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The Use of Real Options in Assessing the Development of Small Energy in Russia

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ABSTRACT

The spatial development of small energy in Russia at the present stage solves the problems of energy supply in remote and inaccessible regions of the country, which determines the relevance of the issues addressed. The aim of the study is to assess the development of small energy in the country based on the use of economic and mathematical methods. The study was conducted using long-term strategic planning tools, real options, and a binomial model. Based on PEST analysis, macroeconomic factors affecting the development of small energy have been identified. To assess the development of small energy, it is necessary to take into account many risks and uncertainty, which necessitates the use of flexible management decisions using the real options method. It was revealed that with the uncertainty of demand, but the possibility of growth in demand in the future, as is the case in small energy, it is advisable to use a real option - CALL. A practical example of quantifying the value of a real CALL option is considered.

Keywords: Small Energy, Real Options, Binomial Model
JEL Classifications: C4, G3, M2, O1, Q4

1. INTRODUCTION

In the short term, small-scale energy in Russia using renewable energy sources will solve energy supply problems in remote and inaccessible regions, while solving environmental problems and ensuring energy conservation. Currently, there is a negative trend in the energy supply by centralized systems, since a significant share of heat and electricity is lost at power generation stations, then when transmitting electricity in electric networks, heat is lost in heating plants.

An analysis of the state of the Russian energy sector shows that the wear of power lines in the Unified Energy System (UES) of Russia is more than 25%, substations 45%. In the heat supply system, 40% of heating networks require repair, 15% are in disrepair, and heat losses in networks are up to 20%.

At the present stage, about 30% of the country's territory is covered by the UES, autonomous power plants provide electricity to 70% of the country's territory. Prospects for the development of small energy are considered in light of these circumstances. It is necessary to develop small and renewable energy in the form of wind, solar, and hydraulic stations. Currently, a change in the structure of the electric power industry is being carried out, while cash flows are changing. The construction of large power plants is associated with large volumes of investments, while insufficient funds will be allocated from the budget for the implementation of projects. In this regard, a rational approach to justifying investments in the development strategy of small energy in Russia, taking into account costs and losses, is an urgent task. According to the forecasts of the International Energy Agency, the share of electricity generation by small energy by 2030 will increase to 30%. For small energy, it is important to consider the possibility of a flexible approach to investing, which increases the attractiveness of this sector for investors. This factor is estimated using the real options method. The real options approach is a generalization of the classical method of discounting cash flows. It should be noted that when using the method of discounting cash flows, the factor of managerial flexibility is not taken into account: fluctuations in interest rates, changes in the cost of production, costs and other changes are ignored. The use of real options makes it possible to determine alternative options for solving managerial problems in situations of uncertainty. The article (Dolan et al., 2018) discusses the methodology of real options for assessing climate risk. The study (Andalib et al., 2018) proposes a fair assessment of real options for the project environment using a behavioral economic approach that uses the binomial method. Economists (Hu et al., 2019) use the real option method in assessing the state of transport of regional aircraft in emerging economies. The study (Brasil et al., 2018) addresses the reasons for using real options in evaluating innovative projects with high uncertainty. In (Ko et al., 2018) technology of the product life cycle based on innovation using complex binomial options is considered. The article (Chi et al., 2019) proposes to use real options in international business, highlight key factors in exogenous and endogenous uncertainty and empirical schemes for testing unique forecasts. The author (Benaroch, 2018) considers the possibilities of using real options in cyber security systems to conduct proactive measures. The paper (Gao and Driouchi, 2018) discusses issues of outsourcing with heterogeneity in the preferences of ambiguity and probability using the model of real options. The article (Morozko et al., 2018a) explores the rationale for strategic policy in developing small businesses based on the use of real options. An economist (Conrad, 2018) in his work notes that one can use the theory of real options to determine the optimal timing of environmental measures. The authors (Erfani et al., 2018) note that the ability of the system AQ1 to adapt to future needs, the flexibility in activating, delaying and replacing engineering projects should be taken into account when planning an intervention with minimal water supply costs. A review of a review of the theory of real options in research on strategic management in work (Trigeorgis and Reuer, 2017). The study (Favato and Vecchiato, 2017) suggests a combined use of scenarios and real options. The author (Lambrecht, 2017) emphasizes in his article that currently, academic research in real options is catching up with current practice. Uncertainties in investment costs, electricity prices, carbon prices are addressed in (Tian et al., 2017). In (Smit et al., 2017), real options are considered in terms of transactional uncertainty and economic uncertainty. The study (Posen et al., 2018) examines the behavioral model of real options using a learning theory with feedback. The article (Savolainen et al., 2017) proposes using three types of real options to analyze the effect of production profitability.

2. METHODS

The development of small energy in the country is influenced by many factors. The PEST analysis technique allows assessing the impact of key factors in the development of small energy in Russia in the future, since PEST analysis is an instrument of long-term strategic planning (Table 1).

Table 1: PEST analysis of small energy development conditions

Political factors		Economic factors	
Trends	**Degree and vector influences**	**Trends**	**Degree and vector influences**
1	2	3	4
Change of law	Medium –	Increase in energy tariffs	Medium –
Improving the competitiveness of the energy system	Medium +	Increasing the volume of small energy in meeting the need for energy in local energy markets	High +
Attracting foreign and domestic strategic investors in the development of small energy	Medium +	Change in inflation	Medium –
The emergence of a trend of support and promotion by the state of small energy	High +	The limited budget for small-scale energy facilitates the use of Russian safety systems in production	Medium –
Gradual strengthening of monitoring and control requirements small energy facilities	Medium +	The growth of public and private funds in the development of infrastructure and increase investment performance	High +
Social factors		Technological factors	
Trends	Degree and vector influences	Trends	Degree and vector influences
Tariff increase for energy resources in the coming years	Medium +	Increased energy production capacity	Medium +
Increased demand for energy services with changes in the income structure of the population	Medium +	Development of the technical infrastructure of the energy sector	Medium +
Improving the efficient use of energy resources by consumers	Medium +	Reducing restrictions on the use of new facilities and improving the quality of capacity	Medium +
Development of socially responsible enterprises in the energy sector	High +	Acceleration of scientific and technological progress	Medium +
Lack of vigorous action by social groups requiring alternative energy supplies	Medium –	The development of energy security monitoring technologies in developed countries, which forms a strong competitor to Russian developments	High –

Key findings from PEST analysis:
- State support and promotion of small energy, attracting strategic investors in the development of small energy, a politically important movement to ensure the safety of facilities. In general, the political factor has a positive impact
- Increasing energy tariffs and at the same time satisfying small energy needs for energy in local energy markets makes it possible to assess the impact of the economic factor as positive
- The social factor is seen as positive, since changes in the structure of population incomes will lead to an increase in demand for energy services and the organization of efficient use of energy resources by consumers
- The technological factor is closer to a positive impact with a general increase in energy production capacity, development of the technical infrastructure of the energy complex
- The results of the PEST analysis indicate that there are opportunities for the development of small energy in Russia. At the same time, it should be noted that in this direction there are many risks and uncertainty, which necessitates the use of flexible management decisions, which is possible using the real options method.

Real options are recommended for use in the following tasks:
- Uncertainty affects the value of the invested project
- The presence of managerial flexibility in decision-making during the implementation of the project
- The strategic approach is real and rational.

The presence of managerial flexibility in decision-making can be considered as an asset in the cost of the project. According to the methodology used, the real options method is identical to the discount method based on discounted cash flow. The risk in the method of real options is a factor contributing to the growth of the value of the project. A project with a higher degree of risk provides maximum profitability under conditions of uncertainty.

When choosing the most adequate financing for a project that gives the greatest benefit, a number of problems arises that make it difficult to accurately quantify:
- Market risks that are difficult to quantify
- The choice of the time frame of the project under the influence of many factors
- Changes in capital expenditures, under the influence of many factors.

The real options method is a modern approach to the assessment and management of strategic investments. This method is based on the theory of financial options in assessing the value of management flexibility in the face of uncertainty. When using the real options method, it becomes possible to track the strategic value of an investment project. Many of the disadvantages of the discounted cash flow method are taken into account when applying the real option method. In management tasks using this method, threshold values of the determining parameters and their distribution are used.

When making flexible management decisions, various types of options are used. To assess the development of small energy in Russian conditions, you can use the flexibility options. The ability to change the parameters of an investment project in the process of preparing or implementing a project means an option for flexibility. The flexibility option is used when choosing between the construction of one central power supply facility and the construction of several power supply facilities in different places. Improving project performance means increasing the level of return under favorable conditions. The possibility of increasing capacity with increasing demand for the products of the ongoing project, which is characterized by a real CALL option. When buying a CALL option, the right is acquired for a certain time at a set cost to buy the underlying asset. As a rule, in the absence of accurate data on the demand for the project's products, but it is known that its growth is possible in the future, it is optimal to use a real CALL option. By analogy, in the financial market, a sequential series of options corresponds to the successive stages of an investment project. Upon successful completion, the previous stage is necessary for moving to the next stage of the project, while the investor receives the right to invest in the next stage of the project.

Based on the analysis of the Black-Scholes formula, one can trace the growth in the price of a real option with the following parameters:
- Increase in the present value of cash flows
- Reducing the cost of the project
- Significant risk in the implementation of the project.

The real options method is more suitable for evaluating projects for investing in small energy than DCF. When using real options, a certain scheme is formed in accordance with which a chronological order of investment decisions in the process of constructing small energy supply facilities is planned, as well as new opportunities are revealed. At the same time, it becomes possible to determine the sequence of decisions on money management (Morozko et al., 2018a). In parallel with the planning of decisions and the development of the decision tree, the main cost factors and risks corresponding to the stages of the project are identified (Gitman and Zutter, 2015). When using real options, alternative approaches to solving managerial problems are considered in order to obtain significant results that cover the planned costs (Mikhailov, 2018).

3. DATA

The rapid development of alternative forms of energy generation allows the population of even the most remote regions of Russia from centralized power supply stations to receive all the resources to ensure quality living conditions.

The main reasons for the construction of an autonomous power plant are:
1. The cost of energy received from an autonomous source is lower compared to other energy sources
2. Losses from interruptions in energy supply are commensurate with the costs of building an autonomous source
3. The construction of an autonomous source is cheaper in comparison with the cost of fulfilling the conditions for joining a centralized energy supply system

4. An autonomous energy source is reliable from a centralized energy supply system
5. An autonomous energy source allows you to be economically independent in the energy market.

Regulatory and legislative acts define stations related to small energy:
- Power plants with a capacity of up to 30 MW with units of up to 10 MW
- Boilers and boiler rooms that produce heat up to 20 gig calories per person
- Hydroelectric power stations and micro-hydroelectric power stations, the unit power of units of which does not exceed 100 kW
- Nuclear power plants with electric power of power units up to 150 MW, thermal power - up to 500 MW
- Power plants using non-traditional types of fuel.

The small electric power industry of Russia currently includes more than 57,000 power plants with a capacity exceeding 19 million kW, which makes up 10% of the total delivered capacity of the country's power plants. At autonomous power plants, the joint annual power generation is 7% of the annual output of the aggregate power plants in Russia. Small power plants have an average power of about 350 kW (An et al., 2019).

The small energy market is developing mainly in the European part of the country, in which there is a large consumer coverage of the Unified Energy System. In areas of Siberia, the Far East, the Far North, there is an acute shortage of energy, which can be compensated by small energy with autonomous energy sources.

The trends in the development of small energy in Russia are perfectly consistent with global trends, which, according to the forecast of the UNEP Frankfurt School Center and Bloomberg New Energy Finance, are steadily growing annually (Figure 1).

The resources of renewable energy sources in Russia are diverse (Table 2). Significant amounts of renewable resources are available in almost all regions of the country, with significant amounts recorded in remote areas.

The potential of renewable energy sources in Russia is 300-355 million tons of fuel equivalent. That is, more than 27% of the country's energy consumption. It should be noted that at present, only 2 million tons of fuel are used. t. In the overall energy balance of Russia, renewable energy sources do not exceed 0.6% for electricity and 5% for heat.

The capacity of generating capacities using non-traditional renewable energy sources includes more than 250 GW. According to the forecast, the planned capacity of power plants operating on alternative energy sources by 2025 may be adequate to the installed capacity of existing hydroelectric power plants. The most dynamically developing small energy industry, which uses projects that use geothermal energy, wind, and the sun.

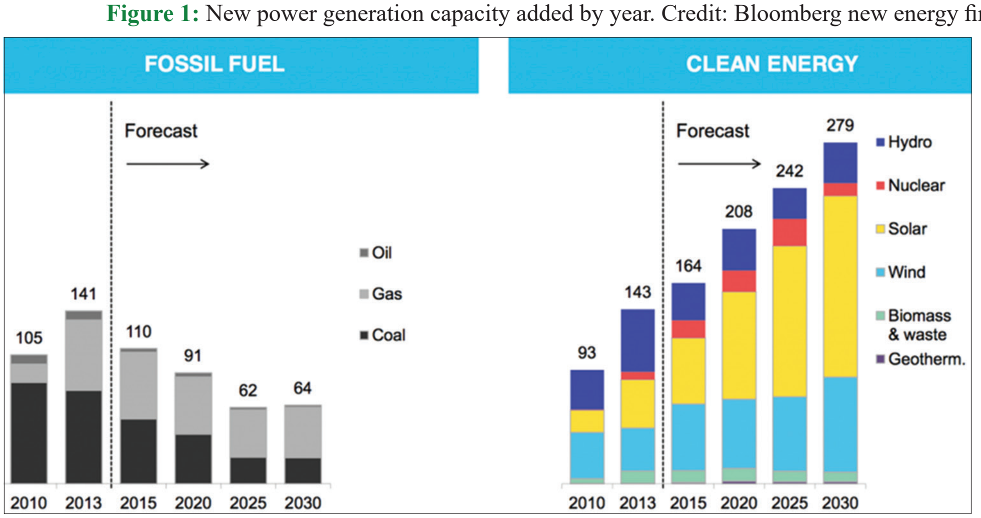
4. MODEL

The development of small energy in Russia is determined by the following opportunities:
1. Improving energy sources when using energy production devices in a combined form
2. Decrease in overall dimensions and cost of mechanisms of heat cogeneration system
3. Reducing the construction time of small autonomous stations using block-modular structures of the highest factory readiness
4. Expansion of energy exploitation of many rivers of the Russian Federation through the use of energy sources based on hydroelectric power plants.

Table 2: Country renewable energy sources

Types of energy resources	Release potential (million tons of fuel equivalent)
Energy of sun	15-17
Wind power	15-18
Energy potential of biomass	45-60
Geothermal energy	120-145
Hydropower at small stations	70-75
Low heat	35-40
Total	300-355

Figure 1: New power generation capacity added by year. Credit: Bloomberg new energy finance



Using the method of flexible management decisions based on real options will allow realizing these opportunities (Morozko et al., 2018c). The sequence of actions can be formulated as an algorithm:

1. Decision-making on the development of the project
2. The ability to use real options
3. The choice of the type of real options that can be included in the project
4. Building a decision tree
5. Valuation of the value of a real option (PVopts)
6. Accepted options project.

Based on the real options method, it becomes possible to quantify the potentials existing in the project and to include them in assessing the effectiveness of the investment project (Morozko et al., 2018d).The net cash flow of an investment project using management options can be calculated as follows:

$$NPVexp=NPVtr+ROV \quad (1)$$

where: *NPVexp* (*expanded NPV*) - Strategic net cash flow using real options
NPVtr (*traditional NPV*) - Net cash flow calculated according to the traditional methodology without the use of real options
ROV - The value of real options.

In the process of building an energy supply facility, there are a large number of decision-making dates, so a binomial option pricing model is being built (Morozko et al., 2018e). The binomial model acts as a decision tree with various directions and makes it possible to visually depict the probable scenarios of the formation of events, probabilities and solutions (Figure 2).

When using the binomial model, the following assumptions are used: in the considered time interval, there can be only two options for the development of events - positive and negative. When constructing a decision tree, the following notation is used:

s - The initial value of the asset
u - Increase in value
d - Cost reduction.

In the practical use of the binomial model, difficulties arise in determining the values of the relative increase (decrease) in the price of an asset in each period. To determine, you can use the calculation of the average annual growth rate (Chan, 2012):

$$CAGR=\left(\frac{V_N}{V_0}\right)^{\frac{1}{N}}-1 \quad (2)$$

where: V_0 - The initial cost of investment
V_N - The final cost of investment
N - The number of periods (years).
CAGR (u) - relative growth (with a value of, for example, 1.10, indicates the expected increase in the project cost of 10%).

The value of the relative reduction in project cost (d) is defined as: $d=\frac{1}{u}$

The probability of relative growth (*P*), assuming that a neutral attitude to risk is taken, is determined by:

$$P=\frac{[(1+r)-d]}{u}-d \quad (3)$$

The probability of a decrease in the project cost will accordingly be equal to (1 - *P*).

The binomial model has significant advantages when analyzing an investment project.

The calculation of the value of real options with a certain degree of accuracy can be made based on the Black-Scholes formula

Figure 2: Binomial grid in the evaluation of investment projects

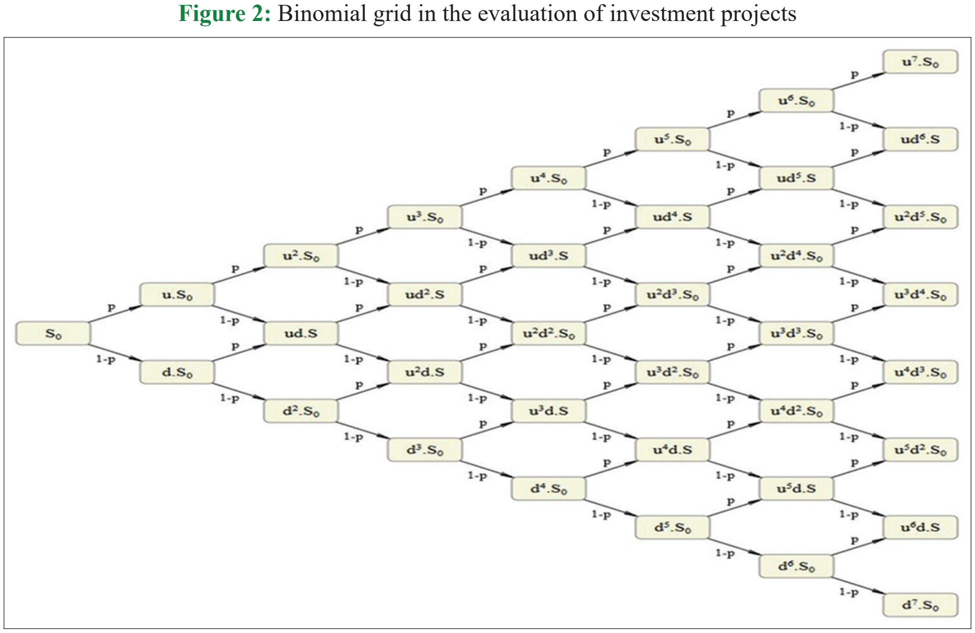


Table 3: Calculation of the real option price according to the Black-Scholes model in VBA

Initial data		Result	Call	Function values	
Expected cash flow	92120	Option price	2.801	d_1	–0.323472
Project acquisition costs	93100	$N(d_1)$	0.3711	d_2	–0.431760
Uncertainty (variance level)	50%	$\frac{N'(d_1)}{S\sigma\sqrt{T-t}}$	0.000040	$N(d_1)$	0.371119
Project Duration	30	$SN'(d_1)\sqrt{T-t}$	–76.2753	$N(d_2)$	0.337123
Days in a year	360	$-\frac{SN'(d_1)\sigma}{2\sqrt{T-t}} - rKe^{-r(T-t)}N(d_2)$	79.5233	$N1(d_1)$	0.365348

(Black and Scholes. The Pricing of Options and Corporate Liabilities, 1973):

$$C(S,t) = SN(d_1) - Ke^{-r(T-t)}\ N(d_2),$$

$$d_1 = \frac{\text{üiüüüü} \quad + \quad + \sigma^2 \quad -}{\sigma\sqrt{T-t}} \tag{4}$$

$$d_2 = d_1 - \sigma\sqrt{T-t}\ .$$

Where:
$C(S, t)$ - The current value of the call option at time t before the expiration of the option
S - The current price of the underlying asset
$N(x)$ - The probability that the deviation will be less under the conditions of the standard normal distribution
K - The exercise price of the option
r - Risk-free interest rate
$T–t$ - Time until the expiration of the option
σ - Volatility of the return on the underlying asset.

Calculation is made using standard software. As an example, we give a calculation of the cost of a CALL option based on the Black-Scholes model for the construction of a small power plant, for which the following data are available: project acquisition costs-$ 93100, project duration - 2.5 years, option type - CALL (Table 3).

In this case, the plant's generating asset converts a certain type of fuel into electricity and turns on only when the cost of the electricity generated exceeds the cost of fuel and energy production.

5. RESULTS AND DISCUSSION

Assessing the development of small energy in the country requires flexible solutions in the face of uncertainty, such management involves the creation of options. This is an option of flexibility, in which it is possible to change the timing, volume, stages of the investment project. With growing demand for the expected output during the implementation of the project, there is the possibility of increasing the production capacity of an autonomous energy supply station. Without a real flexibility option, such a change was not possible. When acquiring a CALL option, the right is acquired to invest in the project for a specified period of time and, accordingly, own this asset. At the same time, it becomes possible to invest additional funds for the development of production under favorable circumstances and generate additional income. Given the uncertainty of demand, but the possibility of growing demand in the future, as is the case in small energy, it is advisable to have a real CALL option, which increases the attractiveness of the project.

Real options are advisable to use in the presence of a significant degree of uncertainty of the results of the investment project. At the same time, it becomes possible to change decisions when new information arises (for example, replacing the type of fuel used, due to price changes). The use of real options makes it possible to establish a sequence of decisions on money management during the implementation of an investment project, but not at the initial stage, at which many factors act as uncertainty. When determining the sequence of decisions to be made in the future, developing a binomial tree, it is necessary to determine the nodal factors that affect the cost and risks at each stage of the project. At the same time, real options act as a universal tool for solving problems of the feasibility of investing and a strategic approach to the dynamics of decisions. At the same time, using this method, you can manage the financial risks of an ongoing project. Such an opportunity increases the attractiveness of the project. The development of small energy contributes to the stability and efficiency of energy supply. This will help reduce the rise in prices for all types of energy and will allow rationally taking into account the needs of consumers.

6. CONCLUSION

Justification of investments in the development strategy of small energy in Russia, taking into account costs and emerging risks, can be carried out on the basis of an integrated approach. The study of many factors influencing the development of small energy in Russia is proposed to be based on PEST analysis, since this analysis is a tool for long-term strategic planning. The results of the PEST analysis indicate that there are opportunities for the development of small energy in Russia.

It was revealed that when investing in small energy there are many risks and uncertainty, this necessitates the use of flexible management decisions using the real options method. The use of real options makes it possible to determine alternative options for solving managerial problems in a strategic approach, which is not possible when applying the discounted cash flow method. The ability to change the parameters of an investment project in the process of preparing or implementing a project means an option for flexibility. It is substantiated that to assess the development of small energy in Russian conditions, you can use the flexibility option. The procedure for calculating the price of a real option is given by a specific example.

The study argued that in the process of building an energy supply facility there are a large number of decision-making dates, so a binomial option pricing model is being built. The binomial model acts as a decision tree with various directions and makes it possible to consider probable scenarios of event formation and decision options. An integrated approach to evaluating projects for investing in small energy demonstrates the preference of the real options method.

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