Електронний журнал «Ефективна економіка» включено до переліку наукових фахових видань України з питань економіки (Категорія «Б», Наказ Міністерства освіти і науки України № 975 від 11.07.2019). Спеціальності – 051, 071, 072, 073, 075, 076, 292.

Ефективна економіка. 2022. № 11.

DOI: http://doi.org/10.32702/2307-2105.2022.11.30

УДК 622.276.6

Kh. Danylkiv,
PhD in Economics, Associate Professor of the Department of Finance, Accounting and Analysis, Lviv Polytechnic National University,
Head of Independent Education Quality Bureau LLC, Ukraine, Lviv
ORCID ID: https://orcid.org/0000-0003-1283-6844
N. Hembarska,
PhD in Economics, Senior Lecturer of the Department of Finance, Accounting and Analysis, Lviv Polytechnic National University, Lviv, Ukraine
ORCID ID: https://orcid.org/0000-0002-7839-4260
O. Basarab,
Senior Lecturer of the Department of Economics and Marketing, Lviv Polytechnic National University, Lviv, Ukraine
ORCID ID: https://orcid.org/0000-0003-1984-7394

ECONOMIC AND MATHEMATICAL MODELING OF INTENSIFICATION OF OIL PRODUCTION BY PULSE-WAVE TECHNOLOGY

Х. П. Данилків,
к. е. н., доцент кафедри фінансів, обліку і аналізу,
Національний університет «Львівська політехніка»,
Директор ТОВ «Незалежне бюро якості освіти», м. Львів, Україна
Н. Є. Гембарська,
к. е. н., старший викладач кафедри фінансів, обліку і аналізу,
Національний університет «Львівська політехніка», м. Львів, Україна
О. В. Басараб,
старший викладач кафедри економіки і маркетингу,
Львівський національний університет природокористування, м. Львів, Україна

ЕКОНОМІКО-МАТЕМАТИЧНЕ МОДЕЛЮВАННЯ ІНТЕНСИФІКАЦІЇ ВИДОБУТКУ НАФТИ ІМПУЛЬСНО-ХВИЛЬОВОЮ ТЕХНОЛОГІЄЮ

The last decades have been characterized by the deteriorating quality of the raw material base of Ukraine's oil industry due to significant production of high-yielding fields, which are in the final stages of development and have a high degree of oil flooding, as well as open fields with so-called hard-to-reach reserves.

The situation in the oil and gas industry requires the development and implementation of technologies that would comprehensively solve the problem of increasing the productivity of low-flow wells and connecting to the active development of immobile and immobile hydrocarbon reserves in low-permeability zones and reservoir intervals. This necessitates the creation and involvement in practical use of technological solutions that are based on the complex application of well-known methods of intensification of well work and new highly effective methods, means and techniques for simultaneously solving a wide range of geological and industrial problems, which make it possible to increase the current production of hydrocarbons.

This article analyzes and performs economic-mathematical modeling of intensification of oil production by pulse-wave actions on productive formations (based on a review of literature sources, which describe the technical means and methods used in a technology). It is determined that this method of increasing the productivity of oil wells by pulse-wave technology is one of the most promising, as it does not require high-cost equipment and chemical compounds, is performed using standard oilfield equipment, and does not pollute the environment.

The work aims to increase the oil production ratio of PJSC Ukrnafta by introducing pulse-wave technology to the well by improving the filtration and throughput characteristics of the bottom hole and remote zones of the reservoir ensuring maximum oil production speed and net profit.

To assess the economic feasibility of the proposed measure, the main performance indicators were used: net discounted income, profitability index, and internal rate of return. Based on the results obtained for the implementation of the proposed project, the provision of the maximum rate of oil recovery and net profit. It is established that these indicators correspond to the strategy of effective development of PJSC Ukrnafta in the field of oil production.

Останні десятиріччя характеризуються погіршенням якісного стану сировинної бази нафтовидобувної промисловості України внаслідок значного виробітку високопродуктивних родовищ, що знаходяться на завершальній стадії розробки та мають високий ступінь обводненості нафтових пластів, а також залучення до експлуатації відкритих родовищ з так званими важкодоступними запасами.

Ситуація в нафтогазовій галузі вимагає розробки та впровадження технологій, які б комплексно вирішували проблему підвищення продуктивності малодебітних свердловин та підключення до активної розробки нерухомих і нерухомих запасів вуглеводнів у зонах низької проникності та інтервалах колекторів. Це зумовлює необхідність створення та залучення до практичного використання технологічних рішень, які базуються на комплексному застосуванні як відомих методів інтенсифікації робіт свердловин, так і нових високоефективних методів, засобів і прийомів одночасного вирішення широкого кола геологічних і промислових завдань, які дають змогу збільшити поточний видобуток вуглеводнів.

У даній статті проаналізовано та здійснено економіко-математичне моделювання інтенсифікації видобутку нафти імпульсно-хвильовими діями на продуктивні пласти (на основі огляду літературних джерел, в яких описуються технічні засоби і методи, що використовуються у тій чи іншій технології). Визначено, що даний спосіб підвищення продуктивності нафтових свердловин імпульсно-хвильовою технологією є одним із перспективних, оскільки не потребує високовартісних обладнання та хімічних сполук, виконується за допомогою штатного нафтопромислового обладнання та не відбувається забруднення навколишнього середовища.

Метою роботи є підвищення коефіцієнта видобутку нафти ПАТ «Укрнафта» впроваджуючи імпульсно-хвильової технології на свердловину за рахунок покращення фільтраційно-пропускних характеристик привибійної та віддалених зон пласта забезпечуючи максимальну швидкість видобутку нафти та тримання чистого прибутку.

Для оцінки економічної доцільності здійснення запропонованого заходу використано основні показники ефективності: чистий дисконтований дохід,

індекс прибутковості та внутрішня норма прибутковості. На основі отриманих результатів, щодо реалізації запропонованого проєкту, виявлено забезпеченість максимального коефіцієнту вилучення нафти та отримання чистого прибутку. Встановлено, що дані показники відповідають стратегії ефективного розвитку ПАТ «Укрнафта» в області видобутку нафти.

Keywords: *Pulse-Wave Technology, Oil Production, Energy Resources, Profitability Index, Sales Revenue, Stable Financial Condition.*

Ключові слава: *імпульсно-хвильова технологія, видобуток нафти, енергоресурси, індекс прибутковості, виручка від реалізації, стійкий фінансовий стан.*

Statement of the problem in general and its connection with important scientific or practical tasks. Modern market relations require businesses to increase production efficiency, the competitiveness of products and services, efficiency of management, and production management, which ultimately leads to the main goal – to maximize profits, which can be achieved by ensuring a stable financial position. The correct definition of the financial condition of the enterprise is of great importance not only for himself but also for shareholders and potential investors.

Fluctuations in world oil and gas prices largely determine the pace of development of the global energy economy, the long-term structure of the fuel and energy balance, directions and rates of R&D in relevant areas. At the moment, the oil market is not experiencing the best of times, the energy sector in Ukraine, and in general, around the world has suffered significantly. The financial crisis has had a profound effect on the profitability of any oil and gas company, affecting the decline in domestic consumption and falling energy prices.

In 2020, world gas production decreased by 146 billion cubic meters (-3.6%) to 3 845 billion cubic meters, as low oil and gas prices have led to a decline in exploration and production. Prices for Urals oil and natural gas reached the lowest values in the last 5 years, reaching $ 20/bar and UAH 1,860/thousand m^3, respectively. Despite the recovery of prices in the second half of the year, in 2020 the average annual price for oil was 35%, and for gas – 33% less than in 2019. Natural gas production in Europe continued to decline, declining by 13.2% in 2020 compared to 2019 and amounted to 96.2 billion cubic meters [1].

In 2020, the total volume of gas production in Ukraine amounted to 20.2 billion cubic meters, which is 0.5 billion cubic meters (-2.4%) less than in the previous year. In 2020, JSC Ukrhazvydobuvannia extracted 14.2 billion cubic meters, which is 4.7% less than in 2019. Ukrgazvydobuvannia JSC is followed by Naftogazvydobuvannia PJSC (DTEK Naftogaz), the largest private gas production company in Ukraine, with an annual production volume of 1.8 billion cubic meters (an increase of 11.3% in 2020). In 2020, PJSC Ukrnafta extracted 1.1 billion cubic meters of natural gas, which is 3.0% (or 33 million cubic meters) less than in 2019 [2, p. 16].

It should be noted that since November 2015, Ukraine has no longer imports gas from the Russian Federation. However, Russian gas is transited through the Ukrainian gas transportation system to the European Union, and from there it is imported in reverse to Ukraine via Slovakia, Poland, and Hungary. In 2019, compared to 2018, the volume of gas transit through Ukraine from the Russian Federation to European countries and Moldova increased to 89.6 billion cubic meters (by 3%), and imports of natural gas to Ukraine for the year increased to 14.2 billion cubic meters (by 34.9%). There are more than 40 deposits from almost 500 wells in five oblasts – Lviv, Ivano-Frankivsk, Volyn, Zakarpattia, and Chernivtsi.

It should be noted that 70% of all gas in the western region of Ukraine (2.1 billion cubic meters of gas per day) is produced by the largest gas company in Ukraine «Lvivgazvydobuvannya» – one of the three branches of the state enterprise «Ukrgazvydobuvannia». The company plans to drill and start gas production in 12 new wells: eight production wells and four exploration wells. Today Lvivgazvydobuvannia Gas Industry provides 5% of gas production in Ukraine. In 2018, 10 new wells received an additional 123 thousand cubic meters of gas per day, and from the intensification of production wells – more than 220 thousand cubic meters of gas per day [4].

It is known that the actual gas production in recent years of operation of the unique Shebelinsky GKR exceeded the project, and additional gas production for the period 2015-2019 amounted to 5.7 billion m^3 [5, p. 27]. In the structure of the oil consumption market in Ukraine, the share of Shebelinsky Gas Refinery (Ukrgazvydobuvannia) is 3.8%: 149 thousand tons of gasoline (production increased by 13%), 88 thousand tons of diesel fuel (3.5%), and 176 thousand of liquefied gas (6.8%) [6].

For many years, Ukraine has neglected its geological prospecting industry by focusing on gas purchases in the Russian Federation, spending billions of dollars on it. The state invests only UAH 100 million a year in upgrading its material and raw material base, but to fully conduct geological exploration for mining companies, it is necessary to spend UAH 1.5 billion annually.

At the same time, according to Ryder Scott Company, Ukraine's natural gas reserves are 270 billion cubic meters. It should be noted that large deposits of unproduced gas in the western region of Ukraine alone are billions of cubic meters (Bilche-Volytsky, Svydnytsky, Letnyansky, and Oparsky fields) and in the Carpathians at great depths (Bytkiv-Babchensky field – subsoil contain about 31.6 billion cubic meters) [7].

In 2020, PJSC Ukrnafta extracted 1.13 billion cubic meters of natural gas, which is 3.0% (or 33 million cubic meters) less than in 2019. The situation is similar for private companies, which continued to increase production, reaching 4.86 billion cubic meters in 2020, which is 5% more than in the previous year (in 2019, production increased by 4.7% – from 1.45 million tons to 1.52 million tons) [1].

Ukrainian oil and gas companies are not living in the best of times. Therefore, this article analyzes and performs economic and mathematical modeling of the current state of methods and means to increase the productivity of oil wells PJSC Ukrnafta pulse-wave action on the reservoir (based on a review of literature sources describing technical means and methods used in a particular other technology).

Analysis of recent research and publications, which initiated the solution of this problem and on which the author relies, the selection of previously

unsolved parts of the general problem, which is the subject of this article. The scientific work proposes the introduction of pulse-wave technology on the well, which will allow PJSC Ukrnafta to increase the rate of oil production by improving the filtration and throughput characteristics of the bottom hole and remote zones of the reservoir. The implementation of this project will ensure a stable production profile and the maximum speed of oil production, increase the efficiency of the development of heavy oil reserves from the reservoir and bring a net profit.

Pulse-wave action, as a method of influencing the productive formation, refers to promising methods of action on the bottom-hole zone of the formation. This method was first tested in the oil and gas field in the 60s of the twentieth century, and immediately received positive data on its technological efficiency [8]. This technology does not require expensive equipment and is environmentally friendly, performed using standard oilfield equipment.

Shock-wave impact on the formation provides for two types of effects:

- direct impact on the near-wellbore formation zone with a coverage radius of up to 50 cm from a source of elastic waves in the ultrasonic frequency range;
- remote impact, which is recorded by hydrophones at a distance of 1-1.5 km from the source generating low-frequency 0.2 Hz elastic waves [9].

The main goal of the technology is to introduce into development low-permeability isolated zones of the reservoir, which react poorly to the impact of the reservoir pressure maintenance system, by exposing them to elastic waves that decay in high-permeability sections of the reservoir, but propagate over a considerable distance and with sufficient intensity to excite low-permeability reservoir sections [10; 11].

From the experience of BFZ treatment in oil wells, it has been noticed that a low-permeability reservoir not saturated with liquid absorbs elastic waves, which leads to a reduction in the coverage area much more than for a reservoir with a fluid-filled pore volume. In the latter case, under the influence of elastic vibrations, the pressure in the pores increases, which leads to the destruction of the membranes between the pores and the formation of additional capillaries, and the difference in the propagation velocity of elastic high-frequency waves through the skeletal rock and the pore fluid leads to the destruction of the spatial network formed by the colloidal-dispersed system. Considering that the impact of elastic waves performs separation of CDS particles from the walls of the capillary due to oscillations near the center of equilibrium, but does not move in space, a more powerful alternating shock effect is needed, which has enough energy to carry the bridging agent from the formation to the well – the «washing» effect [12; 13].

Thus, to reduce filtration resistance, restore the hydrodynamic connection of the «formation-well» system, and expand the network of microcracks, technical means have been developed that allow creating a local geodynamic effect on near-well sections of the formation.

Treatment of the bottom hole zone by the pulse-wave method increases the acceptability of injection and productivity of production wells. These methods allow optimizing the costs of the oil company in the case when the use of more expensive methods to increase productivity is unprofitable [14].

The essence of the pulse-wave action on the formation is to create elastic oscillations in the bottom hole and downhole zones of the formation. To do this, it is necessary to transfer energy from the surface to the lowered equipment or to create fluctuations of the required power on the surface and ensure their transfer to the reservoir. Pressure gradients in the bottom-hole zone of the formation are created by downhole or ground hydraulic generators of elastic oscillations [15].

Analysis and experience of the current state of methods and means of pulse-wave action on the formation show their great diversity using different methods of creating elastic waves in the formation, a wide range of frequencies and intensities, a large number of design solutions for deep, mouth and ground equipment. This indicates the intensive development of this scientific and technical direction and its prospects, primarily to increase oil and gas recovery from the formation without the use of chemical reagents and heaters, given the reduction of hydrocarbon production reserves in the world. The advantage of these methods is their efficiency, relatively low cost, low energy consumption, environmental friendliness [16].

Formulation of the goals of the article (task statement). The work aims to increase the oil production ratio of PJSC Ukrnafta by introducing pulse-wave technology to the well by improving the filtration and throughput characteristics of the bottom hole and remote areas of the reservoir, ensuring maximum oil production speed and net profit.

Presentation of the main material of the study with a full justification of the obtained scientific results. Despite the unstable macroeconomic situation and a significant drop in prices for oil, gas, and demand for petroleum products in 2020, PJSC Ukrnafta managed to prevent a significant decline in production. The volume of oil production with condensate amounted to 1.5 million tons, natural gas – 1.13 billion m3, liquefied gas production reached 117 thousand tons [1].

In 2020, net sales revenue increased compared to 2019 by UAH 7.3 billion to UAH 35.5 billion. The main factor in the growth of net income in 2020 was the completion of the gas agreement and, as a result, the sale of natural gas produced in 2006 for Naftogaz of Ukraine in the amount of 2.061 billion m^3 worth UAH 12.5 billion (excluding VAT) [17].

Net income from the sale of oil with condensate amounted to UAH 0.9 billion. During 2020, PJSC Ukrnafta continued to operate under regulatory restrictions on the sale of oil and gas condensate through state auctions, and as a result, was forced to purchase its oil for further transfer to the Kremenchuk refinery on toll terms and incurred additional costs, related to the monetization of oil. Net income from gas sales amounted to UAH 14.6 billion, including UAH 12.5 billion from the sale of gas produced in 2006. Net income from the sale of petroleum products in the wholesale segment, resulting from the refining of own oil, increased by UAH 300 million and amounted to UAH 12.0 billion. In the retail segment, net income amounted to UAH 5.4 billion. The cost of goods sold amounted to UAH 18.1 billion [1].

According to the results of 2020, PJSC Ukrnafta received a net profit of 4.3 billion UAH against a loss of 4.1 billion UAH in 2019 and became the largest taxpayer in Ukraine according to the publication «Rating. Business in Official Figures» [18]. The company transferred to the state budget of Ukraine unprecedentedly large tax payments of UAH 47.5 billion, which were used to pay both current tax liabilities and to repay the historical tax debt and accrued penalties.

Due to a significant drop in oil, gas, and oil demand during 2020, PJSC Ukrnafta adjusted the company's capital investment. The company was forced to refuse to postpone part of the organizational and technical measures by the new indicators of economic feasibility. The total amount of capital investments in the reporting year amounted to UAH 1.146 billion – 29% less than in 2019 [1]. At the same time, the company provided financing for operating expenses to maintain the company's assets at the appropriate level. Priority areas of investment were supported for sustainable hydrocarbon production, projects on environmental safety, labor protections, and fire safety. In addition, investments were directed to the development of the company's retail business, renewal of the fleet of special equipment and transport, implementation of IT projects.

In total, Ukrnafta conducted 2 fracturing operations last year, completed overhauls of 133 wells, performed 24 operations using coil tubing units without a cattle brigade, conducted 20 production intensification operations, and decommissioned 107 wells. Thanks to these measures, the company managed to obtain an additional 145.4 thousand tons of oil and condensate and 79.4 million m^3 of natural gas [1].

After analyzing the financial and economic activities and technological and technical characteristics of PJSC Ukrnafta we propose the introduction of pulse-wave technology per well – will allow the company to increase oil recovery by improving the filtration and capacity characteristics of the bottom hole and remote zones. The range should be up to 4.3 km. Based on geological and physical requirements, it is necessary to select a site with a large number of reacting wells (N=21-22) and large residual stock, the flow rate of the well should range from 1.2 to 24 t/day.

Let's perform economic and mathematical modeling for the introduction of this technology. The duration of the technological effect is five years from 2021 to 2025.

The installation will run for five years, after which it will be necessary to lift the equipment, conduct an audit and decide on the further operation or complete replacement.

To assess the economic feasibility of the proposed measure, we use the following key performance indicators:

- net discounted income;
- profitability index;
- the inner hole of profitability [19, p. 27-28].

The cost of one barrel of oil is $ 68.94 USA (as of December 1, 2021), ie a ton of oil with a density of 836 kg/m^3 on the world market costs $ 158.89, or UAH 4,323.39 at the cost of one dollar 27.21 UAH. The cost of one installation is UAH 2.8 million.

The operating coefficient of wells K=0.98. The price of sold oil is P_{2021}=4323.39; P_{2022}= 4338.02; P_{2023}=4351.52; P_{2024}=4365.71; P_{2025}=4381.43 UAH per ton of oil. Income tax rate IT=25%. Conditionally variable costs in the cost of one ton of oil C_s=26.43 UAH/t. We will conduct a mathematical and economic justification for this geological and technical event.

Additional oil production is calculated by the following formula (1):

$$\Delta Qt = q\text{h} \times K_\text{e} \times \text{T} \qquad (1)$$

where ΔQ – additional production for the year, t.;

qh – planned estimated increase, t./day;

K_e – well operation factor;

T – period.

It is necessary to take into account the rate of decline in base production. Use the following formula (2) [20]:

$$\Delta Q'_{2021} = \Delta Q \times T_\text{p} \qquad (2)$$

where $\Delta Q'_t$ – additional production for the year, taking into account the rate of decline in production, t.;

T_p – the rate of decline in production.

$$\Delta Q_{2021} = q_h \times K_e \times T = 17 \times 0{,}98 \times 365 = 6080{,}9 \text{ t.};$$

$\Delta Q'_{2021} = \Delta Q_{2020} \times T_p = 6080{,}9 \times 0{,}892 = 5424{,}16\ \text{t.};$

$\Delta Q'_{2022} = \Delta Q'_{2021} \times T_p = 5424{,}16 \times 0{,}9 = 4881{,}74\ \text{t.};$

$\Delta Q'_{2023} = \Delta Q'_{2022} \times T_p = 4881{,}74 \times 0{,}901 = 4398{,}45\ \text{t.};$

$\Delta Q'_{2024} = \Delta Q'_{2023} \times T_p = 4398{,}45 \times 0{,}905 = 3980{,}6\ \text{t.};$

$\Delta Q'_{2025} = \Delta Q'_{2024} \times T_p = 3980{,}6 \times 0{,}905 = 3602{,}44\ \text{t.}$

Knowing the price of oil and the value of additional production, we can calculate sales revenue by the following formula (3):

$$\Delta B = \Delta Q'_{2021} \times P \quad (3)$$

where ΔB – proceeds from the sale of extracted oil for the year, UAH million;

P – oil sales price, UAH/t.

$\Delta B_{2021} = \Delta Q'_{2021} \times P = 5424{,}16 \times 4323{,}39 = 23{,}5$ UAH million;

$\Delta B_{2022} = \Delta Q'_{2022} \times P = 4881{,}74 \times 4338{,}02 = 21{,}2$ UAH million;

$\Delta B_{2023} = \Delta Q'_{2023} \times P = 4398{,}45 \times 4351{,}52 = 19{,}1$ UAH million;

$\Delta B_{2024} = \Delta Q'_{2024} \times P = 3980{,}6 \times 4365{,}71 = 17{,}4$ UAH million;

$\Delta B_{2025} = \Delta Q'_{2025} \times P = 3602{,}44 \times 4381{,}43 = 15{,}8$ UAH million.

The cost of additional oil production per year can be calculated by the formula (4):

$$\text{C} = \Delta Q'_{2021} \times \text{C}_s \quad (4)$$

where C – costs for preparation of additionally extracted oil, UAH million;

C_s – conditionally variable costs of oil preparation, UAH/t.

$C_{2021} = \Delta Q'_{2021} \times \text{C}_s = 5424{,}16 \times 26{,}43 = 14{,}5$ UAH million;

$C_{2022} = \Delta Q'_{2022} \times \text{C}_s = 4881{,}74 \times 26{,}43 = 12{,}4$ UAH million;

$C_{2023} = \Delta Q'_{2023} \times \text{C}_s = 4398{,}45 \times 26{,}43 = 11{,}1$ UAH million;

$C_{2024} = \Delta Q'_{2024} \times \text{C}_s = 3980{,}6 \times 26{,}43 = 10{,}3$ UAH million;

$C_{2025} = \Delta Q'_{2025} \times \text{C}_s = 3602{,}44 \times 26{,}43 = 9{,}7$ UAH million.

Determine the current costs of the technological event according to the formula (5):

$$C_c = C_r + \text{C} \quad (5)$$

where C_c – expenses for the event, UAH million;

C_r – project implementation costs, UAH million;

C – costs for preparation of additionally extracted oil, UAH million.

$\Delta C_{c2021} = C_r + C_{2021} = 2{,}3 + 14{,}5 = 16{,}8$ UAH million;

$\Delta \mathrm{C}_{\mathrm{c}2022} = \mathrm{C}_{\mathrm{r}} + \mathrm{C}_{2022} = 2{,}3 + 12{,}4 = 14{,}7$ UAH million;

$\Delta \mathrm{C}_{\mathrm{c}2023} = \mathrm{C}_{\mathrm{r}} + \mathrm{C}_{2023} = 2{,}3 + 11{,}1 = 13{,}4$ UAH million;

$\Delta \mathrm{C}_{\mathrm{c}2024} = \mathrm{C}_{\mathrm{r}} + \mathrm{C}_{2024} = 2{,}3 + 10{,}3 = 12{,}6$ UAH million;

$\Delta C_{c2025} = C_r + C_{2025} = 2{,}3 + 9{,}7 = 12$ UAH million.

Increase in profit from the technological event (6):

$$\Delta P = \Delta B - \Delta C_c \qquad (6)$$

where ΔP – profit from the technological event, UAH million;

ΔB – proceeds from the sale of extracted oil for the year, UAH million;

C_c – expenses for the event, UAH million

$\Delta P_{2021} = \Delta B_{2021} - \Delta C_{c2021} = 23{,}5 - 16{,}8 = 6{,}7$ UAH million;

$\Delta P_{2022} = \Delta B_{2022} - \Delta C_{c2022} = 21{,}2 - 14{,}7 = 6{,}5$ UAH million;

$\Delta P_{2023} = \Delta B_{2023} - \Delta C_{c2023} = 19{,}1 - 13{,}4 = 5{,}7$ UAH million;

$\Delta P_{2024} = \Delta B_{2024} - \Delta C_{c2024} = 17{,}4 - 12{,}6 = 4{,}8$ UAH million;

$\Delta P_{2025} = \Delta B_{2025} - \Delta C_{c2025} = 15{,}8 - 12 = 3{,}8$ UAH million.

The total increase in profit for the whole period is UAH 27.5 million.

After determining the profit from the sale of extracted oil, it is necessary to calculate the tax on additional income in the year according to the formula (7):

$$\Delta IT_{AI} = \frac{\Delta P \times IT}{100} \qquad (7)$$

where ΔIT_{AI} – additional income tax, UAH million;

ΔP – profit from the event, UAH million;

IT – income tax.

$\Delta IT_{AI2021} = \frac{\Delta P_{E2021} \times IT}{100} = \frac{6{,}7 \times 0{,}25}{100} = 1{,}13$ UAH million;

$\Delta \mathrm{IT}_{\mathrm{AI}2022} = \frac{\Delta \mathrm{P}_{\mathrm{E}2022} \times \mathrm{IT}}{100} = \frac{6{,}5 \times 0{,}25}{100} = 1{,}05$ UAH million;

$\Delta \mathrm{IT}_{\mathrm{AI}2023} = \frac{\Delta \mathrm{P}_{\mathrm{E}2023} \times \mathrm{IT}}{100} = \frac{5{,}7 \times 0{,}25}{100} = 0{,}89$ UAH million;

$$\Delta \mathrm{IT}_{\mathrm{AI2024}} = \frac{\Delta \mathrm{P}_{\mathrm{E2024}} \times \mathrm{IT}}{100} = \frac{4{,}8 \times 0{,}25}{100} = 0{,}73 \text{ UAH million;}$$

$$\Delta IT_{AI2025} = \frac{\Delta P_{E2025} \times IT}{100} = \frac{3{,}8 \times 0{,}25}{100} = 0{,}68 \text{ UAH million.}$$

As a result, the amount of tax payments for additional oil production from its sale will be equal to UAH 4.48 million, which is 25% of profits.

The increase in cash flow in the year can be determined by the formula (8):

$$\Delta CF = \Delta P - \Delta IT_{AI} \qquad (8)$$

where ΔCF – increase in cash flow, UAH million;

ΔP – profit from the technological event, UAH million;

ΔIT_p – additional income tax, UAH million.

$$\Delta CF_{2021} = \Delta P_{2021} - \Delta IT_{AI2021} = 6{,}7 - 1{,}13 = 5{,}57 \text{ UAH million;}$$

$$\Delta CF_{2022} = \Delta P_{2022} - \Delta IT_{AI2022} = 6{,}5 - 1{,}05 = 5{,}45 \text{ UAH million;}$$

$$\Delta CF_{2023} = \Delta P_{2023} - \Delta IT_{AI2023} = 5{,}7 - 0{,}89 = 4{,}81 \text{ UAH million;}$$

$$\Delta CF_{2024} = \Delta P_{2024} - \Delta IT_{AI2024} = 4{,}8 - 0{,}73 = 4{,}07 \text{ UAH million;}$$

$$\Delta CF_{2025} = \Delta P_{2025} - \Delta IT_{AI2025} = 3{,}8 - 0{,}68 = 3{,}12 \text{ UAH million.}$$

Once you have determined the increase in funds, taking into account all the costs, you need to make sure of the effectiveness of the proposed project based on key performance indicators.

First of all, it is necessary to determine the amount of money from investments we will receive, taking into account the time and risk factors, for this we will calculate the discount rate in each year (9):

$$D = \frac{1}{(1+E)^{(t-1)+0{,}5}} \qquad (9)$$

where D – discount rate;

E – annual discount rate;

t – current year of the settlement period.

$$D_{2021} = \frac{1}{(1+E)^{(t-1)+0{,}5}} = \frac{1}{(1+0{,}20)^{(2021-2021)+0{,}5}} = 0{,}71;$$

$$D_{2022} = \frac{1}{(1+E)^{(t-1)+0{,}5}} = \frac{1}{(1+0{,}20)^{(2022-2021)+0{,}5}} = 0{,}66;$$

$$D_{2023} = \frac{1}{(1+E)^{(t-1)+0,5}} = \frac{1}{(1+0,20)^{(2023-2021)+0,5}} = 0,53;$$

$$D_{2024} = \frac{1}{(1+E)^{(t-1)+0,5}} = \frac{1}{(1+0,20)^{(2024-2021)+0,5}} = 0,38;$$

$$D_{2025} = \frac{1}{(1+E)^{(t-1)+0,5}} = \frac{1}{(1+0,20)^{(2025-2021)+0,5}} = 0,29.$$

The formula uses the annual discount rate set at PJSC Ukrnafta. Discounted cash flow is calculated by the formula (10):

$$DCF = \Delta CF \times D \qquad (10)$$

where DCF – discounted cash flow, UAH million;

ΔCF – increase in cash flow, UAH million;

D – discount rate.

$DCF_{2021} = \Delta CF_{2021} \times D_{2021} = 5,57 \times 0,71 = 3,9$ UAH million;

$DCF_{2022} = \Delta CF_{2022} \times D_{2022} = 5,45 \times 0,66 = 3,6$ UAH million;

$DCF_{2023} = \Delta CF_{2023} \times D_{2023} = 4,81 \times 0,53 = 2,5$ UAH million;

$DCF_{2024} = \Delta CF_{2024} \times D_{2024} = 4,07 \times 0,38 = 1,5$ UAH million;

$DCF_{2025} = \Delta CF_{2025} \times D_{2025} = 3,12 \times 0,29 = 0,9$ UAH million.

The sum of the values of net discounted income from the proposed project is equal to:

$$NVP = \sum DCF_n = 3,9 + 3,6 + 2,5 + 1,5 + 0,9 = 12,4 \text{ UAH million.}$$

Value NPV>0 (positive), the project, in this case, is considered profitable, which indicates the feasibility of financing and implementation of the proposed project.

The index of profitability from the technological event will be determined by the following formula (11):

$$PI = \frac{NVP}{C_r} \qquad (11)$$

where NPV – net discounted income, UAH million;

C_r – costs for technology implementation, UAH million.

$$PI = \frac{NVP}{C_r} = \frac{12,4}{2,3} = 5,4 \text{ UAH million.}$$

The profitability index shows the number of monetary units received for each invested monetary unit for the estimated period of project implementation, taking into account discounts.

Conclusions from this study and prospects for further exploration in this direction. Based on the data obtained, we can conclude that the implementation of this project will provide a stable production profile and the maximum rate of oil recovery, increase the efficiency of hard-to-extract oil reserves from the reservoir and bring not just extra income but net profit. These indicators correspond to the strategy of effective development and the goals of the analyzed company in the field of oil production.

The analyzed method testifies to the intensive development of this scientific and technical direction and its prospects, primarily for increasing oil and gas recovery from formations without the use of chemical reagents and heaters, given the reduction of hydrocarbon production reserves in the world. The advantages are environmental friendliness, efficiency, relatively low cost, and low energy consumption.

Література

1. Офіційний сайт ПАТ «Укрнафта». URL: https://www.ukrnafta.com/audijovana-finansova-zvitnist-pat-2020-rik (дата звернення: 26.10.2022).
2. План розвитку газотранспортної системи. ТОВ «Оператор газотранспортної системи України» на 2022-2031 роки, 49 с.
3. Офіційний сайт «BBC News. Україна». URL: https://www.bbc.com/ukrainian/features-47201376 (дата звернення: 28.10.2022).
4. Офіційний сайт Нафтогаз. Укргазвидобування. URL: https://ugv.com.ua/uk/page/pro-kompaniu (дата звернення: 01.11.2022).
5. Філіпчук О.О. Розроблення методів підвищення ефективності та керування газопотоками систем збору газу виснажених родовищ: автореф. дис. … канд. тех. наук: 05.15.13 Івано-Франківськ, 2019. 183 с.
6. Зоркін А.В., Кикоть К.В., Москаленко Ю.Ю. Зелена книга «Регулювання ринку моторних палив», Київ, 2020, 118 с.

7. Офіційний сайт Нафтогазова асоціація України. URL: http://oilers.org.ua/uk (дата звернення: 01.11.2022).

8. Sun F.J., Zeng Z.Z., Qiu Y.C., et al. Pulse high current power supply used for dredging oil and water wells. *High Voltage Eng*. 1999. 25(2). P. 47-49.

9. Zhou H., Zhang Y., Li H., et al. Generation of electrohydraulic shockwaves by plasma-ignited energetic materials: III. Shock wave characteristics with three discharge loads. *IEEE Trans. Plasma Sci*. 2015. 43(12). P. 4017-4023.

10. Lu X.P. Theoretical and experimental research on electrohydraulic pulsed plasma. Huazhong University of Science and Technology. Wuhan. China. 2001.

11. Chen W., Maurel O., Reese T., et al. Experimental study on an alternative oil stimulation technique for tight gas reservoirs based on dynamic shock waves generated by pulsed arc electrohydraulic discharges. *J. Petrol. Sci. Eng*. 2012. 88(89). P. 67-74.

12. Li X., Chao Y., Wu J., et al. Study of the shock waves characteristics generated by underwater electrical wire explosion. *J. Appl. Phys*. 2015. 118(2). P. 3451-3462.

13. Jiayuan He, Rusheng Zhang, Jingchen Zhang, Meijuan Liu, Osuji Nicholas Izuchukwu. Experimental evaluation of near wellbore stimulation – using electrical explosion shockwave on tight sand reservoir. Oil & Gas Science and Technology – Revue d'IFP Energies nouvelles. *Institut Français du Pétrole*. 2018. 73. 60 p.

14. W. Chen et al. Experimental study on an alternative oil stimulation technique for tight gas reservoirs based on dynamic shock waves generated by Pulsed Arc Electrohydraulic Discharges. *Journal of Petroleum Science and Engineering*. 2012. 88(89). P. 67-74.

15. Aici Q., Yongmin Z., Bin K., et al. Application of high power pulse technology in unconventional gas development. Proceeding for 2012 CAE/NEA Energy Forum. *Coal Industry Press*. Beijing. China. 2012. P. 1112–1115.

16. Kharchenko Ye., Hutyi A., Haiduk V. The influence of friction forces on longitudinal wave propagation in a stuck drill string in a borehole. *Tribolog*y. 2018. Vol. 282. No. 6. P. 79-87.

17. Khrystyna Danylkiv, Khrystyna Gorbova. Comprehensive assessment of financial condition of enterprise on the basis of performance reporting: calculated approach. Innovation Technologies in Economy and Society. Series of monographs Faculty of Architecture, Civil Engineering and Applied Arts Katowice School of Technology Monograph 20. Za tekst, odwołania, materiały i ilustracje odpowiadają autorzy Copyright by Wyższa Szkoła Techniczna w Katowicach, Katowice. 2018. P. 25-44.

18. Офіційний сайт Рейтинг. Бізнес в офіційних цифрах. URL: https://rating.zone/top-200-najbilshykh-kompanij-ukrainy-za-sumoiu-splaty-podatkovykh-platezhiv-za-2020-rik/ (дата звернення: 02.11.2022).

19. Іщук С.О. Моделі інтегрального оцінювання результатів фінансово-господарської діяльності промислових підприємств регіону. *Регіональна економіка*. 2008. №2. С. 25-33.

20. Гринькевич О.А., Кіндрацька Г.І. Інформаційно-аналітичне забезпечення управління діловою активністю підприємств. *Економічний аналіз*. 2010. Вип. 6. С. 215-218.

References

1. The official site of the PJSC Ukrnafta (2020), “Audited financial statements of PJSC Ukrnafta for 2020“, available at: https://www.ukrnafta.com/audijovana-finansova-zvitnist-pat-2020-rik (Accessed 26 October 2022).

2. LLC “Operator of the gas transmission system of Ukraine”(2021), Plan rozvytku hazotransportnoi systemy [Gas transmission system development plan for 2022-2031], LLC “Operator of the gas transmission system of Ukraine”, Kyiv, Ukraine.

3. The official site of the BBC News. Ukraine (2019), “Warm up without Russia. Will there be enough gas in Western Ukraine?“, available at: https://www.bbc.com/ukrainian/features-47201376 (Accessed 28 October 2022).

4. The official site of the Oil and Gas. Ukrgazvydobuvannya (2020), “Ukraine and its role in the European gas market“, available at: https://ugv.com.ua/uk/page/pro-kompaniu1 (Accessed 1 November 2022).

5. Filipchuk, O.O. (2019). “Development of methods to increase the efficiency and control of gas flows of gas collection systems of depleted fields”, Ph.D. Pipeline Transport, Oil and Gas Storage Facilities, Ivano-Frankivsk University of Oil and Gas, Ivano-Frankivsk, Ukraine.

6. Zorkin, A.V., Kykot, K.V. and Moskalenko, Yu.Yu. (2020), *Zelena knyha rehuliuvannia rynku motornykh palyv* [Green book “Regulation of the motor fuel market”], Kyiv, Ukraine.

7. The official site of the Oil and Gas Association of Ukraine (2022), available at: http://oilers.org.ua/uk (Accessed 1 November 2022).

8. Sun, F.J., Zeng, Z.Z., Qiu, Y.C., et al. (1999), “Pulse high current power supply used for dredging oil and water wells”, *High Voltage Eng*, vol. 25(2), pp. 47-49.

9. Zhou, H., Zhang, Y., Li, H., et al. (2015), “Generation of electrohydraulic shockwaves by plasma-ignited energetic materials”, *III. Shock wave characteristics with three discharge loads, IEEE Trans. Plasma Sci*, vol. 43(12), pp. 4017-4023.

10. Lu, X.P. (2001), *Theoretical and experimental research on electrohydraulic pulsed plasma*, Huazhong University of Science and Technology, Wuhan, China.

11. Chen, W., Maurel, O., Reess, T., et al. (2012), “Experimental study on an alternative oil stimulation technique for tight gas reservoirs based on dynamic shock waves generated by pulsed arc electrohydraulic discharges”, *J. Petrol. Sci. Eng*, vol. 88(89), pp. 67-74.

12. Li, X., Chao, Y., Wu, J., et al. (2015), “Study of the shock waves characteristics generated by underwater electrical wire explosion”, *J. Appl. Phys*, vol. 118(2), pp. 3451-3462.

13. Jiayuan He, Rusheng Zhang, Jingchen Zhang, Meijuan Liu, Osuji Nicholas Izuchukwu (2018), “Experimental evaluation of near wellbore stimulation – using electrical explosion shockwave on tight sand reservoir”, Oil & Gas Science and

Technology – Revue d'IFP Energies nouvelles, *Institut Français du Pétrole*, vol. 73, 60 p.

14. Chen, W. et al. (2012), "Experimental study on an alternative oil stimulation technique for tight gas reservoirs based on dynamic shock waves generated by Pulsed Arc Electrohydraulic Discharges", *Journal of Petroleum Science and Engineering*, vol. 88(89), pp. 67-74.

15. Aici, Q., Yongmin, Z., Bin, K., et al. (2012), "Application of high power pulse technology in unconventional gas development", Proceeding for 2012 CAE/NEA Energy Forum, *Coal Industry Press*, Beijing, China, pp. 1112-1115.

16. Kharchenko, Ye., Hutyi, A. and Haiduk, V. (2018), "The influence of friction forces on longitudinal wave propagation in a stuck drill string in a borehole", *Tribolog*y, vol. 282, no 6, pp. 79-87.

17. Danylkiv, Kh. and Gorbova, Kh. (2018), *Comprehensive assessment of financial condition of enterprise on the basis of performance reporting*, Wyższa Szkoła Techniczna w Katowicach, Katowice, Poland.

18. The official site of the Rating (2020), "Business in Official Figures", available at: https://rating.zone/top-200-najbilshykh-kompanij-ukrainy-za-sumoiu-splaty-podatkovykh-platezhiv-za-2020-rik/ (Accessed 2 November 2022).

19. Ishchuk, S.O. (2008), "Models of integrated evaluation of the results of financial and economic activities of industrial enterprises in the region", *Rehionalna ekonomika*, vol. 2, pp. 25-33.

20. Hrynkevych, O.A. and Kindratska, H.I. (2010), "Information and analytical support of business activity management". *Ekonomichnyi analiz*, vol. 6, pp. 215-218.

Стаття надійшла до редакції 09.11.2022 р.