DOI 10.18454/PMI.2016.6.892

UDC 338

RESEARCH INTO THE INNOVATIVE POTENTIAL OF AN OIL AND GAS COMPANY AT DIFFERENT STAGES OF FIELD DEVELOPMENT

A.E. CHEREPOVITSYN[1], **A. KRASLAWSKI**[2]
[1] *Saint-Petersburg Mining University, Saint-Petersburg, Russia*
[2] *Lappeenranta University of Technology, Lappeenranta, Finland*

The paper presents an overview of research into the methods and principles used to assess the innovative potential of an oil and gas company. The validation is provided for the conceptual framework of the innovative potential, which is characterized by a combination of resources having a specific value for the oil and gas sector. The paper gives a detailed overview of the resources, which determine the innovative potential of the oil and gas company. A system of indicators for assessing the innovative potential of the oil and gas company, including six indicator groups, has been proposed. Key distinctive features of the oil and gas company technological development have been determined based on the use of potential for innovation at different stages of the field development. Technical and economic indicators of the oil field development at different stages are described. A concept of Intelligent Field technology is outlined, representing an innovative system, implementation of which determines a level to which the potential for innovation of the oil and gas company is tapped.

Key words: innovative potential, oil and gas companies, resources, technology, economic efficiency, intelligent field, oil and gas field development stages.

How to cite this article: Cherepovitsyn A.E., Kraslawski A. Research into the innovative potential of an oil and gas company at different stages of field development. Zapiski Gornogo instituta. 2016. Vol. 222, p. 892-902. DOI 10.18454/PMI.2016.6.892

Introduction. Presently the oil and gas sector of Russia has entered a new stage of its development, when most resources (over 80 %) are already extracted and most fields are at the depletion stage, while resources of the newly commissioned fields are as a rule hard to extract. It shall be noted that the Russian oil and gas companies are now exiting the period of low oil extraction costs. The extraction costs at the new fields are two- to threefold higher as compared to the traditional sites.

Today the Russian oil sector is implementing insufficient innovation in the field of technological development and management. Innovation enabling on a mass scale is an imperative to maintain the current oil production levels. Innovative technological and managerial solutions are critical to exploration of new high-prospect areas and fields, such as the continental shelf, Eastern Siberia and Western Siberia with its unconventional reserves and resources.

Global leading oil and gas companies are investing in the development of high technology for the extraction of oil and gas deposits, thereby the profitable methods for extraction of hard-to-reach hydrocarbon resources are validated.

Innovation in oil and gas industry also makes for the rational use of the subsoil resources, ensures environment sustainability and helps to increase the profits generated by the company. Vigorous innovative efforts shall be coupled with efficient tapping of the innovative potential of the company.

In the present-day context the Russian oil and gas companies need to establish a strategical management system that would focus on innovative development and foster tapping the full innovative potential of the oil and gas company.

The innovative potential of the oil and gas company means a complex of resources required to drive innovation. These are such resources as research and engineering, technological, infrastructure, informational, material and production, financial, human, intellectual, organizational and managerial and other resources (Fig. 1).

DOI 10.18454/PMI.2016.6.892

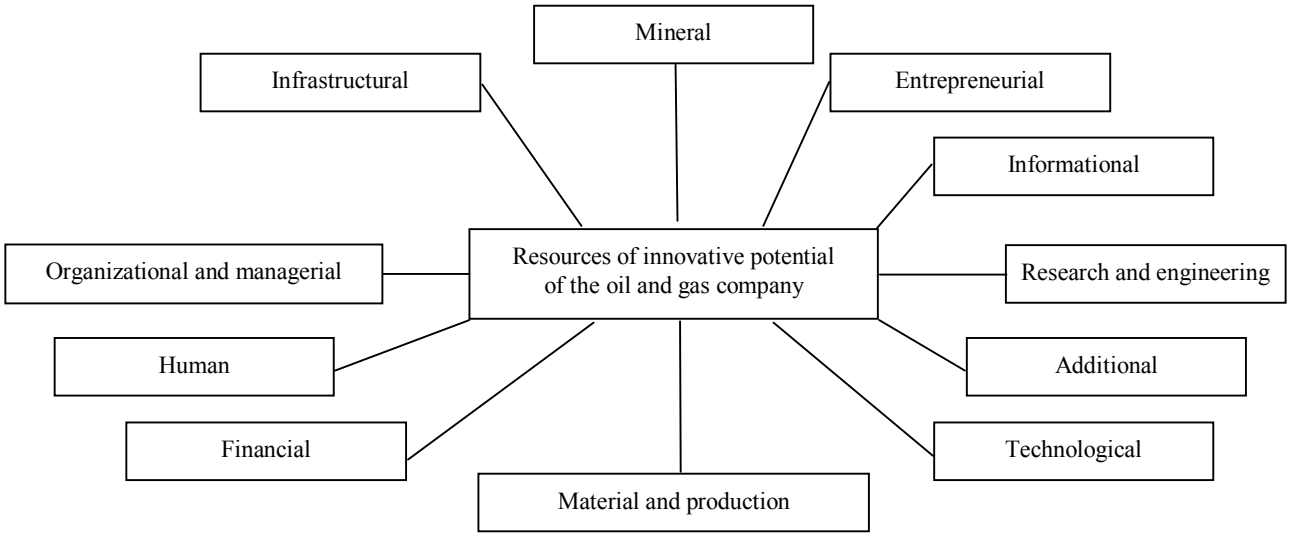

Fig. 1. Resources constituting innovative potential of the oil and gas company

The innovative potential uncovers the company's ability and readiness to embrace new ideas and changes. The company's ability and readiness are the metrics of its resource base, i.e. the innovative potential may refer to the resources, which the company shall invest to transform its strategic roadmap and the organizational and managerial capabilities it possesses.

The innovation potential of the oil and gas company can also be viewed as a consolidated research, engineering and entrepreneurial potential.

The research and engineering potential means the company's ability to invent, acquire and produce something brand new, expressed in the number of patents, proposals for improvement, know-how, etc. Such potential is often measured by spending on research per unit of product or the ratio of the employees engaged in research activities to all the company employees.

The entrepreneurial potential means the management system capability to unleash the research and engineering potential. If the entrepreneurial component is missing or underdeveloped, the overall potential dynamics cannot be ensured [7, 16].

Mineral resources of the company are the basic resources that are unique to a certain extent in each particular case. Such resources represent economically viable subsoil reserves differing by the field geologic setting and the quality of the crudes. Assessment of the mineral resources shall be based on the technical and economical indicators, reflecting the quantity and the quality of reserves, geological features specific to the field and extraction profitability.

For the oil and gas company the key are mineral, material, production and technological resources making it possible to extract hydrocarbons.

Table 1 gives an overview of resources constituting the innovative potential of the oil and gas company. The table is based on systematization of the papers on innovative development of the oil and gas sector [1, 5, 10, 12, 13, 17, 18].

Special attention shall be paid to the entrepreneurial resources, which reflect the company's ability and readiness to embrace innovations in the company. The introduction of new developments and technologies in the company – their transition from the lab environment to the company practice – is associated with certain challenges. The reason is that there are objective contradictions between the innovation essence and the organizational routine, as well as between the need in stability co-existing with the need to change. It is the developed entrepreneurial potential that reflects the company's ability to introduce and sustain innovative ideas and build its day-to-day operations based thereon.

DOI 10.18454/PMI.2016.6.892

Table 1

Overview of resources reflecting the innovative potential of the oil and gas company

Resources	Implied Potential	Description
Research and engineering	Innovative developments and technologies (patents, licenses, copyrights), the company's ability and possibility to acquire rights for the use of certain developments and technologies, and to carry out research and development activities	Research and development results, intangible assets listed on the company's balance sheet; research and engineering stock – number of applications, patents, proposals for improvement; number of innovative projects under development
Technological	Modern innovative technologies for hydrocarbon geological exploration, extraction, processing and transportation	Number, features and intensity of use of technological innovations in the production processes; broad application of methods to enhance the oil and gas recovery rate.
Material and production	The property, plant and equipment (PP&E) and the working capital, including research, experimental, laboratory and office equipment, etc.	Efficiency in using plants and equipment and circulating assets
Infrastructural	Strategic development units, in-house research and development facilities, innovative infrastructure departments, including patents and licenses department, technology licensing and commercialization offices	Scope and efficiency of activities implemented by business units within the company's innovative infrastructure, the company's capacity to ensure that the innovation project goes through all stages of innovation cycle
Informational	Modern information and computer technologies and systems; process control and field operations control systems (ACS), etc.	Number, scope and efficiency of use of the modern information technologies and systems
Financial	Own, borrowed, investment, budgetary, grant funds for research, development and introduction of innovations; financial sustainability and solvency of the company	Spending on research; autonomy coefficients, current liquidity, solvency, financial sustainability; revenue and profitability indicators, etc.
Human	Attitude of executives and staff to innovations and innovation-based development; level and quality of education of the employees; knowledge, skills, competences, background and creative potential of the employees	Indicators describing the company's personnel, its qualification, level of education; employment of highly qualified personnel; number and share of the employees engaged in the innovative process, etc.
Organizational and Managerial	The organizational structure and culture, process technology for all functions and projects, organizational work	General and administrative costs in the total cost structure of the company; the speed of innovation and decision making, etc.
Entrepreneurial	Innovative culture, susceptibility of the company staff to the innovation, readiness and ability to embrace new ideas in the form of innovation	Economic effect of using R&D deliverables; the system capacity to turn the innovation into commercial value, etc.
Mineral resources	Reserves and resources of the oil and gas company; unconventional hydrocarbon resources; by-products; extracted products (oil, gas, gas condensate)	Reserves depletion rate; indicators describing the hydrocarbons qualitative composition; field geologic setting; information on compliance with license agreements; state of geologic exploration; projected and current hydrocarbons extraction ratios; recovery efficiency, etc.
Additional resources	Partnership or personal relations of the company in general or its employees with the academic community, universities; relations with the government and regional authorities; possible state incentives in oil and gas sector	The company's ability to engage and use additional resources

DOI 10.18454/PMI.2016.6.892

The innovative potential growth drivers are usually linked to the development of innovative knowledge and technology; concentration of innovative potential resources for strategic development; creation and development of innovative infrastructure; minimization of innovation-related risks (production, technological, organizational, managerial, etc.);the agility and flexibility of organizational structures and management in dealing with changes in objectives and operating environment, building an incentive scheme to encourage staff at all levels during all stages of innovation process (encouraging research, proposals for improvement, creativity, unconventional thinking, new ideas and projects); deeper involvement of staff in the improvement of business processes and innovation-driven development of the company, etc.

The following factors negatively impact the development of innovative potential and innovative activities: no modern production base for research; inconsistency between the company's business model and the chosen innovative strategy; lack of qualified staff to manage innovations; lack of a framework for cooperation with research organizations and universities; low-efficient knowledge management system at the company; inadequate employee incentive scheme and system for employee continuous development and training.

It is important to distinguish the staff innovative potential, since it is a key element, associated with the ability and capability of the company's staff to develop, generate, effectively pursue and implement both their own and others new ideas and projects.

Research process and findings discussion. *Method for Assessing Innovative Potential of the Oil and Gas Company.* The principles and approaches of the modern strategic management shall be recognized as a methodic framework for managing innovative potential and innovative activity of the oil and gas company [4, 7, 11]. Such approach is fair, as the innovative activity at the company is by its nature strategic, but not operative. The task of building, developing and implementing the innovative potential shall be included in the company's strategy.

In order to successfully tap the innovative potential the following tasks shall be addressed:

• composition and structure of the used factors of production (PP&E and working capital) shall be changed, leading to changed and increased requirements to the company staff skills and qualifications;

• the range of stakeholders of the company, the past experience and established connections which turn out to be insufficient or inefficient, shall be changed;

• innovative activity shall lead to changes in the company's cost and revenue structure – current costs of the company are, as a rule, growing, and the pattern of future profits due to implementation and support of innovation is distant in time and that's why vague.

In order to manage the innovative potential of the oil and gas company, it shall be subject to assessment, which is supposed to include the following stages:

• identification and development of a system of indicators and parameters based on which the company's innovative potential and innovative activities will be evaluated;

• creation of a monitoring system for controlled indicators and parameters;

• matching the real indicators and parameters against the target, evaluation of matching results and deciding on whether the company course of actions needs adjustment.

In order to assess the innovative potential of the oil and gas company it is proposed to use a system of indicators (Table 2).

These specific indicators have been chosen from a broad range with account of unique features of the gas and oil sector, key targets of innovative activity, sufficiency and availability of calculations.

Peculiar Features of Innovative Potential Development at Different Stages of Field Development. Each stage of field development has its intrinsic features and markers, which determine the key areas of innovative technological development and imply the availability of certain resources.

DOI 10.18454/PMI.2016.6.892

Table 2

System of indicators for assessing innovative potential of the oil and gas company

Group of Indicators	Parameters	Description
Financial	R&D costs, monetary units (MU) Specific R&D costs (R&D costs/company proceeds), % Specific R&D costs (R&D costs per unit of product), monetary units/product units	Company's ability to fund R&D, innovative potential of the company
Research and engineering	Share of intangible assets (rights to intellectual property) within the company assets, % Share of research and development deliverables within the company assets, % Number of patent applications, pcs. Number of granted (awarded) patents (patentable items), pcs.	The company's ability to develop (acquire) viable innovation, sufficiency of intellectual property rights and R&D
Entrepreneurial	Efficiency in using R&D deliverables, MU Efficiency in using patents (patentable items), proposals for improvements, licenses, MU Innovation implementation effectiveness (implemented innovation projects in total innovation projects under development), %	Level of innovative activity of the company with respect to new developments, ability to optimally use the available resources and economic effect of innovation
Production and technological	Proven hydrocarbon reserves, bln. m^3 Annual average oil, gas and gas condensate production performance, bln. m^3 Contribution of new fields to oil and gas production, % Scope of geological exploration, MU Plant and equipment renewal coefficient Plant and equipment wear coefficient Production well stock, number of wells Production well stock utilization factor Well operation factor New wells commissioning, number of wells Specific scope of production drilling, meter per 1 ths. tons of production	The company's ability to support innovative technological development with required facilities, as well as the means and factors of production
Economic	Assets at the year end, MU Revenue, MU Equity, MU Long-term and current liabilities, MU Capital investment per 1 ton of production, MU Indicators for economic assessment of innovation projects	The company's economic and financial capacity to support innovative technological development
Human	Staff turnover, % Employees engaged in research and development in total number of the company employees, % Employees engaged in innovative activity in total number of the company employees, % Proportion of staff training costs in total spending on innovative activities, %	Ability of the company's staff to perceive, develop and implement innovation, staff susceptibility to new technologies

Fig.2 shows key technical and economic features inherent to each stage of the field development and priority areas for the production technology development constituting the innovative potential of the oil and gas company.

The Fig.3 shows the main operation indicators of the oil and gas field at different development stages, demonstrating diverse production, technological and economic characteristics at different stages of extraction.

DOI 10.18454/PMI.2016.6.892

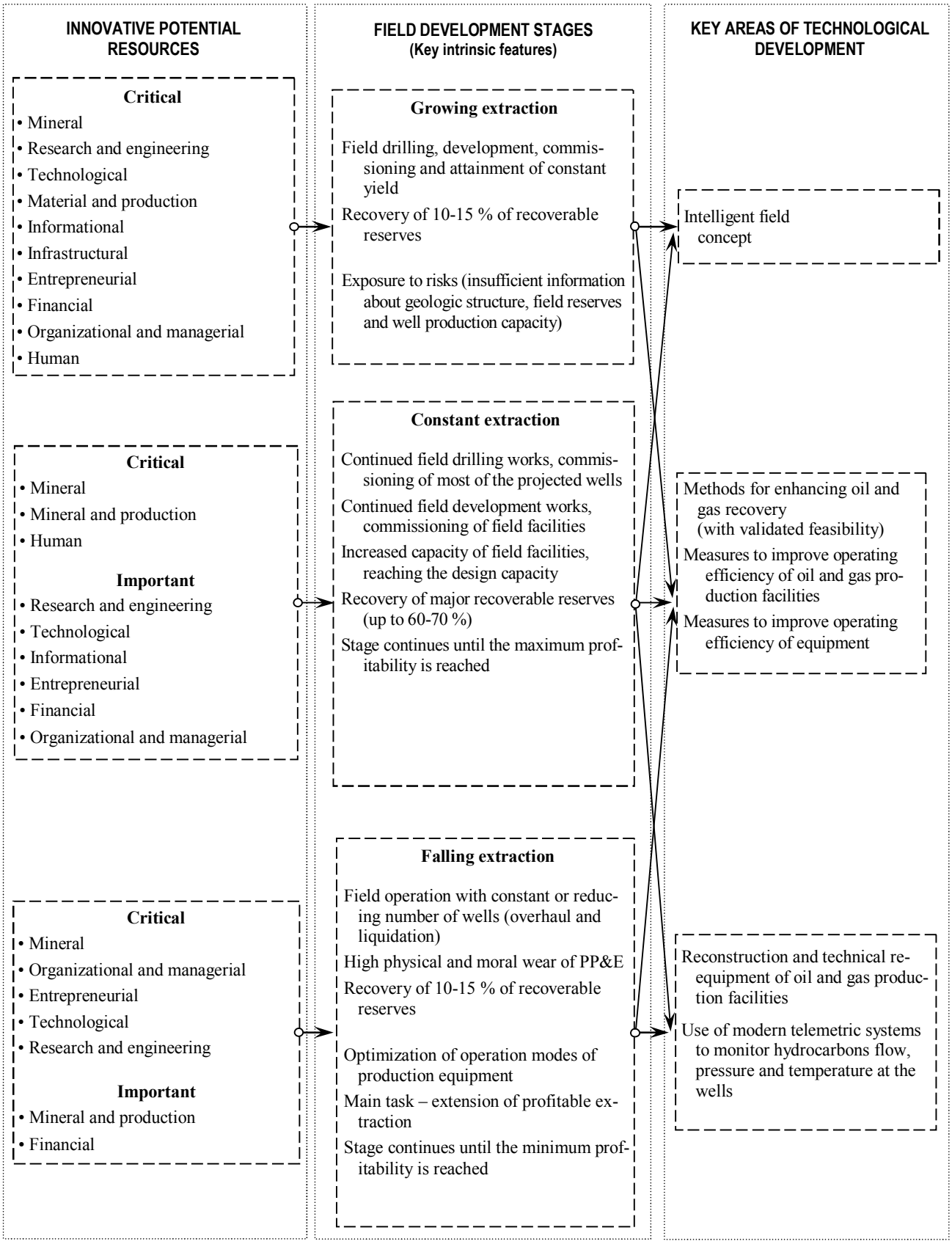

Fig. 2. Technological development of oil and gas company based on use of innovative potential at different field development stages

DOI 10.18454/PMI.2016.6.892

Table 3

Overview of technical and economic indicators of oil and gas field development at different stages

Indicator	Stage		
	Growing extraction	Constant extraction	Falling extraction
	Production indicators		
Mean annual extraction	Growth	Maximum and initial decrease point	Reduction
Total well stock and commissioned well stock	Increase	Increase/ Constant	Decrease
Production infrastructure	Onset of development	Almost built	Built
	Technological indicators		
Water cut	Low	Average/ Increasing	High
Reservoir pressure	High	Average/ Decreasing	Low
Ascending gas flow velocity	High	Average/ Steady	Low
	Economical indicators		
Specific operating costs	High with downward trend	Low	Growing
CAPEX	High (field construction and development)	Minimum	High (reconstruction and technical re-equipment)
Profit	Growing	Maximum	Decreasing
Economic (natural resource rent)	Growing	Maximum with reducing rent proceeds	Reduction
Economic efficiency	Effect of scale, training and gain in experience	Effect of scale, training and gain in experience	Effect of specialization, organizational and technological innovations
PP&E wear	Low	Medium	High

Table 4

Differences in field management systems with and without use of intelligent field (if) technology

Identification attributes	Without use of IF technology	With use of IF technology
Use of software products	Simple information models for data processing, as a rule, Excel-based	Unique specialized software products (Emerson, Eclipse, etc.)
Data management	Data from the production field is not properly structured and requires standardization	Work at the production field with big data volumes concerning the company or the production field in a prompt fashion without processing delays
Technical and technological ware	Scope for improving the production processes is insufficiently studied, digital technologies and devices are not properly integrated in a single system	Use of the most advanced technologies, such as wireless data transmission, remote sensors, robotics
Management decision-making	Medium term and long-term decision-making – data processing required	Fast decision-making – in real time mode
Hydrocarbon fields where use of IF technology is reasonable	All types of hydrocarbon fields, as a rule, with high extent of exploration without geologic or extraction features complicating production	New fields with marginally-profitable reserves Fields at the stage of growing and stable extraction, as a rule, with hard-to-extract reserves
Rational use of subsurface resources	Principles of rational use of subsurface resources are not always abided by, main goal – maximum hydrocarbons extraction at the current moment	Sensitive operation mode – increased extraction of hydrocarbons, stable field performance throughout the entire development cycle without causing disturbance to the ecosystem

DOI 10.18454/PMI.2016.6.892

Intelligent Field (IF) System as an Example of Boosting the Innovative Potential of the Oil and Gas Company. Among the high-prospect areas for oil and gas company technological development outlined in Figure 2 there is a concept of field development using Intelligent Field technology. The ability and capability to rollout IF technology in many respects determine the high innovative potential of the company and requires engagement of plenty of resources.

Intelligent Field system at the oil and gas production facility represents a combination of technologies and a complex of business processes intended to optimize the hydrocarbons extraction, reduce costs by early identification of production issues and fast decision-making by the managers at different levels based on data in real time mode.

Several authors [2, 3] have examined differences in field management systems with and without implementation of IF technology (Table 4).

Implementation of IF technology may yield diverse effects which are actually the determinants of the high innovative potential of the system [5].

Thus generally a considerable saving on operating costs is achieved. IF technology helps to reduce equipment maintenance costs due to efficient measures preventing equipment failure; on-site infrastructure costs due to optimal modes of equipment run; and power costs.

IF technology also accelerates management decision-making due to the use of information from the integrated models and developed databases. The global experience shows that upon introduction of IF technology the management decision-making is 40 % faster as compared to conventional field management systems [1, 3, 6, 9, 21].

The long-term effects of IF technology implementation include optimization of the master development plan and improvement in asset management efficiency, which helps to reduce investment costs, occurring at different time, associated, for instance, with commissioning of new industrial facilities at the field.

Besides there are a some other significant benefits brought by IF technology for oil and gas companies [19-21]: savings on equipment maintenance and lesser involvement of human.

Potential of IF technology is high, which is related to the fact that the need in such systems will grow as oil and gas companies move further to the hardly accessible areas and work at hard-to-develop fields with hard-to-reach resources. With implementation of IF technology the higher standards are set for the employees, their qualification, ability to adapt to innovative systems and efficiently work in such conditions, thus the human resource potential of the oil and gas company is used more efficiently. In general implementation of IF systems will boost the development of the company's innovative potential.

Within the scope of this research the authors have analyzed six foreign projects (such oil and gas companies as Brunei Shell Petroleum, Saudi Aramco, Statoil, ONGC, PEMEX, Saudi Aramco), where IF technology has been introduced. The introduction of IF technology yielded an increase in the annual average profit from 15 % to 20 % [14, 15, 19, 20].

The authors of research have picked an offshore field at the initial stage of its development. Investment costs for IF technology implementation have specific nature due to unique features of the offshore field, manifested in its geologic setting and technical parameters, related to the field natural and geographical specificity.

Structure of Investment Costs for IF System Implementation:

Types of Investment Costs	mln RUB
Project technical re-equipment	270
Purchase of software complexes	308
Purchase of licenses	12.7
Establishment of communication channels	68
Creation of databases and scenarios – consulting and expert services	250
Staff training	95.2
Total, mln RUB	1000.3

DOI 10.18454/PMI.2016.6.892

Technical re-equipment investment includes installation of additional instrumentation, multi-phase flow meters, automated chokes and valves. Investment costs associated with modernization of information component of IF system include software installation, license purchase and communication cables laying. IF system implies creation of databases and development of scenarios. For this purpose external consultants and experts shall be engaged in order to collect expert opinions and develop scenario approaches [2].

The use of high-tech equipment and sophisticated information systems requires better staff training, that's why staff training costs are also included in the cost structure.

Table 5 presents operating costs for project implementation with and without IF system. As the table data shows during the first year of the offshore field development project the implementation of IF technology will help to reduce the operating costs by 13 %. Further on upon re-evaluation of the investment project assuming IF implementation specific operating costs will be lower than in the initial project calculation by 6-9 %

Table 5

Changes in Operating Costs for Hydrocarbons Extraction at Offshore Field With and Without IF System, mln. RUB

Operating Cost Item	Project costs		Reason of changes
	without IF technology	with IF technology	
Auxiliary materials	140.1	140.1	–
Fuel and lubricants (F&L)	881.9	881.9	–
Power supply	6.8	6.3	Reduced production cost due to optimized power consumption
Fixed assets maintenance and repairs	54.8	60.5	Maintenance of expensive equipment
Software updates	0.3	1.7	Purchase of new software
Databases and scenarios updating	35.7	120.6	Ongoing database optimization is required leading to increased costs
Production staff costs	899.7	715.8	Release of staff, optimization of payroll costs
Extraction services	527.3	527.3	–
Transport services	1308.4	1034.1	Optimization of tanker navigation
Geophysical services	2.4	2.4	–
Environment protection	69.7	60.2	Use of automated ecological monitoring system
Occupational health and industrial safety	8.2	5.1	Use of automated industrial safety systems
General and administrative costs	495.8	340.7	Cost reduction due to reorganization of business structure
Total	4431.1	3896.7	

IF system will help to increase project Oil Recovery Rate (ORR) up to 12 % in 10 years after its implementation, thereby extending the field life. Increase in project ORR will lead to increase in hydrocarbons production.

With the help of IF technology the project net discounted proceeds for the entire field life will increase by 95 %.

The provided example shows that implementation of IF system will contribute greatly to changing the offshore field development project indicators by:

DOI 10.18454/PMI.2016.6.892

• enabling more efficient use of the company resources, extending the hydrocarbon field life cycle;

• increasing project ORR and decreasing hydrocarbon production costs;

• continuous optimization of production and technical performance of the oil and gas field;

• ensuring high qualification of employees;

• creating database facilitating development of the company's innovative potential and ready for use in future projects.

Conclusions. It has been established that the innovative potential of the oil and gas company lies in the range of diverse specific resources as required to drive innovation. The study identified mineral, research and engineering, technological, infrastructure, informational, material and production, financial, human, intellectual, organizational and managerial, legal, entrepreneurial and other resources.

Innovative potential determines the readiness and ability of the oil and gas company to embrace the changes and innovations; it is the company's internal capacity to drive innovation.

The research has revealed that the innovation is an essential factor for the development of the oil and gas company and the main possible areas for its innovative technological development have been examined. The fields at different development stages by rate of hydrocarbons extraction (growing, constant and falling) have their inherent features associated with the field geologic setting and technical parameters. An important area for development of the oil and gas company shall be the efficient use of its innovative potential directed at implementation of innovative technologies, information systems and efficient management systems. Such technologies and systems lie at the core of the company's innovative potential building, developing and implementing.

A methodic approach to assessing the innovative potential of the oil and gas company has been outlined with highlighting the most important indicators and determining their value for assessment of the innovative activity.

Key technical and economical parameters of the oil and gas company development at different stages of the hydrocarbon field operation and the main areas for the innovative technological development of the oil and gas company with regard to extraction have been distinguished.

One of the areas for innovative development, as the study has shown, is the implementation of the Intelligent Field technology. Implementation of IF projects implies commitment of a considerable amount of resources constituting the innovative potential of the company in the field of technology, organization and management.

REFERENCES

1. Barber E. Production optimization: productive strata to oil and gas preparation. *Neftegazovoe obozrenie*. 2008, p. 22-37 [in Russian].

2. Berezina A.A. The expediency of the smart field transition concept on the conditions of modern oil and gas complex problems. *Problemy ekonomiki i upravleniya neftegazovym kompleksom*. 2015. N 2, p. 42-44 [in Russian].

3. Berezina A.A., Cherepovitsyn A.E. Economical concept of oil and gas smart field. *Neftyanoe khozyaistvo*. 2014. N 4, p. 14-15 [in Russian].

4. Vasyukhin O.V., Pavlova E.A. Innovative potential of inductrial facility. Moscow: Izd-vo: Akademiya estestvoznaniya, 2010. Available at: http://www.rae.ru/monographs/89 (data of access 28.09.2014) [in Russian].

5. Eremin N.A. Modern production of oil and gas deposits. Smart well. Smart development. Virtual company. OOO «Nedra-Biznestsentr». Moscow, 2008, p.244 [in Russian].

6. Daier C. Smart pumping: smart wellhead. *Neftegazovoe obozrenie*. 2008, p. 4-21 [in Russian].

7. Kravchenko S.I., Kladchenko I.S. Innovation capacity entity research. Nauchnye trudy Donetskogo natsional'nogo tekhnicheskogo universiteta. Ser. ekonomika. DonNTU. Donetsk, 2003. Iss. 68, p. 88-96 [in Russian].

8. Development and control of smart fields. Ed. by D.M.Myurrei. Intellektual'nye mestorozhdeniya. Prilozhenie k zhurnalu E&P Magazine. Sentyabr' 2010. P. 1-24. Available at: http://www2.emersonprocess.com/ru-ru/documents/intelligent %20fields_rus.pdf (date of access 19.10.2016) [in Russian].

9. Morozov I.S., Kharitonov A.N., Kiselev M.N., Skorobogach M.A. Integrated simulation systems for field development control efficiency improvement. *Gazovaya promyshlennost'*. 2011. N 10, p. 31-35 [in Russian].

10. Kiselev S.V., Gilyazutdinova I.V., Bashkirtseva N.Yu., Ponikarova A.S. Industrial innovative activities risk control in renovation of production potential of regional petrochemical complex process. Kazan': Izd-vo Kazan. tekhnol. un-ta, 2009, p. 188 [in Russian].

11. Fakhrislamov V.G., Fakhrislamova S.G. Innovative potential management of organization – competitiveness factor. Molodezh' i nauka: Sb. materialov VIII Vseros. nauchn.-tekhn. konferentsii, posvyashchennoi 155-letiyu so dnya rozhdeniya K.E.Tsiolkovskogo. Krasnoyarsk, 2012. Available at: http://conf.sfu-kras.ru/sites/mn2012/section05.html [in Russian].

12. Fedoseev S.V., Cherepovitsyn A.E. Total strategic potential assessment of the fundomental industries in the Arctic zone of Russian entities. Vestnik MGTU. Sotsial'no-ekonomicheskie nauki. 2014. Vol. 17. N 3, p. 598-605 [in Russian].

13. Cherepovitsyn A.E., Smirnova N.V., Pikalova T.A. Concept view of innovative development strategy of fuel and energy complex. *Ekonomika i predprinimatel'stvo*. 2014. N 12, p. 111-118 [in Russian].

14. Al-Dhubaib T.A. Intelligent fields: industry's frontier and opportunities. Proceedings of conference: SPE Middle East Oil and Gas Show Conference, Manama, Bahrain, September 25-28, 2011, p.9-11.

15. Al-Mulhim W.A., Faddagh H.A., Shehab M.A., Shamrani S.S. Mega I-Field Application in the World. Proceedings of conference: SPE intelligent energy conference and exhibition, Utrecht, The Netherlands. March 23-25, 2010, p. 6-9.

16. Carayannis E.G., Cherepovitsyn A.E., Ilinova A.A. Technology commercialization in entrepreneurial universities: the US and Russian experience. *The Journal of Technology Transfer*, April 2015, Springer Science+Business Media, New York, 2015. DOI 10.1007/s10961-015-9406-y.

17. Cherepovitsyn A.E., Ilinova A.A. Ecological, economic and social issues of implementing carbon dioxide sequestration technologies in the oil and gas industry in Russia. *Journal of ecological engineering*. 2016. Vol.17. Iss.2, p.19-23.

18. Cherepovitsyn A.E. Prospects of CCS projects implementation in Russia. *Environmental protection and economic opportunities journal of ecological engineering*. 2016. Vol. 17. Iss. 2, p. 24-32, DOI: 10.12911/22998993/62281.

19. Sankaran S., Lugo J., Awasthi A., Mijares G. The Promise and Challenges of Digital Oilfield Solutions: Lessons Learned from Global Implementations and Future Directions. Proceedings of conference: SPE digital energy conference and exhibition held. Houston, Texas, 7-8 April 2009. N 13, p. 10-12.

20. Soma R., Bakshi A., Orangi A., Prasanna V.K., Da W.A. Sie Service oriented data composition architecture for integrated asset management. Proceedings of conference: SPE Intelligent Energy Conference and Exhibition, Amsterdam, The Netherlands. April 11-13 2006, p. 1-2.

21. Waleed A. Al-Mulhim, Hussain A. Al-Faddagh, Al-Shehab, Mahdi A., Sultan S. Shamrani. Mega I-Field Application In the World. Proceedings of conference: SPE IECE, Utrecht, The Netherlands. 23-25 March 2010, p.6-8.

***Authors*: A.E.Cherepovitsyn**, *Doctor of Engineering Sciences*, *Professor*, *alekseicherepov@inbox.ru* (*Saint-Petersburg Mining University, Saint-Petersburg, Russia*), **A.Kraslawski**, *Professor, andrzej.kraslawski@lut.fi* (*Lappeenranta University of Technology, Lappeenranta, Finland*).

The paper was accepted for publication on 3 October, 2016.