Preparation of a study the local geological and mining conditions and development of technical, principle based guidelines for designing and implementing a programme for an efficient safe and environmentally conscious mine closure in Albania and Serbia

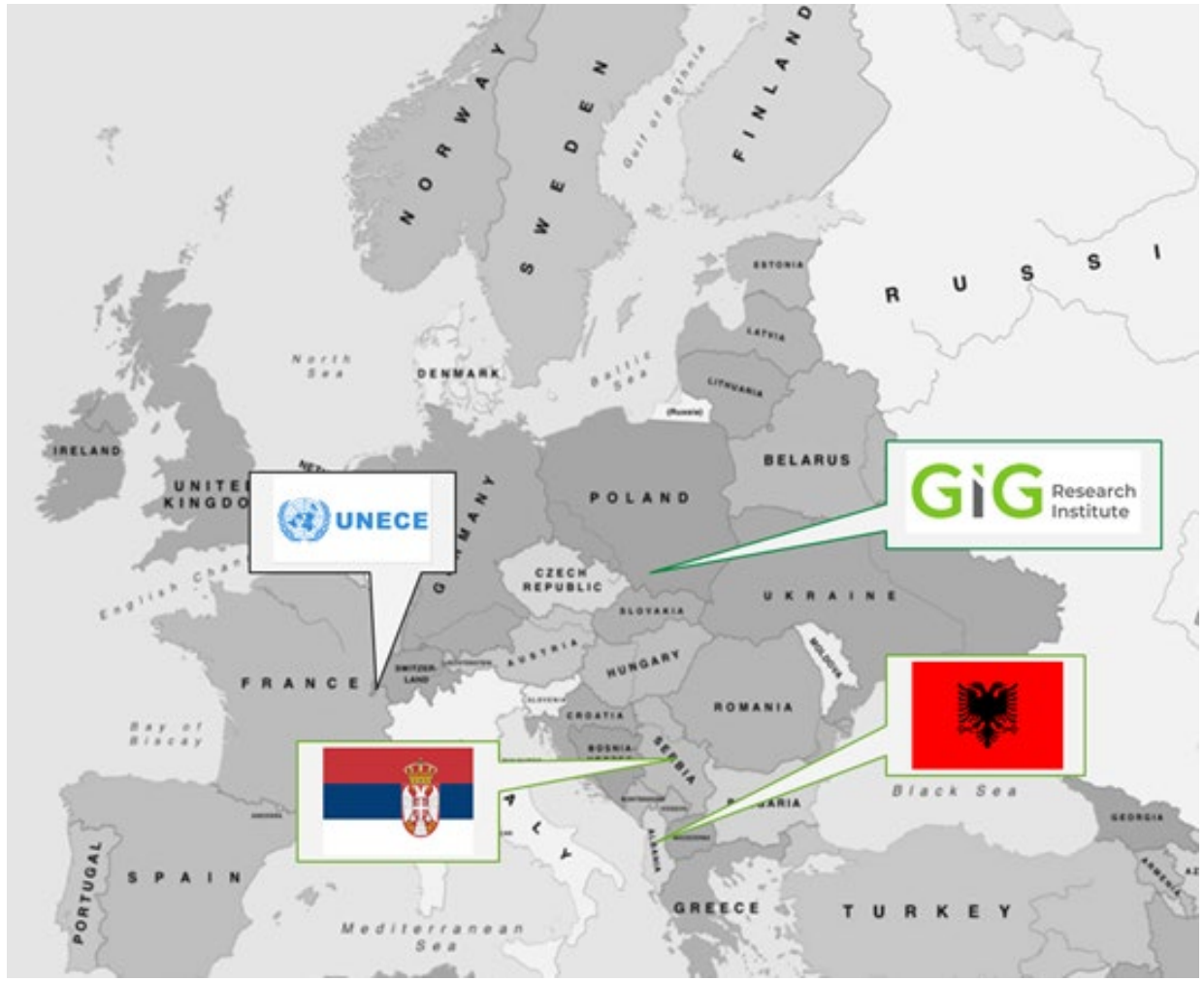
Aleksander Wrana

Aleksander Frejowski

HR EXCELLENCE IN RESEARCH

Analysis of selected aspects of underground coal mining in Albania and Serbia

The goal of the study is to provide a theoretical background for actions allowing to reclaim the coal mined land and mitigate mining and post-mining hazards in Albania and Serbia



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GŁÓWNY INSTYTUT GÓRNICTWA (CENTRAL MINING INSTITUTE) IN BRIEF

- Research Institute, established 1925,
- Subordinates to the Minister of State Assets,
- Employees (2021) – 472 people, including 11 professors, 17 assoc. prof. and 104 DSc,
- **Notifying Body No. 1453** of the European Union within the range of the directives: **2014/28/UE** – for explosives for civil uses, **2014/34/UE** – for electrical equipment for use in potentially explosive atmospheres (ATEX), **2006/42/UE** – for machinery used underground, and **within IECEx** system that facilitates international trade in equipment and services for use in explosive atmospheres.
- **The Scientific Council** holds full academic authorizations to grant the degree of doctor and doctor habil., and to apply for the title of professor in the field of Engineering and Technology - discipline of Environmental Engineering, Mining and Energy.




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2021
facts and figures

3912
research and contract works for over **1555** clients

17
applications for an invention, **8** industrial designs and **4** trademarks

132
people with academic degrees and titles among of about **472** employees

210
scientific publications

93,9
million zł of revenue

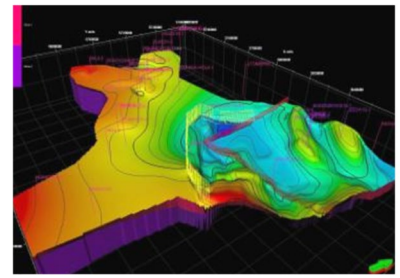
19
accredited testing laboratories

59
projects
22 national ones and **37** international

15
prizes and awards

BASIC AREAS OF CENTRAL MINING INSTITUTE ACTIVITY

- MINING AND GEOENGINEERING
- ENVIRONMENTAL ENGINEERING
- CLEAN COAL TECHNOLOGIES
- OCCUPATIONAL SAFETY IN THE INDUSTRY
- MATERIAL ENGINEERING
- CERTIFICATION AND ATTESTATION
- TRAINING AND EDUCATION



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Analysis of selected aspects of underground coal mining in Albania and Serbia

Final study structure:

1. **Introduction**
2. **Statement of the problem**

- Importance of proper mine closure and hazard identification

3. Current situation of coal mines in Albania and Serbia

- Scale of coal extraction
- Number of active mines and types of extraction methods employed
- Number, types of inactive mines, and their closure status
- Number and types of mines set for closure
- The existing Governmental strategies on mine closure

4. General analysis of the local geological and mining conditions in Albania and Serbia

5. Identification of the problems related to mine closure

- Ground water and surface water
- Fugitive gases (e.g., methane, carbon dioxide)
- Underground coal fires and fires in waste dumps
- Monitoring of subsidence of mined lands and prevention of other ground surface movement
- Monitoring and remediation of chemical pollutants that may leach from mine waste dumps

Analysis of selected aspects of underground coal mining in Albania and Serbia

6. Recommendations on addressing the identified problems

- Management and remediation of ground water and surface water drainage systems
- Prevention of air pollution from fugitive gases (e.g., methane, carbon dioxide)
- Extinguishing and preventing underground coal fires and fires in waste dumps
- Mined lands subsidence
- Chemical pollutants from mine waste dumps

7. Analysis of a potential for repurposing mined land for future use

- Potential uses of the reclaimed mined land by local communities and businesses
- Costs and benefits of various options

8. Technical, principle-based guidelines for designing and implementing national programmes for an efficient, safe, and environmentally conscious mine closure

- The proposed scope, structure, content, and objectives
- Data and knowledge management

9. Conclusions

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Faculty of mining and geology

Рударски институт д.о.о.
Београд

Soko mine

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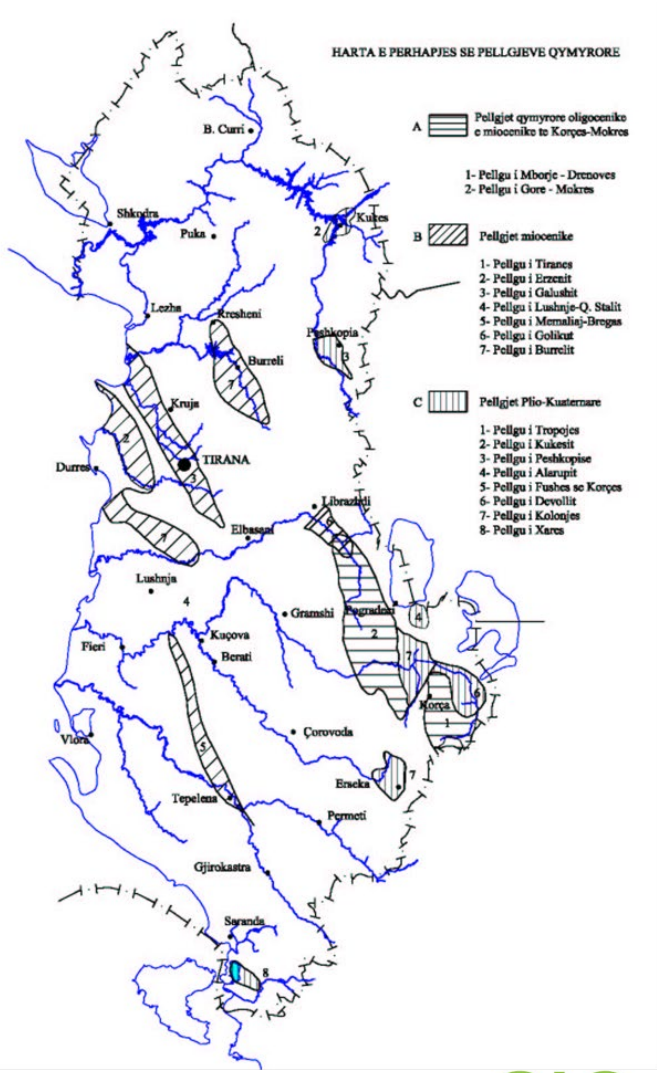
CURRENT SITUATION OF COAL MINES IN ALBANIA

COAL GEOLOGICAL RESERVES IN CLOSED MINES IN ALBANIA

Nr	Name of Deposit	Start exploitation	Government Order for closing coal mines	No. of project (AKBN technical archive)	Production (Ton)	Geological reserves remained (Ton)
1	Valias	1978	Nr.139 dt.20.03.1995	Nr.2978 / 2001	3,515,178	49,186,000
2	Mëzez	1968	Nr.824 dt.04.12.1996	Nr.2978 / 2001	1,435,320	1,426,000
3	Mushqeta	1968	Nr.550 dt.26.08.1996	Nr.2978 / 2001	2,300,000	5,365,000
4	Kërrabë	1938	Nr.101 dt.02.03.2001	Nr.2748 / 2000	1,658,270	8,100,000
5	Priska 2	1980	Nr.550 dt.26.08.1996	Nr.2978 / 2001	374,057	2,682,000
6	Priskë	1980	Nr.101 dt.02.03.2001	Nr.2978 / 2001		2,460,000
7	Gërdec	1978	Nr.550 dt.26.08.1996	Nr.2978 / 2001	293,200	297,000
8	Manëz	1967	Nr.232 dt.15.05.1995	Nr.2978 / 2001	1,317,000	1,281,000
9	Mborje-Drenovë	1930	Nr.349 dt.07.07.2000	Nr.2978 / 2001	1,100,000	3,698,000
10	Selcë	1984	Nr.233 dt.15.05.1995	Nr.2978 / 2001	253,563	125,000
11	Babjen	1984	Nr.233 dt.15.05.1995	Nr.2871 / 2003	75,236	478,562
12	Krosnisht	1978	Nr.500 dt.13.08.1998	Nr.2682 / 1999	1,342,174	496,000
13	Qenckë	1978	Nr.349 dt.07.07.2000	Nr.2682 / 1999	23,000	69,750
14	Bezhan	1972	Nr.233 dt.15.05.1995	Nr.2978 / 2001	1,068,519	7,714,000
15	Alarup	1959	Nr.500 dt.13.08.1998	Nr.2978 / 2001		1,600,000
16	Pretushë	1968	Nr.233 dt.15.05.1995	Nr.2809 / 2002	909,300	2,885,500
17	Dardhas	1972	Nr.349 dt.07.07.2000	Nr.2978 / 2001	1,076,100	6,087,000
18	Vërdovë	1978	Nr.349 dt.07.07.2000	Nr.2978 / 2001	900,000	2,300,000
19	Potgozhan	1985	Nr.233 dt.15.05.1995	Nr.2978 / 2001	105,000	10,869,700
20	Homezh	1986	Nr.233 dt.15.05.1995	Nr.2978 / 2001	1,377,951	8,174,500
21	Memaliaj 1 dhe 2	1916	Nr.268 dt.08.06.1999	Nr.2978 / 2001	10,126,170	820,0000
22	Memaliaj 3	1980	Nr.29 dt.15.01.1996	Nr.2978 / 2001		6,500,000
Sum					**29,250,038**	**129,995,012**



CURRENT SITUATION OF COAL MINES IN ALBANIA

Possible areas for restarting exploitation

Valias Mine

The area of the mining field is 14 km², while the area on which the mine has developed its activity until the moment of closure is 4.2 km² or 420 ha. The village of Valias is located above the source of Valias. The region is described by a dense network of regional and national highways.

The variant of closing the mine was applied by plugging the mouths of the wells on the surface with metal pipes and concrete and surrounding them with walls and metal profiles were placed on them at a certain distance, connected with wire networks.

Geological reserves remained: 49,186,000 t

Memaliaj Mine

Of the 12 coal layers found in the I, II, and III fields, the 5th, 6th, 7th, 4th, and 4th"a" layers are considered industrial. Based on the closure project, the surface facilities were planned to be rented, partially demolished and sold. The vertical shafts (eight in total) are temporarily closed, through a plug with a metal construction. Within the contoured area of the influence of surface use, it was recommended not to carry out constructions of any category and the existing ones are subject to monitoring.

Geological reserves remained: 6,500,000 t

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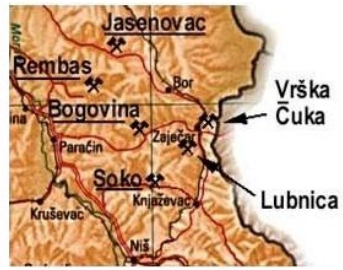
CURRENT SITUATION OF COAL MINES IN SERBIA



MINING SITUATION OF COAL MINES IN SERBIA

Mine		Method of exploitation	Technology of exploitation	Access to the mine by shafts (deep, m/diameter, m),		Access to the mine by drifts (cross-section area, m^2)		Additional information
RMU "Bogovina" (Bogovina-Istok)		Chamber-pillar method	Blasting-drilling works	Ventilation shaft No. 11 (180/3.5)		Main haulage drift GTN (14)		There are also accesses to abandoned pit – shaft No. 10 (210/6) and drift, at closed Bogovina-Zapad site.
RA "Vrška Čuka"			Drilling and blasting and manual loading	Ventilation shaft VO2 (138/5)		Horizontal Avramica drift (16)	Inclined N4 drift (10)	In proximity of industrial estate of the mine is abandoned hoisting shaft Avramica (199/5) , which is now flooded.
RKU "Ibarski rudnici"	**Jarando**		Blasting-drilling works	None		Horizontal Baljevac drift (12)	Inclined GIN haulage drift (12)	Until recently mine operated three pits and in 1998-1999 third pit, Ušće, was closed. Jarando and Tadenje pits are completely separated production units
	Tadenje			None		Horizontal Tadenje drift 360 m (12)	Inclined GIN haulage drift 66 m (12)	
RMU "Jasenovac"				None		Horizontal GIP drift (12)	Inclined GVN drift (12)	
RMU "Rembas"	**Strmosten**			Blind shaft (145/5)		Three drifts - industrial estate (10, 12, 12)	Ventilation drift - dislocated (10)	Although pits of RMU "Rembas" mine are separate, connection between pits exist to single processing facility located at Resavica.
	Jelovac			None		Entrance to Jelovac drift (15)	Entrance to Bučar drift (12)	
	Senjski rudnik			Hoisting shaft (230/6)	Ventilation shaft (220/5)	South drift - connection to Resavica		
RMU "Soko"				Hoisting shaft (246/6)	Ventilation shaft (156/5.5)	Drift GTN-1 (17)		
RL "Lubnica"				None		Osojno-South - two capital drifts - main haulage (17) and main ventilation drift (17)	Stara jama N-2 haulage drift (10) and N-3 roadway (connection between pits)	Mining activities at Lubnica mine are taking place on production in Stara jama and on development in Osojno-South pit. Although, these two pits operates independent one of another, they are connected and, regarding ventilation and material supply, both pits can be treated as a one mine.
RMU "Štavalj"				None		Main haulage drift GIN-1 (13)	Main ventilation drift GVN-2 (13)	During the life of Štavalj mine there was at least one now abandoned pit.

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MINING SITUATION OF COAL MINES IN SERBIA

Mine	Ventilation	Dewatering
RMU "Bogovina"	Fans are located on surface, within ventilation station on ventilation shaft.	Mine have two pumping stations, while other pumps, of smaller capacity and mobile, are pumping water into the main reservoir.
RA "Vrška Čuka"	Fans are located on surface, within ventilation station on ventilation shaft VO2. Ventilation station is equipped with diesel powered generator in case of electric power failure.	Dewatering of the mine is by gravity, through channels in Avramica drift (and roadways H1, H3 and U4). Small and mobile pumps are pumping water into this channel according to water influx in different locations of mine, which is generally low (1 to 2 lit/s). Therefore, there is no pumping station at the mine.
RKU "Ibarski rudnici"	Fresh air is taken into Jarando pit through GIN roadway and directed toward production and working areas, while the used air is taken to the surface via Baljevac drift, which entrance houses ventilation station (main and spare fans, diesel power generator, sound dampening utilities etc).	Main dewatering of both pits is gravitational by channels at horizontal drifts (Baljevac drift at Jarando pit and Tadenje drift at Tadenje pit). Any inflow of water at workings is pumped with submersible pumps to small collectors (two at Jarando pit) from which is then pumped to the level of mentioned drifts.
	At Tadenje pit fresh air is taken into pit via GIN and GTH-1 roadways and through Tadenje drift, which entrance also houses ventilation station.	
RMU "Jasenovac"	Fans are located on surface, within ventilation station on main ventilation drift (GVN).	Dewatering of mine is gravitational via water-way (channel) at GIP roadway to which water is pumped from the locations of influx.
RMU "Rembas"	Fresh air is lead into Senjski rudnik pit via hoisting shaft and through long-term roadways directed to production area, from where it is taken out via ventilation shaft where the fans are installed.	Main water collector at Senjski rudnik pumps the water to the level of South drift from which is then taken to the surface (Resavica) by channels. Also, there are collectors at the bottom of both shafts from which water is pumped directly to the surface.
	At Strmosten pit, route of fresh air is GN-1 and GTU-1 from which it is distributed to development and production areas. Used air is taken out via drift +45, blind shaft and ventilation drift, which is location of ventilation station.	Main water collector at Strmosten pit is at the bottom of blind shaft, from which is pumped to the level of haulage drift and then by gravity taken out. There are also two smaller pumping stations in GN-1 roadway, both of which directly pumps the water into the channel in haulage drift.
	Fresh air is lead into Jelovac pit via Jelovac drift and then distributed to development faces. Used air is taken out via Jelovac drift beyond pit and Bučar drift connection to surface where the fans are installed.	Main water collector at Jelovac pit long term by-pass is now developed and in operation, but during development of GTN-1 roadway (one of the long-term by-pass roadways) face is flooded and second pumping station was installed. Water from both collectors is pumped to the level of Jelovac drift from which is streaming to the surface in direction of Vodna.
RMU "Soko"	Fresh air is brought into Soko pit through hoisting shaft and directed toward production and working areas, while the used air is taken to the surface via ventilation shaft. Ventilation station is at the entrance of ventilation shaft.	Dewatering of the pit is by central water collector located near the bottom of the hoisting shaft, from where it is pumped to surface. Water is pumped into this collector from auxiliary collectors around the mine. Pumping station exists also at the bottom of the ventilation shaft.
RL "Lubnica"	Intake of fresh air at Lubnica mine is through main haulage drift GTN (Osojno) and at the connection with N-3 roadway intake is split – toward Stara jama (via N-3) and toward workings on developing of Osojno-South, from where it is taken out through main ventilation drift (GVN). From the N-3 roadway fresh air is directed toward production areas of the Stara jama and return air is taken out via ventilation roadways.	Both Stara jama and Osojno-South have water collectors from which water is pumped to the surface.
RMU "Štavalj"	Intake of fresh air at Štavalj mine is through main haulage drift GIN-1 and via other long term roadways (GIN-4 and TN-2) directed toward production are. Exhaust air is taken to the surface through main ventilation drift (GVN-2). Ventilation station is located on the entrance of the GVN-2 (equipped with fans, diesel powered generator, etc).	Average water influx is 3.5-4 m^3/min (highest is 6 m^3/min). For combating this amount of inflow mine have 8 water collectors, some of which with several pumps. Gravity of dewatering issue at Štavlj mine is best described with the fact that total installed power of the pumps is more than 1.3 MW.

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CURRENT SITUATION OF COAL MINES IN SERBIA

ЈАВНО ПРЕДУЗЕЋЕ ЗА ПОДЗЕМНУ ЕКСПЛОАТАЦИЈУ УГЉА
ЈП ПЕУ РЕСАВИЦА

Mine	RMU "Bogovina" (Bogovina-Istok)	RA "Vrška Čuka"	RKU "Ibarski rudnici"		RMU "Jasenovac"	RMU "Rembas"			RMU "Soko"	RL "Lubnica"	RMU "Štavalj"
			Jarando	Tadenje		Strmosten	Jelovac	Senjski rudnik			
Number of employees in the mine 2017	294	167	512		270	1189			590	330	472

Mine	RMU "Bogovina" (Bogovina-Istok)	RA "Vrška Čuka"	RKU "Ibarski rudnici"		RMU "Jasenovac"	RMU "Rembas"			RMU "Soko"	RL "Lubnica"	RMU "Štavalj"
			Jarando	Tadenje		Strmosten	Jelovac	Senjski rudnik			
Average annual coal production, t	10,000-30,000	6,000-8,000	120,000-180,000		40,000-55,000	120,000-160,000			80,000-125,000	50,000-70,000	65,000-80,000

Mine	RMU "Bogovina" (Bogovina-Istok)	RA "Vrška Čuka"	RKU "Ibarski rudnici"		RMU "Jasenovac"	RMU "Rembas"			RMU "Soko"	RL "Lubnica"	RMU "Štavalj"
			Jarando	Tadenje		Strmosten	Jelovac	Senjski rudnik			
Geological balance reserves 2017, t	780,000	127,000	2,212,000		567,000	6,000,000			600,000	1,600,000	8,600,000
Exploitation coal reserves 2017, t	600,000	85,000	1,500,000		380,000	5,000,000			500,000	1,200,000	6,160,000
Exploitation life from 2017, years	15	9	9 (100 after investment)		7.5 (17.5 after investments)	21			4 (30 after investments)	20	55-80
Possibility to increase coal resources, 2017	No	No	Bajovac deposit, €13,000,000		"Stari Jasenovac" and "Padina Mare" deposit - 0.4 Mt	Yes	6 Mt, €6,000,000	No	blocks B-6 and B-7 of eastern field - 9 Mt, €25,000,000	4.4 Mt,€9,000,000	Štavalj-zapad deposit - 93 Mt, €65,000,000

Mine	RMU "Bogovina" (Bogovina-Istok)	RA "Vrška Čuka"	RKU "Ibarski rudnici"		RMU "Jasenovac"	RMU "Rembas"			RMU "Soko"	RL "Lubnica"	RMU "Štavalj"
			Jarando	Tadenje		Strmosten	Jelovac	Senjski rudnik			
Type of coal	brown coal	anthracite	hard coal		brown coal	brown coal			brown coal	lignite	lignite
Caloric value, MJ/kg	16 - 22	21 - 24	15		9 - 19	17 - 25			14 - 19	7 - 15	12 - 19
Sulphur content, %	0.99	2.26	5.81	5.7	1.01	1.59	1.19	0.97	1.7	2.15	0.98
Moisture, %	17.33	0.96	3.6	5.02	22.79	18.75	13.12	15.33	19.22	14.92	28.33

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COAL RESERVES AT ACTIVE AND POTENTIALS DEPOSIT

Balance of coal reserves at active underground mines - deposits, as at 31.12.2020

Mine -deposit-	Balance reserves per category (t)				Off-balance reserves (t)	Type of coal
	A	B	C_1	A+B+C_1		
V. Čuka	25.687	626.383	1.624.608	2.276.678	350.000	Hard coal
Ibar mines	-	928.154	283.434	1.211.588	1.326.580	
Rembas	710.275	2.187.052	4.531.823	7.429.150	581.590	Brown coal
Bogovina	-	1.647.267	676.248	2.323.515	1.652.058	
Soko	245.642	13.529.675	37.160.407	50.935.724	2.997.725	
Jasenovac	-	176.744	-	176.744	25.960	
Štavalj	1.477.710	99.326.316	84.197.469	185.001.495	7.423.342	
Lubnica	660.239	8.859.215	506.079	10.025.533	4.565.562	Lignite
UKUPNO	1.641.843	127.290.806	128.983.071	259.380.427	18.832.817	

After Ivković et al., 2022

Balance reserves of coal in inactive deposits with potential for underground exploitation

Deposit	Determined reserves per categories (t)				Type of coal
	A	B	C_1	A+B+C_1	
Jerma	-	5.767.600	-	5.767.500	Hard coal
Melnica	-	21.121.761	8.899.908	29.921.669	Brown coal
Aleksinac	2.732.960	17.017.380	7.776.280	27.919.620	
Poljana		48.467.000	10.527.270	58.994.540	Lignite
Ćirikovac		121.036.207	27.881.661	147.517.868	
Despotovac		15.080.000	9.710.000	24.790.000	
Zap.basen		72.111.343	21.792.492	93.903.835	
Dragačevo		-	-	62.000.000	
TOTAL	2.732.960	300.601.291	86.587.611	450.815.032	

After Ivković et al., 2022

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CLASSIFICATION OF RESOURCES AND RESERVES

Comparison of Polish and international classifcations of resources and reserves

Klasyfikacja polska	JORC – code (CRIRSCO)	PRMS	UNFC (2008)	
			Dokumentacja geologiczna	PZZ
	Prospecting results	Prospective resources Low, best high	Resources 334	
Zasoby bilansowe (anticipated economic resources) D (D_1), C_2 C_2, C_1 A+B	Resources Inferred Indicated Measured	Contingent resources Low, best, high	Resources 2 2 3, 2 3 3 2 2 2, 2 3 2 2 2 1, 2 3 1	
Zasoby pozabilansowe (anticipated, subeconomic resources) D (D_1), C_2 C_2, C_1 A+B			Resources 3 2 3, 3 3 3 3 2 2, 3 3 2 3 2 1, 3 2 1	Resources 3 1 3 3 1 2 3 1 1
Zasoby nieprzemysłowe (subeconomic resources) C_2 C_1 A+B				Resources 3 1 3 3 1 2 3 1 1
Zasoby przemysłowe (economic resources) C_2 C_1 A+B				Resources 2 1 3 2 1 2 2 1 1
Zasoby operatywne (extractable resources) C_2 C_1 A+B				Resources ("economic") 1 1 3 1 1 2 1 1 1
Zasoby eksploatacyjne (reserves) C_2 C_1 A+B	Reserves Probable Proved	Reserves Proved, probable, possible		

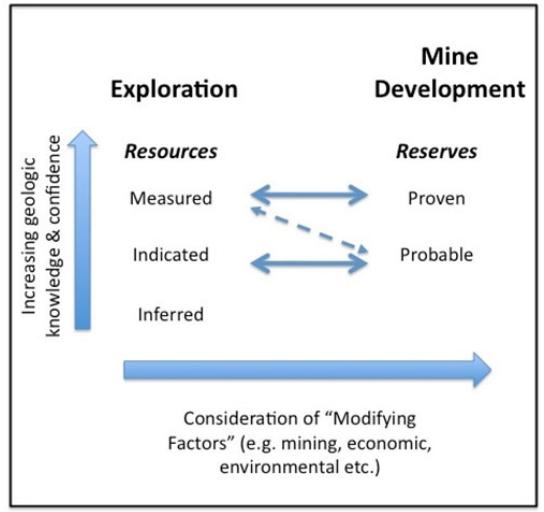
After Nieć, 2010

CONVERSION MAP,
IN NEW BOOK OF REGULATIONS
SOLID MINERLAS

Proposed New Book of Regulations for Solid Mineral Raw Materials	Results of Geological Exploration	Mineral Resources			Mineral Reserves	
		Inferred	Indicated	Measured	Probable	Proved
Official Book of Regulations for Solid Mineral Raw Materials (1979)		Mineral Reserves				
	Potential	Potential	Established (*in situ* – Geological: *Out-of-Balance and Balance*)		Exploitation (*inclusive of dilutions and losses during mining*)	
	D_2, D_1	C_2	C_1	B,A	C_1	B,A
UNFC (2009)			Mineral Resources		Mineral Reserves	
	334	223	222	221	112	111

After Vukas and Dajovic, 2017

Resources and Reserves: The relationships between the five groups of mineral asset reporting



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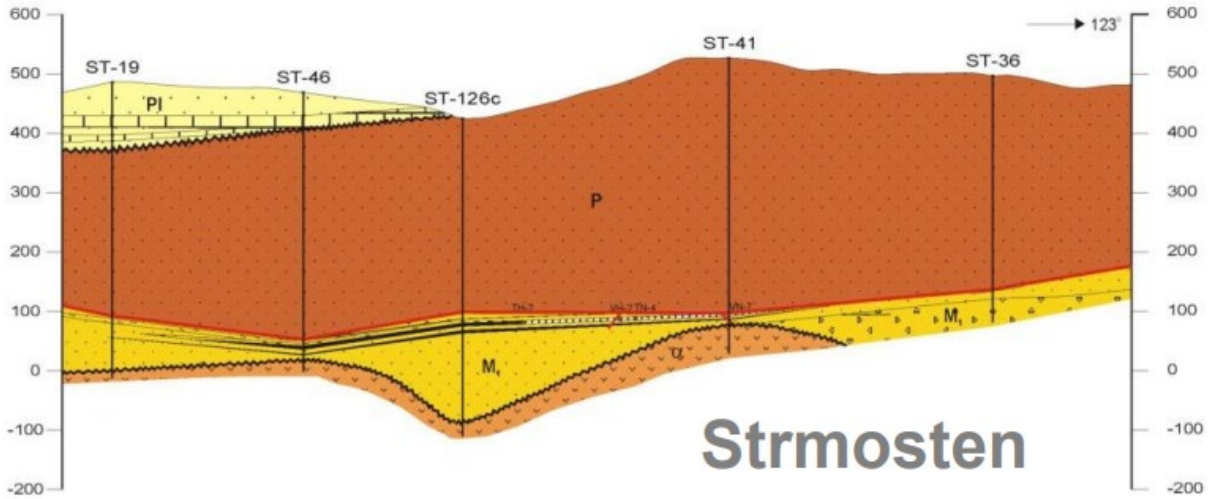
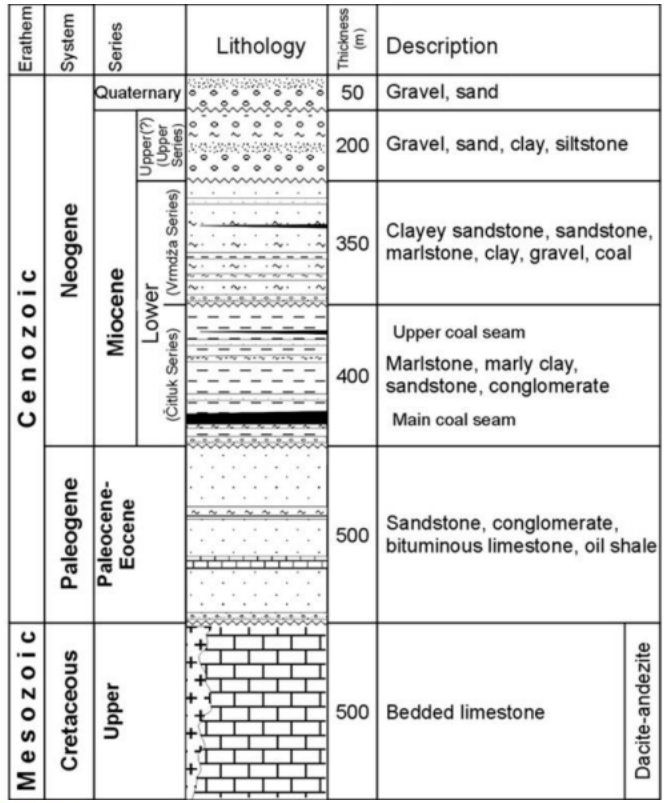
GENERAL ANALYSIS OF THE LOCAL GEOLOGICAL AND MINING CONDITIONS IN SERBIA

Mine	RMU "Bogovina" (Bogovina-Istok)	RA "Vrška Čuka"	RKU "Ibarski rudnici"		RMU "Jasenovac"	RMU "Rembas"			RMU "Soko"	RL "Lubnica"	RMU "Štavalj"
			Jarando	Tadenje		Strmosten	Jelovac	Senjski rudnik			
Coal seams	Two coal seams	Main seam and interlayers	Two coal seams	Five coal seams	One coal seam	One coal seam	One coal seam	One coal seam	One coal seam	Two coal seams	One coal seam
Coal seam thickness, m	1-7.2 m and 1-4.5 m	0.3-3.0 with thickenings up to 6.0 m	1.5-12 m and 1-2.5 m	4.4 m, 2.2 m, 1.95 m, 1.9 m and 2.4 m	5-29 m	7.7 m	4.5 m	7 m	25-40 m	5-9 m and 2-5 m	10.0-14.0 m
Coal seam slope, °	12-14°	0-35°	10-40°	5-25°	20-33°	10-20°	5-10°	10-25°	35-45°	20-33°	5-20°
Hanging wall rocks (roof rocks)	Marls	Clayey sandstones	Marls	Marls, clays	Clays, sandstones	Marls and red sandstones	Red sandstones	Marls	Marls	Marls, clays	Marls
Foot wall rocks (floor rocks)	Clays	Clayey sandstones	Sandstones	Marls	Sandy clays	Green sandstones	Green sandstones	Clayey marls	Coal clays	Sandstones and clays	Marls
Tectonics	Expressed	Very expressed	Expressed	Expressed	Expressed	Expressed	Expressed	Expressed	Expressed	Expressed	Expressed



Ivkovic et al., 2012



RMU "Soko"

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What can be done to improve underground coal mining in Serbia?

It is necessary to:

- introduce new modern equipment for the construction of pit rooms, excavation and transport and raise the level of production (especially in RMU "Soko,,, RMU "Štavalj,,, RMU "Rembas,, (Strmosten), and RL "Lubnica,,),
- conduct technical and organizational changes (change of structure, and reduce the number of employed non-production workers in the company to the optimal number),
- begin work on the construction of a new mine,
- and start a program of planned closure of mines whose coal reserves are about to be exhausted.

IDENTIFICATION OF THE PROBLEMS RELATED TO MINE CLOSURE

Closure procedures will commence following decision of proper authorities (Company Management and Ministry of Mining and Energy). Issues related to closure of the mines are as follows:

- Legal and financial issues;
- Physical closure issues;
- Environmental issues and
- Social mitigation issues.

Physical closure of the mine starts with development of technical documentation regarding:

- Disassembly and recovery of underground equipment, including steel support;
- Isolation of all mine accesses – backfilling of shafts and construction of concrete slabs on shafts entries and construction of isolation dams on drifts entries;
- Demolition of surface facilities;
- Rehabilitation and reclamation of mine industrial estate.

IDENTIFICATION OF THE PROBLEMS RELATED TO MINE CLOSURE NATURAL HAZARDS IN ACTIVE MINES IN SERBIA

Water hazard

Mine	RMU "Bogovina" (Bogovina-Istok)	RA "Vrška Čuka"	RKU "Ibarski rudnici"		RMU "Jasenovac"	RMU "Rembas"			RMU "Soko"	RL "Lubnica"	RMU "Štavalj"
			Jarando	Tadenje		Strmosten	Jelovac	Senjski rudnik			
Water inflow, m^3/min	0,04	1,5 l/s	1	0,5	3	2,5	0,6-1,0	3	3,67	0,5	6,0-8,0

Gas hazard

Ivkovic et al., 2012

Mine	RMU "Bogovina" (Bogovina-Istok)	RA "Vrška Čuka"	RKU "Ibarski rudnici"		RMU "Jasenovac"	RMU "Rembas"			RMU "Soko"	RL "Lubnica"	RMU "Štavalj"
			Jarando	Tadenje		Strmosten	Jelovac	Senjski rudnik			
Relative methane-bearing capacity, m^3 CH_4/t	registered appearance	8,93)	0,025-0,245	non-methane	non-methane	registered appearance	registered appearance	registered appearance	11,74	registered appearance/non-methane	non-methane
Absolute methane-bearing capacity, m^3 CH_4/min	registered appearance	0,147	0,008-0,079	non-methane	non-methane	registered appearance	registered appearance	registered appearance	2,71	registered appearance/non-methane	non-methane

Dust hazard

Mine	RMU "Bogovina" (Bogovina-Istok)	RA "Vrška Čuka"	RKU "Ibarski rudnici"		RMU "Jasenovac"	RMU "Rembas"			RMU "Soko"	RL "Lubnica"	RMU "Štavalj"
			Jarando	Tadenje		Strmosten	Jelovac	Senjski rudnik			
Dust explosives (g/m^3)	225	non-explosive	70-100	270	225	180	230	200	230	110	-
Dust self-ignition (°C)	250	not self-ignition	630-700	no data	260	280-290	300	260-290	250-350	215-235	220-280

Fire hazard

Mine	RMU "Bogovina" (Bogovina-Istok)	RA "Vrška Čuka"	RKU "Ibarski rudnici"		RMU "Jasenovac"	RMU "Rembas"			RMU "Soko"	RL "Lubnica"	RMU "Štavalj"
			Jarando	Tadenje		Strmosten	Jelovac	Senjski rudnik			
Coal self-ignition, °C/min	80-120	not self-ignition	69-98	no tendency	80-100	110-120	70-110	118-140	115-188	80	103-111

Ivkovic et al. 2012; Savic, 2015; Todorovic et al., 2020

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IDENTIFICATION OF THE PROBLEMS RELATED TO MINE CLOSURE REDUNDANT SURFACE FACILITIES AND ENVIRONMENTAL RECLAMATION

Mine	Objects for demolition during closure of mine		Objects for potential for social mitigation		Other objects (objects dislocated from industrial estate of the mine and in use for non-mining purpose)		Total	
	Number	Area, m^2	Number	Area, m^2	Number	Area, m^2	Number	Area, m^2
RMU "Bogovina"	23	3,999	15	3,331	9	1,224	47	8,554
RA "Vrška Čuka"	12	2,595	4	1,48	0	0	16	4,075
RKU "Ibarski rudnici"	21	4,861	9	2,039	4	4,074	34	10,974
RMU "Jasenovac"	9	1,478	7	1,552	1	0,620	17	3,650
RMU "Rembas"	11	8,243	14	10,93	11	4,567	36	23,740
RMU "Soko"	10	1,596	10	8,804	0	0	20	10,400
RL "Lubnica"	6	2,555	5	2,946	3	1,499	14	7,000
RMU "Štavalj"	15	0,826	7	4,393	0	0	22	5,219
Total	**107**	**26,153**	**71**	**35,475**	**28**	**11,984**	**206**	**73,612**

Mine	Area for reclamation (industrial estate)		Waste heaps	Total area for reclamation
	Area, m^2		Area, m2	Area, m^2
RMU "Bogovina"	Bogovina-Zapad, 52,500	Bogovina-Istok, 2500	Several loactions: 153,800	208,800
RA "Vrška Čuka"	23,000		Four locations: 100,700	123,700
RKU "Ibarski rudnici"	89,900		80,000	160,900
RMU "Jasenovac"	35,500		2,000	37,500
RMU "Rembas"	79,000		Five locations: 377,700	456,700
RMU "Soko"	130,000		43,100	173,100
RL "Lubnica"	85,000		104,300	189,300
RMU "Štavalj"	87,000		73,300	160,300
Total	**584,400**		**934,900**	**1,510,300**

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HOW CAN THE INFRASTRUCTURE/RESOURCES OF THE ACTIVE MINES IN SERBIA AND THE CLOSED MINES IN ALBANIA BE BETTER UTILISED?

POTENTIALS
RFCS AM PROJECT

Synergistic POTENTIALS of end-of-life coal mines and coal-fired power plants, along with closely related neighbouring industries: update and re-adoption of territorial just transition plans.

EU Research Fund for Coal and Steel (RFCS)

Grant Agreement No 101034042

www.potentialsproject.eu

Green JOBS
RFCS RESEARCH PROJECT

Leveraging the competitive advantages of end-of-life underground coal mines to maximise the creation of green and quality jobs.

EU Research Fund for Coal and Steel (RFCS)
Grant Agreement No 101057789

www.greenjobsproject.eu

GIG Research Institute

POTENTIALS Project

POTENTIALS
RFCS AM PROJECT

It focuses on taking advantage of the joint potential of end-of-life coal mines and coal-fired power plants to stimulate new economic activities and develop jobs in Coal Regions in Transition.

It identifies and assess opportunities by means of a prospective analysis, enabling to develop business models that rely on renewable energy, on the circular economy or scale energy storage, guaranteeing a sustainable and combined use of assets and resources.

ACTIONS	DEFINITION
A1_VIRTUAL	Virtual power plant
A2_H2	Green hydrogen plant
A3_ECOPARK	Eco-industrial park
A4_TOURIST	Cultural heritage and sports/recreations areas using green energy
A5_PANELS	Floating PV panels at flooded open-pit coal mine
A6_PHS	Pumped hydroelectric storage (PHS) at former open-pit coal mines
A7_FISHES	Fisheries in flooded open-pit coal mines
A8_C/O_CGT	Combined-cycle gas turbine (CCGT) power plant powered by natural gas
A9_MINEGAS	Mine gas utilization for gas-powered CHP power units
A10_SMR	Small modular reactors (SMRs)
A11_BIOFUE	Biofuels combustion energy plant
A12_SALT	Molten salt plant
A13_PUMP	Hydropumping open-pit
A14_APV	Agrophotovoltaics (APV) at former open-pit coal mine areas

CRITERIA	DEFINITION
C1 EnerSec	Energy security
C2 Greenin	Renewable resources (greening)
C3 Cost	Low investment barriers
C4 Benef	Benefits
C5 RegDev	Regional development
C6 Envirom	Environment
C7 Job	Job creation

POLICY	DEFINITION
Climate	No net emissions of greenhouse gases by 2050
Growth	Economic growth decoupled from resource use
People	No person and no place left behind

GIG Research Institute

Using MULTIPOL program (Multicriteria and policy), first, the scoring of actions with respect to criteria from 0 to 20 is made.

Actions \ MULTIPOL Criteria		Actions short label	Consensus values						
			CM1	CM2	CM3	CM4	CM5	CM6	CM7
			Energy security	Renewable resources (greening)	Low investment barriers	Benefits	Regional development	Environment	Job creation
A1	Virtual power plant	A1_VIRTUAL	10	20	8	10	10	15	3
A2	Green hydrogen plant	A2_H2	15	20	4	5	20	20	5
A3	Eco-industrial park	A3_ECOPARK	10	15	10	5	17	15	20
A4	Cultural heritage and sports/recreation areas using green energy	A4_TOURIST	5	5	10	5	15	20	5
A5	Floating PV panels at flooded open-pit coal mines.	A5_PANELS	10	15	10	8	10	15	5
A6	Pumped hydroelectric storage (PHS) at former open-pit coal mines	A6_PHS	20	20	7	10	10	15	5
A7	Fisheries in flooded open-pit coal mines	A7_FISHES	1	5	12	10	10	10	8
A8	Combined Cycle Gas Turbines (CCGT) plant. Open Cycle Gas Turbines (OCGT)	A8_C/O_CGT	15	10	13	10	5	5	10
A9	Mine gas utilization for gas-powered CHP power units	A9_MINEGAS	1	0	15	10	3	15	2
A10	Small modular reactors (SMRs)	A10_SMR	20	3	2	10	20	18	15
A11	Biofuels processing energy plant	A11_BIOFUE	15	15	15	10	12	15	10
A12	Molten salt plant	A12_SALT	20	20	16	10	10	15	5
A13	Agrophotovoltaics (APV) at former open-pit coal mine areas	A13_APV	15	20	8	10	10	15	8

Second, matrix values corresponding to policy evaluation with respect to the criteria are assigned. As this concerns the set of criteria weights, the row sum must always equal 100.

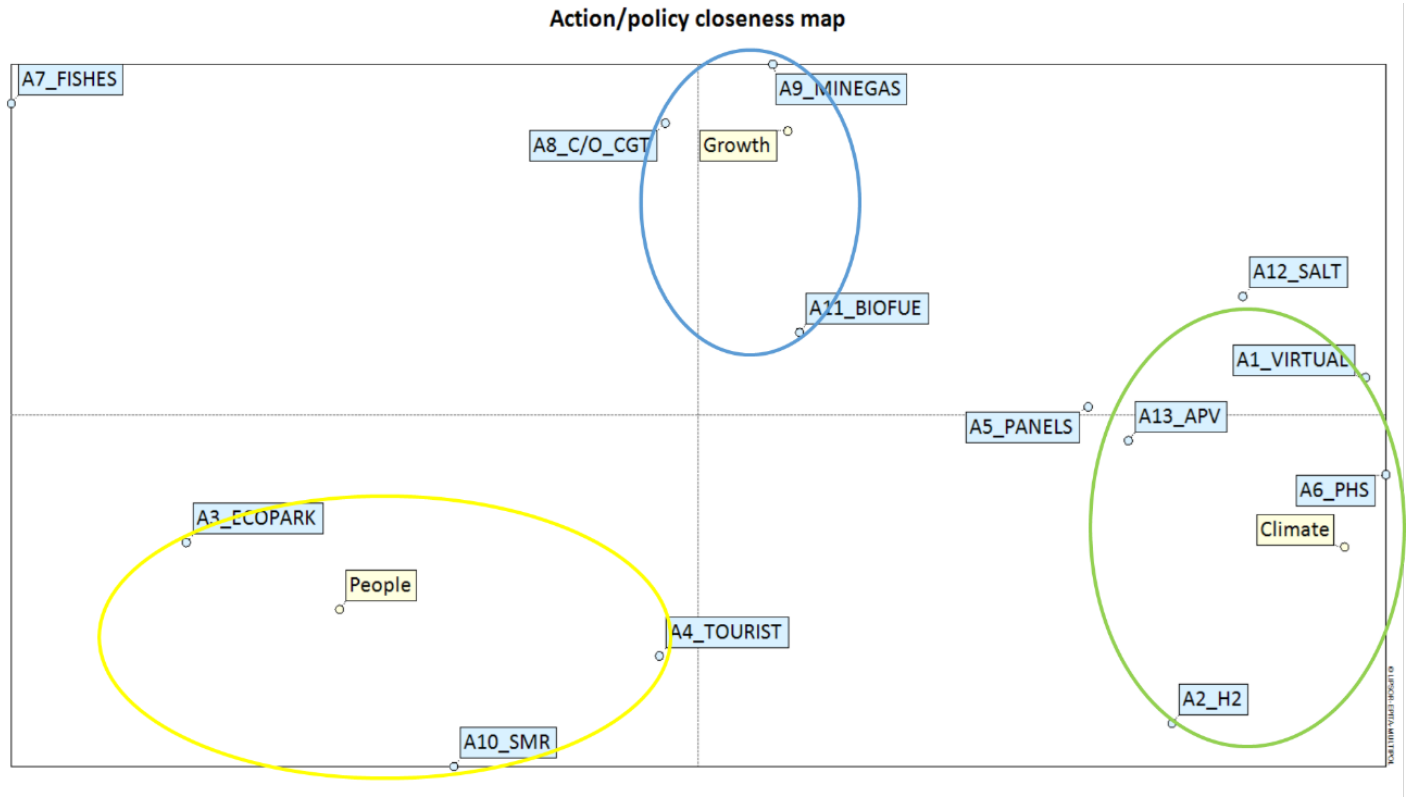
Policies \ Criteria		CM1	CM2	CM3	CM4	CM5	CM6	CM7	SUM
		Energy security	Renewable resources (greening)	Investment cost	Benefits	Regional development	Environment	Job creation	
P1	**Climate** (No net emissions of greenhouse gases by 2050)	40	20	10	0	0	30	0	100
P2	**Growth** (Economic growth decoulped from fossils resources use)	20	10	25	10	10	5	20	100
P3	**People** (No person and no place left behind)	15	0	15	0	20	10	40	100

POTENTIALS Project

POTENTIALS
RFCS AM PROJECT

Evaluation of actions related to policies and cctions/policies closeness map.

ACTIONS	POLICIES			Mean	Standard deviation
	P1: Climate	P2: Growth	P3: People		
1 : A1_VIRTUAL	13,3	9,4	7,4	10	2,5
2 : A2_H2	16,4	10,5	10,9	12,6	2,7
3 : A3_ECOPARK	12,5	12,9	15,9	13,8	1,5
4 : A4_TOURIST	10	8	9,2	9,1	0,8
5 : A5_PANELS	12,5	9,6	8,5	10,2	1,7
6 : A6_PHS	17,2	11,5	9,6	12,8	3,2
7 : A7_FISHES	5,6	7,8	8,1	7,2	1,1
8 : A8_C/O_CGT	10,8	11	9,7	10,5	0,6
9 : A9_MINEGAS	6,4	6,4	5,3	6	0,5
10 : A10_SMR	14,2	11,7	15,1	13,7	1,4
11 : A11_BIOFUE	15	13,2	12,4	13,5	1,1
12 : A12_SALT	18,1	13,8	10,9	14,2	3
13 : A13_APV	15,3	11,4	10,1	12,3	2,2



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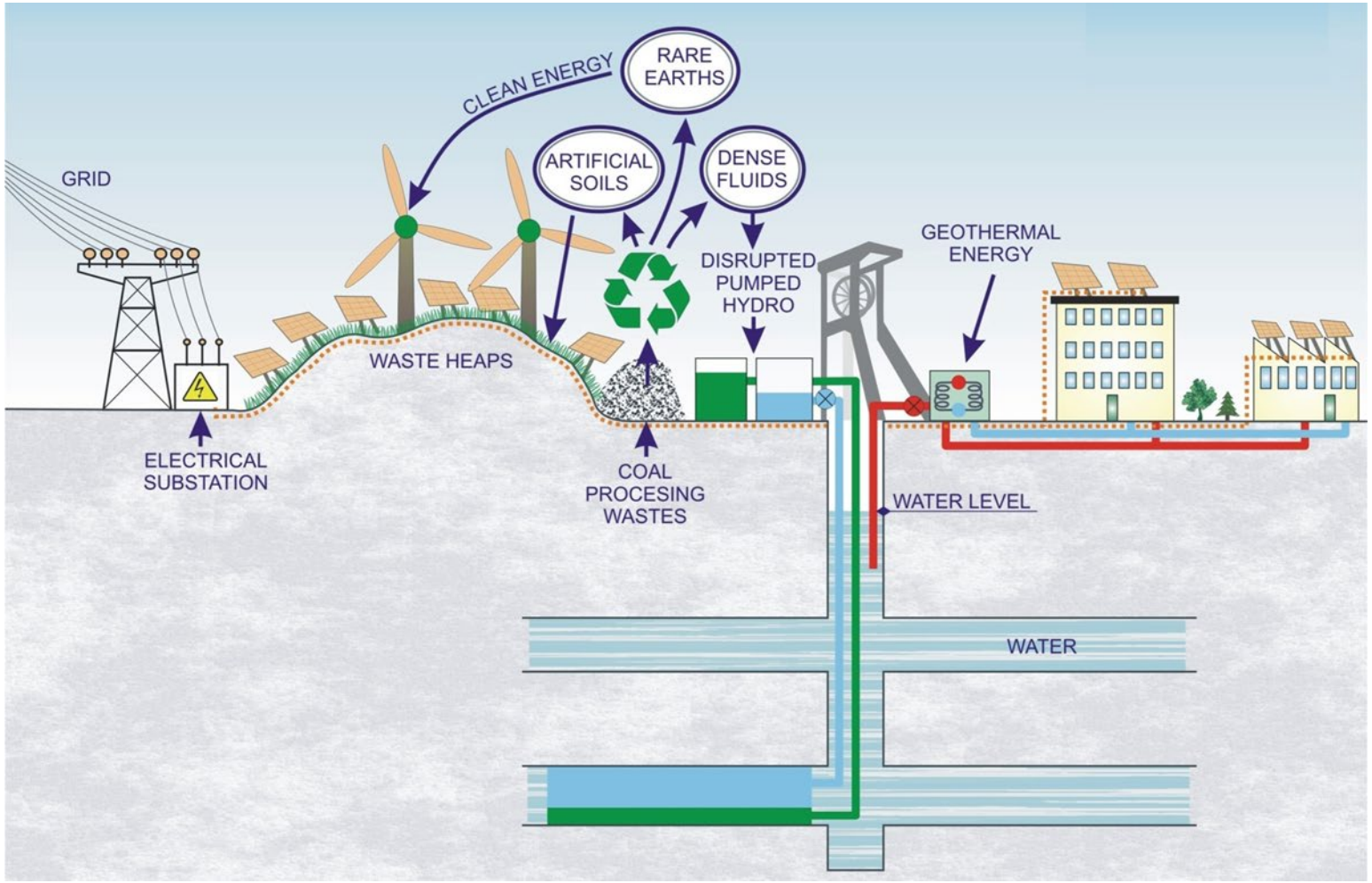
GreenJOBS Project

Business model 1: Virtual Power Plant where energy is sold to the grid.



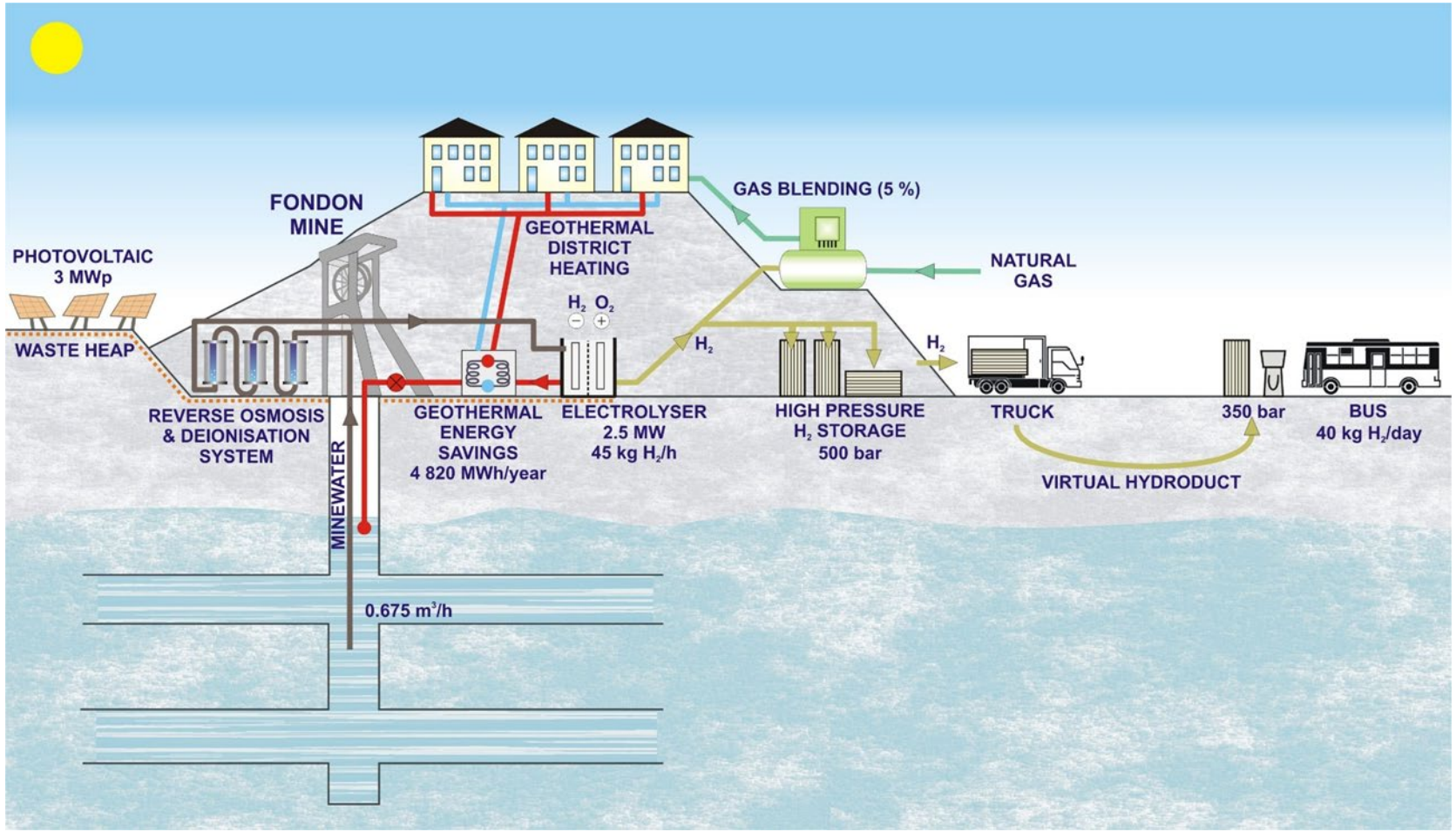
Photovoltaic deployment parameters

Photovoltaic parameters for a 50 ha waste heap area with an installed capacity of 1 MW/ha, a capacity factor of 30% and 50% of energy to be stored.

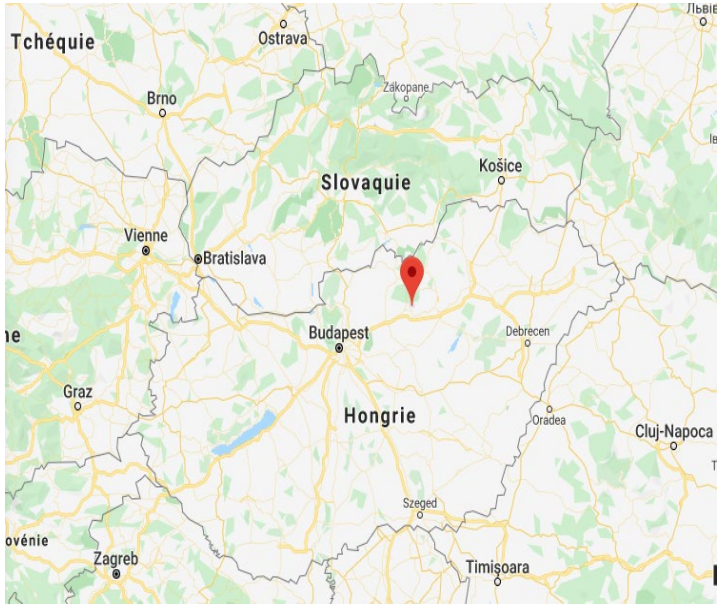
Parameter	Value
Installed capacity	50 MW
Estimated investment (plant life: 25 years)	20 M€
Capacity factor (% time of use of the installation per year)	30%
Daily production (50 MW x 30% x 24 hours)	360 MWh
Fraction of energy to be sold, the rest to be stored	50%
Daytime energy sold (360 MWh x 50%)	180 MWh
Daytime energy price	40 €/MWh
Daytime revenue (180 MWh x 40 €/MWh)	7,200 €
Photovoltaic annual revenues (7,200 € x 365)	2.63 M€
Annual expenditure (staff, maintenance and overheads)	0.50 M€

GreenJOBS Project

Business model 2: Green hydrogen plant.



EXAMPLES OF POST MINING LAND USAGE



Sun park Vistonia – 16MW of solar energy

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EXAMPLES OF POST MINING LAND USAGE

Sun park in Lorraine (France)

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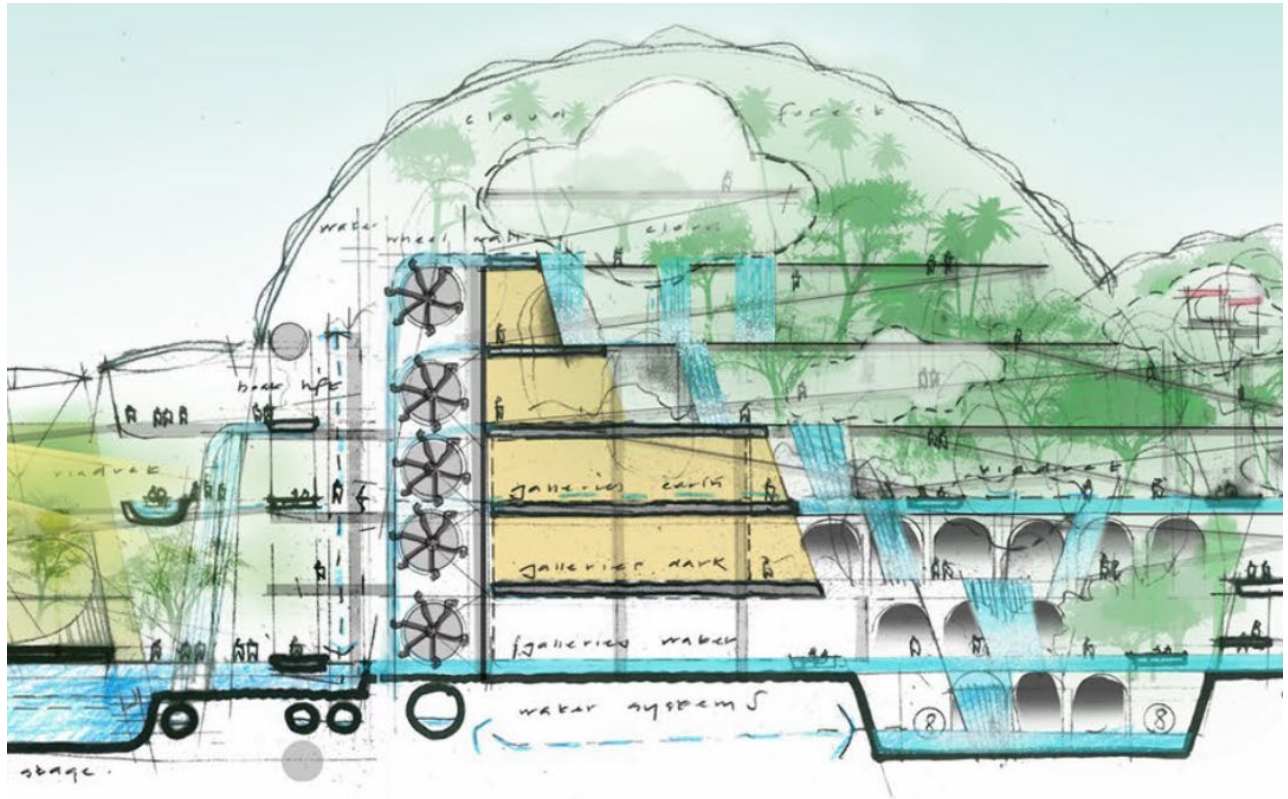
EXAMPLES OF POST MINING LAND USAGE

Wind farm in Forth (Lanarkshire)



Project Eden

THANK YOU FOR ATTENTION

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