Efficiency gains for using production capabilities of an oil and gas production enterprise based on innovative process solutions

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Abstract. This article touches upon the issues of efficiency gains for using the production capabilities of an enterprise in the oil and gas industry environment. It is suggested that the most critical elements, including innovative potential would be comprised in the production potential. To assess the degree of utilization of the production capacity of an oil and gas producing enterprise, a rapid assessment methodology based on performance indicators that take into account industry characteristics has been proposed. Implementation of this technique for an oil and gas company has shown that reserves for the fuller employment of its resources are available. Calculations have also been made proving that implementation of innovative process solutions will increase the efficiency of the production potential above the industry average level.

1. Introduction
Currently, most oil and gas fields are characterized by a high reserve recovery and a tendency towards a decrease in oil and gas production. In this regard, to identify ways to improve the efficiency of employment of the production capacity of oil and gas enterprises will be the priority task for the foreseeable future [1]. The issue of the development of scientific and methodological foundations for the building and assessment of the production capacity, as well as the development of specific mechanisms for its implementation, seems relevant.

Production capacity of an enterprise forms a basic prerequisite for its innovation-driven development. There is a relationship between them – the higher the technical and economic level of components of the potential and the greater the utilization efficiency, the stronger is the physical facilities for innovation, the ampler are the opportunities for the implementation of science and technology achievements, improving and increasing the components of an industrial enterprise. This is of particular importance for the oil and gas industry.

2. Theoretical foundations of the production capacity in the oil and gas industry
A review of the scientific literature has shown that almost all researchers believe that the production capacity forms the economic potential of an enterprise [2]. Based on the study of publications, a great variety of approaches to the building of the production potential has been established [3].

For the study of production capacity of industrial enterprises, the major challenge is that all its components perform simultaneously and interdependently, tied together, that is, the production capacity for system, which is a complex and dynamic one, since it is the interconnections between individual constituents of the potential that directly affect its components by changing the initial specifics of their operation, thus contributing to the transition of the potential to a new quality. That is, depending on the extent to which the laws governing the functioning of individual components are studied, it is possible to identify specific features of performance of the production potential of an enterprise as a system as a whole [4].
Development of the production capacity of an enterprise is determined by the influence of innovations, instability of external and internal factors, market conditions, resulting in certain structural changes in the production capacity, as well as in qualitative and quantitative changes in technical and economic indicators that characterize the potential.

Currently, the priority of the economy is the transition to an innovative basis; for this purpose, the majority of enterprises, including oil and gas companies, have developed appropriate innovative programs by creating operational environment for the production. Given this fact, we suggest that capacity for innovations be included in the production capacity as its component. Thus, the production capacity will include four main elements (Figure 1).

![Figure 1. Components of production capacity for an oil and gas enterprise](image)

A constituent element of the production capacity of an enterprise should also be the capacity for innovations that determines the scale, pace, and effectiveness of economic development. Innovative potential is the ability of an enterprise to produce products on a new technical and technological basis. Capacity for innovations is a resource pool available to the company for scientific discoveries, inventions, and technical innovations. Certainly, when studying capacity for innovations, the main attention is paid to the consideration of scientific and technical resources available to the enterprise. In the modern context, innovation-based development is the only option for the development of enterprises that ensures its qualitative growth.

3. Assessment procedure for utilization of production capacity

The issue of assessment of the extent to which production potential of an enterprise is utilized, as well as the formation of a strategy of management of the existing potential is one of the most pressing and critical problems, both in research terms, and in terms of the practical significance for an enterprise.

A rapid assessment technique makes it possible to get a comprehensive view of the extent to which production potential of an enterprise is utilized [5].

For the purpose of rapid assessment of oil and gas companies, we suggest clarifying the assessment technique based on the author’s classification of components of the production capacity (Figure 2).
Figure 2. Stages of rapid assessment of efficiency of production capacity of an oil and gas enterprise

Assessment of the efficiency of utilization of the production capacity of an enterprise makes it possible to identify the integral summarized value of this indicator, and to determine the extent to which production capacity is used relative to industry average values.

Stage 1. To assess the utilization of production capacity, it is necessary to determine the components of generalizing and individual indicators for assessing the state, change and efficiency of its utilization and calculate their values for the company under study. Then, the threshold values should be determined, which allow to classify the production capacity by levels. The level B is determined by industry average indicators, while Level A (high) is above average, and Level C (low) is below average. Next, an assessment is made of the indicators that form the production capacity with regard to their threshold values. Given the industry average values, the components of indicators have been provided, taking into account the specifics of the oil and gas industry, and their threshold values have been identified based on the expert estimates (Table 1).

Table 1. Indicators of the assessment of the levels of production capacity of an enterprise and their threshold values

| Indicator                                      | Level | Threshold values |
|------------------------------------------------|-------|------------------|
| 1. Mineral and raw materials potential        |       |                  |
| Hydrocarbon reserves recovery factor, %       | A     | > 140            |
|                                               | B     | 100 - 140        |
|                                               | C     | < 100            |
| Hydrocarbon reserves depletion factor, %      | A     | < 4              |
|                                               | B     | 4 - 6            |
|                                               | C     | > 6              |
| Average petroleum production rate, tons per day| A     | > 25             |
|                                               | B     | 15 - 25          |
|                                               | C     | < 15             |
| 2. Physical facilities                        |       |                  |
Plant and equipment update ratio, %

| Level | A | B | C |
|-------|---|---|---|
| > 15  |   |   |   |
| 7 - 15|   |   |   |
| < 7   |   |   |   |

Return on assets, %

| Level | A | B | C |
|-------|---|---|---|
| > 1   |   |   |   |
| 0.5 - 1|   |   |   |
| < 0.5 |   |   |   |

Return on assets, rubles/rubles

| Level | A | B | C |
|-------|---|---|---|
| > 5   |   |   |   |
| 3 - 4 |   |   |   |
| < 3   |   |   |   |

3. Human capacity

Human employment turnover ratio, %

| Level | A | B | C |
|-------|---|---|---|
| < 0.4 |   |   |   |
| 0.4 - 1|   |   |   |
| > 1   |   |   |   |

Well stock maintenance support, person/well

| Level | A | B | C |
|-------|---|---|---|
| < 1   |   |   |   |
| 1 - 3 |   |   |   |
| > 3   |   |   |   |

Output change, %

| Level | A | B | C |
|-------|---|---|---|
| > 10  |   |   |   |
| 0 - 10|   |   |   |
| < 0   |   |   |   |

4. Capacity for innovations

Scientific and research assets ratio, %

| Level | A | B | C |
|-------|---|---|---|
| > 10  |   |   |   |
| 5 - 10|   |   |   |
| < 5   |   |   |   |

Production gain tempo due to innovation-based technologies, %

| Level | A | B | C |
|-------|---|---|---|
| > 20  |   |   |   |
| 10 - 20|   |   |   |
| < 10  |   |   |   |

Innovative growth ratio, %

| Level | A | B | C |
|-------|---|---|---|
| > 1   |   |   |   |
| 0.5 - 1|   |   |   |
| < 0.5 |   |   |   |

Stage 2. To evaluate the efficiency, a combination of levels for individual indicators shall be considered to assign a level to each component of the production capacity. Next, these indicators reflecting the effectiveness of utilization of individual components of the production capacity for a particular enterprise shall be calculated. Based on the assessments of the levels assigned to the indicators, the expert shall determine their combination to assign the assessment to the level of the relevant component (Table 2).

### Table 2. Score of the extent to which the production capacity components are utilized

| Extent of utilization of the components | Mineral and raw materials potential | Physical facilities | Human capacity | Capacity for innovations |
|----------------------------------------|--------------------------------------|---------------------|----------------|-------------------------|
| High level (A)                          | A.A.A.                               | A.A.A.              | A.A.A.         | A.A.A.                  |
|                                        | A.A.B.                               | A.A.B.              | B.A.A.         | A.A.B.                  |
|                                        | A.A.C.                               | B.A.A.              | A.B.A.         | B.A.A.                  |
|                                        | A.B.B.                               | A.A.C.              | A.C.A.         | A.A.C.                  |
This is to determine the extent of utilization of the production capacity of an enterprise according the same pattern as the level of components (Table 3).

| General extent | Levels of the components | Description of utilization of the production capacity |
|----------------|--------------------------|-------------------------------------------------------|
| High level (A) | A.A.A.A                   | The company is in a state of absolute equilibrium in almost all components in accordance with all assessment criteria. The physical volume of production has remained unchanged. The equipment and technology used in manufacturing the products are in good condition. |
| Medium level (B) | A.B.C.B                   | The company’s current business is successful; difficulties can be overcome, because adaptation mechanisms do work. Manufactured products are being sold. The physical volume of production has been maintained (although there may be a decrease in certain periods). The equipment and technology are in good condition. Resource efficiency is industry average. |
| Low level (C)   | A.C.C.C                   | Most of the parameters of all functional components are chronically violated, i.e. there are problems with the provision of enterprises with raw and other materials, human resources – these are used inefficiently. Technical and technological support of production activities causes concern. Utilization of basic production assets, labor and material resources is below the industry average. |
Stage 3. To determine efficiency of utilization of the production capacity, it is necessary to provide the scoring. For this, each value of the indicator within the range should be assigned a certain score, which is used afterwards with due regard to the weighting ratio. The highest score should correspond to the most favorable value, while the lowest score – to the most critical one. The level and range of scoring shall be determined by experts (Tables 4).

**Table 4. Scoring for utilization of the production capacity of an enterprise**

| Level | Indicator | Group of indicators | Scoring, points | Threshold values, points |
|-------|-----------|---------------------|-----------------|-------------------------|
| A     | 10        | 30                  | 26 - 30         |
| B     | 6         | 18                  | 14 - 22         |
| C     | 2         | 6                   | 6 - 14          |

Weighting ratio also shall be determined by experts (Tables 5).

**Table 5. Weighting ratio**

| Component of the production capacity | Weighting ratio |
|-------------------------------------|-----------------|
| 1. Minerals and raw materials potential | 0.2  |
| 2. Physical facilities              | 0.3             |
| 3. Human capacity                   | 0.1             |
| 4. Capacity for innovations         | 0.4             |
| **Total**                           | **1**           |

The proposed improved procedure for rapid assessment of efficiency of utilization of production capacity was applied to the operational environment of the oil and gas company PJSC Rosneft [6]. Table 6 shows the final values for all elements and the production capacity as a whole.

**Table 6. Results of assessment of the indicators for efficiency of utilization of the production capacity of an oil and gas company**

| Indicator                                      | Value | Level | Score | Weighting ratio | Total score |
|------------------------------------------------|-------|-------|-------|-----------------|-------------|
| 1. Assessment of minerals and raw materials potential | 15.0  | A     | 10    | -               | -           |
| Hydrocarbon reserves recovery factor, %         | 22.30 | B     | 6     | -               | -           |
| Hydrocarbon reserves depletion factor, %        | 4.2   | B     | 6     | -               | -           |
| Average petroleum production rate, tons per day | 186.0 | A     | 10    | -               | -           |
| 2. Assessment of physical facilities indicators | 4.36  | B     | 6     | -               | -           |
| Plant and equipment update ratio, %             | 1.32  | A     | 10    | -               | -           |
| Return on assets, %                             | 4.3   | B     | 6     | -               | -           |
| Return on assets, rubles/rubles                 |       |       |       |                 |             |
| 3. Assessment of human capacity                 | 1.23  | B     | 10    | -               | -           |
| Human employment turnover ratio, %              | 3.4   | B     | 6     | -               | -           |
| Well stock maintenance support, person/well     |       |       |       |                 |             |
| Output change, %                                |       |       |       |                 |             |
Thus, in accordance with the total score, PJSC Rosneft is at an average level in terms of the efficiency of utilization of the production capacity (which corresponds to the industry average value).

4. Ways of improvement of efficiency of utilization of the production capacity

The key way of raising the efficiency of utilization of the production capacity of the enterprise in general is the development of its innovative component [7]. To this end, PJSC Rosneft has developed a program focused on the achievement of strategic objectives, based on the main priorities, such as efficiency, sustainable growth, transparency, social responsibility and innovation [8].

The objectives can be achieved through a set of activities aimed at the development and implementation of new technologies; design, manufacture and launch of new innovative products and services that meet international standards; promotion of modernization and technological development of the Company through a significant improvement in the main indicators of the efficiency of production processes; increasing the capitalization and competitiveness of the company in the global market.

Capacity for innovations can also be improved on the basis of the introduction of a system of digital field technologies [9]. Information or digital technologies have been already widely used in the global oil complex at all stages of the oil chain. The costs of these technologies are one of the important items of the world leading companies, which allows improvement of the efficiency of field development, increase of production rates, and reduction of expenditures at all stages of the oil cycle [10].

Innovation-based development of the company will lead to increased efficiency in utilization of the production capacity.

The implementation of ways to increase the extent to which the corresponding types of production capacity are utilized by PJSC Rosneft enterprises will allow reaching higher projected values of efficiency indicators.

Based on the rapid assessment, projected values of the efficiency of the production capacity have been calculated with due regard to implementation of the innovative technologies envisaged by the program. The company may reach a high extent of the utilization of almost all constituent components of the capacity, with the score increasing from 20.4 (medium level) to 27.2 (high level).

5. Conclusions

The calculations performed have demonstrated that, in general, for the period concerned, the value of the production capacity of PJSC Rosneft has increased. However, indicators of the efficiency of its utilization, as well as indicators of the efficiency of individual types of capacity, changed diversely.

Based on the improved assessment methods, the efficiency of utilization of the production capacity of the enterprise, the generalized value of this indicator has been identified, and the extent of utilization of Rosneft’s production capacity against industry average values has been determined. The calculations showed that, according to the total core, the company is at an average level of efficiency in the production capacity efficiency.

Based on the analysis of the system of objectives of the company’s innovation-based development program, the following areas have been identified:
- ensuring the development of PJSC Rosneft as a high-tech energy company;
- ensuring technological leadership in key competencies, namely, oil and gas production, oil processing;
- maintenance of the specific capital and operating costs at the highest global industry level;
improvement of the energy efficiency of production to the highest global level. Accomplishment of these areas as well as the introduction of digital technologies of management of field development will let the company improve the efficiency of utilization of the production capacity, provide the competitive edge of the company both in the domestic and global markets.

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