Journal of Achievements in Materials and Manufacturing Engineering
VOLUME 43
ISSUE 2
December
2010

Large capacity cnergy from Geo-Plutonic formation for power plants with zero CO_2 emissions

R.H. Kozłowski [a,*], B.M. Zakiewicz [b]
[a] Advanced Technology Workshop, Faculty of Mechanical Engineering, Cracow University of Technology, ul. Warszawska 24, 31-155 Kraków, Poland
[b] Geothermic Solution Ltd., California, USA
Academy of Ecological Mining, Stuttgart, Germany
* Corresponding author: E-mail address: rhk.@pk.edu.pl

Received 15.10.2010; published in revised form 01.12.2010

Technical paper

ABSTRACT

Purpose: The publication presented is a realistic, one of the practicable idea for a substitute to system power plants, consisting in the construction of combined heat and power plants using renewable resources of geo-plutonic energy.
Design/methodology/approach: There are various methods of obtaining geothermal energy and various uses for it. The proposed GEO-PLUTONIC ENERGY represents an endless, renewable source of energy coming from nuclear reaction in the Earth's nucleus, where the temperature reaches 6,000 Centigrade. Mass production of electricity from the Earth's heat, possible in Iceland due to the volcanic nature of these resources and the shallow depth at which they occur, was difficult in other countries due to the high cost of drilling to greater depths. This barrier has been overcome by us through using a special horizontal drilling technique.
Findings: In order to extract and collect the accumulated energy from the area of a large thermal field, a modified shaft/drilling system (called a Super Daisy System) equipped with a 3D grate of directional bore-holes called Jet-Stingers fitted with multi-functional heat exchangers is used. The emission-free concept of Geo-Plutonic Energy with the temperature of only over 250ºC, from which we can obtain about 30 MPa of pressure on the turbine. With increased the depth the temperature and heat transmissibility will be raised significantly, which can resulted the yield even to 7-10 MWe (of electricity) from one deep heat exchanger.
Research limitations/implications: From the rock mass we can collect renewable resources of „dry" ascending energy from the paleo heat flow coming from the great atomic furnace – the magma.
Originality/value: We are experienced in using the appropriate hydro-thermodynamic theory and its applications which allows us to almost precisely forecast and control the quantity of heat not exceeding 20% of the 100% regeneration capability in the same time range.
Keywords: System power plants; Geo energy; Renewable source of energy

Reference to this paper should be given in the following way:
R.H. Kozłowski, B.M. Zakiewicz, Large capacity energy from Geo-Plutonic formation for power plants with zero CO_2 emissions, Journal of Achievements in Materials and Manufacturing Engineering 43/2 (2010) 790-795.

1. Introduction

Cutting green house gas (GHG) emissions by 30% by 2030 may cost Poland over €90 bn. The Copenhagen UN Climate Summit has made the EU wonder whether it should not set itself a new target: reducing atmospheric GHG emissions by 30% as early as by 2020 (so far 20% is the target). In Europe, Poland is viewed as the brakeman of climatic adjustment - even though we are only now learning how much all this can cost, and the total amount including the fines for international obligations that can hardly be met (Appendix) may be sky high.

Currently, the Polish economy is one of the largest emitters of GHGs in Europe in terms of the ratio of CO_2 emission to the GDP. Every year, some 386m tons of CO_2 are pumped into the atmosphere from Poland. To generate $1.000 of GDP, 760 kg of CO_2 are emitted into the atmosphere. Compare this with: 290 kg in France, and 400 kg of CO_2 in Germany.

In 2006, some 90 m Mg of hard coal and approx. 60 m Mg of lignite were mined in Poland. In 2030, it is planned to mine ca. 13.5 bn Mg of hard and lignite in the world, of which some 140 m Mg in Poland. Our production will represent only 1 per cent of the total global coal consumption. In the US, it is planned to build hard coal fired system power plants with the total capacity of 255,000 MW by 2030. The proportion of electricity produced from coal in Poland is 95% (vs. USA: 50%, Germany: 40%).

1.1. Projection of Polish energy demand until 2030

- Annual growth of electricity demand: 4%
- In 2007, the installed capacity was: 34,673 MW
- Old units to be decommissioned by 2030 have the capacity of: 15,000 MW
- By 2030, units should be installed with the capacity of: 45,000 MW
- In 2030, the installed capacity should amount to: 65,000 MW

1.2. Realistic ability to meet the above energy demand

If all government projections actually materialise, by 2030 the following can be achieved:

- approx. 3,000 MW of wind energy;
- between approx. 3,000 MW and 5,000 MW of nuclear energy;
- if lignite energy is not fully developed, only approx. 7,000 MW;
- if there are no investments into hard coal, only about 15,000 MW.

Poland will then be forced to buy electrical energy and hard coal equivalent to approximately 50 m Mg a year.

A separate problem is the condition of Polish power transmission lines.

1.3. The Government strategy is being implemented by the following structures

- Ministry of Science and Higher Education: Strategic R&D Programme: Advanced Technologies for Energy Generation;
- Ministry of Environment: National Programme for Geological Carbon Dioxide Storage;
- Ministry of Economy: Demonstration Programme: Clean Energy Industry Based on Coal;
- EU Flagship Program - ZEP Platform. Post-combustion and pre-combustion technologies with the intention to develop the CO_2 storage part by 2015.
- The best energy offering for Poland in the 21st century is considered to consist of:
- Developing the Legnica and Gubin-Mosty deposits which in 30-40 years' time would support raising the production of lignite in Poland to 100m-120m Mg per year and maintaining it at that level for at least 100 years.
- (Such a level of lignite production would ensure doubling the current installed capacity of lignite-fired power plants to 15,000 or 20,000 MW).
- Developing nuclear energy.

1.4. The disadvantages of the so-called best offering and the option of developing nuclear energy

This so-called best offering does not account for the following facts:

- Polish debt has risen during the last 20 years from $30 bn to over $200 bn (PLN 740 bn);
- The development of lignite production up to the maximum capacity takes some 18 years (Appendix).
- As a result of building open-pit mines, lunar landscapes (Appendix) will be created, water relationships in the vicinity will be upset, and the cost of reclaiming former pits are comparable to the cost of developing open pit mines and the power plant fired with this fuel in the first place.
- The unit CO_2 emission of fossil fuel firing, in kg CO_2/GJ, is the greatest for lignite and amounts to 101.20 CO_2/GJ
- (natural gas: 56.10, hard coal: 94.60, petroleum: 74.07).
- Worldwide data suggests that the cost of capturing and storing CO2 makes it the most expensive method, as it amounts to €38 per ton (which means that using this technology, Poland would have to spend €14,668 bn).
- The above idea of developing lignite deposits would require destroying some 50 localities and relocating 40,000 inhabitants of those areas, which means providing these people with residences and jobs.

1.5. Shortcomings of the option of developing nuclear power

An independent group of scientists has found that the global resources of uranium ore will be exhausted in the second half of this century. Even assuming that in the future we will mine deposits of ores containing 0.01% of uranium, this will still not save us from exhausting this fuel in late 2070s ("Auch uran wird knapp", Von Fred Winter, SONNEN ENERGIE, Ausgabe 1&2, Jan./Feb. 2007, pp. 22-24).

The construction or any proposals for extending nuclear energy generation based on a limited quantity of uranium ore are pointless in the longer term, especially as the cost of constructing a nuclear power plant is only recovered after 30-40 years.

The current annual consumption of nuclear fuel amounts to 67 kilotons globally, whereas the capacity of mines is around 42 kilotons (and the remaining shortage of 24 kilotons is covered with uranium from the nuclear arsenals of the US and Russia).

This is the main reason why Germany is moving away from nuclear power generation, even though it had spent an astronomical amount of 6 billion German marks on this industry.

Nuclear power is also useless as a remedy for climate change. The best proof of this is that France, even though it is the only country in the world with such a huge concentration of nuclear power (77.8% of all electricity generated), is still one of the main emitters of GHGs.

2. General assumptions of the project proposed

The project presented is a realistic, practicable idea for a substitute to system power plants, consisting in the construction of combined heat and power plants using renewable resources of geo-plutonic energy.

Humanity has used thermal energy obtained from the depths and the surface of Earth for a long time. There are various methods of obtaining geothermic energy and various uses for it. It represents an endless, renewable source of energy coming from nuclear reactions in the Earth's nucleus, where the temperature reaches 6,000 Centigrade.

Mass production of electricity from the Earth's heat, possible in Iceland due to the volcanic nature of these resources and the shallow depth at which they occur, was difficult in other countries due to the high cost of drilling to greater depths. This barrier has been overcome by us through using a special horizontal drilling technique. In order to extract and collect the accumulated energy from the area of a large thermal field, a modified shaft/drilling system (called a Super Daisy System) equipped with a 3D grate of directional boreholes called Jet-Stingers fitted with multi-functional heat exchangers is used. We are also planning a different method of horizontal drilling (Figure 1).

The emission-free project of Geothermic Energy with only the temperature of over 250ºC, from which we can obtain about 30 MPa of pressure on the turbin With increased the depth the temperature and heat transmissibility will be raised significantly , which can resulted the yield even to 7-10 MWe (of electricity) from one deep heat exchanger.

From the rock mass we can collect renewable resources of "dry" ascending energy from the paleo heat flow coming from the great atomic furnace - the magma.

We are experienced in using the appropriate hydro-thermodynamic theory and its applications which allows us to almost precisely forecast and control the quantity of heat not exceeding 20% of the 100% regeneration capability in the same time range. This means that we are continuously extracting 1/5 of the capability of heat exchange in the rock mass.

Jet Stringers - heat exchangers, several of them, are at the first level (800-1,000 m) placed in a shaft with a steel lining, from which they protrude at a predefined angle to reach the desired depth in the rock mass. This technology allows us to achieve a thermo-active volume of some 160 km^3 and the active thermodynamic surface of some 340 km^2.

Preliminary estimations show that the most practical total electrical capacity with several Jet Stringers at the high temperature of could reach 70-100 MWe, depending on the thermal conditions achieved.

The new generation SHD (Super Heavy Duty) drilling rig can drill and line-up the SDS (the shaft) down to 1,000 m and then drill several Jet Stingers at the rate of 6-10 m/h.In parallel, during the next year, the plant of a ground-level combined heat & power plant with the capacity of 70-100 MWe can be completed. The investment cost of 1 MWe is around 1,700,000 €, and production cost is in the range of 0.02 € per 1 kWh.

The subsequent Power Plant(s) can be financed with income from the sale of electricity for to-days price of 0.10 € per kWh.

3. Future emerging technologies for energy applications

The development of energy technologies is often impeded by bottlenecks which require the development and application of basic science and cross-cutting technologies. Also, real breakthroughs in the energy sector come quite often from progress in basic materials science that underpins energy technologies due to the radical upgrade in the properties of the materials. This topic aims at ensuring a genuine chance for „emerging ideas" to be funded. It is to provide rewards for, high risk / high impact" science and to vigorously promote multi - disciplinarity. Research for concrete implementation should embrace a wide spectrum of radical novel technologies and novel materials for energy applications should have tangible objectives beyond „Increased Understanding" and be ahead of conventional approaches, be highly novel, very ambitious, with an orientation towards long - term innovation. Project should try reaching a clearly defined scientific - engineering goal and/or proof of concept of a new basic technology, which in either case has the potential to open up new fields of enquire and lies well beyond what is considered state of the art at international level. This European Commission dream, at „Work Programme 2010, Theme 5, Energy" is realistic in our conception

Comparison of the economic efficiency for electric energy generation from renewable resources has been shown in Table 1 and 2.

4. Appendix

Obligation scope

Energy Charter Treaty (1994)

Rules of energy industry development in accordance with the market system and environmental requirements following the sustainable development principle were defined.

Table 1.
Comparison of the economic efficiency for electric energy generation from renewable resources

PROPOSAL: SYDICATE CPV - UNENERGY Corp., PLRT - GEOTHERMIC SOLUTION	CEEC Complex Coal Energy Extraction	CEEG Geo-Plutonic Dry Heat Energy	Coal Mining & Fired Conventional	Coal Mining & fired with 75% Geo-sequestration	Nuclear 2009 Estimate
Estimated life in years	25	60	25	25	25
Gross output	100 MW/hr	100 MW/hr	1000 MW/hr	1000MW/hr	1000MW/hr
Auxiliary use	5 MW/hr	3,5 MW/hr	50 MW/hr	200MW/hr	55MW/hr
Mining, water, waste equivalent (MW/hr)	5 MW/hr	0	50 MW/hr	150MW/hr	130MW/hr
Net output (MW/hr)	90	96,5	900	650	815
Output efficiency	90.00%	96,50%	90.00%	65.00%	81.50%
CAPITAL COSTS					
Design Cost	$8 920 000	$7 600 000	$100 000 000	$500 000 000	$750 000 000
Test Plant	$5 920 000	$16 200 000	Not required	$500 000 000	$1 000 000 000
Materials/Equipment Cost	$144 420 000	$157 200 000	$700 000 000	$1 000 000 000	$1 000 000 000
Construction Cost	$49 920 000	$70 300 000	$250 000 000	$500 000 000	$500 000 000
Labor cost	$24 320 000	$24 320 000	$250 000 000	$400 000 000	$500 000 000
Total Capital Costs	$233 500 000	$ 275 620 000	$1 300 000 000	$2 900 000 000	$3 750 000 000
Cost per MW installed	$2 335 000	2756200	$1 300 000	$2 900 000	$3 750 000
OPERATIONAL COSTS					
Interest @ 6%	$14 010 000	$16,500,000	$78 000 000	$174 000 000	$225 000 000
Fuel Cost	$3 300 000	0	$200 000 000	$300 000 000	$400 000 000
Fuel/waste Disposal cost	$1 100 000	0	$100 000 000	$250 000 000	$250 000 000
Water use (including mining process)	$1 800 000	$250,000	$100 000 000	$150 000 000	$300 000 000
Maintenance costs	$1 940 000	$1,225,000	$150 000 000	$250 000 000	$375 000 000
TOTAL COSTS INCLUDING MINIMUM PRICE FOR CARBON					
CO_2 emissions including mining	0T per MW	0T per MW	1.35T per MW	0.6T per MW	0.4T per MW
Net CO_2 emissions (Tonne)	0	0	11 826 000	5 256 000	3 504 000
CO_2 cost at $50 per Tonne	0	0	$591 300 000	$262 800 000	$175 200 000
Yearly running costs	$22 150 000	$17,975,000	$1 219 300 000	$1 386 800 000	$1 725 200 000
Net yearly cost (life/capital) + running	$31 490 000	$22,268,667	$1 271 300 000	$1 502 800 000	$1 875 200 000
Saleable MW produced in 1 year	$788 400	845,340	7 884 000	5 694 000	7 139 400
Net cost per MW sale	$18,00	$26.34	$161,25	$263,93	$262,66
Cost per kwh to produce	$0,018	$0.026	$0,16	$0,26	$0,26
Current cost retail to consumer	$0,14	0.14	0,14	0,14	0,14
Profit/Loss on installation based on market rates of 0.14c kw/h for 15 years	$1 442 900 000 + $471 900 000 from synthesis gas sale	$1,445,531,400	-$2 513 100 000	-$10 584 600 000	-$13 135 260 000
Can design be duplicated easily?	Yes	Yes	No	No	No
Will cost come down?	Yes	Yes	No	Yes	Yes
How long for the cost to come down? (if we start now)	1-5 years	1-3 years	N/A	20-25 years	20-25 years
Does it leave pollution?	No	No	Yes	Yes	Yes
Companies Proposing this technology	Multiple players	Geothermic Solution	Mature industry. Multiple players	Mature industry. Multiple players	Mature industry. Multiple players
Yearly cost including capital repay	$17 480 000	$5,768,000	$1 193 300 000	$1 328 800 000	$1 650 200 000
Life return	$3 183 000 000	$7,100,856,000	$27 594 000 000	$19 929 000 000	$24 987 900 000
Life cost	$787 250 000	$346,080,000	$31 782 500,00	$37 570 000,00	$46 880 000,00
Net return per annum	$95 830 000	$112,579,600	-$1 102 488 700	-$795 657 200	-$997 640 800
Net return % per annum (No finance)	41%	41%	-8,48%	-2,74%	-2,66%
Est. Crew & Staff Health/life Security	98%	99%	70%	60%	70%
NO.	1	2	3	4	5

Table 2.
Comparison of the economic efficiency for electric energy generation from renewable resources

PROPOSAL: SYDICATE CPV - UNENERGY Corp., PLRT - GEOTHERMIC SOLUTION	Solar Tower 2009 Estimate	Combined Solar tower and PV panels	Geothermal steam	Concentrated Solar Tower (steam)	Conventional PV	Wind Farms
Estimated life in years	60	60	15	15	15	25
Gross output	200 MW/hr	350MW/hr	300MW/hr	100MW/hr	100MW/hr	200MW/hr
Auxiliary use	5MW/hr	10MW/hr	15MW/hr	5MW/hr	5MW/hr	10MW/hr
Mining, water, waste equivalent (MW/hr)	0	0	15MW/hr	2MW/hr	0	0
Net output (MW/hr)	195	340	270	93	95	190
Output efficiency	97.50%	97.14%	90.00%	93.00%	95.00%	95.00%
CAPITAL COSTS						
Design Cost	$150 000 000	$220 000 000	$250 000 000	$150 000 000	$100 000 000	$100 000 000
Test Plant	$150 000 000	$250 000 000	$500 000 000	$250 000 000	Not required	Not required
Materials/Equipment Cost	$400 000 000	$500 000 000	$550 000 000	$550 000 000	$750 000 000	$800 000 000
Construction Cost	$250 000 000	$350 000 000	$350 000 000	$250 000 000	$150 000 000	$300 000 000
Labor cost	$90 000 000	$130 000 000	$200 000 000	$200 000 000	$200 000 000	$150 000 000
Total Capital Costs	$1 040 000 000	$1 450 000 000	$1 850 000 000	$1 400 000 000	$1 200 000 000	$1 350 000 000
Cost per MW installed	$5 200 000	$4 142 857	$ 6 166 667	$14 000 000	$12 000 000	$6 750 000
OPERATIONAL COSTS						
Interest @ 6%	$62 400 000	$87 000 000	$111 000 000	$84 000 000	$72 000 000	$81 000 000
Fuel Cost	$0	$0	$0	$0	$0	$0
Fuel/waste Disposal cost	$0	$0	$30 000 000	$0	$0	$0
Water use (including mining process)	$250 000	$250 000	$15 000 000	$5 000 000	$0	$0
Maintenance costs	$10 000 000	$20 000 000	$50 000 000	$25 000 000	$50 000 000	$100 000 000
TOTAL COSTS INCLUDING MINIMUM PRICE FOR CARBON						
CO_2 emissions including mining	0T per MW	0T per MW	0.15T per MW	0T per MW	0T per MW	0T per MW
Net CO_2 emissions (Tonne)	0	0	394 200	0	0	0
CO_2 cost at $50 per Tonne	$0	$0	$19 710 000	$0	$0	$0
Yearly running costs	$72 650 000	$107 250 000	$225 710 000	$114 000 000	$122 000 000	$181 000 000
Net yearly cost (life/capital) + running	$89 983 333	$131 416 667	$349 043 333	$207 333 333	$202 000 000	$235 000 000
Saleable MW produced in 1 year	683 280	1 191 360	2 365 200	325 872	332 880	665 760
Net cost per MW sale	$131,69	$110,31	$147,57	$636,24	$606,83	$352,98
Cost per kwh to produce	$0,13	$0,11	$0,15	$0,64	$0,61	$0,35
Current cost retail to consumer	0,14	0,14	0,14	0,14	0,14	0,14
Profit/Loss on installation based on market rates of 0.14c kw/h for 15 years	$85 138 000	$530 606 000	-$268 730 000	-$2 425 668 800	-$2 330 952 000	-$2 126 904 000
Can design be duplicated easily?	Yes	Yes	Yes	Yes	Yes	Yes
Will cost come down?	Yes	Yes	Yes	Yes	Yes	Yes
How long for the cost to come down? (if we start now)	1-2 years	1-3 years	2-3 years	3-5 years	5-10 years	5-10 years
Does it leave pollution?	No	No	Minor waste water	No	No	No
Companies Proposing this technology	Enviromission	Unenergy Corp.	Geodynamics			Pacific Hydro Renewable Energy Holdings
Yearly cost including capital repay	$27 583 333	$44 416 667	$238 043 333	$123 333 333	$130 000 000	$154 000 000
Life return	$2 391 480 000	$4 169 760 000	$8 278 200 000	$1 140 552 000	$1 165 080 000	$2 330 160 000
Life cost	$5 399 000,00	$7 885 000,00	$5 235 650,00	$3 110 000,00	$1,950,000,000	$3,850,000,000
Net return per annum	-$39 768 017	-$69 364 583	-$551 530 957	-$75 829 467	-$13,492,000	$79,016,000
Net return % per annum (No finance)	-0,38%	-0,48%	-2,98%	-0,54%	-1.12%	5.85%
Est. Crew & Staff Health/life Security	99%	99%	99%	99%	99%	99%
NO.	6	7	8	9	10	11

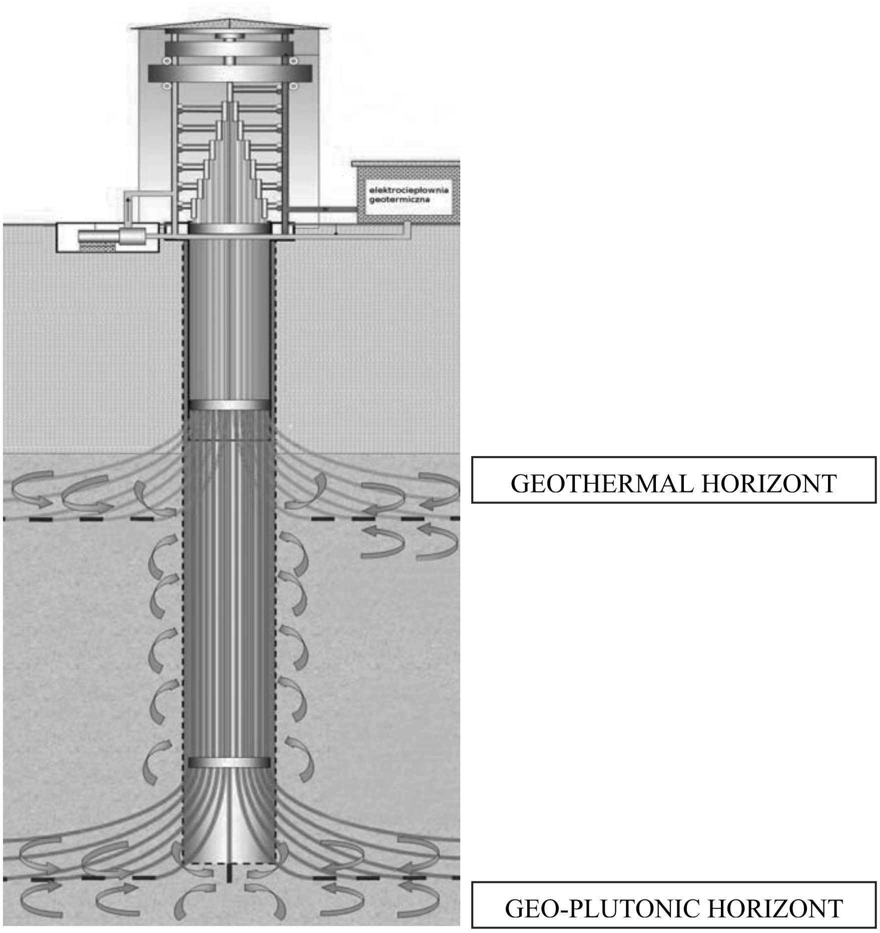

Fig. 1. Horizontal and semi-horizontal drilling

Second Sulphur Protocol (1994)

The total SO_2 emissions should be cut to 2m tons by 2003 and to 1,398k tons by 2010.

Kyoto Protocol (1997)

Reducing CO_2 emissions by 6% until 2012 against their level of 1998.

Second NO_x Protocol

The total emissions of NO_x should be brought down to 2m tons by 2003 and to 330k tons from 2010.

	Emissions (1000 tons)	
	SO_2	NO_2
2003	454	254
2010	426	251
2012	353	239

6 priority areas concerning a strategy for sustainable, competitive and secure energy.

- Green Paper (2006)
- Climate and Energy Package (2007)
- EU Concept 3x20
- Reducing the emission of GHG in the UE by at least 20% by 2020 compared to 1990
- Raising the share of energy from renewable sources in the EU’s energy balance by 20% by 2020

Reducing EU's energy consumption by 20% against the projections for 2020.

Lignite coal proposal

- 2008-2010

Study activities - technical, economic, social and environmental to achieve the appropriate agreements, the financial engineering of the investment and its necessary social acceptance.

- 2011-2014

Preparatory work, purchasing land, draining it, constructing infrastructure.

- 2015-2021

Completing the access excavation.

- 2022-2026

Developing coal production to its full capacity.

- 2026-2065

Full-scale coal mining.