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THE POSSIBILITIES TO DEVELOP SUSPENDED COAL RESERVES IN UKRAINE

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МОЖЛИВОСТІ ОСВОЄННЯ ЗАКОНСЕРВОВАНИХ ЗАПАСІВ ВУГІЛЛЯ УКРАЇНИ

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ВОЗМОЖНОСТИ ОСВОЕНИЯ ЗАКОНСЕРВИРОВАННЫХ ЗАПАСОВ УГЛЯ УКРАИНЫ

Abstract. This article presents methodical approaches to the assessment of possibilities to involve the dormant coal reserves into mining process in small mines with view to increase economic potential of the coal-producing region. The proposed model makes it possible to select priorities for quantitative and qualitative parameters of the mine fund with taking into account technical, technological and organizational relationships and restrictions between different levels. It is proposed to base evaluation of the coal-producing region investment effectiveness not on production conditions in a particular enterprise but on analysis of initial assumptions. Changes in economic potential of enterprises were analyzed in terms of additional investments into diversification of production processes through recycling of waste heaps and using of the mine water and methane heat. To this end, priority and targeted funding of exactly those measures (increase in capacity at promising mines, diversification or new construction), which would ensure growth of living standards in specific coal-producing region, were estimated.

Keywords: coal industry, extended reproduction of capacity, potential, diversification, ecology, subsidy.

Setting the problem. In terms of innovative component and technological process control of coal extraction, current state of Ukraine's coal industry can be described as very complex. Not better situation with the problem of the industry development. Let's consider the perspective of 20 -30 years. For previous century in Ukraine (mostly - in the Donetsk Basin) it was obtained 9.4 billion tons of coal, more than a quarter of existing reserves. Naturally, the coal bedsfor the most favorable conditions were worked out. Almost all anthracite reserves in the Donetsk are developed and largely - in the Lugansk region; extraction of scarce coking coal brands decreased. For this reason, in the future it will be change in the quality of coal produced, for the worse. However, the main (and it was not drawn enough attention) is the problem of the structure and state of mine fund.

Mines will get older, and in 20-30 years will turn into a very complex facility, operating with low efficiency and more difficult working conditions [1]. If you use the experience of the past, to save the coal industry capacity it will be necessary to reconstruct enterprises with relatively favorable geological conditions and build new mines. The first ones in the Donbasare approximately 50; new ones we can build no more than 12-15. With the current prices the reconstruction will take about 35 billionUAH,to build new - about 60 billion UAH. If we assume that these funds will now be found, the new mine will full pay off after 15-20 years. As a result, spending about 100 billion UAH, the country will receive a new Donbasfor coal mining of lower quality compared to the current status, and fuel reserves are in difficult geological conditions at great depths with high gas contain in layers. Beside the excavation level will drop to 40-50 million tons. Building new mines with relatively favorable conditions of occurrence of layers in the west and north from West Donbas requires the withdrawal from agricultural use large amounts of expensive and in some ways priceless black earth. With increasing of food shortages in the world such a move is unlikely to be justified, as the agenda is already standing a problem of food security providing.

We cannot talk about the economic feasibility of extracting the coal like that. Wherein we will in fact re-established industry with low technical level, even with the mechanization of individual processes and operations, besides of high cost. A number of new mines can be built on the west and north from Pavlograd. But there we will have to create a new complex infrastructure, derive from agricultural use large amounts of expensive and in some ways priceless black earth. It seems more reasonable in the next 10-20 years to gradually eliminate unpromising mine sectors. This requires a balanced and careful approach and is also associated with significant costs (approximately 100 - 200 million UAH per mine), the resolution of complex social and environmental problems. This is not about general and kampaniysky approaches.

As of January 1, 2016 there are 94 vacantareas in the Donetsk basin. Completed earlier study [2] showed that the geological conditions of 45 free sites can be recommended for laying 48 new mines, another 14 sites to be used for cutting reserves for reconstructed mines and extension the life of currently operating mines. Additional gather of areaswhich are considered to be a site for new mines, was performed bydesign institutes considering the presence of a sufficient number of layers with enough thickness of seams and reserves, as well as favorable conditions in tectonic respect of mining. Out of 45 sections 32 and 13 explored in detail and in advance respectively. At nine mines it can be extracted coking coal, at 39 mines - coal for energy purposes, including the last 8 mines engaged in mining of anthracite. Balance reserves of considered sites are: category A + B + C1 – 8798 million tons, C2 - 873 million tons, including coking coal reserves respectively are 3.152 billiontons and 534 million tons.

At the State Enterprise "Artemvugillya", "Dzerzhynskvuhillya", "Orgonikidsevuhillya", "Donbasantratsyt" and "Sverdlovantratsit" there are no free sites for laying mines there. Geological areas are characterized by mostly thin coal

beds of 0,7 -1m capacity, except for some areas (including Bogdanovskayawith thickness of coal seams reached up to 3.35 meters). The predominant angle of incidence of seams is 3-12o (31 mines), less 20-25o (12 mines) and 5 mines are characterized by sloping and steep bedding layers. Number of seams that lie in these areas varies widely from one (sector "Krasnoarmejskij 2-3 West") to thirty one (sector "Miusskaya 1-2"). The depth of layers is also quite different, in this regard, there are 24 mines are with upper limits to depths of 300 meters, 10 mines - from 300 to 600 meters, with 8 mines - from 600 to 800 m and 6 mines - from 800 to 900 m. The depth of the lower limits of more than 1400 m is at the mines, "Abakumivska-Hlyboka" (1600 m), "DobropolskayaCapitalnaya" (1600 m), "DonetskaCapitalnaya" (1670 m), "Novosvetivska" number 2-4 (1450 m), "Novoannivska" (1450 m), "Krasnodon-Hlyboka" (1650 m), "Myronivska-Hlyboka" (1650 m), "Mountain-Deep" (1650 m), "Svetlonivska" (1650 m) "KholodnaBalka" (1500 m) and "BorzhynivskaPivdenna" (1500 m).

Side rock, mainly is represented by clay and sandstone shales of secondary durability, the complexity of the structure of land belonging to the groups I and II of complexity. On 22 areas layers are dangerous with sudden emissions of coal and gas, on 13 areas coal are proneto spontaneous combustion.

Project studies performed by institutes of former Soviet Union Coal Ministry confirmed that almost all the planned to the construction of a mine belonging to the deep, or have very complex conditions of layers occurrence. These circumstances lead to an increase in the terms and estimated construction cost to the state that practical implementation of projects under the current state of the economy becomes unrealistic. For the reasons considered above reserves of free sites cannot be definitely attributed to effective. The general policy of restructuring as a separate mine and mine fund as a whole must be based on the need to develop exactly effective reserves, a category of which is still limited in Ukraine. Optimistic forecasts that coal reserves will be enoughfor us for hundreds of years do not is beyond criticism. [3]

We must add that the number of mines is already in the construction stage for quite a long time. As an example we mentioned mine "Dobropolskaya-Capitalnaya" (now preserved) with a capacity 2.4 million tons, located in favorable geological conditions. The total cost of construction of the mine is 1972 million UAH, of which more than in 10-year time period it was involved 58 million UAH. If you continue funding like this, the mine should be built more than 100 years! Even on those mines that are relatively close to completion of construction, its completion stretched for many years.

Article purpose. The purpose of the article is to develop a methodical approach to the selection of cost-effective options for the development of preserved coal reserves. As the mathematical tools it is pertinently to use the principles of dynamic programming.

The main material studies with full justification of scientific results. Basically in networks mine workings research is studied stationary Vertexflow, which is the task of maximizing the flow from one point to another in a network with limited throughput. In our point of view, this problem is the most important one of that is considered

whenselectingthe options for reserves improvements of the state unprofitable mines.The solution of thisproblem answers the question of admissibility of options, and this is the most important aspect of support management of unprofitable mines capacity considering the topological features of mining reserves in underground conditions. Quite simple design, which is the result from the study of this problem in conjunction with the methods ofsolution the open model of appointment, is a key to the development of various methods of problem solving minimum cost flow [4].

The result of the formation of reserves extraction options at the mine field is a technological model (graph) of the subject studies, submitted in a tree formof many compatible options of technical and technological solutions and limitation system. They characterize the region of modeled schemes economic parameters. If you model a mine as a working network, in terms of optimal programming it is reduced to a subclass of linear problems about streams that distinguishes with their comparative ease and convenience of practical use.

Thus, the formalized presentation of set of solutions to maintain capacity, reconstruction, or closing mines in scale of association (region) as multigraphwith block structure makes it possible to select priorities by quantitative and qualitative parameters of the mine fund, taking into account technical, technological and organizational interrelation and limitations between different levels. Let's consider one possible approach to formalized description of options of the technological scheme of mine with graphs language. Let's name graphic analyzing model of estimating the durability of the technological scheme of mine the graphic representation of its elements and links that allows to define clearly with a set of formal rules the state of the system (providing with defined volume of production) for any set of conditions (providing with specified throughput) components. By definition, the description of technological systems using graph-analytic model is possible providing that all of the elements and the system as a whole have only two possible states - providing capacity or failure. Thus, for a clear and unambiguous formalized description of the technological system of the mine we should establish ways to display on the graph of possible options interaction of its elements.

There should also be given a set of formal rules on the definition of the power system level with a given number of possible states of elements. In accordance with the above, graph analytical model of technological scheme of the mine can be represented as anoriented graph. The elements of studied technological scheme aregraph tops, and the interaction of the constituent elements is indicated by arcs (arrows). Curvesorientation on the graph should correspond to the direction of coal flow traffic.For unambiguous definition of technological system disability for a given set of states of its constituent elements in the graphic-analytical model to identify vertexes of higher and lower ranks. Thus, the top has a higher rank if all associated arcsare directed only to her, and vice versa - it has a lower rank if all arcs are focused only from her. Beside the concept of hierarchy when considering the technological system of graphic-analytical model the concept of path obtains the great importance. It usually means an arbitrary sequence of vertexes, which are part of the trajectory oriented along the edges or arcs. The top of graph is transit for routes if the corresponding el-

ement of technological scheme is in working condition. In case, when the technological component element is in a state of failure, the corresponding Vertex of graph-analytic model is nottransit for routes that pass through Vertex. This Vertex is in a way up if there is at least one path that connects it to the Vertex of highergrade. For the transition from graphic-analytical to analytical form technological scheme topology, typically it is usedlogic unit, incidence matrix and tabular notation.

The tabular form of the graphic-analytical model of technological scheme is of particular interest as an intermediate stage of thetechnological and geological mining data input into a computer. In addition, this notation is more evident than of the language of algebraic logic. This unidirectional oriented graph of arbitrary structure is uniquely defined using a given set of Vertexes and arches. These graph parameters can be specified most appropriate when each vertex placed in line numbers of all the vertexes, which she directed from the arc. Thus, the tabular notation in a form, suitable for simulation, is a table consisting of two columns. The first of thosecolumns is specified with the Vertexnumber of the investigated graph. The second –with the numbers of vertexes, to which are sent arcs from a given Vertex. Tabular method,considered above, of displaying the topology of the technological scheme of mine can increase the size of the problem compared to the method where each vertex of the graph we put in correspondence number of vertexes, from which to itarcs were directed. This is due to the fact that in technological schemes of coal mines when considering the flow of coal to one vertex can be sent a large number of arcs. In addition, on these graphs the number of vertexes that are not obtained any arc is also low. Therefore, at the first method of formalized representation of technological schemes topology of coal minesthe output information is distributed on the table rows more evenly because it contains minor amount of blank lines.

One of the most common forms of presentation of analytical topology technological scheme of mine is also Incidence matrix. Tabular form of the graph noting is built that way. In the matrix vertically is written the entire vertex and horizontally - all outgoing graph arcs of technological scheme. Wherein the element, belonging to theith raw and j-th column of the matrix, is equal to *+1*, if the curve is directed from this vertex, and *i-1*, if the arc is directed to this vertex. Otherwise, at the intersection of i^{th}-raw and i^{th}-column we write zero.

In case of power optimization and other parameters of the mine through its graphic-analytical models is specified output oriented unidirectional graph becomes a multigraph. Each multigraph arc is associated with a cost function F and the value of the throughput of P. The number of arcs γ, connecting the it hand j-th multigraph vertex, should be equal to the number of possible solutions of characteristics variation of throughput P of the given technological scheme structure element. Arches orientation of multigraph corresponds to thearches orientation of the output graph.

If certain functions $f_k(A)$ is not defined at all A, instead them we enter penalty function - an arbitrarily large number of M. Application instead of the function $f_k(A)$ the profit or performance indicator, you can determine the maximum value $f_k(A)$. If costs are accounted with options, then value of the function $f_k(A)$ will be minimal. These thoughts are the basis for constructing dynamic acyclic network of shortest

path (Figure 1).

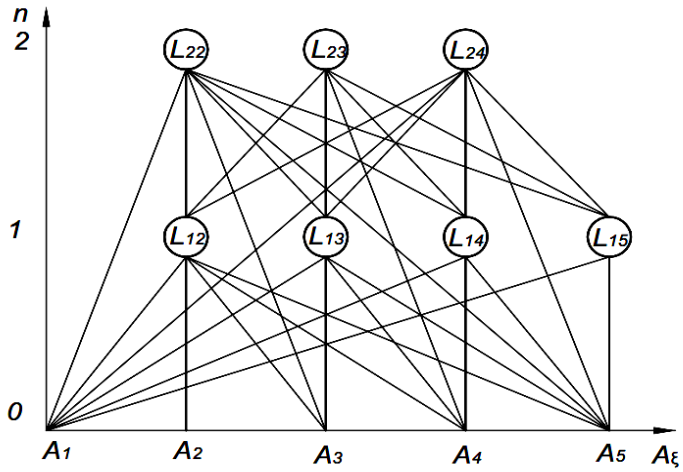

Figure 1 - Acyclic network versions of mines development

Exactly acyclic network recalls the unique coal reserves in the Donbas. They are relatively small in terms of practical use at a present time. The state is unable to fund defectivelyin dubious new construction projects in conditions of market relations. It can only contribute to development of new sites under the conditions quickly enough compensation for investment. It is an axiom, and it is dictated not only by the desire to ensure state energy security, but the reality of the development of new coal reserves without stress, which is characteristic for long-term working mines from the Soviet era. Then only inclined Komsomol mines were built quickly only built in World War II, and relatively successfully were mastered Western Donbas stocks [5].

There is a large variety of hardly-forecasting characteristics of the natural environment and their values that determine the efficiency of coal mining, on the one hand, and the limited options of technological schemes and types of mechanization - from the other, we determine the need for the latter in a wide range of geological conditions. There are much of the stochastic component, a large variation in absolute values of projected condition parameters of coal mining, by average value of which we can choosethe technique and technology of mining for each face area. Engineering and technology are not always optimal for the conditions, consisting, or as more often and generally operate in unforeseen conditions. The same equipment on the same technological scheme of coal mining can work with various productivity and efficiency at almost the same cost to operate, but at a different wear. Production cleaning and continuous resource equipment depends not only on established machine-hours, but on conditions and aggressive operating environment, which requires an adjustment in depreciation policy.

Unsteadiness in time and space jobs in face and continuous workingsareexplainedby individual topology of network of working at each mine. The number of types of used schemes of opening, preparation and development of fields is limited. In reality, depending on the characteristics of natural ingredients, each technological scheme takes the form of a unique network of mine workings that are constantly changing due to new and abandoning of those, which lost the produc-

tion value. Each mine differs with total length of the network of workings, their specific length and volume of carrying, which falls on 1 m of face and 1 ton of daily production. However, in our view, variability of the implementation process of coal mining, which negatively affects all aspects of production and business activities, the most precisely determined by heterogeneity of natural components and variability oftemporary characteristics of operations and activities [6].

The technology itself of underground coal mining is in constant development of the network of mine workings and providing with access to undeveloped areas of mine layers and assumes at some point the need for reconstruction, without which the future of mining is complicated or even impossible. Opening new horizons, developing ventilation shafts, deepening existing, others capital operations should be performed at defined stage of the life cycle of the coal enterprise. This reduces the set of alternative of mine development compared to companies in other industries, where decisions about reconstruction of production do not depend on technological features.

In this article the object of studying is the Donbas mines that produce fuel for energy needs (particularly for household needs) of the available remaining reserves. The following analysis of the possibilities of development of new coal reserves for Ukraine we will consider regarding anthracite seams. Areas of anthracite seams distribution are located in the south-eastern part of the Donetsk Basin. Available geological areas in these regions can be divided into three groups by the basis of their impact on key performance parameters of the operation and construction of mines: production volume, methods of opening, extent and type of mining operations, the amount of initial capital investment and construction time. The most characteristic feature of these positions is the incline angel of layers, the overall coal reserves and their distribution in depth.

The first group - is geological areas with flat beds, a deep upper limit and large reserves. In this case there is a limited number of working layers, horizontal distribution of stocks of large areas prevailing in a relatively narrow vertical range, but at a significant depth. The highest investments efficiency in the construction of mines in these conditions is achieved with technical solutions that have become traditional: vertical shafts section, working mine field with units, panel method of preparation, large production capacity. However, the feasibility of industrial development of these areas in the near future is unlikely due to high volume and cost of construction, very long construction time, which are beyond the period of deficit of steam coal and limited possibilities of the state, which subordinates the Donbas mines.

There are also free explored sites "Miusskii 1-2" and "Hrabivskyy mine" the rock surface of these areas is covered with a small thickness of Tertiary and Quaternary sediments, the upper limit of coal seams is located on a small depth of 30-80 m (Table 1).

Among the possible options for industrial development there are two, which can compete: the construction of large mines (one or two) at each site and gradual industrial development of areas at first primary construction of group of mines with low capacity (300-400 thousand tons / year), followed by - in 20-25 years (if necessary) unification of mine operations at the same horizon.

Table 1 - Site characteristics "Miusskii 1-2"

Mining and geological features	Indicators
Size, km: Seam dip	4,0
Seam strike	9,0
Limits depth, m Upper	
	30,0
Lower	1390,0
Number of operating seams	31
Bed thickness, m	0,6-1,42
Dip angle, degrees	45-50
Coal mark	A,T
Industrial reserves, million tons	120,0

Using mentioned approach, we can consider options for the development of new areas reserves, with funds for capacity expansion in the region by the amount of 1.8 million tons/year by building one or several mines. The corresponding acyclic network is shown in Figure 2.

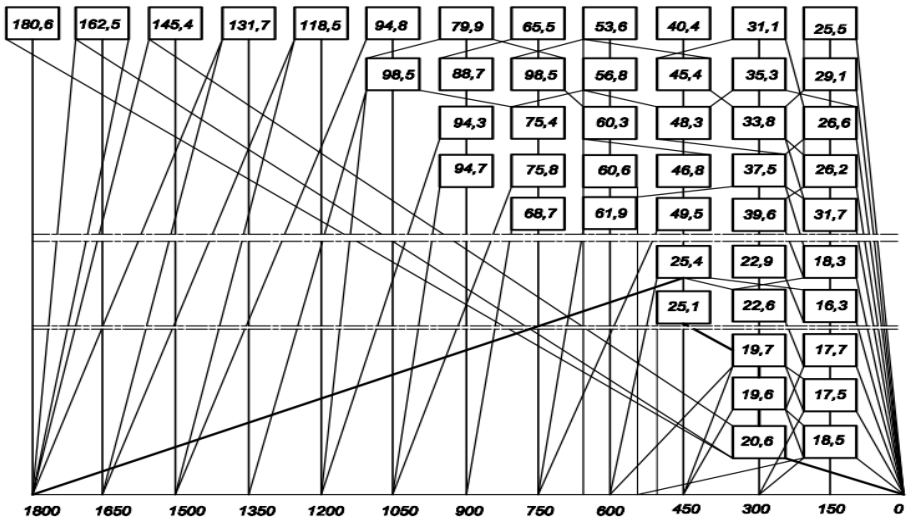

Figure 2 - Acyclic network of selection the type of mines in the area "Miusskii 1-2"

In 70th for industrial development of the areas it was developed an original way to cross them with inclined workings in connection with steeply inclined shafts an low power mode section inclined workings combined with steeply inclined shafts and surface [2]. This method involves placing the auxiliary shafts with an angle 140-160. The maximum length of one inclined shaft's rope haulage is 1300-1400 m, which provides working out two floors in the given conditions of occurrence of layers (Fig. 3). It was defined minimum distances between the outermost operating layers of a mine field in the range of rock's angles of occurrence in geological areas of this type (400-600), in which the surface crosscutsare not going beyond the working layers'

boarders. At the same time assumed the maximum inclined floor height of 140 m.

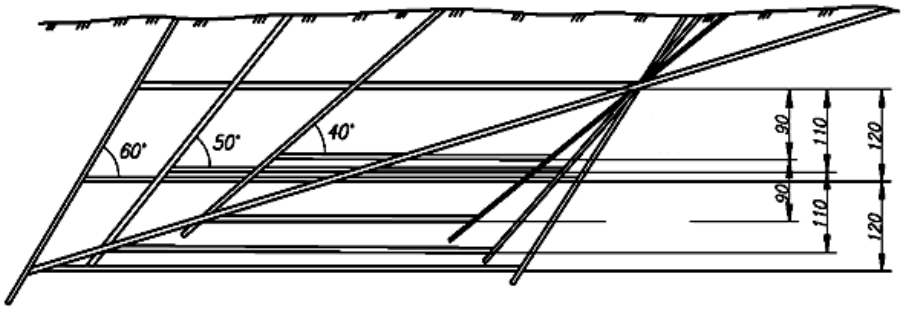

Figure 3 - Location of inclined shafts depending on the dip angle of the layers [3]

That is why this is important to have an opportunity to prepare at one time two horizons in the fields of mines at "Miusskii 1-2" area by the inclined crosscut and modern organization of mine construction without driving the most difficult workings - shafts.

At one time, there were quickly built and operated 20 years mines "Richkova" and "Yablunivska". The first one was irresponsibly flooded in the early 2000th, and the other was stopped. Sufficient capacity of beds, lack of gas at shallow depths allowed to provide high steep seams load on the long wall face -350-400t / day. For comparison, the daily load on the long wall in terms of steep seams of the Donbas Central District barely reaches 100t. The capacity of proposed for the construction of two mines was assumed in the initial operation period of 300 thousand tons, with following possible increase to 450 thousand tons per year.This is due to, on the one hand, the forecastof decreasingrate in production in the region, on the other, the need to build them in the short term. Mines are designed to mine the four horizons with a lifetime of 26 for extracting the balance reserves in the amount of 24.9 million tons. The most important reason that has caused the necessity ofminesconstruction "Faith" and "Hope" is a social situation - the need to provide employment to workers who quit from other mines region.The duration of main construction period is 20.3 months.

Using modeling techniques for mine development by concepts of dynamic programming the analysis was made of changes in the economic potential of enterprises in terms of additional funding diversification of production processes by recycling waste heaps, using heat energy of mine water and methane. The possibility of the improvement of the region during putting into operation the first two mines in the area "Miusskii 1-2" was proved. Due to their rapid construction (24 months) annual production in the region will grow by 600 thousand tons. When you consider that the cost of production in the mines of this type will not exceed 550-600hrn./t, this circumstance will immediately impact positively on wages in the region and revenue amounts of income tax and profit tax of newly constructedenterprises.

Conclusions

1. When simulating the distribution of state funds in coal-producing region, we can say that the degree and importance of sensitivity of the decisions are determined only by the dynamic analysis (dynamic programming). Therefore, we proposed an

assessment of the effectiveness of investment in coal-producing region, based on analysis of the output data systems and not on conditions of a particular company's operations.

2. Beside the absence of significant funds for new construction (more than 100 billion UAH), the terms of construction of deep mines with difficult conditions of layeroccurrence willgo beyond the need for coal. In addition, we will have to create a new complex infrastructure, to withdraw from agricultural use large amounts of expensive and in some ways priceless black earth.

3. The expedience of development of available sites with shallow seam occurrence of low capacity mines (300-400 thousands tones/year) was proved. In the areas, where most of the population is connected with work at the coal mines, the degree of development is characterized by full employment. Therefore, the mainsubject of state regulation isproviding break-even production and estimationthe priority and targeting of funding precisely those measures (increase in power of promising mines, diversification or new construction), which will ensure the growth of living standards in a specific coal-producing region.

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Анотація. У статті запропоновані методичні підходи щодо оцінки можливості включення до відпрацювання законсервованих запасів вугілля шахтами невеликої потужності з позиції підвищення економічного потенціалу вуглепромислового регіону. Запропонована модель дає можливість вибирати пріоритети за кількісними та якісними параметрами шахтного фонду з урахуванням технічних, технологічних і організаційних взаємозв'язків, а також обмежень між окремими рівнями. Запропоновано оцінку ефективності інвестування вуглепромислового регіону грунтувати на аналізі системи вихідних припущень, а не умов діяльності конкретного підприємства. Виконано аналіз зміни економічного потенціалу підприємств на умовах додаткового фінансування процесів диверсифікації виробництва за рахунок переробки териконів, використання теплової енергії шахтної води та метану. Для цього зроблена оцінка приорітетності та адресності фінансування саме тих заходів (збільшення потужності перспективних шахт, диверсифікація або нове будівництво), які забезпечать зростання життєвого рівня населення конкретного вуглепромислового регіону.

Ключові слова: вугільна галузь, розширене відтворення потужності, потенціал, диверсифікація, екологія, дотації.

Аннотация. В статье предложены методические подходы к оценке возможности включения в отработку законсервированных запасов угля шахтами небольшой мощности с позиции повышения экономического потенциала углепромышленного региона. Предложенная модель позволяет выбирать приоритеты по количественным и качественным параметрам шахтного фонда с учетом технических, технологических и организационных взаимосвязей, а также ограничений между отдельными уровнями. Предложена оценка эффективности инвестирования углепромышленного региона основывать на анализе системы исходных предположений, а не условий деятельности конкретного предприятия. Выполнен анализ изменения экономического потенциала предприятий на условиях дополнительного финансирования процессов диверсификации производства за счет переработки терриконов, использования тепловой энергии шахтной воды и метана. Для этого сделана оценка приоритетности и адресности финансирования именно тех мер (увеличение мощности перспективных шахт, диверсификация или новое строительство), которые обеспечат рост жизненного уровня населения конкретного углепромышленного региона.

Ключевые слова: угольная отрасль, расширенное воспроизводство мощности, потенциал, диверсификация, экология, дотации.

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