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PROBLEMS OF RESOURCE INTENSITY OF UKRAINIAN METAL PRODUCTS

The authors of the article study the concept of resource intensity of Ukrainian steel production and point out its constituent parts: materials consumption, energy consumption, capital and labour intensity which account for certain financial costs in the formation of production costs of finished rolled metal. The dynamics of the given economic categories for the last 5 years is calculated to illustrate the qualitative development of metallurgical industry: consumption of material resources, energy-output ratio of finished steel production, capital and labour intensity ratios. The authors generalized the impact factors of the evaluated economic categories under the conditions of the country's current industrial development. It was also determined that each economic category has its own list of impact factors.

Keywords: *resource intensity; metal industry; materials consumption; energy-output ratio; capital intensity; labour intensity.*

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ПРОБЛЕМАТИКА РЕСУРСОЄМНОСТІ УКРАЇНСЬКОЇ МЕТАЛУРГІЙНОЇ ПРОДУКЦІЇ

У статті досліджено поняття ресурсоємності української металургійної продукції та виділено його складові: матеріалоємність, енергоємність, фондоємність і трудомісткість, які відповідають за певне коло фінансових витрат у формуванні виробничої собівартості готового прокату. Проілюстровано динаміку показників за останні 5 років, що характеризує якісний розвиток металургійної галузі: обсяги витрат матеріальних ресурсів, показник енергоємності виробництва готової металургійної продукції, показники фондоємності та трудомісткості. Виявлено та узагальнено чинники впливу на рівень розрахованих економічних категорій в умовах сучасного розвитку промисловості країни, а також визначено, що кожній економічній категорії відповідає власний перелік чинників впливу.

Ключові слова: *ресурсоємність; металургійна галузь; матеріалоємність; енергоємність; фондоємність; трудомісткість.*

Рис. 6. Літ. 14.

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ПРОБЛЕМАТИКА РЕСУРСОЕМКОСТИ УКРАИНСКОЙ МЕТАЛЛУРГИЧЕСКОЙ ПРОДУКЦИИ

В статье исследовано понятие ресурсоемкости украинской металлургической продукции и выделены его составляющие: материалоемкость, энергоемкость, фондоемкость и трудоемкость, которые отвечают за определенные финансовые затраты в формировании производственной себестоимости готового проката. Проиллюстрирована динамика приведенных показателей за последние 5 лет, что характеризует качественное развитие металлургической отрасли: объемы затрат материальных ресурсов, показатель энергоемкости производства готовой металлургической продукции, показатели фондоемкости и трудоемкости. Выявлены и обобщены факторы влияния на уровень рассчитанных экономических категорий в условиях современного развития промышленности страны, а также определено, что каждой экономической категории соответствует собственный перечень факторов влияния.

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Ключевые слова: *ресурсоемкость; металлургическая отрасль; материалоемкость; энергоемкость; фондоемкость; трудоемкость.*

Introduction. Under the conditions of the post crisis economic reality, Ukrainian economy requires positive development of construction, machine building, pipe production and the related industries. The formation of metal production costs is associated with the use of expensive materials, fuel and energy resources, new equipment and large-scale capital investments within the continuous efforts to increase companies' capacity. This problem refers to the determination of the current state of the resource intensity of metal products and their components for the purpose of further development of methods and suggestions for resource saving at metal plants, namely, at the background of increased materials consumption in the metal industry.

Latest research and publications analysis. Theoretical and practical research on the problem of efficient use and rational management of companies' material and energy resources and human capacity is reflected in the works of Ukrainian and foreign scientists, such as: S. Mochernyi et al. (2002), W. Owen and A. Sobey (1985), K. Jones (1988), B. Rayzberg, L. Lozovskyi and E. Starodubtseva (1999), S. Chirkov (2010), E. Malyarenko and A. Teslenko (2010), O. Bogdanov (2011), M. Kopalek and T. Raghuveer (2013) and others.

The object of this research is the notion of resource intensity and its components at Ukrainian metal industry companies.

Key research findings. After the world economic crisis, Ukrainian metal industry is gradually reaching new production and sales objectives; owners of metal plants and their associations constantly face the main problem of their industry, great resource intensity of finished metal products.

The notion of industrial products resource-intensiveness is rather complex and includes such categories as materials consumption, energy-output ratio, capital intensiveness and labour intensity. The authors of the work represent the formation of resource-intensiveness of a company in Figure 1.

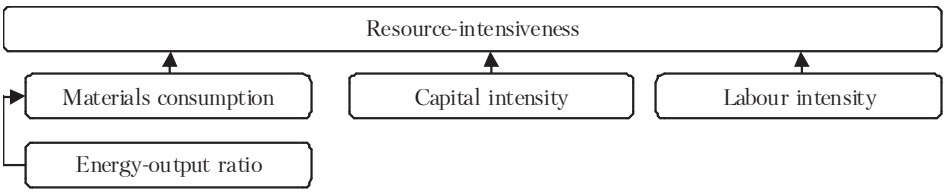


Figure 1. **Resource intensity of an industrial company,** *developed by the authors*

Materials consumption is one of the principal indicators of production economic efficiency. Material consumption characterises the specific consumption of material resources (basic and auxiliary materials, fuel, energy, depreciation of fixed assets) per product unit. Materials consumption is measured as physical units, monetary value or percentage comprising the share of the cost of materials in the total production costs or as production cost (Rayzberg, Lozovskyi and Starodubtseva, 1999). The materials consumption indicator is applied to analyse the industrial companies' production and economic activities, namely, production costs, to conduct the comparative analysis of

specific costs in various industry sectors and to plan material and technical resources and form prices for brand new products.

The total materials consumption ratio consists of the sum of the specific materials consumption ratio for the products manufactured by a company divided by the number of items and depends upon changes in the volume of materials costs (Chirkov, 2010).

1% of materials cost reduction results in a greater economic effect than the reduction of other costs. The results of the analysis of material resources use may be applied as the basis for decision-making in the process of production activity management of a company, which includes the development of tactical and strategic policies in the area of resource saving aimed at increasing materials use efficiency, production cost reduction, income and profitability increase (Chirkov, 2010).

The materials consumption reduction has great economic value: it determines the reduction of labour costs materialised in saved material resources and the products output increase under the same production conditions (The Great Soviet Encyclopedia, 1978).

The major methods for materials consumption reduction are as follows: the use of the most saving materials (grades, sizes and trademarks), their preliminary processing (for example, enrichment of extractable resources), the production waste reduction (precision casting and stamping methods), the introduction of optimal safety design.

It should be noted that the analysis methods for certain types of materials in different economy sectors are determined by the specific character of production organisation and technology, the types of materials used and the available information sources (Chirkov, 2010).

The materials consumption reduction in the metal industry has always been one of the key issues, both for technology specialists and economists. Contemporary iron and steel plants use very consuming technologies that date back to the Soviet Union and require constant scientists' involvement at practically all stages of finished rolled products manufacture.

The today's Ukrainian metal making is a rather material consuming production process requiring the use of expensive iron ore and other materials (Figure 2) in the process of cast iron production by Ukrainian iron and steel plants (Metallurgprom, 2010–2012).

The analysis of the indicators (Figure 2) demonstrates that iron and steel plants are actively reducing their materials consumption required to manufacture end products. For instance, in 2012 the average consumption of iron ore raw materials to produce cast iron amounted to 1,717.0 kg/t, which is down by 0.9% year on year (Metallurgprom, 2011–2012). Given that the agglomerate and blast furnace process is the most material consuming one within metal making and makes up about 75% of the end products cost, the above measures to reduce the specific cost of iron ore raw materials will enable reducing the finished rolled metal production costs significantly.

It should be noted that during the latest 3 decades, American scientists has been conducting active research of high materials consumption of American industry. For example, W. Owen and A. Sobey (1985) emphasise in their works that American industry should save such strategically important materials as chrome, cobalt, man-

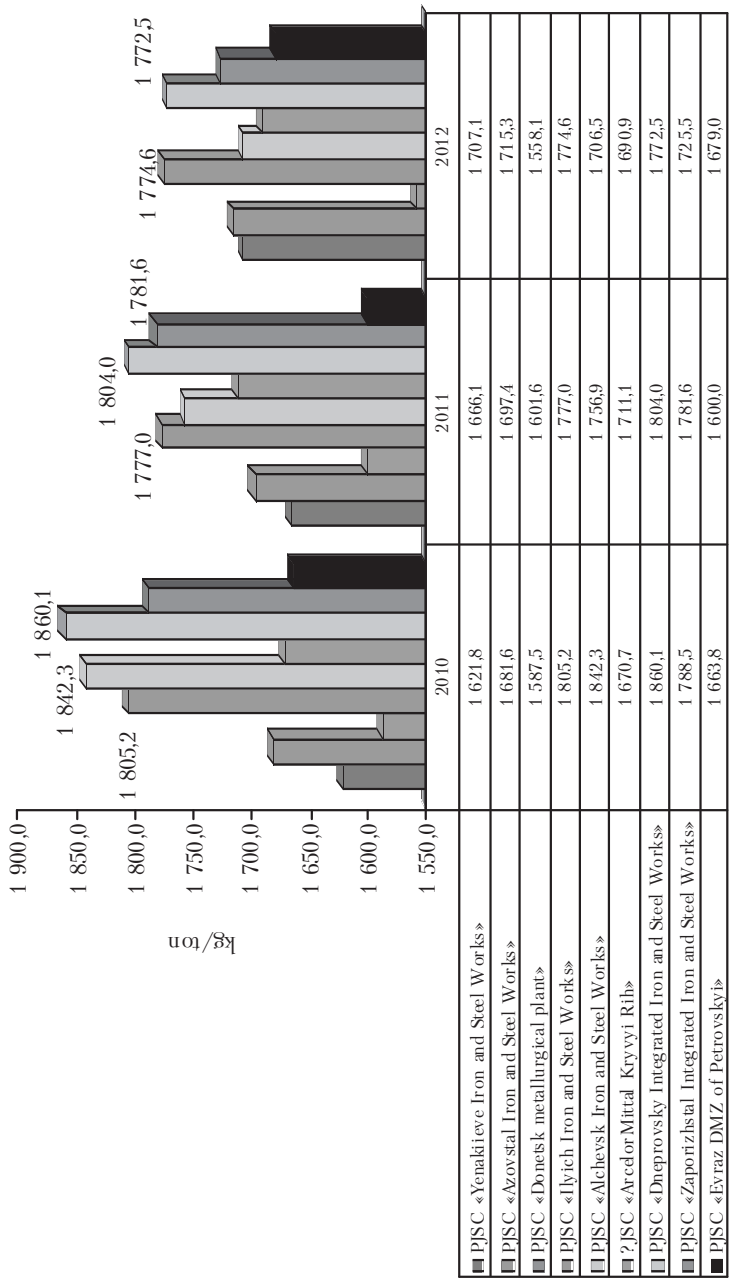


Figure 2. **Specific consumption of iron ore raw materials (agglomerate, pellets and iron ore) in the process of cast iron production by Ukrainian iron and steel plants during 2010–2012,** *based on the data by* Metallurgprom (2010–2012)

ganese, platinum-group metals – the materials that are actively used in metal making and chemical production.

American scientist K. Jones (1988) raises the problem of both high materials consumption in the USA and, first of all, of the country's dependence upon imports of many mineral resources, which is of great importance to state security and economy of such a big country.

The next indicator is the energy-output ratio, being part of materials consumption and representing a component of fuel and energy costs in the process of industrial production.

The energy-output ratio means the consumption of energy and (or) fuel for the basic and auxiliary technological processes, works, services, on the basis of the defined technological system. The numerical expression of the energy-output ration of the system is the following indicator: the correlation between the energy consumed by the system and the indicator characterising the result of system functioning (Wikipedia, 2013).

It should be noted that the total energy-output ratio at the entire technological chain determines energy consumption per product unit at the entire technological cycle. In this case, there is a possibility to follow certain components of the total energy-output ration to compare the results obtained in the process of applying different methods for extraction and production of raw materials, transportation, end products manufacture at a company, levels of using recycled material and energy resources (Malyarenko, Teslenko, 2010).

The work illustrates the energy-output ratio for metal making in Ukraine (Figures 3, 4); the diagrams are developed by the authors in accordance with the information taken from (Metallurgprom, 2012).

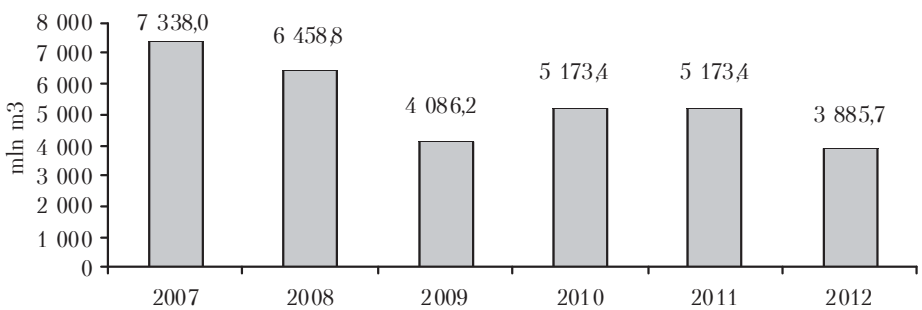


Figure 3. **Actual natural gas consumption by Ukrainian iron and steel plants in 2007–2012,** *based on the data by* Metallurgprom (2010–2012)

The actual natural gas consumption by Ukrainian iron and steel plants in general (Figure 3) during the above period was maximal in 2007 (7,338 mln m^3), and minimal in 2012 (3,885.7 mln m^3) (Metallurgprom, 2012), which is determined by the natural gas price increase and the necessity of replacing it by cheaper energy resources or the introduction of innovation technological solutions in the process of metal production at the entire production chain.

European countries face the problem of expensive natural gas used in practically all industrial sectors, too. For instance, according to the data of the International

Energy Agency (IEA) M. Kopalek and T. Raghuveer (2013), in 2011 European industrial companies used coal by 8% more than natural gas to produce European gross domestic product (GDP); in 2012, this figure grew by 2%.

The actual electric power consumption by Ukrainian metal industry shows the similar dynamics (Figure 4): the maximal figure was in 2007 (17,932.4 mln KW/h), and the minimal figure was in 2009 (14,502.2 mln KW/h) (Metallurgprom, 2012), which can be attributed to production decline during the crisis of both Ukrainian and the world economies.

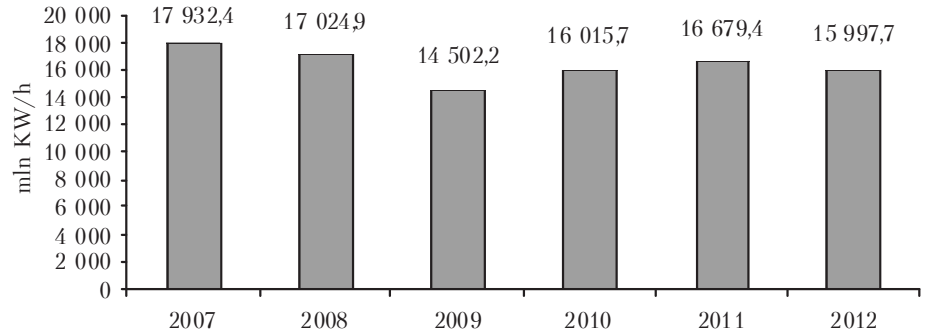


Figure 4. **Actual electric power consumption by Ukrainian iron and steel plants in 2007–2012,** *based on the data by* Metallurgprom (2010–2012)

The authors of the article agree with the opinion A. Bogdanov (2011) that Russian economy (as well as Ukrainian one) is distinguished by its extremely high energy intensity. At the same time, the problem of introducing energy saving technologies in Russia is not in the lack of scientific knowledge and technologies, but in the replacement of market relations by very inefficient energy regulators.

Capital intensity means the cost of fixed production assets (fixed assets) per product unit. This indicator is measured by dividing the average annual balance value of fixed production assets into the cost of the products manufactured by means of these assets during the year. The balance value of fixed production assets should be taken as the annual average or as of the end of the respective year. The capital intensity indicator is used in the economic analysis of the fixed assets use efficiency, the determination of the reserves to increase production efficiency. The increase in labour efficiency and equipment use efficiency compared with the increase in their cost determines the tendency towards capital intensity reduction and capital productivity increase.

Capital intensiveness depends upon production specific character and product's peculiarities, as well as the prices for production means. It shows the greatest level in the mining industry, heat and electric power production and machine building; the lowest level is in the light and food industries. The capital intensity reduction is one of the factors leading to production efficiency increase. This reduction is achieved by the raise of labour productivity, the choice of the most saving variants of production facilities increase, mainly, due to reconstruction and technical re-equipment of the existing plants, the cheapening of construction and installation works, the reduction of technological equipment costs per unit, the increase in the overage machine shift and the reduction of machine idle time (Mochernyi et al., 2002).

It should be noted that there are the following factors to increase capital intensity: the outrunning growth of prices for production facilities compared to the increase rate of labour productivity, the decrease in capital productivity, organisational and technological designs and the absence of a unified state technical policy.

The authors calculated the capital intensity indicator (Figure 5) both for certain iron and steel plants and for the sector in general during 2008–2012 (Metallurgprom, 2010–2012).

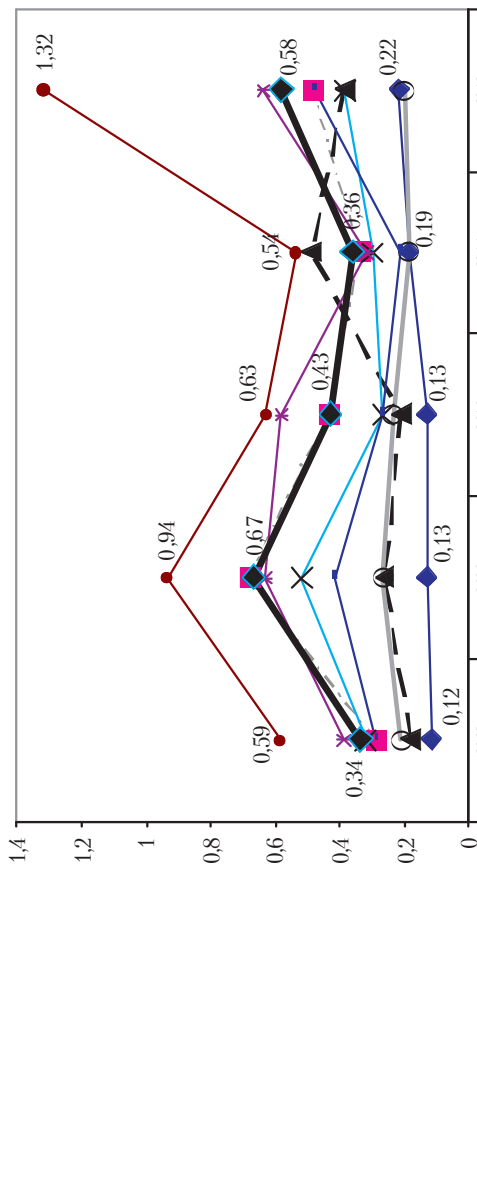
The capital intensity indicator that the authors calculated for the entire industry (Figure 5) demonstrates the following dynamics: capital intensity grew in 2009 (by 97%), which can be attributed to the significant decrease in the metal production volume during the crisis, due to the fact that products were export-oriented (the demand decline at foreign markets and export prices fall) (Metallurgprom, 2010–2012). In 2010–2011, certain stabilization of the world ferrous metal market resulted in the decrease in the capital intensiveness indicator due to the increase in production volumes.

The reasons for the increase in capital intensity in 2012 are as follows (Figure 5): the new surge in the metal price decline at the world markets, revaluation of fixed assets by certain Ukrainian iron and steel plants and the launch of new facilities – 7 out of 17 largest facilities in the sector increased their capital investments in renewing their fixed assets compared with 2011 for the total amount of 1,553.8 mln UAH (Metallurgprom, 2011).

According to the data provided by Metallurgprom (2010–2012), the leaders in terms of investment disbursement in 2012 are PJSC "ArcelorMittal Kryvyi Rih" (1,510.1 mln UAH) and PJSC "Illyich Iron and Steel Works" (1,080.6 mln UAH). Totally, the specific investment per 1 t of steel produced in 2012 amounted to 24.5 USD compared with 22.5 USD in 2011. It should be noted that the specific investment per 1 t of steel produced in 2011 in Russia amounted to 80 USD (Metallurgprom, 2011).

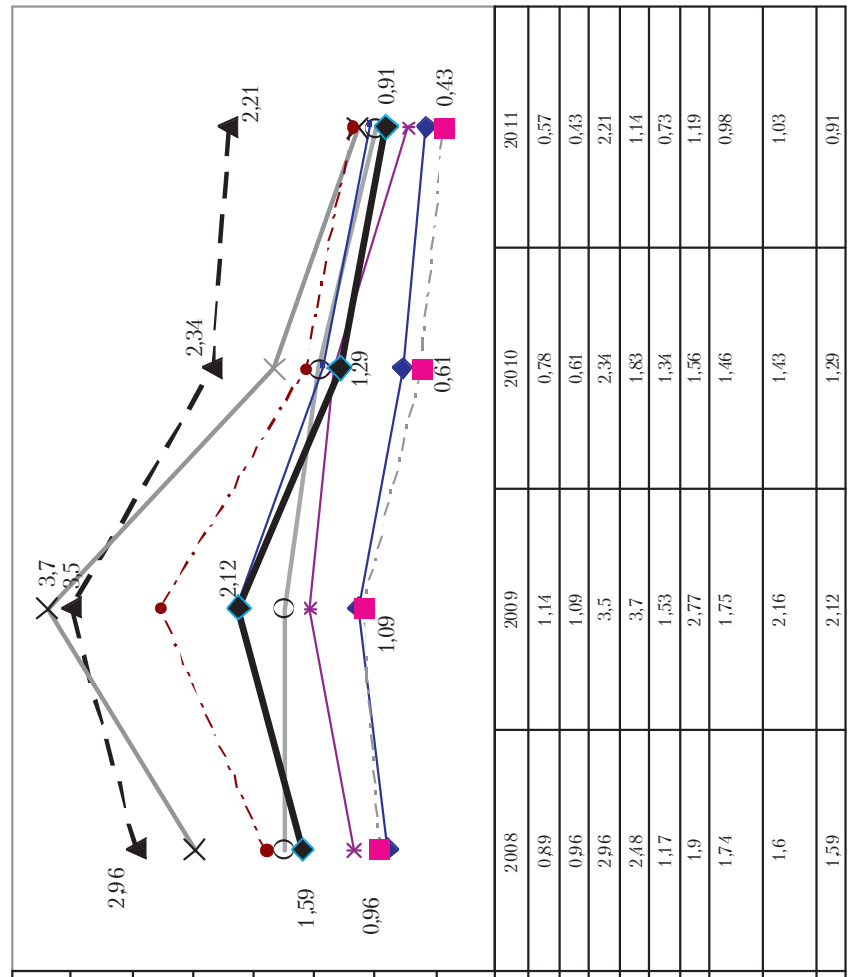
Labour intensity is the indicator to characterise the working hours spent to produce any consumption value or to conduct a certain technological process. Labour intensity is the reverse indicator of labour productivity. It determines the efficiency of using the major productive force of the society, the workforce. There is a number of factors which can affect the rate of labour intensity: production technology development (capital-labour ratio and energy-labour ratio, quality of labour subjects, production technology), qualification of employees, labour organisation and conditions, complexity of products manufactured.

The labour intensity indicator is applied to determine the rate of working time costs at all production stages to manufacture a certain product. It includes the working time costs for all production employees directly involved in product manufacture and labour costs as represented in raw materials, fuel, equipment and other production facilities involved. The precise quantitative characteristics of aggregated expenditures to produce material benefits or render specific services is obtained by using the total labour intensity indicator. It should be noted that the average total labour intensity in the sector means socially necessary labour time standards, i.e. the important quantitative and qualitative indicator of social conditions to produce specific material benefits or services (Economic Reference Dictionary, 2013).



	2008	2009	2010	2011	2012
PJSC «Yenakiieve Iron and Steel Works»	0,12	0,13	0,13	0,19	0,22
PJSC «Azovstal Iron and Steel Works»	0,29	0,68	0,44	0,34	0,48
PJSC «Donetsk metallurgical plant»	0,18	0,26	0,21	0,49	0,39
PJSC «Ilyich Iron and Steel Works»	0,32	0,52	0,27	0,3	0,39
PJSC «Alchevsk Iron and Steel Works»	0,39	0,63	0,58	0,32	0,64
PJSC «ArcelorMittal Kryvyi Rih»	0,59	0,94	0,63	0,54	1,32
PJSC «Dneprovsky Integrated Iron and Steel Works»	0,21	0,27	0,24	0,19	0,2
PJSC «Zaporizhstal Integrated Iron and Steel Works»	0,29	0,42	0,27	0,21	0,48
All	0,34	0,67	0,43	0,36	0,58

Figure 5. **Capital intensity of Ukrainian iron and steel plants in 2008–2012,** *based on the data by* Metallurgprom (2010–2012)



	2008	2009	2010	2011
PJSC «Yenakiieve Iron and Steel Works»	0,89	1,14	0,78	0,57
PJSC «Azovstal Iron and Steel Works»	0,96	1,09	0,61	0,43
PJSC «Donetsk metallurgical plant»	2,96	3,5	2,34	2,21
PJSC «Ilyich Iron and Steel Works»	2,48	3,7	1,83	1,14
PJSC «Alchevsk Iron and Steel Works»	1,17	1,53	1,34	0,73
?JSC «ArcelorMittal Kryvyi Rih»	1,9	2,77	1,56	1,19
PJSC «Dneprovsky Integrated Iron and Steel Works»	1,74	1,75	1,46	0,98
PJSC «Zaporizhstal Integrated Iron and Steel Works»	1,6	2,16	1,43	1,03
All	1,59	2,12	1,29	0,91

Figure 6. **Labour intensity at Ukrainian iron and steel plants in 2008–2011,** *based on the data by* Metallurgprom (2010–2012)

The authors calculated the labour intensity indicator (Figure 6) both for certain iron and steel plants and for the sector in general for 2008–2011 (according to the data obtained at Metallurgprom, 2010–2012).

Given the fact that personnel and labour costs are the categories characterised by lower degree of turnover compared with other production factors, the calculated labour intensity indicator (Figure 6) demonstrated the following dynamics: in 2009 labour intensity increased (by 33.3% year on year), which is attributed to the decrease in net sales income at all the plants, due to the decrease in production and sales volumes during the crisis, and in 2010–2011 the labour intensity indicator decreased (from 1.29 persons/mln UAH down to 0.91 persons/mln UAH, or by 29.85%), due to the increase in the production volume and the increase in the load on the iron and steel plants – for instance, the 2011 manufacture of rolled products per 1 employee involved in major activities in the industry sector is by 3.36% greater than in 2010 (Metallurgprom, 2010–2011).

Conclusions. The research of the notion "resource intensity" has enabled determining the components of this economic term, such as materials consumption, energy-output ratio, capital and labour intensity, which attribute to their own resource costs to manufacture finished metal products.

It has been found out that the first 3 technological processes are the most resource consuming: agglomerate production, cast iron production and steel smelting, which at the same time are the most material consuming processes requiring expensive fuel resources and numerous qualified personnel to maintain fixed production assets.

Our analysis has demonstrated that the actual consumption of agglomerate, pellets and iron ore in the industry is gradually reducing, which is related to the production decrease during the post-crisis years of the development of Ukrainian and the world economies and the introduction of innovation measures to save resources.

It has been determined that the increased metal production energy-output ratio is associated with the use of expensive, but technologically necessary fuel and energy resources: imported natural gas and blast-furnace coke, while energy consumption remains at the high level.

It has been found out that the 2009 increase in the capital intensity indicator calculated by the authors is attributed to the significant production volume reduction during the crisis, and the reasons for the increase in capital intensiveness in 2012 are as follows: the new surge in the metal price decline at the world market, revaluation of fixed assets by iron and steel plants and the launch of new facilities. It should be noted that the leaders in terms of investment disbursement in 2012 are PJSC "ArcelorMittal Kryvyi Rih" and PJSC "Illyich Iron and Steel Works".

It has been determined that the metal products labour intensity calculated by the authors for the recent years demonstrates a stepwise tendency towards the decrease, due to the production volume growth and the increased load on the iron and steel plants' capacity combined with rather stable number of production personnel.

Consequently, it should be noted that as of today, metal production in Ukraine is indeed resource consuming and requires constant search for the solutions aimed at resource saving, not only by changing technologies, but also by developing and introducing economic mechanisms to optimise companies and their associations' financial assets.

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Стаття надійшла до редакції 22.11.2013.