

# Innovation Development of Oil and Gas Industries: Technology and Management Aspects

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**Abstract**— Advancement of innovative trends in the development of the Russian economy under current geopolitical and economic conditions is the only way for the Russian enterprises to preserve and hold favorable positions on the home and international markets. In order to improve the current situation and pass from decay to the growth stage, it is necessary to initiate the activities for innovative development of Russian enterprises. The authors assume that the given problems can be resolved in two ways. First, oil and gas enterprises should widely introduce a wide range of innovative technologies since, on the one hand, this industry is one of the most important sectors of the Russian economy and is supported by the government, and on the other hand, enterprises of the given sector display a sufficiently high potential for internal reserves. Implementation of innovative technologies by empowerment of the energy resources allows for significant economic benefits and upgrading the efficiency of an enterprise within a short term. To resolve the given problem, the authors propose an innovative technology for raw hydrocarbons processing focused on enhancing efficient utilization of internal reserves.

Another aspect of the problem is related with supporting innovation technologies interconnected with managerial technologies or managerial innovations being the changes aimed at providing a favorable environment for the outcome of innovative technologies. The practice shows that one of effective tools in innovation management is the project-based approach in implementation of innovative projects.

**Keywords**— *innovation development, energy efficiency, project management, oil and gas industry, management innovation*

## I. INTRODUCTION

Today we need to react promptly to the ongoing changes, and apply innovations as highly effective market tools in order to preserve and develop businesses. Through detailed case studies the researchers demonstrate the only way in which Russia can benefit from the present-day geopolitical and economic situation is an accelerated transition of the Russian economy towards an innovative socially-oriented development model [1]. The aspects which determine the relevance of innovative activities include direct influence on competitive recovery, development of the business entity, and compliance with the changing technological mode. Thus, the aspect related with the positive impact of innovations on the growth, profitability and creation of added value has been analysed on the basis of empirical data provided by a group of researchers

(V.A. Rebyazina, S.P. Kush, A.V. Krasnikov, M.M. Smirnova) [2].

The need for innovation development is also declared on the level of the government policy, based on supporting the processes concerning the development and implementation of innovative ideas by the Russian enterprises. The focus is made on the main document dealing with innovations in the domestic economy "The Strategy for Innovative Development of the Russian Federation Within the Period up to 2020", which determined the key objectives and priorities in the development of economic agents in Russia [3]. The programs supporting the development of separate branches of economy are realized in accordance with the priorities of the state. For example, the Ministry of Industry and Trade of the Russian Federation established the Industrial Development Fund aimed at modernization of the Russian industry, creations of new industries, and ensuring the import substitution programme, which provides favourable terms for co-funding the projects targeted to develop new high-tech products, modernize and create industries based on the latest technologies [4].

Despite the keen interest of the government to the problems of innovation development and continuous discussion of these issues in academic circles, the real index of innovative activity and incorporation of innovations into the businesses in Russia is low, which is reflected in the reports referring implementation of the above mentioned Strategy.

In 2016 the share of extractive industry and manufacturing companies out of the total number of organizations amounted to 9.7% [5], whereas the amount set in the Strategy for the development of domestic enterprises was 50 %. Taking into account that at the time when the Strategy was under development the given value was at 9.4% (2010), by 2020 under the sustained growth rate, the proportion of organizations characterized for high level of innovative activity will hardly exceed 10%. Moreover, if we analyze the actual content of innovative activities at industrial enterprises in Russia, then according to the data of the above mentioned research, the main component of such activities is acquisition of machinery and equipment (63.9%), while research and development projects make about 36.7%, and acquisition of new technologies equals 9.9% [5].

The analysis of innovative activity at our domestic enterprises shows that their innovation performance is

insufficient, and consequently, the probability that they achieve the set strategic aims is low.

## II. PROBLEMS OF INNOVATIVE DEVELOPMENT OF DOMESTIC ENTERPRISES

The works of contemporary researchers and experts describe the various aspects of the present-day situation. A group of Russian experts point out the factors which negatively influence the dynamics of innovation processes, which include: significant drop in the world oil prices, which are the main source of funding the state supported innovative projects; development of resource-based economy; corruption; high budget spending on the maintenance of security agencies; economic sanctions; high investment risks [6]. Emphasized on inadequate development of innovative infrastructure and theory of the science of innovations, lack of clear-cut rules for "innovative games" and deficiency of the system of innovation risk management, which results in the low rate of innovations [7]. We also come across the references concerning insufficient financial support to realize innovations, the necessity to adopt additional laws in the particular area to be applied to protect innovative ideas, the importance of interaction between real businesses and research institutes being the source of innovative ideas.

The analysis of the negative dynamics referring innovation development shows that the negative factors both external and internal accumulated over time. Thus, within the period of transition from command to market economy the low level of innovation activities could be accounted for by the lack of knowledge and skills needed to implement innovation projects, lack of financial resources and large-scale collapse of domestic enterprises which could not cope with existing problems and adopt to the new business models in the economy. However, the present situation, after more than twenty years, is characterized by the same factors.

## III. INNOVATIONS IN THE OIL AND GAS INDUSTRY OF RUSSIA

Taking into account the neural network model created between the business entities operating in various branches of economy, we can assume that innovations must be evenly diffused along all the levels and structural components of economy. In other words, the diffusion should work as a kind of "coating" for the domestic economy, where innovations should be introduced into all the spheres of activity to reach the maximum effect. Meanwhile, it is critically important to determine the "initiation points" of innovations, which could give an impulse for innovative development of the national economy. In our opinion, initiation of dynamic innovative development should proceed from prioritized sectors of economy having the necessary financial resources and state support. The branches of the resource economy must work as a "driving force" for innovative economic development. Reports of the experts referring the major trends in the Russian economy certify that along with decline and stagnation of industrial production we observed growth in oil and gas production [8].

Oil and gas industry is an important strategic sector in the Russian economy, which ensures financial stability of

domestic economy, budgetary receipts, and consequently, it is a resource for development of the social sphere and other sectors of the national economy. This industry is one of the most powerful sectors in the Russian Federation. Development of the national economy as a whole depends on the level of oil and gas industry and prosperity of its business entities. Therefore, experts emphasize that innovations in oil and gas industry provide the prospects for its further development [9,10,11].

To implement the adopted development concept, it will be necessary to resolve both general problems and various subproblems characteristic of the oil and gas complex. Among the general problems commonly faced by the majority of domestic companies are absence of innovation infrastructure, low innovation activity, focus on immediate results, imperfection of the legislative basis, the lack of interaction between business and academic institutions, and finally, prioritizing short-term objectives, such as increase of operation efficiency of an industry [12]. Individual subproblems include prevalence of funding (up to 90%) the upstream sector over refining and petrochemical sectors [12], as well as lack of interest to innovations among the industry entities due to their monopoly in the industry [13].

Thus, currently we are facing the following situation: the state emphasizes the need for innovations in the oil and gas complex through the development of programs aimed primary exploration and development of new and unconventional deposits. Whereas the entities mainly focus on the present-day problems related with improving efficiency of the day-to-day operations, which do not require significant inflow of funds, since they do not involve serious risks or losses in case of failure to reach any results. We assume that solution to the given problems should be introducing innovations through activation of in-house resources of enterprises.

### *A. An Innovative Energy Supply System for Technological Processes of Processing raw Hydrocarbon*

At present the domestic industry of processing raw hydrocarbons fails to keep pace with its global counterparts. Consequently, it is facing high competition and the companies are suffering from significant losses. This can be explained by such factors as tough environment conditions, significant amount of hard-to-reach oil fields, changes in the quality of raw materials, and remoteness of the oil fields from refinery facilities. Among negative trends affecting the industry we can highlight the outdated material and technical base of enterprises, ineffective methods of economic management of companies, high energy consumption, inefficient usage and heavy losses of energy resources. It is worth mentioning that the average share of energy resources in the product costs is about 50%. Meanwhile, the majority of hydrocarbon processing plants (HPP) have considerable potential to improve their economic and energy efficiency through introduction of cutting-edge approaches to the management of companies, modernization of outdated material and technical base, large-scale introduction of energy saving technologies, such as utilization of alternative fuels, and organization of autonomous power supply systems.

Current practices in the development of HPP, including their energy utilities, are based on the principles of introducing effective enterprise management models, increasing the depth of resource recovery in order to produce high quality products, upgrading the rational use of energy resources, introducing low-waste technologies, organizing a closed cycle technology of water supply/water removal with maximum utilization of secondary energy resources, including combustible wastes incinerated in the flare systems of enterprises.

The Process system (PS) of HPP is the basic structure of the whole enterprise and internal energy supply system (IESS). The IESS is indissolubly linked with the technological system and consists of fuel, electrotechnology and heat technology basic subsystems, has high potential for upgrading the efficiency, which allows for obtaining significant economic effect. Realization of this potential, formation of a rational structure used to determine optimal operation modes of energy facilities at HPP taking into account the real conditions of technological processes can be obtained at the following stages: structuring the business object, selecting and justifying the indicators and performance criteria, developing mathematical models and algorithms for structural and parametric optimization, synthesizing the rational energy complex and developing alternative efficient energy systems of energy supply.

Designing the structure of the fuel conveying system for HPP is the first aspect in the analysis of effectiveness of individual components and the whole IESS based on the decomposition-aggregation approach and block-hierarchy principle for analyzing complex systems. The main objective in the analysis of the fuel supply system structure is finding out its relationship with the process, electrical and thermal systems of the IESS, as well as external energy supply systems. Figure 1 gives the general view of relationships between PS and IESS of the HPP.

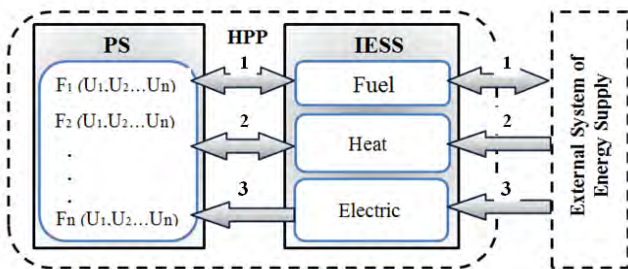


Figure 1. The energy-technology scheme of the HPP

F1, F2... Fn – production facilities of the HPP; U1, U2...Un – production units of the HPP  
1 – fuel; 2 – heat energy; 3 – electric energy.

Analysis of the block-hierarchical structure (Fig. 1) shows that the IESS and all of its subsystems are closely interlinked with the PS and external energy supply system in a continuous process of energy generation and consumption. The designed structure of the object is the basis for creation of mathematical models to calculate and optimize the fuel and energy balances, develop indicators of the local and system efficiency, define the potential to upgrading the efficiency of heat energy resources, and determine directions for its realization.

Justification of directions for increasing the efficiency of the IESS incorporated in the HPP is based on the system of indicators of power efficiency of individual components, including devices, production facilities and systems.

The potential for improving efficiency of fuel utilization is estimated by the difference between the annual actual consumption and demand ratio [14, 15]

$$P_T = (\varphi_t + \varphi_m) \cdot \left[ \sum_{j=1}^N B_{ja} - \sum_{j=1}^N V_j \cdot E_{sj} + b_j \cdot \tau \right], \quad (1)$$

where  $P_T$  is the technically feasible potential of energy saving in the fuel supply system, t/year;  $\varphi_t$ ,  $\varphi_m$  are the share of factors provided by changing the technology structure and improving the technical conditions, or modernizing the equipment and facilities;  $\sum_{j=1}^N B_{ja}$  is the actual consumption of fuel gas by the main and auxiliary enterprises of the PS and IESS of HPP, t/year;  $V_j$  is the volume of the standardized process flow of corresponding rate (m<sup>3</sup>/year or t/year);  $E_{sj}$  is the specific fuel gas consumption requirement (t) per unit in the corresponding process flow;  $b_j$ ,  $\tau$  are the standard fuel gas consumption rates (t/h), and operation time (h/year) of intermittent facilities.

A possibility for including low-grade fuel gases and wastes of the PS from HPP into the fuel balance is estimated using the *generalized power capacity rate value*

$$E_s = \frac{\sum_{j=1}^N E_j^{ER} - \beta_j \cdot E_j^{SER}}{V} \quad (2)$$

where  $E_j^{ER}$  is consumption of all types of fuel and energy resources of the main and auxiliary production facilities  $j$ , t;  $V$  is the amount of recycled hydrocarbons, thousand m<sup>3</sup> or thousand tons;  $\beta_j$  is utilization ratio of all types of secondary energy resources (including fuel wastes) in the IESS of HPP;  $E_j^{SER}$  is the volume of secondary energy resources (t) disintegrated from the production facility  $j$ .

The task for rationalizing fuel consumption / generation and energy resources, as well as water consumption and removal, was solved using the *index for rationalization of balances*.

The undertaken multiple factor analysis of the energy complex at hydrocarbon processing enterprises, using the developed performance indicators, allowed for working out the ways for increasing the efficiency of an object, as well as finding complex technical solutions.

Using the methods of system analysis and synthesis of intricate energy technology engineering systems, the variants of energy supply schemes have been designed [16, 17], which



might be integrated into a hybrid oil refining unit. Figure 2 presents a block diagram to a variant of the in-house energy supply source including disposal of spent fuel and waste.

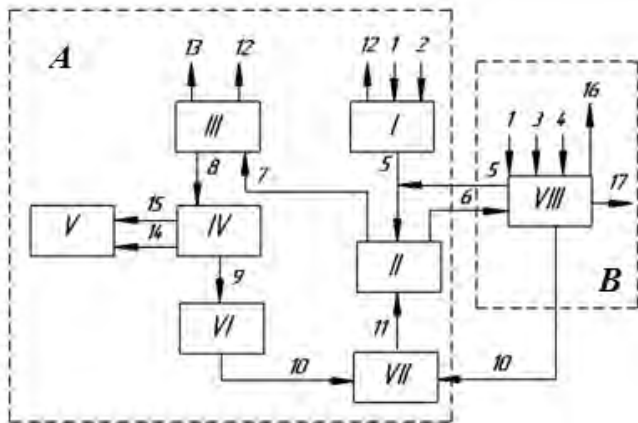


Fig.2. A block diagram to an in-house source of energy supply with a fuel waste recovery and discharge channel block

A, B energy recovery units: A – combined-cycle plant (CCP); I – gas turbine unit (GTU); II – heat-recovery boiler; III – steam turbine unit (STU); IV – integrated heat exchangers; V – heat consumer; VI – waste steam condensation unit; VII – water conditioning; B – disposal of spent fuel and waste; VIII – neutralizer of industrial wastes; 1-17 – process streams: 1 – power gas; 2 – air; 3 – recycled gas fuel; 4 – industrial wastes; 5 – high temperature flue gases; 6 – flue gases for drying; 7 – 9, 17 – steam (7 – turbine intake, 8 – turbine offtake, 9 – for condensation, 17 – for technological needs); 10 – condensed water; 11 – chemically purified water; 12 – electric power; 14, 15 – heating load and gas-air mixture; 16 – dried flue gas; 17 – dry waste

Sales gas and partially dry gas produced in-house during the feedstock processing (stream 17 in Fig. 1), are used as fuel gas in the gas turbine (I). Sales gas and partially dry gas (stream 17 in Fig. 1), as well as processed hydrocarbon (streams 7 and 15 in Fig. 1), serve as fuel to neutralize industrial wastes (VIII) [18]. Efficient combusting of hydrocarbon gases generated by mixing is provided due to the special features of the designed burner [19].

Design characteristics of the proposed scheme are determined by specific technological topology of the target for hydrocarbon processing, as well as required parameters for the generated energy carriers. In the case of the hybrid unit GK-3, the given technological parameters include the required amount of heat (342 GJ/year) and electric (61.02 GW•h/year) energy needed for oil processing.

Introduction of the in-house source of energy supply along with the disposal unit for waste fuel and effluents into the GK-3 structure allows for increasing the system efficiency due to the technological, schematic and design solutions.

Effectiveness of power supply for the complex oil processing facility GK-3, excluding the waste fuel and effluents in the fuel balance, is characterized as follows:

TABLE I. TECHNICAL AND ECONOMIC INDICATORS OF PERFORMANCE

Feature	Mesuare	Amount
Electric power capacity	MW	9.2
Thermal power capacity	MW	10.4
Fuel consumption	t/h	2.844
Integrated effect (within 10 years)	dollars	17.3·10 <sup>6</sup>
Payback period	years	no more than 5

Thus, implementation of the presented innovative technology of energy supply is one of the solutions to the existing problems relating the innovation development of the oil and gas complex. Focused on enhancing effective usage of internal reserves, the presented method allows for upgrading the performance efficiency within the shortest time, and does not entail substantial costs.

However, intensification of innovation development at domestic enterprises is determined not only by advancements in the oil and gas complex as the key drivers of innovation. Significantly, introducing the change-oriented management system is of prior importance in the process of innovative development.

*B. Innovative development of enterprises: management aspect*

It can be argued that the goals relating the innovative development of Russian enterprises, defined on the state level, are not supported by the available resources and, above all, by the management resources. As indicated, "for the present the management decision making processes concerning our domestic industry have not achieved high quality" [20].

In the context of innovative development, the problem of effectiveness of the management system is aggravated by the need to solve complex management problems connected with implementation of innovative projects by enterprises. Introduction of new technologies for manufacturing new products requires advanced management technologies. The present-day management system, which does not meet the requirements and objectives of business, is a serious barrier for the development of enterprises, limits their competitive capacity, and results in their low performance rate. The focus on improvement and greater market access is imminently associated with reforms in the management system [21]. The need for the changes in the existing management systems is confirmed by the conducted research, according to which at present up to 90% of the Russian enterprises can improve their performance by 20-25% by creating an adequate management model; developing effective patterns of financial and economic activities, and retraining the managerial staff in terms of new knowledge concerning the management system of enterprises [22].

Therefore, implementation of innovation development strategy in the domestic market should start with optimization of the present-day management systems in order to create the relevant management environment required to stimulate the innovation process. Organization of innovation activities is one of key issues of the strategy [23].

An important prerequisite for engagement in innovative activities is availability of management innovations targeted to improve effectiveness of the current management systems and their compliance with ongoing changes in the business environment. Creation and implementation of innovations in management system provides conditions for innovations of other types and forms the basis for organization of innovative processes.

The relevance of commitment to management innovations is defined by the fact that realization of new engineering initiatives is associated, firstly, with the need for substantial funding, and secondly, with time span. In other words, development and implementation of technological innovations require the relevant material resources and timing budget, which presently are unavailable for practically all business entities to improve their competitive capacity. Under present conditions, building competitive advantages through effectiveness of the management system based on organizational and managerial innovations has a number of benefits. First, forming and implementation of organizational and managerial innovations is not always connected with substantial costs, which might easier the problem with additional sources of funding the modernization plans. Moreover, the positive effect from implementing management innovations may be achieved in terms of sources of funding product innovations. Secondly, optimization of the management system is the basis for creating conditions to introduce technological innovations, having additional positive effect on competitiveness of enterprises [24].

Management innovations are an essential component of innovative potential of enterprises, as they determine motivation for the changes interconnected with innovative activities [25, 26]. In practice, preliminary work for organizational and managerial innovations lays the ground for the changes in the system, which makes the transition less radical and painful for all the participants of the given process. It is implementation of organizational and managerial innovations, and bringing the management system in conformity with the requirements, as well as providing the necessary conditions for further development and introduction of product innovations, form the basis for choosing development strategies. Hence, organizational and managerial innovations should be given the priority in innovation development of enterprises. Moreover, adherence to continuity and complexity principles regarding their implementation on all the management stages is of prior importance.

At present we must introduce a new approach to forming a management system based on management innovations, which can ensure both an increase in the efficiency of innovation activities of domestic enterprises, and improve the management practices. The concept of innovative management approach is based on assertion that the enterprise's management system must be based on continuous development and implementation of management innovations, which can ensure advancement of a business entity in terms of environmental needs. Thus, continuous management system renewal is the key parameter of the given system. The characteristic of the proposed approach is presented in Table 2.

TABLE II. CHARACTERISTICS OF INNOVATIVE APPROACH TO FORMING THE MANAGEMENT SYSTEM BASED ON ORGANIZATIONAL AND MANAGERIAL INNOVATIONS

<b>Main characteristic</b>	Based on the key role assigning of innovations in various spheres of activity
<b>Environmental characteristic</b>	Great impact of external factors, rapid changes, severe competition
<b>Key factor</b>	Innovations
<b>The management system aims and objectives of</b>	Providing conditions for the development of a business entity by continuous development and implementation of organizational and managerial innovations
<b>Role of innovation in enterprise performance</b>	Technological and other forms of innovation are equally important, and complement each other

One of the tools for practical implementation of the given approach is working out the concept of the management system, which defines a uniform understanding of the mainstream, aims and objectives of the transition by all the participants of the management process. Formulation of this concept will facilitate the so-called formalization of the management processes based on management innovations, help in working out procedures needed for enterprises to introduce innovations on a regular basis. The ideas of the concept should be formulated in a document including the goals, objectives and principles of the management system achieved due to management innovations, and defining the roadmap for reforms in the system.

Thus, on the one hand, setting the in-house management rules and regulations helps in providing a uniform approach to the in their essence and objectives and, on the other hand, allows for the development of an optimal management system corresponding to the ongoing changes. This will ensure the most favorable conditions for implementation of the projects dealing with the development and introduction of technological forms of innovation at domestic enterprises, and as a result, facilitate the growth an increase of innovative activity in Russia's economic sectors.

#### IV. CONCLUSIONS

Summarizing the results of our research, it is important to highlight the following aspects:

- initiatives aimed at dynamic growth of innovation development of the Russian economy should primarily refer the industries having the necessary innovative potential and state support. One of these industries is the oil and gas complex;
- the basis for implementation of innovation trends within the oil and gas complex should be the projects targeted to improve the efficiency of technologies utilized and focused on enhancement of internal resources;
- the key factor which determines successful implementation of innovation strategy targeted at the

development of domestic enterprises concerns the reforms of their current management systems based on the development and implementation of management innovations.

On the basis of the conducted researches it is possible to draw a conclusion that implementation of the given directions will contribute to the solution of the current problems and promote successful innovative development of Russian enterprises and the economy on the whole.

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