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CASE STUDY ON THE APPLICATION OF UNFC TO ENERGY AND GROUNDWATER RESOURCES IN THE REPUBLIC OF SRPSKA, BOSNIA AND HERZEGOVINA

Zvornik, July 2020

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The List of Abbreviations

B&H	Bosnia and Herzegovina
CRISCO	Committee for Mineral Reserves International Reporting Standards
DARLING	Danube Region Leading Geothermal Project
ESMA	European Securities and Markets Authority
FB&H	Federation of Bosnia and Herzegovina
RS	Republic of Srpska
WFD	Water Framework Directive
UNFC	United Nations Framework Classification 2019 Update

Text colour of chapter instruction

Text colour	**Related topic**	**Explanation**
INTRODUCTION	General	Applicable to both case studies
ENERGY (GEOTHERMAL) PROJECT	Energy	Pertain on energy case study
GROUNDWATER PROJECT	Groundwater	Pertain on groundwater case study

1. INTRODUCTION

The case studies consider the application of UNFC on two projects related to energy and groundwater in the Republic of Srpska, B&H. The first case study considers the application on energy resource (geothermal "Slobomir" project), the second one the application on groundwater ("Vivia" project).
For the studies, the last version of UNFC (2019 update) is applied. UNFC was initially designed for the application in the minerals and oil/gas sectors. Over the years it was extended to a much larger variety of Natural Resources. The United Nations Framework Classification for Resources (UNFC) Update 2019, which includes specifications for its application, has been developed through the cooperation and collaboration of the United Nations Economic Commission for Europe (ECE) and non-ECE member countries, other United Nations agencies and international organisations, intergovernmental bodies, professional associations and societies and the private sector.
The report intends to provide all relevant projects information so that a potential investor can make a decision whether or not to invest in the projects.
The document is the first entity and national attempt ever to apply UNFC to energy and groundwater.

ENERGY (GEOTHERMAL) PROJECT

Slobomir town is a private project located in Semberija, NE part of the Republic of Srpska, B&H, in the border belt with Serbia (Figure 1). One of the essential sub-projects is geothermal cascade use.
Climate elements indicate modest-continental conditions, with dry and hot summers and cold and dry winters. Average annual precipitations are 780 mm, average annual temperature about 11°C.
The city is very well connected with other parts of the Republic of Srpska and B&H in general, as well as with Serbia and the countries of the region.

Figure 1: Location of Slobomir geothermal project (violet circle)

The geothermal project is based on the borehole GD-2, located at the overall eastern zone of the RS, B&H part of the transboundary geothermal aquifer Semberija-Mačva. It is already being used for the heating of the constructed facilities in Slobomir (administrative building, bank, university). There is planed additional utilisation of thermal water in the recent future also for:

- Touristic and sport-recreation centre – Aqua Park Slobomir (Figure 2):
  - ✓ outdoor 47000 m^2,
  - ✓ indoor 8000 m^2,
  - ✓ 15 pools of different purposes;
- Additional heating of the residential and business space;
- Greenhouse heating (cultivation of health food, medicinal herbs and flowers);
- Spa and recreation purposes;
- Production of the ecologically sound electrical energy in a thermal power plant (additional study is necessary to prove feasibility).

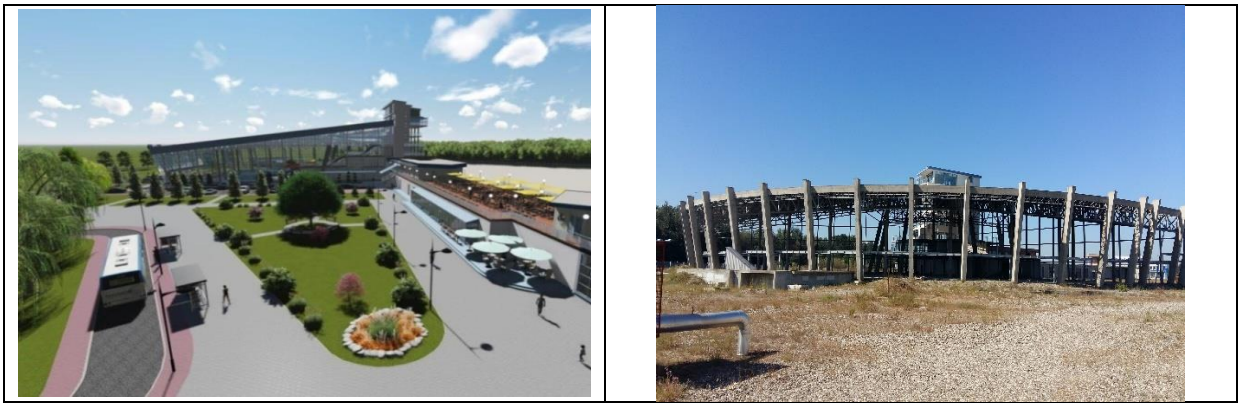


Figure 2: Planed aqua-park (left) and its construction in progress in 2020 (right, photo B. Jolović), Slobomir project

Product type

Primary: Heat (energy for heating) and an aqua park (Figure 3);
Secondary: spa, sanitary water, greenhouse food and herbs production, the potential also electricity.

Reference point

The reference point is where fluid touches the heat exchanger. Due to the very close distance between the geothermal well GD-2 and the plant as well as modern isolation techniques, there is negligible heat loss between the wellhead and the heat exchanger.

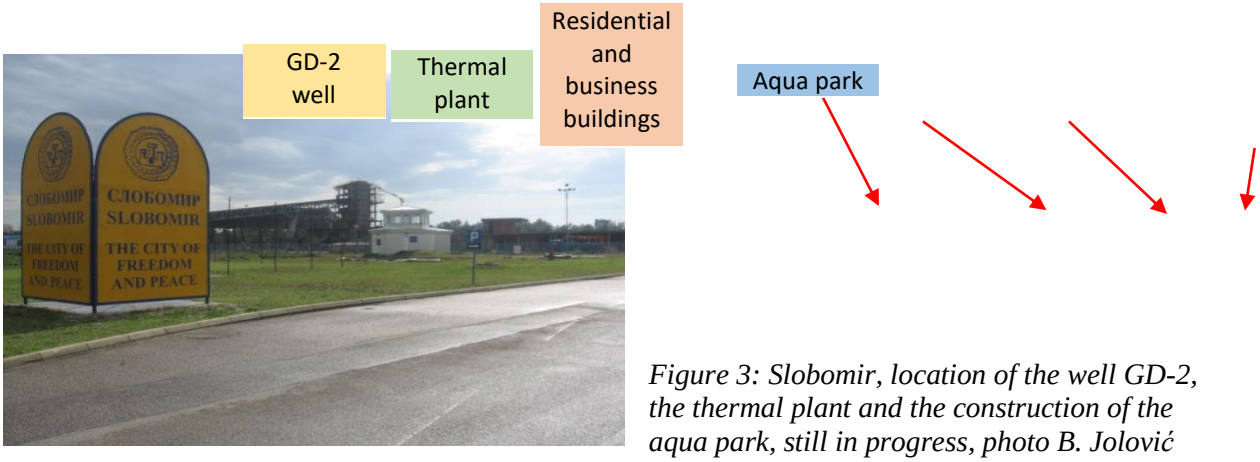


Figure 3: Slobomir, location of the well GD-2, the thermal plant and the construction of the aqua park, still in progress, photo B. Jolović

Project lifetime

The project is active from 2011 when the first stage of the thermal plant is constructed. The borehole GD-2 was completed in 2010. Foreseen well operation lifetime is 25 years, but the concession contract with the Government is valid up to 2036, and estimation will be calculated for the period of 16 years [1].

GROUNDWATER PROJECT

"Vivia" is a private project of the "Vitinka Company", located in the overall eastern part of the Republic of Srpska, B&H, near to the border belt with Serbia (Figure 4). One of the most important company's sub-projects is groundwater tapping and bottling of regionally well-known high-quality groundwater.
The location of the facilities is very well connected with other parts of Srpska and B&H in general, as well as with Serbia and countries of the region.

Figure 4: Location of "Vivia" groundwater project and m*odern water bottling facility located in the beautiful karstic area, courtesy of N. Toholj*

In the purpose of water tapping, intake located in untouched nature of Udrč Mountain was constructed in 2007. Before the intake construction, the regime of the aquifer discharges in the spring Banjica was permanently observed more than two years in both, quantitative and qualitative sense. After the quantity and quality were proved as those in line with the national standards deal with natural bottled water, a modern facility for bottling was constructed 0.7 km distant from the intake.
Because the "Vitinka Company" also bottled mineral water (another locality and of course a totally different aquifer) and represented regionally well-known brand, "Vivia" became one of the leaders in bottling water sale on the regional market very soon. At the very first moment it touched just market of B&H, but recently covers also a significant part of the bottled water market in neighbouring Serbia and Montenegro.

Product type
Primary: Bottled water
Secondary: Not applicable.

Project lifetime
The project has been active since 2007 when the intake and bottling facilities were constructed. Foreseen operation lifetime is not less than 25 years, because the concession contract signed with the Government of the RS is valid up to 2045 [1].

2. NATIONAL CLASSIFICATION SYSTEM FOR ENERGY AND GROUNDWATER RESOURCES AND MAPPING TO UNFC

2.1. Description and details of the national classification and management systems

2.1.1. Legal background

The responsible Ministry for the mineral resources managing in the Republic of Srpska is the Ministry of Energy and Mining. The Ministry proposes to the National Assembly of the RS laws related to mineral resources managing and after the Assembly adoption, in addition, prescribed a sub-law regulation related to the law. Key legal policy related to mineral resources managing is listed in the paragraph below.
The Law on Geological Explorations (Official Gazette of the Republic of Srpska 110/13, 91/17, 107/19) and the Rulebook on Classification, Categorization and Mineral Reserves Calculation and Record Keeping (92/14) (further referred as: *Rulebook*) are essential legal documents that define a national system of the classification of mineral resources (where mineral resources in accordance with the mentioned law include beside solids also energy, geothermal and groundwater). Regarding

management aspect, especially exploitation, the Low on Mining (Official Gazette of the Republic of Srpska 62/18) and the Law on Concessions (Official Gazette of the Republic of Srpska 53/09 and 16/18) play the key role.
Strategic documents deal with mineral resources are not prepared yet. Heretofore, the Mineral Resources Strategy is not adopted, and its preparation, mandatory in accordance with the mentioned Law on Mining (article 8), has not started yet. As a background document for the Strategy, the Geological Survey of the Republic of Srpska, released in 2012 the document "Mineral Resources of the Republic of Srpska", as the inventory of all identified mineral resources up to 2012, with basic data on each resource (geology, quantity, quality, brief exploration and exploitation history etc.)

2.1.2. Details of the national classification and management systems

Majority of the former Yugoslavian countries (as Bosnia and Herzegovina, Serbia, Montenegro and Northern Macedonia) usually apply the Former Soviet Union (FSU) system of the mineral reserves categorisation and classification. It is the case in Bosnia and Herzegovina in both entities, in the RS and the FB&H.
The Rulebook prescribes criteria for determination of mineral resources, conditions for categories and classes identification and procedures/methodologies of reserves calculation. Mineral resources, in accordance with the Rulebook, are considered as:

1. solid mineral resources (energy, metallic, non-metallic);
2. groundwater (include drinking, mineral, thermal and thermo-mineral);
3. liquid and gaseous hydrocarbons and other natural gasses.

Deposits of solid mineral resources are divided into groups and subgroups based on:

1. morphological characteristics - size and complexity of a deposit shape;
2. genesis type;
3. geological setting;
4. the character of distribution of useful components;
5. structure and tectonic properties;
6. post-mineralisation tectonic events.

The reserves of mineral resources are split into the following classes and categories (Table 1).

Table 1. Mineral reserves categorisation and classification in the Republic of Srpska, B&H

Category of reserves	Class
A	Balance (economically viable exploitation) and non-balance (economically non-viable exploitation) reserves
B	
C_1	
C_2	Potential reserves

The use of terms of the categories A, B, C_1, C_2 of reserves of solid minerals, geothermal energy and groundwater is described below:
1. **A** – Well-known and defined characteristics of a deposit (explored ore reserves; allowed estimation error +/- 15 %)
2. **B** – Known and established characteristic of a deposit (explored ore reserves; allowed estimation error +/- 30 %)
3. **C_1** – Partly known and defined characteristic of a deposit (explored ore reserves; allowed estimation error +/- 50%)
4. **C_2** – Partly tested deposit conditions and mostly determined by analogy with known parts of a deposit (Inferred/ Perspective)

2.2. UNFC for resources application

The United Nations Framework Classification for Resources (UNFC, here considered in the latest version, update from 2019) is a resource project-based and principles-based classification system for defining the environmental-socio-economic viability and technical feasibility of projects to develop resources. The UNFC provides a consistent framework to describe the level of confidence of the future quantities produced by the project. Sources, such as solar, wind, geothermal, hydro-marine, bioenergy, injection for storage, hydrocarbons, minerals, nuclear fuels and water, are the feedstock to resource projects from which products can be developed [2].
The sources may be in their natural or secondary (anthropogenic sources, tailings, etc.) state.
Products of the project may be bought, sold or used, including electricity, heat, hydrocarbons, hydrogen, minerals and water. It is noted that with some projects, such as for renewable energy, the products (electricity, heat, hydrogen, etc.) are different from the sources (wind, solar irradiation, etc.). In other projects, the products and sources may be similar, e.g. in petroleum projects both the sources and products are oil and/or gas, although the fluid state and properties may change from a reservoir to surface conditions.
A project is a defined development or operation which provides the basis for environmental, social, economic and technical evaluation and decision-making. The project plan may be detailed or conceptual (in the case of long-term national resource planning). The project plan should be sufficiently detailed to allow an appropriate assessment for the stakeholder needs at the defined level of maturity.
The UNFC has been designed to meet, to the extent possible, the needs of applications pertaining to:

- policy formulation based on resource studies;
- resources management functions;
- corporate business process
- financial capital allocation.

2.2.1. UNFC categories and sub-categories

The UNFC is a principles-based system in which the products of a resource project are classified on the basis of three fundamental criteria of environmental-socio-economic viability (E), technical feasibility (F), and degree of confidence in the estimate (G), using a numerical coding system[2]. Combinations of these criteria create a three-dimensional system (Figure 1). Categories (e.g. E1, E2, E3) and, in some cases, sub-categories (e.g. E1.1) are defined for each of the three criteria as set out and defined in the Annexes I and II.
The first set of the categories (the E axis) designates the degree of favourability of environmental-socio-economic conditions in establishing the viability of the project, including consideration of market prices and relevant legal, regulatory, social, environmental and contractual conditions. The second set (the F axis) designates the maturity of technology, studies and commitments necessary to implement the project. These projects range from early conceptual studies through to a fully developed project that is producing and reflect standard value chain management principles. The third set of categories (the G axis) designates the degree of confidence in the estimate of the quantities of products from the project.
The Categories and Sub-categories are the building blocks of the system, and are combined in the form of "Classes". The UNFC can be visualised in three dimensions, as shown in Figure 1, or represented in a practical two-dimensional abbreviated version, as shown in Figure 5.

2.3. Relationship with the UNFC and current national (entity) classification

The UNFC classification is used in some legal documents in the B&H entities, but it is quite unknown to many experts deal with energy and mineral resources classification systems.
For the first time, it is mentioned in some legal document in the above mentioned Rule on classification and categorisation adopted in 2014. Indeed, the section 5 in the Article 15 of the Rule considers the UNFC 2004 version and contains the following parallels between the national classification and the UNFC 2009:

Article 5

(1) In accordance with the level of exploration and knowledge of quality, solid mineral resources are split into categories A, B, C_1 and C_2.
(2) In accordance with the United Nations Framework Classification (UNFC) reserves of A and B categories of the national classification approximately match Proven Reserves in the UNFC, and C_1 matches Probable Reserves in the UNFC.
(3) In analogy with the previous, the reserves of C_2 category, matches Inferred Reserves.
(4) The Categories and classes mentioned under (1) in this article area applied in the UNFC and use appropriate three-axis based system.

From the above-listed paragraph of the Article 5 of the actual Rulebook and in comparison with Figure 6 it is obvious that this transposition of the UNFC (in that moment 2009 version) does not properly consider this classification. Used terms: proven, probable and inferred matches CRISCO standard, not the UNFC.
On the other side, the positive fact is that the UNFC classification was for the first time mentioned in the legislation of the Republic of Srpska, B&H and adopted in one entity sub-law document that deals with mineral resources.

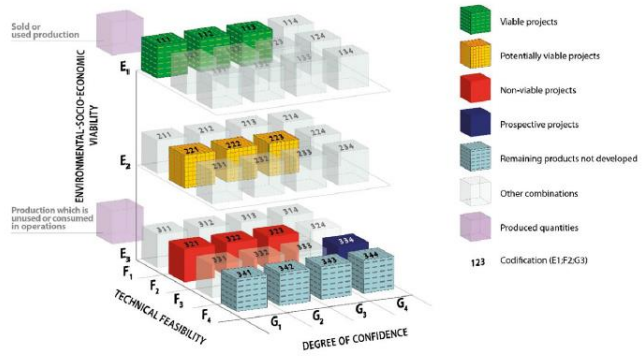


Figure 5: UNFC Categories and Examples of Classes

UNFC and European countries

The United Nations Framework Classification for Resources (UNFC) is an important tool for natural resource management that can harmonise data from different classifications and reporting standards and hence make a significant contribution in attaining of the Sustainable Development Goals.
The Expert Group on Resources Management of the UNECE noted the progress made by the "UNFC and UNRMS for Europe" initiative to harmonise classification and management of raw materials at the EU level under the European Commission's Raw Materials Initiative and the encouraging results of the EU Battery Initiative. The Expert Group noted the increasing use of the UNFC by a number of Horizon 2020 projects and the UNFC-focussed workshop organised as a part of the EU Raw Materials Week 2018.
Some important facts regarding the UNFC and the European countries classification systems are the following[1]:

- The Nordic countries (Norway, Sweden and Finland) have developed standard sub-regional guidelines for applying the UNFC to the mineral sector;
- "UNFC for Europe"– European Commission led initiative to assess the use of the UNFC in Europe;
- The Russian Federation has bridged its oil and gas classification system to the UNFC

[1]https://www.gob.mx/cms/uploads/attachment/file/346084/01_Development_of_the_UNFC__the_Stakeholders___SDGs.pdf

Further, in accordance with [15] Lithuania, Poland, and Romania aligned national classification systems to the UNFC. In addition, this document mentioned that amongst the European countries have a national resource code, and there is an even split between (a) some derived from the Russian code, for example, Hungary, Slovenia and Croatia; (b) a unique national code, such as Austria; and (c) a code compliant with the CRIRSCO template, such as Norway, Finland and Sweden. In these countries, some form of a resource management system is in place, and the minerals industry will often have a legal obligation to report figures to a national body.
The Republic of Srpska and Bosnia and Herzegovina, in general, belong to the first identified group (derived from the Russian code, or precisely from the Former Soviet Union classification). Besides the RS, B&H, a similar classification is in neighbouring Serbia, Montenegro and Northern Macedonia.

2.4. Proposal for Mapping Scheme

Once again, here is emphasised that findings, interpretations and conclusions expressed herein are those of the report author and do not necessarily reflect the views of the United Nations or its officials or the Member State. Also, the author mentions that at the level of the Republic of Srpska and Bosnia and Herzegovina in general, considerations about bridging between the official classification and the UNFC are not considered anytime, despite the fact that the actual sub-law document deals with mineral resources classification mention the UNFC (*see the previous section*).
Because there is no any bridging document, the mapping scheme (Figure 8) is given in both purpose, as the key issue of this document but also to trigger future discussion about possible new scheme within the national expert and scientific community.
Between the actual classification and the UNFC, the new possible classification is proposed, based on the CRISCO standard. At the same time, it plays the role of a facilitating tool for understanding/bridging to the UNFC (Figure 7). The reason for the CRIRSCO consideration lies in the fact that it is recognised by the ESMA for use on the European Union stock exchanges and accepted in a number of other stock exchanges around the world (Canada, Singapore, etc.) as well as the fact that from year to year the Republic of Srpska attracts many international investors in the mineral sector.
In addition, the terms are given in *Article 5* of the Rulebook (see the previous section) are mostly those that follow the CRISCO standard. Personally, the opinion of the author of this document is that a "transitional scheme" is the best way toward a correct and comprehensive understanding of the UNFC.

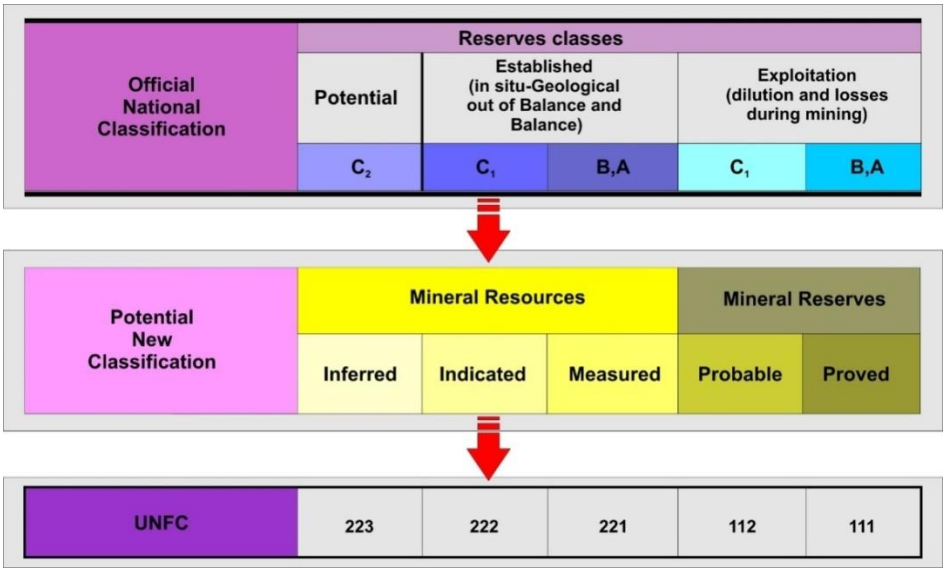


Figure 6: Proposed Mapping Scheme between official classification of the Republic of Srpska, B&H and the UNFC with "transitional" classification based on the CRISCO standard for solid mineral resources (Vukas & Jolović, 2020)

Actually, the scheme given below is not fully self-developed, and it is generally based on the numerous proposals of authors [3] from different countries, applied in the past different versions of the Soviet/Russian classifications, especially neighbouring Serbia. This country today has a very similar system of national classification as the Republic of Srpska.

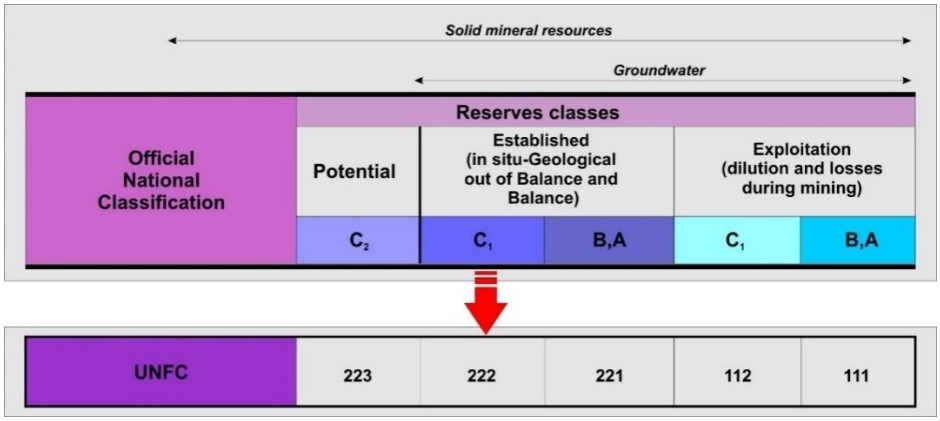


Figure 7: Proposed Mapping Scheme between the official classification of the Republic of Srpska, B&H and the UNFC, without "transitional" scheme for solid minerals (Vukas & Jolović, 2020)

From the scheme given in Figure 7 it is obvious that groundwater reserves, differently from solid minerals, are just considered as balance and split into A, B and C_1 categories.
The following scheme seems to be the most appropriate (Figure 8). For more details, see Annex 5.

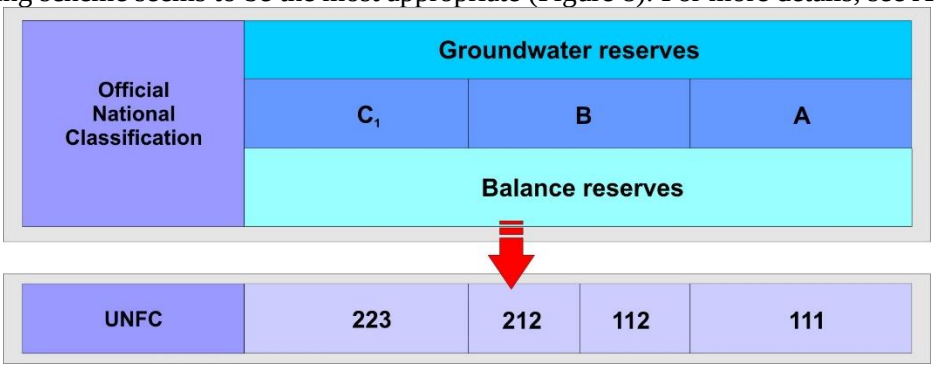


Figure 8: Proposed Mapping Scheme for groundwater between the official classification of the Republic of Srpska, B&H and the UNFC (Jolović, 2020)

3. BACKGROUND INFORMATION OF THE ENERGY PROJECT AND GROUNDWATER UTILISATION

3.1. Previous work on energy and groundwater resources

3.1.1. Previous work on energy resources

The Semberija thermal aquifer, captured for Slobomir geothermal project, extends on more than 400 km^2 in B&H and under the current state of the art, it is a part of the huge transboundary geothermal aquifer with extension in Mačva, Serbia. The total area of the transboundary aquifer is roughly estimated on 2000 km^2 [4].
According to the results of the previous exploration, Semberija region reveals the most prospective geothermal properties in the Republic of Srpska. Also, it represents the best explored geothermal area in the entity. The highest values of the geothermal gradient (>50^0C/km) and heat flow (>100 mWm^{-2}) in the RS and B&H, registered here, prove it.

Heretofore, six boreholes were drilled in the area of approximately 200 km^2, each deeper than 1.300 m (in total 10.460 m). The deepest one is the borehole BIJ-1 (2479 m), near the administrative and economic centre of the Semebrija region - Bijeljina (finished in 1984).
Based on the results of previous explorations, there is an assumption about one unique (transboundary) geothermal aquifer in Semberija and Mačva (Serbia), that probably also extends on some parts of Srem (Serbia). Under Milivojević and Perić (given in [4]) minimal extension of this transboundary thermal aquifer is roughly 2.000 km^2.

3.1.2. Previous work on groundwater resources

In the last 20 years, very complex geological explorations were performed with the aim to define the groundwater regime of the tapped spring for the "Vivia" project. It covers (Figure 9):

- detail geological and hydrogeological mapping;
- geophysical explorations;
- hydrogeological exploration, including spring quantitative and qualitative regime explorations;
- hydrochemical exploration.

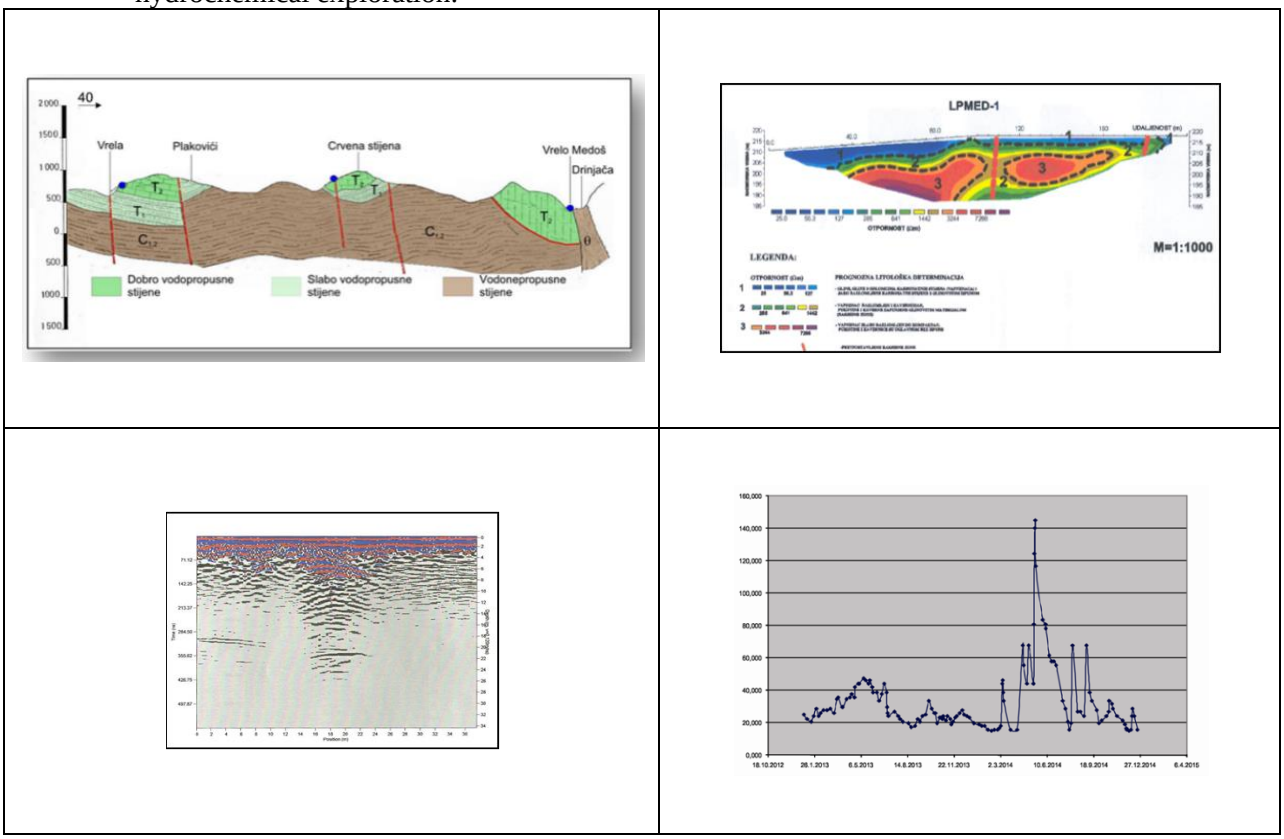


Figure 9: The results of different geological explorations: upper left – regional geological mapping; upper right – geo-electrical chromatography; lower left - geo-radar; lower right – two-years hydrograph observation of Banjica spring

As the result of the explorations, the aquifer recharge/discharge regime is defined, flow patterns characteristics, hydrochemical and microbiological properties, the depth of the groundwater circulation etc. Detail results of the explorations are given in [10].

4. SOCIAL, ECONOMIC AND ENVIRONMENTAL ASPECTS OF THE PROJECTS

4.1. Energy --Geothermal project "Slobomir"

4.1.1. Economic aspects of energy resource development

The economic calculation could be available for the coming 16 years because the concession contract, signed with the Government of the RS, is valid until 2036 [1]. The concession fee is defined and paid to the Government on a regular base (annually) [5].

The existing geothermal borehole GD-2 in Slobomir is already being used for the heating of the constructed facilities in Slobomir town, and there is a plan for further utilisation in the purpose of:

- Tourist and sport-recreation centre – Aqua Park which is at a construction stage;
- Additional Heating of the residential and business space Greenhouse heating (production of health food, medicinal herbs and flowers);
- Spa and recreation purposes;
- Production of the ecologically sound electrical energy in thermal power plants.

4.1.2. Social aspects of energy production

Strengthening the local economy and entrepreneurship

The Slobomir town project comprises a few economy sectors:

- Banking;
- Education (University);
- Heating production;
- Sport and recreation.

All these sectors have very positive effects on the economy because they increase employment and living standard in this rural area, in the past primarily recognised exclusively as an agricultural area. The geothermal project is one of the most important segments, especially because the finalisation of the aqua park should provide significant additional employment.

In entrepreneurship sense, for the first time in this part of the Semberija region, there are presented some other business models than agriculture. Planned activities could be the driving force for the local people to consider other potentials, based on the Slobomir projects (touristic-accommodation capacities, organic food production, etc.).

Improving infrastructure

Parallel with Slobomir town construction, here is also the development of additional infrastructure. The company Slobomir constructed a bridge on the Drina River (2 km away from the town) that connects Bosnia and Herzegovina and Serbia. Also, a few kilometres of a new road is constructed. By these facilities, the connection with other parts of the Semberija region and neighbouring Serbia is drastically improved. Anyhow, it contributes more intensive move of people and goods.

Further, available energy provides a chance for the local district heating development with plugging of new consumers on the available power plant. This step is also positive in the sense of the decreasing of fossil fuels (coal) and firewood in the purpose of heating.

Promoting culture and sports

The aqua park is one of the most important parts of the project and it will be a good opportunity for local inhabitants to slightly change habits and have a possibility for new cultural and sport activities. Numerous swimming pools should provide the possibility for water sports which have no tradition in this area. Tourists from neighbouring countries and the region can also introduce themselves with the unique cultural heritage of the Semberija region.

Improving education

One of the main components of the town concept is education. The Slobomir University, established in 2003, is one of the most important educational institutions in the region. The existing university and unique and very successful geothermal project, next to each other, represent very good opportunity to organise education for different target groups (geologists, energy sector, economists, NGOs) about the development of substantial environment-friendly projects.

4.1.3. Environmental issues of energy production

Geothermal energy production – legal environmental framework

International level

The expansion and efficiency increase of the utilisation of renewable energies, including geothermal energy is a global interest for the replacement of fossil energy sources causing the greenhouse effect. There are a great number of international agreements, treaties and directives dealing with this issue: the Kyoto Protocol (1997), the declaration of the Earth Summit in Johannesburg, the findings of the Bali Climate Change Conference or the (2007), or the conclusions of the EU Water Framework directives. The newest climate agreement was signed by the participants of the world conference held the last fall in Paris.

Compliance with the national, entity and local regulations and strategies

The national Law on Water (Official Gazette of the RS 50/06) is entirely harmonised with provisions of the European WFD. In accordance with this law, the water management is under the jurisdiction of the PC "Vode Srpske" as a part of the Ministry of Agriculture, Forestry and Water Management. This PC, together with the Ministry, is responsible for water permits and fees related to water utilisation.
Further, for the projects which could impact the environment, based on their nature, size and location, the estimation of possible impacts is defined in the Study of environmental impact (further: Study) The Study preparation is prescribed by the Article 61, paragraph 1 of the Law on Protection of the Environment (Official Gazette of the RS 71/12 and 79/15).
This document deals with the identification and analysis of direct and indirect impacts of a project regarding the following elements and factors:

- human, plants and animals
- soil, water, air, climate and landscapes
- goods and cultural heritage
- interaction of the factors listed above.

Also, the study is a basic document for issuing ecological permission. Moreover, any institution in charge of issuing construction permission cannot provide it before the Study preparation.
It is prepared in a two-stage procedure:

- within the first step, the Ministry of Spatial Planning, Construction and Ecology decide about the necessity of the study. If the study is necessary, the scope of the analysis is also defined in this step.
- the second step is the Study preparation, in accordance with content defined in the previous step (article 66, paragraph 2).

In accordance with the entity legal policy environment permit must be provided for all facilities that belong to one of the following industry/craft sectors: energy, chemical, metal processing, mining, food, infrastructure projects, wood and paper etc.
The Law on Environment Protection (Official Gazette of the RS 71/12) prescribes mandatory preparation of the Study (article 63, paragraph 1) of impact on the environment (further: Study) for all facilities listed in the Rule on projects for which it is being implemented estimation on environment impact and criteria for decision and scope of estimation of impact on the environment (Official Gazette of the RS 124/12).
This kind of study is mandatory for groundwater extraction or reinjection of more than 10.000.000 m^3 (more than 315 L/s). Taking into account the seasonal character of heating in Slobomir (6 months) it

is not realistic to expect the exploitation more than 10.000.000 m^3 of thermal water for the cities in the Republic of Srpska.
On the other side, for any deep boreholes drilling, especially those geothermal, the Ministry of SPCE decides about the necessity of the study (also in the case of abstraction less than 10.000.000 m^3/year) (Article 3 of the above-mentioned Rule). The Slobomir geothermal project is a deep borehole based energy project, and it requests environmental permit. The request for issuing the permit is submitted to the responsible Ministry in March 2017, and it was issued in May 2017.
The project is also in line with proclamation statement in B&H and the RS that for the heating sector additional incentive must be provided for renewable energy sources (biomass, geothermal energy) in the system of existing and new district heating systems [6]and the national [7] and the entity [8] energy strategy.

4.1.4. Resource depletion aspects

Pumping tests of the borehole GD-2 provided valuable data on the thermal water reserves calculation. It discloses that 35 L/s could be pumped without deterioration of the reservoir capacity and water quality suitable for heating (safe form the system effectiveness aspect – no negative impact on equipment like pumps, pipelines, exchangers etc.). Currently, just 5 L/s is used during the winter season.
It means that there are no depletion effects [9].

4.1.5.Thermal water recharge, depletion or contamination aspects

Recharge and depletion aspects are described in the previous section. Contamination issue could be considered as thermal effect related to discharge of used thermal water.
Namely, used water of the temperature about 60°C is released in the shallow freshwater aquifer by one shallow well.
Here is probably an effect of "thermal island" around this "reinjection" well. Because here is not the downstream user of freshwater, this effect does not affect any consumers. Whatever, this effect should be explored in detail.

4.1.6. Other remarks

The whole geothermal concept is based on 7 boreholes. Heretofore, just one is drilled. The reason is a lack of finances. By mentioned boreholes number and their energy potential, whole nearby Bijeljina town, with about 100000 inhabitants, could be heated by renewable energy source.

4.1.7 Energy project E axis details

UNFC E axis class – E1, sub-category E1.1
The development and operation of the project are confirmed to be environmentally-socially-economically viable. The essential reasons for this statement are the following:
Environmentally:

- fossil fuel in the heating sector is substituted by renewable energy (geothermal);
- low CO_2 emission technology;
- very positive and quantified effects on the reduction of coal consumption what is in line with the national strategies (energy and environmental).

Socially:

- clean energy provides better residential conditions;
- employment;
- new technology application based on renewable could be a trigger for the other communities to consider environment-friendly heating (currently exclusively based on coal);
- conditions for thermal water-based recreation and sports activities.

Economically:

- the project has been operating for nine years, and it is based on all experiences it is foreseen to run at least another 16 years;
- the project is economic under the current market conditions and is supplying a substantial and existing heat market. The substitution of fossil fuel by geothermal energy provides huge financial saving and energy price in the future is not dependent on market condition (expected to be more favourable in the foreseeable future).

4.2. Groundwater – groundwater bottling project "Vivia"

4.2.1. Economic aspects of groundwater resource development

The economic calculation could be available for the coming 25 years because the concession contract signed with the Government of the RS is active up to 2045 [1]. The concession fee is defined and paid to the Government on a regular base (annually) [5].
The existing intake is already being used for the bottling in nearby facilities, and there is a plan for additional bottling in the recent future, based on the market indicators and increased water demands especially in the summer period in three countries where the company operates). Here is no plan of the company for the Vivia project related to some other kind of services than water bottling sale.

4.2.2. Social aspects of groundwater utilisation

Strengthening the local economy and entrepreneurship
The Vivia project touch one economic sector, bottled water "producing" and very successful sale on a very challenging domestic and foreign markets.
The project has very positive effects on the economy because it increases employment and life standard of a very rural area, in the past primary recognised exclusively as livestock and primitive agricultural area. Ambitious plans of the company should trigger additional employment.
In entrepreneurship sense, for the first time, it is presented some other business model than mining, wood processing, live stocking and agriculture in this part of Srpska.
Further, the concession fee belongs to local authorities (the budget of Milići municipality) is very valuable for local budget allocation.
Improving infrastructure
Parallel with the project, here is also the development of additional infrastructure. The company "Vitinka" in cooperation with the local authorities (Milići municipality) constructed a new asphalt road. A few kilometres of new road connects people in some remote villages with regional road Sarajevo - Belgrade (B&H and Serbia).

4.2.3. Environmental issues of groundwater utilisation

There is no negative environmental impact of the project. The amount of captured water vs reserves is very favourable (see next section), and it will not affect groundwater depletion and dependant ecosystems.

4.2.4. Resource depletion aspects

The long-term observation of spring discharge before tapping indicates a minimum of 15 L/s [10]. The average annual abstraction in the last ten years is about 30.000.000 (0.95 L/s). It shares just 6.3% of minimal discharge [11], and there is no evidence about resource depletion.

4.2.5. Groundwater recharge, depletion or contamination aspects

Groundwater recharge is exclusively supported by precipitations. Relatively high annual precipitations ranged in the catchment area from 980 to 1010 mm/annual. Climate changes scenarios for Bosnia and Herzegovina [6] indicate temperature increasing and precipitation reduction in the next 50 years. A rough estimation is that minimum discharge will be reduced for 10-15%. In case if the

abstraction doubles (2 L/s), which reduces the minimal discharge of 15% (to 12.75 L/s), only 15% of minimal discharge will be abstracted. Taking into account high replenishment potential of the aquifer during the wet period and low abstraction rate, it is obvious that there is no risk on overexploitation.
Regarding contamination, it is a well-known fact that any karst aquifer is naturally high vulnerable medium. But contamination potential also depends on hazard, which multiplies with natural vulnerability represent a risk to pollution. In the catchment area of the tapped spring, point sources of the pollution are not registered. Prevention from their future presence, as well as management of potential diffuse pollution, is prescribed by a document deals with sanitary protection of the catchment area [12] and there are clearly prescribed allowed and disallowed activities in accordance with the domestic legal policy. Three zones of sanitary protection are established, with different level of protection based on the possible impact of contaminant to water quality and quantity.

4.2.6. Groundwater project E axis details

UNFC E axis class – E1, sub-category E1.1
Development and operation are confirmed to be environmentally-socially-economically viable.
Development is environmentally-socially-economically viable on the basis of current conditions and realistic assumptions of future conditions. Essential reasons for the classifications are the following:
Environmentally:
- fully friendly environment project, no negative impact on the environment.

Socially:
- employment
- infrastructure (new asphalt road for the local community)

Economically:
- the project has been operating for 13 years, and based on all experiences, it is foreseen to run at least another 25 years.
- the project is economic under the current market conditions and is supplying a substantial and existing heat market. The company is a national market leader on the bottled water market, with slight extension to neighbouring countries markets (Serbia and Montenegro).

5. FIELD PROJECT STATUS AND FEASIBILITY FOR ENERGY PRODUCTION AND GROUNDWATER UTILISATION

5.1. Technological feasibility aspects for energy resource production

The borehole GD-2 (Figure 10) was completed in 2010. Past energy production (in the last ten years) reveals there are no observed problems in energy production. The borehole was finished at 1800 m from the surface; screen occupies last 200 m of the borehole. It was passed the Tertiary sediments (thermal isolator) and reached the Triassic carbonate rocks (thermal aquifer). The temperature on the wellhead is 73^0C (Annex 2). The mineralisation is low, about 0.7 g/l (Annex 3). There are no gasses affect the technological feasibility of energy production. The borehole and the thermal power plant were located in the mid of the planned activities (heating, aqua-park, agriculture, etc.), with short transport and no heat losses.

Figure 10: Well head of GD-2 and the thermal power plant near to well, 2019, photo B. Jolović

Figure 11: Completed subsurface installations of the aqua park, 2019 (courtesy of N. Toholj)

5.1.1. Detailed studies conducted and results

The results of the geological studies are described in detail in the previous sections of the document. The results obtained by the exploitations of the system show that feasibility study findings are met in the field during the system exploitation.

5.1.2. Detailed studies planned

The whole geothermal project was preliminary based on more than one deep borehole. Very positive results of the first borehole (GD-2) reduce ambitious but costly drilling plans. Here is more than enough energy for the planed sub-projects (heating, swimming, agriculture, etc.). At the moment here is not realistic to expect any further drilling in the foreseeable future.
The project of the aqua-park is finished, but the construction is stopped after huge progress (Figure 11) because of the company's financial problems. In accordance with the studies, agricultural production in greenhouses based on geothermal energy is realistic here as well.

5.1.3. Energy project F axis details

UNFC F axis class – F1, sub-category F1.1
The technical feasibility of the development project has been confirmed. The production is currently taking place.
The gradually expanding project has been operating since 2011. The available energy (well GD-2) drastically exceeds current needs and gives a serious possibility to plug energy source to other consumers. The modern thermal plant (Figure 10) is just 20 m away from the thermal well, without energy losses. Further, the modern pipe technologies (e.g. pre-isolated pipes) provide very low heat loss for long distances. It means that available technologies could provide heat transfer to neighbouring residential/economy important sites with negligible heat losses.
All production licenses are available and secured in the long-term period. The environmental study is verified by the responsible Ministry (the Ministry of Construction, Spatial Planning and Environment of the Republic of Srpska). In addition, thermal water reserves are verified by the responsible Ministry as well (the Ministry of Energy and Mining). The concession contract, signed with the Government of the Republic of Srpska is valid until 2036. All licences for construction and spatial planning related permissions are issued by national and local authorities. The water permit is confirmed by the public institutions in charge of water permit-issuing (Public Institution "Vode Srpske").

5.2. Technological feasibility aspects for groundwater

As previously mentioned, after the positive results of the geological/hydrogeological/geochemical explorations, the "Vitinka" company management decides to construct intake (Figure 12) and groundwater bottling facility near the intake. These facilities are connected with 0.7km long, high-quality pipeline. The system has been operating during the last 13 years.

Figure 12: Intake of Banjica spring (left) and the device for automatic registration of temperature and turbidity, Vivia project, courtesy of J. Tomić

Installed modern bottling equipment (Figure 13) has embedded micro-philtres and UV-lamps, which represents the only treatment allowed by domestic regulation regarding bottled groundwater.

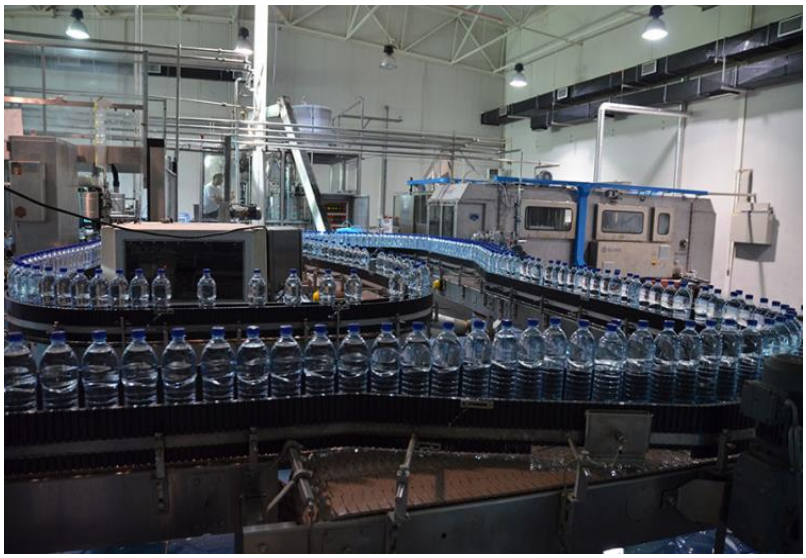


Figure 13: Fully automated groundwater bottling, Vivia, courtesy of J. Tomić

5.2.1. Detailed studies conducted and results

The results of the geological studies are described in detail in the previous sections of the documents. The results obtained by exploitation of the system show that feasibility study findings are met in the field. Regarding quality, high groundwater quality of Banjica spring is proved. Water is HCO_3-Ca-Mg, and pH value is 7.46, Ec 386 µS/cm, HCO_3^- prevails among anions (256 mg/L), Ca among cations (47 mg/L). Total dissolved solids are in the range of 250-310 mg/L [10].

5.2.2. Detailed studies planned

During the last 3 years, two deep boreholes were drilled near the spring. There are a little bit surprising results because the thermal water of 33.1°C was captured. The Well-1 is 150 m deep and the Well-2 256 m [10]. This water could be used for energy production or for spa and recreation/swimming pools purposes. Studies about it are not prepared yet, but this possibility seems realistic in the future.

5.2.3. Groundwater Project F axis details

UNFC F axis class – F1, sub-category F1.1

The technical feasibility of the development project has been confirmed. The production is currently taking place.

The gradually expanding project has been operating since 2007. The modern bottling facility delivers 30.000.000 L of bottled water annually.

All production licenses are available and secured in the long-term. The environmental study is verified by the responsible Ministry (the Ministry of Construction, Spatial Planning and Environment of the Republic of Srpska)). In addition, groundwater reserves are verified by the responsible Ministry as well (the Ministry of Energy and Mining). The concession contract, signed with the Government of the Republic of Srpska is valid until 2045. All construction and spatial planning related permissions are available, issued by national and local authorities. The water permit is confirmed by public institutions in charge of water permit-issuing (Public Institution "Vode Srpske").

6. LEVEL OF KNOWLEDGE/CONFIDENCE IN ESTIMATES

6.1. Geological or other relevant aspects – energy project

The first deep borehole in Semberija, S-1, was drilled in 1957 in Dvorovi village. The borehole (1345 m) is the only one in use (Dvorovi spa), beside GD-2 in Slobomir. Until 1962 additional two boreholes were completed in Semberija (S-2 and S-3, S-2 in Popovi, 1591 m and S-3 in Svinjarevac, 1746 m). The data about these boreholes are very limited, and it is only known that borehole was finished in the Triassic limestones and registered thermal water, but not with an artesian level like S-1.

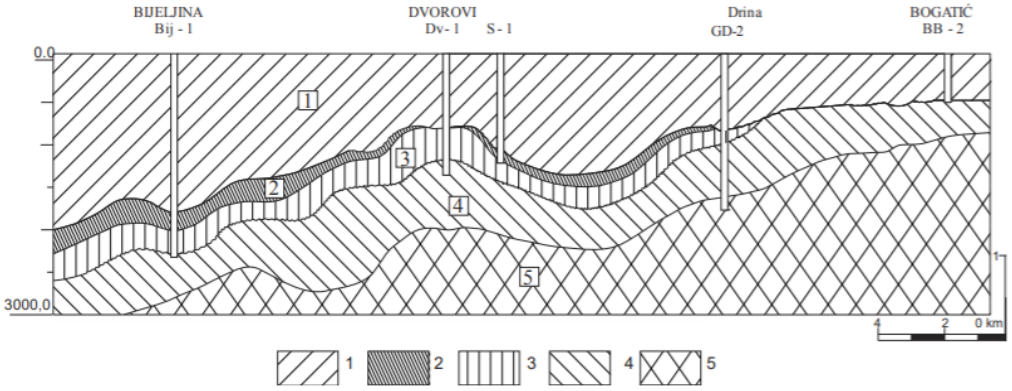
The borehole S-1 has represented the "backbone" of Dvorovi spa during the last 40 years. Water wellhead temperature is 75°C and discharges 7.5 l/s (artesian level). This is the only borehole finished in the Cretaceous sediments (probably limestone sequence of the flysch formation, Figure 14).

The drilling of the borehole BIJ-1 started in 1983, as a part of the oil and gas project of Semberija. The borehole was finished at 2479 m, because the equipment crash and it was not completed to the originally planned depth (4000 m). At a depth of 2410 m, the borehole reached the Triassic limestone (Figure 2). Qualitative and quantitative characteristics of thermal water were not tested because of the above-mentioned drilling problems at 2479 m. The results obtained during the borehole drilling provided numerous useful geothermal data of the western part of Semberija plain and transboundary aquifer. It is calculated that it is possible to obtain water T>100°C deeper than 2500 m [4].

In 1988 the drilling of the borehole DV-1 started one kilometre south of the borehole S-1 (Figure 3). It was the first "pure" geothermal borehole in Semberija, not oil-gas exploratory borehole. The expectation was to obtain three times more thermal water than in the S-1 (about 20 l/s), but there were similar thermal water quantity, artesian level and temperature like in the S-1. Because of the financial obstacles, the borehole was not completed (not cased till the bottom, pumping test was not provided etc.). The borehole was conserved in 1989, and its current status is unknown.

The borehole GD-2 was completed in 2010 in the locality Slobomir. It was completed at 1800 m; screen occupies the last 200 m of the borehole. The borehole was passed the Tertiary sediments and reached the Triassic carbonate rocks. The temperature on the wellhead is 75^0C, yield 44 l/s (pumping). Mineralisation is about 0.7 g/l. The borehole is planned for cascade use: heating, pools and agriculture.

Except for the S-1, each borehole drilled the Triassic carbonate rocks, which position from the surface is given in Annex 1. In accordance with available data, the map of sediments depth to the Triassic limestone is constructed [4]. These limestones represent the most important geothermal reservoir in Semberija and Mačva (Figure 14, given in [13]).



1. tertiary sediments, 2. Upper Cretaceous limestones, 3. Upper Cretaceous marls and sandstones, 4. Triassic limestones and dolomites, 5. bedrock sediments

Figure 14: Generalised Geological cross section across Semberija and Mačva geothermal boreholes

6.1.1. Estimates of quantities of energy

The estimations of the thermal water quantities and energy volumes are based on the results of pumping and hydrochemical tests. These results are basic exploration results used for reserves classification and categorisation and for the approval of the reserves by the responsible authority (the Ministry of Energy and Mining) in accordance with the actual legal policy (Law on Geological Explorations, Official Gazette of the Republic of Srpska 113/10 and the Rulebook).
Appropriate percentages of probability, key for determination of UNFC (2019) G axis are given in the next table and graph. Pumping tests provided during the exploration stage reveal that for the maximal allowed well drawdown 56 L/s could be abstracted. Taking into account the pumping period and other reservoir properties, it is defined as reserves of C_1 category, in accordance with the actual classification. Taking into account some quality issues (turbidity, send content) it is defined that 35 L/s could be pumped with no restriction in quality and quantity sense and impact on applied heating technology (defined as B reserves). Also, during the past ten years, just 5 L/s had been pumped during the winter season for heating, what proved reserves of 99% (here signed as A*), and give the base for the identification of A category reserves. Actually, under prescribed probability for A category (85%), the reserves of this category are definitely higher than 5 L/s (about 16 L/s), but just 5 L/s is proved by long-time pumping hydrograph (during exploitation), what are the criteria for this category (Article 163, paragraph (9) of the Rulebook.

Table 2: Thermal water reserves of the well GD-2

Reserve category- national (entity) classification	Probability (%)	Q (L/s)	Remark
A*	99	5	Based on long term abstraction
A	85	16	Based on pumping test
B	70	35	Based on pumping test
C_1	50	56	Based on pumping test

**-author interpretation, not in national classification*

Further, it is reliable that current abstraction rate of 5 L/s, in hydrogeological sense, is available in 99%.

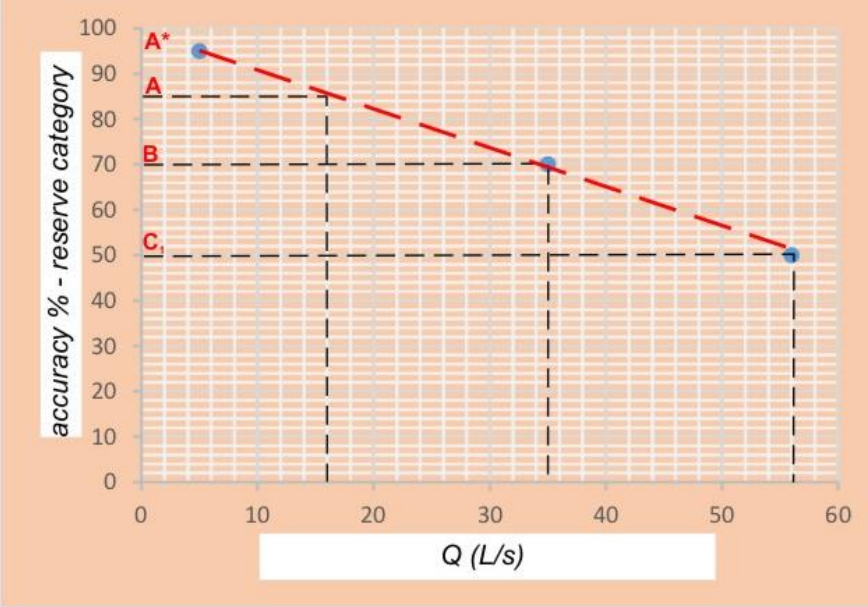


Figure 15: Well GD-2 Slobomir, thermal water reserves

Energy volume is calculated based on appropriate reserves and useful temperature. For the current project A* reserves are taken into account because, at the moment, thermal water is only used for heating, in regime 73°C/48°C (Table 3).
For the potential project, considered in addition, cascade use including the aqua-park (currently in advance constructions stage), agricultural application, and additional space heating is assumed, with consequently output temperature of 20°C. Because the complete cascade use (with temperature decreasing up to 20°C in output) is only available during 6 months (heating active), estimations for the potential project will be considered on the base of 6 months annually.
The table below gives a review of the appropriate energy related to thermal water quantities and utilisation regime.

Table 3: Energy reserves of well GD-2

Reserve category	Output temperature (°C)	Probability	Project	Estimate	Energy/annual (PJ)
A*	48	99%	Current	Low	0.053
A	20	85%	Potential	Low	0.36
B	20	70%	Potential	Best	0.78
C_1	20	50%	Potential	High	1.25

6.1.2. Energy project G axis details

UNFC G axis class - G1, G2, G3

The quantity associated with the present project that can be estimated with a very high level of confidence (0.053PJ heat energy to be extracted) for the next 16 years (period of the concession contract validity). It is based on 6 months exploitation with an average pumping rate 5 L/s, heat regime 73°C/48°C, what is the actual status of the exploration in the last 7 years.

Quantities associated with a potential project are estimated as Low, Best and High, based on long-term pumping test (see table above and graph below), with probabilities 85%, 70% and 50% (reserves of A, B and C_1categories in national classification).
Quantities associated with a potential project that can be estimated with different level of confidence, based on long-term pumping test, are given in table 3 and figure 16.

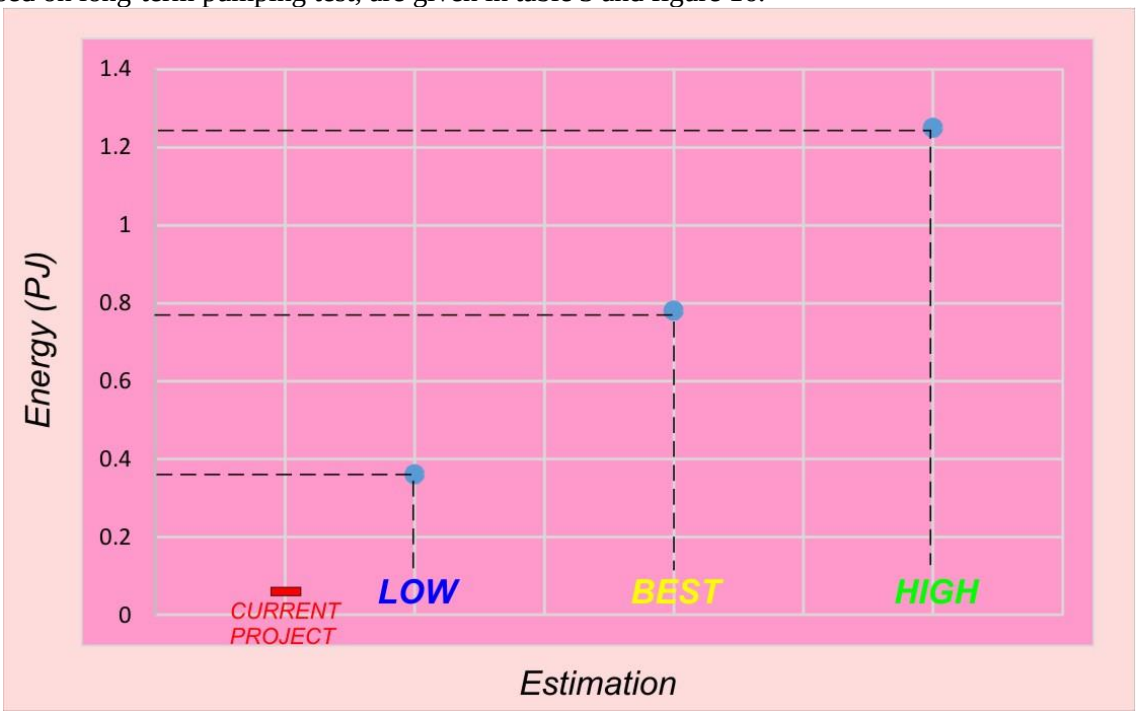


Figure 16: Well GD-2 Slobomir, energy volume estimations

6.2. Geological or other relevant aspects – groundwater project

Groundwater reserves are defined based on two years discharge observation, for the period January 2013 – December 2014 (Annex4), accompanied with relevant hydrochemical and microbiological analyses. The two-year observation period is a prerequisite for A reserves determination (reserves of highest category) in accordance with domestic regulation (Figure 17).

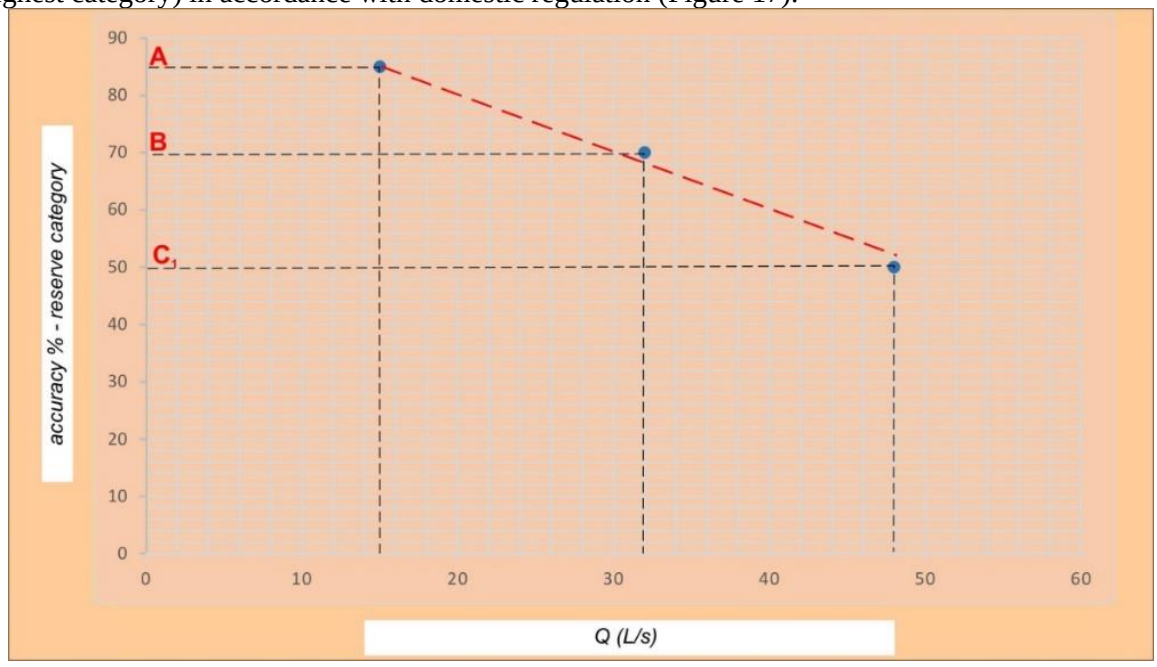


Figure 17: Banjica spring reserves probability based on the two-year hydrograph

Based on the above-mentioned, the following reserves were identified (Table 4):

Table 4: Groundwater reserves of Banjica spring

Reserve category in accordance with national legal policy	Probability (%)	Q (L/s)	Remark
A*	99	1	Based on 13-year abstraction period
A	85	15	Based on two-year hydrograph
B	70	32	Based on two-year hydrograph
C_1	50	48	Based on two-year hydrograph

**-author interpretation, not in national classification*

Further, it is reliably that current abstraction rate of 1 L/s, in a hydrogeological sense, is available in 99%.

6.2.1. Groundwater project G axis details

UNFC G axis class – G1

Product quantity associated with a project that can be estimated with a very high level of confidence. It is based on 13 years of exploitation history and market operation with average abstraction rate about 1 L/s and bottling of 30.000.000 L of high-quality groundwater annually.

7. SUMMARY OF CLASSIFICATION OF THE ENERGY AND GROUNDWATER RESOURCES USING UNFC

7.1. Energy – Geothermal - Present project

7.1.1.E axis - Environmental-Socio-Economic Viability

National Classification	Category	UNFCdefinition	The reasoning for the classification
A class	E1	Development and operation are confirmed to be environmentally – socially –economically viable.	
A class	E1.1	Development is environmentally-socially-economically viable on the basis of current conditions and realistic assumptions of future conditions.	Essential reasons for the classifications are the following: • the project has been operating for 9 years and based on all experiences, it is foreseen to run at least another 16 years. • the project is economic under the current market conditions and is supplying a substantial and existing heat market. • it has very positive and quantified effects on the reduction of gas consumption what is in a line with the national strategies.

7.1.2. F Axis – Technical Feasibility and Maturity

National Classification	Category	UNFC definition	Reasoning for the classification
A class	F1	Technical feasibility of a development project has been confirmed.	
A class	F1.1	Production is currently taking place.	The gradually expanding project has been operating since 2011. All production licenses available and secured in the long-term.

7.1.3. G Axis – Degree of Confidence

National Classification	Category	UNFC definition	Reasoning for the classification
A* class	G1	Product quantity associated with a project that can be estimated with a high level of confidence.	Based on the production forecast for 0.053PJ heat energy to be extracted can be foreseen with a high level of confidence for the next 16 years (0.51MWh_{th} x 16/2years, because the heating 6 months/annual).Estimation based on average pumping rate 5 l/s, what is actual status of the exploration last 7 years.

7.2. Energy – Geothermal - Potential project

7.2.1. E axis - Environmental-Socio-Economic Viability

National Classification	Category	UNFCdefinition	The reasoning for the classification
C_1 class	E2	Development and operation are expected to become environmentally-socially-economically viable in the foreseeable future.	Development and operation are not yet confirmed to be economically viable (finalisation of the aqua park construction, agriculture application, additional space heating etc.) but on the basis of realistic assumptions of future conditions, there are reasonable prospects for economic viability in the foreseeable future.

7.2.2. F Axis – Technical Feasibility and Maturity

National Classification	Category	UNFC definition	Reasoning for the classification
	F1	Technical feasibility of a development project has been confirmed.	
B class	F1.3	Studies have been completed to demonstrate the technical feasibility of development and operation. There shall be a reasonable expectation that all necessary approvals/contracts for the project to proceed to development will be forthcoming.	Proven extraction potential of the thermal borehole GD-2 is 11 times higher than the current one, and it is proven by long-term pumping tests 56 l/s (current abstraction just 5 l/s), but sub-projects use energy (finalisation of the aqua park construction, agriculture application, additional space heating etc.) are on hold because economically reasons

7.2.3. G Axis – Degree of Confidence

National Classification	Category	UNFC definition	Reasoning for the classification
A class	G1	Product quantity associated with a project that can be estimated with a high level of confidence.	85% of probability 0.36PJ

B class	G2	Product quantity associated with a project that can be estimated with a moderate level of confidence.	70% of probability 0.42PJ
C_1 class	G3	Product quantity associated with a project that can be estimated with a low level of confidence.	50% of probability 0.47PJ

7.3. Classification of the energy projects using the UNFC scheme

Status	**UNFC**	**Class**	
Present project	E1.1; F1.1; G1	Viable Projects	
Potential Project	E2; F1.3; G1	Potentially viable projects; Development on hold;	85% of probability
	E2; F1.3; G2		70% of probability
	E2; F1.3; G3		50% of probability

7.4. Groundwater - Present project

7.4.1. E axis – Environmental -Socio-Economic Viability

National Classification	Category	UNFC-2019 definition	Reasoning for the classification
A class	E1	Development and operation are confirmed to be environmentally-socially-economically viable.	
A class	E1.1	Development is environmentally-socially-economically viable on the basis of current conditions and realistic assumptions of future conditions.	Essential reasons for the classifications are the following: • the project has been operating for 13 years and based on all experiences, it is foreseen to run at least another 25 years. • the project is economic under the current market conditions and is supplying a substantial and existing heat market • it has very positive and quantified effects on the reduction of gas consumption what is in line with the national strategies

7.4.2. F Axis – Technical Feasibility and Maturity

National Classification	Category	UNFC-2019 definition	Reasoning for the classification
A class	F1	Technical feasibility of a development project has been confirmed.	
A class	F1.1	Production is currently taking place.	The gradually expanding project has been operating since 2007. All production licenses available and secured in the long-term (until 2045).

7.4.3. G Axis – Degree of Confidence

National Classification	Category	UNFC-2019 definition	Reasoning for the classification
A class	G1	Product quantity associated with a project that can be estimated with a high level of confidence.	It is based on 13years history of exploration and market operation with average abstraction rate 1L/s.

7.5. Classification of the groundwater project using the UNFC scheme

UNFC-2009 classification and quantification of the current project

Status	**UNFC-2019**	**Class**
Present project	E1.1; F1.1; G1	Viable Projects

Table 5: Summary of geothermal and groundwater resources

ENERGY RESOURCES			
Project	UNFC	Energy volume (PJ)	Thermal water volume (L/s)
Present project	E1.1; F1.1; G1	0.053	5
Potential Project	E2; F1.3; G1	0.36	16
	E2; F1.3; G2	0.78	35
	E2; F1.3; G3	1.25	56
GROUNDWATER RESOURCES			
Project	UNFC	Groundwater volume (L/s)	
Present project	E1.1; F1.1; G1	1	

8. ALIGNMENT TO SUSTAINABLE DEVELOPMENT GOALS IMPLEMENTATION

8.1. National approaches

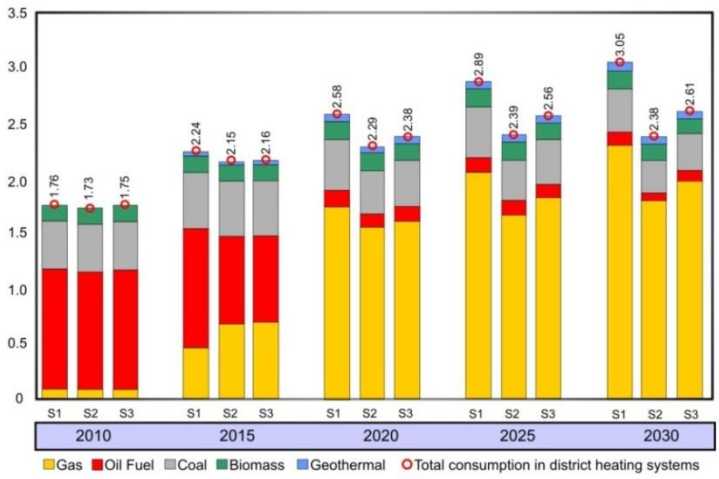
In general, the analysed projects meet not less than 5 identified UN sustainable development goals (Figure 18).

Figure 18: Sustainable development goals met by the projects

Aqua Park, in the construction stage, one of the hugest in the region, met goal 3 – Good Health and Well-being. Geothermal heating is in line with goal 7 –Affordable and Clean Energy. At the same time is it closely related to additional two goals – Sustainable cities and Communities (11) and Climate Actions (13), taking into account prevention from GHG emission and meeting of the demands for their permanent decreasing in the future. The Vivia project met goal 6 – Clean Water and Sanitation.

8.2. National sectoral strategies

It is also mentioned that the Slobomir project is in line with the committed statement in the RS and B&H in general, that additional incentive must be provided for renewable energy sources (biomass, geothermal energy) utilisation in the existing and new district heating systems, referring to national and entity energy strategies.
Energy Strategy of the Republic of Srpska [8], under objectives mentions:
"*Establish an efficient system of energy efficiency stimulation and **use of renewable energy sources** in accordance with goals and obligations that arise from the future membership of Bosnia and Herzegovina in the European Union*".



Further, in section 11 that considers district heating, slow increasing of geothermal energy in consumption structure up to 2030 is planned (Figure 19).

Figure 19: Structure of final heat consumption in district heating systems [8]

Further, the Strategy of the environment protection of the RS, from 2011 [14], in section 2.4.1, chapter Energy, prefers utilisation of renewable energy resources, including geothermal.
It means that geothermal projects, like Slobomir, represent broadly acceptable projects regarding key national strategic documents, deal with energy and environment.
As the state intends to be a part of the EU in the future, B&H must meet the requirements of numerous directives and strategies of the EU. In the context of this document, it is important to emphasise that the Republic of Srpska fully harmonised the Law on Water (Official Gazette of the RS 50/06) with the Water Framework Directive 2000/60/EC. Two mentioned projects are prepared to take into account provisions of the mentioned law, and it means that met challenging requests by the WFD. Also, the national report on climate changes [6], prepared in line with the EU standards, strongly emphasise the importance of clean energy and CO_2 emission reduction.
In addition, the EU Energy Green Deal is briefly described and analysed in the context of two projects.

8.3. Case study project(s) specific aspects

The development of the, e.g. Slobomir geothermal project and its results have been in the focus of numerous transboundary considerations with neighbouring Serbia, because, on the other side, in Serbia, there is an intensive abstraction of thermal water in the locality Bogatić, just a few kilometres away from Slobomir. It is the reason why the utilisation of geothermal energy in the area must be considered as transboundary issue. At the same time, it is a good base for regional connection between scientific and education community, energy experts, decision-makers, legal policymakers, economists, environmental experts and other branches. In the last decades, only hydrogeological experts put strong focused and provide fruitful cooperation in this transboundary issue. But this valuable renewable energy resource entails the inclusion of the all other experts to contribute the long-term planning of the future utilisation.
At the same time, it means an opportunity for cooperation and trust-building between countries which left behind periods of conflicts and misunderstanding.

8.4. EU New Green Deal

Climate change and environmental degradation are an existential threat to Europe and the world. To overcome these challenges, Europe needs a new growth strategy that transforms the Union, but also other countries, into a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases by 2050 economic growth is decoupled from resource use no person and no place is left behind. The European Green Deal is a roadmap for making the EU's economy sustainable [18]. The EU intended to be climate neutral in 2050. To do this, the European Climate Law turning the political commitment into a legal obligation and a trigger for investments proposed.
Reaching this target will require action by all sectors of the economy. The Slobomir project "touches" some key proposed action (from the viewpoint of local conditions; it means that some actions like geothermal heating is not totally innovative for the EU developed countries but for the level of the Republic of Srpska and Bosnia and Herzegovina it is; signed by black point in the next table):

Table 6: The Slobomir geothermal project "touches" key proposed action by the Green Deal

investing in environmentally-friendly technologies	●
supporting industry to innovate	●
rolling out cleaner, cheaper and healthier forms of private and public transport	not applicable for Slobomir project
decarbonising the energy sector	●
ensuring buildings are more energy efficient	●
working with international partners to improve global environmental standards	potential for cooperation with national authorities involved in international projects related with improvement of

	global environmental standards

This project could be a "leading star" for another relevant project at the local and national level.
The partners must take into account that the EU will also provide financial support and technical assistance to help people, businesses and regions that are most affected by the move towards the green economy. This is called *the Just Transition Mechanism* and will help mobilise at least €100 billion over the period 2021-2027 in the most affected regions.
Document [19], as a supporting document of the New Green Deal, gives good EU examples and acceptable praxis. Based on this document, Slobomir project included the following good praxis:

- Cut CO_2 emission and lower energy bills;
- Energy efficiency investments in companies;
- Reduce greenhouse gas emissions;
- Creating employment with environment acceptable technologies.

8.5. COVID-19 related issues

The paragraph is mostly based on the information given on the official web page of the UNECE related to the Sustainable Development Goals[2] and the author's review of possible respond of two analysed projects on local and entity (Republic of Srpska) scale.
With almost half of the world under lockdown, the continued supply of certain critical raw materials needed for an effective response to the COVID-19 pandemic has become a concern.
One example of a raw material widely used in the pharmaceutical industry is phosphate. It is also used in food additives and fertilisers. An effective response to the COVID-19 pandemic has become a concern.
The UNECE Executive Secretary Olga Algayerova said: "If we are to stay on course to meet the goals of the 2030 Agenda for Sustainable Development, it is crucial that the related massive investments are directed towards a "green" and not a brown recovery". It is obvious that we should follow this statement in the upcoming decades.
Anyhow, renewable energy in the Republic of Srpska, B&H, especially geothermal (direct use or with heat pumps) must play an important role in the future energy consumption, especially in the heating sector (district and individual heating). The Slobomir project represents a good example with the potentiality to heat numerous residential building in neighbouring settlements and substitute coal and wooden based heating, parts of Bijeljina town as well. This approach will be indeed in line with *"green" and not a brown recovery".*
High quality bottled groundwater "Vivia" presents well-recognised brand on a market, but with significantly higher reserves than abstraction, also could be a very valuable source of drinking water in a case of different diseases and endangering of public water sources for the intervention reaction in drinking water supply, especially in challenging climate change conditions.

[2] https://www.unece.org/?id=54209

9. CONCLUSIONS ON THE UNFC CLASSIFICATION OF INTEGRATED ENERGY AND GROUNDWATER RESOURCE PROJECTS IN THE REPUBLIC OF SRPSKA, BOSNIA AND HERZEGOVINA

9.1. Advantages and disadvantages of UNFC for national- and project-level decision making

The energy production from renewables, included geothermal energy, is a part of relevant energy strategies and considered as an important factor in future energy adaptation on climate changes. On the other side groundwater is a key resource of drinking water supply (from porous and karstic aquifers), provides more than 4/5 of total consumptions. Also, groundwater provides significant support for water for industrial processes. It means that groundwater is one of the basic resources for the entity and country, in the social and economic sense.
Groundwater, as well as geothermal energy management, is based on different geological studies, in most cases provided in the last half of the previous century. The resources (energy and groundwater) are classified in accordance with the national classification system, but usually not recognised and understandable on a global level (excluded former Soviet and Yugoslav republics and the restricted number of countries in Eastern Europe).
UNFC serve wide acceptable approach to explain in a more familiar manner project related to commodities.
In general, advantages should be considered as [15]:

- It is easy to compare a wide range of commodities, including minerals, petroleum, renewable energy sources, water, etc.
- UNFC has been designed for national- or continent-scale reporting and has the flexibility to accommodate a wide range of different types of information.
- UNFC is the only commonly used, internationally recognised system that can incorporate something close to the concept of 'all there is' in terms of mineral resources and can, therefore, provide a relatively complete picture of mineral stocks.
- The majority of other internationally recognised systems cannot accommodate uneconomic and undiscovered resources, including early-stage exploration and historical estimates, while UNFC give tools for it.
- It is already being used for mineral resource inventories in some countries – e.g. Hungary, Finland, Ukraine, Romania – and possible Norway in the future.
- Backed by the UN – internationally recognised.
- Although competency to report using the UNFC framework is required, this is not an essential requirement (i.e. the UNFC is not a certifying body). As a result, it is more readily accessed by geological surveys.

Opposite, disadvantages are considered as the following:

- No bridging document between national classification system and UNFC
- Many companies do not report data to UNFC, and their data will need to be bridged across (but this is possible if they report in accordance with the CRIRSCO template as a bridging document (already exists).
- The three axes approach makes it appear complicated – this can be an issue if trying to communicate with policymakers or encouraging others to adopt it. The positive fact is that 2D representations are possible as well.

9.2. Suggestions for improvement of UNFC if any and added benefits such as improving resilience

UNFC has a long history of evolution, and experts included hard working. It is the above mentioned that the classification can incorporate something close to the concept of 'all there is' in terms of mineral resources. Further, bridging documents are prepared for many other classifications (CRISCO, PERC, NAEN code, etc.), but general suggestions for the improvement (from the author point of view) are addressed as:

- Inclusion of small countries (as, e.g. B&H) in the process of bridging of their national classification with UNFC; the mapping scheme developed in the study could be a start point for the bridging and application in the Western Balkan region.
- Because very similar classification system (based on Former Soviet Union (FSU) system) common consultation process is possible for all former Yugoslav countries (Slovenia, Croatia, B&H, Serbia, Montenegro, North Macedonia), but also for some other countries use classification system based on Former Soviet System (balance and non-balance, in general with reserves of A, B, C_1, C2, sometimes D_1 and D_2 categories).
- This kind of approach should disseminate idea about the value of UNFC and, e.g. in consultation between UNECE and some workgroup (it could be ad-hoc) contributes preparation of the bridging document for the above-mentioned countries.
- UNECE, with UNFC dissemination idea, must be in general more active in the Western Balkan region.

9.3. Benefits in using UNFC for alignment to SDGs

This subchapter is mostly based on finding in UNECE web site information.[3]
Ensuring sufficient, reliable, affordable, and environmentally responsible supplies of energy and raw materials for sustainable development is a key challenge for all countries. UNFC is a tool for effective management of national resource endowments needed for realising the Sustainable Development Goals (SDGs).
UNFC applies to energy and mineral resources; injection projects for the geological storage of CO_2; and the anthropogenic resources such as secondary resources recycled from residues and wastes. UNFC aims to provide necessary specifications and guidelines for optimising the management and development of resources, with positive impacts on the society, environment, local economies and employment.
UNFC has a strong focus on future societal aspirations and incorporates these aspects in a major way. UNFC's major comparative advantage resides in the fact that it is closely aligned to the Sustainable Development Goals (SDGs) (Table 7).

Table 7: Benefits of UNFC regarding SDGs

	UNFC is a tool that aims at optimising the management of national endowments of energy resources, with positive implications for local economies, employment, royalties, and tax revenues.
	The management of macro and micro soil nutrients like potassium and phosphorous sources are important for food production and can be done effectively thanks to the UNFC.
	The UNFC is used as an interconnected tool with other systems to manage impacts on water systems and monitor progress during resource extraction. Trans-boundary sharing of water infrastructure can be part of the mitigation plans, which UNFC can contribute to integrated management and monitoring.

[3] *https://www.unece.org/energywelcome/areas-of-work/unfc-and-sustainable-resource-management/applications/unfc-and-sustainable-development-goals.html*

	UNFC is used in many countries for effective management of national resource endowments and socio-economically efficient development of the energy resources contributing to sustainable development.
	UNFC directly contributes to managing resources efficiently during extraction by promoting cleaner and environmentally sound technologies and industrial processes.
	UNFC fundamental criteria for resource development include socio-economic factors that promote the continued viability of a project. These criteria include factors like gender equality and fruitful employment of disadvantaged sections of the local population.
	UNFC can be an effective tool for local governments to optimise the management of local and sub-regional endowments of energy resources.
	UNFC is an international best practice for sustainable management of mineral resources, petroleum, uranium and renewable energy resources. UNFC provides the tools for addressing the issues related to environmental impact and mitigation and can be part of various sustainability reporting regimes.
	UNFC can be used to manage renewable energy projects such as geothermal energy, bioenergy, solar energy, wind energy and hydropower. UNFC is applicable to the management of Carbon Capture and Storage projects.
	UNFC application for the management of various natural resources is very effective in the context of regional and international cooperation. UNFC can serve as a global framework of reference for providing data on natural resources.

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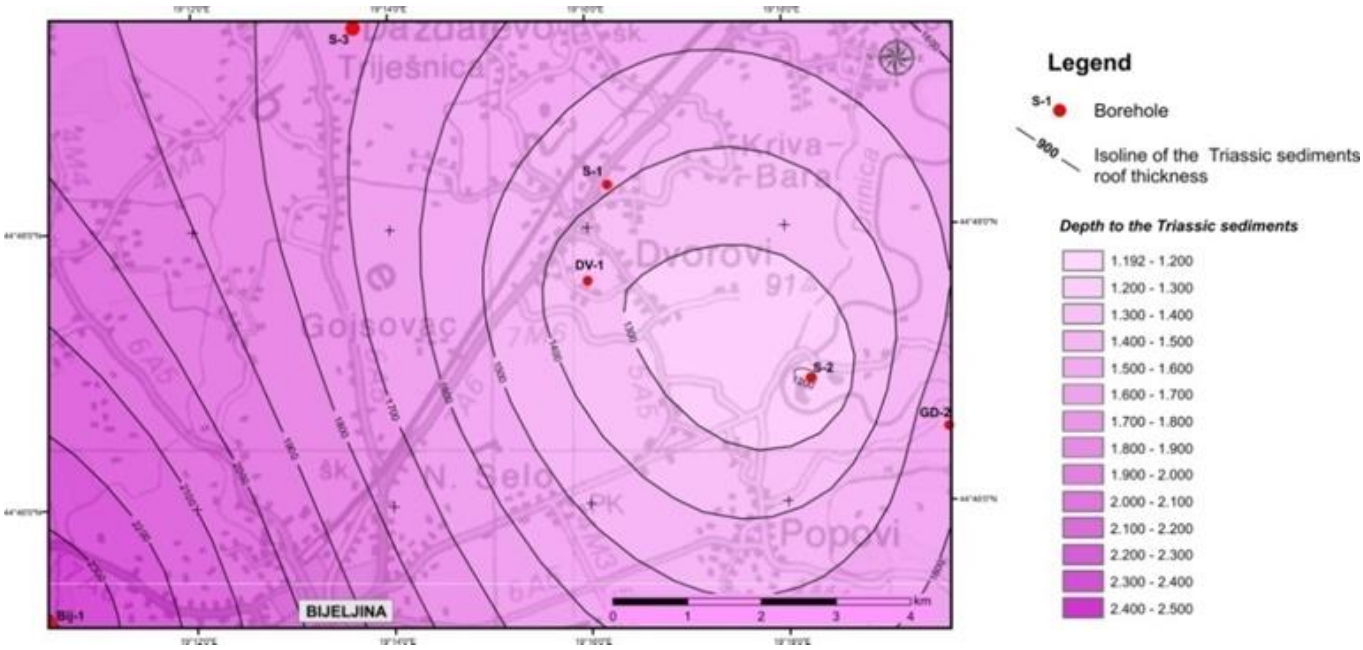
[18]	Group of Authors	The European Green Deal, European Commission, Brussels, 2019
[19]	Group of Authors	EU Funded Projects to Green the Economy, The European Green Deal, Brussels, 2020

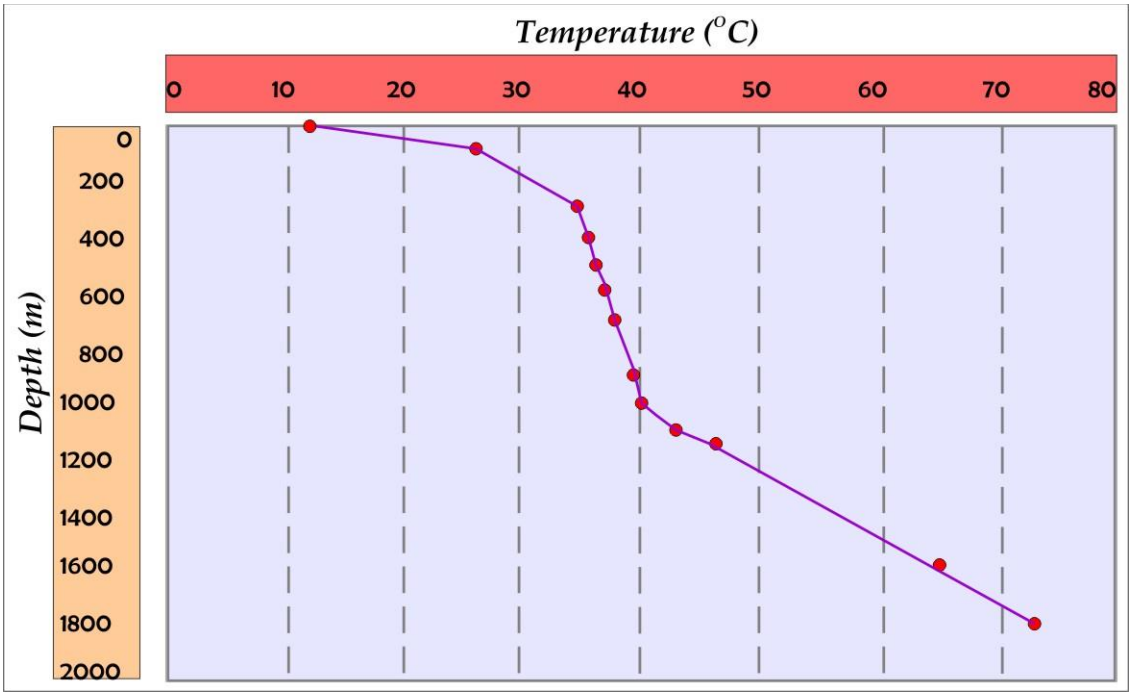
ANNEX 1

MAP OF ISOLINES OF THE DEPTH TO THE TRIASSIC GEOTHERMAL AQUIFER IN SEMBERIJA REGION, REPUBLIC OF SRPSKA, B&H



ANNEX 2

DIAGRAM OF TEMPERATURE VS DEPTH, THERMAL WELLGD-2

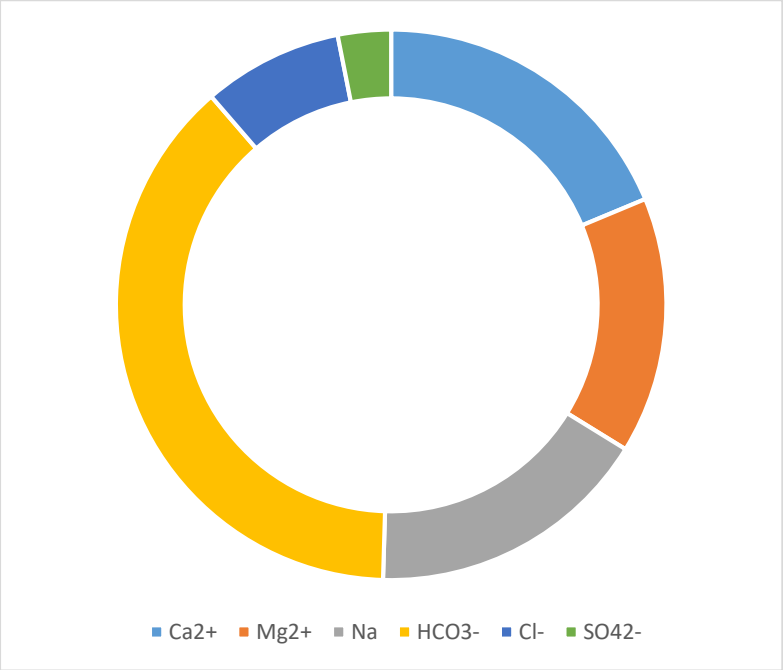


PUMPING TEST, THERMALWELL GD-2 SLOBOMIR, 2010

ANNEX 3

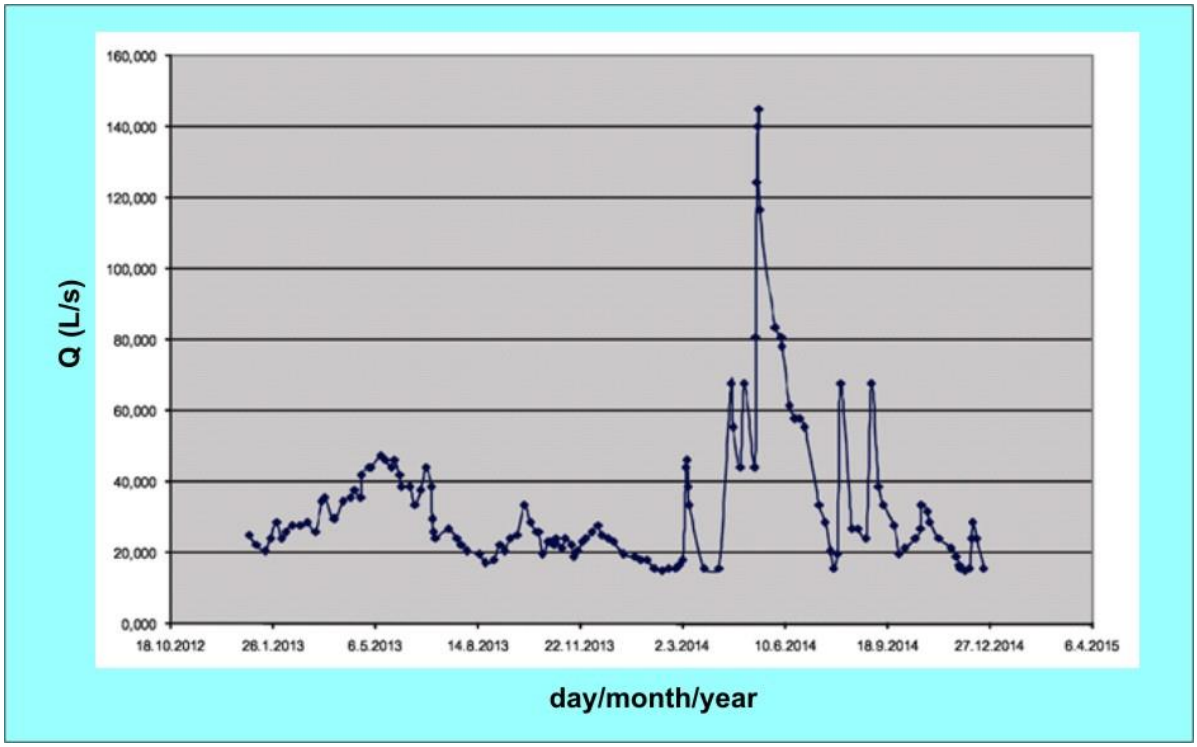
MACRO-COMPONENTS, THERMAL WELL GD-2

Cation	*mg/l*	*mg ekv*	*% ekv*	*%*		*Anion*	*mg/l*	*mg ekv*	*% ekv*	*%*
Ca^{2+}	45	2.25	0.37	37.0917		HCO_3^-	280	4.59	0.77	77.11
Mg^{2+}	22	1.81	0.30	29.84974		Cl^-	35	0.98	0.16	16.58
Na^+	45	2.00	0.33	33.05856		SO_4^{2-}	18	0.37	0.063	6.30



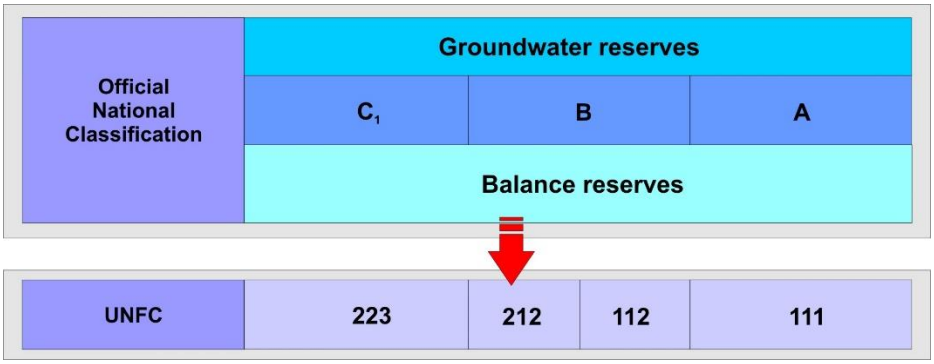
ANNEX 4

HYDROGRAPH OF BANJICA SPRING FOR THE PERIOD JANUARY 2013 – DECEMBER 2014



ANNEX 5

EXPLANATIONS OF THE REASONS FOR THE GROUNDWATER MAPPING SCHEME



For A - 111

E: Viable under current market conditions;
F: All permissions provided;
G: Groundwater reserves defined with the highest probability, based on the Rulebook.

For B - 112

E: Viable under current market conditions; clear opportunity for the development based on market history and current conditions (e.g. realistic possibility to improve sale for additional 50% because the different reasons, e.g. problems in water supply related with climate changes, obstacles with bottling water import because the current COVID-19 situation or some other reason);
F: All permissions provided (concession contract, as the key permission, is provide for long time period, usually for 30 years)
G: Groundwater reserves defined with the moderate probability (B), based on the Rulebook, necessary additional explorations to reach A reserves (to move from B to A, or in the other words from G2 to G1)

For B - 212

E: Not viable under current market conditions; opportunity for the development in foreseeable future, based on market history and current conditions;
F: All permissions provided (usually concession contract, as key permission is provide for long time period, usually for 30 years); technical parameters are mostly designed to meet increasing of the system in foreseeable future.
G: Groundwater reserves defined with the moderate probability, based on the Rulebook, necessary additional explorations to reach A reserves (to move from B to A, or in the other words from G2 to G1)

For C_1 - 223

E: Not viable under current market conditions.
F: Usually concession contract, as key permission is provide for long time period (for 30 years), but technical feasibility is questionable, because the projects are usually gradually developed, and it is not realistic that someone construct at the beginning project stage, e.g. pipelines for maximal available resource, over and above defined with the lowest probability (C_1 reserves). It is reason for F2.
G: Groundwater reserves defined with the low probability, based on the Rulebook. Necessary additional exploration to reach B reserves (to move from C to B, or in the other words from G3 to G2).