Uncertainty factor in estimation of Kovykta gas utilization variants

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***Abstract*: The paper deals with efficiency of the Kovykta gas utilization variants in terms of uncertainty of external conditions and investment risks.**

***Key words:* efficiency, investment, uncertainty, risks, natural gas.**

The Kovykta gas condensate field is one of the largest fields in Russia. Its proved reserves allow production of more than 30 billion m^3 of gas a year. However, up to now there is no final decision about the time of starting large-scale gas production and directions of its rational use.

Conversion of the Irkutsk Oblast to gas will require no more than 3-4 billion m^3, and the basic portion of gas produced can be exported. There are also variants of creating a large gas-chemical complex in the Irkutsk Oblast [1] and a large-scale production of liquefied natural gas (LNG) based on the technology with parallel electricity generation [2]. Helium extraction is an important part of the process in both variants. Construction of a large thermal power plant (TPP) in situ with electricity export to China is also discussed as a variant [3].

High uncertainty of initial data that can be specified only as intervals of their possible values complicates comparison of theses variants. It concerns first of all potential dynamics of gas prices and demand in external markets and also required capital investment.

There are no generally acknowledged methods for efficiency assessment of the variants under uncertainty of initial data given as intervals. The methods for such estimation are thought to take into account importance and scale of the considered investment projects as well as uncertainty level of the information applied.

Because of an essential role of the Kovykta gas in the future energy balance and the economy of Siberia and Russia it is expedient to apply a staged approach to estimation of the possible variants of its utilization in terms of the level, at which these variants are considered: country, region, branch systems, companies.

It is of particular importance to compare variants of the Kovykta gas export in forecasting studies on the national fuel and energy complex (FEC). Forecasts at the regional and branch levels should take into account variants of the multi-purpose gas utilization with production of other energy carriers and products of gas chemistry. Optimization calculations of FEC should follow the analysis and selection of such variants, the investment risks and attitude of potential investors to them being considered.

Short description of methodological approaches to estimation of the Kovykta gas utilization variants and the calculation results are given below.

COMPARISON OF EXPORT VARIANTS

Three variants of export are dealt with: to Northeast China, in the western direction with connection of the gas pipeline (in the Proskokovo area) to the Unified gas system (UGS) of the country and to Nakhodka city with construction of a plant for gas liquefaction and liquefied natural gas export to countries of the Asia-Pacific region (APR). Every variant is characterized by a high degree of information uncertainty concerning both prices and investment and annual costs.

Probable ranges of capital investment in gas transport and liquefaction that is needed for implementation of gas export variants are based on available estimates, as shown in Table 1. The average annual operating costs for gas transport make up (in doll./thousand m^3/thousand km): 5.6-6.4 for the export variant to China; 4.8-5.3 for the variant of the Kovykta gas inclusion in UGS; 5.7-6.5 for the variant of LNG export to APR countries. LNG is supposed to be produced by the liquefaction plant of the total capacity about 24 million t/year that consists of 8 production lines and to be transported by 14 methane carriers of the capacity 135 thousand m^3 each.

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TABLE 1. APPROXIMATE VOLUMES OF CAPITAL INVESTMENT IN DIFFERENT VARIANTS OF KOVYKTA GAS EXPORT

Export variant	**Gas pipeline length, km**	**Capital investment, billion doll.***
Gas export to China	3590	7.2-7.9
Gas inclusion in UGS	2800	4.7-4.9
LNG export to APR	4300	12.3-13.5 (including 5.8-7.0 for construction of LNG production plant

* Here and further the information about market prices and investment is given in 2005 dollars (without considering inflation)

The highest uncertainty is characteristic of possible prices in the gas market of APR countries. Analysis reveals a strong dependence of the gas cost in the world markets on oil prices. Dynamics of prices shown in Table 2 is assumed on the basis of revealed trends and the latest forecast of the world oil prices. Gradual increase of gas trades at the rated capacity of gas pipelines (30 billion m^3 /year) for the variant of gas export to China is expected in 10 years after start of gas supply, for the variant of gas inclusion in UGS in 4 years and for the variant of LNG export to APR in 8 years.

The calculations were made based on the following conditions of financing: the share of borrowed funds for every variant makes up 50% of the volume of required investment and the loan is issued for 10 years starting from the first year of gas supply to consumers; the period of gas pipeline construction is taken equal to 3-4 years; the interest rate is determined as a sum of the base rate equal to 6% for all variants and the risk premium. The risk premium varies as follows: 2-8% at gas export to China; 2.0-2.5% at gas inclusion in UGS; 2-6% at LNG export to APR. Taxation is taken into account in calculations as an excise rate (30% for natural gas supplied for export, 15% for gas used in Russia) and as a profit tax (24%) and as a fixed asset tax (2%).

The export variants were estimated by using the method of comparing the intervals of values of generalizing efficiency indices [4]. The values of cash flows were calculated for every variant. They were applied as the basis for determination of the expected values of internal rate of return (IRR) by the known Hurwitz formula:

$$f = \lambda f_{max} + (1 - \lambda) f_{min}, \qquad (1)$$

where f_{max}, f_{min} – the maximum and minimum value of the variable, respectively; λ – a coefficient of "pessimism-optimism".

Based on the Kovykta gas export conditions the following values of λ are assumed: 0.25 for export to China, 0.5 for LNG export to APR, 0.75 for connection to UGS.

Adjustment of the obtained expected values of IRRexp in terms of risk is the final stage of calculations. In general this adjusted value (IRR_R) is determined as:

$$IRR_R = IRR_{exp} \bullet R. \qquad (2)$$

The risk level R is used in the sense of discount or premium. It is considered that the risk is the higher the far is the lower bound of the IRR range from the minimum value in all the variants.

The calculation results are demonstrated in Table 3. They show that the variant of the Kovykta gas inclusion in UGS under the assumed initial data is preferential. This variant is considered as the base one by JSC "Gazprom" as well. Below it is compared with possible variants of multi-purpose utilization of the Kovykta gas.

COMPARATIVE EFFICIENCY OF VARIANTS FOR MULTI-PURPOSE KOVYKTA GAS UTILIZATION

Construction of a thermal power plant (TPP) on the Kovykta field will call for 3.7-5.0 billion dollars. The tariff for exported electricity is forecasted to be in the range between 5.0 and 7.5 cent/kWh. The volume of natural gas consumed at its price in the range from 45 to 60 doll./1000 m^3 will amount to 4.7 billion m^3 a year. The volume of exported electricity is forecasted in the range from 29.5 to 31 billion kWh a year.

Creation of a gas-chemical complex on the Kovykta gas suggests production of polyethylene, propylene, pyrolysis condensate, helium.

TABLE 2. FORECAST OF GAS PRICE DYNAMICS, DOLL./THOUSAND M^3

Gas sales market	2010	2015	2020	2025	2030
LNG to APR	205-260	205-270	205-290	210-295	215-295
Piped gas to Northeast China	130-190	135-215	140-230	145-240	150-250
UGS (the eastern part of RF)	65-70	70-80	75-90	80-95	85-100

TABLE 3. EFFICIENCY OF COMPARED VARIANTS FOR KOVYKTA GAS EXPORT, %

Export variant	IRR range	Comparative efficiency of variants	
		Without regard for risk	With regard for risk
Gas inclusion in UGS	14.8-19.8	100	100
LNG export to APR	11.7-23.6	95	77
Gas export to China	10.7-27.7	80	64

The planned volumes of the annual production and the forecasted prices of these products are: 1.45-1.6 million t (at a price of 1170-1464 doll./t) of polyethylene; 0.16-0.17 million t (at a price of 1000-1250 doll./t) of propylene; 0.13-0.14 million t (at a price of 29-36 doll./t) of pyrolysis condensate; 29-33 million m^3 (at a price of 2-3 doll./m) of helium. The volume of investment in construction of the gas-chemical complex is estimated at 3.5-4.5 billion dollars and operating costs – 380-430 million dollars.

Since the process of gas liquefaction and helium extraction needs a considerable volume of electricity, it is economically sound to use a plant for combined production of LNG and electricity on the Kovykta field. The surplus electricity can be supplied to the power system.

The forecasted LNG price without transportation charges is 170-210 doll./1000 m^3, the price of electricity in the Irkutsk Oblast is 3-5 cent/kWh. The volumes of LNG production at 10 blocks of the plant amount to 15-16 billion m^3, electricity – 11.8-12.4 billion kWh, helium – 62-65 million m^3. The average price of natural gas consumed makes up 45-60 doll./1000 m^3 at its annual consumption of 22 billion m^3. The required capital investment amounts to 5-6 billion dollars.

The prices and the exchange rate were calculated as of 2005.

The variants were compared by using the multi-stage approach that explicitly takes into account investment risks. At the first stage the value of the risk premium (Δr_1) is determined individually for each factor influencing the risk. In this case at first the value of the net present value (NPV) is calculated for the minimum and maximum values of the variable and the same discount rate. Then the value of discount rate which would equate the NPV to its value for the worst conditions is determined for the most favorable variant. Difference between these two discount rates is representative of the risk associated with the considered factor (Δr_i).

When calculating Δr_i the values of other variables that influence NPV are assumed equal to mathematical average values (if probability distribution is known) or determined by the known Hurwitz formula (for the variables set by intervals).

At the second stage the total risk index of the project (R) is calculated. It is a weighted mean sum of all Δr_i:

$$R = \sum \gamma_i \Delta r_i \quad , \qquad (3)$$

where γ_i – a share of the i-th factor in NPV.

At the third stage of calculations the risk index R is compared with the economic efficiency of the project that is measured, for example, by the profitability of investment (*PI*). It represents the relation between NPV and investment volume. The profit-risk coefficient (*PR*) that shows the profitability per risk unit for the considered project is calculated for every competing project:

$$PR = \frac{PI}{R}. \quad (4)$$

The coefficient can be considered as an index of comparative economic efficiency under uncertainty of initial data set by intervals. Its drawback is inability to take into account different attitude of the potential investor to risk.

As a rule, large expected profit increases risk propensity. Correspondingly an acceptable maximum admissible value of the index *PR* rises disproportionately. Account of the propensity of a potential investor to risk makes it possible at the final stage of calculations to construct a curve that shows the maximum admissible risk value as a function of the expected efficiency of investment. Position of the coordinates of the point representing indices of the risk and profitability for each of the considered variants with respect to this curve indicates their competitiveness in terms of the investor propensity to risk. The variant, whose point on the curve is located farther from the risk propensity curve at the equal values of *PI* is preferential. This corresponds to the maximum value of the index that can be called a subjective efficiency coefficient:

$$CR = \frac{R'(PI) - R(PI)}{PI}, \quad (5)$$

where $R(PI)$ – the R value for the considered project at the profitability level PI; $R'(PI)$ – the R value on the indifference curve at the profitability level PI.

The value of $R(PI)$ represents the maximum possible risk value from the investor viewpoint for the given profitability PI.

Table 4 and Figure present the results of using this methodological approach to the analysis of variants of the Kovykta gas utilization.

Table 4 shows that all the projects (at the discount rate of 15% NPV of all projects is positive) are cost effective, but their profitability is different. Preference should be given to the variant of constructing a gas-chemical complex, whose profitability is 0.6. The next in efficiency is the project of LNG production with the profitability 0.5. However, if to take

TABLE 4. CALCULATED INDICES OF RISK AND PROFITABILITY

Indices	**Units**	**Connection to UGS**	**Export TPP**	**Gas-chemical complex**	**LNG production**
NPV (without inflation)	billion doll..	1.75	1.14	2.25	2.60
Share of factor in NPV (γ_i): price	shares	0.39	0.38	0.37	0.36
costs	shares	0.07	0.05	0.07	0.12
demand	shares.	0.31	0.34	0.37	0.36
investment	shares	0.23	0.23	0.19	0.16
Profitability of investment (*PI*)	shares	0.38	0.28	0.6	0.5
Risk premium: Δr_{price}	percent	1.8	3.6	3.2	4.4
Δr_{costs}	percent	0.3	0.5	0.3	1.8
Δr_{demand}	percent	0.4	0.6	1.3	1.1
$\Delta r_{capital}$	percent	0.7	3.4	2.1	1.6
Total risk (*R*)	percent	1	2.4	1.6	2.5
Profit/risk ratio (*PR*)	shares	0.38	0.12	0.38	0.2
Subjective efficiency coefficient (*SE*)	unit	5.02-3.99	0.34-(-0.86)	3.42-2.60	1.67-0.77

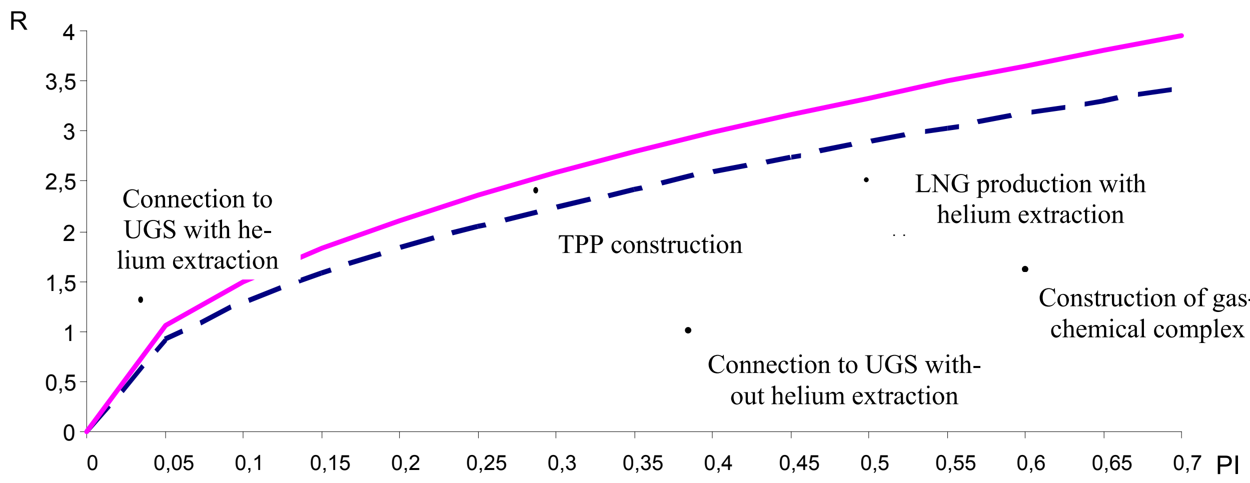

Figure. Position of variants with respect to risk propensity curves

into account risk the project preference changes. The projects with construction of TPP and LNG production are most risky, since the value of total risk index is 2.4% and 2.5%, respectively. In this case the prices of and the demand for a realized product is the main factor influencing the risk.

If the project riskiness is taken into consideration, connection of the Kovykta field to UGS and construction of a gas-chemical complex become the priority projects, since their index of the profit/risk ratio *PR* is equal to 0.38, which is by 0.26 higher than the value of *PR* for TPP construction and by 0.18 higher than the value of *PR* for LNG production.

An additional consideration of risk propensity of potential investors (Figure) specifies the general situation. The project of the Kovykta field connection to UGS has the largest deviation from the critical level of total risk per unit of the forecasted income – 5.02-3.99. By the subjective efficiency index this variant is more preferable than construction of a gas-chemical complex, for which *CR* = 3.42-2.60.

Thus, it may be concluded that at a low risk propensity the project of capital investment in construction of a gas-chemical complex that is the most effective is preferential. For a more prudent investor the least risky variant of field connection to UGS may prove to be preferential. However, it should be noted that in the assessment of this variant the costs of helium extraction were not considered. Otherwise this variant will be uncompetitive and advantages of constructing a gas-chemical complex become more obvious.

The final decision on the rational way of the Kovykta gas utilization can be taken after additional estimation of social, budget and geopolitical value of the competing variants.

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