https://doi.org/10.33271/nvngu/2022-3/005

D. V. Miroshnichenko[1],
orcid.org/0000-0002-6335-8742,
S. V. Pyshyev[2],
orcid.org/0000-0003-0737-1122,
V. V. Lebedev[1],
orcid.org/0000-0001-6934-2349,
D. Yu. Bilets[1],
orcid.org/0000-0002-1521-826X

1 – National Technical University "Kharkiv Polytechnic Institute", Kharkiv, Ukraine, e-mail: dvmir79@gmail.com
2 – Lviv Polytechnic National University, Lviv, Ukraine

DEPOSITS AND QUALITY INDICATORS OF BROWN COAL IN UKRAINE

Purpose. To carry out marking of existing deposits of brown coal in accordance with domestic and international classifications. To give a comparative assessment of the distribution of balance reserves of brown coal in accordance with different classification systems.

Methodology. Reserves and quality indicators data for brown coal in Ukraine were taken from the site of the State Research and Production Enterprise "State Information Geological Fund of Ukraine" and on the basis of our own research. Some quality indicators were calculated according to the formulas given in the periodical scientific literature. Ukraine's brown coal reserves were estimated using Ukrainian and international brown coal classifications.

Findings. It is confirmed that the balance reserves of brown coal in Ukraine are located in Dnipropetrovsk, Zhytomyr, Zakarpattia, Kirovohrad, Kharkiv and Cherkasy regions and are (thousand tons): categories $A + B + C_1$ – 2,593,359; category C_2 – 299,181. Among the existing classifications, the most suitable for the brown coal distribution in Ukraine is the International Code System of Brown Coal, which is regulated in ISO 2950:1974 "Brown coal and lignites – Classification by types on the basis of total moisture content and tar yield".

Originality. For the first time, a range of changes in brown coal quality indicators in Ukraine has been established, and its reserves have been marked using Ukrainian (DSTU 3472:2015) and international (ISO 2950:1974; International Classification of Coal in Reservoirs; ISO 11760:2005; ASTM D388–12) classifications**.** Comparative assessment of coal reserves will allow choosing the optimal ways of their processing, depending on the predicted properties of raw materials.

Practical value. The reserves of brown coal deposits by regions and the degree of industrial development up to 01.01.2021 have been described, and the production of brown coal from 2011 to 2020 has been shown. Determining the quality of brown coal deposits in Ukraine allows us to develop the most effective methods for using the coal.

Keywords: *Dnipro basin, brown coal, deposit, indexes of quality, classification, subbituminous coal*

Introduction. In an effort to provide targeted support to EU regions facing a steady decline in the coal industry, in December 2017, the European Commission initiated a program on transitional coal regions as a stimulus action under the "Clean Energy for All Europeans" package. Building on the work done under this package, in December 2019, the European Commission announced the European Green Agreement, an integral part of the Commission's strategy to support the EU's goal of achieving climate neutrality by 2050. Under the Green Agreement, the Just Transition Mechanism (JTM) is a key tool to ensure that the transition to a climate-free economy takes place fairly, leaving no one behind. The Transition Coal Initiative, extended to shale and peat mining regions in 2020, is a key building block of the European Green Agreement and Just Transition Mechanism.

In September 2020, the European Commission presented its plan to reduce EU greenhouse gas emissions by at least 55 % by 2030 compared to 1990 levels. This level of ambition for the next decade will lead the EU on a balanced path to climate neutrality by 2050. This will require a fundamental restoration of our energy system balance, a shift to an accelerated abandonment of the "traditional" use of fossil fuels (coal, oil shale, peat), whose burning has the most negative environmental impact, and a more sustainable economic framework that potentially poses significant challenges for many regions [1, 2].

The initiative for coal regions in transition in the Western Balkans and Ukraine was launched in December 2020 and aims to help countries and regions move away from coal to a carbon-neutral economy, while ensuring the transition fairness. It will provide support to coal regions in the EU's neighboring countries, such as Bosnia and Herzegovina, Kosovo, Montenegro, Northern Macedonia, Serbia and Ukraine [3].

So, it is becoming necessary to determine the further use of fossil fuels in Ukraine, which would not cause a negative impact on the climate. To solve this task, it is advisable to analyze the available deposits of fossil fuels, as well as innovative technologies for their use [4, 5]. This publication is devoted to the analysis and labeling of the existing brown coal deposits in Ukraine, as one of the most common types of fuel mentioned above.

Literature review. On the territory of Ukraine, brown coal deposits are associated with various geological structures:

- Ukrainian crystal shield (Dnipro basin);
- Dnipro-Donetsk basin;
- Volyn-Podilska plate (Transnistrian coal-bearing area);

- deflections (Carpathian and Transcarpathian coal-bearing areas);
- depressions in neogene sediments (Lower Dniester Square);
- a number of coal manifestations are found in the mountainous part of the Crimea (Fig. 1).

The largest Dnipro lignite basin occupies the territory of right-bank Ukraine and stretches from the southeast to the northwest for almost 650 km with a width of 70–175 km, and covers 150 thousand km^2 area. About 200 deposits and coal occurrences have been discovered within the basin, of which 27 have industrial reserves.

The industrial coal content of the basin is related to the continental Buchak Paleogene world deposits, which fill the depressions in the basement of the crystalline shield. The thickness of coal seams varies from 1–2 to 5–6 m and more, reaching 28–29 m at some deposits.

The most stable working capacity of coal seams is acquired in the central and south-eastern parts of the basin. The depth of coal seams varies from 10 to 150 m and has an average value of 50–70 m, which is favorable for open pit development. The reserves of individual brown coal deposits, mainly in the south-eastern part of the basin, are represented by bituminous coal (bitumen content over 6–7 %), which is suitable for the rock wax production. The development level of stocks by industry is not high. The brown coal deposits development is practically curtailed. Cuts and mines have been shut down due to unprofitable mining and low-grade coal.

Within the Dnipro-Donetsk basin, the Novodmytrivske deposit of Oligocene-Miocene brown coal was explored, which is located within the western pericline of the Korul dome and is confined to a depression developed above the Devonian salt stock.

The capacity of the main productive coal seam is 40–50 m with a maximum value of 73.8 m and a depth of 57–412 m. The coal of the deposit is well briquetted and is suitable for extracting bitumen from it for rock wax production.

Perspective brown coal resources of Paleogene-Neogene and Carboniferous age of the Dnipro-Donetsk basin are estimated at 2.3 billion tons. Brown coal deposits in the western regions of Ukraine are characterized by coal content, which is associated with Neogene sediments. There are three coal-bearing areas here: Transnistria, Prykarpattia and Zakarpattia. Layers of brown coal in these areas are thin, rarely reaching 1–2 meters. The resources of the areas are classified as unpromising, the industry is developing only Ilnytsya deposit in Transcarpathia [6].

As of January 1, 2021, the number of deposits in Ukraine is 80, among them 3 are being developed. Balance reserves of brown coal in Ukraine are:

- categories $A + B + C_1$ – 2,593,359 thousand tons;
- category C_2 – 299,181 thousand tons.

The brown coal distribution reserves by regions on 01.01.2021 is given in Table 1.

Table 1

The brown coal distribution reserves by regions on 01.01.2021

Region	Number of deposits	Balance reserves, thousand tons	
		$A + B + C_1$	C_2
Dnipropetrovsk	21	1,320,644.00	258,053.00
Zhytomyr	2	10,884.00	0.00
Zakarpatttia	4	38,783.00	0.00
Kirovohrad	44	750,833.00	39,604.00
Kharkiv	1	389,985.00	0.00
Cherkasy	8	82,230.00	1,524.00
Total	80	2,593,359.00	299,181.00

Analyzing the data given in Table 1 it can be concluded that the largest deposits of brown coal categories $A + B + C_1$ in Ukraine are in Dnipropetrovsk (1,320,644 thousand tons), Kirovohrad (750,833 thousand tons) and Kharkiv (389,985 thousand tons) regions. Fig. 2 shows data on brown coal production in Ukraine in the period from 2011 to 2020.

It can be noted that the production of brown coal in Ukraine was almost the same and reached 2–15 thousand tons per year.

The distribution of deposits by the industrial development level on 01.01.2021 is given in Table 2. Based on the data given in Table 2, in Ukraine there are only 3 operating sections with balance reserves of categories $A + B + C_1$ equal to 9,331 thousand tons.

Tables 3 and 4 show the minimum and maximum values of brown coal quality indicators, namely: W_t^r – moisture in working condition, %; W^a – moisture in analytical condition, %; W_t^{raf} – moisture in a working ashless condition, %; $w_{\max}^{af}$ – maximum coal moisture content , %; A^a – ash in analytical condition, %; A^d – ash on dry condition, %; A^r – ash in working condition, %; MM^a – content of mineral mass in analytical condition, %; MM^d – content of mineral mass in dry condition, %; S_t^a – content of total sulfur in analytical condition, %; S_t^d – dry sulfur content, %; V^{daf} – volatile matter in the dry ashless condition, %; $T_{s,K}^{daf}$ – output of semi-coking resin, %; $R_{o,\max}$ – maximum reflection of vitrinite , %; $R_{o,r}$ – average reflection index of vitrinite, %; Q_s^{daf} – the highest heat of combustion in dry ashless condition, MJ/kg; Q_s^{af} – the highest heat of combustion in wet ashless condition, MJ/kg; Q_s^{mmf} – the highest heat of combustion in dry mineral-free condition, MJ/kg; Q_i^r – lower heat of combustion in operating condition, MJ/kg.

The following formulas are known [7, 8] and designed [9]

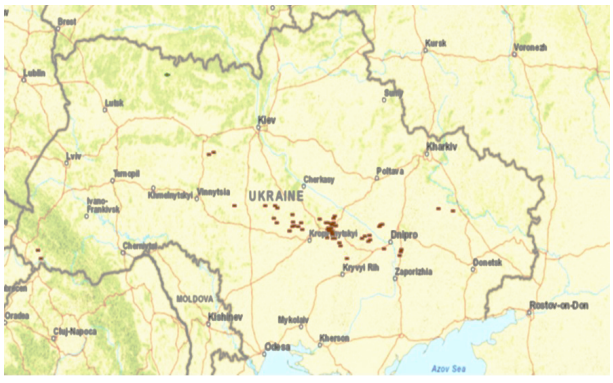

Fig. 1. Brown coal deposits in Ukraine

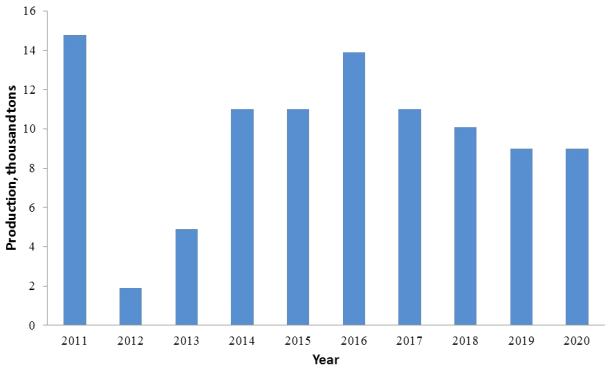

Fig. 2. Brown coal production in Ukraine from 2011 to 2020

Table 2

The distribution of deposits by the industrial development level on 01.01.2021

Industrial development level	Number of deposits	Balance reserves, thousand tons	
		$A+B+C_1$	C_2
Free areas near existing opencast coal mine	1	784.00	0.00
Free areas near existing coal mine	8	48,869.00	0.00
Areas for exploration	1	6,285.00	2,169.00
Current opencast coal mine	3	9,331.00	0.00
Closed opencast coal mine	8	87,887.00	307.00
Closed mines	7	87,463.00	2,022.00
Perspective areas for opencast coal mine exploration	7	61,766.00	849.00
Perspective areas for coal mine exploration	25	1,196,315.00	285,095.00
Reserve areas for opencast coal mine	13	748,499.00	0.00
Reserve areas for coal mine	7	346,160.00	8,739.00
Total	80	2,593,359.00	299,181.00

Table 3

Moisture, ash content and mineral mass of brown coal

Indicator	Minimum value	Maximum value
W_t^r, %	26.1	60.7
W^a, %	4.6	35.4
W_t^{raf}, %	23.4	57.7
$W_{\max}^{af}$, %	10.2	38.2
A^a, %	9.1	28.6
A^d, %	10.1	40.0
A^r, %	4.9	20.2
MM^a, %	10.5	32.2
MM^d, %	11.6	35.1

Table 4

Sulfur, volatile matter output, semi-coking resin output, vitrinite reflection index and heat of combustion

Indicator	Minimum value	Maximum value
S_t^a, %	1.16	4.91
S_t^d, %	1.10	5.41
V^{daf}, %	42.8	68.7
$T_{s,K}^{daf}$, %	4.7	21.8
$R_{o,\max}$, %	0.45	0.71
$R_{o,r}$, %	0.42	0.66
Q_s^{daf}, MJ/kg	20.63	30.94
Q_s^{af}, MJ/kg	12.74	27.79
Q_s^{mmf}, MJ/kg	21.70	32.87
Q_i^r, MJ/kg	4.22	17.70

for calculating some indicators of brown coal quality, which were not given in the electronic resource [6]

$$W_t^{raf} = W_t^r \cdot \frac{100}{100 - A^r}; \quad (1)$$

$$w_{\max}^{af} = \frac{100 - Q_s^{af}}{Q_s^{daf}}; \quad (2)$$

$$MM^a = 1.08 \cdot A^a + 0.55 \cdot S_t^a; \quad (3)$$

$$MM^d = \frac{100}{100 - W^a}; \quad (4)$$

$$R_{o,max} = \frac{1}{\sqrt[1.05]{V^{daf} / 29.63}}; \quad (5)$$

$$R_{o,r} = \frac{R_{o,\max}}{1.07}; \quad (6)$$

$$Q_s^{af} = 1.459 \cdot Q_s^{daf} - 17.36; \quad (7)$$

$$Q_s^{mmf} = \frac{100 - A^d}{100 - MM^d}. \quad (8)$$

It should be noted that the minimum value of W_t^r, the maximum value of A^d and the range of values for Q_i^r and Q_s^{af} raise some doubts, and should be confirmed by subsequent studies.

According to DSTU 3472:2015 "Brown coals, hard coals and anthracite. Classification", brown coal has only one grade "B" and is characterized by the following quality indicators (Table 5).

Analyzing Table 5 data, we can argue that according to DSTU 34725:2015, brown coal should have a value of vitrinite average random reflection less than 0.4 %, the volatile matter in the dry ashless condition from 50 to 70 %, as well as the higher heat of combustion in wet ashless condition less than 24 MJ/kg.

The first international brown coal code system was regulated in the standard ISO 2950:1974 "Brown coals and lignites — Classification by types on the basis of total moisture content and tar yield". The standard applies to brown coal and lignite and establishes their classification by type based on two parameters: the total moisture content of the working fuel, designed for ashless condition (W_t^{raf}), and semi-coking resin output in the dry ashless condition (T_{sK}^{daf}).

According to the first parameter, coal is divided into 6 classes, and according to the second parameter, 5 groups are allocated within each class. The type of brown coal is denoted by a two-digit code number, in which the first digit means the class number, and the second digit – the group number (Ta-

Table 5

Quality indicators of brown coal according to DSTU 3472:2015

Coal type		Brown
Coal brand		Brown
Classification indicators	The average random rate of vitrinite reflection, $R_{o,r}$, %	Less than 0.4
	The volatile matter in the dry ashless condition, V^{daf}, %	50–70
	The plastic thickness layer, Y, mm	–
	Roge Index , RI, units	–
	Higher heat of combustion in wet ashless conduction, Q_s^{af}, MJ/kg	Less than 24
Indicator	Brand	B
	Group	–

Table 6

Code numbers of brown coal according to ISO 2950:1974

Group		Code numbers					
T_{sK}^{daf}	Number						
More than 25	4	14	24	34	44	54	64
20–25 (including)	3	13	23	33	43	53	63
15–20 (including)	2	12	22	32	42	52	62
10–15 (including)	1	11	21	31	41	51	61
10 and less	0	10	20	30	40	50	60
Class number		1	2	3	4	5	6
W_t^{raf}, %		20 and less	More than 20 up to 30 (including)	More than 30 up to 40(including).	More than 40 up to 50 (including)	More than 50 up to 60 (including)	More than 60 up to 70 (including)

ble 6). The International Classification of Coal in Seams was developed to characterize coal deposits and was not intended for use in Ukrainian and international trade, as well as in industry. Table 7 shows the characteristics of low-grade coal according to the International Classification of Coal in Seams. According to the general concept, low-grade coal is considered to be coal with $Q_{s,V}^{af} < 24$ MJ/kg and $R_{o,r} \geq 0.6$ %. Brown coal with $R_{o,r} \geq 0.6$ % should be classified by indicator Q_s^{af} (MJ/kg); moreover, the maximum moisture content can be replaced by the total moisture of the working fuel or moisture in the reservoir, because determining the maximum moisture content results of low-grade coal are poorly reproduced.

According to the International Classification of Coal in Seams, the distribution of low-grade coal by categories *A*, *B* and *C* is performed at the highest heat of combustion in a wet ashless condition, ($Q_{s,V}^{af}$):

- ortho-lignite has $Q_{s,V}^{af}$ less than 15 MJ/kg;
- meta-lignite – 15–20 MJ/kg;
- subbituminous coal – from 20 to less than 24 MJ/kg.

Based on the International Classification of Coal in Seams, the standard ISO 11760:2005 "Classification of coals" has been developed and approved, which is a somewhat simplified version of coal in seams classification. Table 8 shows the distribution of low-grade coal according to ISO 11760:2005.

According to ASTM D388-12 "Standard Classification of Coals by Rank" low-grade coal is divided into subbituminous and lignite. Classes and groups of coal are set on the basis of the following parameters: non-volatile carbon output on dry fuel without mineral mass (C_f^o), higher heat of combustion on wet fuel without mineral mass ($Q_{s,V}^{MMf}$, MJ/kg) and the volatile substances output on dry fuel without mineral mass (V^o, %).

Table 9 shows the distribution of low-grade coal according to ASTM D388–12.

Unsolved aspects of the problem. Given the differences in the brown coal classification in the world and in Ukraine, it is advisable to try to mark its existing deposits according to international standards. This, firstly, will make it possible to assess the ability of Ukrainian and international classifications to adequately label Ukrainian brown coal, and, secondly, will determine the ways of its rational processing.

Purpose. To mark existing brown coal deposits according to national and world classifications. To give a comparative assessment of the distribution of balance reserves of lignite according to different classification systems.

Table 7

Low-grade coal according to the International Classification of Coal in Seams

Name	$R_{o,r}$, %	Q_s^{af}, MJ/kg
Ortho-lignite	<0.6	<15
Meta-lignite	<0.6	15–<20
Subbituminous coal	<0.6	20–24

Table 8

Low-grade coal according to ISO 11760:2005

Name	$R_{o,r}$, %	$W_{\max}^{af}$, %
Lignite C	<0.4	$35 < W_{\max}^{af} < 75$
Lignite B	<0.4	≤35
Subbituminous coal A	$0.4 \leq R_{o,r} < 0.5$	Not regulated

Table 9

Low-grade coal according to ASTM D388–12

Class	Group	Classification parameter						Caking
		C_f^o, %		V^o, %		$Q_{s,V}^{MMf}$, MJ/kg		
		≥	<	≥	<	≥	<	
Subbituminous coal	subA	Not normalized				24.418	26.743	Absent
	subB					22.09	24.418	
	subC					19.30	22.09	
Lignite	ligA	Not normalized				14.65	19.30	Absent
	ligB					–	14.65	

Methodology. The data on brown coal reserves and quality indicators in Ukraine were taken from the State Research and Production Enterprise "State Information Geological Fund of Ukraine". Some quality indicators were calculated according to the formulas given in the periodical scientific literature and on the own analyzes basis of brown coal. Ukraine's brown coal reserves were estimated using Ukrainian and international brown coal classifications.

Results. In Tables 10–14, distribution of the balance reserves (thousand tons) of brown coal according to the mentioned classifications is shown. Analyzing this data, we can conclude that according to DSTU 3472:2015, in Ukraine there are no deposits of brown coal. In our opinion, this circumstance is provoked by the standard imperfection, namely because the classification was developed for the coal and anthracite labeling, and brown coal was labeled on a residual basis.

In addition, Ukraine has very limited data on the value of the lignite vitrinite random reflection, so its value (<0.4 %) was used only to determine the limit for coal, the value of the mean random vitrinite which was sufficient.

In contrast to the Ukrainian standard DSTU 3472:2015, the international code system of brown coal ISO 2950:1974 al-

Table 10

The balance reserves (thousand tons) distribution of brown coal according to DSTU 3472:2015

Balance reserves (thousand tons)	
$A + B + C_1$	C_2
0.0	0.0

Table 11

The balance reserves (thousand tons) distribution of brown coal according to ISO 2950:1974[1]

Groups number	Class number						Total for the group
	1	2	3	4	5	6	
4	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	0,0 / 0,0
3	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	14,004.1 / 5,235.8	4,668.0 / 0.0	0.0 / 0.0	18,672.1 / 5,235.8
2	0.0 / 0.0	0.0 / 0.0	0.0 / 0.0	167,531.0 / 5,265.7	120,591.2 / 2,423.6	0.0 / 0.0	288,122.2 / 7,689.3
1	0.0 / 0.0	12,966.8 / 0.0	8,558.1 / 0.0	841,804.4 / 123,292.6	1,081,171.5 / 162,934.2	0.0 / 0.0	1,944,500.8 / 286,226.8
0	0.0 / 0.0	336,099.3 / 0.0	259.3 / 0.0	1,037.3 / 0.0	4,668.0 / 29.1	0.0 / 0.0	342,063.9 / 29.1
Total in class		349,066.1 / 0.0	8,817.4 / 0.0	1,024,376.8 / 1,337,94.1	1,211,098.7 / 165,386.9	0.0 / 0.0	2,593,359 / 299,181

[1] In the numerator – the amount (thousand tons) of brown coal category $A + B + C_1$, in the denominator – the amount (thousand tons) of brown coal category C_2

Table 12

The balance reserves (thousand tons) distribution of brown coal according to International Classification of Coal in Seams

Name	Balance reserves (thousand tons)	
	$A + B + C_1$	C_2
Ortho-lignite	3,890.0	59.8
Meta-lignite	256,483.2	15,946.3
Subbituminous coal	1,760,631.4	170,293.8
Total	2,021,004.6	186,299.9
Undistributed coal	572,354.4	112,881.1

Table 13

The balance reserves (thousand tons) distribution of brown coal according to ISO 11760:2005

Name	Balance reserves (thousand tons)	
	$A + B + C_1$	C_2
Lignite C	0.0	0.0
Lignite B	0.0	0.0
Subbituminous coal A	2,242,218.2	292,958.0
Undistributed coal	351,140.8	6,223.0

Table 14

The balance reserves (thousand tons) distribution of brown coal according to ASTM D388–12

Grade	Group	Balance reserves (thousand tons)	
		$A + B + C_1$	C_2
Subbituminous coal	subA	133,039.3	6,941.0
	subB	21,784.2	0.0
	subC	4,668.1	59.8
Lignite	ligA	0.0	0.0
Total		159,491.6	7,000.8
Undistributed coal		2,433,867.4	292,180.2

lows fully distributing the available deposits of Ukrainian brown coal. It is established that the largest amount of brown coal is located in 4, 5 classes of group 1, i. e. it is characterized by the following quality indicators: $W_t^{raf} = 40–60$ %; $T_{s,K}^{daf} = 10–15$ %. The data given in Tables 12–14 show that the International Classification of Coal in Formation, ISO 11760:2005 and ASTM D388–12 are not able to fully separate the existing brown coal deposits in Ukraine. According to these classifications, subbituminous coal mainly exists in Ukraine, and lignite deposits are very limited.

Conclusions.

1. It is established that the balance reserves of brown coal in Ukraine are located in Dnipropetrovsk, Zhytomyr, Zakarpattia, Kirovohrad, Kharkiv and Cherkasy regions and are (thousand tons): categories $A + B + C_1$ – 2,593,359; category C_2 – 299,181.

2. Among the existing classifications, the most suitable for the distribution of lignite in Ukraine is the International Code System of Lignite, which is regulated in ISO 2950:1974 "Brown coal and lignites – Classification by types on the basis of total moisture content and tar yield".

3. Taking into account the fact that brown coal production in Ukraine from 2011 to 2020 ranged from 2 to 15 thousand tons per year, the search and development of non-energy methods of its use is a very perspective scientific and practical task.

References.

1. Kapetaki, Z., Alves Diaz, P., Conte, A., Kanellopoulos, K., Mandras, G., Medarac, H., ..., & Tarvydas, D. (2021). *Recent trends in EU coal, peat and oil shale regions*. EUR 30618 EN. Publications Office of the European Union. Luxembourg. https://doi.org/10.2760/510714.

2. Alves Dias, P., Kanellopoulos, K., Medarac, H., Kapetaki, Z., Miranda Barbosa, E., Shortall, R., ..., & Tzimas, E. (2018). *EU coal regions: opportunities and challenges ahead*. EUR 29292 EN, Publications Office of the European Union, Luxembourg. https://doi.org/10.2760/064809.

3. *Initiative for coal regions in transition in the Western Balkans and Ukraine* (n.d.). Retrieved from https://ec.europa.eu/energy/topics/oil-gas-and-coal/coal-regions-in-the-western-balkans-and-ukraine/initiative-coal-regions-transition-western-balkans-and-ukraine_en.

4. Belov, O., Shustov, O., Adamchuk, A., & Hladun, O. (2018). Complex processing of brown coal in ukraine: history, experience, practice, prospects. *Solid State Phenomena*, *277*, 251-268. https://doi.org/10.4028/www.scientific.net/SSP.277.251.

5. Babets, Ye. K., Bielov, O. P., Shustov, O. O., Barna, T. V., & Adamchuk, A. A. (2019). The development of technological solutions on mining and processing brown coal to improve its quality. *Naukovyi*

Visnyk Natsionalnoho Hirnychoho Universytetu, (6), 36-44. https://doi.org/10.33271/nvngu/2020-6/005.
6. *Mineral resources of Ukraine* (n.d.). Retrieved from https://minerals-ua.info/.
7. Balaeva, Y.S., Miroshnichenko, D.V., & Kaftan, Y.S. (2018). Method for calculating the gross calorific value of coal on a moist ash-free basis. *Solid Fuel Chemistry, 52*(5), 279-288. https://doi.org/10.3103/S0361521918030023.
8. Balaeva, Y.S., Miroshnichenko, D.V., & Kaftan, Y.S. (2017). Moisture-holding capacity of coals. *Solid Fuel Chemistry, 51*(6), 337-348. https://doi.org/10.3103/S0361521917060027.
9. Cheng, Y., Jiang, H., Zhang, X., Cui, J., Song, C., & Li, X. (2017). Effects of coal rank on physicochemical properties of coal rank and on methane adsorption. *International journal of coal science and Technology*, *4*, 129-146. https://doi.org/10.1007/s40789-017-0161-6.

Родовища та показники якості бурого вугілля України

Д. В. Мірошниченко[1], *С. В. Пиш'єв*[2], *В. В. Лебедєв*[1], *Д. Ю. Білець*[1]

1 – Національний технічний університет «Харківський політехнічний інститут», м. Харків, Україна, e-mail: dvmir79@gmail.com
2 – Національний університет «Львівська політехніка», м. Львів, Україна

Мета. Виконати маркування наявних покладів бурого вугілля згідно з вітчизняними та світовими класифікаціями. Дати порівняльну оцінку розподілу балансових запасів бурого вугілля відповідно до різних систем класифікації.

Методика. Дані про запаси й показники якості бурого вугілля України були взяті з сайту Державного науково-виробничого підприємства «Державний інформаційний геологічний фонд України». Деякі показники якості були розраховані за формулами, наведеними в періодичній науковій літературі. Запаси бурого вугілля України були оцінені з використанням української й міжнародних класифікацій бурого вугілля.

Результати. Підтверджено, що балансові запаси бурого вугілля в Україні розташовані у Дніпропетровській, Житомирській, Закарпатській, Кіровоградській, Харківській і Черкаській областях та становлять (тис. т): категорій $A + B + C_1$ – 2593359; категорії C_2 – 299181. Серед існуючих класифікацій найбільш придатна для оцінці покладів бурого вугілля України Міжнародна кодова система бурого вугілля, що регламентована в ISO 2950:1974 «Brown coal and lignites – Classification by types on the basis of total moisture content and tar yield».

Наукова новизна. Уперше встановлено діапазон зміни показників якості бурого вугілля в Україні. Уперше запаси бурого вугілля України промарковані з використанням української (ДСТУ 3472:2015) та міжнародних (ISO 2950:1974; Міжнародна класифікація вугілля в пластах; ISO 11760:2005; ASTM D388-12) класифікацій. Порівняльна оцінка запасів вугілля дозволить обрати раціональні методи їх переробки залежно від прогнозованої якості сировини.

Практична значимість. Описані запаси родовищ бурого вугілля по областях і ступеню промислового освоєння станом на 01.01.2021 року, показана величина видобутку бурого вугілля з 2011 по 2020 роки. Визначення якості родовищ бурого вугілля України дозволяє перейти до розробки найефективніших методів його використання.

Ключові слова: *Дніпровський басейн, буре вугілля, родовище, показники якості, класифікація, суббітумінозне вугілля*

The manuscript was submitted 27.08.21.