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ARTICLE

METHODOLOGICAL APPROACHES TO ECONOMIC JUSTIFICATION OF INDUSTRIAL DEVELOPMENT OF OIL FIELDS

Marat R. Safiullin[1*], Amur F. Yartiev[1,3], Aliya A. Abdukaeva[1,2]

[1]Kazan Federal University, 18 Kremlyovskaya str., Kazan, 420008, RUSSIA

[2]State Budgetary Institution Center of Perspective Economic Researches of Academy of Sciences of the Republic of Tatarstan, 23/6 Karl Marx Str., 420111, Kazan, RUSSIA

[3]Tatnipineft Institute of PJSC Tatneft, 32 M. Djalil Str., 423230 Bugulma, Republic of Tatarstan, RUSSIA

ABSTRACT

The oil industry is an example of a high-risk business. The first risk appears already at the stage of well drilling - whether the well will produce oil or will be "dry". In addition, there are uncertainties associated with the political and economic situation in the world, changes in the world oil prices. Involvement in the development of hard-to-recover oil reserves is associated with the upcoming increase in efforts to extract them, which will ultimately affect the production cost. Energy resources are extracted primarily for the purpose of generating energy, so it is important to know the level of energy costs, which can become a criterion for the economic efficiency of an oil field. The application of method proposed by us and used to calculate the technical and economic indicators of oil production based on the total energy costs allows estimating the maximum production rate of the well and the maximum water cut of the extracted oil and gas, regardless of fluctuations in the world prices for these energy carriers and changes in the state tax policy.

KEY WORDS
energy resources, energy costs, oil producing fields, oil production, energy costs, tax system.

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***Corresponding Author**
Email: C.p @tatar.ru
Tel.: +7 987 297 06 79

INTRODUCTION

Increased industry competition and unstable profitability are inherent in today's oil industry. There is a problem of constant containment of cost growth. The end of the "era of light oil" and the increase in capital intensity of the oil industry are reflected in increased costs.

The oil industry is an energy-intensive industry of the Russian Federation. Therefore, special attention is paid to the limit of well operation and timely shutdown or transfer to other categories at the present stage of its development. This is due to the fact that many of the country's oil fields have entered the late stage of development, which is characterized by high water cut with a low production rate of the wells [5-12].

The current regulations for the preparation of design technological documents for the development of oil and gas and oil fields are "Temporary Guidelines for the Preparation of Technical Projects for the Development of Hydrocarbon Deposits" (hereinafter - TG), which determines the forecasting and comparison of technical and economic indicators for the predicted and cost-effective period of field development. The economic limit of field development is determined by the last year of profitable facility operation. The technological limit of the production well operation is determined on the basis of the water cut of the produced products at the level of 98%.

We propose to determine the field operation limit using the total energy costs. The approach taken to justify the well operation limit based on the level of energy costs was previously considered in the scientific papers [1–5]. Firstly, the energy equivalent of the extracted oil and associated gas extracted with it is determined, then the energy costs for producing hydrocarbon raw materials are determined.

The approach taken as a basis was supplemented by measuring the energy costs necessary for servicing wells and eliminating oil production facilities, oil and gas transport, maintenance systems for reservoir pressure and oil preparation, as well as reclamation of mining allotment lands, which significantly changes the results.

MATERIALS AND METHODS

The universal nature of the proposed energy-economic approach is as follows [13-17]:

- Only energy costs are used, which are converted into fuel equivalent through the calorific value of the group concerned;
- The calorific value of oil, gas, etc. are independent of fluctuations in the world and domestic oil and gas prices;
- The current tax system and its changes do not affect the ultimate energy equivalent;
- The last settlement year of the assessment of technical and economic indicators of oil field development is determined;
- The marginal production rate of the producing well and the maximum water cut of the product are estimated.

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The decision to stop calculating the technical and economic indicators of the field development is made on the basis that the energy costs exceed the energy equivalent of the produced products of the well (field). This provision is substantiated by the fact that the bulk of the oil produced is currently used as fuel with a certain refining depth, which needs to be increased [18, 19].

The total energy costs minus unforced losses can be aggregated into 5 groups:

- Oil and associated gas for own needs;
- Electric energy costs, taking into account losses in power lines;
- Thermal energy costs for the oil preparation;
- Oil product costs for well servicing and facility liquidation;
- Propane and acetylene costs for facility liquidation.

$$Э_з = Q_{нн} * m_н + Q_{пгн} * m_г + Э_э * \sigma * \frac{Q_{тов}}{1-B} + Э_т * m_г + , \\ + \left(э_п^1 + э_п^2\right) * m_п + Э_{c3н8} * m_{c3н8} + Э_{сн=сн} * m_{сн=сн} \quad (1)$$

where: $Э_з$ - total energy costs, kgoe;

$Q_{тов}$ - commodity volume of oil production, t;

$Q_{нн}$ - oil for own needs, t;

$Q_{пгн}$ - amount of associated petroleum gas for own needs, m3;

$Э_э$ - electricity costs, taking into account losses in power lines for extraction, transportation, preparation of oil and gas and maintenance of reservoir pressure, kWh/t;

$Э_т$ - thermal energy costs for oil preparation, kWh;

$Э_п^1$ - petroleum product costs for maintenance and operation of equipment, overhaul and current repair of wells, workshop and general production costs and application of oil recovery increase methods, t;

$Э_п^2$ - oil product costs for the elimination of wells, dismantling of well sites and gauges, oil gathering systems, maintaining reservoir pressure and oil treatment, pipelines, high-voltage lines and substations, removal of dismantled structures and land reclamation, t;

$Э_{c3н8}$ - propane costs for dismantling well sites and metering devices, oil gathering systems, maintenance of reservoir pressure and oil preparation, pipelines, high-voltage lines and substations, m3;

$Э_{сн=сн}$ - acetylene costs for dismantling well sites and metering devices, oil gathering systems, maintenance of reservoir pressure and oil preparation, pipelines, high-voltage lines and substations, m3;

$m_н$ - calorific value of oil, kgoe/t;

$m_г$ - calorific value of associated petroleum gas, kgoe/m3;

$m_п$ - calorific value of oil products, kgoe/t;

$m_{c3н8}$ - calorific value of propane, kgoe/m3;

$m_{сн=сн}$ - calorific value of acetylene, kgoe/m3;

σ - specific consumption of equivalent fuel for electricity generation, kgoe/kWh;

B - water fraction in the withdrawn liquid, unit fractions.

By transforming formula 1, we can obtain a formula that allows determining the total energy costs for one production well:

$$\gamma_з = q_н * m_н * \left(k_{сн} + \frac{k_{сг} * q_г}{1000}\right) + \gamma_э * \frac{q_н * \sigma}{1-B} + \gamma_{ппд} * k_о * \frac{q_н}{1-B} * \frac{N_{нагн}}{N_{доб}} * \sigma + \\ + \gamma_{под} * \frac{q_н}{l} * \sigma + \left(\gamma_п^1 + \gamma_п^2 + \gamma_п^3 * \frac{N_{нагн}}{N_{доб}}\right) * m_п + \left(\gamma_{c3н8}^1 + \gamma_{c3н8}^2 * \frac{N_{нагн}}{N_{доб}}\right) * , \\ * m_{c3н8} + \left(\gamma_{сн=сн}^1 + \gamma_{сн=сн}^2 * \frac{N_{нагн}}{N_{доб}}\right) * m_{сн=сн}$$

(2)

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where: $\gamma_з$ - specific energy costs, kgoe;

$q_н$ - oil flow rate, t/day;

$q_г$ - gas factor, m3/t;

$k_{сн}$ - oil fraction for own needs, units fractions;

$k_{сг}$ - associated gas fraction for own needs, unit fractions;

k_o - oil selection compensation ratio by water injection, unit fractions;

$N_{нагн}$ - number of injection wells, wells;

$N_{доб}$ - number of producing wells, wells;

$\gamma_э$ - specific energy costs, taking into account losses in power lines for the extraction and transportation of oil and gas, kWh/t;

$\gamma_{ппд}$ - specific energy costs, taking into account losses in power lines to maintain reservoir pressure, kWh/m3;

$\gamma_{под}$ - specific electricity costs, taking into account losses in power lines for oil treatment, kWh/t;

γ_n^1 - specific petroleum product costs for maintenance and operation of equipment, overhaul and current repair of wells, workshop and general production costs and application of oil recovery increase methods, t/well;

γ_n^2 - specific oil product costs for of well elimination, dismantling of well sites and metering devices, oil gathering systems, oil treatment, oil and gas pipelines, high-voltage lines and substations, removal of dismantled structures and land reclamation, t/well;

γ_n^3 - specific oil product costs for dismantling the maintenance system for reservoir pressure, water pipelines, power lines, removal of dismantled structures and land reclamation, t/well;

$\gamma_{с3н8}^1$ - specific propane costs for dismantling well sites and metering devices, oil gathering systems, oil treatment, oil and gas pipelines, high-voltage lines and substations, m3/well;

$\gamma_{с3н8}^2$ - specific propane costs for maintenance systems for reservoir pressure, water conduits and power lines, m3/well;

$\gamma_{сн=сн}^1$ - specific acetylene costs for dismantling well sites and metering devices, oil gathering systems, oil treatment, oil and gas pipelines, high-voltage lines and substations, m3/well;

$\gamma_{сн=сн}^2$ - specific acetylene costs for dismantling of maintenance systems for reservoir pressure, water conduits and power lines, m3/well;

l - oil fraction in the fluid passed through the oil treatment unit, unit fractions.

RESULTS

[Fig. 1] shows the enlarged structure of energy costs at a well flow rate of 1 t/day for oil and various water cuts of produced products. The water cut varies from 80 to 99 percent in increments of 1%.

The largest relative share in energy costs is represented by conditionally fixed energy costs, which include: costs of fuel, propane and acetylene attributable to the elimination of production, transportation, oil treatment and reservoir pressure maintenance systems; energy costs as a part of oil and gas costs for own needs; oil product costs for well servicing and maintenance of current oil production. The conditional variable ones include energy costs, depending on the current well flow rate, which are as follows: electricity costs for extraction to the surface, transportation, preparation and maintenance of reservoir pressure; heat energy costs for oil preparation [Fig. 1] shows that when the water cut of the extracted products exceeds 90%, the conditionally variable costs begin to increase significantly.

In the Republic of Tatarstan, the potential energy content in 1 ton of extracted Devonian oil and associated gas extracted with it is 1,456.29 kg of oil equivalent, taking into account losses for technical reasons. Oil losses account for 0.6% and associated petroleum gas - 1.3%.

[Fig. 2] shows the dependence of the total energy costs on the water cut of the product at different oil production rates for the producing well.

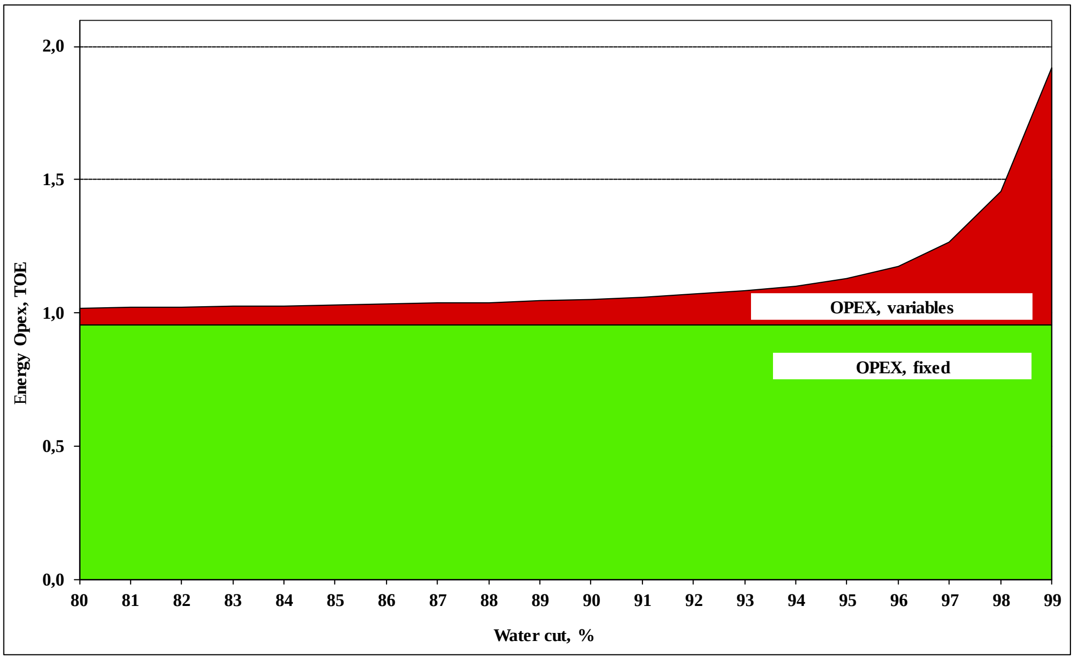

Fig. 1: Energy costs vs. water cut.

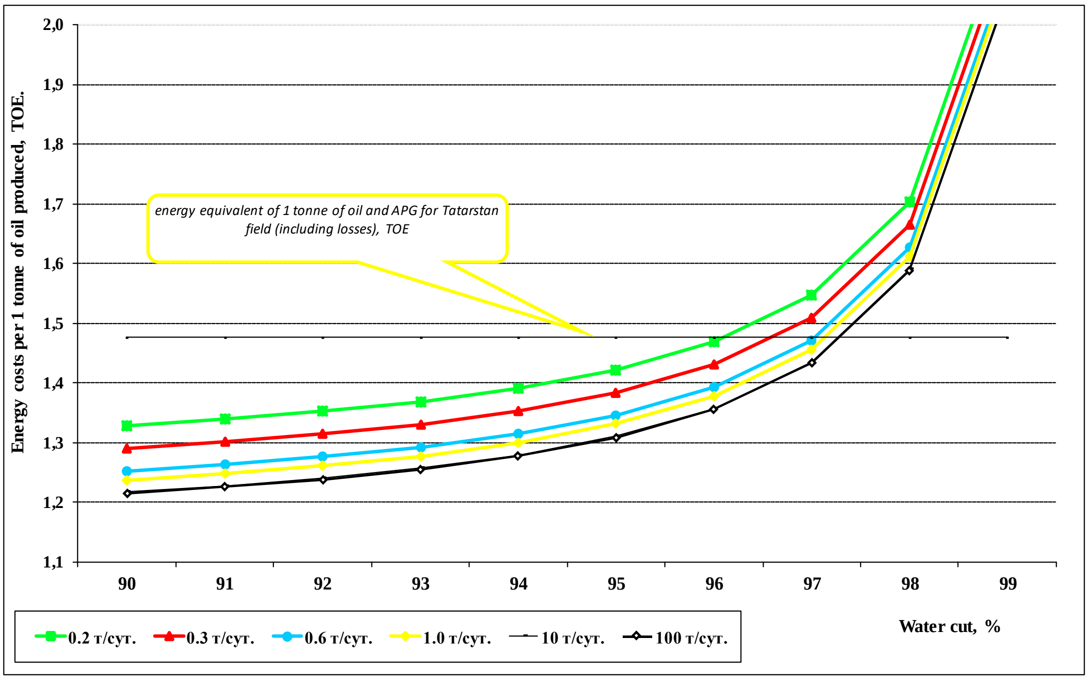

Fig. 2: Energy costs vs. oil production rate and water cut.

SUMMARY

The dependence given in [Fig. 2] shows that, the total energy costs will exceed the energy equivalent of the produced oil and associated gas with a well production water cut of 97% with an average daily production rate of 1 ton and above. Oil production at water cut above the indicated value will indicate unjustified energy consumption. The average daily oil production rate of more than 10 tons does not have any effect on the total energy costs, since the energy dependence curves at a production rate of 10 and 100 t/day are very close. If we consider low-production and high-water cut wells, then the water cut limit can be considered 96% for wells with an oil production rate of up to 0.2 t/day, 96.5% for wells with an oil production rate of 0.2 to 0.4 t/day and 97% for wells with an oil production rate of 0.5 t/day and higher.

CONCLUSION

The application of the proposed method for determining the calculation limit of technical and economic indicators for oil field development on the basis of total energy costs allows estimating the maximum production rate of wells and the maximum water cut of produced products, regardless of fluctuations in world oil and gas prices and, most importantly, changes in the state tax policy regarding mining taxation. The proposed energy equivalent shall be recalculated, if we use extracted oil and associated gas as raw materials for petrochemicals.

CONFLICT OF INTEREST

There is no conflict of interest.

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