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FORMING OF THE SUSTAINABLE SUPPLY CHAINS BASED ON INCREASING OF THEIR INTEGRATED ENERGY EFFICIENCY

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Abstract. Purpose. Key challenges and barriers of mining machinery enterprises in the context of forming sustainable supply chains in the mining industry are specified. **Methodology.** The algorithm of forming the industrial relations, which are carried out by the enterprises of mining machinery in order to increase the sustainable development of a mining industry, is offered. **Conclusions.** Modern supply chains are confronted with dynamic trends and developments that are hard to predict. In order to respond to these changes and remain competitive advantage, companies should be able to identify and understand new sustainability issues in their branches. It is established that in the conditions of globalization of the market and the general orientation of Ukraine's economy to the European principles of development, for mining machinery enterprises a proof of the commitment and observance of requirements of energy efficiency, i.e. energy saving, energy safety and social energy responsibility are very important. Supply channels should increase not only energy efficiency, economic and production stability of the company, but also strengthen the stability of all participants in the production chain, as well as other stakeholders (business partners, customers, investors, local communities, etc.). **Originality.** The interrelation of an indicator of energy efficiency in forming sustainable supply chain in a mining industry is established. **Practical value.** Using the principles of sustainable development in the forming of value chains will improve energy efficiency of industry in general; provide a competitive advantage to entry into the global production chains in terms of European integration of Ukraine.

Keywords: *sustainable development; energy efficiency; responsible production; mining engineering; supply and distribution channels; Ukrainian market of components*

ФОРМУВАННЯ СТІЙКИХ ВИРОБНИЧО-ЗБУТОВИХ ЛАНЦЮЖКІВ НА БАЗІ ПІДВИЩЕННЯ ЇХ ІНТЕГРАЛЬНОЇ ЕНЕРГОЕФЕКТИВНОСТІ

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Анотація. Мета. Уточнити ключові завдання і бар'єри підприємств гірничого машинобудування в контексті формування стійких ланцюгів постачань в гірничодобувному секторі. **Методика.** Запропонований алгоритм формування виробничих зв'язків, що здійснюються підприємствами гірничого машинобудування для цілей забезпечення і розподілу, з метою підвищення стійкості розвитку видобувної промисловості в цілому. **Результати.** Встановлено, що в умовах глобалізації ринку та спільної орієнтації економіки України на європейські принципи розвитку, для підприємств гірничого машинобудування стає важливим доказ своєї прихильності і дотримання вимог енергоефективності, тобто енергозбереження, енергобезпеки та соціальної енерго-відповідальності. Канали забезпечення та розподілу повинні підвищувати не тільки енергоефективність, економічну і виробничу стабільність підприємства, а й сприяти зміцненню стійкості розвитку всіх учасників виробничого ланцюга, а також інших зацікавлених сторін (бізнес-партнерів, покупців, інвесторів, територіальних громад, т. п.). **Наукова новизна.** Встановлено, що існує взаємозв'язок показника енергоефективності з формуванням стійкого виробничо-збутового ланцюжка у видобувній промисловості. **Практична значимість.** Використання принципів сталого розвитку при формуванні виробничо-збутових ланцюжків дозволить підвищити енергоефективність промисловості в цілому, забезпечить досягнення конкурентної переваги для входження в глобальні виробничі ланцюжки в умовах євроінтеграції України.

Ключові слова: *сталий розвиток, енергоефективність, відповідальне виробництво, гірниче машинобудування, канали забезпечення і розподілу, український ринок комплектуючих*

ФОРМИРОВАНИЕ УСТОЙЧИВЫХ ПРОИЗВОДСТВЕННО-СБЫТОВЫХ ЦЕПОЧЕК НА ОСНОВЕ ПОВЫШЕНИЯ ИХ ИНТЕГРАЛЬНОЙ ЭНЕРГОЭФФЕКТИВНОСТИ

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Аннотация. *Цель.* Уточнить ключевые задачи и барьеры предприятий горного машиностроения в контексте формирования устойчивых цепей поставок в горнодобывающем секторе. *Методика.* Предложенный алгоритм формирования производственных связей, осуществляемых предприятиями горного машиностроения для целей обеспечения и распределения, с целью повышения устойчивости развития добывающей промышленности в целом. *Результаты.* Установлено, что в условиях глобализации рынка и общей ориентации экономики Украины на европейские принципы развития, для предприятий горного машиностроения становится важным доказательство своей приверженности и соблюдения требований энергоэффективности, т.е. энергосбережения, энергобезопасности и социальной энерго-ответственности. Каналы обеспечения и распределения должны повышать не только энергоэффективность, экономическую и производственную стабильность предприятия, но и способствовать укреплению устойчивости развития всех участников производственной цепи, а также других заинтересованных сторон (бизнес-партнеров, покупателей, инвесторов, территориальных общин, т. д.). *Научная новизна.* Установлена взаимосвязь показателя энергоэффективности и формирования устойчивой производственно-сбытовой цепочки в добывающей промышленности. *Практическая значимость.* Использование принципов устойчивого развития при формировании производственно-сбытовых цепочек позволит повысить энергоэффективность промышленности в целом, обеспечит конкурентное преимущества для вхождения в глобальные производственные цепочки в условиях евроинтеграции Украины.

Ключевые слова: устойчивое развитие, энергоэффективность, ответственное производство, горное машиностроение, каналы обеспечения и распределения, украинский рынок комплектующих

Introduction. Due to the ratification of economic part of the Ukraine–European Union Association Agreement, Ukraine has to provide implementation of the provisions fixed in the section V "Economic and sectorial cooperation". This section contains the basic provisions of the harmonization of Ukrainian legal system and EU legal system, the principles of cooperation between Ukraine and the EU, and also a number of liabilities for reforming establishments in the main fields of activity, including industry, energy, environment protection etc. The fastest implementation of basic provisions of this section will allow the ratification of the section IV «Trade and issues related to trade». It will promote full integration of Ukraine into EU internal market.

The industrial sector is one of the main in economy of Ukraine as it provides a third of Ukraine's GDP. During the last decade the share of the industry in GDP of Ukraine fluctuated from 36.7% in 2007 to 25% in 2014 (See Fig. 1). Therefore, priority Ukraine must reconsider their attitude to the principles of develop-

ment of the industry, especially in terms of reducing energy consumption and increasing the sustainability of resource use, increase social transparency and accountability, the connection to the international initiatives aimed at creating a sustainable development in the industrial supply chain and distribution. [12]

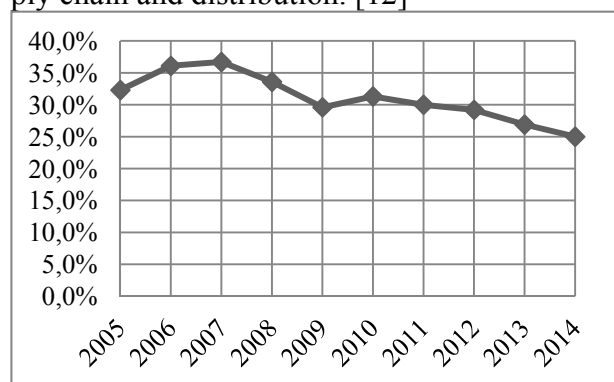


Fig. 1. Share of industry in GDP of Ukraine 2005 - 2014 (Source: calculated and compiled by the authors according to [11])

In order to harmonize national and European standards it is necessary to: 1) implement the European method of industry standards; 2) transit from compulsory to voluntary certifica-

tion; 3) mutually recognize of certificates which will promote export-import operations; 4) carry out information campaigns.

Results. It should be noted that industrial enterprises in Ukraine, as in many other post-Soviet countries, take first place in the world in specific energy consumption and resource intensity of products. This is proved by GDP per unit of energy use (See Fig. 2).

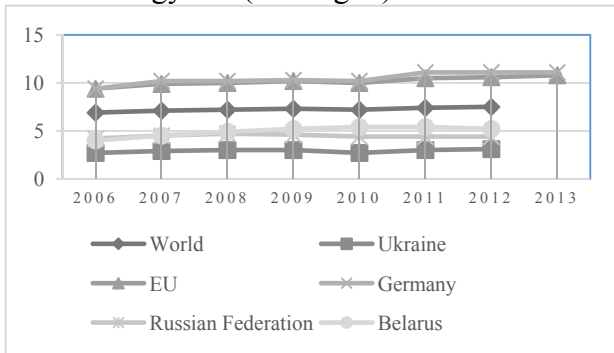


Fig. 2. GDP per unit of energy use (constant 2011 PPP \$ per kg of oil equivalent) 2006 – 2013 (Source: calculated and compiled by the authors according to [16])

The reason for this situation in the post-Soviet Union space is the absence of well-founded state energy policy, which presupposes:

- established branch indicators of energy intensity;
- state structure responsible for compliance with the established rules;
- effective policy of taxation and financing of industrial enterprises;
- principles of responsible environmental management in society.

Today progressive tendencies of resource-saving, responsible mining, processing and using extend in the majority of industrialized countries, particularly in the EU. This is due to global trends of rising energy prices, growing public awareness of environmental protection and climate (reducing CO2 emissions). The EU plans to reduce primary energy consumption by 20% until 2020. According to the energy program of the EU it is expected annual increase in energy efficiency by 2.1% up to 2050. This will be achieved through the introduction of modern technologies. The EU at the political level supports wider use of energy efficient technologies through the relevant standards. According to researches which were conducted by the Ger-

man organization Roland Berger Strategy Consultants, energy efficiency will be of importance in the future for companies developing technologies and technically complicated products. It will allow to realize competitive advantages. In European countries today, increasing energy efficiency is one of the consumer's important selection criteria. It is a central factor of differentiation (Unique Selling Proposition, USP) the company's offer to consumers. Also one of the main criteria for making management decisions is life cycle costing: in increasing frequency consumers take into account not only purchase price, but also all operating costs, including costs of energy consumption. Moreover, energy efficiency is considered as a significant long-term market entry barrier for new sellers.

In the conditions of increasing energy prices Ukrainian industrial products become more and more uncompetitive in comparison with technologically developed products such as Germany, Britain, etc., that is one of the main factors of decreasing the volume of national industrial production. For example, for the last three years in Ukraine sales of machine-building production decreased by 27,5%, and the number of cars produced for the mining industry (drilling and tunneling equipment) – decreased by 73,7% (see Table 1). Such dynamics was followed by increase in prime cost almost by 9 times. By 2013 the share of electric energy expenses in structure of costs of machine-building production increased from 30 to 55%.

Table 1

Dynamics of production of machine-building products in 2012-2014*

	2012	2013	2014	in % to 2012
Sales of machine-building products, mln. UAH	140539,3	113926,6	101924,7	72,5
Production of equipment for the mining industry (drilling, tunneling equipment), thousand pieces.	1,9	0,9	0,5	26,3

*In 2014 - excluding the occupied territories of Autonomous Republic of Crimea and regions of Donetsk and Lugansk. (Source: calculated and compiled by the authors according to [2])

The most part of needs for means of production is satisfied on an extensive basis, which

is due to accumulation of absolute volumes of mining of raw products. It leads to increase the weight of the mining and processing industries, as a result, considerable scales of environmental destruction. At the reached sizes and rates of mining, and primary processing of fuel, raw materials the existing mechanisms of relationship between industrial enterprises in supply and distribution channels, and also a measure for environmental protection don't allow to solve the arisen problems as are aimed only at eliminating the consequences, but not the reasons of the developed situation. The crisis state of machinery, including the mining industry, indicates weaknesses in the supply chain management and marketing, lack of orientation of the enterprise policy on sustainable development, imperfection of the current management system of energy resources and production costs. Low energy and resource efficiency of products increases its competitiveness, and, as a result, complicates entry of companies into profitable industry supply chain.

Analysis of recent researches and publications. The worsening of situation in machine-building branches of Ukraine intensified search of scientific decisions to optimize resource management and supply policy for the production purposes. A number of fundamental and applied academic researches is dedicated to this subject. In particular, the attention to problems of economic stability management of machine-building enterprise based on reduction of resource policy risks is increased (for example, Maslyuk O. [9], Zanora V. [3]). A number of researches are devoted to the method of strategy management of logistics procurement as a tool for adapting the machine building company to the changing market conditions (for example, Kopilets P. [5], Neurov I. [7]).

New directions of scientific research are connected with understanding of the concept of sustainable supply chains. In particular, there are researches on development of logistic integration into production chains from a position of level system approach (for example, Kuzmenko Yu. etc. [6], Kiryukov S., Krotov K. [4]). Issues of using the voluntary standards of a sustainable development for forming the stable horizontal and vertical production supply

chains (for example, Palekhova L., Pivnyak G. G. [17]) became the important direction of researches. At the same time, these researches need to be deepened for individual industries, for which adaptation to globalization and integration is especially critical factor of competitiveness. The relevance and importance of solving this problem for the enterprises of mining machinery are caused by insufficiency of system development concerning ways of accumulation of the mining sustainability.

Purpose. This research aims to clarify key challenges and barriers of mining machinery enterprises in the context of forming sustainable supply chains in the mining.

The presentation of the main research material. The paradigm of supply chain management based on sustainable development initiatives has led to subsequent changes in business behavior concerning the interaction strategy between enterprises in supply chains. As a result, traditional theories (for example, resource approach of firm, the transaction theory) aren't able to provide a comprehensive explanation of management of a sustainable development in these chains. The modern management theory of supply chains, can't explain and predict the behavior observed concerning initial sources of sustainability [13].

It is known that economic actors in production chains (distribution and supply) enter into a specific interaction (or interrelation) during rather long time. Such interaction represents the certain combined process, including not only physical movement of goods, but also social, business, information exchange across the supply chain [12].

Entry into stable production chains reduces uncertainty in the conditions of supply of material resources and services for their own production, and also promotes stabilization of demand for the final products. In addition, each of the subjects included in the production chain, have different possibility of impact on stability development of other participants. Machine building enterprises, due to the specifics of their specialization and role in the technical development of production, can be a powerful generator of vertical stability of enterprises in a number of industries, allowing to meet modern

requirements to save resources, energy efficiency, environmental sustainability and safety.

Enterprises of mining machinery are good examples of such opportunities. Activity of such enterprises and their products should consider tendencies of development and the increasing requirements (branch, regional, national, international) to the mining production and promote formation of its responsibility in Ukraine. Unfortunately, in Ukraine, as well as in other post-Soviet countries, mining production is in a critical condition and requires a profound transformation. In transition economy conflicts confrontation of mining sector becomes a serious barrier for forming the sustainability of the national industry.

Apparently, from Fig. 3, for the last four years production of a mining industry have a steady trend on increase in sales, while industrial production in Ukraine decreased. Substantially such increase is due to stressful condition of the Ukrainian energy market – the Russian-Ukrainian political conflict threatened direct supply of gas from the Russian Federation. Therefore, Ukraine is forced to look for other ways to solve the problem of energy supply, including building its own production of hydrocarbons and enhance energy independence. The increase in production of coal and lignite, crude oil and natural gas has to promote the solution of problems of energy safety of domestic production.

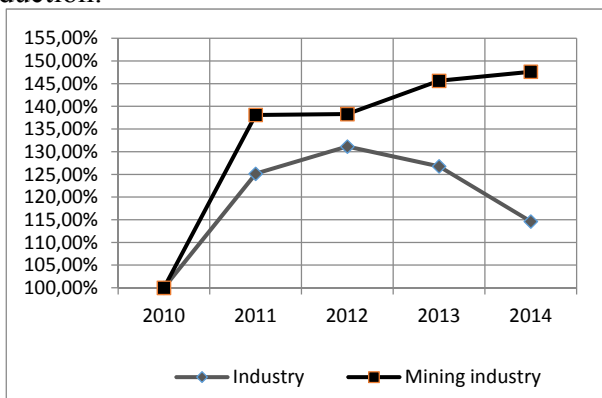


Fig. 3 The basic indicator of growth rate of industrial products sales in general and in mining industry for 2010-2014. (Source: calculated and compiled by the authors according to [10])

It should be emphasized that the crisis state of Ukraine's energy sector generates not only a challenge, but unique opportunities for transition of mining industry to absolutely new mod-

el of development which will bring them out from traditionally low-profitable, ecologically dangerous and socially unstable sector of economy.

According to the modern vision of progress of the mining industry, management of mining company has to provide its responsibility of all supply chain. Forming the sustainable supply chains in terms of minimization of energy consumption or a share of the energy component in product cost will provide a sustainable competitive advantage.

It is planned that in 2016 the international standard "Initiative for Responsible Mining Assurance" – IRMA will come into force. It will be recommended for wide use by all mining companies in the world. It is supposed that this standard will become key part of global system of ensuring responsibility of mining sector, will help to form responsible branch chains of industrial productions, calculated on using of the extracted metals and minerals. IRMA forms multilateral agreement on the establishment of general values for all stakeholders, the use of responsible practices by all participants of the production chain. IRMA offers the guidelines for all life cycle of production – from investigation and an operational phase to closing of object and long-term monitoring of environment [15].

Besides, in September, 2009, Ukraine began the process of accession to the international standard EITI (Extractive Industries Transparency Initiative) – the standard of responsibility of the mining branches; and till 17.10.2015 the country has to publish its first EITI report. According to the accepted obligations Ukraine carries out necessary reforms in the organizations of subsurface use and the mining industry [10].

In these conditions, requirements to the enterprises of mining machinery change. Producers of the equipment for mining production have to join in carrying out reforms and promote strengthening of technical and technological progress in a mining complex [1].

The process of increasing the energy efficiency of the mining enterprise covers all elements of its value chain. At each stage of the value chain for energy efficiency management

is necessary to determine the key factors affecting energy efficiency, identifying dependencies that determine the impact of energy consumption on the production component.

It is possible to allocate the following stages for increasing the energy efficiency:

1. analysis of the economic and environmental impact of the accepted changes;

2. determination at each stage of the supply chain problem energy-intensive places, which can be eliminated and ranking;

3. identification of the impact of changes on the entire value chain. Each change in any place of a chain influence the energy efficiency of its subsequent units. Therefore, it is necessary to take into account the integral effect of the events on the energy efficiency of individual units. So improving the quality of the output product of one of the links, even with an increase of the specific energy consumption for its production, may lead to a noticeable reduction in energy consumption during its further processing, i.e. integral effect can be positive, and with a slight increase - negative.

As one of the main difficulties for forming the sustainable chains of the mining enterprises is that these companies are the largest consumers of mining equipment, component parts, fuel and energy resources, some of which they receive from suppliers, and another part of them produce by itself. Due to the high-energy intensity of products, reduction of the share of energy component in the cost of production is a very complicated issue. It is obvious that the main sources of energy consumption reduction of mining companies consist in supply of the corresponding equipment and component parts to them. Mining companies establish precise and explicit criteria of quality to equipment and component parts before making the purchase. Thus, formation of sustainable interrelations occurs when products meet these criteria. These criteria are often quantitative: the percentage of energy consumption reduction, the percentage of increase in efficiency or productivity, etc.

Potentially, mining machinery enterprises have good market prospects of sales, because today in the Ukrainian mining companies replacement more than 40% of all park of drilling rigs is required. At the same time the drilling

companies seek to receive the hi-tech installations that meet high production characteristics. They require carrying out the control of the installation of drilling rigs on a platform of the producer and carrying out their tests in the presence of the customer.

However more than 75% of the drilling equipment made in Ukraine are already obsolete, and its production doesn't meet the international requirements in terms of energy consumption, reliability, safety, level of equipment instrumentation, computerization, etc. New development has too long terms of implementation and becomes outdated even before their launch [8]. As a result it is difficult to domestic producer to compete with foreign corporations which seek to expand the sales markets and to create the stable production chains covering the Ukrainian consumers.

Analysis of export and import structure of trade flows allows confirming that in 2014 import of drilling rigs exceeds export that defines import focused structure of the market of component parts. Mining machinery companies, which specialize on the production of parts, components for machines, simple mechanisms, can focus on repairing of both domestic and imported equipment, as well as the production of component parts for them. This product is an integral part of the mining machine. They are the most high-loaded and responsible elements of drilling machine. Therefore, if the quality of components is higher, the easier it is to overcome the complexity of mining and geological conditions, allowing mining enterprise to implement the principles of sustainability of production. Decisive factors of efficiency of the components are operational stability, decrease in loss of time for installation, dismantling and also replacement of the worn-out tool and reliability of assemblies and mechanisms. Expenses on the boring tool for the entire period of equipment using exceed by several times cost of it as their life duration is less than the drilling rig, and the change is more frequent.

Since, as noted earlier, mining machinery is obsolete, the number of mining companies that use the upgraded mining machines does not exceed 20%, respectively, the entire value chain does not correspond to European stand-

ards of sustainable development, including energy efficiency. Germany and the United States take the leading place in production of high-tech mining equipment. Today, the majority of foreign producers of components for mining machinery focused on customers that have modern equipment and require a correspondingly high-quality tool. The Ukrainian producers of similar components deliver them mainly on companies with "worn" machine park, with the appropriate technical level of production. But also in this case the quality and durability of the components is important, because the reduction in the time of their installation and dismantling impact on energy efficiency of production (the less often it will be carried out, the production process will be more effective).

In the context of the modernization of the equipment (for example, "Ukrgezvydobuvannya" in 2016 plans to upgrade a half of the existing drilling rigs) it is advisable to develop a mechanism of interaction between all actors of supply chain.

It should be noted that the increase of the share of new equipment is not due to a gradual upgrade of capacities, but due to the creation of new industries. The peculiarity of the formation of technological and production chain is the high technical complexity of the task. Therefore, in this case the supplier should be flexible. Foreign producers of equipment and components more often do not create a network of regional offices and technical specialists who used to provide the necessary service to customers. It allows domestic producers of component to take place in supply and distribution chain of mining machinery.

Conclusions. One of approaches in the development of Ukrainian mining machinery can be stimulation of the creation of joint ventures such as technology parks with the participation of foreign companies. At the same time, it is necessary to consider that such approach will require from domestic producers to observe standards of sustainable production, which observe the parent companies. Today the western producers of the mining equipment are guided

by the principles and standards of sustainable production, which provide energy efficiency and high technological efficiency, reliability of production and compliance to the best world samples. The use of reliable components will help to reduce operating costs up to 30%.

In the context of globalization and the pursuit of sustainable industrial relations, marketing of machine-building enterprises increasingly takes the form of deliveries in cooperation with the high interest of the parties. In this situation, for the purposes of strategic planning of markets, foreign practice widely uses a horizontal segmentation and situational analysis allowing to define entry points and a format of responsibility in the markets of mining equipment. Using results of situation analysis it is possible to choose the most effective supply channels. It will allow not only to predict volumes of ensuring production with resources (raw materials, etc.), but to standardize and harmonize the requirements in the supply chain, including their energy efficiency. To reduce the involvement extent of raw materials and energy resources in economic circulation it is necessary to reduce unit costs and increase re-use of material resources. Thus, an urgent need of modernization the reproduction model is dictated as political, economic, social, and ecological circumstances.

In recent years in Ukraine, there are high expectations on the formation of a global sustainable supply chains, which, according to domestic and foreign experts, are capable to solve fundamental socio-economic problems, including reproductive rebuild of the structure. However, to overcome gaps between desired result and existing will require a long time. For transition to their formation should be created corresponding starting conditions, including implementation of standards (IRMA, EITI), modernization of reproduction structure, a competent tax policy and other organizational and economic measures. Otherwise, the Ukrainian industrial enterprises cannot be participants in the global value chain.

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