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Resource Conservation as the Main Factor in Increasing the Resource Efficiency of Russian Gas Companies

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Abstract: The complex modern trends in the growth of the consumption of raw hydrocarbon materials around the world, and as a consequence their accelerated depletion, have forced oil and gas industry enterprises to identify progressive resource-saving methods and technologies. Such methods could enable the environmental and technological effects of production processes to be achieved under conditions of sustainable economic development and with a policy of balanced consumption and resource provision. This research is devoted to the improvement of the scientific and methodological foundations and the development of predictive and analytical tools for assessing the efficiency of resource use in gas industry enterprises. With the application of the proposed instruments, we carry out simulation modeling of the efficiency of natural gas production, processing and pipeline transportation companies. In the course of a comparative analysis of the efficiency indicators for Russian gas companies, a resource-efficient variant of their development is selected and the most promising business projects are identified. Three branch companies of the Russian gas industry are accepted as the objects of the research in this study. As a result of the conducted approbation process, it is revealed that the existing practice of assessing consumption and resource provision in companies in the industry, as well as the use of methods and approaches to resource conservation, does not have a single and complex character. The methodology proposed by the authors makes it possible to approach industry companies with the same set of indicators, systematize and calculate them, identify existing unused reserves for resource conservation and identify promising resource-efficient projects.

Keywords: gas industry; industrial enterprises; resource efficiency assessment; resource consumption; resource conservation; selection of resource-efficient projects

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1. Introduction

The leading activities of the Russian gas industry are related to the extraction, processing and pipeline transportation of natural gas. Produced natural gas in Russia remains the main energy resource both in the domestic and the foreign markets. Natural gas is supplied to consumers via pipeline transport as a finished product or undergoes deep processing at gas processing enterprises. The production structure of the gas industry enterprises is complex and multisectoral, and the production processes are resource-intensive. Regarding this, the rational use of production resources is the main direction for improving the efficiency of Russian companies, and in particular the gas industry. This approach requires the development of modern methods for the efficient use of resources and the application of a valid methodology for assessing resource efficiency. In conditions of constant uncertainty and increasing complexity for production risks, a focus on the principles of sustainable development and increased resource efficiency is becoming the most relevant area of research for many research teams.

A review of the literary sources showed that they form in general four separate groups for the problems we are considering. The disadvantages of each group are presented in Table 1.

Table 1. The main research groups in the field of resource efficiency.

Group	Authors	Research Content	Disadvantages
I	[1–17]	Includes studies aimed at the balanced provision of energy resources for production processes and reduced consumption.	The studies consider only the production task of providing resources and consuming them. The resources include only electric energy and natural gas. Material, investment, innovation and other resources of the company are not taken into account at all when identifying reserves for improving energy efficiency.
II	[18–33]	Considers the tasks involved in increasing energy and resource efficiency by reducing the load on the environment and assessing energy efficiency.	The authors narrowly try to solve the problem of increasing energy efficiency from an environmental point of view and do not consider the problem in the complex mix of economic, investment, innovation and other areas of the company's activities.
III	[34–47]	Devoted to identifying reserves for resource conservation and resource efficiency growth. The authors consider the process of modeling efficient energy systems at the regional and national levels.	The studies are relevant, but their aggregation reduces their applicability to production systems and individual companies, and they also have regional and national specificities.
IV	[42–45]	Examines the impacts of innovations on improving resource efficiency.	Studies assessing the impacts of innovations on improving resource efficiency do not sufficiently take into account the specifics of production systems; therefore, their application is not possible.

It should be mentioned that the existing methods for assessing resource conservation and improving resource efficiency in relation to gas industry enterprises are insufficiently developed [1,2,11–15]. The studies in this field mainly include the development of optimization models of energy consumption and the provision of specific territories and regions with them [15,16,33–39,45–51]. Additionally, the production models in the various studies solve only individual resource-saving tasks, are scattered and do not have a systematic and targeted nature [7–9,40,41].

Various authors have conducted research to identify the economic effects of the implementation of resource-saving measures in production processes to obtain savings from reducing energy consumption [7–9,13] and, in particular, at oil and gas industry enterprises [1,2,5,9–11,21]. The research focuses on the expansion and refinement of the concept of the efficiency of fuel and energy resources and the testing of methodological, scientific and practical approaches that determine the requirements for the rational use of fuel and energy resources [18,19].

One of the most significant European documents is the United Nations Environment Program, which includes a number of state regulatory measures in the fields of energy conservation and energy efficiency improvement [18]. Most authors consider the problem of increasing the resource efficiency of production systems through reducing the environmental load and improving climate policies [4,20–33]. In this regard, it is advisable to reduce the task of increasing the resource efficiency to the search for agreed scenarios for the development of gas industry companies. These scenarios should correspond to the maximum approximation of the selected system of economic and resource indicators to the goals characterizing the development of the gas industry as effective. At the same time, resource-efficient development (e.g., an increase in gross product per capita, an improvement in the quality of life) is directly related to an increase in the efficiency of the processes of production, processing, provision and consumption of resources.

To solve this task, predictive and analytical tools and information technologies are needed that would allow for scientifically sound forecasts of the results of resource-saving policies to form balanced systems of targets for the resource efficiency growth of industry companies and to assess their achievability.

In publications devoted to resource-saving policies, a large number of authors have considered the methods of efficient use for certain types of energy resources in the form of creating simple models [7–9,13], while other authors have focused on modeling complex multifactor systems of rational resource consumption for manufacturing companies and countries as a whole [3,6,14,29,39–43].

Some authors emphasize the importance of introducing innovation in solving issues of resource efficiency growth [48–50]. The most developed methods and tools for making design decisions in the oil and gas industry are the earlier works of scientists [47,51] who have practical experience in the implementation and assessment of the applicability of computational and analytical models and their comparative characteristics.

In [36,37,39–44,47], the methodological aspects of modeling economic and energy systems and the existing limitations of their application for short- and medium-term forecasting are considered. One of the main elements of modeling the fuel and energy complex of the country is the relationship with other sectors of the economy. In [46], an assessment of more than two hundred models of the efficient use of energy resources, which were used to model the energy balances of national economies, is presented.

The modeling of the efficiency of energy systems at the regional and national levels is considered in [14–17,34–36,50,51], the authors of which believe that the development of global energy systems is possible by improving existing and developing new methodological materials and instructions, in order to assess the levels of energy conservation and energy efficiency and determine the balanced provision and consumption of energy resources.

The authors of [6,45] considered the "computable general equilibrium models", which allow calculations of the rational consumption and balanced provision of resources. Such models are most effective for assessing the consumption of the energy resources of individual territories and industries, as well as the results of energy and environmental policies [16,39–44]. Systems capable of predicting the impacts of external factors are the most in demand and are used to evaluate the results of resource-saving and resource-efficient activities [15].

In some studies [1,2,5,10–12,20], the authors have paid special attention to the development and forecasting models reflecting the specifics of the oil and gas industry and including general principles of the formation and expenditure of resources of companies and industries, as well as the creation of statistical information databases.

The authors analyzed various types of predictive and analytical models of consumption and the provision of resources for industry companies, the methods used in forming the fuel and energy balance; multifactorial simulation models of efficient resource consumption, multivariate and scenario forecast models, balance models based on multi-criteria optimization and others. In our opinion, the most applicable for the gas industry is the model information complex (SCANER), developed by the Russian Institute for Energy Research, which allows for systematic studies of the development of the fuel and energy complex. This methodological approach using a model information complex is widely used by various scientists to forecast the energy requirements of the world, individual states, industries and large companies [52,53].

An analysis of the literature sources showed that the existing papers on the formation of regional and sectoral fuel and energy balances do not fully meet the urgent need for the sectoral development of the country's energy model [39–44]. In particular, they lack tools for the formation of forecast energy balances, and also do not solve the problems related to the rational consumption of resources and the balanced provision of oil and gas to other sectors of the state economy.

In difficult competitive conditions for gas industry companies, the main direction in improving the efficiency of their activities remains the identification of resource-saving reserves. Therefore, the developed methods should be based on an integrated approach, including the selection of such indicators that will help in determining resource-saving effects, assessing the overall effectiveness of an industry company and developing promising directions for resource-efficient development.

The purpose of this study is to develop methodological tools for assessing the resource efficiency of gas companies as a basis for balanced resource supply and the rational consumption of resources.

The structure of the presented research paper includes four sections. The introduction examines the relevance and reviews the literature for the existing methods and tools in the field of the resource efficiency of industrial companies and formulates the purpose of the study. The second section is devoted to substantiating the methodology for a comprehensive assessment of the resource efficiency of gas companies. The third section presents the results of the study and discusses the methodology developed by the authors in relation to the gas industry companies. The fourth section presents the main conclusions of the research.

2. Materials and Methods

The resource-efficient development of any manufacturing company directly depends on its elaborated optimal strategy. Due to the complex and rapidly changing market conditions related to alterations in the volume of natural gas production and supply, the leading companies in the gas industry act as the main centers of control over resource consumption and resource conservation.

In order to regulate industry and corporate relations in the sphere of resource consumption and the balanced provision of such resources by gas industry companies, it is necessary to create a methodology for comprehensive assessments of resource efficiency. The concept of its creation is based on the organizational and methodological scheme of the interaction of gas industry companies with economic entities in the market, including industrial and non-industrial sectors of the economy, the population, public administration bodies and other market participants characterizing the market balance of the supply and demand of energy resources (Figure 1).

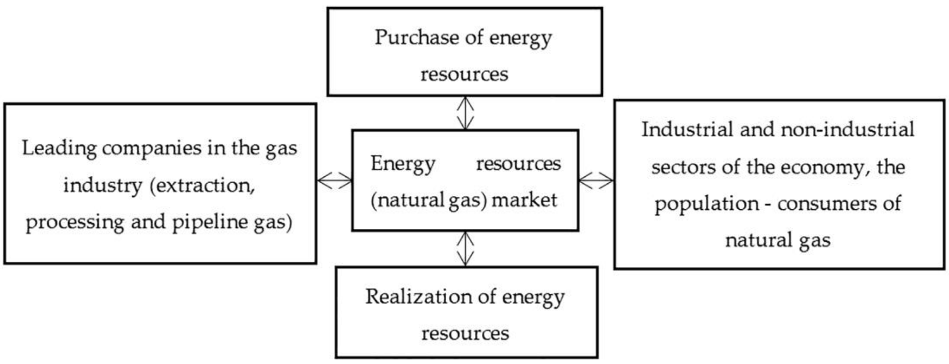

Figure 1. The main economic entities of the gas industry.

In accordance with the All-Russian Classifier of Economic Activities (OKVED) [54], the main subjects of the gas industry are the leading companies involved in the extraction, processing and pipeline transportation of natural gas.

The leading companies in the gas industry produce the main products that they sell on the domestic or foreign market. This includes intermediate consumption goods and services (including energy resources used for processing, conversion and final use) and investment and consumer goods and services [52,53].

The main products of the leading companies in the gas industry include natural gas, dry gas, liquefied gas, gas processing products and electric and thermal energy.

The methodology proposed by the authors for the comprehensive assessment of resource efficiency includes the construction of a simulation economic and mathematical model of an industry company. To this end, it is necessary to establish internal control and evaluation criteria for analyzing consumption and providing resources at the company level. The simulation model of the activity of an industry company is described by the authors in this study as having two directions of production functions: (1) as producers forming the market supply; (2) as consumers forming the demand for intermediate products (including energy resources).

The aggregated production function of the leading company $i \in Igp$, which is part of the gas industry and generates fund and resource flows, can be represented as follows:

(1) Flow of products produced by companies (production, processing and transport):

$$Z_i^{out}(t) = \min\left\{Z_i^{prog}(t), Z_i^{poten}(t), Z_i^{dem}(t) + \Delta Z_i(t)\right\}, \quad (1)$$

(2) Flow of input production resources:

$$Z_i^g(t) = A_i(t) Z_i^s(t), \quad (2)$$

(3) Flow of funds from the sale of company products (production, processing and transport):

$$d_i^s(t) = \left(Z_i^{out}(t) - \Delta Z_i(t)\right) P_I^T(t), \quad (3)$$

(4) Outflow of funds for the supply of products and production resources:

$$d_i^g(t) = Z_i^g(t) \hat{P}_I^T(t), \quad (4)$$

where $Z_i^{out}(t)$ is the column vector of the actual production for the i-th agent (in natural measurement units); $Z_i^{prog}(t)$ is the column vector of the forecasted output (in natural measurement units); $Z_i^{pot}(t)$ is the potential production volume of the i-th agent, depending on the state and use of production resources (in natural measurement units); $Z_i^{dem}(t)$ is the vector of demand for products produced by the i-th agent (in natural measurement units); $\Delta Z_i(t)$ is the vector of production growth rates of the i-th agent (in natural measurement units); $Z_i^g(t)$ is the column vector of consumed resources (in natural measurement units); A_I is the cost matrix of the i-th agent, as consumed resources per unit of output; $d_i^s(t)$ is the agent's revenue from product sales (in cost measurement units); $d_i^g(t)$ is the agent's cost for acquiring resources (in cost measurement units); $P_I(t)$ is the column vector of product prices (in cost measurement units); $\hat{P}i(t)$ is the column vector of product prices for consumers in the market (in cost measurement units).

The potential output of the i-th agent is calculated as follows:

$$Z_I^{pot}(t) = C_I \sqrt{p_I(t) h_i(t) r_i(t)}, \quad (5)$$

where C_i is the vector characterizing the scale of production with indicators of production factors; $p_i(t)$ is the cost of the fixed assets of the i-th agent; $h_i(t)$ is the number of people employed in production; $r_i(t)$ is the labor productivity gain.

In the scheme of the interaction of the gas industry with economic agents in the markets of conditional products and hydrocarbons, the equilibrium state is maintained by the commodity–sector balance (CSB), formed on the basis of the system of national accounts [53]. A building balance is provided for all conditional products used in the model and 15 types of fuel and energy resources. For example, the balance of the j-th type of fuel and the energy resources $j \in J_{TER}$ in physical terms can be represented as:

$$z_j^{s1}(t) + z_j^{s2}(t) + z_j^{s3}(t) + z_j^{s4}(t) = z_j^{out}(t) - z_j^{exp}(t) + z_j^{imp}(t) - \Delta z_j(t) \quad (6)$$

On the left side of Expression (6), the demand for resources for the j-th type in the gas industry is presented as the product of electrical and thermal energy $\left(z_j^{s1}\right)$, gas processing (z_j^{s2}), the consumption as non-energy raw materials (z_j^{s3}) and end use (z_j^{s4}). The components

z_j^{s1}, z_j^{s2} represent the costs of acquiring fuel and energy resources by the leading companies that are part of the gas industry. The values z_j^{s3} and z_j^{s4} represent the volume of consumption of the *j*-th type of hydrocarbons in gas processing and the volumes of consumption of the *j*-th type of resources by all companies in the gas industry.

The right side of the balance model (Equation (6)) shows the volume of supply of the *j*-th type of product in the hydrocarbon market, where z_j^{out} is the volume of output of the *j*-th type of products by all companies in the gas industry; z_j^{exp} is the export of the *j*-th type of hydrocarbons; z_j^{imp} is the acquisition of the *j*-th type of import resources; Δz_j is the change in stocks of the *j*-th type of resources. In monetary terms, the balance expression for the *j*-th type of resources can be represented as:

$$\left(z_j^{s1}(t) + z_j^{s2}(t) + z_j^{s3}(t) + z_j^{s4}(t)\right)\hat{p}_j(t) = (z_j^{out}(t) - z_j^{exp}(t) - \Delta z_j(t)p_i(t) + z_j^{imp}(t)\hat{p}_j(t) + \Delta d_j \quad (7)$$

where $\hat{p}_j$ is the average consumer price of the *j*-th type of resources in the hydrocarbon market; p_j is the average producer price of the *j*-th type of resources; Δd_j is the trade mark-up for the *j*-th type of resources.

The balance ratios (Equations (6) and (7)) are part of the overall commodity sector balance, and through inter-balance relations allow the modeling of the mutual influence of the gas industry and other sectors of the economy.

The solution to the problem of increasing the resource efficiency and economic growth of the gas industry companies comes down to finding the best options for their development if the system of indicators proposed by the authors is used.

For a comprehensive assessment of increasing the resource efficiency of a leading company (segment, industry), we propose the use of Formula (8):

$$R = [R_{eff}, R_{res}]^T, \quad (8)$$

where R_{eff} is the vector of indicators of the company's economic growth (production, processing and transportation of gas); R_{res} is the vector of resource efficiency indicators.

Let us denote the following:

$$R^0(t) = [R^0_{eff}(t), R^0_{res}(t)]^T. \quad (9)$$

The vector of the target values characterizes the development prospect $[0,\ t_T]$ at points $t = t_1, t_2, \ldots t_T$; the vector of target values characterizes the indicators of resource efficiency $R^0(t)$ and corresponds to the option of the resource-efficient development of the company. The inclusion of the "resource efficiency" vector $R^0_{res}(t)$ in the methodology for a comprehensive assessment of the leading company (Equation (9)) increases its development.

The resource-efficient development of the gas industry involves the use of modern management decision support systems and should take into account the introduction of resource-saving measures in gas production, processing and pipeline transportation companies. Since management decisions in companies and segments of the gas industry have certain specifics, the choice of the best ratio between indicators of general economic and resource efficiency should be carried out using multi-criteria optimization tasks. In the study, the authors, using such a task, based on the selected system of indicators, set benchmarks for the resource-efficient development of industry companies.

Mathematically, the problem of increasing resource efficiency in a gas company can be represented as a multi-criteria optimization problem:

$$||R(Y,t) - R^0(t)|| \to \min_{Y(t)\subset M_V};\ t = t_1, t_2, \ldots t_T, \quad (10)$$

$$R(Y,t) = S_O(N, Y, t), \quad (11)$$

$$dN(t)/dt = S_s(N, Y, t), \quad (12)$$

$$N(t) \subset Mn(Y,t). \quad (13)$$

where $S_O(Y,t)$ is the dependence that helps in determining various options for the development of a leading company in the gas industry:

$$Y(t) = \begin{bmatrix} Y_{gas\ industry}(t) \\ Y_{gas\ company}(t) \end{bmatrix},\ Y(t) \subset M_V, \quad (14)$$

where $Y_{gas\ industry}(t)$ is the vector of industry resource efficiency indicators; $Y_{gas\ company}(t)$ is the vector of company resource efficiency indicators; Mv is the multitude of resource-saving decisions; $N = [n_1, n_2, \ldots, n_n]^T$ is the vector of corporate resources; $S_s(N,Y,t)$ is the company production function; $Mn(Y,t)$ is the resource limit.

The simulation model for the integrated resource efficiency assessment developed by the authors is a software program and instrumental environment for predicting balanced resource provision and rational consumption rates in industry companies based on the information and iterative coordination of the forecasts of production and consumption of energy resources in the form of the formation of fuel and energy balance (FEB) values.

The authors consider the fuel and energy balance, formed within the framework of the simulation model of a large company, as a part of the overall product and sector balance of the fuel and energy complex of the country. This innovation provides the role of the "balance of balances" and allows, through inter-balance relations, simulations of the mutual influence of gas industry companies, fuel and energy complexes and other sectors of the economy.

In accordance with the algorithm for implementing a comprehensive assessment of the effective use of resources (Figure 2) in the study, in the first stage, with the help of a software and tool environment, the calculation of indicators selected as part of the resource efficiency assessment is carried out.

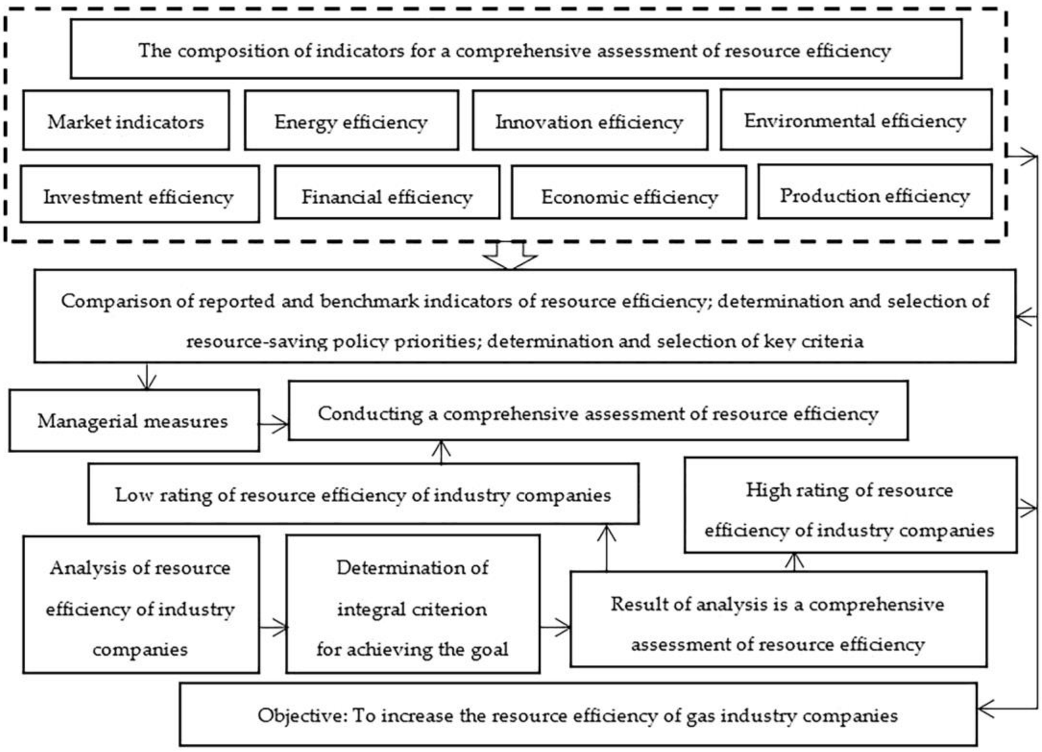

Figure 2. Algorithm for complex assessments of the efficient use of gas industry companies' resources (compiled by the authors).

In the second stage, the calculated and reference values of the indicators are compared. In the third stage, the priorities of the resource-saving policies are determined and the selected resource-saving measures are justified. In the fourth stage, an integral assessment of the resource efficiency of the industry companies is carried out. In the fifth stage, a comparative analysis of the integral criteria for achieving or not achieving the goal of increasing the resource efficiency is carried out.

The methodology for the complex assessment of resource efficiency presented in the study in the form of a software and tool environment (IPR) is implemented using such systems and software products as MS Office, MS Excel, MS Access, MathCAD, Mathematica, MATHLAB and the model information complex (SCANER).

It is aimed at supporting management decisions in the tasks related to increasing the resource efficiency, rational resource consumption and balanced resource supply of gas industry companies.

3. Results and Discussion

The use of administrative decision-making procedures required the IPR to maximize the use of production data in the calculations, with full compliance with the conceptual and information structure in force in the official statistics. The software and tool environment were tested on the statistical reporting material of large gas companies. This methodology will make up for the lack of scientific, methodological and scientific–practical literature in the field of forecasting rational resource consumption and balanced the provision of resources for industrial companies.

In the conducted research, the authors calculated a predictive resource-efficient option, including a set of resource-saving projects, taking into account the balanced provision and consumption of resources of all spheres of activity for gas companies.

In the forecast version of the gas production company, the growth in natural gas production by 2025 will be 110 billion m^3, and in 2030 will be 127 billion m^3. The increase in the annual growth rate of consumption of petrochemical products in Russia for 2020–2025 is 4%, and over the five years of the forecast period the value will be 20%.

Taking into account the projected target values under the energy saving and efficiency improvement program of the gas transportation enterprise, the specific consumption of fuel and energy resources (natural gas and electricity) for the country's own needs per year will amount to 27.5 kg of cu.t./million m^3 km. The forecast for decreases in energy consumption by 2025 in relation to 2020 will be 5% for natural gas and 6% for electricity. The technological loss of natural gas per year is 61.5 million m^3, and by 2025 it will reach 358.5 million m^3.

The forecast of changes in the resource efficiency of gas companies for 2025, as estimated by the authors, is presented in Table 2.

The indicators of production efficiency in the forecast period show characteristic growth. For the gas processing company, the increase in capital return will be 11%. Production growth can be observed for all gas companies. As a result of the rational expenditure of working capital in the gas processing company, the material consumption rate will decrease, the duration of the turnover will be reduced and some of the current assets will be released. Based on the implementation of a number of promising projects and activities in the forecast period, gas companies will achieve increases in economic and investment efficiency.

The decrease in the consumption of energy resources in the gas industry companies is due to the improvement of regulatory and methodological documentation and the introduction of energy-saving measures in the forecast period, which, accordingly, will have a positive impact on energy efficiency indicators. The stabilization of the financial efficiency of the gas industry companies under study with the forecasted resource-efficient variant will be observed as increased equity, joint venture organization and reduced amounts of short-term liabilities.

Table 2. Forecasting of resource efficiency indicators of gas industry companies for 2025.

Efficiency Indicators	Gas Production	Gas Processing	Gas Transport
1. Changes in market conditions			
Output, bcm	109		
Throughput, bcm		37.8	
Volume of transported products, bcm			866.3
Growth rate of output, %	110	110	110
Growth rate of proceeds from product sales, %	113	112	113
Growth rate of production costs, %	109	106.8	107
Investment growth rate, %	108.2	117	118.4
Growth rate of natural gas consumption, %	107.8	-	100
Growth rate of electricity consumption, %	107.5	108	96.6
Growth rate of heat energy consumption, %	107.3	105	103.5
Growth rate of pollutant emissions, %	89.9	89.9	98.1
Growth rate of environmental protection costs, %	175	178	116
2. Increase in production efficiency			
Fixed assets turnover ratio, thous.cm/rub	0.18	26.6	216.5
Labor efficiency, mmcm/person	8.2	9.84	104.5
Working capital turnover, times	2.8	1.42	0.297
Material productivity, thous.cm/rub	3040	204.3	41.1
Material productivity, rub/rub	27.4	4.42	0.013
Materials-output ratio, rub/rub	0.037	0.23	76.9
3. Increase in economic efficiency			
Product profitability, %	38.1	68	24
Margin on sales, %	32.1	47.3	28.6
EBITDA margin, %	47.8	48.5	60.7
Return on assets, %	89.5	69.2	28.9
Return on equity, %	17	24.8	13.1
Return on investments, %	14.8	17.3	12.4
4. Increase in financial efficiency			
Debt ratio	53.2	1.93	28.6
Leverage ratio	0.02	1.05	0.036
Equity ratio	1.1	0.5	1.2
Coverage ratio	1.9	1.23	12.4
5. Increase in investment efficiency			
Simple rate of return (SRR), rub/rub	0.56	0.56	1.09
Payback period (PBP), years	1.79	1.79	0.92
Benefit-cost ratio (BCR), rub/rub	0.37	0.46	0.235
Profitability index (PI), rub/rub	0.34	0.55	0.1
6. Increase in energy efficiency			
Specific natural gas consumption, thous.cm/thous.rub	4.8	-	255.1
Specific electricity consumption, kWh/thous.rub	0.002	-	53.6
Specific electricity consumption, kWh/rub	-	0.03	-
Specific heat energy consumption, Gcal/thous.rub	0.001	0.06	0.023
Gascapacity, thous. cm/thous.cm	31.9	-	62.3
Electric capacity, kWh/thous.cm	13.3	386	13.0
Heat capacity, Gcal/thous.cm	6.6	0.79	0.006
7. Increase in environmental efficiency			
Environmental impact index (EII), t/mmcm	0.82	2.79	2.33

Reducing the negative impacts on the environment in gas companies will have a positive impact on environmental performance indicators in the forecast period. This will be achieved by increasing the environmental costs of companies and reducing emissions. As a result of the approbation of the methodology for the comprehensive assessment of the effective use of resources of gas industry companies, we calculated the integral indicator using the method of multidimensional groupings based on multidimensional averages. The obtained integral values indicate the level of resource efficiency of each gas company and the industry as a whole (Figure 3).

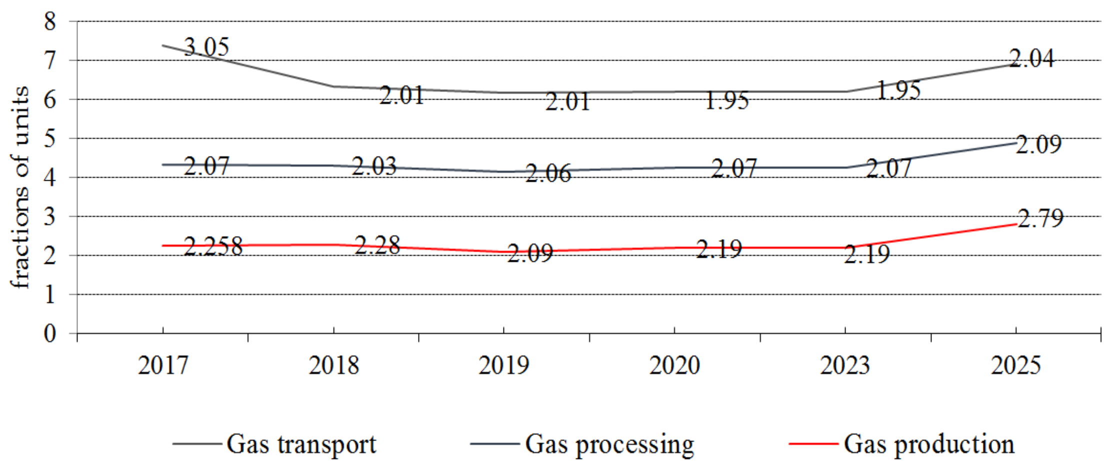

Figure 3. Results of the integrated assessment of gas industry companies.

The highest level of resource efficiency in 2017 was observed for gas transportation and the lowest for the processing plant. The level of resource efficiency in the gas-producing company does not change and should increase by 24% in the forecast period. For the gas processing enterprise, the level of resource efficiency in the forecast and post-forecast periods is stable. During pipeline transport, the value of the indicator decreases from 3.05 in 2017 to 2.04 by 2025, which will be almost 50%.

Our analysis of the previous studies in the field of resource conservation and resource efficiency improvements showed the interest of the authors in studying this problem. Most publications considering industrial companies [12,13,23–25] take into account their specifics well, but they do not use a sufficient set of indicators and do not give a complete assessment of resource consumption and provision with them. In our study, these methods and models were considered and taken into account. Additionally, when determining resource-saving effects, many authors prefer to calculate the energy efficiency and do not consider other areas of production activity, such as economic, investment, financial, innovation and environmental factors. As the analysis presented herein of the efficiency of the production activity shows, these areas contain great potential for resource conservation via the application of progressive scientific, methodological, practical and methodological methods and principles in the organization of the production, labor and management of oil and gas companies.

The individual authors have mainly devoted their research efforts to calculations of energy supply and energy consumption for territories and regions (countries) [1,2]. Additionally, most developments involve the creation of disparate optimization models of individual production processes or strictly aggregated regional models of energy development. Previous studies [3–11,13,14] have presented statistical models of energy systems of production processes. In previous [18–29,34–47], the authors considered the future development of their countries and the improvement of energy efficiency through the replacement of raw hydrocarbon materials with the wider use of renewable energy sources and reductions in CO_2 emissions.

Thus, the previous studies on resource conservation and resource efficiency do not fully take into consideration the specifics of the functioning of Russian oil and gas companies and do not allow the determination of possible resource-saving effects and the future development of companies and industries in general. This article took into account the positive and negative aspects of the previous studies considering theoretical and methodological assessments of resource conservation and resource efficiency improvements for industrial companies, and in particular the oil and gas industry.

The authors, based on corporate methodological and regulatory documents, reporting and open-access statistical data published by industry companies, have developed a system of indicators within the framework of the methodology for a comprehensive assessment of resource efficiency, which includes all areas of the company's activities. In each type of resource efficiency, the authors included the composition of the main parameters reflecting the state and level of resource consumption and provisions for them. The advantage of the proposed system of resource indicators is its completeness and consistency.

The developed methodology for a comprehensive assessment of resource efficiency using a software and tool environment allows one to determine the level of rational consumption of companies' resources and their balanced provision. With the help of the proposed methodology, an integrated assessment of all areas of the company's activities was carried out, which took into account the specifics of the production processes of the Russian gas industry. Due to the universality of the methods and means of the resource conservation assessment proposed in the methodology, it can be applied to other industries and spheres of production and services. The methodological principles and approaches developed by the authors to improve the resource efficiency of oil and gas companies correspond to the circular economy principles and can be adapted for use in other industries countries and regions.

It should be noted that the proposed methodology is suitable for complex assessments and comparisons of the investment projects in the energy sector, in particular the gas industry.

The methodological approach proposed by the authors to determine the resource-efficient options within the framework of the integrated assessment methodology was tested on industrial companies involved in natural gas extraction, processing and pipeline transport. The authors planned to forecast a resource-efficient option in the gas industry as a whole and build a fuel and energy balance model, but due to the lack of reliable and complete information, this was not possible at the current stage.

4. Conclusions

Our analysis of the literature sources in the fields of resource conservation and resource consumption for oil and gas industry enterprises has shown that there is no single methodology for assessing the effective use of resources. Different authors offer disparate methods that include a number of indicators and allow assessments of a separate area of the company's activity, as in general the energy and environmental sphere acts as the object of the research.

The authors of this study propose a methodological approach to assessing the effective use of the resources of an industrial gas company, including a set of indicators for the specific areas of the company's activities, which will allow for a multivariate analysis of promising business processes and the selection of the most resource-efficient scenario for the development of an individual company and the gas industry as a whole. Using the proposed methodology, a comparative integral assessment of the resource efficiency of natural gas extraction, processing and pipeline transportation companies was conducted. In accordance with the principles of sustainable development in a rapidly changing environment, the authors compared the results and costs of the proposed resource-saving measures and projects during the testing of this methodology. The chosen optimal option is to equalize the resource efficiency indicators and take into account the industry specifics for natural gas extraction, processing and pipeline transport companies, along with the implementation of promising measures and current trends in the market environment.

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