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ENVIRONMENTAL-ECONOMIC FEASIBILITY OF A NEW TECHNOLOGY FOR LOW-WASTE COAL MINING OF THIN SEAMS

ЕКОЛОГО-ЕКОНОМІЧНА ДОЦІЛЬНІСТЬ НОВОЇ ТЕХНОЛОГІЇ МАЛОВІДХОДНОГО ВИДОБУВАННЯ ВУГІЛЛЯ З ТОНКИХ ПЛАСТІВ

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Despite the alternative energy growth dynamics, coal still remains the dominant type of fuel among available and cheap energy sources, accounting for 37% of Ukraine's total energy balance against 8.9% for renewable energy sources (including hydroelectric power plants) [1, p. 27]. In the depths of Ukraine, out of 41. billion tons of coal (4% of world reserves), 80% is concentrated in seams less than 1.0 m thick [2, p. 35]. This is the lowest indicator among coal deposits exploited in the developed countries of the world. In addition, balance reserves, also remaining within the boundaries of closed minefields, amount to more than 1.0 billion tons. The mines of PJSC

DTEK Pavlohradvuhillya, which develop mainly low-thick (< 1.0 m) coal seams in the Western Donbass, produced over 65% of the national coal volume in 2019 [3, p. 2]. Thus, this indicates the important strategic significance of this region in the energy balance of our country. However, underground mining of coal from low-thick seams using modern stope technologies is difficult for a number of reasons and is not conducted in the leading coal-mining countries of the world. The main difficulties of this mining are as follows [4, p. 67; 5, p. 123; 6, p. 149]: deterioration of the mined coal quality due to the cutting of waste rocks; additional accumulation on the daylight surface of waste rocks from stope operations (excluding tunneling operations); significant loss of coal reserves in seams less than 0.7 m thick; loss of coal reserves in protecting pillars under settlements, water bodies, and protected objects. The above problematic aspects in the coal-mining regions of Ukraine, which develop flat-lying coal seams, can be comprehensively eliminated by switching from traditional bulk mining using mechanized machine complexes to selective (separate) coal mining with the undercut rocks accumulated in the mined-out spaces of longwall faces. The technology efficiency indicators based on the authors' assessment are given in Table 1.

Table 1

Efficiency indicators of low-waste coal mining technology

Indicator	Value
Geological thickness of the seams, m	0.5 – 0.8
Ash content of mined coal , %	15 – 18
Decrease in rock outcrop on the earth's surface, %	30 – 40
Decrease in the earth's surface subsidence, %	40 – 50
Extension of mine operation, years	15 – 25

The specified technology and the principles of its functioning are presented in detail in the works [7, p. 771]. However, it requires a generalization of the complex of positive aspects arising from its implementation. According to the authors, the following aspects are the most important.

1. Reducing the waste rock volume accumulated on the daylight surface. In the Western Donbass mines, in addition to the volume of rocks brought to the surface from tunneling operations, annually in the rock mass mined from the stope faces, there is an unproductive movement of waste rocks in the technological chain from the stope faces to the beneficiation plant. After beneficiation, large rock fractions are transported to rock dumps, and finely dispersed fractions are transported to tailing dumps. Rock dumps and tailing dumps pollute the soil and air, as well as occupy valuable land areas that can be used for agricultural purposes. In addition, mining enterprises pay an environmental tax for environmental damage caused by storing 1 ton of

waste. The use of selective technology with the placement of undercut rocks in the mined-out space will reduce the rock output by 30 – 40% in the "stope faces – beneficiation plant – rock dump" system and reduce the intensity of the expansion of rock dumps with land alienation.

2. Reducing subsidence and flooding of the daylight surface. When coal is mined from seams with roof management by complete caving of rocks, a zone of stratification and fracturing of overlying rocks is formed above the mined-out space. As a result of their deflection, a shift trough is gradually formed on the surface, which leads to the daylight surface subsidence. Usually, the surface subsidence is 0.9 *m* (*m* is the seam thickness). In the case when several seams are mined simultaneously, the subsidence increases proportionally. If the subsidence value is higher than the groundwater level, the territories are flooded and waterlogged, which especially harms areas near residential buildings, other civil buildings and structures, as well as lands where agricultural crops are grown. Cases of flooding of territories in the Western Donbass are observed on an area of 17 km^2 near the city of Ternivka and the village of Bohdanivka. The use of selective technology with mechanical placement of undercut rocks in the mined-out space allows filling up to 50% of the removed seam thickness, thereby reducing subsidence on the daylight surface. The combination of methods, techniques and types of materials for backfilling the mined-out space will make it possible to obtain backfill masses that are optimal in terms of parameters, which will significantly reduce the surface subsidence.

3. Improving the mined coal quality. Modern mining equipment for stope operatopns (shearer mining) in the Western Donbass mines, according to technical characteristics, allows mining coal seams only if the geological thickness of the seam is at least 1.0 m. Therefore, when mining coal seams 0.7 – 0.9 m today, a shearer is forced to cut the waste rocks of the seam roof or bottom, which leads to mixing of broken rocks with valuable coal, and, consequently, to a decrease in its quality (ash content index). According to traditional technology, coal is mined with an ash content of 40 – 45%, and after the technological beneficiation cycle, the ash content is reduced to 25% according to the requirements of the thermal power plant. Previous studies indicate that selective mining technology will allow coal to be mined with ash content slightly higher than that of the parent coal, at the level of 18 – 20%, without a beneficiation cycle.

4. Increasing the completeness of mining coal reserves. One of the most important indicators of coal mining from the subsoil, in addition to its quality, is the volume of losses in the subsoil. To date, coal seams up to 0.7 m are industrially developed by traditional bulk mining with mechanized complexes, and, for example, in the range of 0.55 – 0.7 m, the volume of coal reserves in the Western Donbass is 35%, and less than 0.55 m – 25%. The maximum limit of the geological thickness of the seams that can be mined by selective technology with the placement of rocks in the mined-out space will

depend on the degree of its filling with undercut rocks, as well as their physical and mechanical properties. Preliminary assessment indicates that seams up to 0.55 m can be efficiently mined using this technology. In addition, in the Western Donbass, 30 – 35% of all balance coal reserves (as calculated up to 0.7 m) are located under protected objects (settlements, water bodies, industrial enterprises, forest areas, etc.). Research on the formation of a strong combined backfill mass with improved compression characteristics and optimal parameters of placement in mined-out spaces will make it possible to involve these reserves in industrial safe exploitation and prolong the operation of coal mines in the Western Donbass by 15 – 25 years (from the design terms of their decommissioning).

The selective technology for coal mining with the undercut rocks placed in the mined-out space, taking into account its subsequent implementation, will improve mined coal quality, reduce the volume of waste rock formation on the surface, reduce the surface subsidence value and attract additional coal reserves for industrial exploitation.

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