SPE-174889-MS

Offshore Project Risk Management Model (OPRMM) As a Tool for Efficient Field Development

Aminam Talipova, Gubkin Russian State University of Oil and Gas

This paper was prepared for presentation at the SPE Annual Technical Conference and Exhibition held in Houston, Texas, USA, 28–30 September 2015.

Abstract

Risk Management approach is an essential part of the project. Large industries and particular companies incorporate RM Culture. Statistics shows, that companies with Project Management (PM) Structure reduce cost ineffectiveness up to 20%. In oil and gas industry PM Risk Analysis (PRMA) has been widely used for the last years. Various models and procedures have been developed to manage projects of different scale.

Nonetheless, Offshore Projects (OP) complexity, high uncertainty of technical, financial, market and government factors, as well as different sea conditions, still makes sense to improve general PRMA models according to the oil and gas OP features. Traditional RM tools and techniques are not appropriate to cope with complex projects in the Arctic. Companies will have to modify risk assessment process or look for new methods. The paper suggests OPRMM, where the attempt to implement PM tools and techniques together with mathematical modeling and expert assessment is made and institutional factors are included. Practically, it is founded on the comparison between offshore field development in the Barents Sea and the Kara Sea. The reason for research is debates around future Arctic oil and gas projects and their commercial potential. Several large projects with participation of major international companies in the Barents Sea and the prospectivity of the Kara Sea Projects in conditions of technology difficulties are under discussion and have not reached the investment project phase yet. OPRMM starts with identifying the key factors, which could affect offshore field development. Inside the investment regime modified real option value (ROV) model for OP is developed: stop option and scale transformation option. Basing on the binominal trees and Monte Carlo Simulation it is possible to see the perspectives of the OP at an early stage in the conditions of high uncertainty. Incorporating the ROV model into investment regime allows operator to choose the territory to explore.

The research shows, that offshore projects in the Arctic offshore is not only under the pressure of internal corporative factors, but also under influence of external institutional factors. New tools and approaches will be required in Arctic projects where no one wants to be looking in the wrong place.

Introduction

For the last decade oil and gas industry has shown a rapid technological progress, which was a result of past researches and new market conditions. The supermajors[1] understand that the value of company depends on the resource base and proven reserves that is the main company asset. However, easy recoverable reserves are limited, new technologies are required to raise recovery factor and make

[1] A word usually associated with the largest transnational oil and gas companies by revenue and assets in the world: Shell, BP, Exxon Mobil, Total.

depleting field economically efficient as well as new regions are required to be explored and provide the stability of resource base. The Arctic offshore is considered to be one of the possible new prospective regions for exploration.

According to USGS release in 2008, the estimated resources of the region are equal to 90 billion barrels of undiscovered, technically recoverable oil, 1,670 trillion cubic feet of technically recoverable natural gas, and 44 billion barrels of technically recoverable natural gas liquids. These resources account for about 22 percent of the undiscovered, technically recoverable resources in the world. The Arctic accounts for about 13 percent of the undiscovered oil, 30 percent of the undiscovered natural gas, and 20 percent of the undiscovered natural gas liquids in the world. About 84 percent of the estimated resources are expected to occur offshore. From 6 bordering countries Russia has the largest part of the Arctic. Gazprom, Russia National Gas Company that owns 70% of all gas reserves in the country has estimated proven 5791,4 billion cubic feet of natural gas, 47,4 million tones of oil and 100,8 million tones of condensate reserves on the Arctic offshore license area according to PRMS classification in 2012.

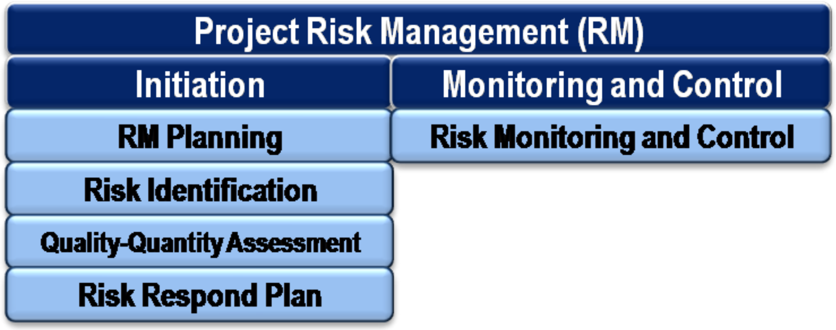
Even though the Arctic offshore is of a high value of perspective, such decisions and programs have been worked out in the period of high oil prices and large capital Arctic projects were taken as profitable. However, when such factors as price uncertainty, strict tax and investment regimes, vulnerable market demand and high costs are concurrently active for every company it indicates to stop or liquidate the project. Companies face a difficult choice: new drilling and completion technologies are being developed, traditional onshore fields are being depleted and difficult projects become more realistic with good assessment from one side; shock price oscillations, state conditions and high capital demand for project realization from another side. Many researches, expertise, ecological and safety controls will be provided before starting active Arctic development. Huge amount of possible reserves can compensate the production decline on onshore fields and companies will rather search for better project assessment tools and risk management techniques than stop projects. Low geological information and poor experience of complex projects realization means that in the nearest future each project is going to be unique. It means that analogue assessment method and many other traditional techniques are not available. In the frame of Project Management it means that some input parameters are not appropriate and new paradigms are required to be found.

Such questions have been already discussed by M.Kampf (2011). Also traditional Risk Models assume risk as identifiable, predictable and measurable, so that risk register and mitigation plan can be worked out. This tendency is shown in Pollak's work (2007), where PM literature from 1992 till 2007 was surveyed and prevalence of linear processes in statistical and mathematical modeling is found. In Zhang's work (2011) it is noted, that most of literature on PM finds risks as objective fact, not subjective as it often happens in practice. The same traditional risk analysis and decision-making is described in Macmillan's work (2011). In

2008, Bredillet—the editor of PMI's academic journal Project Management Journal—called for a new perspective and approach in project management research to meet the challenges of an unpredictable, discontinuous, unstable and nonlinear project environment. In the paper there is an attempt to evaluate projects that are being realized in the Arctic offshore in completely other conditions.

Traditional Risk Project Management

According to PMI Book Guide, Risk Management is a part of Project Management Concept, which also includes management of integration, scope, cost, time, quality, HR, communications, procurement and stakeholder. Inside each part of the concept input and output processes provide the realization. Between input and output processes definite tools and techniques are used to transform input data into output result information. Risk Management Process is consistent of 5 major Sub processes, inside each of them definite input-output data, tools and techniques are used (See Picture 1).



Picture 1. Risk Management General Subprocesses.
Sourse: PM Book Guide 5th Edition.

The structure of the process intend that risks can be identified, measured and assessed, including the probability, possible damage and the category (low, medium, high). In the Arctic operators work in increasingly complex and not sustainable systems. Five practiced types of problem areas and relevant approaches should be noted:

1-known output and known results: deterministic approach
2-known output and unknown results: scenarios approach
3-known output and known probability: stochastic modeling
4-known output and unknown probability: options theory
5-unknown output and unknown probability: uncertainty

Most of traditional PM works are related to 1, 2, 3 types of problems in the project and only little part of researches deal with 4 and 5, while the latest characterize features of Arctic projects. Some authors (Loch, DeMeyer, Pich – 2006; Hancock – 2010) use the similar types of and note that 4, 5 problems are the output of complex, tightly coupled systems.

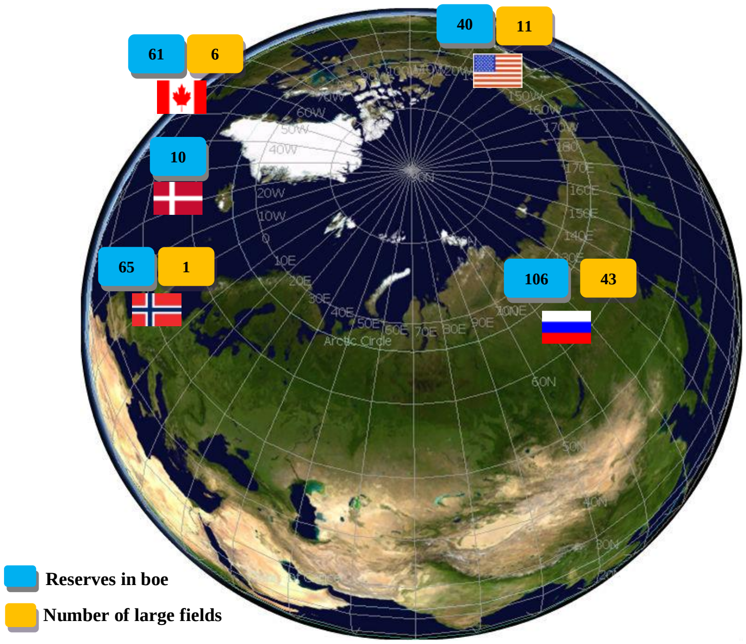
Operators may blame system failures, but it is rather a trigger for occasion, than a root of the problem and much more deeper, than risk respond plan or inappropriate risk monitoring. While generally accepted RM process is appropriate for conventional projects, Arctic project operate in increasingly complicated environmental, nature, technological systems, which make them much more complex and require new processes.

Arctic conditions: the Barents Sea and the Kara Sea

The century of large the Arctic oil and gas reserves discovery started in Russia, 1962. This year the Tazovskoye field was discovered. After 6 dry holes on the North Slope offshore cavern, ARCO-Humble opened the largest field in the history of North America oil and gas industry. The Prudhoe Bay Field was discovered in 1967. Today there are 61 oil and gas fields in the borders of Arctic Circle with approximately more than 500 mln.t.o.e reserves.

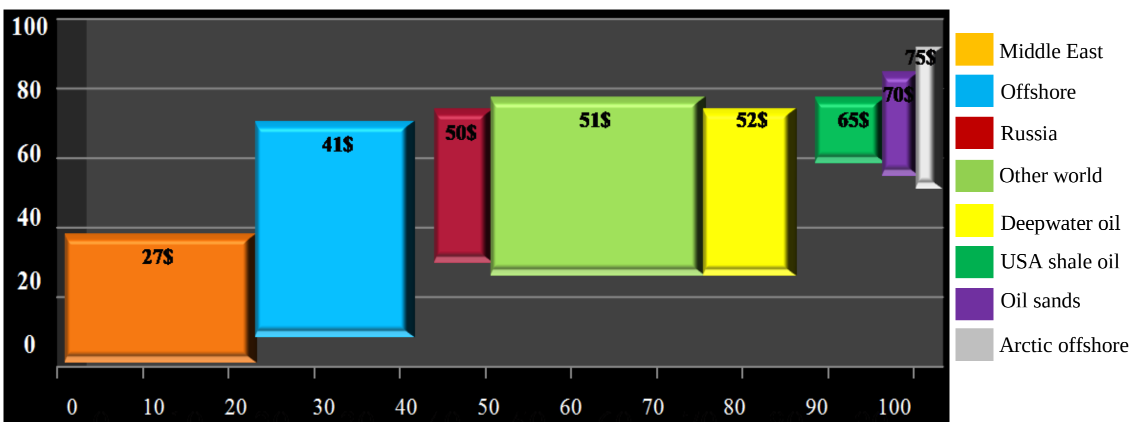
In 2008 the United States Geological Survey (USGS) released this first-ever wide-ranging assessment of Arctic oil based on 10% possibility estimation of the region’s undiscovered and technically recoverable conventional oil and natural gas resources. USGC survey covered 33 sedimentary provinces. 25 of them turned out to be potential for oil and gas deposits lager than 50mln.t.o.e with more than10% probability. The final conclusion of USGS assessment is that the Arctic offshore may contain about 90 billion barrels of oil, 1,669 trillion cubic feet of gas, and 44 billion barrels of natural gas liquids (NGLs). Converting the data, the total amount is 412 billion barrels of oil equivalent (boe). Approximately 84% of this amount is expected to be discovered on the offshore territories and about 67% is expected to be a natural gas. These Arctic reserves can provide about 13% of the world’s total undiscovered oil reserves at the present time and more that 30% of the world’s natural gas reserves.

Associating the above mentioned survey results to the countries borders and exclusive economic zones (EEZ), Russia’s estimated reserves are more than 50% of total amount of the Arctic offshore (See Picture 2).



Picture 2. Oil and gas surveyed reserves and large fields allocated to the countries' EEZ.
Source: prepared by the author basing on the USGC report.

The most significant that Arctic high-risky and capital intensive resources become commercially recovered and exploitable only in conditions of high oil prices and high investors' expectations. It also makes sense to enter a reservation that only affordable technologies and current costs on drilling and field development are taken into consideration (See Picture 3).



Picture 3. Cost of production in different oil and gas production regions in 2014.
Source: Rystad Energy, Morgan Stanley Commodities Research.

The most prospective geological basins of the whole Russian offshore territories are South Kara, the East Barents, the East Siberian, and the Sea of Okhotsk (See Picture 4). Two of them are in Arctic zone.

Picture 4. Allocation of prospective Arctic reserves according to the sea territories in Russia.
Source: Russian Geographical Society.

15 large fields were discovered in the Kara Sea and in the Barents Sea (including the Pechora Sea that is a part of the Barents Sea) offshores in the period from 1981 to 2000 years. 4 of them are oil fields (Prirazlomnoye, Varandey-more, Medynskoye-more and Dolginskoye), one is oil and gas-condensate (Severo-Gulyaevskoye), five of them are gas condensate (Pomorskoye, Shtokmanovskoye, Rusanovskoye, Leningradskoye and Ledovoye) and remain 5 are gas fields (Murmanskoye, Severo-Kildinskoye, Ludlovskoye, Severo-Kamennomysskoye and Kamennomysskoye-more). The Sea depth varies from 10 meters on the Severo-Gulyaevskoye field to 380 meters on the Shtokmanovskoye field. The latter is the deepest currently developed field. There are 8 projects being developed in the Russian Arctic offshore today (See Picture 5).

Picture 5. On-the-Day projects of field development in the Russian Arctic territory.
Source: prepared by the author basing on the Gazprom and Rosneft reports.

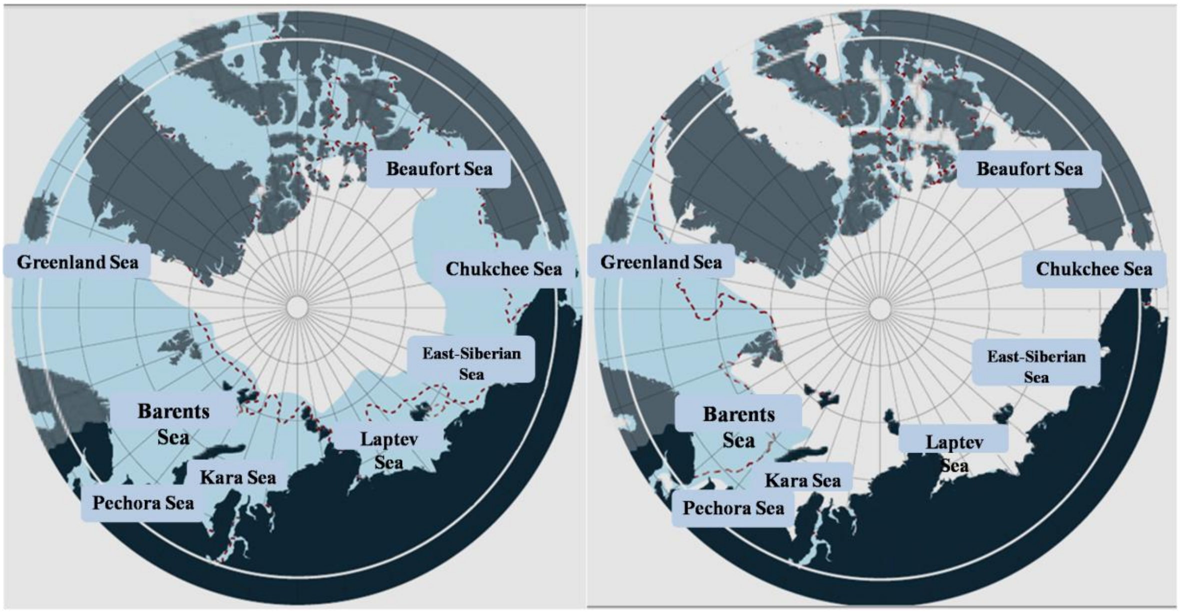
The first problem any operator comes across before starting exploration is severe climate. The main parameters of arctic sea natural environment are: minimum temperature, w maximum wind, wave summit, stream velocity, open water days, maximum thickness of ice without pressure ridge, rafting thickness. We consider these environmental factors to be the key nature barriers in arctic oil and gas project realization in any part of production chain (exploration, drilling, development, platform and personnel transportation, production transportation, costs for equipment, costs for ice-breaker sheep and etc.). The comparison of the factors in the Kara Sea, the Barents Sea, The Pechora Sea and the Beaufort Sea are given in the Table 1.

Table 1. Comparison of climate conditions in arctic Seas.

Parameter	The Kara Sea	The North of Barents Sea	The Center of Barents Sea	The Pechora Sea	The Beaufort Sea
minimum temperature, t°C	-50	-35	-24	-48	-52
w maximum wind, m/sec	40	36	40	41	42
wawe summit, m	5,7	10	12,5	6,2	6,3
stream velocity, m/sec	1,8-2	0,8	0,5	1	0,5
open water days	0-130	190	180-365	110	90
maximum thikness of ice without pressure ridge, m	1,8	1,8	1	1,3	2,1
rafting thikness, m	3,6	2	2	2,6	4,6-6,1

Source: S.Loeset, K.Shkhinek, O.T.Gudmestad, P.Sgrass, E.Michalenko, R.Frederkins, T.Karna. Comparison of Environmental conditions of some Arctic Seas in Basics of Offshore Petroleum Engineering and Development of Marine Facilities with Emphasis on the Arctic Offshore, Stavanger/Moscow/St.Petersburg/Trondheim, 1999.

If take a look at the map when the thickness of ice is minimum in August and September and maximum in February and March, The Kara Sea turns out to have the most strict environmental condition for drilling and transporting unlike other territories and only The Barents Sea is free from ice almost the whole year that provides opportunity for non-stop exploration drilling (See Picture 6).



Picture 6. Ice cover of arctic offshore water areas in August and September (left side); in February and March (right side).
Source: National Snow and Ice Data Center report.

Though the number of appraisal and exploration wells on west Russian arctic territory was 86 by the end of 2013, the exploration degree is 10 times lower than in USA arctic offshore and 20 times lower than in Norwegian arctic offshore. Nevertheless, it is worth mentioning that geological success degree in the Kara Sea and the Barents Sea are the highest. 1300 potential traps were discovered, 190 squares were prepared for drilling, and 58 sea and transit fields were opened. Average geological success ratio on the Russian arctic offshore is 0.48. The maximum rate was reached in the Kara Sea (1.0) and the Barents Sea (0.52). The results affirm USGS assessment of the Arctic offshore (See Picture 7).

Picture 7. Resource potential of main Arctic geological basins.
Source:USGS 2008 report.

Though arctic projects are one of the most complex, capitals intensive and run a high risk, their realization is not only a technological, but also strategic challenge for both countries and transnational oil and gas companies. For countries it means a short-term effect as excess profit taxes and long-term multiplicative effect of investments and related sectors. Strategic development in logistic also should be taken into account as the decade ago unreasonable North-West way, which would connect Pacific Ocean with Atlantic Ocean as well as transportation way through the North Sea would connect European markets with East Russian and Asian markets today becomes economically feasible. For companies it affords opportunities to reserves growth, rise company value, acquire access to new markets. But if ecological safety and strict government control in this region will not be sufficient, the consequences would certainly be dramatic.

Project Investment Environment

PMI definds project as means of achieving company's strategic plan. It is a temporary endeavor undertaken to create a unique product. First of all, Arctic project are associated with high uncertainty, unique conditions for each field where many risks may not be identified even on the development stage. That is why it is under PRM competence. Secondly, any Arctic development is associated with high investments and special regulating regimes from exploration to abanonment. Difficult complex projects that involve a huge amount of financial and technological resources are more likely realized by a group of companies with solid reputation. It is attributable to the demand for receiving access to global financial markets. Hence such a project is directly influenced by investment climate. It can be accounted for a three level system, which is clearly described in Project Finance rule: the rank of the project can't be higher, than company's (group of companies) rank, whereas the company's rank can't be higher, than country's rank. Country rank is external factor for operator. From many international ranks and agencies three global country ratings are usually taken into consideration: Moody's, Standard & Poor's, Fitch IBCA. Before borders Ba1(Moody's) or BB+ (Standard&Poor's, Fitch IBCA) the rank defines investment category and credit rate (LIBOR+[2] as an example) on financial markets. Table 2 shows LIBOR+ determinied in accordance with investment or speculative grade.

Table 2. Libor+ in accordance with country investment and speculative ratings.

	Moody's	S&P	Fitch IBCA
Investment grade	Aaa	AAA	AAA
	Aa1	AA+	AA+
	Aa2	AA	AA
	Aa3	AA-	AA-
	A1	A+	A+
	A2	A	A
	A3	A-	A-
	Baa1	BBB+	BBB+
	Baa2	BBB	BBB
	Baa3	BBB-	BBB-
Speculative grade	Ba1	BB+	
	Ba2	BB	BB
	Ba3	BB-	BB-
	B1	B+	B+
	B2	B	B
	B3	B-	B-
	Caa	CCC+	CCC
	Caa2	CCC	CCC
		CCC-	--
	Ca	CC	--
	C	C	--
	--	--	DDD
	--	SD	DD
		D	D

LIBOR+ <4.25%

Prime 1- Issuers (supporting institutions) have a superior ability to repay short-term debt obligations.

LIBOR + <4.25%

Prime 2- Issuers (supporting institutions) have a strong ability to repay short-term debt obligations.

LIBOR + <6%

Prime 3- Issuers (supporting institutions) have an acceptable ability to repay short-term obligations.

LIBOR + <14%

Not Prime- Issuers (supporting institutions) do not fall within any of the Prime rating categories.

LIBOR + <19%

LIBOR + <200%

Source: prepared by the author basing on Moody's, S&P, Fitch IBCA credit ranks reports.

[2] Libor 1Y 19.03.2014: USD=0,56, GBR=0,90

As certain credits and loans are commonly quoted as a spread over (+) LIBOR, basis point spread is the key indicator for company when it goes to the financial markets. In the syndicated loan market credits are priced at LIBOR+ rates. The higher risk of the country the higher the rate. For instance, a low risk AAA borrower may pay LIBOR + 50 basis points whereas a higher risk BBB borrower will pay LIBOR + 250 basis points. Another significant pointer of how attractice investment climate for project is SOI (stage of involvement). The company and project is not guaranteed if country has not signed or (and) ratified multilateral international interstate investment agreements. As the analyzed territories of the Kara Sea and the Barents Sea are under jurisdiction of Russia, several interstate agreements are adduced in Table 3. The more investment flows globalized, the more attempts are made to build a strong framework for protecting international ivestments to minimize investor risks. Next level of investment climate is legal and tax regimes or special investment regime on the territory of the country the project realized in. For the foregoing reasons Arctic offshore is expected to be a regulated zone with special investment warranties and tax regime for a long-term period until it becomes well-developed region with extended infrastructure, trade and transit terminals etc.

Table 3. Multilateral international interstate investment agreements and spheres of responsibility[3].

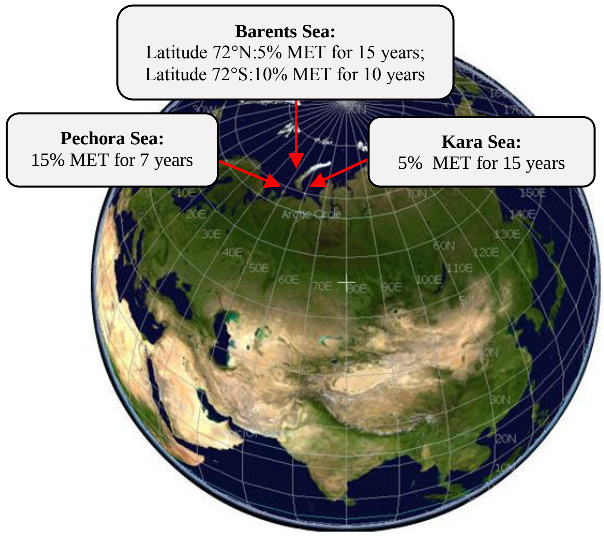
Organizations and number of members	Russia official standing	Warranties	Coverage of economic domains	Spheres of responsibility				
				Investment	Trade	Transit	Energy efficiency	Disputes
ICSID (159)	ICSID signed, ratification pending	Statutory liability	Full coverage	Yes	No	No	No	Yes
MIGA (181)	Member	Statutory liability	Full coverage	Yes	No	No	No	Yes
Energy Charter Treaty (54)[4]	Not ratified, the use on a temporary basis	Statutory liability	Energy domain	Yes	Yes	Yes	Yes	Yes
WTO (161)	Member	Statutory liability	Full coverage	Yes*[5]	Yes	Yes/No**[6]	No	Yes
OECD (34)	Candidate country. In March 2014, the OECD halted membership talks	Statutory liability	Full coverage	Yes	No	No	No	No
APEC (21)	Member	Non-jurisdictional	Full coverage	Yes	Yes	No	No	No
IEA (29)	Not member, cooperating country	Statutory liability	Energy domain	No	No	No	Yes	No

Source: prepared by the author.

The first law on Russian Continental Shelf was adopted in 1995 and remained unaltered before 2012. Understanding the necessity for new law regulations in Arctic were partly constrained by current market environment, such as high oil prices, increasing demand, focus on shale revolution, gas market development and etc. The process of law change was slow and Arctic was not declared a strategic way. In April 2012 Federal Government Decree on the main measures to strengthen the strategic position of Russia in the global energy industry included the order to develop regulations to establish preferential tax and investment treatments of offshore fields. In September 2013 Federal Assembly approved the Law № 268 which assigned new investment and tax regime for continental shelf. The law changed almost all previous investors' expectations. The main point of the law is the requirements for companies to be allowed to participate in Arctic offshore development. There is also new tax regime, which incorporates ad valorem tax on mineral extraction. The main point of taxation is differentiation arctic offshore according to the natural environment (See Picture 8). In spite of the fact, that the law is quite affordable for investments (corporate tax is the lowest among othe arctic bordering countries, the territory is free from VAT and export taxes and there is no import tax for technological equipment), some sections are still questionable for investors and could be a stumbling stone in future. Decision making and assessment process in these conditions will be completely different for projects in the

[3] Information at the end of 2014 year
[4] 52 countries+ EC and European Atomic Energy Council as independent members
[5] If take into account Agreement on Trade-Related Investment Measures
[6] Energy transit and transit pipelines are not under WTO regulation and currently under discussion

Barents Sea or the Kara Sea by contrast with the North Sea or Alaska. Particularly, the first stop option for operator will be rather dependent on externalities, than on geological success ratio. The third rule, that the rank of the project can't be higher, than company's (group of companies) rank appoints investment feasibility of the project. From the other side, there are three consititutive components of any project, which combination makes options sence from the beginning: sales, risks and resources. Any other parameter such as costs, logistics, finance, taxes, profit etc. in any case is a part of one component. The logically derived formula of inequality system from this point of view for ideal feasible project is that: Stop option< (project rank<company rank<country rank); Property transfer option< (company rank<country rank); Scale transformation option< (project rank<company rank).



Picture 8. Mineral Extraction Tax (MET) rates and validity period of preference tax regime
Source: prepared by the author

Table 4. Comparison of internal investment climate in Arctic bordering countries.[7]

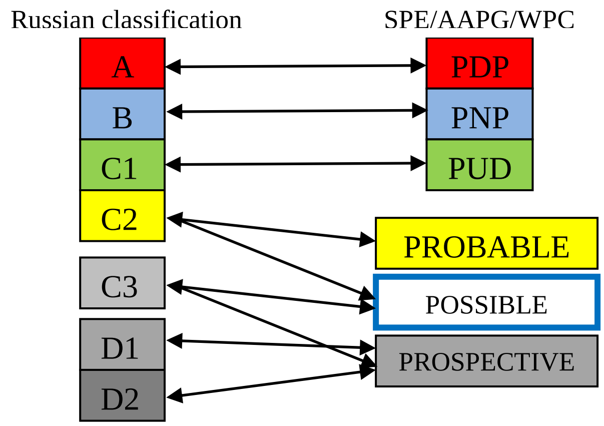
	USA	Canada	Norway	Greenland	Russia
Tax regime					
Taxation basis	Profit based Corporate income tax, royalty	Profit based Corporate income tax and royalty	Profit based Corporate income tax, additional income tax on upstream activities	Profit based Corporate income tax	Revenue based Corporate income tax and royalty (MET)
Compensation bonus	Yes	No	No	No	Yes
Royalty	12,5%	Annual 1% increase till 5%,5% till 10% till 10% profitability	No	No	5%-15% MET dependent on the territory
Profit tax	35%	26,5%	37%	28%	20%
Rentals and other resource taxes	25-75% net profit tax in Alaska	30% royalty of net profit after 10% profitability	50%	3 level royalty of net profit: 7,5%, 10%, 12,5%	No
Loss carryforward/ carryback period	20 years/ 2 years	20 years/ 3 years	Indefinitely/ 0 years	Indefinitely/ 0 years	10 years/ 0 years
Average level of overall fiscal burden on project's economics at 80$/bbl	48-72%	42-54%	79%	35-40%	75%
Investment regime					
Compulsory state participation	No			12,5% (new licenses)	>50%
Non-government companies participation	100% independent or groups of companies			Consortium with state company	Share in operating company without share in license
Qualifying requirements	Registration in the country, financial and technological abilities				5 years experience on offshore fields
Preliminary qualifying	Compulsory for all companies				Not applicable
Procedure for granting licences	Auction	Competitive selection			Non-competitive
Multi-client seismic access	For all open offshore territories				Prohibited

Source: prepared by the author

[7] 2013year relevant information.

Reserves classification systems difference

One more very important element for analyzing oil and gas projects is reserves classification. As it is main asset, the difference in classification methodology may change the final results of estimation. Two main systems the companies and world market relate on are SEC (last version established in 2008) and PRMS guide by SPE (2007). However the reserves of the Barents and Kara Seas are more likely to be classified according to national approved classification, than according to PRMS or SEC standards. Russian reserves classification system, established in 2005, based on the analysis of geological features, excluding commercial factors. Proved reserves are divided into categories A, B, and C1; estimated reserves (C2); potential reserves (C3) and probable reserves (D1 and D2). Natural reserves of categories A, B and C1 are considered to be fully recoverable. Given definition of reserves categories are incomparable with reserves classification in PRMS and SEC. A, B, C1, C2 - are categories according to the degree of geological certainty, while the western proved, developed and undeveloped reserves reflect the degree of uncertainty and probabilistic by nature. There is no direct compliance between these systems. In this sense, equating the volume of A, B and C1 categories of reserves to the «proved» concept is not correct, despite the fact that the whole of Russia quantify volume of these reserves are approximately equal. This is only a mathematical coincidence, but does not correspond to the categories. However, the comparison of concepts for better understanding and mapping are given on Picture 9.



Picture 9. Russian and SPE reserves classification.
Source: prepared by the author

Model description

Generally, in any project we model our cashflow generated by production of oil, that we want to be positive with the highest rate of certainty and which would include as more factors as it is possible. In each model production is a mathematical representation of the set of technologically feasible operations or actions within the production process:

$$Y=f(\beta,x)+\xi \quad (1)$$

where we assume that Y is endogenous variable, x is exogenous variable, β is empirically reached coefficient and ξ is an error of classic model where x variables are determined and ξ is "white noise" error. This is classic representation of regression models. They are quite good for analyzing different variables such as profit, costs, production and etc. Unfortunately, they are irrelevant for projects, when there is no any database for modeling processes in comparison with common projects where:

- details and features of the project are known
- inputs and outputs are mostly determined, the main risks are predictable
- distribution type is known, DCF is assessable
- available historical data, sufficient number of observations to develop multifactor model

When X variables are probabilistic, the error of the model is not a "white noise", but the level of uncertainty we could not factored in. In other word the hypotheses the Gauss theorem are failed:

- Multifactor regression model specified as linear: $Y_i=\beta_1+\beta_2 x1_i+\beta_3 x2_i+\ldots+\beta_n xn_i+\xi_i$
- Xn are determined (we have vector of prevous observations)
- Model error is not systematic: $E(\xi_i)=0$
- Error mean square is constant: δ^2
- Errors are noncorrelated: $Cov(\xi i;\xi j)=0$

It means that we don't expect normal distribution for our parameters as well as we are not able to make any forecasts with classic regression or time series model. Another problem is multicollinearity of the factors. The reason for that is direct dependence in decision-making process on the previously achieved results. However, from the background experience we suggest that oil field development life cycle conform a lognormal distribution. OPRMM is a case in point how complex project in Arctic could have assessed in conditions of internal and external uncertainties and how PM tools and techniques could be combined. The model describes the sequence of decisions and methods that could be applied. In the model there are following assumptions:

1. The model is by nature of 3 options sequence with 3 alternative options
2. Options are not binominal.
3. One possible option at any stage is expropriation and one possible option after the first stop option.
4. One more option flows out from the most significant assumption that project rank is influenced by tax regime change
5. Any used parameter is stochastic and has unknown distribution we are just trying to detect it. We also know that central theorem of normal distribution is likely to be failed.
6. Payoff is not linear.
7. The results in decision-making process are interdependent. In other way the results on one stage and accept/decline option determines the next option evaluation.

Let us specify the last assumption. For example, there is no doubt that the basin we are going to explore depends on the institutional factors in the region and technical abilities of the company. Following this line of reasoning the decision what play to license is made. Only after that the prior objective is the decision which prospect to drill first. Thus we can present our production (Y_1) as different factors dependence function plus our uncertainty we can not assess (2). The same is for cashflow (Y_2) (3).

$$Y_1 = f\,(G, D, R, E, T) + \xi_1 \quad (2)$$

G- geological success, D- efficient drilling, R -recovery rate, E - EOR methods, T – technology.

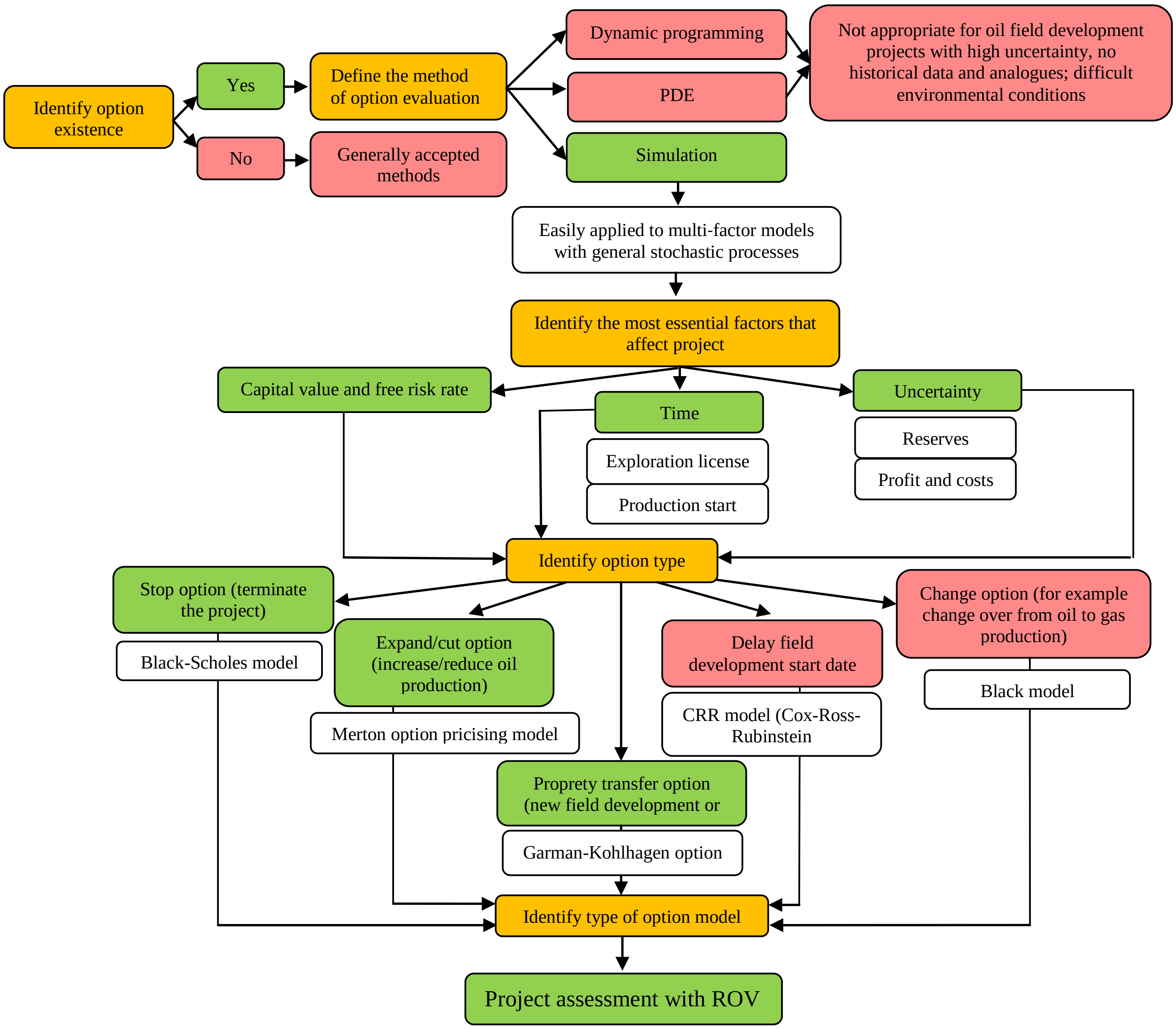
$$Y_2= (P, C, p, t, d, A) + \xi_2$$

P- production, C - cost, p - price, t- taxes, d- demand, A - alternate product.

These are basic functions we will use in modeling and integrate into option valuation. Each factor run the risk and appears stochastic. The open questionis what appear the error of the model we are not able to predict. In classic model we take ξ as difference between actual and predicted value. In case of absence actual values ξ could be assumed as different institutional factors for cashflow plus unpredictable emergence of factors. There is a difference between unpredictable emergence and risk. The latter we try to model stochastically while the appearance of the first one is unknown. In the option model we will try to take ξ as institutional emergences. One of the possible ways is investment climate assessment into the frame of project risks. E.Schwartz (2012) determines three possible option valuation methods: dynamic programming, partial differentiation equation (PDE) and simulation approach. We suggest that complex project alike companies realize in the Arctic are necessarily can be assessed with simulation real option valuation. The main reasons for implement simulation ROV are:

- easily applied to multi-factor models
- directly applicable to path dependent problems
- can be used with general stochastic processes
- intuitive, transparent, flexible and easily implemented

Complete modeling process is shown on Picture 10.



Picture 10. Full process of project assessment with ROV.
Source: prepared by the author.

The decision to terminate project after exploration or continue is determined from Black-Scholes model. It is the most well known model and the easiest to implement.

$$C=SN(d_1) - N(d_2)Ke^{-rt} \quad (3)$$

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\delta^2}{2}\right)t}{\delta t^{1/2}}$$

$$\mathrm{C} = \mathrm{SN(d1)} - \mathrm{N(d2)K}e^{-rt}$$

$$d_2 = \mathrm{d1} - \mathrm{s} * \sqrt{t}$$

C- option premium (option value, value of the project on the current stage), S- current stock price (obtained result on the exploration stage), K- option striking price (expenditures for seismic), t – time until option exercise (time of the project stage), r- risk free interest rate (rate of state bonds as an

example of the country the project realized in), δ – standart deviation, ln- ntural log, N – cumulative normal distribution, e- exponent.
The Merton option pricing formula generalization the Black-Scholes (1973) equation:

$$C=se^{-qt}\phi(d_1)-xe^{-rt}\,\phi(d_2)\ (4)$$

$$d_1=\frac{\log\left(\frac{S}{x}\right)+\left(r-q+\frac{\delta^2}{2}\right)t}{\delta t^{1/2}}$$

$$d_2=d_1-\delta t^{1/2}$$

The difference between Black-Scholes model is that q-continuously compounded annual dividend yield and r - continuously compounded risk free rate.
Later Garman and Kohlhagen extended the Black–Scholes model so that it became possible to take into account currency difference. Mathematically, the formula is identical to Merton's formula for options ondividend-paying stocks.
Only the term *q*, which did represent a stock's dividend yield, now represents the foreign currency'scontinuously compounded risk-free rate.

$$C=se^{-qt}\phi(d_1)-xe^{-rt}\,\phi(d_2)\ (5)$$

$$d_1=\frac{\log\left(\frac{S}{x}\right)+\left(r-q+\frac{\delta^2}{2}\right)t}{\delta t^{1/2}}$$

$$d_2=d_1-\delta t^{1/2}$$

One of the good properties of these options is ability to use lognormal distribution.
Usually, oil productions follows lognormal distribution.

Practice example

For the analysis perspective fields in the Barents or Kara seas waters was applied. As in any other model, the following suppositions are made:

- Current available state-of-the-art
- Current taxation regime
- Project stakeholder is not state company
- Drilling costs were taken according to the public available data (Table 5)
- 12 month average price is used to determine economic producibility according to SEC rules
- Each potential analysed deposit contains the same prospective amount of reserves. It allows opposing options of the project and regimes.
- Geological chance factor was taken in reliance on previous explorations.
- Key terms given in Table 6.

On the analysed territories three case positions of prospective deposits (A, B and C) were chosen. Each case point was chosen basing on key environmental conditions and climate difficulties operator can meet (see “Arctic conditions”) as they directly impact project options.

Conditions in each point (Table 1) will directly influence CAPEX and field development system. Secondly, environmental conditions (Picture 11) will determine project rank.

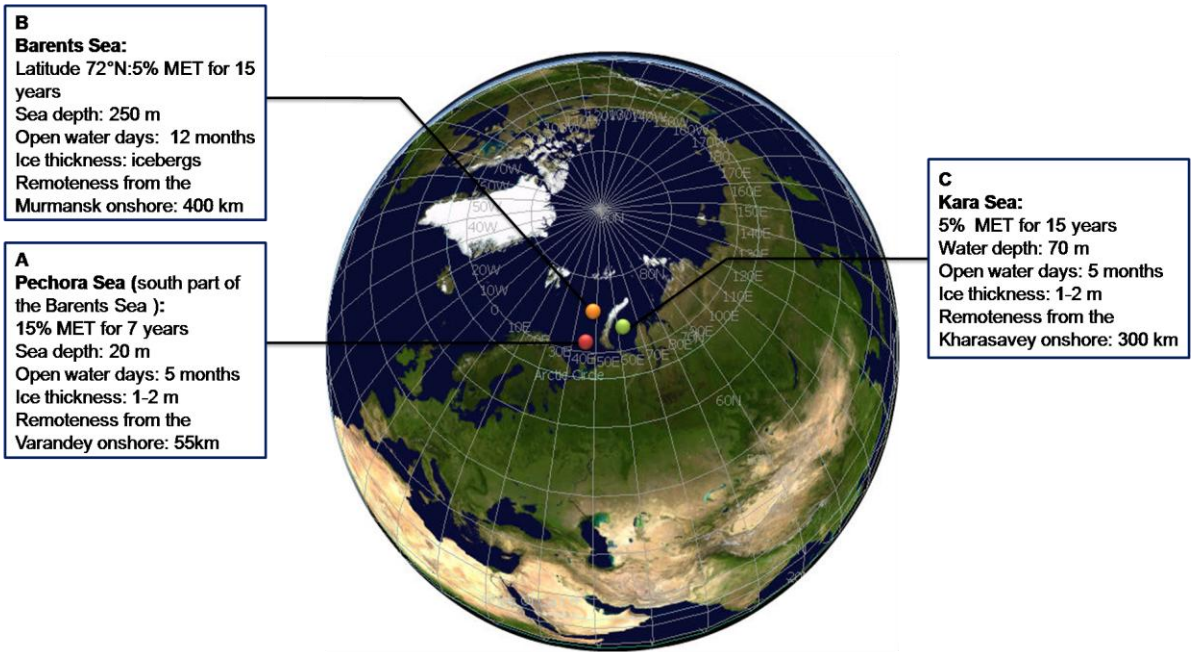
A – Elevated difficulty level. A point is located in the Pechora Sea (south part of the Barents Sea).

B – Arctic difficulty level. South-West of the Barents Sea (Latitude 72°N).

C- Arctic difficulty level.

One of the two license territories in the South-West part of the Kara Sea Vostochno-Prinovozemelsky- licence bloc.

All the examples are hypothesis and based on the published licensed territories in the Kara Sea and the Barents Sea. It should be noted that analyzed territories were chosen in the location where the largest oil fields in The Arctic for the past decade were opened. In these probable location climate condition are mostly close for those, which mentioned in Table 1.



Picture 11. Environmental and tax conditions for different projects.
Source: prepared by the author.

Table 5. Rig types and average dayrates

Parameters	Jackup rig	Jackup rig deepwater	Semisub	Semisub	Drillship
Maximum depth	(<200-250+, MS,IS)	(300-300+, IC,IS)	1500+	4000+	4000+
Total Rig Fleet	163	383	67	108	112
Average day rate, USD	93 000	116 000	357 000	440 000	524 000

Source: http://www.rigzone.com/data/dayrates/, June 2014

Table 6. Key terms for project assessment.

Parameter	Value
12 month average price	85$
Platform type	A,C – stationary gravity-based offshore platform; B – floating platform with subsea production module
Useful life of the platform from the year of production start	20 years
Cumulative oil production	352,4 mmbbl
Operating number of wells	35

Source: prepared by the author.

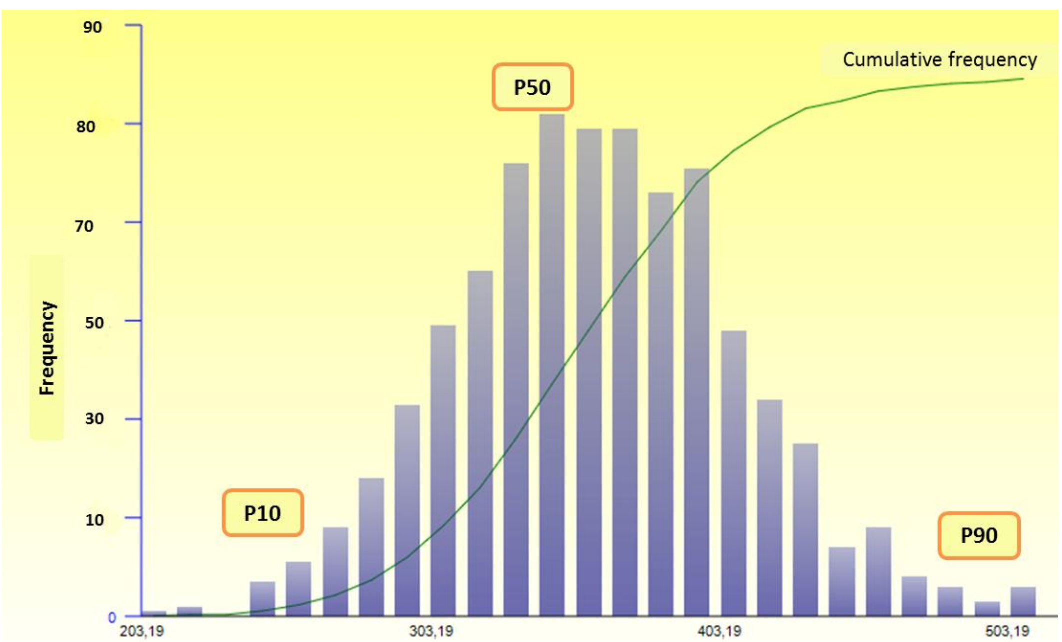
Modeling process:

1. In conditions of the lack of information the first step before starting option evaluation is analyzing of the first level of investment climate. We look at ate rank of the country and make suggestion about future possibilities on financial markets if we operate project in this country. But the main

we should take into consideration is stability of the country. If the rank is on the border of stable and good ranks it doesn't necessarily maen that the rank will be the same in the nearest future. In the model we make suggestion the the first level of investment climate is appropriate for the next analyzing.

2. The second step is analyzing investment and taxation regimes in the country we are going to operate. At the first glance we see, that Arctic territories are under special taxation regime. It means that this region is strategic and prior to the government. We also see that now taxation base is revenue based, not the profit based. This allows us to make a suggestion that taxation regime development for Arctic region is in progress and comparing it with othe Arctic bordering countries where taxation is profit based, with a high level of confidence the suggestion of possible change in future could be made.
3. On the next step we can see, that our options are under uncertainty of external investment regime while internal is appropriate. The main objective is to assess if any changes in country rank may affect the project. If changes will not influence production and transportation, they can be accepted. Otherwise incorrect expert suggestion may be unfortunate.
4. The next step in modeling is the third level – rank of the project.
5. As it was mentioned in step one, lack of the information leaves a few tools for analysis. For Arctic projects to assess the risk that our reserves approved we suppose Monte Carlo simulation as a good tool to identify the probability of success. Thus, Simulation is made from the results of EV calculating (Picture 12). It is recommended to use not P50, but P10 for the avoidance of overestimating. In other words, on this stage negative result is accepted.

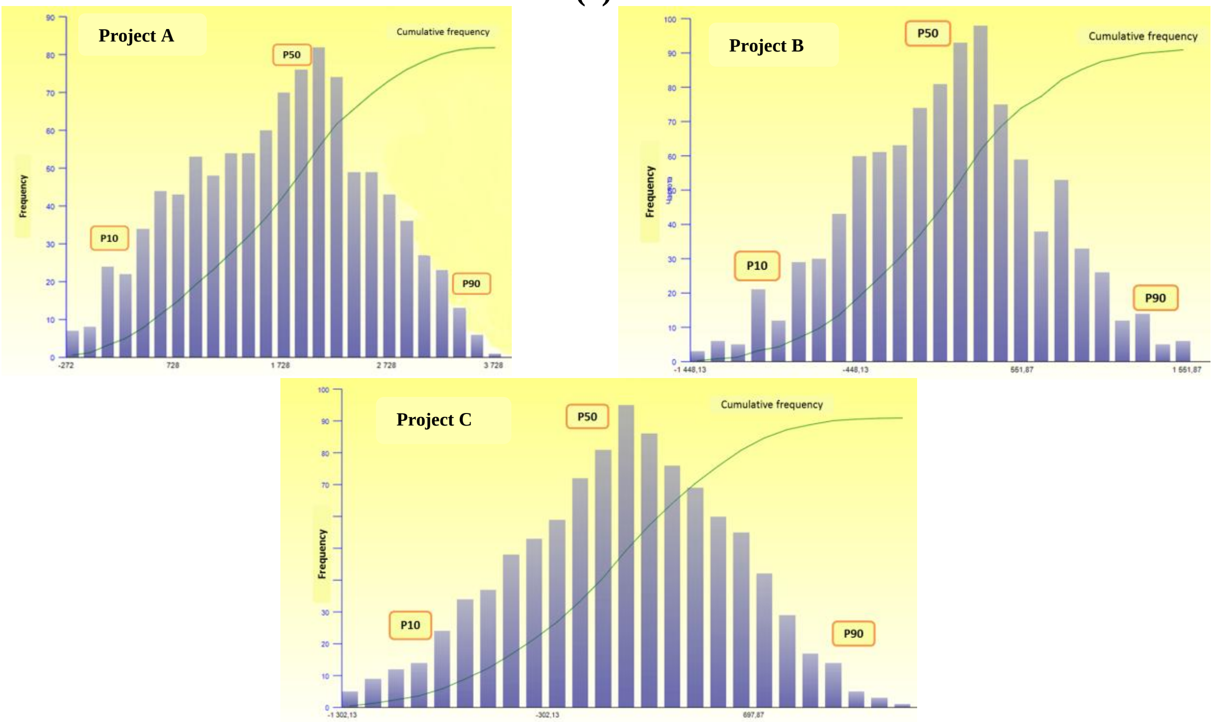
EV = (probability of success × profits in case of success) - (probability of failure × loss in case of failure) (6)



Picture 12. EV of project success with 1000 Monte Carlo simulations for three projects.
Source: prepared by the author.

Where probability of success and failure can be assumed as geological and environmental conditions.
If EV is positive, company should start to evaluate the project deeper, including stochastic simulation of risks. Further, if project accepted, resource planning and project finance reasonable to transform EV into ENPV:

ENPV = probability of commercial success×(NPV, the value of the distribution of estimated commercial reserves) - probability of business failure×(net cost if negative Geological Exploration) (7)



Picture 13. ATENPV of the project with 1000 Monte Carlo simulations for three projects.
Source: prepared by the author.

Further, on the implementation phase of the project calculation of the net present value of the project after tax ATENPV is carried out. Using EV results we build a deterministic model for the first and only after that calculate stochastic distribution of ATENPV. The idea is to take into account project rank and see the influence of internal investment and tax regimes (Picture 13). It is recommended to use not P50, but P10 for the avoidance of overestimating. In other words, on this stage negative result is accepted.

ATENPV = probability of success×[(revenue reserves share ×reserves× price of oil at the wellhead) - (investment + OPEX + taxes)] - probability of failure×[after tax cost of a dry hole+cost of geological and engineering work and the purchase of the license area] (8)

6. After we completed all these steps, it is possible to start Real Option Evaluation.

Table 7. ROV parameters for stop option.

№	Parameter	Project A Results	Project B Results	Project C Results	Reference
	Stop option (the firs exploration stage of the project)				
1	Option striking price	300 mmUSD	450 mmUSD	700 mmUSD	Seismic
2	Current stock price	1693 mmUSD	661 mmUSD	mmUSD	In accordance with the possible successful of geologic exploration
3	Time until option exercise	5 years	5 years	5 years	Period of geologic exploration work
4	Standart deviation	25%	25%	25%	Standard deviation of reserves confirmability in the analyzed territories
5	Risk free interest rate	8%	8%	8%	Risk free rate. Equal to the rate of state bonds.
6	Option premium	1750 mmUSD	693 mmUSD	543mmUSD	P10 Monte Carlo simulation result

Source: prepared by the author.

Table 8. ROV parameters for scale transformation option.

№	Parameter	Result for project A	Result for project B	Result for project C	Reference
1	Scale transformation option (start development phase)				
2	Option striking price	4286 mmUSD	3451 mmUSD	8000 mmUSD	Seismic
3	Current stock price	4301 mmUSD	3415mmUSD	7986 mmUSD	In accordance with the possible successful of geologic exploration
4	time until option exercise	10 years	10 years	10 years	Period of geologic exploration work
5	standart deviation	25%	25%	25%	Standard deviation of reserves confirmability in the analyzed territories
6	Compound risk free interest rate	8%	8%	8%	Risk free rate (rate of state bonds).
7	Option premium	540 mmUSD	504 mmUSD	319 mmUSD	P10 Monte Carlo simulation result

Source: prepared by the author.

Obtained results show, that the most profitable project is A. No doubt, because it is the nearest to the onshore and has the most preferable climate conditions. Project B is less profitable by the reason of long distance and deep water. That is why operational cost wil be higher. However, this territory has the best climate conditions. It means that technologically the project will be realistic. Project C has the probably the lowest attractiveness from the first glance. Not seeing that the highest geological success ratio was reached in the Kara Sea (1.0) while in the Barents Sea it is 0.52, climate conditions, economically it is not the best one. But the idea of ROV is future opportunity. If technological difficulties will be overpassed and external investment climate is appropriate, the project is likely to be attractive for analyzing (Table 7,8). The main idea of the work that ROV gives us opportunity to compare technical part of the project with external factors we can't calculate (Table 9). The crossroads of combination and types of the option is the most preferable and sufficient condition for the project. For example the prefect project is when country rank is very stable, project rank (investment and taxation regimes are favorable and company holds all technologies to realize the project). For such kind of project no other conditions are needed to start ROV. But if the project has only technologies and other conditions are not appropriate, there is option to transfer property and sell project.

The part of the modeling parts is above mentioned key economical indexes as there should be something to compare with. Stage by stage more certain information becomes available, Table 10 transforms into Table 11 and will be more informative.

Table 9. Possible combinations of ROV acceptance hypothesizes

	Favorable combination	**Moderate combination**	**Unfavorable combination**
Stop option	<External climate+project rank+tecnology	<country rank+technology	<Project rank+technology
Property transfer	< External climate+Country rank+tecnology	<Project rank+ tehnology	<Technology
Scale transformation	Country rank+Project rank+technology	<Technology	<Unpredicted external market conditions

Source: prepared by the author.

Table 10. First pre-exploration stage options.

	EV	**ENPV**	**ATENPV**
Stop option			
A	1750	Not available on this stage	Not available on this stage
B	693	Not available on this stage	Not available on this stage
C	543	Not available on this stage	Not available on this stage
Scale transformation			
A	540	Not available on this stage	Not available on this stage
B	504	Not available on this stage	Not available on this stage
C	319	Not available on this stage	Not available on this stage

Source: prepared by the author.

Table 11. First pre-exploration stage decision making.

	Favorable combination	Moderate combination	Unfavorable combination
Stop option			
EV A	Accepted	Accepted	
EV B		Accepted	
EV C		Accepted	
Scale transformation			
EV A		Accepted	
EV B		Accepted	
EV C			Accepted

Source: prepared by the author.

Results and conclusion

1. Arctic projects are going to be new technological, political and economical challenge not only for the majors, but also for the countries.
2. The first and the main option is START option. If most start options of the project are approved, then there is a strong possibility of the next technological wave in oil and gas industry has come.
3. The most powerful factor of project still remains technological. The second factor is external investment climate.
4. The results show, that investment and taxation climate are of a great importance. However, these measures unusefull when the relative share of platform costs are the biggest.
5. A possible combination of ROV acceptance hypothesizes was offered and will be improved in the future work.
6. The idea of comparing Monte Carlo Simulation results with ROV makes sence as well as the idea of comparing further ROV results with three level investment climate conditions of the project.
7. According by the obtained results the most preferable way of starting analyzing possible start of the project is the territory in the Barents Sea and then some licensed territiroes in The Kara Sea. The first one has more easy condition to start ROV while the second one has the highest resource potential.

Incorporating real options valuation into the full project assessment is not the only method to identify project feasibility. In three level model we suggest to combinate quantitive and quality analysis. There is no so much opportunity to start quantitive assessment without consistent quality analysis. Also, suggested steps of quality analysis are not the necessary alternative, but the most covering to our personal opinion.

Important result of the work is that the model allows implementing Monte Carlo Simulation and ROV in reliance on the significant quality assessments. There are no options in theproject with high level of uncertainty if the quality analysis is not positive even if some economical benefits are possible.

Arctic projects are seem to be the most challenge for arctic bordering countries and oil and gas companies in the nearest future. Still there are many controversial opinions as to whether Arctic offshore should have been developed because of its unknown feasibility.

We are sure this question is going to be opened and disputable until the Northern Sea Route and other infrastructure will be enough developed. The same is questionable about oil and gas market, where the price will stay overrepresentating factor above others possible. It was the main reason for chosing these territories for analyzing while the model as appropriate for other offshore fields development quality and quantity risk analysis.

In conclusion it is worth to say, that Project Management concept is multi functional. The models are not unique and Risk Management models should be developed individually basing on uncertainty and territorial features. Project of offshore field development will be more likely successful with understanding applicability of ROV and simulation methods after quality analysis in PM risk models than not.

REFERENCES

1. Black, Fischer and Myron S. Scholes (1973). The pricing of options and corporate liabilities, Journal of Political Economy, 81, 637-654.

2. Garman, Mark B. and Steven W. Kohlhagen (1983). Foreign currency option values, Journal of International Money and Finance, 2, 231-237.

3. Merton, Robert C. (1973). Theory of rational option pricing, *Bell Journal of Economics and Management Science*, 4 (1), 141-183.

4. Boyle, Phelim P. (1977). "Options: A Monte Carlo Approach". Journal of Financial Economics 4 (3): 323–338. doi:10.1016/0304-405x(77)90005-8. Retrieved June 28,2012.

5. Broadie, M.; Glasserman, P. (1996). "Estimating Security Price Derivatives Using Simulation" (PDF). Management Science 42: 269–285. doi:10.1287/mnsc.42.2.269. Retrieved June 28, 2012.

6. Longstaff, F.A.; Schwartz, E.S. (2001). "Valuing American options by simulation: a simple least squares approach". Review of Financial Studies 14: 113–148.doi:10.1093/rfs/14.1.113. Retrieved June 28, 2012.

7. Rose Peter R. Risk Analysis and Management of Petroleum Exploration Ventures / / Moscow - Izhevsk: NITs " Regular and Chaotic Dynamics ", Institute of Computer Science , 2011.- 304p.

8. McMillan F. Risk, Uncertainty and Investment Decision-Making in the Upstream Oil and Gas Industry/ / International scientific and practical conference of Aberdeen university "Oil and Gas", Edinburgh , 2005, 241p .

9. World Energy Overview: International Energy Agency, 2013, 668p.

10. PM book guide. The Knowledge Project Management, M. :PMIInc., 2008 , 496p.

11. The Definitive Guide to Project Management. Nokes, Sebastian. 2nd Ed.n. London (Financial Times / Prentice Hall): 2007.

12. Securities and Exchange Commission, 17 CFR Parts 210, 211, 229, and 249 [Release Nos. 33-8995; 34-59192; FR-78; File No. S7-15-08] RIN 3235-AK00 “MODERNIZATION OF OIL AND GAS REPORTING”.

13. Arctic council, “ARCTIC OFFSHORE OIL AND GAS GUIDELINES”,2009, 98p.

14. The Arctic Institute (September 2011), The Future of the Northern Sea Route - A “Golden Waterway” or a Niche Trade Route.

15. S.Loeset, K.Shkhinek, O.T.Gudmestad, P.Sgrass, E.Michalenko, R.Frederkins, T.Karna. Comparison of Environmental conditions of some Arctic Seas in Basics of Offshore Petroleum Engineering and Development of Marine Facilities with Emphasis on the Arctic Offshore,

Stavanger/Moscow/St.Petersburg/Trondheim, 1999.

16. Charpentier, R.R., Klett, T.R., and Attanasi, E.D., 2008, Database for assessment unit-scale analogs (exclusive of the United States): U.S. Geological Survey Open-File Report 2007-1404 [http://pubs.usgs.gov/of/2007/1404/].

17. USGS World Assessment Team, 2000, U.S. Geological Survey World Petroleum Assessment 2000-Description and Results: U.S. Geological Survey Digital Data Series – DDS60 [http://pubs.usgs.gov/dds/dds-060/].

18. Fridtjof Nansen Institute, “Arctic Resource Development: Risks and Responsible Management”, ONS SUMMIT 2012”THE GEOPOLITICS OF ENERGY”.

19. WEC (World Energy Council). 2007. Survey of energy resources 2007. http://www.worldenergy.org /publications/survey_of_energy_resources_2007 /default.asp

20. Deutsche Bank Markets Research, “Is the Arctic the future of Russian oil?” 24 September 2012.