Analysis of the hydrodynamic modeling market under the environmental conservation concept

Artem Ivanov[1], *Marina* Kruk[2,*], and *Vladimir* Litvin[3]

[1]Student, Department of Development and Operation of Oil and Gas Fields, St. Petersburg Mining University, St. Petersburg, Russia
[2]Associate professor, Department of Economics, Organization and Management, St. Petersburg Mining University, St. Petersburg, Russia
[3]OOO Gazpromneft-Snabzhenie, St. Petersburg, Russia

Abstract. The paper presents a comprehensive analysis of the global software market for modeling technological processes in the field of oil and gas based on data from independent analytical agencies. The work covers various aspects of the industry through a study of key competitors. The paper also provides a better understanding of the meaning of modeling software implementation. The assessment of the potential of the domestic market (TAM-SAM-SOM method) was carried out and the expediency of introducing Russian software for hydrodynamic modeling of high-viscosity oil was substantiated.

1 Introduction

Today, the high-tech market enters many sectors of the economy, including the oil and gas business. Despite the challenges the world faced due to the pandemic, the market will only grow in the near future.

As part of the topic under consideration, it is worth noting that special attention within the country's fuel and energy industry is also focused on promising hydrocarbon reserves in the Arctic. This area is a challenge requiring the application of the most advanced scientific solutions, both theoretical and practical. It is in this regard, the possibility of creation and application of domestic software solution for hydrodynamic modeling of high-viscosity oils is able to guarantee the safety, stability and efficiency of works in this direction, as well as improve the environmental safety of their production. Highly specialized software for solving problems of hydrodynamic modeling under various conditions of occurrence and filtration of oil will allow large oil companies to significantly reduce costs by increasing the accuracy of field processes modeling.

The current global market of information and communication technologies, according to various estimates, is about 269.88 trillion. rubles (3.69 trillion dollars). The global lockdown situation in 2020 led to a 4.3% drop in the global economy, which is 2.5 times more than during the global financial crisis of 2009. The contraction of the global economy had a significant impact on energy markets and led to the 4.3% drop in global energy demand, mainly due to carbon-intensive electricity generation, transport, and tertiary sector [1]. According to Gartner [2], it is projected that after a decline of 2.7% in 2020 due to the coronavirus pandemic, the global IT services market will show stable growth of around 6% per year in the next few years. It is expected that an increase in the activity of field development around the world and an increase in the costs of oil and gas companies will contribute to the growth of global software for modeling technological processes in the oil and gas market. In addition, the growing penetration of IT solutions is one of the key growth drivers for the global oil and gas process modeling software market. The Russian market in 2020, according to the IDC analytical company, grew by 14% to 1.833 trillion. rubles ($25 billion) [2].

Scientific and technological progress in the energy sector is currently living at a tremendous momentum. According to some experts, the degradation of competencies in this industry will practically catch up with the IT sphere by 2030 and will have a lifespan of about 2–3 years. In this regard, the launch of the new personnel training with ‘‘job-ready’’ skills in the digital power grid complex should have started quite a long time ago. It is important to note that the digitalization should take place simultaneously with the modernization of the laboratory base, with the ad-hoc formation of the required number of students (technicians, engineers) by teachers having the situational knowledge in dedicated universities [3].

Despite the growth of the domestic IT services market, the fuel and energy complex remains highly dependent on imports of foreign software. In 2019, an RF Presidential Decree approved a new Doctrine of Energy Security of Russia. was It takes into account the latest changes in the international situation, actualizes the challenges and risks of energy security, directions and tasks of the state policy. The provisions of the Doctrine have been included in the Energy Strategy of Russia for the period up to 2035. Within the framework of these tasks, a reasonable question arises about the necessity to increase the competitiveness of the Russian

* Corresponding author: marina_kruk@mail.ru

software solutions for a number of field tasks, including the prospective development of the deposits with high-viscosity oils. Due to the shortage of heavy grades of oil (the parties to the agreement on regulation of oil production (OPEC+) mainly reduce the production of heavy oil), the role of Russian companies in ensuring global energy security has increased. By replacing Iranian and Venezuelan heavy crude, companies supplying Urals crude to the world market benefit. [4] Refinery efficiency is very sensitive when it comes to changes in consumer demand. For instance, the OPEC+ agreement on the reduction of oil production has affected oil consumption, the COVID-19 pandemic has reduced global demand for petroleum products (kerosene, gasoline, diesel fuel, etc.), and finally has affected oil and petroleum product prices. [5] Nevertheless, taking into account the implemented concept of sustainable development, it does not always take into account the specifics of the commodity sector of the world economy, which includes both "traditional" hydrocarbon carriers, and developed "green energy". The main challenges concern access to investment resources, as well as the impact of discriminatory policies that hinder the full implementation of strategic initiatives to find a path to sustainable development. [6] Some experts argue that in the case of Russia, the energy sector will develop according to the optimistic scenario with a significant share of conservative elements. The transition to the high-tech scenario requires a number of changes in the process of forming technological reserves, as well as elimination of institutional and infrastructural risks. [7] The purpose of the development of the Russian fossil fuel energy industry, on the one hand, is to strengthen and maintain its position in the global socio-economic development, and on the other hand, to strengthen and maintain its position in the global energy sector, as well as to maintain a reliable quality and economic supply of energy and raw materials, taking into account the principles of energy conservation and energy efficiency. [8] Like any developing system, there is both advantages and disadvantages in the modern Russian corporate relations model. A number of unresolved problems remain hindering it. These include the weakness of the institutional structure of the corporate sector, the presence of significant administrative barriers, the uncertainty of state policy, etc. An important problem is the uncertainty and imperfection of the regulatory framework governing the organization of corporate entities: legal regulation is fragmentary and superficial; methods of coordinating the work of industrial complexes with federal and municipal administrative and economic departments are not fully developed. [9]

Process modeling in the oil and gas industry is used for the design, development, analysis and optimization of technical processes. The use of machine learning technologies in the oil and gas industry has increased significantly in recent years. An important task in the development of the oil and gas industry in the coming years is to improve the efficiency of oil and gas production and well drilling, and the main impetus for the introduction of machine learning methods was the drop in oil prices. Oil and gas companies have focused on resource efficiency, optimizing production processes [10]. The demand for the introduction of software for modeling technological processes at oil and gas facilities is growing, because it allows to effectively design and analyze each process during exploration and increase oil and gas production, and allows to reduce the risk of errors and increase productivity [11]. For example, a Bayesian neural network was used in the work of Al-Yami and Schubert [12]. The method used made it possible to create a system for making expert decisions during drilling. This method can be implemented to train young engineers. The system can also provide advice at all stages of well construction. These recommendations may relate to well completion, monitoring of drilling and cementing of wells, selection of drilling fluids, etc. [11] Analysis of Data Bridge market research shows that the average annual growth rate of oil and gas modeling market will be 4.8% in the forecast period of 2021-2028 and the market is expected to reach 108.43 billion rubles (1.48 billion dollars) by 2028. The growing introduction of innovative and advanced technologies to improve production efficiency is a major factor driving the growth of the oil and gas process modeling market.

Growing demand for oil and gas, combined with the growth and expansion of the oil and gas industry, will drive the demand for modeling of oil and gas production processes. Increasing interest in the research and development area for investment in innovative technologies such as 3D technologies will create additional lucrative opportunities for the growth of the oil and gas process modeling market. Growing demand for automation systems in the oil and gas industry will also play a decisive role in the growth of the market [13]. The North American region has the largest market share worldwide, followed by Europe and the Asia-Pacific region. The USA and Canada dominate the North American market. The growth of the market in North America is due to technological advances and the wider adoption of software applications for modeling in small and medium-sized enterprises. In addition, the region has a well-developed infrastructure that allows for faster implementation of advanced technologies.

It is expected that during the forecast period, the Asia-Pacific region will see ample opportunities for growth in the manufacturing and IT sectors. The presence of a large population, developing infrastructure and technology are the main factors contributing to the growth of the modeling software market in the region. The governments of India and China are accelerating the development of the manufacturing sector to develop and test vehicles, IT-related products and solutions, as well as defense equipment. High market growth is also expected due to technological advances and the use of modeling and analysis technologies.

It is expected that the global market of IT solutions for modeling will grow at a rate of ~16% per year [14] during 2017-2023 (Figure 1).

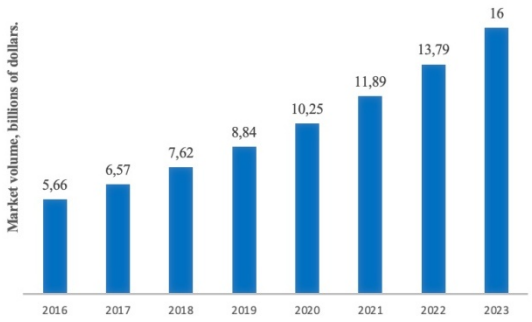

Fig. 1. Global modeling software market (Source: MRFR Analysis.

According to the Markets&Markets analytical agency, it is expected that the volume of the global modeling software market will grow from 928.86 billion rubles ($12.7 billion) in 2020 to 1.97 trillion rubles ($26.9 billion) by 2026 with a cumulative annual growth rate (CAGR) of 13.2% during the forecast period [15].

According to the mentioned data of a number of analytical agencies (Table 1), we can see that the annual growth of the whole market of IT-services in modeling in the coming years will average 14.6%, while the growth of the modeling market in the oil and gas sphere is only 4.8% [13]. Thus, according to this estimate, the market share of modeling in the oil and gas sector will decrease from 8.89% in 2020 to 3.4% in 2023 of the total market, but will grow in volume from 74.6 billion rubles (1.02 billion dollars) in 2020 to 85.57 billion rubles (1.17 billion dollars) in 2023. This is due to the widespread introduction of modeling in various industries due to the global digitalization of most technological processes. The main factors driving the modeling software market are the growing demand for an efficient solution to reduce production and training costs, as well as the expansion of modeling capabilities in advanced technologies such as digital twins, AR/VR and 3D printing. In order to be competitive in the market, enterprises are paying more and more attention to research activities.

Table 1. The volume of modeling and simulation markets in the oil and gas industry (billion dollars, excluding interest)

Source	CAGR, %	2020	2021	2022	2023	2024	2025	2026
MRFR Analysis	16	10.3	11.9	13.8	16	-	-	-
Markets and Markets	13.2	12.7	14.4	16.3	18.4	20.9	23.6	26.9
Data Bridge	4.8	1.02	1.07	1.12	1.17	1.23	1.29	1.35

The main players represented in the oil and gas process modeling market are Aspen Technology Inc., Honeywell International Inc., KBC., AVEVA Group plc, Process Systems Enterprise Limited, Chemstations Inc., KONGSBERG, GSE Systems, Inc., Schlumberger Limited., ProSim, Schneider Electric, Bryan Research & Engineering, LLC, Halliburton., CULGI B. V., SimuTech Group, Simul8 Corp., ANSYS, Inc., ESI Group, MOSIMTEC, LLC, Hexagon AB and TietoEVRY and domestic players [13].

2 The importance of the fuel and energy sector for Russia

Russia's energy sector, the basis of which is the fuel and energy complex, makes a significant contribution to national security and socioeconomic development of the country. Therefore, special attention should be paid to it, since the fuel and energy complex plays a key role in the formation of the country's budget revenues. Its share in fixed capital investment is about one-third of all investments in fixed capital of the country, in the structure of federal budget revenues it is about 40%, and in Russian exports (in value terms) - more than half.

Today special attention within the country's fuel and energy complex is paid to promising hydrocarbon reserves in the Arctic. This is due to the fact that the Arctic Zone of the Russian Federation (AZRF) is a zone of strategic interests of Russia, where 12-15% of the country's GDP is created, providing about a quarter of the export of Russian natural resources [16]. The Arctic zone has the potential of a hydrocarbon resource base of about 13 billion tons of oil and 86 trillion m^3 of gas. Their development is also a driving force for progress in the economic sector and a lifeline for the energy transition [17]. At the same time, the development of the hydrocarbon resource base on the Arctic shelf has considerable limitations, and all the significant advances in recent years in the preparation of new reserves have led to the rediscovery of offshore extensions of onshore fields [18]. The effective development of these fields provides not only material benefits, but also stimulates the development of science, because working with oil fields on the shelf, especially with large taxable oil reserves, has always required advanced solutions in related specialized disciplines. It is important not only to study individual problems of Arctic zone development, but also to form scientific knowledge about the Arctic as a unique integrative object of economic activity. The proposed main directions of scientific research approximately and comprehensively describe the problem of Arctic zone development, will help to solve the problem of improving the efficiency of economic activities in the Arctic zone of the Russian Federation [19]. The creation of an independent internal hydrodynamic simulator, which will also be applicable to Arctic sediments, can guarantee the safety, stability and efficiency of works in this direction. The potential expected effect for the mining areas from the implementation of the projects of the backbone zone will be as follows: development of production facilities; positive impact on investment attractiveness; reduction of the burden on the environment; increased accessibility

of transport in remote areas; support of the interest of the Russian Federation in the presence in the Arctic; improvement of living conditions of the population; strengthening economic security of the macro-region [20]. Today, the volume of the domestic software market in the entire fuel and energy complex is 286 billion rubles ($3.91 billion) [21]. Russia has successfully implemented a number of projects to introduce Russian digital developments in the oil and gas industry. Thus, the tNavigator software product from Rock Flow Dynamics LLC, with the grant support of the Skolkovo Foundation, is successfully used in more than 200 companies around the world. The leading module of this product is a hydrodynamic simulator used to model the processes of field development. Another example is the Prime system of Yandex Terra LLC. This is full-featured Russian software for 2D/3D/4D/3C/4C seismic data interpretation that meets all the requirements of modern technical specifications, and also includes a number of innovative algorithms for solving geophysical problems. Among the domestic solutions in the field of geological modeling are Geoplat-Pro (GridPointDynamic company), the tNavigator software package module "Designer of Geology" (Rock Flow Dynamics LLC), as well as the "Sphere.Geology" module (the STC RIT Delta company) [22].

However, domestic IT companies offering their own solutions often face a number of difficulties, which can be divided into three groups.

Firstly, Russian companies representing traditional sectors of the economy, as a rule, demonstrate low interest in the introduction of digital technologies. One of the key tasks in this area remains the development of effective mechanisms to stimulate demand for digital solutions from companies.

Secondly, the lack of a necessary regulatory framework for effective regulation of the digital economy of Russia remains a barrier. Here, the task of the state is to create the clearest and most transparent rules of the game for all market participants. Active work in this area is being carried out within the framework of the corresponding federal project - "Regulation of the digital environment".

Thirdly, it is the low level of competitiveness of Russian digital solutions and, as a result, the high dependence of our market on foreign products.

3 Demand satisfaction level

According to Russian analysts, the dependence on foreign products in the oil and gas industry for 2020 is 80-90%, and the share of exports of ICT services in total Russian exports in the first half of 2019 was 8.4% [23].

Russian companies' exports of computer services grew much faster in the first half of 2020 than in 2019. According to Russoft, in the first six months of 2020 it grew by 14% compared to the first half of 2019 —to 175.53 billion rubles ($2.4 billion), whereas in the first half of last year the growth was 10.5% compared to the same period of 2018. And this is despite the fact that total exports of services during the same period decreased by 21% to 1.7 trillion. rubles ($23.3 billion) [24].

A number of difficulties arise in connection with the use of foreign solutions:

1. Foreign geological modeling software products use various interpolation and extrapolation algorithms, which are usually not common enough, which often leads to inexplicable results – for example, unjustified replacement of a reservoir by a non-collector.
2. The absence of a Russified shell of foreign products, which, on the one hand, complicates their use and, on the other hand, directly contradicts Russian legislation.
3. A significant workload of trainers with various options, which dictates the need for long-term training (which suppliers may be interested in).

In addition to the challenges mentioned, we may add the following [25]:

1. High dependence on the existing institutional environment – the state has to consider creating an independent regulator.
2. The need to develop additional procedures for monitoring capital expenditures.
3. Increased burden on the regulatory body to collect more information for better analysis.

Some large oil and gas companies deliberately refuse to use market simulators and prefer to create their own software tools, because, in their opinion, they are more trustworthy. Even inferior to the licensed analogues offered on the market, mainly by the services offered, they turn out to be quite a powerful computational tool in the hands of their authors. For example, work on the creation and improvement of hydrodynamic simulators in Severnipigaz, a branch of VNIIGAZ, has been going on for more than 20 years. This was caused first by the lack of reliable software tools on the market, then by a lack of funds in the branch to purchase them. All this resulted in the creation of the Proteus software package, which has been repeatedly tested at the oil and gas condensate fields of the Timan-Pechora province [26].

To date, among the popular simulators (Table 2) there also are Russian ones; however, for hydrodynamic modeling of high-viscosity oils on the market there are no domestic analogues to the most common CMG STARS simulator, which was created by the Canadian company CMG Software.

Table 2. Comparison of the most common simulators

Company	**Revenue for 2020, million rubles**	**Profit for 2020, million rubles**	**The main activity of the company**
tNavigator	958,1	116	Research and development in the field of natural and technical sciences
Schlumberger	26 213	6 100	Manufacture of other instruments, sensors, instruments and instruments for measurement, control and testing

Roxar	104,5	-83,2	Computer software development, consulting services in the field and other related services
CMG STARS	5 085	1 739,7	Computer software development, consulting services in the field and other related services
Surgutneftegaz (TechScheme)	1 062 200	729 600	Oil production
Rosneft (RN-KIM)	5 750 000	181 000	Oil production

4 Methods and methodology

Methods of critical and comparative analysis methods were used for the analysis. To determine the final market segment as a potential consumer of the developed software product, the TAM-SAM-SOM method was modified (Table 3). The method of estimation and calculation of it was improved for specific given conditions.

Table 3. Semantic content of indicators for assessing the market potential for the introduction of domestic software for hydrodynamic modeling of high-viscosity oils

Parameter	Meaning	Quantitative assessment
TAM (Total Addressable Market)	Is the product in demand?	The volume of the global market for the production of high-viscosity oils
SAM (Served/Serviceable Available Market)	How many companies can buy such an IT product?	The volume of the domestic market of IT solutions for high-viscosity oils
SOM (Serviceable & Obtainable Market)	The part of SAM that you can take	The volume of the domestic IT solutions market, which can be displaced due to the advantages of the new simulator

TAM:

$$Ae_\gamma = Q_d \cdot 365 \cdot Cp \cdot \gamma, \quad (1)$$

where:
Q_d – average daily oil consumption
Cp – average cost of oil production in Russia
γ – the share of highviscosity oil in global reserves
Ae_γ – high – viscosity oil production costs

SAM:

$$V_m^R = \frac{(\frac{P \cdot \eta}{n} - \sum R) \cdot \gamma_R}{30} \quad (2)$$

where:
P – economic effect due to digitalization;
n – duration of economic effect;
η – share of software for hydrodynamic modeling;
V_m – the volume of the hydrodynamic modeling market;
ΣR – total revenue of the main competitor companies;
γ_R – Russian share of high – viscosity oil reserves;
V_m^R – volume of the Russian hydrodynamic modeling market.

SOM:

$$V'^R_m = V_m^R \cdot 0{,}242 \quad (3)$$

where:

V'^R_m – Serviceable & *Obtainable Market*.

5 Results

Table 4. Initial data for the calculation [26, 27, 28, 29, 30, 31, 32, 33, 34, [35]

Parameter	Dimension	Sign	Value
Average daily oil consumption	million barrels/d	Q_d	107,3
Average cost of oil production in Russia	USD /barrel	Cp	11
The share of high-viscosity oil in global reserves	%	γ	21
Economic effect due to digitalization	USD billion	P	1000
Duration of economic effect	years	n	5
Share of software for hydrodynamic modeling	%	η	5
The volume of the hydrodynamic modeling market	USD billion s/year	V_m	10
Total revenue of the main competitor companies	USD billion /year	$\sum$ R	0.44574
Russian share of high-viscosity oil reserves	%	γ_R	22
Volume of the Russian hydrodynamic modeling market	USD billion /year	V_m^R	0.07
The really achievable volume of the domestic market	Usd billion /year	V'^R_m	0.017

To estimate TAM, we need to calculate the entire volume of the oil and gas market, which is accounted for by high-viscosity oil. To do this, we use OPEC data on daily oil consumption (107.3 million barrels per day) [27] and the average cost of production of one barrel of oil in Russia in 2020 ($11/barrel) [28]. Let us assume that the share of high-viscosity oil in the global recoverable reserves is 21% [29].

Since the paper calculates the feasibility of creating domestic software for hydrodynamic modeling of high-viscosity oil, we will proceed from the average cost of 1 barrel of Russian oil.

As a result of calculations, the total volume of the target market (TAM) amounted to 90.47 USD billion /year or 6,616.87 billion rubles/year.

When calculating Served/Serviceable Available Market (SAM), we take into account that, according to experts of the World Economic Forum, the global oil and gas industry due to digitalization can achieve an economic effect of $1 trillion by 2025. Let us assume that digitalization of processes will allow oil and gas companies to generate a total of $200 billion annually [27, 32]. However, these amounts do not reflect the "percentage of IT solutions in the cost of 1 barrel of oil". An accurate model helps to reduce costs and prevent possible complications, therefore mining is getting faster and cheaper.

According to the most conservative estimate, let us assume that hydrodynamic modeling of high-viscosity oils gives only 5% of the "gain" [30,31]. We get that

thanks to digitalization, we will receive USD 200 billion, but only 5% of it will be considered the market volume of hydrodynamic modeling.

From Table 2, we take into account that the main competitors in the market of hydrodynamic simulators are tNavigator, Roxar and CMG STARS, Schlumberger; we subtract the annual revenue of these companies for a rough estimate. The total revenue of the companies for 2020 amounted to $ 0.44574 billion.

Based on the fact that Russia accounts for 22% of all high-viscosity oil in the world [29, 34], it is possible to make a formula for calculating the available volume of the domestic market. The duration of field development should also be taken into account. For a rough estimate, we may assume that the development period of an oil field is 30 years, then we get the value of the volume of the served available market (SAM) is equal to $ 0.07 billion /year or 5.8 billion rubles/year.

To calculate Serviceable & Obtainable Market (SOM), we take into account that companies such as Rosneft and Surgutneftegaz have their own hydrodynamic simulators, and the volume of the market they occupy, according to various calculations, can account for 34.8% and 10.8%, respectively [32, 35-38]. Let us assume the worst-case scenario in which all major players in the Russian oil and gas market have their own hydrodynamic simulators, then the market share that these simulators can occupy, will be 24.2%. Thus, the resulting value of the Serviceable & Obtainable Market volume was $0.017 billion/year or 1.23 billion rubles/year.

6 Conclusion

Thus, we can say that under the conditions of the implementation of the strategy of digitalization of the fuel and energy complex and the doctrine of digital security of the energy complex, it is advisable to introduce new special software for modeling high-viscosity oils. An economic analysis was carried out, on the basis of which it is clear that such a software solution will be able to occupy its niche of 1.23 billion rubles/year in the case of its low price and high quality.
Such a solution will increase competition in the Russian market and will enable many companies to expand their activities due to the concomitant increase in the accuracy of development and reduction of expenses. The accuracy of the development, in its turn, will minimize possible costs and meet the key criteria and requirements of today's environmental agenda. It is also important that the implementation of such a highly specialized Russian software solution can be more accurate due to the fact that all algorithms will rely on the experience of developing domestic deposits, and more operational support from the software manufacturer is also possible.

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