

# Management of local economic and ecological system of coal processing company

T V Kiseleva<sup>1</sup>, V G Mikhailov<sup>2</sup> and V A Karasev<sup>2</sup>

<sup>1</sup> Siberian State Industrial University, 42 Kirova Street, Novokuznetsk, 654007, Russia

<sup>2</sup> T. F. Gorbachev Kuzbass State Technical University, 28 Vesennyaya Street, Kemerovo, 650000, Russia

E-mail: mvg.eohp@kuzstu.ru

**Abstract.** The management issues of local ecological and economic system of coal processing company – coal processing plant – are considered in the article. The objectives of the research are the identification and the analysis of local ecological and economic system (coal processing company) performance and the proposals for improving the mechanism to support the management decision aimed at improving its environmental safety. The data on the structure of run-of-mine coal processing products are shown. The analysis of main ecological and economic indicators of coal processing enterprises, characterizing the state of its environmental safety, is done. The main result of the study is the development of proposals to improve the efficiency of local enterprise ecological and economic system management, including technical, technological and business measures. The results of the study can be recommended to industrial enterprises to improve their ecological and economic efficiency.

## 1. Introduction

The development of coal industry determines the high level of anthropogenic impact on the environment, causing the need to resolve the problem of resource and nature conservation. A special role belongs to the coal processing enterprises, which, by controlling the quality of processed products, create conditions to improve the environmental safety of all the natural, technical, and ecological and economic systems for the extraction, processing and use of coal [1]. The coal processing plants also make all kinds of negative impacts on the environment [2, 3]. The improvement of efficiency of nature conservation activities depends on the local ecological and economic system “Concentration plant – environment” management process. The additional complication is caused by the uniqueness of the particular ecological and economic system and labor content of use of existing management algorithms developed for the other similar objects [4, 5]. Therefore, the study of the properties of ecological and economic systems and management methods requires the independent research in every particular case. This situation is complicated by such property of most ecological and economic systems, as the irreversibility of processes occurring in them. On this basis, we can formulate the main objectives of ecological and economic improvement of coal preparation process:

- environment protection from all kinds of man-made impacts resulting from the coal preparation plant activities and the use of the processed coal products;
- resources conservation and rational use of natural resources by reducing losses of coal, waste recovery, and increasing of the output and value of coal concentrates.

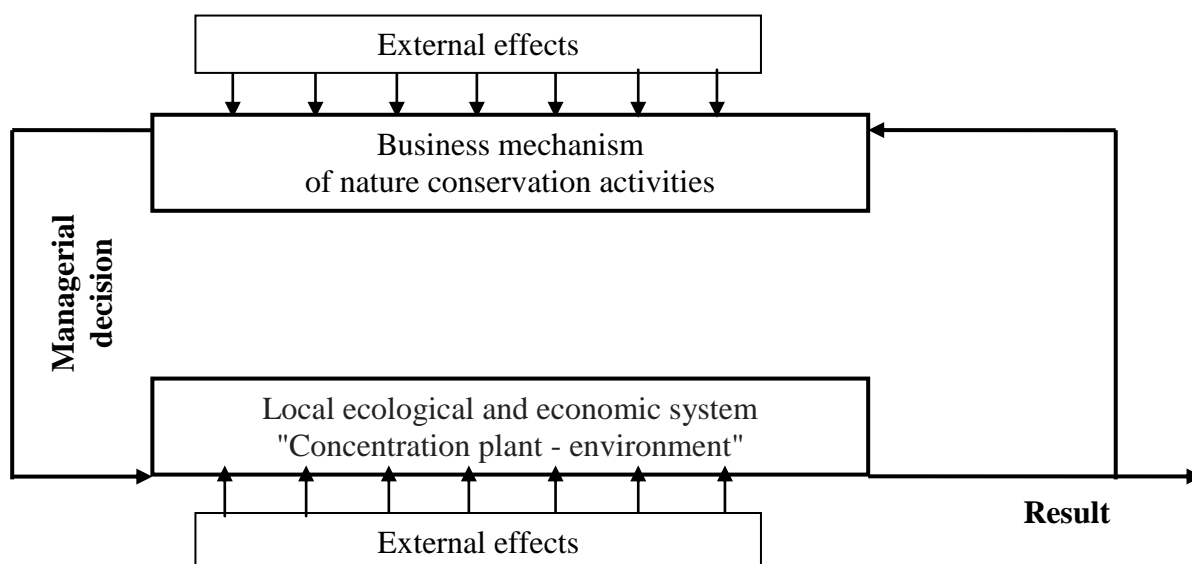


## 2. Materials and methods

The study object is the management system of ecological and economic system of coal processing plant. The study subject is LLC “Coal-processing Plant “Listvyazhnaya” ecological and economic system management efficiency based on selected indicators. This company has various negative effects on the environment. To study this process the statistical processing of environmental data on the basis of the relevant reporting forms was carried out. The elements of system analysis and the results obtained by specialists in the field of ecological and economic system management are also used in the paper.

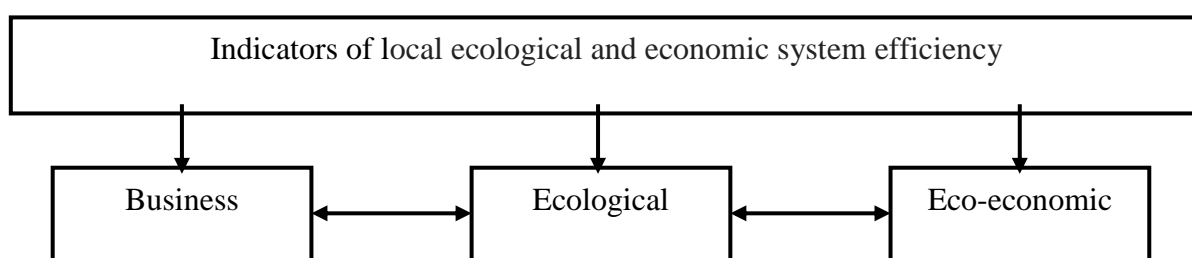
## 3. Results and discussion

In the conditions of region with advanced coal processing industry the efficient management of local ecological and economic system “Industry – environment”, the simplified management scheme of which is shown in Figure 1 [8, 9], is of vital importance [6, 7].



**Figure 1.** Simplified scheme of the local ecological and economic system management mechanism.

Figure 1 shows that a key element of the scheme of the local ecological and economic system management mechanism is the business mechanism of nature conservation activities [10-15]. The efficiency of the system functioning is evaluated by groups of related indicators presented in Figure 2.



**Figure 2.** Correlation of the indicators functioning of local ecological and economic system efficiency.

The economic indicators of ecological and economic systems of coal processing enterprises include the run-of-mine coal processing products (output, concentrate, screenings, waste), profit, cost, technical condition of fixed assets, the level of capacity utilization, and others. The ecological indicators [16] include the parameters of negative impact on the environment (air emissions from stationary and mobile sources, sewage discharges, and industrial and consumer waste) and other characteristics. As seen in Figure 2, the determining indicators are eco-economic, including the cost valuation of the negative impact on the environment, as well as its reduction (economic assessment of the negative impact on the environment - economic damage; fee for the negative impact on the environment; fines for violation of environmental legislation, current expenditure on fixed assets intended for nature protection purposes, etc.).

To assess the efficiency of the local ecological and economic system we propose to analyze the structure and the dynamics of run-of-mine coal processing products, as well as the indicators fee for the negative impact on the environment, which is especially important in connection with the prospective increase of this payment [4, 5].

To test the research proposals the data of processing plant “Listvyazhnaya”, which was commissioned in 2007 and became part of the Holding Company “SDS-Ugol” in 2010, were used. LLC “Coal-processing Plant “Listvyazhnaya” is a modern and powerful Russian coal processing plant involved in the steam coal processing which produces the high-quality D-grade coal concentrate (low ash and sulfur content, high caloric value) on an industrial scale.

This company pays great attention to environmental safety using the modern automated process and production management system. In addition, the company uses the modern coal processing technology and has a closed production cycle, using mine water. The coal processing waste are used for remediation of man-made landscape of the former mine “Inskaya”. The utility water is purified with the modern treatment plants of Heat and Water Complex which applies the efficient physical and chemical purification method.

The assessment of the efficiency the local ecological and economic system of the processing plant can be carried out with the help of economic indicators (processing, output, concentrate, screenings and waste), shown in Table 1 and Figure 3.

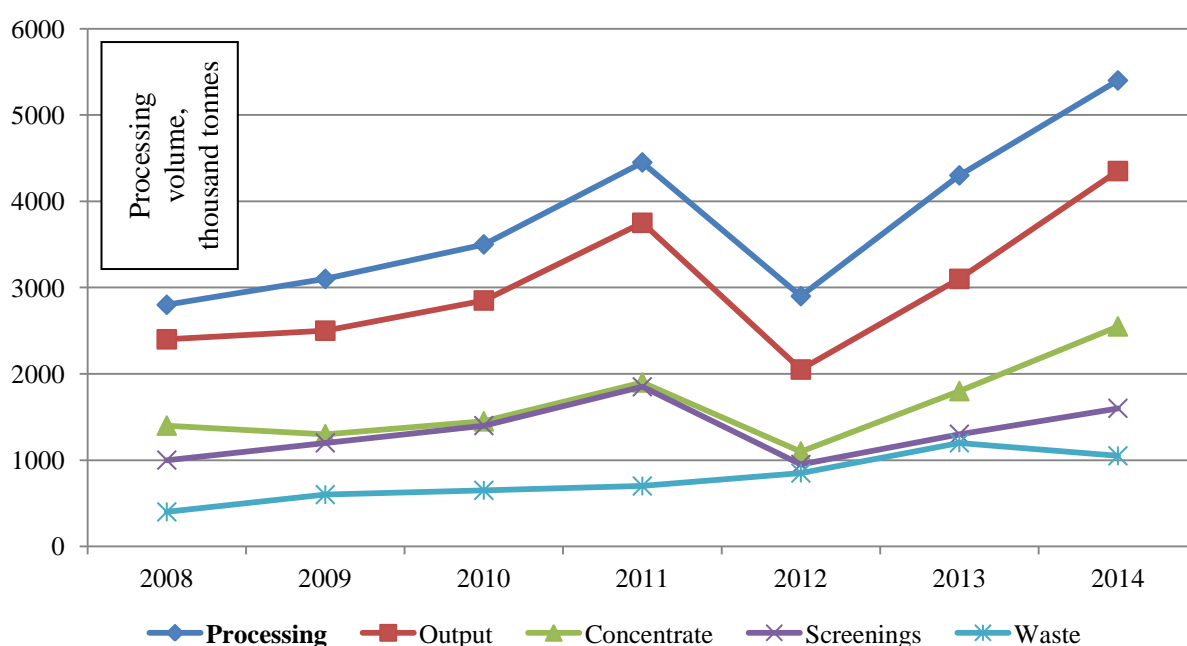
**Table 1.** Structure of run-of-mine coal processing products of LLC “Coal-processing Plant “Listvyazhnaya”.

Indicator	Measurement unit	2008	2009	2010	2011	2012	2013	2014
Processing	thousand tonnes	2800	3100	3500	4450	2900	4300	5400
	%	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Output	thousand tonnes	2400	2500	2850	3750	2050	3100	4350
	%	85.71	80.65	81.43	84.27	70.69	72.09	80.56
Concentrate	thousand tonnes	1400	1300	1450	1900	1100	1800	2550
	%	50.00	41.94	41.43	42.70	37.93	41.86	47.22
Screenings	thousand tonnes	1000	1200	1400	1850	950	1300	1600
	%	35.71	38.71	40.00	41.57	32.76	30.23	29.63
Waste	thousand tonnes	400	600	650	700	850	1200	1050
	%	14.29	19.35	18.57	15.73	29.31	27.91	19.44

Table 1 allows us to conclude about the structure of run-of-mine coal processing products of coal processing plant. If we consider an indicator such as the “Output”, it has a maximum value in the

processing volume in 2008 (85.71%) and minimum in 2012 (70.69%). The important characteristic is the specific amount of the concentrate, which also has a maximum value in 2008 (50.00%) and minimum in 2012 (37.93%). The significant fluctuations in the proportion are observed when considering the “Screenings” indicator: from the minimum in 2014 (29.63%) to the maximum in 2011 (41.57%). The evaluation of the processed coal quality and the efficiency of management of the local ecological and economic system “Concentration plant – environment” can be made using the specific value of the indicator “Waste”, which has a wide range of values from 14.29% in 2008 to 29.31% in 2012.

Improving the adequacy of evaluation of economic parameters of ecological and economic system can be achieved by studying the dynamics of indicators of run-of-mine coal processing products, presented in Figure 3.



**Figure 3.** Dynamics of indicators of run-of-mine coal processing products of LLC “Coal-processing Plant “Listvyazhnaya”.

Figure 3 shows that the indicators “Processing”, “Output” and “Concentrate” follow the similar trend – the increase up to 2011, the decline in 2012 and rise to a new level in 2013 and 2014. Another positive trend is shown by the indicator of “Screenings” – after a peak in 2011 (1850 thousand tonnes) and minimum in 2012 (950 thousand tonnes) the growth rate slowed down to 1600 thousand tons in 2014. The dynamic of the indicator “Waste” is smoother – the sustained growth until 2013 (1200 thousand tonnes) and a significant reduction in 2014 (1050 thousand tonnes).

Despite the efficient environmental performance, the company LLC “Coal-processing Plant “Listvyazhnaya” makes various types of negative impacts on the environment, carrying out emissions of inorganic dust, iron oxide, manganese compounds, gaseous fluorine compounds, and produces the I, III-V hazard class waste. Therefore, the tightening of environmental legislation [6], including the prospect of increasing the raising factors in the calculation of charges for the negative impact from 5 to 100 requires the assessment of complex ecological and economic indicators of the local ecological and economic system “Concentration plant – environment”, presented in Table 2.

**Table 2.** Indicators of the negative impact on the environment of LLC “Coal-processing Plant “Listvyazhnaya”.

Environment element	2008	2009	2010	2011	2012	2013	2014
The fee for a negative impact on the environment within the established limits, including, kRUR:							
water	-	-	-	-	-	-	-
air	0.40	1.27	1.40	6.68	1.77	7.54	7.21
waste	-	-	-	1.81	0.01	0.22	0.53
Total	0.40	1.27	1.40	8.49	1.78	7.76	7.74
The fee for a negative impact on the environment over the established norms, including, kRUR:							
water	-	-	-	-	-	-	-
air	-	-	-	329.94	180.07	93.95	93.90
waste	37.60	2.63	2.65	15.76	-	66.15	48.60
Total	37.60	2.63	2.65	345.70	180.07	160.10	142.50
Total fee for a negative impact on the environment, kRUR							
	38.00	3.90	4.05	354.19	181.85	167.86	150.24
The specific fee for a negative impact on the environment per 1 thousand tonnes of run-of-mine coal processing, rubles / thousand tonnes							
	13.57	1.26	1.16	79.59	62.71	39.04	27.82
The specific fee for a negative impact on the environment per 1 thousand tonnes of concentrate produced, rubles / thousand tonnes							
	27.14	3.00	2.79	186.42	165.32	93.26	58.92

Table 2 shows that the maximum charges for the negative impact on the environment are observed in 2011 - 354.19 thousand rubles. The similar trend is observed for the specific fee for negative environmental impact per 1 thousand tons of run-of-mine coal processing (79.59 rubles / thousand tonnes) and specific fee for negative environmental impact per 1 thousand tonnes of concentrate produced (186.42 rubles / thousand tonnes). If we consider the total fee for a negative impact on individual elements of the environment, the maximum value for the air is observed in 2011 (331.71 thousand rubles) and for the waste – in 2013 (66.37 thousand rubles). If we consider the maximum spread of rates of specific fee for a negative impact on the environment per 1 thousand tons of run-of-mine coal processing products and per 1 thousand tonnes of concentrate produced, for the first specific indicator ranges from rubles / thousand tonnes in 2010 and from 1.26 rubles / thousand tonnes in 2009 to 79.59 rubles / thousand tonnes in 2011. The second measure also has the minimum value in 2010 and 2009 (respectively, 2.79 rubles / thousand tonnes and 3.00 rubles / thousand tonnes) and a maximum in 2011 (186.42 rubles / thousand tonnes).

To improve the efficiency of management of the local ecological and economic system of the enterprise the technological and business solutions [17-25] aimed at the reduction of waste proportion and the increase of concentrate proportion in the run-of-mine coal processing products are required. In addition, there is a steady trend of high fees for the excess negative environmental pollution that requires a review of permits and the inventory of pollution sources. It should be noted that the current conditions for enterprises, including those actively operating in the foreign market, are connected to the need to use the environmental management systems, certification of products and processes according to the ISO-14001 series of standards. Another independent solution aimed to the increase of efficiency of the local ecological and economic system management can be the use of the best available technologies to reduce the environmental burden on the environment that is caused by the modern environmental requirements.

#### 4. Conclusions

The concluded study of efficiency of the local ecological and economic system of the enterprise LLC “Coal-processing Plant “Listvyazhnaya” to improve the mechanism to support the management decisions, led to the following conclusions:

- the simplified scheme of the of the local ecological and economic system management mechanism is formed;
- the relationship of indicators of efficiency of the local ecological and economic system is shown;
- the structure of the efficiency indicators for the local ecological and economic system is studied;
- the analysis of the structure of run-of-mine coal processing products is conducted;
- the indicators of negative impact on the environment are considered;
- the technological and business solutions to improve the efficiency of the local ecological and economic system management are developed.

## 5. Acknowledgements

The authors express their gratitude to the management of the enterprise LLC “Coal-processing Plant “Listvyazhnaya” for the information provided.

## References

- [1] Kleyn M S and Vakhonina T E 2014 *Bulletin of KuzSTU* **3** (103) 125–128
- [2] Galanina T V 2009 *Mining Informational and Analytical Bulletin* **7** (12) 174–177
- [3] Kovalev V A, Potapov V P and Schastlivtsev E L 2013 *Monitoring of the Natural Environment of Kuzbass Coal-mining Areas* (Novosibirsk: SB RAS) p 312
- [4] Burkov V N, Novikov D A and Shchepkin A V 2008 *Ecological and Economic System Management Mechanisms* (M.: Physical and Mathematical Literature) p 244
- [5] Lipenkov A D 2005 *Modelling of Ecological and Economic Systems* (Chelyabinsk: CSU) p 130
- [6] Pantjukova M E 2011 *Herald of KSTU* **17** (1) 200–202
- [7] Skryl O K 2015 *Bulletin of KuzSTU* **5** 222–227
- [8] Kravets O Ya and Solomakhin O N 2013 *Economy and Management of Management Systems* **3.1** (9) 190–198
- [9] Mikhailov V G, Kiseleva T V and Mikhailov G S 2015 *Proc. of the Russian Conf. on Information and Telecommunication Systems and Technologies* (Russia, Kemerovo) URL: <http://www.sibscience.ru/page/ITSIT/1-informacionnye-sistemy-v-nauke/1082.pdf>.
- [10] Busygin V P, Puzanov Yu V, Batyukhnova O G, Zakharova P V and Semenova I V 2012 *Ecological Systems and Devices* **4** 3–38
- [11] Mikhailov V G and Bugrova S M 2015 *In the World of Scientific Discoveries* **6.1** (66) 548–564
- [12] Mikhailov V G, Koryakov A G and Mikhailov G S 2015 *Journal of Mining Science* **51** (5)
- [13] Bolsunovskaya Y A and Bolsunovskaya L M 2015 *IOP Conf. Series: Earth and Environmental Science* **24** 012003
- [14] Nevidimova O G, Yankovich E P and Yankovich K S 2015 *IOP Conf. Series: Earth and Environmental Science* **24** 012020
- [15] Shinkevich A I, Lubnina A A, Koryakov A G, Mikhailov V G and Vodolazhskaya E L 2016 *International Review of Management and Marketing* **6** (2) 328–332
- [16] Ponomarenko D, Tanayants I and Grunicheva S 2013 *TekhNadzor* **2** 30–31
- [17] Vakhonina T E, Kleyn M S and Gorbunkova I A 2009 *Bulletin of KuzSTU* **1** 15–17
- [18] Vaisberg L A, Azbel Yu I, Arsentiev V A and Kononov O V 2013 *Ore Dressing* **4** (346) 47–49
- [19] Arkhipov V A, Paleev D Yu, Patrakov Yu F and Usanina A S 2014 *J. of Mining Science* **50** (3) 587–594
- [20] Kondratev S A, Rostovtsev V I, Bochkarev G R, Pushkareva G I and Kovalenko K A 2014 *J. of Mining Science* **50** (5) 959–973
- [21] Petukhov V N, Kubak D A and Subbotin V V 2015 *Coke and Chemistry* **58** (3) 101–108
- [22] Lavrinenko AA and Golberg GYu 2015 *Coke and Chemistry* **58** (9) 362–366
- [23] Lavrinenko AA. and Golberg GYu 2015 *Coke and Chemistry* **58** (10) 404–409
- [24] Lavrinenko AA and Golberg GYu 2015 *Coke and Chemistry* **58** (11) 451–454

- [25] Antipenko L A 2015 *Coal* **12** 68–71