- category)

7.4. Categories of geological and balance reserves of coal and groundwater of the subject projects for energy and water resource within UNFC

7.4.1. Energy resource – coal deposit "Tamnava – West field"

Based on all above-mentioned in this Report, and based on the content of Tables 1 and 2, i.e. a proposed map of conversion, the quantities and categories of geological and balance reserves from coal deposit "Tamnava – West field" are adjusted to the UNFC-2019 system, as shown in Table 8.

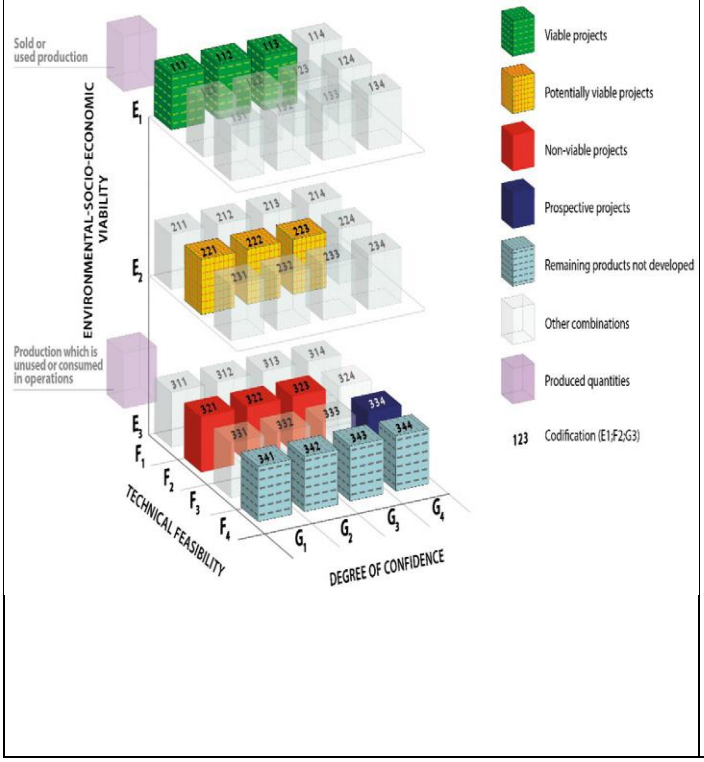
7.4.2. Water resource – groundwater in Zlatibor area

Approvals and decisions for groundwater reserves that, according to the law, issues state authority, do not recognize the UNFC-United Nations Framework Classification for Resources (Update 2019).

Groundwater project in Zlatibor area, in regards to the adjustment to the UNFC-2019, was considered according to the categories A, B, C_1, C_2, D_1 and D_2 of geological and A, B and C_1 of balance reserves, based on unofficial and here proposed *map of conversion* given in Table 3 (B. Jolović, R. Vukas, Dj. Milanković, 2020-unpublished).

Energy and water resources of Serbia **have been considered in reserves categories, adjusted to the UNFC system, and given in** Table 11 [prepared by R.Vukas, 2020].

Table 11: Categories A, B, C_1, C_2, D_1 and D_2 of geological and balance reserves for subject projects: coal deposit "Tamnava – West field" and groundwater in Zlatibor area, within UNFC-2019 system [prepared by R.Vukas, 2020].



UNFC (Update 2019)	Serbian classification system			
	Coal deposit "Tamnava-West field" Category of coal reserves, end 2019 (Mt)		Groundwater of Mountain Zlatibor Balance reserves - Karst and fracture aquifer (l/s)	
111	Balance/Exploitation A+B	3,916	A	
112	Balance/Exploitation C_1	238,697	B	158,5
113				
221	Off-balance A+B	37,268	212-B	
222	Off-balance C_1	44,675	213-C_1	35,0
223	Potential reserves C_2	-	C_1	
321	In situ, Geological reserves A+B	41,184		-
322	In situ, Geological reserves C_1	283,372		-
323	In situ, Geological reserves C_2	-		-
334	In situ, Geological reseves D_1 and D_2	-		-

8. Harmonization with the implementation of Sustainable Development Goals (SGD)

8.1. National approach

Government of the Republic of Serbia participated in the development and writing of the Agenda on Sustainable Development Goals of the United Nations UNDP program [www.rs.undp.org].

Sustainable development goals, globally speaking, all 17 of them represent the universal call to action towards poverty eradication, environment protection and ensuring peace and prosperity for all. Sustainable development goals that encompass around 170 countries in the world have come to force in 2016, with the intention of being fulfilled in the following 15 years.

These 17 goals are based on the current development plan, and according to the priority, they encompass new areas, such as climate change, economic inequality, innovations, sustainable consumption, peace and justice. Subject goals are mutually interconnected, while the activities for fulfilment of sustainable development goals are taking place through partnership in a pragmatic way so that the right choices can be made, which would ensure the sustainable improvement of life for future generations.

Development agency of the United Nations – UNDP offers support to the integration of Sustainable Development Goals and national policies, development and strategic plans, as can be seen through the realization of the subject project "Integrated energy and water resources management in Serbia in using UNFC system" (as support to development goals 6 and 7). Fulfilment of Sustainable Development Goals is achieved through the partnership of governments, private sector, civil society and citizens, [www.rs.undp.org].

The national approach in *Sustainable Development Goals implementation* is reflected in creation and implementation of strategic policies and planning documents, as well as in the adequate application of legal regulation that is being harmonized with the Sustainable Development Goals. Legal-administrative regulation of the Republic of Serbia comes from the highest state legal action, and it includes: National strategy on sustainable development in Serbia until 2025 with projections until 2030 (2015); National strategy of sustainable utilization of natural resources and goods (2015); Energy Strategy until 2025 with projections until 2030 (2015): Energy balance of the Republic of Serbia (2020); National strategy on water resources management (2015); Spatial plan of Serbia 2010-2020 (2010); Law on the spatial plan of the Republic of Serbia 2010-2020 (2010): Law on Energy (2014); Law on Mining and Geology Exploration (2015); Law on Waters (2010, 2012, 2016, 2018); Law on Planning and Building (2009, 2013); Law on Environment Protection (2005), Law on Statistics of the Republic of Serbia (2015), and other planning acts and strategic documents.

At the national level, subject issues of *goals and indicators for sustainable development are processed by the Statistical Office of the Republic of Serbia*, [www.sgz.gov.rs]. The Office processes and shows sustainable development indicators from the United Nations Agenda, that are implemented, for the Republic of Serbia, in 17 sustainable development goals, for the observed period from 2010 to 2018.

According to the statistical data, procedures and indicators in the Republic of Serbia (for 2019), for subject *Case Study* Sustainable Development Goals 6 and 7 are important (ensuring the availability and sustainable management of water and sanitation for all, ensuring the access to available, reliable and modern energy for all), and they *show even and uniform flow and positive trend of development, with mild oscillations.* [www.stat.gov.rs]

In accordance with all above-mentioned, the project *Integrated energy and water resources management in Serbia in using UNFC system* fully supports Goals 6 and 7. Meaning, regarding Goal 6, it can be seen that through set procedures during project implementation for energy (coal) and water resource (groundwater), the work on project improvement and development is active in aspects of water quality and environment. There are efforts for reduction of dangerous chemicals and materials release into waters, i.e. for an increase in the degree of purification. Water recycling is being considered in all sectors, as well as more efficient utilization of resources. The local community is perceived as significant in playing a role in improvement towards integrated water management. From the aspect of fulfilling Goal 7 of sustainable development, through constant improvement of sectoral regulations, is it clear to see the approach to cheaper energy and improvement of energy efficiency conditions. [www.stat.gov.rs].

8.2. Sectoral / industrial strategies

In the ***energy resources sector***, Energy Strategy until 2025 with projections until 2030 (2015), Energy Balance for 2020 (2019) and current laws and rulebooks have the dominant role in the development. For energy and environment protection, the significant is Spatial Plan of the Republic of Serbia (2010), National Strategy on sustainable utilization of natural resources and goods (2012), Strategy on the utilization of renewable sources of energy, Environment Protection Strategy of the Republic of Serbia, National program for environment protection (2010), Proposal of the environment protection strategy for the period from 2019 to 2025 and other accompanying planning and strategic documents. Subject documents are available at www.mre.gov.rs; www-mgsi.gov.rs; www.mpolj.gov.rs, and all statistical energy indicators of the Republic of Serbia (comparable to EUROSTAT and International Energy Agency) are available at www.stat.gov.rs

Water resources sector (surface and groundwater, for water supply and as hydro-energy potential) is governed by the following documents: Strategy on water management in the territory of the Republic of Serbia; Analyses and exploration, 2015 (Institute "Jaroslav Černi" Belgrade) and *Vodoprivredna osnova* of the Republic of Serbia (by the Republic Hydrometeorological Service of Serbia) and accompanying laws, regulations and rulebooks.

In the ***environment protection sector***, based on the Law on environment protection (2004… 2009), the dominant place is given to National program for environment protection from 2010 (it relates to the period of at least ten years), and appropriate projects from the energy sector. For the purposes of full harmonization with the EU Directives, the subject projects envision the reduction of air pollution from big industrial facilities and power plants, as well as insurance of appropriate management for power plant ash landfills, etc.

As predicted, Serbia shall invest significant financial means in environment protection in the following two-three decades – approx. $15x10^9$ RSD; 1RSD=0,0085€ at the date of June 20th, 2020. The biggest scope of funds is intended for industrial and household sewer waters purification systems that are currently not being purified in necessary, satisfactory scope.

8.3. COVID -19 related issues

United Nations made the COVID-19 response priority in providing support in many areas. Emergency interventions that UNECE took regarding the UNFC and UNRMS include announcements from April 17th 2020 such as: "Ensuring the critical raw materials supply is crucial for the response to COVID-19", stating that UNFC and UNRMS can be used for a gathering of consistent data and information on critical raw materials from conventional and non-conventional sources, as well as female entrepreneurship in natural resources management as: "Challenges and possibilities for MMSP sector in socio-economic sector post-COVID-19 recovery."

A study was planned within UNDP project "Integrated energy and water resources management for support to sustainable development in Europe and East Asia" with focus on "COVID-19 impact to critical supplies of raw materials necessary for health protection sector."

According to the data from the Ministry of Health (https://covid19.rs) on the date of June 4th 2020 in the Republic of Serbia, the total number of registered cases is 15,829. The number of deaths is 306, meaning that the mortality rate is 1.93 per cent. There are 23 most innovative local solutions presented in Serbia – ideas for reducing the effect of COVID-19 pandemic, valued at 7 M $US (with the support from USAID and Germany);
(https://www.rs.undp.org/content/serbia/sr/home/blog/2020/the-covid-19-pandemic--a-human-development-crisis.html).

When we consider the COVID-19 pandemic within the subject mining-energy project for coal deposit "Tamnava – West field", it must be observed from the aspect of coal excavation and regular electric energy production in Serbia and its delivery to the consumers. In this sense, COVID-19 has the biggest impact on environmental-social-economic data (E-axis), with a lesser impact on project implementation (F-axis). Besides the health status and care for employees health that is a priority, this impact is clearly visible, in everyday work engagement of the employees, through the introduction of working from home, reduction of work time, shift or workplace change, the introduction of new means of communication among employees, and thus the reduction in financial income of the employees, etc. Basically, implementation of this project is performed in accordance with the new emergency situation and movement of the COVID-19 pandemic, which is harmonized with the priority task of electric energy production, economic development, etc.

When the project for groundwater in Zlatibor area is considered from the COVID-19 aspect, there is clearly visible the impact it has on the state of environmental-social-economic data (E-axis), on project implementation in water supply and bottling (F-axis), and on population and employees. In the first case, COVID-19 is reflected almost identically to the energy resource – coal project.

In both cases, there are enough stimulations for the development of public and private sectors, i.e. small and medium entrepreneurship, especially for the development of new technologies with the aim of public health protection, production and utilization of safety equipment, application of critical, deficient mineral raw materials in the health protection system. All of this in accordance with the presented 23 innovative solutions in Serbia and general Agenda for Sustainable Development Goals.

9. Conclusions on energy and water resources classification in the Republic of Serbia within the UNFC system for resources classification

9.1 Advantages of UNFC on national and project level of decision-making

Classification of energy resources (coal) and water resources (groundwater) in the Republic of Serbia is performed in accordance with the current legal regulations and still valid regulations (rulebooks) that date from the period of former SFR Yugoslavia.

Energy resources (solid, liquid and gas) in the deposit (*in situ* quantities) are classified in accordance with the Law on Mining and Geology Exploration of the Republic of Serbia (2015) into categories A, B, C_1, C_2, D_1 and D_2 of geological reserves (in situ) and a class of balance and outbalance reserves according to the Rulebook on classification and categorization of reserves of solid mineral raw materials and their record-keeping (1979), and according to the Rulebook on classification and categorization of reserves of oil, condensate and natural gases and their record-keeping (1987).

Water resources – groundwater are sorted into categories A, B, C_1, C_2, D_1 and D_2 of groundwater reserves and balance class (A, B, C_1) in accordance with the provisions of the Rulebook on classification and categorization of groundwater and their record-keeping (1979). *Petro-geothermal resources*, as a separate energy resource, are classified according to the provisions of the Rulebook on conditions, criteria, content and manner of classification of petro-geothermal resources and manner of their presentation in the elaborate of the Republic of Serbia (2018).

In legal regulation of Serbia, currently, there is no legal provision or decision on the application of the UNFC system and resource classification. There is initially stated the need for harmonization of data on resources of Serbia with the UNFC system, which is recorded in technical documents for the cooperation of Serbia with UNECE in the next period.

Globally speaking, UNFC system for resource classification, through the regional forum, provides help to the government for the development of practical instruments in the form of conventions, regulations, norms and standards at national and project level of decision-making, according to the UNFC-United Nations Framework Classification for Resources (Update 2019). Based on the neutral platform, an open and transparent process for pragmatic work system is being implemented (ECOSOC Decision 2004/233).

Accordingly, subject project *Integrated energy and water resources management in Serbia in using UNFC system and Case study with subject Report* was developed with the task of achieving goals of integrated energy and water resources management at the national level, by application of UNFC system for resource classification. Implementation of UNFC system for resource classification achieves the goals of sustainable development and provides more than optimal solution for making all sorts of decisions and public policies in the sector of energy and water resources of Serbia, at the national level and wider.

Energy resources – *coal project "Tamnava – West field"* according to the UNFC system is classified as:

Total Products Project of coal " Tamnava-West field"	**Produced**	**Sold or used production**			
		Production which is unused or consumed in operations			
		Class	**E**	**F**	**G**
	The projects environmental-socio-economic viability and technical has been confirmed	Viable projects	1	1	1
		Potentially Viable Projects	2	2	1,2
	The projects environmental-socio-economic viability and technical has yet to be confirmed	Non-Viable Projects	2	2	3
			3	2	1

Water resource – *Project groundwater in Zlatibor area* is classified as:

Total Products Project of groundwater of Mountain Zlatibor	**Produced**	**Sold or used production**			
		Production which is unused or consumed in operations			
		Class	**E**	**F**	**G**
	The projects environmental-socio-economic viability and technical has been confirmed	Viable projects	1	1	1,2
		Potentially Viable Projects	2		2,3
	The projects environmental-socio-economic viability and technical has yet to be confirmed	Non-Viable Projects	2	2	3

9.2 Limitations in using UNFC

In the legal, formal sense, in the Republic of Serbia, there is no appropriate decision that would define the application of the UNFC framework for resource classification. This means that there are certain limitations in the sense of the formal application of the UNFC framework for resource classification, for the process of project reporting on categories and classes of energy and water resources according to the Sustainable Development Goals, not just on a national level, but wider. Because of the lack of an appropriate decision from competent authorities in Serbia, and thus of Aligned System as well as Bridging Document, and other instructions and tools of UNFC, the application of this system is completely disenabled. In Serbia, there is, at this moment, proposed *map of conversion* (by the competent individuals) that makes the basis for adjustment of data on categories A, B, C_1, C_2, D_1 and D_2 and classes of geological reserves of energy and water resources from national resource classification system of Serbia in the three-component system of E, F and G-axis of UNFC (Update 2019).

9.3 Benefits and using of UNFC system for adjustment to the Sustainable Development Goals (SDG)

Keeping in mind all the facts, that the UNFC system of classification is a global system for resource classification and that it encompasses different resources (Update 2019), its adequate application would be a significant benefit, primarily because for particular resources the acceptable classification systems are not yet known or developed. This system developed in the area of energy and water resources, in accordance with the adopted Sustainable Development Goals is more than clear benefit, given that the aim of all interested parties (government, industries, investors, etc.), it could be said, is a wholly uniform and integrated manner for their management.

As seen from the aspect of Sustainable Development Goals (SDG) at the national level, said Project contains data on energy (coal) and water resources (groundwater) that are processed and monitored by the Statistical Office of the Republic of Serbia (ww.stat.gov.rs). Data on quantities of A, B and C_1 of energy and water resources that are processed statistically, certainly have its flaws due to the unharmonized regulations, and thus incomplete statistical data processing.

By application of UNFC system for resource classification (2019), subject data would be annulled, which is certainly a benefit towards the integrated energy and water resources management in accordance with the uniform manner of reserves classification, and then towards general recognition in planning, industry (business), trade, statistics, etc.

9.4. Other remarks

It is important to stipulate once more that in Serbia there is not one act of the competent authority or legal provision that would classify energy and water resources for public presentation and harmonization according to the UNFC system of resource classification (earlier 2009).

This project shows many deficiencies in the assessment of current projects, i.e. giving the mark for their progress (regarding the entire viability), even though the legal regulation was innovated in the meantime. Meaning, the categorization of mineral resources and reserves (solid mineral raw materials reserves) is still based on the system of reserves categorization from the earlier, socialist period. Very little was done in the area of approaching and understanding of categories of geological and balance reserves and new terms of mineral resources and reserves.

Given that the almost identical categorization and classification of solid mineral raw materials, oil and groundwater reserves is still applied in the countries of former Yugoslavia, there is a growing need for their adjustment to the UNFC system for resource classification, through joint, national and UNECE activities in this region, through regional summits, founding of ad hoc workgroups for this issue, case studies, etc., which this author proposes for the upcoming period. Author, besides, suggests drafting of more extensive case study for uranium deposits, critical or scarce mineral raw materials in the EU for various needs (healthcare, agriculture, new technologies, etc.).

10. References

[1]. Denić M., Kokerić S., 2013: Position of underground coal exploitation in Serbia energy sector; Committee for underground exploitation of mineral raw materials *Resavica*, Mining operations, (Pozicija podzemne eksploatacije uglja u energetskom sektoru Srbije; Komitet za podzemnu eksploataciju mineralnih sirovina Resavica, Rudarski radovi), UDK 622, N°47.

[2]. Đokić I., Nikolić B., 2012: Elaborate on groundwater reserves of spring source in Gostilje-Bunar BSG-1/09 (Čajetina municipality), Fund documentation of the company Geco inženjering doo, Belgrade (Elaborat o rezervama podzemnih voda izvorišta vrelo u Gostilju-Bunar BSG-1/09)

[3].Galos K, Nieć M., Saluga P.W, Uberman R., 2015: The basic problems of mineral resources valuation methodologies within the framework of system of Integrated Environmental and Economic Accounts, Gospodarka Surowacami Mineralnymi - Mineral Resources management, Volume 11, issue 4, DOI, 2015-0034.

[4]. Grujić G., 2018. Water resources of the Republic of Serbia, State Analysis; (Vodni resursi Republike Srbije, Analiza stanja) OASIS, Beograd.

[5]. Ilić M., Pavlović V., Vukas R., Beljić Č, 2009: A comparative analysis of Serbian and World classification of mineral reserves and resources and proposal for innovation and harmonization of Serban classification, VIII International Conference Nonmetals 2009, Vrujci spa, 14-17 October 2009.

[6]. Ilić M., Jelenković R., Vukas R., Beljić Č, 2013: Correlation of resources and reserves of solid mineral raw material codified in the United Nations Framework classification and in Serbian legislature, 6thInternational conference, COAL 2013, Zlatibor, 2-5 October 2013.

[7**].** Ilich M.,Vukas R., 2016: On the harmonization of Serbian classification and accompanying regulations on resources/reserves of solid minerals with the PERC standard, European Geologist Journal 41.

[8]. Ilić S., 2009: Methods and principles of soil sanitation upon land reclamation of coal pit mines, VIII International Conference Nonmetals 2009, Vrujci spa, 14-17 October 2009.

[9]. Jelenković R., 2014: A brief overview of the metallic mineral resources of Serbia, European Geologist Journal 37.

[10]. Jokić V., Petovar K., 2010: Assessment of impact on the social development in the projects regarding opening and expansion of surface mining (1,6AT), Thematic Collection No. 61, publisher Institute for Architecture and Urbanism, March 2010, Belgrade; (Procena uticaja na socijalni razvoj u projektima otvaranja i širenja površinskih kopova (1,6AT), Tematski zbornik, br. 61, Izdavač Institut za arhitekturu i urbanizam, Mart 2010 Beograd.

[11]. Kezović M., 2013: Geological and minable coal reserves in the Western part of Kolubara coal basin, 6thInternational conference, COAL 2013, Zlatibor, 2-5 October 2013.

[12]. Kezović M., 2013: The coal of Kolubara basin, 6th International conference, COAL 2013, Zlatibor, 2-5 October 2013.

[13]. Kezović M., 2014: Assessment criteria perspective Kolubara basin, 1^{1th} International opencast mining conference, OMC 214, Zlatibor, 15-18 October 2014.
[14]. Konig C., Filipović D., 2010: 3D Groundwater-Model for defining a concept of dewatering coal mine „Tamnava west “, Lazarevac, Serbia. 15th Congress of the Geologists of Serbia, Belgrade, 26-29 May 2010.
[15]. Kolonja B., 2007: The Serbian Mining Industry (power point presentation), 18th Annual General Meeting, Belgrade, June, 23-27 (Mining and geology Faculty).
[16]. Kostić A., Ilić M., 2013: On the treatment of oil in the proposed new legislation in the field of geological exploration and mining in Serbia; ^{6th} International conference, COAL 2013, Zlatibor, 2-5 October 2013.
[17]. Milenic, D., Milankovic, Dj., Petric, M., Savic, N., Vranjes, A., 2014: “Integrated management od karstic waters-a case study of the Zlatibor mountain massif, Serbia” Global NEST
[18]. Milenic, D., Milankovic, Dj., Vranjes, A., 2011: Possibilities of groundwaters bottling in Zlatibor ultramafic massif, Water and Sanitary Technic, pp. 33-46 („Mogućnosti flaširanja podzemnih voda Zlatiborskog ultramafitskog masiva“, Voda i sanitarna tehnika, pp. 33-46), ISSN 0350-5049, UDK: 663.64.059(497.11)
[19]. Milankovic, Dj., Milenic, D., Vranjes, A., Doncev, B., 2014: “Integrated Management of Groundwaters in Mountain Areas-Zlatibor Mountain Case Study (Western Serbia, Europe) “Abstract Proceedings of the AWRA 50th Annual Water Resources Conference, Tysons Corner, VA, USA
[20]. Milenic, D., Vranjes, A., Milankovic, Dj., Savic, N., 2013: “Subthermal karst occurrences in the eastern part of Zlatibor mountain massif “, Proceedings of the 21th International Karstological School “Classical Karst” Hypogene speleogenisis (between theory and reality), Postojna, Slovenia, pp. 89
[21]. Milankovic, Dj., 2012: Basic hydro-geological characterization of karst springs on mountain Zlatibor, Paper Collection from XIV of Serbian symposium on hydro-geology with international participation (Osnovna hidrogeološka karakterizacija karstnih vrela planinskog masiva Zlatibora, Zbornik radova XIV srpskog simpozijuma o hidrogeologiji sa međunarodnim učešćem), Zlatibor, pp. 505-512, ISBN 978-86-7352-236-4, COBISS.SR-ID 190619660
[22]. Milenic, D., Milankovic, Dj., 2012: New review on ultramafic water-bearing on mountain Zlatibor, Paper Collection from XIV of Serbian symposium on hydro-geology with international participation, (Novi osvrt na vodonosnost ultramafita zlatiborskog planinskog masiva, Zbornik radova XIV srpskog simpozijuma o hidrogeologiji sa međunarodnim učešćem), Zlatibor, pp. 519-524, ISBN 978-86-7352-236-4, COBISS.SR-ID 190619660
[23]. Milenić, D., Milanković, Đ., Vranjes, A., Prohaska, S., 2011: Defining of sanitary protection zones on the accumulation “Zlatibor” in Ribnica, Eleventh international conference Water and sewer systems, Association for water technology and sanitary engineering, (Definisanje zona sanitarne zaštite na akumulaciji „Zlatibor” u Ribnici, Jedanaesta medjunarodna konferencija Vodovodni I kanalizacioni sistemi, Udruženje za tehnologiju vode i sanitarni inženjerstvo), Jahorina, Pale, pp. 69-75, Catalogization in publication National Library of Serbia 628.1/.3(082) ISBN 978-86-82931-41-61, COBISS.SR-ID183722252
[24]. Milenic, D., Milankovic, Dj., 2014: New concept of water supply to the Čajetina municipality from groundwater sources, Conference “Water is life – future of water supply for the city of Užice and Čajetina municipality („Novi koncept vodosnabdevanja opštine Čajetina iz podzemnih voda”, Konferencija “Voda je život-budućnost vodosnabdevanja Grada Užica i Opštine Čajetina”) Zlatibor, Serbia

[25]. Nikić Z., Pušić M., Papić P., Marić N., 2020: Hydrodynamic model of hydrogeologic fracture system in Gruda ultramafic rocks, western Serbia, Journal of Hydrology, Volume 580, January 2020, (https://doi.org/10.1016/j.jhydrol.2019.124268)
[26]. Nikolić D., Savić D., Živković D., 2010: Results of the geological survey of the western part of Kostolac Basin 2009; IX International scientific opencast mining conference, OMC 2020, Vranjacka banja, 20-23 October, 2010.
[27]. Pavlović V, Kolonja B, Ilić M, Milanović R, 2010: Sustainable minerals policy of Republic of Serbia, IX International scientific opencast mining conference, OMC 2020, Vranjacka banja, 20-23 October 2010.
[28]. Pavlović V., Ivezić D, Ignjatović D, 2013: Coal sector in the Serbian energy development strategy draft till the year 2025 with projection to the year 2030; 6th International conference, COAL 2013, Zlatibor, 2-5 October 2013.
[29] Polomčić D., Stevanović Z., Dokmanović P., Papić P., Bajić D., Ristić-Vakanjac V., Hajdin B., Milanović S., 2011: Water supply from groundwaters in Serbia – state and perspectives, Monograph "Our 40 years", Faculty for Mining and Geology (Vodosnabdevanje podzemnim vodama u Srbiji - stanje i perspektive, Monografija Naših 40 godina, Rudarsko-geološki fakultet) COBISS.SR-ID 187923468, 45-79 p.
[30] Polomčić D., Stevanović Z., Bajić D., Hajdin B., Ristić-Vakanjac V., Dokmanović P., Milanović S., 2012: Water supply and sustainable groundwater resources management in Serbia (Vodosnabdevanja i održivo upravljanje podzemnim vodnim resursima u Srbiji), VODOPRIVREDA 0350-0519, 44 (2012) 258-260 p.
[31]. Polomčić D., Pavlović V., Bajić D., Šubaranović T., 2013; Multiannual effects of Peštan source operation in the function of pre-dewatering the future Kolubara basin opencast mine, 6th international conference, COAL 2013, Zlatibor, 2-5 October 2013.
[32]. Rudko G.I., Lovnyukov V.I., Netskyi O.V., Nazarenko M.V., Khomenko S.A., 2013: National and international classification systems for mineral reserves and resources: State and harmonization prospects, Kyiv, 2013.
[33]. Sobezyk E., Saluga P.W., 2013: Coal resource base in Poland from the perspective of using the JORC code, Conference Paper-January, 2013.
http//www.resourcgategate.net/publication/266391342).
[34]. Spasić N., Džunić G., 2010: Large coal basins and issues regarding fossil energy raw materials utilization (1,2 AT), Thematic collection, No. 61, Publisher: Institute for Architecture and Urbanism, March 2010, Belgrade (Veliki ugljeni baseni i problem korišćenja fosilnih energetskih sirovina (1,2 AT), Tematski zbornik, br. 61, Izdavač Institut za arhitekturu i urbanizam, mart 2010 Beograd).
[35]. Spasić N., Džunić G., 2010: Surface exploitation of lignite and its impact on nature and man-made (anthropogenic) environment, Thematic collection, No. 61, Publisher Institute for Architecture and Urbanism, March 2010, Belgrade (Površinska eksploatacija lignita i njen uticaj na prirodnu i stvorenu (antropogenu) sredinu (1,5AT), Tematski zbornik, br. 61, Izdavač Institut za arhitekturu i urbanizam, mart 2010 Beograd).
[36]. Spasić N., Đurđević J., 2010: Starting point for spatial development planning in large lignite basins (2,7AT) Thematic collection, No. 61, Publisher: Institute for Architecture and Urbanism, March 2010, Belgrade, (Polazišta za planiranje prostornog razvoja u velikim lignitskim basenima (2,7AT) Tematski zbornik, br. 61, Izdavač Institut za arhitekturu i urbanizam, mart 2010 Beograd).
[37]. Stevanović Z., Dokmanović P., 2010: Current state and perspectives of hydrogeological activities of Serbia (Aktuelno stanje i perspektive hidrogeološke delatnosti Srbije); 15th Congress of the Geologists of Serbia, Belgrade, 26-29 May 2010.

[38]. N. Stevanović-Petrović N., Stojanović S., Cojić M., 2013; Pestan riverbed replacing for opening phase of new open pit-Kolubara coal basin, 6th international conference, COAL 2013, Zlatibor, 2-5 October 2013.
[39]. Tomas P.L., 2013: Coal resources and reserves; 6th international conference, COAL 2013, Zlatibor, 2-5 October 2013
[40**].** Vučković B., Stojković H., Ignjatović M, Šubaranović T., Rakijaš M., 2014: Energy value of Kolubara lignite-comparison with selected aspects of electricity generation (natural parameters, e.g. kJ/kg, kcal); IV MKOIEE • 345.
[41]. Vukas R., 2009: Approaching of data on solid mineral raw materials of the Republic of Serbia to international standards (Približavanje podataka o rezervama čvrstih mineralnih sirovina Republike srbije međunarodnim standardima); TEHNIKA, Nº 4., Beograd.
[42]. Vukas R., 2010: Geological resources of metals and balance reserves of the Republic of Serbia, in general relation: exploration results→mineral resources→ore reserves from International standards, MISKO MMX, Mineralno sirovinski kompleks Srbije danas: izazovi i raskršća, Urednik S.Vujić.
[43]. Vukas R., Dajović A., 2017: The main elements of the official Serbian system classification of solid mineral resources/reserves; UNECE Resource Classification Week; Expert Group on Resource Classification-Eighth Session, Geneva (Powerpoint presentation (www.unece.org)
[44]. Vukas R., 2018: Display data on categories of total (geological) reserves of uranium in Serbia in the class of mineral reserves from current legislative, TEHNIKA, Nº 3., Beograd.
[45]. Živanović-Miljković J, Đurđević J., 2010: Natural and man-made limitations and benefits to spatial development of the western part of Kolubara lignite basin (1,7At**),** Thematic collection, No. 61, Publisher: Institute for Architecture and Urbanism, March 2010, Belgrade, (Prirodna i stvorena ograničenja i pogodnosti za prostorni razvoj zapadnog dela Kolubarskog lignitskog basena (1,7At**)** Tematski zbornik, br. 61, Izdavač Institut za arhitekturu i urbanizam, mart 2010 Beograd).
[46**].** Životić D., 2010: Serbian coal resources-condition and perspective, MISKO MMX, Mineralno sirovinski kompleks Srbije danas: izazovi i raskršća, Urednik S.Vujić.
[47].www.mgsi.gov.rs, Law on Spatial Planning of the Republic of Serbia from 2010 to 2020 (Zakon o prostornom planu Republike Srbije od 2010 do 2020) (2010).
[48].www.mgsi.gov.rs, Law on Planning and Building (Zakon o planiranju i zgradnji) 2009,2010,2011,2013,2018,2019).
[49].www.mgsi.gov.rs; Spatial Plan of the Republic of Serbia 2021-2035, basic conceptual approach to spatial planning for public insight (Prostorni plan Republike Srbije od 2021-2035; osnovni konceptualni pristup protornom razvoju za javni uvid) (2020).
[50].www.mgsi.gov.rs; Spatial Plan for the area of Kolubara lignite basin exploitation – Spatial Plan Draft, Book II, documentary basis (Prostorni plan područja eksploatcije kolubarskog lignitskog basena-Nacrt prostornog plana, Knjiga II; dokumentaciona osnova), Belgrade, 2016.
[51].www.paragraf.rs; National Strategy on sustainable utilization of natural resources and goods of the Republic of Serbia (Nacionalna strategija održivog korišćenja prirodnih resursa i dobara Republike Srbije), 2012.
[52].www.mre.gov.rs; Strategy for energy development of the Republic of Serbia until 2025 with projection until 2030 (Strategija razvoja energetike Republike Srbije do 2025 sa projekcijama do 2030), (2015).
[53].www.mre.gov.rs; Law on Energy (Zakon o energetici) (2014,2018).
[54].www.mre.gov.rs; Law on Efficient Energy Utilization (Zakon o efikasnom korišćenju energije) (2013).
[55].www.mre.gov.rs; Energy Balance for 2020 (Energetski bilans za 2020) (2019).

[56].www.mre.gov.rs; Law on Mining and Geology Exploration (Zakon o rudarstvu i geološkim istraživanjima) (2015).
[57].www.mre.gov.rs Rulebook on classification and categorization of solid mineral raw materials and their record-keeping (Pravilnika o klasifikaciji i kategorizaciji rezervi čvrstih mineralnih siroivna i vođenju evidencije o njima) (1979).
[58].www.mre.gov.rs Rulebook on classification and categorization of oil, condensate and natural gases reserves and their record-keeping (Pravilnika o klasifikaciji i kategorizaciji rezervi nafe, kondenzata i prirodnih gasova i vođenju evidencije o njima) (1987).
[59].www.mre.gov.rs Rulebook on classification and categorization of groundwater reserves and their record-keeping (Pravilnik o klasifikaciji i kategorizaciji rezervi podzemnih voda i vođenju evidencije o njima) (1979).
[60].www.mre.gov.rs Rulebook on the content of the elaborate on conditions of groundwater exploitation and conditions and manner of elaborate technical control (Pravilnik o sadržini elaborata o uslovima eksploatacije podzemnih voda ili hidrogeotermalnih resursa, odnosno petrogeotermalnih resursa i uslovima i načinu vršenja tehničke kontrole elaborate) (2018)
[61].www.mre.gov.rs Rulebook on conditions, criteria, content and manner of classification of petro-geothermal resources and manner of their presentation in the elaborate (Pravilnik o uslovima, kriterijumima, sadržaju i načinu razvrstavanja petrogeotermalnih resursa i načinu prikazivanja u elaborate) (2018).
[62].www.mre.gov.rs; Geoliss-GIS; Hydrogeological map of Serbia (Hidrogeološka karta Srbije) (2015).
[63].www.mpolj.gov.rs; Law on Water (Zakon o vodama) (2010,2012,2016,2018).
[64].www.rdvode.gov.rs; Strategy on water management on the territory of the Republic of Serbia; Analyses and exploration (Strategija upravljanja vodama na teritoriji Republike Srbije; Analize i istraživanja), Institute "Jaroslav Černi" Belgrade (2015)
[65]. www.srbijavode.rs; Vodoprivredna osnova Republike Srbije (2015)
[66].www,hidromet.gov.rs; Vodoprivredna osnova Republike Srbije,Podzemnih voda-RHMZ
[67]. ems-undp.rs; Law and by-laws – UNDP (Zakon i podzakonski akti-UNDP).
[68].www.zelenaenergija.pks.rs; Geothermal energy, Green energy and PKS (Geotermalna energija, Zelena energija i PKS).
[69] www.makroekonomija.org; Geothermal resources potential in Serbia (Potencijal geotermalnih resursa u Srbiji).
[70] www.javno.rs; Small power plants in Serbia (Minielektrane u Srbiji), (2020).
[71] www.elektrosbija.rs; MHE Srbija, (2020).
[72] www.mzs.gov.rs; Law on Environment Protection (Zakon o zaštiti životne sredine) (2005),
[73] www.mfins.gov.rs; Law on Taxes for Public Goods Utilization (Zakon o taksama za korišenje javnih dobara) (2018,2019),
[74] www.mzdr.gov.rs; Law on Public Health (Zakon o javnom zdravlju) (2016).
[75]www.eps.rs Coal production in Kolubara basin (Proizvodnja uglja u kolubarskom basenu) (2019).
[76] www.rbkolubara.rs; Geology Service Baroševac: Expert Documentation Fund (Geološka služba Baroševac: Fond stručne dokumentacije), (2020)
[77]www.sgz.gov.rs; Industrial production in Serbia in 2019 (Industrijska proizvodnja u Srbiji u 2019) (2020)
[78]www.pks.rs; Industrial parameters (Industrijski parametri), (2020).

Annex

Fig. 1 : Kolubara Coal basin and groundwater of Mountain Zlatibor of the Republic of Serbia (www.mre.gov.rs)

Fig. 2: Coal deposits of the Republic of Serbia (Ž.Đorđević; R.Vukas modified 1998 and 2020)

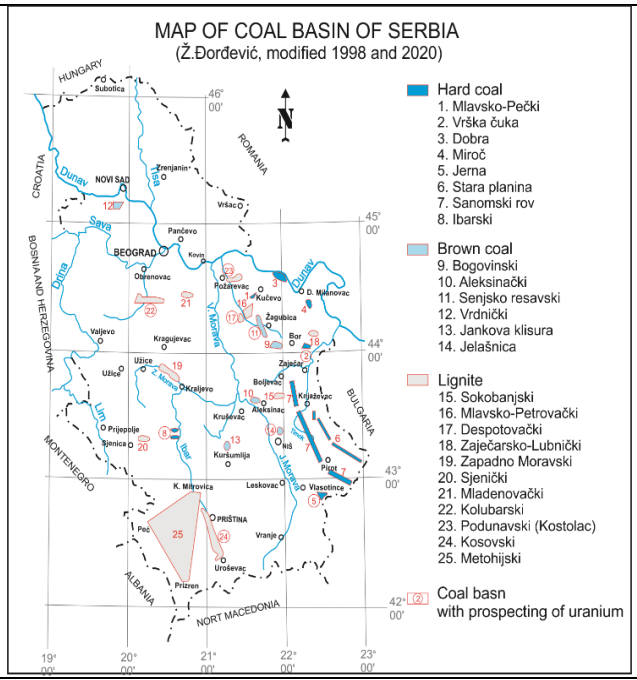


Fig. 3: Hydrogeological regionalization of the Republic of Serbia (Spatial Plan of Serbia, 2015, www.mgi.gov.rs)

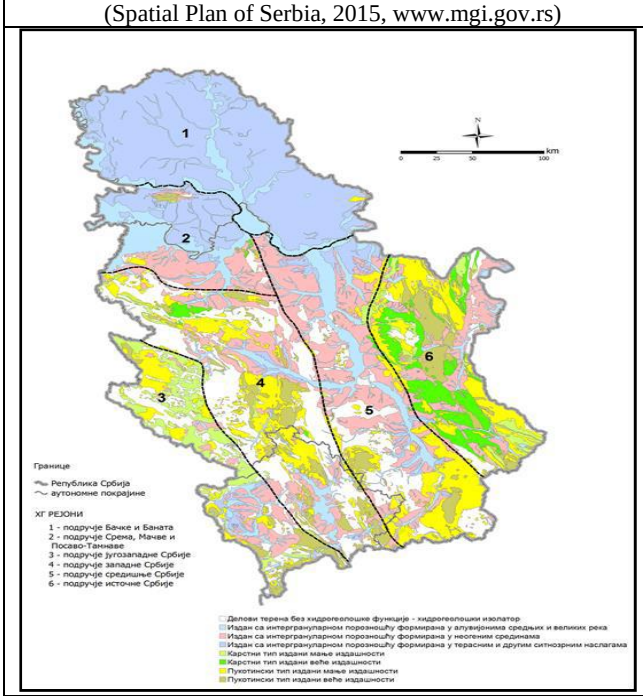


Fig. 4: Energy and water infrastructure of the Republic of Serbia (Spatial plan, 2010-2020;www.mgi.gov.rs)

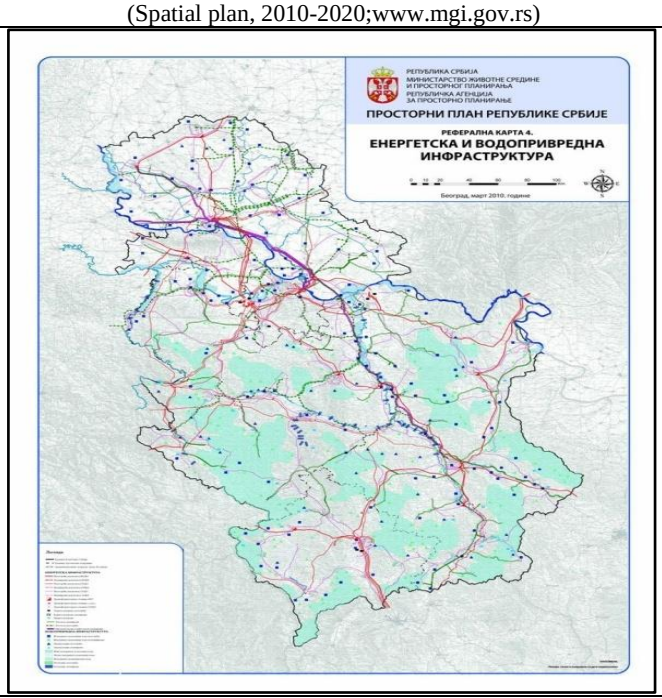


Fig. 5: Electric Power System of Serbia (http://www.stat.gov.rs)

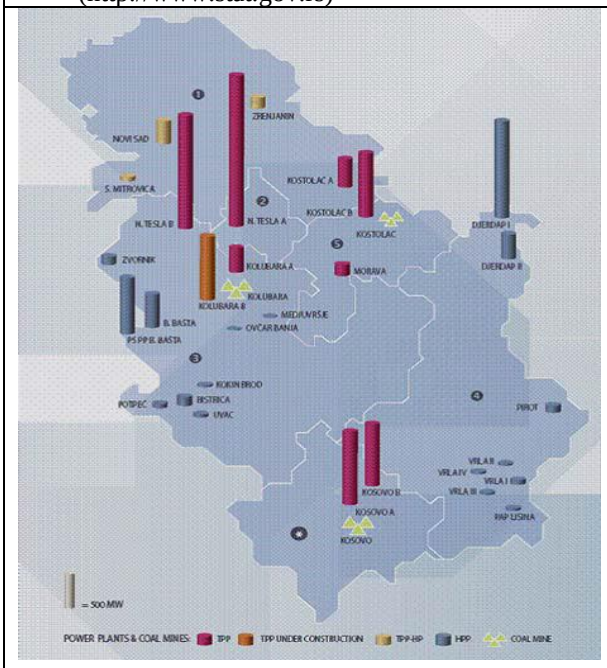


Fig. 6: Index of produce of electricity of Serbia (http://www.stat.gov.rs)

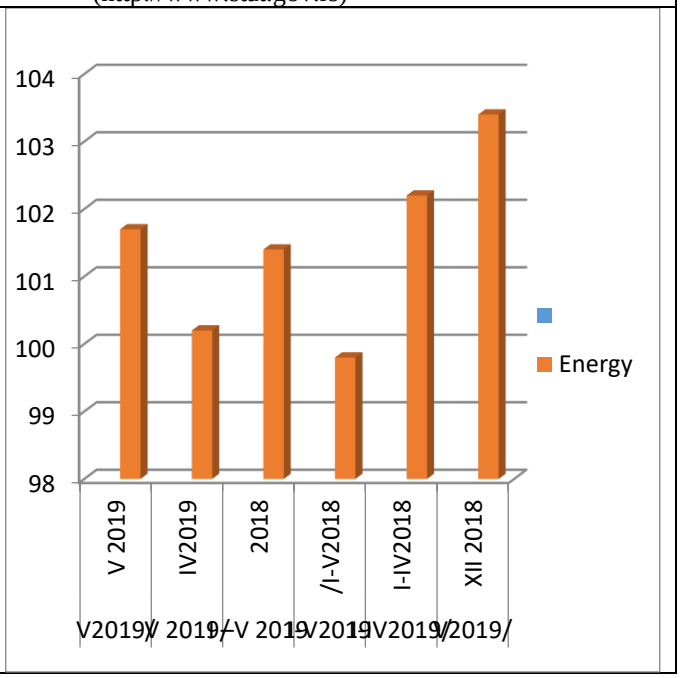


Fig. 7: Kolubara coal basin- Coal deposits "Tamnava-West field", Nº 5 (http://www.eps.rs; R.Vukas modified 2020)

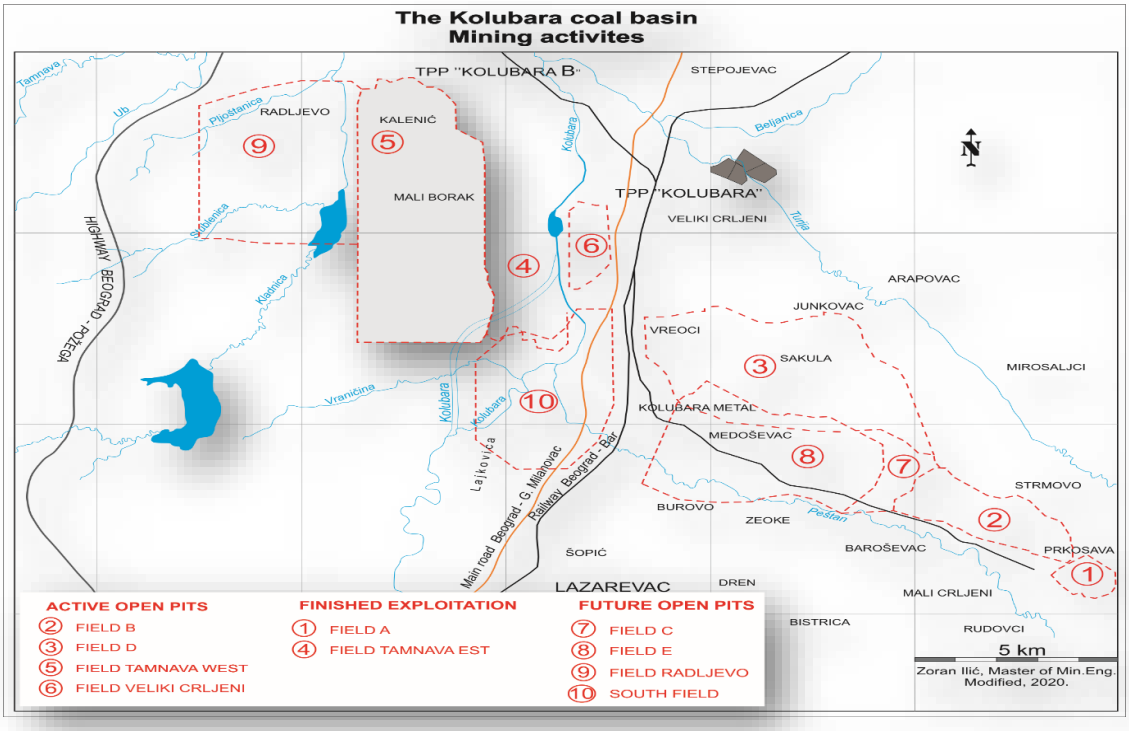


Fig. 8: Coal reserves of deposits “Tamnava-West field” in category of UNFC system (R.Vukas, 2020)

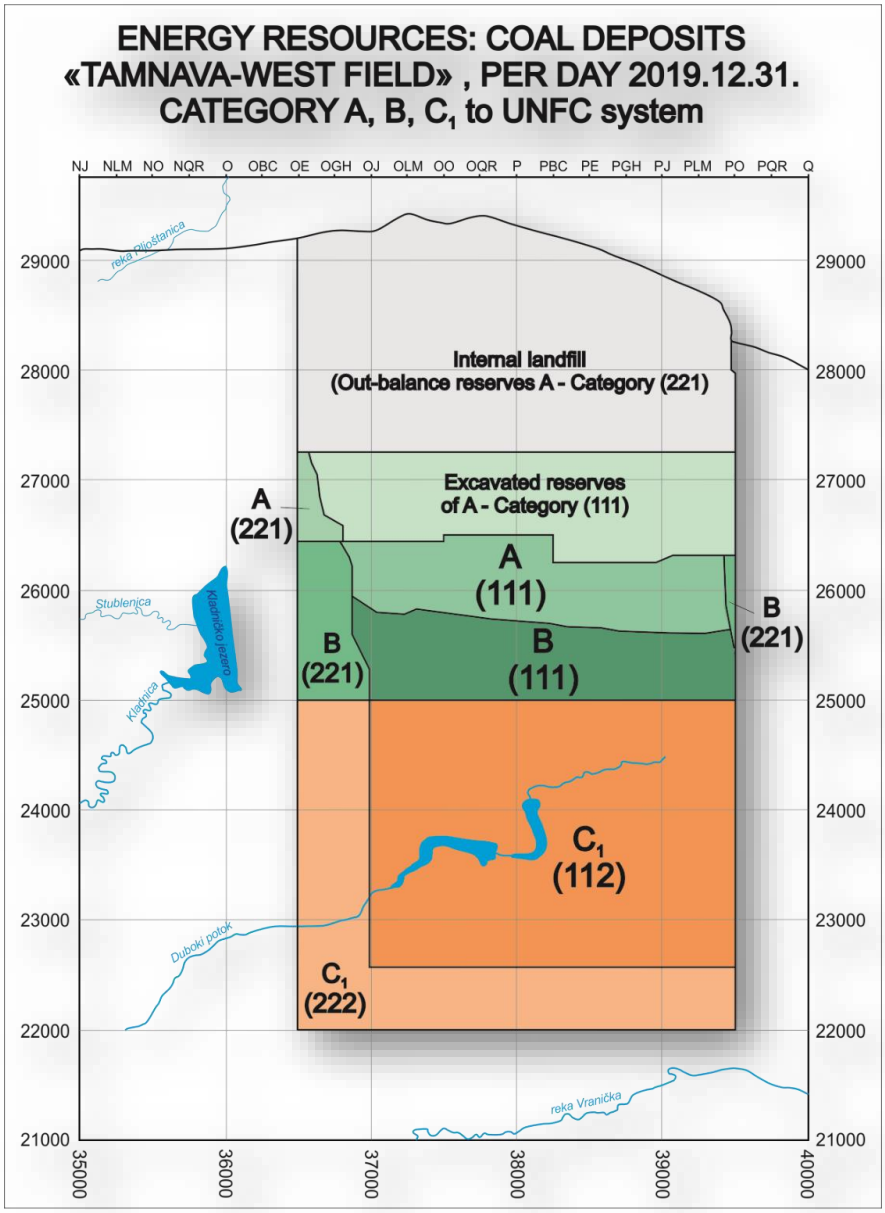


Fig. 9: B, C_1 – category of Groundwater of Mountain Zlatibor to UNFC system
(Dj. Milanković, R.Vukas, 2020)

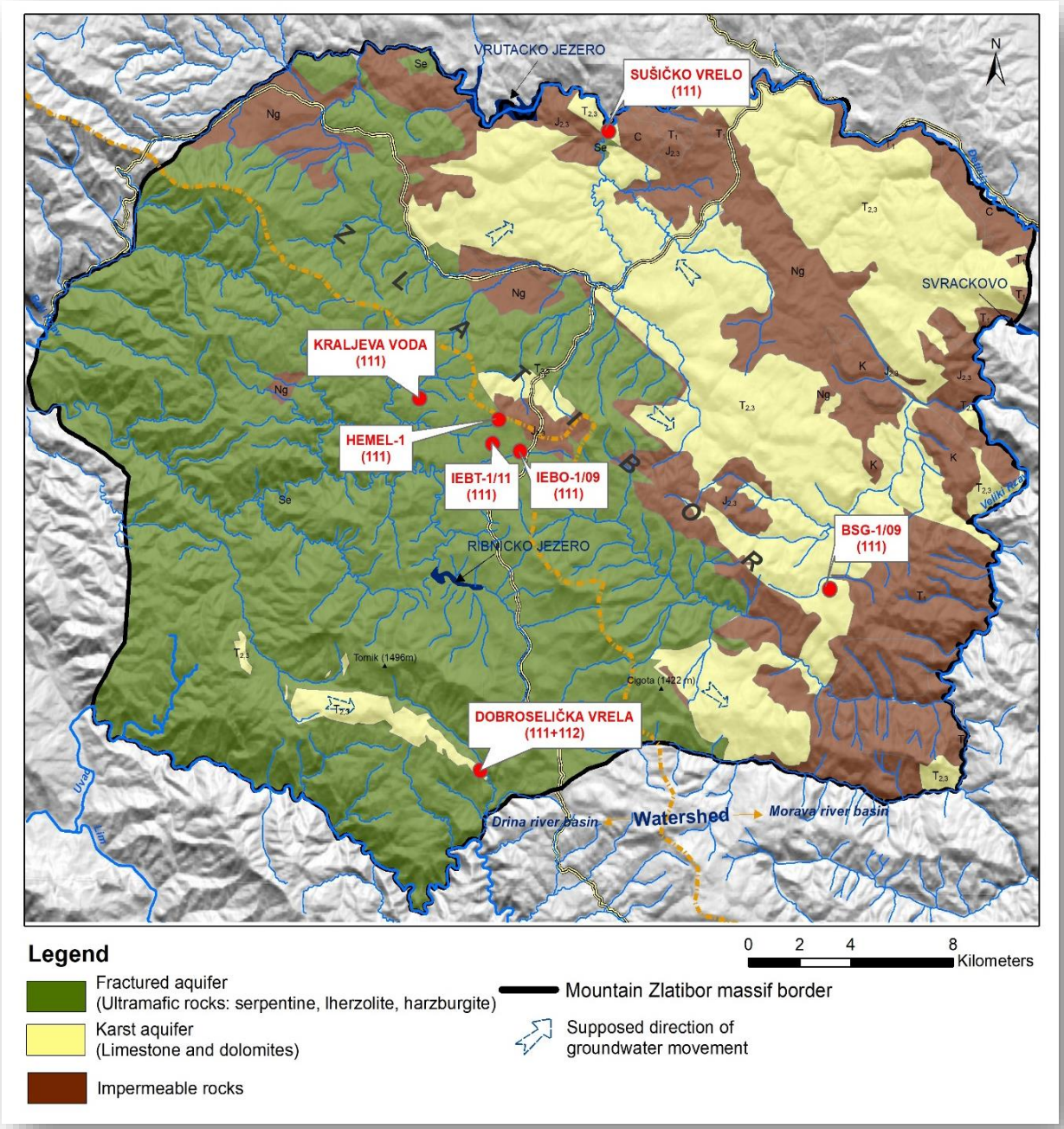


Fig. 10: Geological and Balance reserves of mineral raw materials (mineral resources and reserves) of Serbia [41]

Geological reserves (mineral resources / reserves) of solid mineral raw materials in Serbia					
According to	Division on the basis	Reserves	Definitions of reserves		the possibility of cost-effective exploitation
According to legislative	Degree of deposits exploration	Explored	Reserves of mineral raw materials are classified into categories of explored reserves if the data on their reservoir conditions and quality for further processing, ie exploitation of a higher degree of reliability		
		Potential	Reserves of mineral raw materials are classified into categories of explored reserves if the data on their deposit conditions and quality for further processing, ie exploitation of a lower degree of reliability		
	Degree of deposits exploration (risk) and degree of knowledge of raw material quality	Explored	A-category (error +/- 15 %)	fully known and established characteristics of deposits and mineral raw materials	**Balance and Out-balance reserves (Elaborate of resources and reserves)**
			B (error +/- 30 %)	known and established characteristics of deposits and mineral raw materials	
			C_1 (error +/- 50 %)	partially known and determined characteristics of deposits and mineral raw materials	
		Potential	C_2 (error +/- 70-80 %)	partially checked bearing conditions and determined on the basis of analogy with the studied parts of the deposit	
			D_1	assumed on the basis of geological conditions, detailed prospecting data, exploration and exploitation works and in unexplored parts of known ore fields and reserve category	
			D_2	assumed on the basis of data on geological development and specificity of geological structure of a certain territory, which were obtained by complex geological, geochemical, geophysical research as well as parts of the region where deposits and ore phenomena were discovered and reserve determination is done using statistical method of analysis of formation and analytical-synthetic methods	
According to bibliography	Ways of obtaining and degree of exploitation	Geological	the total amount of mineral raw material, which was established in the deposit by prospecting and explored works		
		Exploitation	hose quantities of mineral raw material that can be extracted from the deposit during its excavation, and are obtained when the losses during exploitation and dilution are deducted from the geological ones (3-50%; calculated average ≈18%; according to the professional literature)		
		Commercial (Industrial)	those quantities of mineral raw material that can be used in the processes of preparation and processing, and are obtained when the losses incurred during the preparation and processing are deducted from the exploitation reserves (calculated average ≈ 9%; according to professional literature and published papers)		
	Degree of readiness for excavation	Open	reserves for the excavation of which all necessary capital mining works have been performed, which are foreseen by the opening project		
		Prepared	reserves located in blocks or parts in which all mining preparatory works have been performed		
		Done	excavation reserves, which are prepared for excavation		