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ЭКОНОМИЧЕСКИЕ АСПЕКТЫ ИССЛЕДОВАНИЯ УГОЛЬНЫХ МЕСТОРОЖДЕНИЙ УЛУГ-ХЕМСКОГО БАССЕЙНА (ТУВА)

***Аннотация**: в статье отмечено, что Государственным Резервным Регистром Российской Федерации обозначено 11 месторождений угля на территории Тувы, общие рентабельные запасы которых определены в размере 1,12 млрд тонн, в том числе 936,6 тыс. тонн коксующихся углей. Подавляющее большинство исследованных угольных месторождений республики находятся в бассейне Улуг-Хем, общий объем проектных ресурсов превышает 20 млрд т. Подтверждено, что коксующийся уголь бассейна Улуг-Хем является наиболее конкурентоспособным ресурсом Республики Тыва. Низкое содержание золы, превосходный индекс спекания, низкий уровень содержания серы и фосфора в коксующемся угле рангов GG и GZh являются показателями высокого качества, в соответствии с этими характеристиками угли рангов GG, GZh превалируют над кузнецким и печорским углями. В России ежегодно добывается около 70 млрд тонн коксующегося угля, но на некоторых участках наблюдается дефицит. В первую очередь это связано с ростом внутренних цен на коксующийся уголь в России. Согласно прогнозам ученых, дефицит угля в стране достигнет 15–17 млрд тонн.*

***Ключевые слова**: уголь, Улуг-Хем, месторождение, инвестиции, развитие, исследование, экономика, бюджетно-финансовые последствия, запасы.*

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ECONOMIC ASPECTS OF COAL DEPOSITS EXPLORATION OF THE ULUG-KHEM BASIN (TUVA)

***Abstract**: in accordance with the article, 11 deposits coal on the territory of Tuva are accounted by State Reserves Register of the Russian Federation, the total profitable reserves are estimated at 1,12 billion tons whereof 936.6 thousand tons are dealt with*

as coking coals. The vast majority of explored deposits of coals of the republic are concentrated in the Ulugh-Khem basin, the total projected resources of which exceed 20 bill.t. It is substantiated that coking coal of the Ulugh-Khem basin is the most competitive resource of Tyva Republic. Low ash content, excellent caking index, low sulfur and phosphorus in coking coal of ranks GG and GZh indicate their high quality, according to these characteristics GG, GZh coal ranks take precedence over Kuznetsk and Pechora coals. About 70 bill.t of coking coal are annually mined in Russia, but there is a deficit on certain coal ranks. It is primarily related to internal prices increase for coking coal in Russia. According to forecasts of researchers coal deficit will rise up to 15–17 bill.t in the country.

Keywords*: coal, Ulugh-Khem, deposit, investition, development, exploration, economy, budgetary and social effects, reserves.*

In the case of development of the Ulugh-Khem basin with an aim of transportation of coking coal for supplying metallurgical companies of the country and for exporting, for these cases a railway construction of 450 km long is needed. The mentioned deficit can be eliminated as a result of development of new coal basins of the country, including the Ulugh-Khem [8].

The railway construction to coal deposits of the Ulugh-Khem basin not only solves the problem of the elimination of internal deficit of coking coal, but deals with much more federal-wide and regional problem – providing transport accessibility of Tuva Republic [5]. Table 1 shows the quantitative indicators of commercial reserves ($A+B+C_1$) of coals of Russia and Tuva.

Table 1

Economic reserves of coals

	Russia	*Siberian Federal District*	*Tuva Republic*	*Coal reserves of Tuva Republic in % in comparison with coal reserves of Russian Federation*	*Coal reserves of Tuva Republic in % in comparison with coal reserves of Siberian Federal District*
Coal, billion ton	41.3	33.2	1.1	2.7	3.3

In recent years, interest in Tuva's deposits is increased; this is primarily due to the inclusion of Kuragino-Kyzyl railway construction into the list of projects of Russia Investment Foundation [1; 2]. In 2006 the Chinese company «Lunsin'» acquired a license for the development of the Kyzyl-Tashtyg lead-zinc deposit, in 2007 JSCompany «Mining and Metallurgical Company «Norilsk Nickel» has acquired the license to develop the Ak-Sug copper-molybdenum deposit. In 2008 there was an auction for mineral resources use of Mezhegei coal deposit.

Two coal mining companies: JSCompany «Kaa-Khem coal mining» and Yenisei Industrial Company (EPC) are functioning for the moment in the republic. JSCompany «Kaa-Khem coal mining» mines coal in two deposits – Kaa-Khem and Chadan. According to the data of Industry and Energy Ministry of Tuva Republic during 2008 the company mined 670 thousand tons of G, GZh coal ranks. Mined coal is primarily sold at a local market and is used for thermal power generation. Coal consumers in Tuva are population of the republic, heating boilers of companies and organizations, Heating and power plants of Kyzyl and Ak-Dovurak. We are of the opinion that it is based on the volume of local user market (500 thousand tons), up to 25% of mined coal by JSCompany «Kaa-Khem coal mining» is supplied to metallurgical plants of Russia.

The second company – Yenisei Industrial Company has begun developing Elegest coal deposit in 2008, the extraction volume is about 50 thousand tons per year. Projected capacity of the company is 12 bill.t per year. Projected capacity of the company has a tendency to overgo in 2014 after Kuragino-Kyzyl railway commissioning, the construction of which is expected to start in 2010.

An integrated assessment of natural and mineral resources of Tuva is needed to carry out for Kuragino-Kyzyl railway construction defense. However, in this article we do not set such goal but we evaluate the economic potential of coal deposits exploration of the republic, due to the fact of Kyzyl-Kuragino railway construction from a potential resource they go into the actual value.

The following approaches are introduced in the methodological literature as the basis of the economic evaluation of natural resources: income approach, cost method,

comparable and optional approaches. The income approach recently received recognition, whereby economic evaluation criterion is the net present value (NPV). Additional indicators such as payback period of investment, internal rate of return, profitability index are covered by valuation of deposits.

Valuation of coal deposits development of Tuva Republic is carried out using the income method enable to determine the profitability of the development of a field. Besides, criterion of summarized gross value added (GVA) is selected as a criterion for regional effectiveness, which provides a gain for a corresponding amount of gross regional product (GRP) of Tuva Republic.

The following main positions are suggested on the basis of the valuation of coal deposits of Tuva Republic:

1. Performing calculations the initial project data have been taken from technical-economic justifications (TEJ) previously drawn-up by specialized organizations, technical-economic reports (TER) using their values to the level of the current time due to the conversion factors – deflator.

2. We took into consideration standard tax payments described by the Tax Code of the Russian Federation and the Subsoil Law while economic valuation of deposits exploration development.

3. Price level for mineral resources and products is used [4].

4. Calculations on the economic evaluation of coal deposits development in Tuva Republic are carried out in MS Excel spreadsheets.

Coal deposits valuation of the republic is formed of two stages. At the first stage the commercial efficiency of deposits development is estimated using the income approach [9]. Regulatory compliance with the standard values of key indicators of profitability in the income approach allows to select the most efficient from an economic point of view of a deposit. Objects that have a positive assessment, take further to the second stage of economic evaluation of deposit development, which can be called the valuation of reserves in national wealth of the region, the essence of which is to determine the increase in the gross discounted value added (GDA) as a result of mineral

resources deposit exploration on the basis of data of cost-effective deposits. GDA increment is the main criterion of regional economic impact assessment of coal deposits, which provides the increase by a corresponding amount of the gross regional product (GRP) in the region [3]. Social and budget efficiency are determined at this stage.

Six deposits meet commercial effectiveness criteria according to our calculations. Their valuation shows that the total increase in the gross value added makes up 1,259 billion rubles (table 2).

Maximum assessment efficiency of deposit exploration belongs to the Western part of the Ulugh-Khem basin, GDA is estimated at 626.0 bill.rub.

Table 2

Valuation of coal deposits of Tuva Republic (bill. rub.)

Deposit name	*GDA increment*
Elegest deposit	315966,0
Mezhegei deposit	66059,7
Kaa-Khem deposit, №1,2,3 areas	76699,0
Eastern part of the Ulugh-Khem basin	150268,6
Western part of the Ulugh-Khem basin	626017,0
Erbek deposit	23503,0
TOTAL	1258513,2

Fraction of gross value added in the Western part is more than 50% of the total growth in gross value added as a result of the economic evaluation of coal deposits development of the republic. Elegest coal deposit is on the second place by opportunity of coal deposits exploration, GDA growth is estimated at 315.9 bill. rub. The third place in the growth of GDA belongs to the Eastern part of the Ulugh-Khem basin (12%) as a result of economic evaluation of coal deposits. The following deposits share considerable proportion in the growth of GDA: Kaa-Khem deposit territories №1, 2, 3 (6%), Mezhegei deposit (5%) and Erbek deposit (2%).

Key indicators of exploration valuation of the Elegest and Mezhegei coal deposits (bill. rub.)

Table 3

	Capital investment	Projected capacity	Annual costs	Gross national product, %	Income index	Payback period, years	NPV

Elegest	56755	12,0	10015	27,1	1,98	69	25923
Mezhegei	48603	10,5	9525	25,4	1,85	23	29337

Valuation results show great opportunities for the development of the coal industry of Tyva in the future. In support of this, we consider the effectiveness of the most prepared for the Elegest and Mezhegei deposits development that during the construction of the Kuragino-Kyzyl railway deposits can become major budget revenue generating enterprises of the republic. Key indicators of development valuation of these coal deposits show (table 3) that both projects have a high efficiency. Calculations showed that internal rate of return on invested capital will make up 27.1%, the payback period of capital investment will make up 10 years as a result of investing in Elegest deposit in the amount of 56.7 bill. rub. Similar calculations for Mezhegei deposit show that discounted payback period of capital investment will make up 9.7 years, internal rate of return will make up 25.4% as a result of capital investing in the amount of 48.6 bill. rub. Further the projects implementation is of great importance for the development of the region. Annual GRP growth could reach 58.1 bill. rub., republican budget revenues would make up 10.6 bill. rub., more than four thousand jobs (table 4) would be required in developing Elegest and Mezhegei deposits.

Table 4

Exploration valuation of the Elegest and Mezhegei coal deposits

Deposit	Annual increase	Republican budget revenues, bill. rub.	Quantity of vacancies
Elegest	30803,6	5655,5	2271
Mezhegei	27321,4	4993,3	1950

Reserves of Zh, GZh and G rank coals explored according to industrial categories and planned for development are located on Kyzyl and Erbek areas. Total reserves of ($A+B+C_{1+2}$) categories of Kyzyl area consists of 3620.3 bill.t, Erbek area – 342.4 bill.t. Besides, coal resources of the mentioned ranks occur on these areas: the contours of Kyzyl area – 716.1 bill.t, Erbek area – 591.5 bill.t. Total amount of reserves and resources at depth intervals from the surface up to 300 m, from 300 to 600 m and more than 600 m, respectively, are evaluated: in the contours of Kyzyl area – 1600.9 bill. t.,

2673.6 bill.t and 3851.9 bill.t (total is 8125.4 bill.t); Erbek area contours – 520.4 bill.t, 869.3 bill.t and 1252.2 bill.t (total is 2641.9 bill.t). Coals of the Ulugh-Khem basin is characterized by: low ash-content, low sulfur, high caking index (from 10 to 42 mm) and volatile content (from 36 to 44%), relative purity of heavy metals and toxigenics. However, the enrichment by volatile and low ash-content promote coal oxidability, creating problems during storage and transportation.

Given information on quantity and quality of developed reserves of coking and forge coals near Kyzyl area indicates on the unlimited possibilities of large-scale, of mainly mining production. Unfortunately, the efficiency of explored deposits development is low due to the high cost and explored coal, sophisticated transport scheme of its implementation, the backlog mine preparation and overburden operations at existing mines. Mastering of Erbek deposit is complicated by underground fire.

«Energy, Power and Chemical Processing of coals of Tuva» program is primarily prepared in TuvIENR SB RAS in view to improve the efficiency of Tuva black «gold» developing and to solve the ecological problems of Tuva Republic and its capital.

Fundamentally new manufacturing process «TSEOFORMING» for coal processing into unleaded gasoline with an octane rating of 80–95 is formulated and manufactured at the Institute of Catalysis of SB RAS under the supervision of Doctor of Chemistry, Professor K.G. Ione. Experimental and industrial technology facilities were constructed and manufactured for the production of 20–40 tons per year of high-octane unleaded gasoline from synthesis gas produced in the processing of petroleum products in Poland at oil refinery plant «GLIMAR» and in Russia (Nizhnevartovsk), with scientific support of Institute of Catalysis of SB RAS (Novosibirsk), by «LURGI» company (Germany) and JSCompany «NZKHK» (Novosibirsk). Process regulations of closed process of a premium gasoline extraction from coals (or refinery wastes) combines two energy and chemical process.

First – synthesis gas production in the low-temperature pyrolysis of coking coal according to the technological scheme developed at TuvIENR SB RAS for the production of carbon adsorbents with various capacity, smokeless fuel briquettes, propane-butane mixture and biohumates for improving soil fertility, ferroalloys of high value

technology developed in the JSC company Regional Exhibition Center «KUZBASS» (Novokuznetsk, Kemerovo region).

It is possible for the synthesis gas production to use the equipment produced by «LURGI» company (Germany) and implemented in the Republic of South Africa. It is advisable to favour home factories of Siberia to place an order for the design and manufacture (Novokuznetsk metallurgical factory, Novosibirsk plants).

Secondly – catalytic conversion of the obtained synthesis gas into high-octane unleaded gasoline according to the technology developed by Engineering research center «TSEOSIT» of SB RAS (Novosibirsk) and implemented for the ennobling of petroleum products and their processing wastes in Nizhnevartovsk (Russia) and Glimar (Poland). Technological and economic assessment of the feasibility of a plant construction for integrated energy-chemical processing of coals of Tuva Republic, total value of which is 1,8 bill. rub.; the assessment suggests the possibility of producing commercial products in the amount of 1,117 bill. rub. from 420 tons of coking coal of GG-GZh ranks of the Kaa-Khem deposit, including:

– carbon adsorbents – 70 tons (790 bill. rub. / year);

– ferroalloys – 12 tons (90 bill. rub. / year);

– propane-butane mixture – 15 tons (18 bill. rub. / year);

– aqueous vapour – 167 thousand tons (66 bill. rub. / year);

– heating energy – 480 Gcal (36 bill. rub. / year);

– unleaded gasoline, octane №80–95 – 80 thousand tons (96 bill. rub. / year);

– aviation fuel – 20 tons (21 bill. rub. / year).

Time upon signature of the contract is 3 year for factory project developing (with investment guarantees for its construction) until the finishing of commissioning works and the start of commercial operation of the complex. Costs are carried out as follows: *the first year – 10%* of total cost of the plant *(180 bill. rub.)* would be spent to develop the project and constructive and technological adaptation of the plant to the local raw materials and conditions selected by industrial area near Kyzyl, including, the creation of experimental-industrial adaptation of the plant – *38 bill. rub.; the second year – 70%*

(1260 bill. rub.) – to manufacture and supply to the installation area of the process equipment, *and the third year – 20% (360 bill. rub.)* – for pre-commissioning works.

Another technological approach to solving the problem of complex coal processing is used in the process of heat treatment in order to obtain valuable components. This technology is implemented in an experimental facility of coal thermolysis created in TuvIENR SB RAS. The facility consists of coal preparation unit from which the coal is fed into the hopper. Further coal is served into heater knot by screw feeder, where the temperature is maintained for coal liquefaction. Here is its low-temperature pyrolysis. After warming up semifluid coal mass fed into the molding point, where a coking piece is formed and its shape is fixed. Gaseous products of coal thermolysis are used for its warming up, thereby coke prime-cost is reducing and atmospheric harmful emissions are excluded. After molding a coke piece enters the cooler, where it is cooled by water and it is fed into the packaging unit and then to the warehouse. Facility is designed in a modular design in order to reduce costs and ensure the primary technological flexibility. Heat excess can be used for heating of industrial premises or for sale to consumers.

Table 5

Technical specification of the facility

Coke productivity	3 tons per day
Gas productivity	600000 m^3 / year
Gas output	52%
Process temperature	400–800 degree
Sizes	1x1.5x1.2 m
Water flow	10 m^3 / hour
Air flow	3600 m^3 / hour

Table 6

Characteristics of coke

Pieces dimensions	length – 0.5–10 cm; diameter – 0.5–6 cm
Ash-content, %	not more than 20

Mass fraction of total moisture content	not more than 14.0%
Mechanical performance, %	M 40, at least 73
Sulfur content, %	not more than 0.6
Mass fraction of phosphorus, %	not more than 0.06
Devolatilization	when heated up to 850 C°
Air tight, %	not more than 1.2
Mass fraction of carbon, %	not less than 95.5
Mass fraction of hydrogen, %	not more than 0.8
Mass fraction of oxygen, %	not more than 0.7
Nitrogen content, %	not more than 1.1
Calorific value, kcal / kg	7000
Coke cost per ton, rub.	2100

As follows from the coal pyrolysis intensive evolution of low molecular weight hydrocarbons in the form of gas is shed, which can be used for heat generation and electric power development by way of burning in a special engine or turbine. The resulting gas is used to heat the reactor. Gas generating composition: 55% of pentane and its derivatives, 25% of hexane and its derivatives. Resulted upon coke cooling hot water can be used for space heating or realized for outside customers.

Feasibility study of using coke gas as a fuel for internal combustion engines are jointly carried out with the Mechanic Transport Department of Tuvan State University. There is a desk for research in the Department and its calibration is carried out on AI-92 gasoline. Autogas system is installed and calibration is performed on the propane-butane gas mixture.

Table 7

Coal thermolysis facility

№№	Specification description	Value
1	Coal condensate rate, t/day	3,0
2	Process temperature, C	400–800
3	Coal holding time under isothermal conditions, min.	10–30
4	Material of flow channel of the facility	X18H10T, BT1–0

Structure of the facility:

1. Hopper-feeder.

2. Frequency-controlled actuator of coal feed rate.

3. Thermolysis reactor – extruder with units for the insertion of water vapor and gas vapor (N_2, O_2).

4. Semi-coke handling unit.

5. Gas extraction unit.

6. Rectification unit, purification unit and gas compression.

Work is carried out in four stages:

Stage I – development of design-and-engineering documentation for the facility;

Stage II – project documentation procedure on facility location;

Stage III – production of the facility;

Stage IV – delivery service, installation of the facility, pre-commissioning and experimental works.

Cost of the mentioned works is estimated at 36.7 bill. rub., and works total duration is 18 months. New equipment introduction as a high-tech, environmentally safe, coal processing unit with capacity of 10 bill.t of advanced energy-chemical coal processing will provide: 20000 jobs, the production of briquettes of smokeless fuel for private sector or gasification; conversion to gas fuel; powerful refrigeration facilities creation for storing and processing of livestock products.

The proposed energy-chemical processing of coke and forge coals of the Ulugh-Khem basin of Tuva according to «TSEOFORMING» technology can prospectively provide higher economic benefit in comparison with coal sales income while even in transportation along the planned Kuragino-Kyzyl railway (table 8).

Table 8

Characteristics	Railway transportation: in practice – 0 / project – 10 bill.t	Automobile transportation: project – 2,5 / calculation – 10 bill.t x 4	Advanced processing: experimental – 0,45 / calculation – 10 bill. t x 22
Investment in Cross regional product, bill. rub.	0 / 18,4	2,9 / 11,6	1,9 / 42,22
New-created acancies, job	0 / 13000	1171 / 4500	960 / 20000

Annual income of scenarios sales, bill. rub.	0 / 5,6	0,9 / 3,6	0,4 / 8,9
Federal subvention, %	92 / 15	68 / 17	74 / 3,3

Facility operation of energy-chemical processing require coal mining in total of 420 thousand tons/year, but 22 facility units, providing the GRP increase and federal subventions reduction of the region from the federal budget to 3.3% would make up 10 bill. t / year.

Conclusions. Coal deposits of Tuva have significant potential; investitions in their development and exploration will repay not only for a high merchantable profitability but it also have a significant economic, budgetary and social effects. Valuation of coal reserves shows that the gross reserves value additions for their realization exceeds 1.3 trillion rubles.

References

1. Dabiev D.F., Soyan M.K. & Lebedev V.I. Valuation of coal deposits of Tyva Republic / Coal. – 2009. – №10. – P. 50–52.

2. Dabiev D.F. Valuation of mineral resources development effectiveness in Tyva Republic // ECO. Russian Economic Journal. – №4 – p. 114–122.

3. Economic evaluation of mineral resources of Karelia / edited by Sh.Sh. Baybusinova. Petrozavodsk. – 2001. – p. 284.

4. Informational-analytical center «Mineral» [Electronic resource]/ – Access mode: http://www.mineral.ru 29.03.2009.

5. Lebedev N.I. Coals of Tuva: Status and prospects of mineral resources development / Executive editor. Doctor of Geology and Mineralogy V.I. Lebedev. – Kyzyl: TuvIENR SB RAS, 2007. – P. 180.

6. Lebedev V.I., Lebedeva M.F., & Lebedev N.I. Mineral resource potential of the Republic of Tyva and prospects of its development / Economic revival of Russia. – 2009. – P. 66–73.

7. Lebedev N.I. Mineral resources of Tuva: review and analysis of minerals / Executive editor Doct. of Geol. and Miner. V.I. Lebedev. – Kyzyl: TuvIENR SB RAS, 2012. – P. 284.

8. Russian coal base. / V. III: Coal basins and deposits of Eastern Siberia (Krasnoyarsk region, Kansk-Achinsk basins; Republic of Khakasia, Minusinsk basin, Republic of Tyva. Ulughkhem basin and other deposits; Irkutsk basin, and coal deposits of Baikal region) – Moscow: «Geoinformtsentr», 2002. – P. 488.

9. Spatial aspect of socio-economic development of the region / Edited by A.S. Novosyelov. – Novosibirsk: IEIE SB RAS, 2006. – P. 138.

10. The development strategy of the Russian coal industry in the first decade of the XXI century / A.E. Kontorovich, V.V. Kuleshov etc. – Novosibirsk: Publishing House of SB RAS, Inst. «Geo», 2000. – P. 55.

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