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

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RESOURCE MANAGEMENT WEEK 2021

ENABLING SUSTAINABILITY PRINCIPLES IN RESOURCE MANAGEMENT

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GEOGRAPHY

Brief review of the Country Organization and Mineral Politic

- **Bosnia and Herzegovina**
- Republic of Srpska and FB&H

The **political divisions of Bosnia and Herzegovina** were created by the Dayton Agreement, which recognized country comprising of two entities:

- The Federation of Bosnia and Herzegovina (51%)
- The Republic of Srpska (49%)

•Entities create independant mineral politic;

•There is no state ministry responsible for mineral resources mangement, as well as nationa startegy on mineral resources management(only entity).

•No state geological survey, but two entity geological survey.

State level important mineral resources

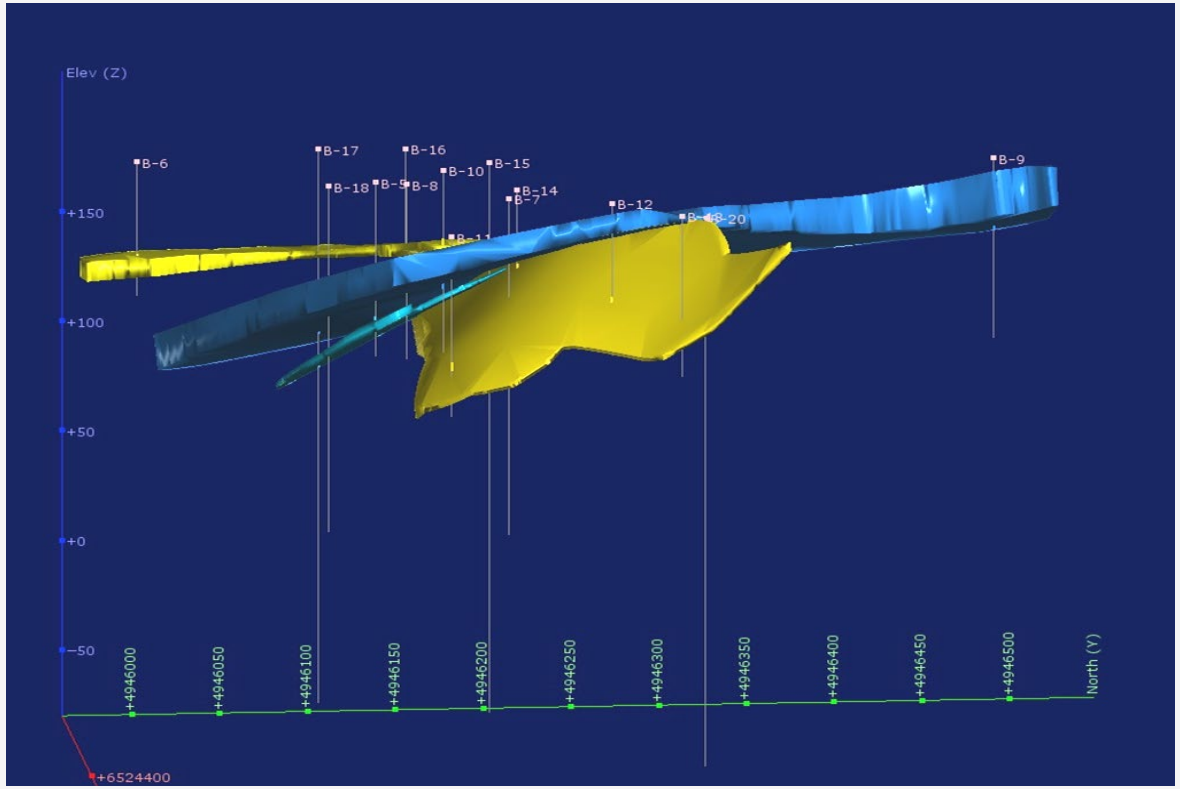
Driving forces

Key mineral resources:

- Coal (brown coal and lignite)
- Iron
- Bauxite
- Lead and zinc (+Cu, Ag, Au...)

Potential:

- Lithium and borates
- Nickel and Cobalt
- Antimony



MINERAL RESERVES CLASSIFICATION SYSTEM

SOLID MINERAL RESOURCES

GROUPS AND SUBGROUPS

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RS legislation, preentscreen of the Article 15 of Low On Geological Explorations (110/13)

5. Категоризација резерви чврстих минералних сировина

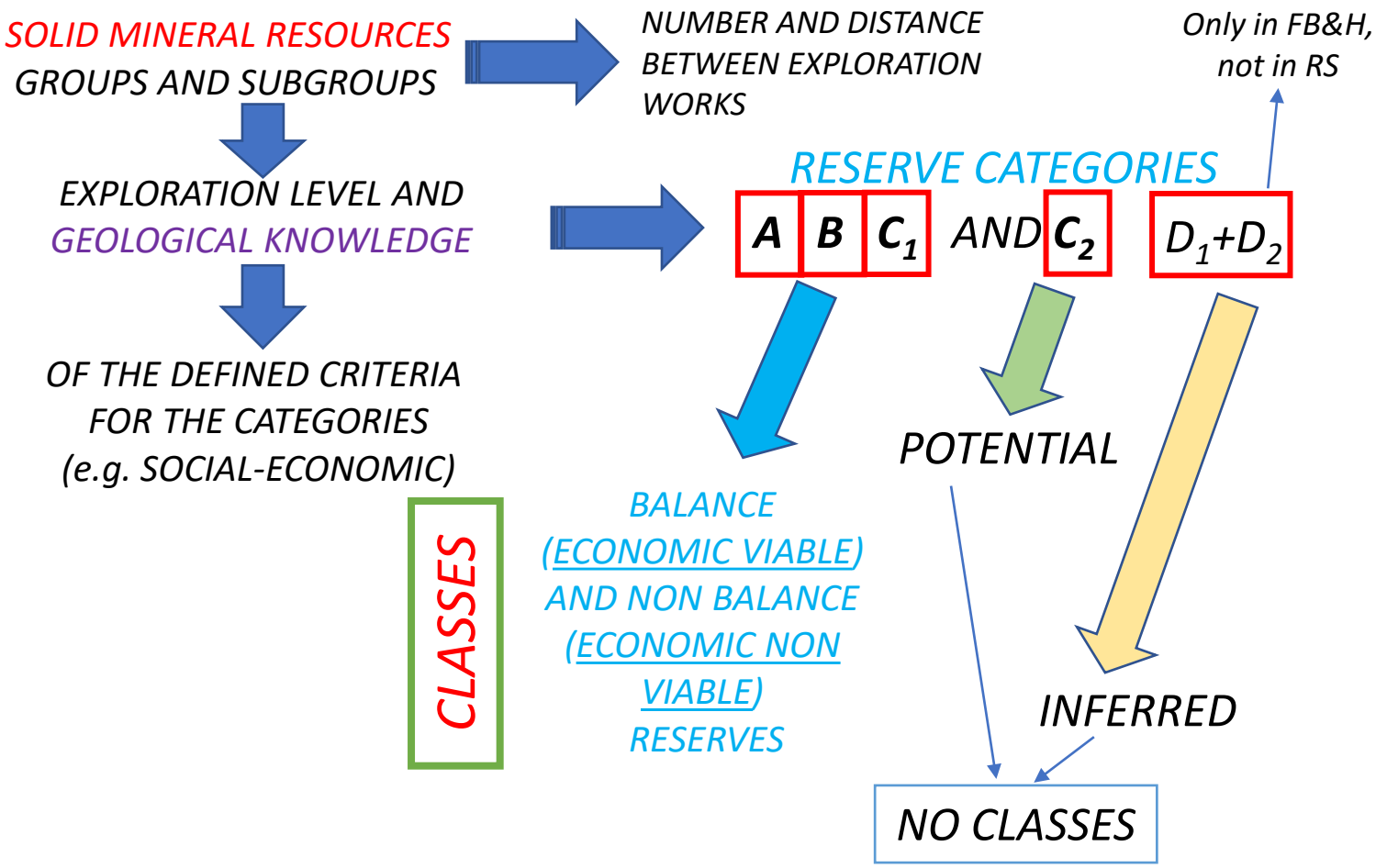
Члан 15.

(1) Према степену истражености и степену познавања квалитета, утврђене масе резерви чврсте минералне сировине разврставају се, по правилу, у категорије А, В, C_1 и C_2.

(2) Према Оквирној класификацији Уједињених нација (UNFC), резервама А + В категорије оријентационо одговарају "доказане резерве" (енгл. Proved reserves), а C_1 категорији "вјероватне резерве" (енгл. Probable reserves).

(3) Према истим класификацијама резервама C_2 категорије одговарају "претпостављене резерве" (енгл. Assumed reserves).

(4) Категорије и класе из става 1. овог члана примјењују се и у оквирној класификацији ресурса и резерви чврстих минералних сировина и ресурса UN, уз коришћење одговарајућег тродимензионалног графикона.



MINERAL RESERVES CLASSIFICATION SYSTEM

SOLID MINERAL RESOURCES

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Classes and categories

The reserves of mineral resources are split into the following classes and categories (Table 1).
Use of terms of 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 the deposit (explored ore reserves; allowed error +/- 15 %)
2. **B** – Known and established characteristic of the deposit (explored ore reserves; allowed error +/- 30 %)
3. **C_1** – Partly known and defined characteristic of the deposit (explored ore reserves; allowed error +/- 50%)
4. **C_2** – Partly tested deposit conditions and mostly determined by analogy with known parts of the deposit (Inferred/ Perspective)

Category of reserves	Class
A acceptable error +/- 15 %	Balance (economically viable exploitation) and non-balance (economically non-viable exploitation) reserves
B acceptable error +/- 30 %	
C_1 acceptable error +/- 50 %	
C_2	Potential reserves

MINERAL RESERVES CLASSIFICATION SYSTEM

CURRENT MINERAL RESERVES CLASSIFICATION SYSTEM AND LINK WITH UNFC-2009

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CATEGORIES

*BALANCE (**ECONOMIC VIABLE**) AND NON BALANCE (**ECONOMIC NON VIABLE**) RESERVES*

A, B, C_1 AND C_2 D_1+D_2

Viable - in accordance with generally adopted economic and social criteria

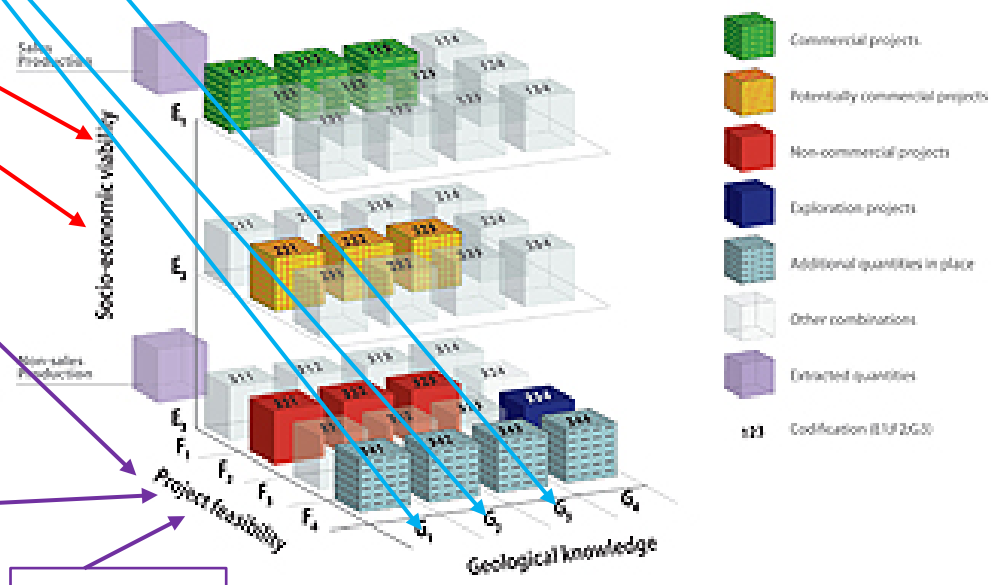
CLASSES

COMPLEX TECHNICAL AND ECONOMIC ANALYSES

Social (importance of the MR for region, entity, state; harmonization with different strategies; environmental issues, e.g. land recovery after exploitation etc)

Ecological aspects

Permits



UNFC APPLICATION

ENERGY (GEOTHERMAL) PROJECT

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- ENERGY PROJECT

Product type

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

Reference point

The reference point is where fluid touches the heat exchanger. Due to the very close distance between geothermal well GD-2 and plant as well as modern isolation techniques, there is negligible heat loss between the wellhead and the heat exchanger (T=72^{o}C).

Project lifetime

The project is active from 2011 when the first stage of the thermal plant is constructed. Earlier, borehole GD-2 was completed (in 2010). Foreseen well operation lifetime is 25 years and concession contract with the Government is valid up to 2036. Thus, estimation is done for the period of 16 years.

UNFC APPLICATION

Social aspects

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Social end economic aspects

Strengthening the local economy and entrepreneurship

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

All these sectors have **very positive** effects for the economy because increase employment and life standard in this rural area, in the past primary recognised exclusively as agricultural area. Geothermal project is one of the most important segments, especially because finalisation of the aqua park should providesignificant additional employment. In entrepreneurship sense, for the first time in this part of the Semberija region, it is presented some other business model than agriculture. Planned activities could be 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. Company Slobomir constructed bridge on the Drina River (distanced 2 km from the town), connected Bosnia and Herzegovina and Serbia. Also, a few kilometres of the new road is constructed. By these facilities, connection with other parts of 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 local district heating development with plugging of new consumers on the available power plant. This step is also positive in the sense of decreasing of fossil fuels (coal) and firewood in the purpose of heating.

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

Improving education - one of the main component of the town concept is education. Slobomir University, established in 2003, is one of the most important educational institution in the region. Existing of the university and unique and very successful geothermal project, distances just few meters, is very good opportunity to organise education for different target groups (geologists, energy sector, economists, NGOs...) about the development of huge environment-friendly projects.

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Environmental issues of energy production

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- **Geothermal energy production – environmental framework**

- ***International efforts for transition to green energy*** (the Kyoto Protocol (1997), the declaration of the Earth Summit in Johannesburg, the findings of the Bali Climate Change Conference or the (2007), the EU Water Framework directive (2000), newest climate agreement signed by the participants of the world conference held in Paris 2019).

- ***In line with the national, entity and local regulations and strategies*** regarding energy transition and environment protection. (Energy strategy up to 2035, Environment strategy-in preparation)

a) Resource depletion aspects

Pumping tests of borehole GD-2 provided valuable data on the thermal water reserves calculation. It discloses that 35 L/s could be pumped without deterioration. Currently, just 5 L/s is used during winter season. It means that there are no depletion effects.

b)Thermal water recharge, depletion or contamination aspects

Contamination issue could be considered as thermal effect related to discharge of used thermal water. Namely, used water of 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.

c) 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

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ENERGY PROJECT E axis – E1, sub-category E1.1

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Development and operation of the project are confirmed to be environmentally-socially economically viable.
Essential reasons for this statement are the following:

Environmental:

- fossil energy in heating sector is substituted by renewable energy (*hydrogeothermal*);
- 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).

Social:

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

Economical:

- 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. Substitution of the 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 favorable in the foreseeable future).

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Technological feasibility aspects for energy resource production

The borehole GD-2 was completed in 2010. Past energy production (in the last 10 years) reveals there is 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 73ºC.
Mineralisation is low, about 0.7 g/l. There is no any gasses affect technological feasibility of energy production. A borehole and thermal power plant were located in the mid of the planned activities (heating, aqua-park, agriculture etc.), with short transport and no minimal losses.

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

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

Detailed studies conducted and results

Results obtained by the exploitations of the system show that feasibility study findings are met in the filed during the system exploitation.

Detailed studies planned

The whole geothermal project was preliminary based on more than one deep boreholes. Very positive results of the first borehole (GD-2) reduce ambitious, but very expensive 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 aqua-park is not completed yet, construction is stopped after huge progress because of the company's financial problems. Under studies, agricultural production in greenhouses, based on geothermal energy, is realistic here as well.

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ENERGY PROJECT F axis – F1, sub-category F1.1

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- Technical feasibility of a development project has been confirmed. 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 give the serious possibility to plug energy source to the other consumers. The modern thermal plant is just 20 m distanced from the thermal well, without energy losses. Further, 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.*
- 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 Ministry of Energy and Mining.
- All licences for construction and spatial planning related permissions are issued by national and local authorities.
- The water permit is confirmed by public institutions in charge of water permit-issuing (Public Institution "Vode Srpske").
- **Concession contract, signed with the Government of the Republic of Srpska is valid until 2036.**

UNFC APPLICATION

Historical geological explorations and State of the art - energy resource

- The 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 shared Serbia.

- According to the results of the previous exploration, the region reveal the most prospective geothermal properties in the Republic of Srpska. Also, it represents the best explored geothermal area in the country. The highest values of the geothermal gradient (>50ºC/km) and heat flow (>100 mWm^{-2}) are registered right here.

- Heretofore, six boreholes were drilled in the area approximately 200 km^2, each deeper than 1.300 m (in total 10.5 km). The deepest one is 2479 m.

- Based on the results of previous explorations, there is an assumption about one unique (transboundary) geothermal aquifer in RS, B&H and Mačva (Serbia) that probably also extends on 2.000 km^2.

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ENERGY PROJECT G axis – G1, G2 and G3

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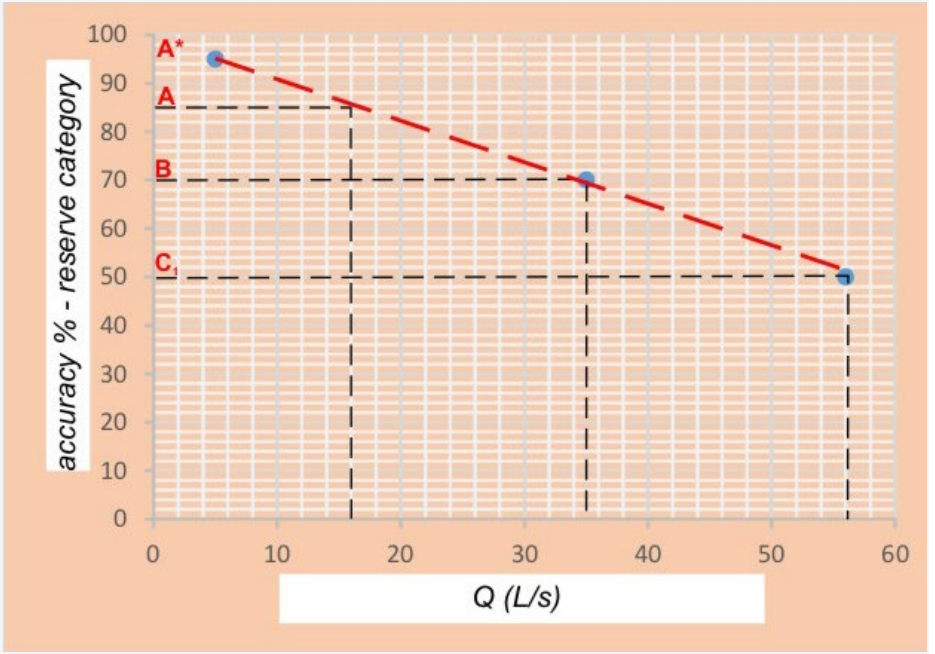
Energy volume is calculated based on appropriate reserves and useful temperature. For the current project A* reserves were taken into account because, at the moment, thermal water is only used for heating, in regime 73°C/48°C (Table 3).
For the potential project, considered in addition, cascade use including aqua-park (currently in advance constructions stage), agriculture 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.

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

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



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Energy – Geothermal - Present project

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National Classification	Category	UNFC definition	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.

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.

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 a production forecast for 0.053 PJ heat energy to be extracted can be foreseen with a high level of confidence for the next 16 years (0.51 MWh_{th} x 16/2 years, 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.

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Energy – Geothermal - Potential project

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National Classification	Category	UNFC definition	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 (finalization 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.

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 time higher than currently 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

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

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CLASSIFICATION OF THE ENERGY PROJECTS USING THE UNFC SCHEME

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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

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

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MAPPING SCHEME BETWEEN OFFICIAL CLASSIFICATION OF THE REPUBLIC OF SRPSKA, B&H AND UNFC

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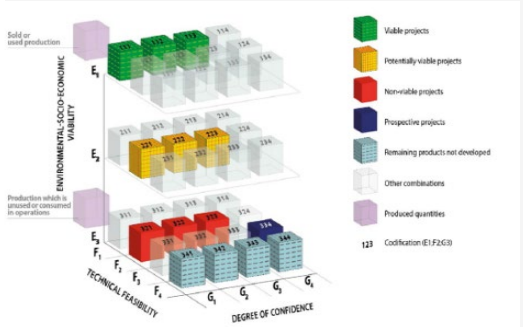
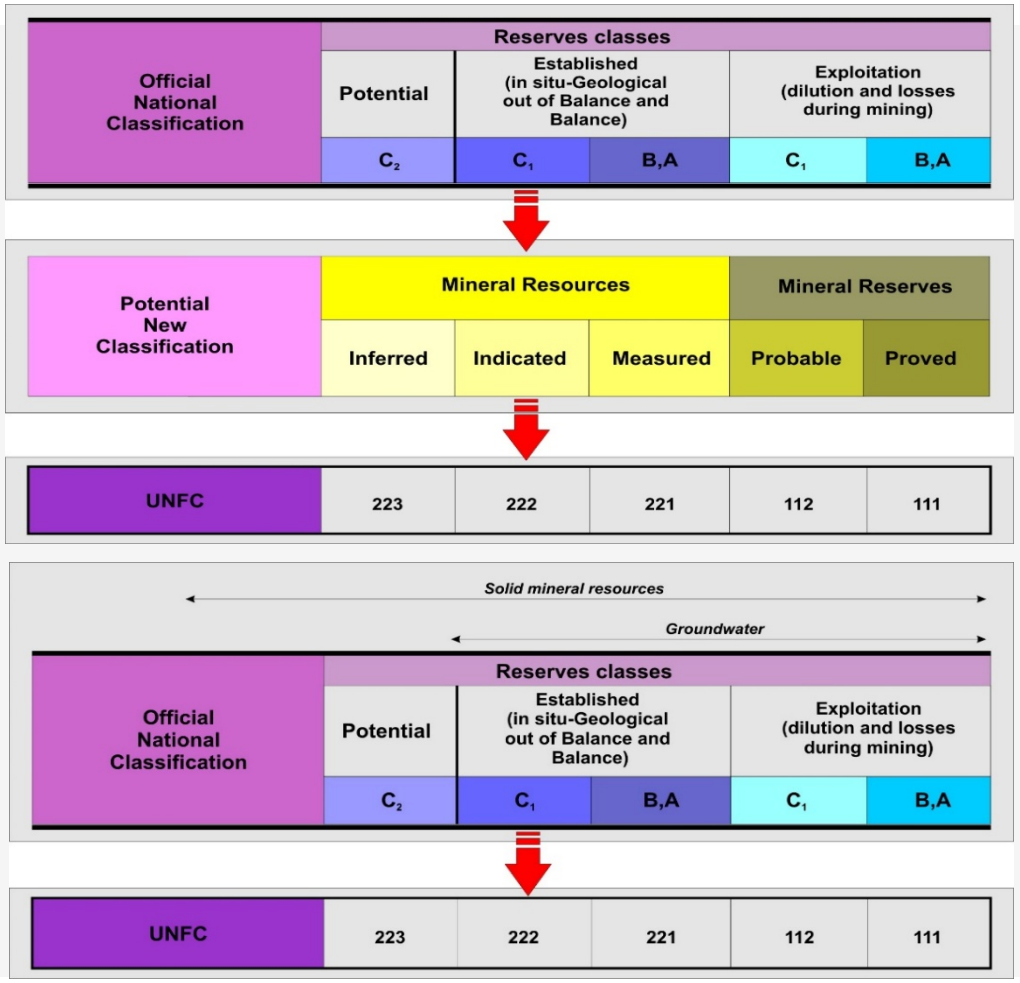
Mapping Scheme





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

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

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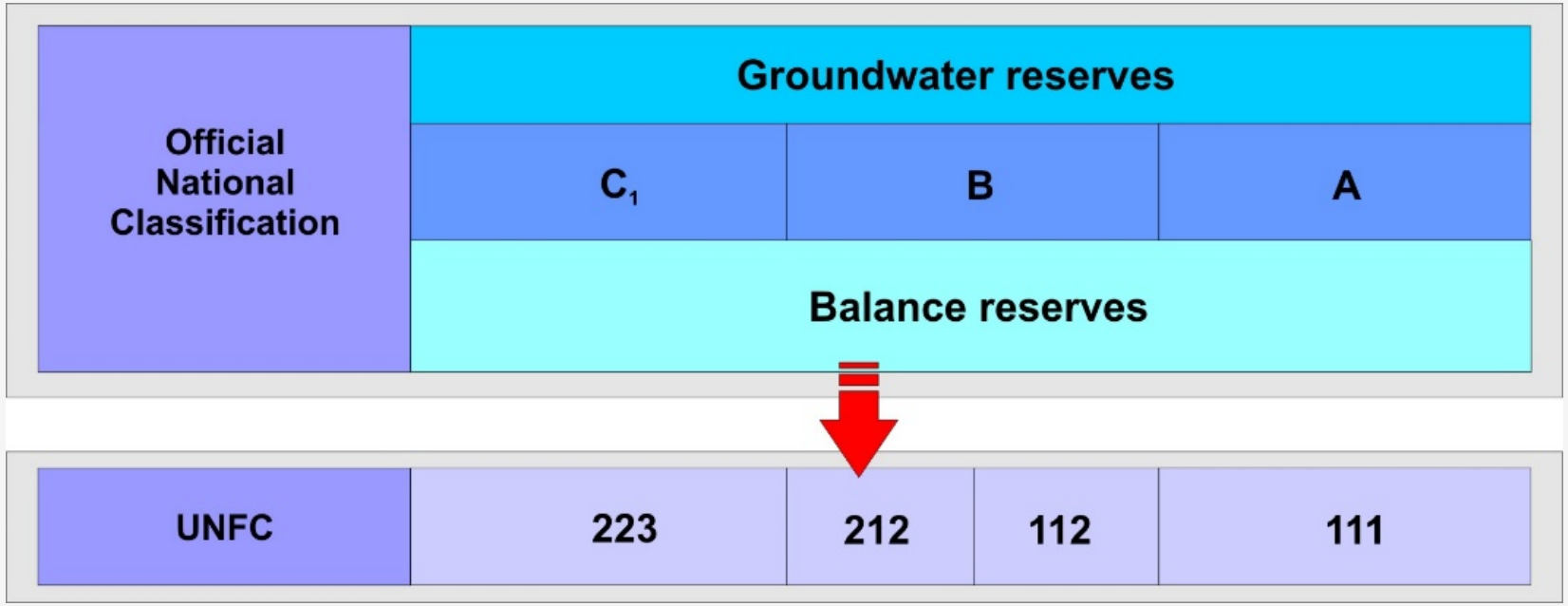
GROUNDWATER

Mapping Scheme



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

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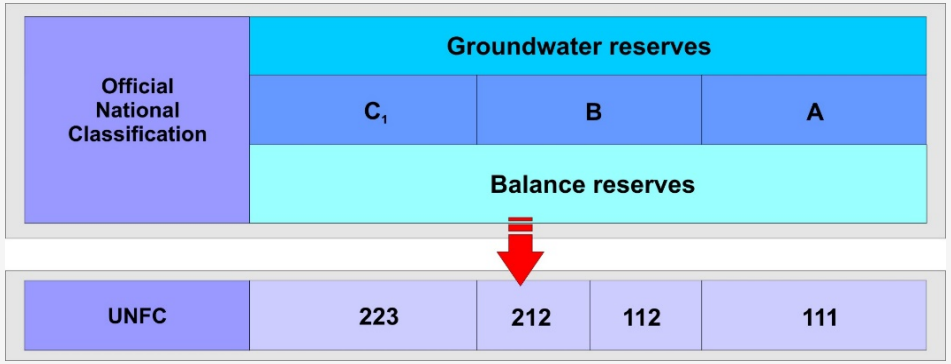
EXAMPLE OF THE EXPLANATIONS OF THE REASONS FOR B-112



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)

UNFC APPLICATION
MDG AND COVID-19 RELATED ISSUES

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

COVID-19 related issues

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. effective response to the COVID-19 pandemic has become a concern.

As it stressed by UNECE Executive Secretary Olga Algayerova *"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".*

Anyhow, **renewable energy in Republic of Srpska, B&H, especially geothermal (direct use or with heat pumps) must play important role in future energy consumption, especially in heating sector (district and individual heating)**. *Slobomir project represent good example* with potentiality to heat numerous residential building in neighbouring settlements and substitute coal and wooden based heating.. This approach will be indeed in line with *"green", and not a brown recovery"*.

High quality bottled groundwater "Vivia" present well-recognised brand on a market, **but with significantly higher reserves than abstraction, also could be 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 and COVID-19 pandemic period.

UNFC APPLICATION

SUGGESTIONS FOR IMPROVEMENT OF UNFC UNDERSTANDING AND APPLICATION

- UNFC has a long history of the 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 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 at regional level for all former Yugoslav countries (Slovenia, Croatia, B&H, Serbia, Montenegro, North Macedonia), but also for some other countries which use classification system based on Former Soviet System (balance and non-balance, in general with reserves of A, B, C_1, C2, sometime D_1 and D_2 categories).
- This kind of approach should to 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.

Thank you!

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RESOURCE MANAGEMENT WEEK 2021

ENABLING SUSTAINABILITY PRINCIPLES IN RESOURCE MANAGEMENT

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