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## TENDENCIES OF COAL INDUSTRY DEVELOPMENT IN UKRAINE

V. Snihur<sup>1</sup>, D. Malashkevych<sup>2\*</sup>, T. Vvedenska<sup>3</sup><sup>1</sup>MA "Ternivske", PJSC "DTEK Pavlohraduhillia", Pavlohrad, Ukraine<sup>2</sup>Underground Mining Department, National Mining University, Dnipropetrovsk, Ukraine<sup>3</sup>Translation Department, National Mining University, Dnipropetrovsk, Ukraine\*Corresponding author: e-mail [malashkevychnmu@gmail.com](mailto:malashkevychnmu@gmail.com), tel. +380562469047, fax: +380562473209

## ТЕНДЕНЦІЇ РОЗВИТКУ ВУГІЛЬНОЇ ПРОМИСЛОВОСТІ УКРАЇНИ

В. Снігур<sup>1</sup>, Д. Малашкевич<sup>1\*</sup>, Т. Введенська<sup>2</sup><sup>1</sup>ППУ "Тернівське", ПрАТ "ДТЕК Павлоградувгілля", Павлоград, Україна<sup>2</sup>Кафедра підземної розробки родовищ, Національний гірничий університет, Дніпропетровськ, Україна<sup>3</sup>Кафедра перекладу, Національний гірничий університет, Дніпропетровськ, Україна\*Відповідальний автор: e-mail [malashkevychnmu@gmail.com](mailto:malashkevychnmu@gmail.com), тел. +380562469047, факс: +380562473209

### ABSTRACT

**Purpose.** Analysis of the current state and prospects of Ukraine coal industry development until 2020.**Methods.** Complex analysis of data regarding mine productivity, coal reserves, mine funds as well as coal consumption and electricity generation has been presented in the paper. The studies of statistics related to geological and extraction thickness in longwall faces are discussed.**Findings.** The current state of Ukraine coal mining industry and prospects of its development for the period until 2020 are considered. The analysis of Ukraine mine fund conditions is carried out. Statistical data of gross coal production at state-maintained and private mines are given. The reasons for low profitability and coal production decline in the country are considered. Results of the research into ash content of extracted coal, formation and accumulation of mine waste are interpreted. The main promising trends of efficient energy resources use and reduction of environmental impact on coal-mining regions are emphasized.**Originality.** According to the analysis of the current state of coal industry, several options of its further development are formulated.**Practical implications.** The presented results can be used to evaluate the investment attractiveness of Ukraine coal mining enterprises.**Keywords:** coal-mining industry, coal extraction, mine fund, tendencies, perspectives

### 1. INTRODUCTION

Currently, due to geopolitical situation in Ukraine, the present state of the coal mining industry and its position in our country are of topical interest, and, in fact, an open issue. Military actions in Eastern Ukraine paralyzed a large part of domestic enterprises. Lack of production capacities at the abandoned coalmines affected work of thermal power energy, metallurgy and other industries.

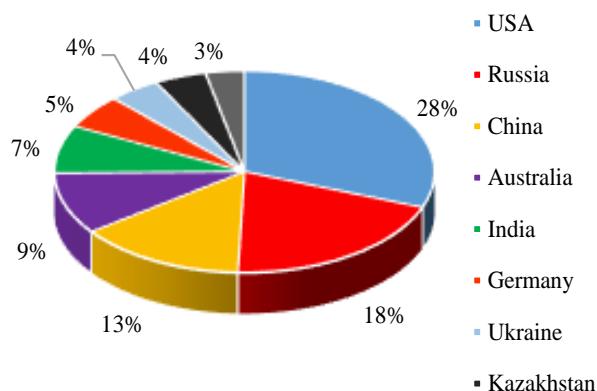
The tendencies of coal industry development in Ukraine have brought about many researches. Particular attention to these questions is paid in the papers (Amosha, Starichenko & Cherevatskyi, 2013; Zvyagilskiy & Zaloznova, 2013). However, in the context of the events taking place in the country, the problems of coal mining industry have not been yet sufficiently considered. The current difficult situation in the energy sector

increases the role and importance of coal as a guarantor of Ukrainian energy independence.

### 2. CURRENT STATE OF COAL INDUSTRY

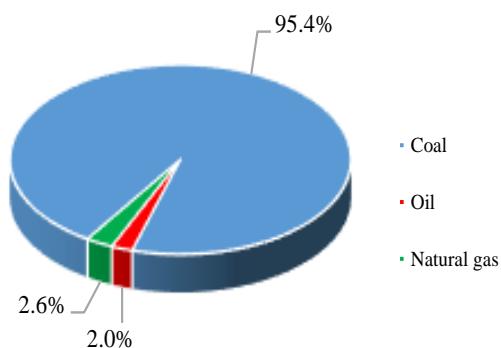
#### 2.1. Coal reserves

Ukraine is a country with vast coal reserves of all grades. The estimated coal reserves in Ukraine are 33.9 bill t which is around 4% of the world coal reserves whereof 15.4 bill t are anthracite and bituminous coal and 18.5% – lignite (Energy Information Administration, 2016). Figure 1 shows the distribution of world coal reserves by countries. According to the estimation of Ukrainian geologists, the interior of our country could contain more than 110 bill t of coal (Ukraine coal, 2013). At present, the reserves of operating mines account to about 6.5 bill t.



**Figure 1. World coal reserves**

There are three coal basins located on the territory of Ukraine: Donetskyi, Lvivsko-Volynskyi and Dniprovskyi. Donetskyi coal basin is the largest containing 85% of Ukraine coal resources. The structure of Ukraine energy resources is shown in Figure 2.



**Figure 2. Structure of Ukraine energy resources**

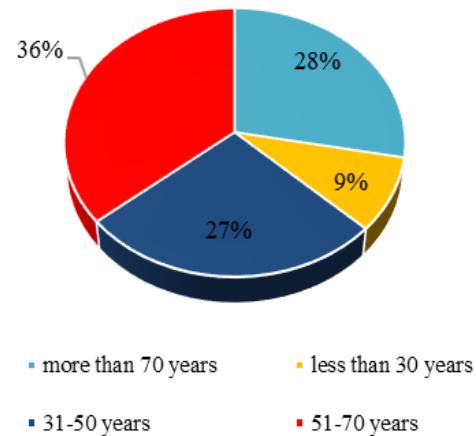
Coal deposits are characterized by difficult mining and geological conditions. More than 60% of total coal reserves are buried at the depth of more than 900 m, maximum depth exceeding 1500 m. The disadvantage of Ukraine coal reserves is low thickness of seams, the average value being 1.2 m. Coal seams with thickness more than 1.2 m constitute only 20.4% of the structure of coal reserves, thin coal seams (0.71 – 1.2 m) comprise 74% including very thin (less than 0.7 m) – 33.3%. It is the lowest value among coal deposits exploited in the developed countries of the world. In addition, significant risk during coal mining is associated with high methane presence in coal seams. Low consumer quality of coal is determined by high ash content (40%) and sulfur content (1.5 – 2.5%), which requires additional techniques for their utilization and, as a result, rises costs and significantly reduces competitiveness of coal mining enterprises (Vivcharenko, 2014; Zientara, 2009).

## 2.2. State of mine fund

The mine fund of Ukraine coal industry is in extremely difficult conditions. The vast majority of coal mines were designed and constructed in the '50s and '70s of the previous century. Nearly 96% of mines have worked for over 20 years without reconstruction. Two-thirds of central stationary equipment has worked out

its operational lifetime and requires immediate replacement. State of the art mechanized complexes and continuous heading machines make only 33% and new loading machines and belt conveyors around 15% in the total quantity of mining equipment. Almost 60% of the total amount of coal is extracted by pneumatic hammers in mines that operate on steeply inclined seams (Petenko & Maidukova, 2014).

From the total number of coal mines, 64% have a life cycle of more than 50 years, of which 28% have been exploited for over 70 years (Fig. 3). More than 40 mines carry out mining operations at the depth of more than 800 m.



**Figure 3. Distribution of coal mines by working lifespan**

At the beginning of 2014, there were 243 mines in Ukraine, among them 150 operating mines with 90 state-owned mines and 60 non-state-owned mines. More than 250.000 people were involved in coal industry, including about 155.000 in state enterprises (DTEK Annual Report, 2014).

The state of mine fund has changed dramatically after the outbreak of hostilities in the Donetsk and Luhansk regions. As a result, out of 90 mines subordinated to the Ministry of Energy and Coal Industry of Ukraine, only 35 remain under state control. From 60 non-state maintained mines – 30 are located in the zone of military conflict. Thus, 85 mines of all forms of ownership – 57% of the total number of mines in Ukraine – are presently in the zone of anti-terror operation (ATO). 60 enterprises of this region have reserves of thermal coal. The number of employees working in this area has reduced to 120.000 people.

## 2.3. Balance of coal production

In 2015, the total amount of gross coal production was 39.7 mln t that is 38.8% less than the level of 2014 (Statistical Information..., 2016). Production of coking coal in 2015 dropped by 49.8% (7.984 mln t) to 8.155 mln t, and steam coal – by 35.3% (17.252 mln t) to 31.7 mln t. The dynamics of coking and thermal coal production, as well as overall coal production in 2000 – 2015 are shown in Figures 4, 5.

The sharp decline in coal production volumes began with the expansion of the territory affected by warfare in Donetsk and Luhansk regions in June 2014.

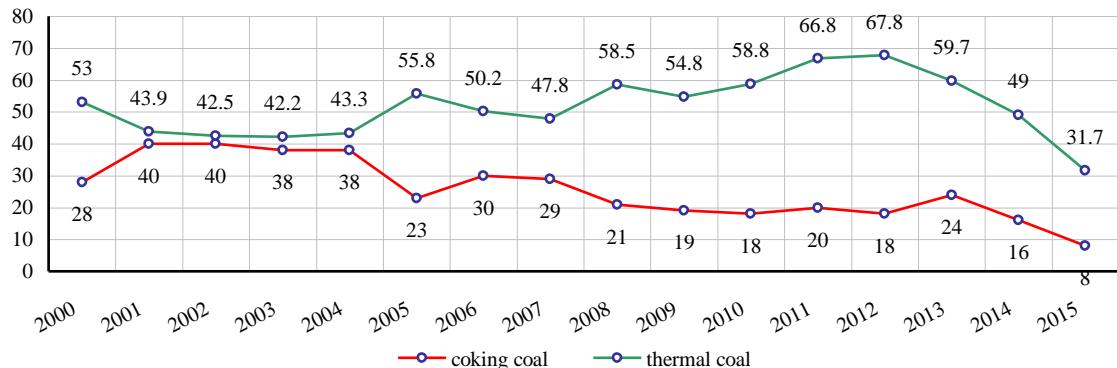


Figure 4. Dynamics of coking and thermal coal production in Ukraine in 2000 – 2015, mln t

As a result, problems arose with the coal transportation to thermal power plants (TPP). Railway communication was disrupted and delivery of materials and equipment to coal mining enterprises ceased (Krasnyk, 2015; Egorova &

Otto, 1998). Due to the caused damage, coal production was continued only at 28 of the 90 state-owned mines, and 62 coal mines worked in the life-sustaining regime – in other words they only pumped water.

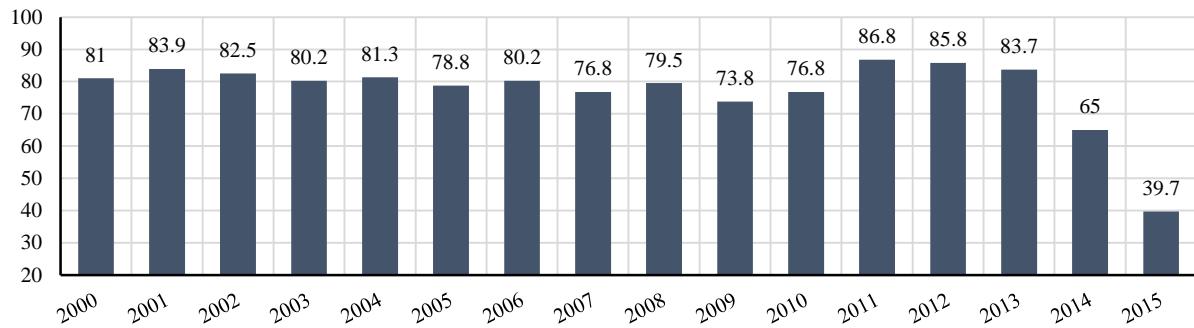


Figure 5. Dynamics of overall rough coal production in Ukraine for the period of 2000 – 2015, mln t

Under these circumstances, coal mines subordinated to the Ministry of Energy and Coal Industry of Ukraine reduced their coal production by 62% in 2015 (10.984 mln t) to 6.742 mln t including coke production decline by 57.6% (2.652 thou t) to 1.950 mln t, steam

coal by 63.5% (8.332 mln t) to 4.792 mln t. At the end of 2015, the share of coal production at state mines in overall fuel balance was 16.8%.

The general map of coal production distribution in Ukraine by regions in 2015 is presented in Figure 6.

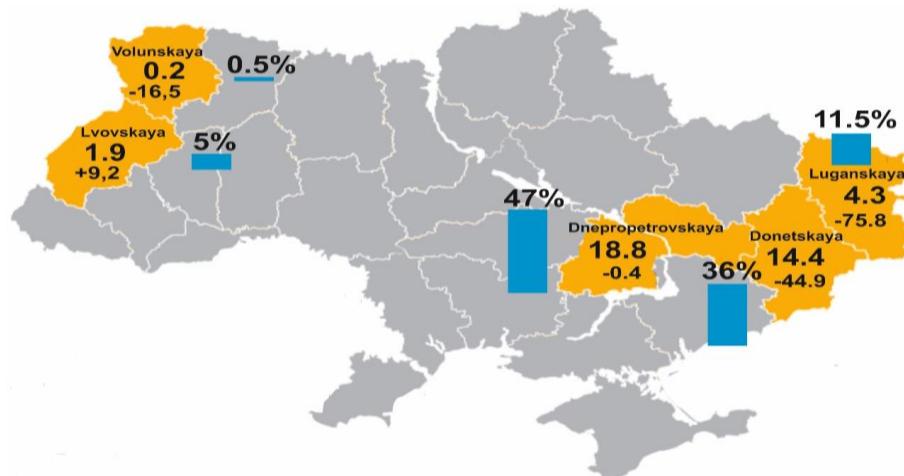


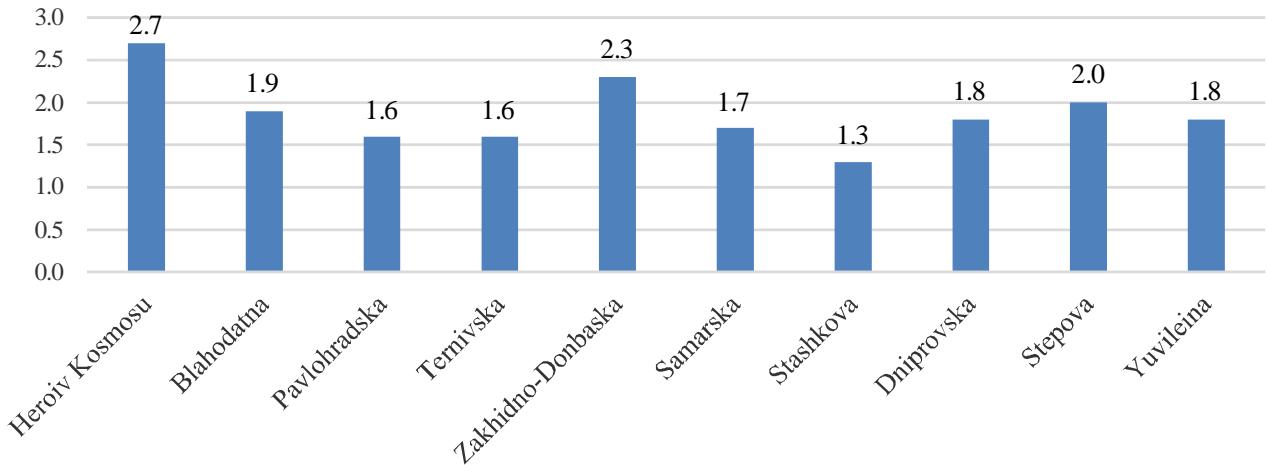
Figure 6. Distribution of coal production by regions in 2015, mln t

The regional distribution of rough coal production by mines of all forms of ownership is as follows: Donetsk region – 14.367 mln t ( $-44.9\%$  compared to 2014),

Luhansk region – 4.332 mln t ( $-75.8\%$ ), Dnipropetrovsk region – 18.832 mln t ( $-0.4\%$ ), Lviv region – 1.982 mln t ( $+9.2\%$ ), Volyn region – 243 thou t ( $-16.5\%$ ).

In 2015, mines of Dnepropetrovsk region – where DTEK Pavlohraduhillia is the sole operator – produced the largest amount of coal – 47% from total production in the country. DTEK Pavlohraduhillia comprises

10 mines as well as transportation and production infrastructure enterprises. The rough coal production of DTEK Pavlohraduhillia mines in 2015 is shown in Figure 7.



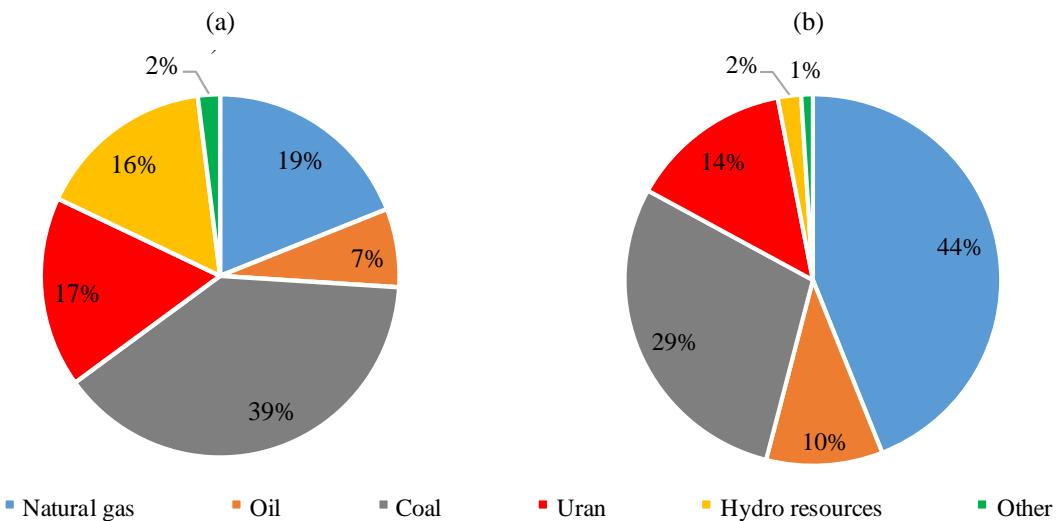
**Figure 7. Rough coal production of DTEK Pavlohraduhillia mines in 2015, mln t**

Heroiv Kosmosu mine achieved the best results among all the mines of DTEK Pavlohraduhillia and became one of the most efficient in domestic coal-mining industry. According to the data of 2015, the average production capacity of coal enterprises in Dnepropetrovsk region was 1.7 mln t.

Currently, 35 state maintained mines are beyond the zone of combat operations, with two of them operating in water hoisting mode. On average, the other 33 mines produce around 20 thou t of coal per day (about 250 thou t of finished product per month). The produced coal is exclusively of thermal grades (mostly gas-coal), coal products are shipped to Vuhlehirksa TPP and energy enterprises of DTEK company.

#### 2.4. Coal consumption and power generation

Coal takes only 29% in the structure of primary energy consumption in Ukraine. For comparison, this figure in Germany is 58%, China – 70% and Poland – 90% (Popovich, 2014). It should be noted that, despite the fact that coal occupies the first place in the structure of energy resources, natural gas share in their consumption is the highest – 41%. It determines the dependence of Ukraine on natural gas import (Bondarenko, Lozynskyi, Sai & Anikushyna, 2015). Specific share of the consumed natural gas in other countries of the world is only 19%. The structure of energy resources consumption in Ukraine and in the world is shown in Figure 8.

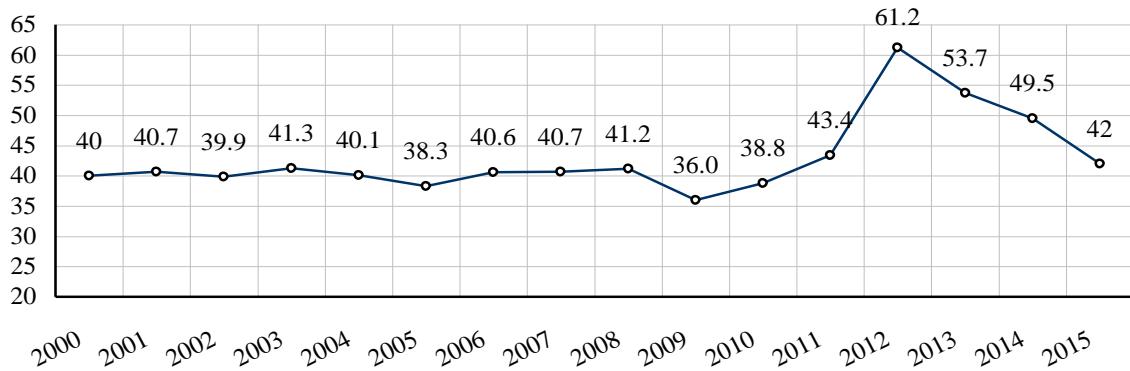


**Figure 8. The structure of energy resource consumption in Ukraine (a) and in the world (b), %**

The main consumers of coal are power plants, population, metallurgical and coke plants. The total capacity of all generating power plants is 53 GW whereof about 52% of power is produced by thermal power plants. The

share of TPP operating on coal in the total balance of power generation is 45%.

The dynamics of coal consumption in Ukraine is shown in Figure 9.

**Figure 9. Dynamics of coal consumption in Ukraine, mln t**

In peacetime, about 90% of the produced steam coal was consumed by power generation companies in the country. The remaining part was distributed between metallurgical plants (4%), population (3%) and other industries (cement producers, soda and sugar factories). In 2000 – 2013, the average coal consumption was 40 mln t, i.e. 50% of the total coal production.

Thermal coal is used at 14 TPPs in Ukraine. However, the main feature of coal conversion into energy is that the domestic power plants are designed for the combustion of different coal types because of closeness of their delivery to TPPs. Table 1 shows thermal power plants distribution according to the type of coal used.

**Table 1. Distribution of thermal power plants by coal type**

Name of TPP	Coal type
Zuivska	
Zaporizka	
Vuhlehirkska	G (gas flame coal)
Kurakhivska	
Ladyzhynska	
Dobrotvirksa	
Burshtynska	
Trypilska	
Zmiivska	
Prydniprovska	A (anthracite)
Starobeshivska	S (short-flame coal)
Slovianska	
Luhanska	
Kryvorizka	S (short-flame coal)

Thereby, seven from 14 TPPs of Ukraine technologically designed for operation on high-reactive coal type G (gas flame coal), six for burning of low-reactive coals A (anthracite) and S (short-flame coal) types and Kryvorizka TPP can operate just only on coal S type which exceptionally produce in Donetsk region. The main problem is that almost all anthracite mines are in the zone of military activities (Shakhtarsk, Krasnyi Luch, Antratsyt, Rovenky, Sverdlovsk). On 35 functional mines are extracted coal L (long flame coal), G types and only some F (fat coal) types use for coal coking.

To provide the country with coal and electricity, Ministry of Energy and Coal Industry of Ukraine signed an agreement with Steel Mont Trading Ltd company about the supply of South African coal. Hence, at the end of

2014, the country received about 500 thousand t of anthracite. To meet the needs of the country, 14.6 mln t of coal were imported in 2015. Deliveries were made from South Africa, Russia, USA and Kazakhstan.

## 2.5. Coal price in domestic market

Coal in Ukraine is sold through direct contracts with mining companies and consumers or with the state enterprise "Vuhillia Ukrainskyy" as the operator of the wholesale market.

About 65% of all coal supplies from state enterprises are sold under contracts with "Vuhillia Ukrainskyy". The wholesale market operator distributes coal products at fixed prices. This done by cross-subsidization of loss-making state-owned mines at the expense of profitable ones. Private companies set prices for their products based on supply and demand in Ukraine, taking into account general trends in international markets.

The wholesale price of a ton of marketable coal product from state-owned enterprises grew by 27.6% to UAH 627.8 (USD 52.7) in 2014. The production cost increased by 30.8% to UAH 1.766.3 (USD 148.2). To partially cover this gap in 2014, the state allocated USD 768.5 mln from the national budget, compared to USD 1.7 billion in 2013.

## 2.6. Coal ash content

The most important indicator of the quality of extracted coal is ash content. Ukrainian coal has high ash content, and it can not be used directly in energy and coking industries. Over 90% of all coal is processed at coal-preparation plants. Mines are selling marketable output primarily as washed products with average ash content 20 – 25% (Chernyavskiy, 2016).

The conducted analysis (Bondarenko, Russkih, Yarkovych & Malashkevych, 2014) shows that ash content of coal has a tendency of gradual growth. Thus, over 15 years, this index has increased by 3.8% reaching 40.2% in 2015. The maximum value of the average coal ash content was 41.1% in 2011. The graph of average ash content in coal produced at Ukrainian mines is presented in Figure 10.

High ash content of coal is explained by low geological thickness of seams. The use of traditional technologies for coal extraction is accompanied, as a rule, by the significant wall rock undercut of the roof or floor. It increases the ash content of coal due to artificial mixing with waste rock which reduces its quality.

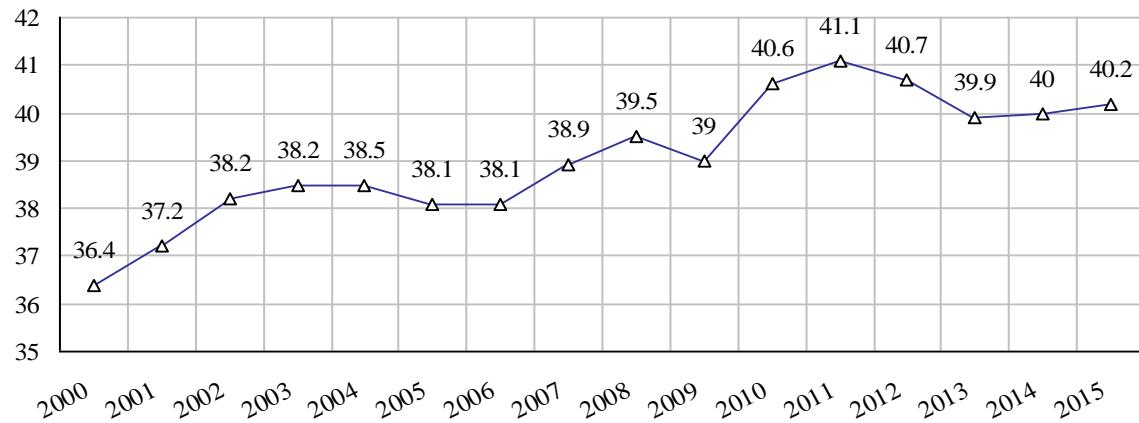


Figure 10. The average ash content of coal produced in Ukrainian mines, %

Analytical research into statistics of mining and geological thickness of longwall faces in DTEK Pavlohraduhillia mines shows that annual average mining thickness varies from 1.05 to 1.2 m. The geological thickness of coal seams in various mines has a value from

0.7 m (Pavlohradska mine) to 1.54 m (Ternivska mine). The dynamics of the average value of mining and geological thickness in longwall faces of DTEK Pavlohraduhillia mines in 2000 – 2015 is shown in Figure 11.

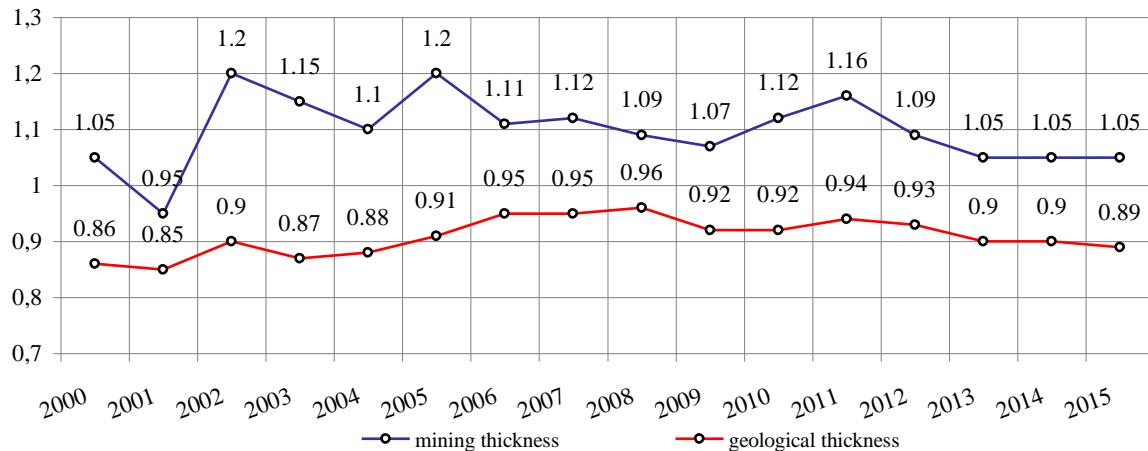


Figure 11. The dynamics of the average value of mining and geological thickness in stope faces of DTEK Pavlohraduhillia mines, m

According to the present data the average value of wall rock undercut changes within the range from 0.1 to 0.3 m. While at some mines, the wall rock undercut in longwall faces reaches 0.4 – 0.5 m.

Wall undercut rock is not only the product deteriorating coal quality but also a source of waste rock accumulation on the surface. Annually, mines and coal-preparation plants store more than 20 mln t in waste dumps. Consequently, more than 3.000 hectares of land are disposed annually.

High ash content of coal negatively influences financial condition of coal mining enterprises. As non-productive transportation expenses on haulage of rough coal from the mine to preparation plant grow, the release of marketable products reduces and the volumes of coal product realization decrease.

The expenditures of coal mining enterprises and preparation plants incurred by transportation, stockpiling and payments for waste rock allocation make around 15% of the primary production cost. The limited possibilities of waste rock application in our country and foreign

countries make it necessary to develop and implement rational non-waste and low-waste technologies of underground mining.

### 3. PERSPECTIVES OF UKRAINE COAL INDUSTRY DEVELOPMENT TO 2020

According to the analysis of the situation in coal industry, it is possible to formulate the following perspectives of its development:

- by the end of 2020, coal industry will function entirely within market relations and the government will not regulate and subsidize the activity of coal enterprises;

- the economic and political situation in the country will become stabilized, coal mines will reach annual production of 50 mln t, while a part of mines with low technical and economical levels and small coal reserves will be liquidated and conserved;

- coal consumption will gradually reduce, the share of nuclear and alternative energy in the energy balance of the country will grow.

#### 4. CONCLUSIONS

2014 was a crucial moment for the coal industry of Ukraine. Coal mining enterprises worked in extremely difficult conditions. Mines significantly reduced their production volumes, and some enterprises stopped their operation. The results of the analysis showed the difficulties of maintaining production profitability in unfavorable mining and geological conditions.

Domestic reserves have low attractiveness for investors, particularly in view of the fact that in recent years, new deposits of high-quality coals (Mozambique, Mongolia and Indonesia) have been explored. The tendencies in the world show that coal demand has been dropping as the result of harsh environmental norms and standards especially in the countries of European Union. Coal mines in Germany, France, Great Britain and Belgium are closed. China, the main coal producer and importer reduces its consumption. Currently, China has chosen a strategy of coal substitution by alternative energy sources.

Taking into account the experience of developed countries, it is necessary to intensify research activities aimed at the efficient use of energy resources and reduction of man-made impact on the environment. It is time to explore the feasibility of thermal energy of deep rocks, develop man-made deposits, to advance coal gasification, utilize mine methane gas. Following these strategy will enhance the competitiveness of Ukrainian coal. Thereby the coal industry must take the path of "green" clean energy.

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#### ABSTRACT (IN UKRAINIAN)

**Мета.** Аналіз сучасного стану та перспектив розвитку вугледобувної галузі України до 2020 року.

**Методика.** Для досягнення мети використано комплексний аналіз даних виробничої потужності вугільних підприємств, запасів вугілля, шахтних фондів, а також споживання вугілля та вироблення електроенергії. Представлені дослідження статистичних даних геологічної та вимальної потужності в очисних вибоях.

**Результати.** У статті проведено аналіз поточного стану вугільної промисловості України та представлені перспективи її розвитку до 2020 року. Проведено аналіз стану шахтного фонду України. Наведені статистичні дані видобутку вугілля підприємствами державних і недержавних форм власності. Розглянуто причини низької рентабельності видобутку вугілля у країні. Представлені результати досліджень зольності вугілля, утворення та накопичення відходів гірничодобувних підприємств. Виділені основні пріоритетні напрямки ефективного використання енергоресурсів і зниження екологічного впливу на вугледобувні регіони.

**Наукова новизна.** Згідно проведеного аналізу поточного стану вугільної промисловості сформульовано три напрями її подальшого розвитку.

**Практична значимість.** Представлені результати можуть бути використані для оцінки інвестиційної привабливості вугледобувних підприємств України.

**Ключові слова:** вугільна промисловість, запаси вугілля, шахтний фонд, тенденції, перспективи

#### ABSTRACT (IN RUSSIAN)

**Цель.** Анализ современного состояния и перспектив развития угледобывающей промышленности Украины до 2020 года.

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**Методика.** Для достижения цели использован комплексный анализ данных производственной мощности угольных предприятий, шахтных фондов, а также потребления угля и производства электроэнергии. Представлены исследования статистических данных геологической и вынимаемой мощности в очистных забоях.

**Результаты.** В статье проведен анализ текущего состояния угольной промышленности Украины и представлены перспективы ее развития до 2020 года. Проведен анализ состояния шахтного фонда Украины. Представлены статистические данные добычи угля предприятиями государственной и негосударственной форм собственности. Рассмотрены причины низкой рентабельности добычи угля в стране. Представлены результаты исследований зольности добываемого угля, образования и накопления отходов горнодобывающих предприятий. Выделены основные приоритетные направления эффективного использования энергоресурсов и снижения экологической нагрузки на угледобывающие регионы.

**Научная новизна.** Согласно проведенного анализа текущего состояния угольной промышленности сформулировано три направления ее дальнейшего развития.

**Практическая значимость.** Представленные результаты могут быть использованы для оценки инвестиционной привлекательности угледобывающих предприятий Украины.

**Ключевые слова:** угольная промышленность, запасы угля, шахтный фонд, тенденции, перспективы

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## ABOUT AUTHORS

Vasyl Snihur, Candidate of Technical Sciences, Director of MA "Ternivske", PJSC "DTEK Pavlohraduhillia", 76 Lenina Ave., Pavlohrad, Ukraine. E-mail: [SnigurVG@dtek.com](mailto:SnigurVG@dtek.com)

Dmytro Malashkevych, Doctoral Student of the Underground Mining Department, National Mining University, 19 Yavornyskogo Ave., 4/60, 49005, Dnipropetrovsk, Ukraine. E-mail: [malashkevychnmu@gmail.com](mailto:malashkevychnmu@gmail.com)

Tetiana Vvedenska, Candidate of Sciences in Philology, Head of the Translation Department, National Mining University, 19 Yavornyskogo Ave., 4/78, 49005, Dnipropetrovsk, Ukraine, E-mail: [vved@list.ru](mailto:vved@list.ru)