IMPACT OF STATE SUPPORT MECHANISMS ON THE COST OF RENEWABLE ENERGY PROJECTS: THE CASE OF DEVELOPING COUNTRIES

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ABSTRACT
The effective investment of private capital in renewable energy projects is impossible without intensive and comprehensive support for investors from the state. However, each mechanism of state support is characterized by its own level of risk. Political instability may lead not only to the loss of investment, but also to a decrease in the investment attractiveness of renewable energy projects. This paper summarizes the main types of state support mechanisms, as well as their impact on the development of renewable energy sources (RES) around the world. As a result of the analysis, the types of investors in the global RES market are identified, taking into account their attitude to risk and profit. The paper presents an approach to assessing the level of impact of state support mechanisms on the cost of RES projects based on the evaluation of a system of investment indicators. The calculations are made using Russian RES projects as an example and taking into account their energy and regional features. The results of the study will be used for the development of a methodology for the comprehensive assessment of the effectiveness and appropriateness of state support measures for RES in developing countries, as well as for supplementing the existing approach to the study of competition in the global energy market with a deterministic assessment of the relevant risk.
Keywords: energy, renewable energy sources, state support of RES, risks, investment project, investment attractiveness, project cost, global energy market, developing countries, economic capital.

1 INTRODUCTION

The development of renewable energy under the conditions of strong competition with conventional energy technologies is always accompanied by active state support. However, earlier studies and expert surveys [1]–[4] showed that the most dangerous risks in this sector are the ones caused by various political factors [1], [2], such as:

- *Risks of sudden changes in the strategy of renewable energy sources (RES) development* and schemes for its support: complete overhaul, scrapping of the present support scheme, retroactive changes in the support scheme. This reduces the effectiveness of the renewable energy development mechanisms.
- *Financial aspects of investors' dependence on state programs.* This is due to instability in the volume or duration of such support.
- *Regulatory risk*, i.e. flaws in legislation: the emergence of legal obstacles to the participation of independent electricity producers, the absence of an independent regulatory body, the lack of comprehensive accounting of all risks, etc.

The risks caused by political factors have a huge impact on the investment attractiveness of RES projects, especially on their costs. Therefore, there is a difficult and urgent need to conduct not only a theoretical but also an applied study of the level of influence of state support mechanisms on the development of renewable energy. This study was conducted on RES projects in developing countries; the developing countries are those countries that are characterized by a high degree of economic dependence on developed countries and are not members of the Organisation for Economic Co-operation and Development (e.g. Russia).

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The result of the study is the systematization and theoretical evaluation of the effectiveness of RES support mechanisms in the global market, as well as the identification of specific investors in the industry, taking into account their attitude towards such projects. The paper presents a practical assessment of the cost of renewable energy projects in developing countries on the basis of a system of traditional and industry-specific indicators. The comparative assessment of the suitability of support mechanisms for RES in developing countries is based on these calculations. The obtained results have practical importance and will be used to develop a deterministic approach to assessing the risks caused by political factors in the field of RES, and its integration into the concept of studying competition in the global energy market.

2 FEATURES OF SUPPORT MECHANISMS FOR RENEWABLE ENERGY PROJECTS: GLOBAL EXPERIENCE

An examination of the global and Russian renewable energy markets [5]–[9] showed that these markets are influenced by specific support mechanisms. Initially, a relatively low investment attractiveness of RES required government incentives. The worldwide practice of feed-in tariffs was supplemented with the idea of providing support based on the RES capacity charge. Later on, mechanisms for selling the capacity of RES generators through annual competitive selection of investment projects were introduced; a range of target indicators for the period 2014–2020 and later were established in the Resolution of the Russian Government [10] and RUSNANO [11]. Developing countries, like the majority of developed countries, do not have a system of direct government subsidies for renewable energy.

Table 1 (based on Ermolenko et al. [1], Dia-Core Project [2], Brummer [12], Hayes and Goodarzi [13]) summarizes the main mechanisms of state support for RES in the global market, and provides a short description of these mechanisms and the results of the assessment of their impact on the development of renewable energy in certain regions.

A comprehensive description of the main investors in the renewable energy market, taking into account their specific features – the role, duration of participation in projects, as well as risk and profit ratio – is presented in Table 2 [1], [2].

3 ESTIMATION METHOD FOR THE COST OF RENEWABLE ENERGY INVESTMENT PROJECTS

The proposed method for estimating the cost of RES projects is based on the calculation of a set of indicators while taking into account the peculiarities of the state support mechanisms for the sector in developing countries. The specific feature of the method is that each mechanism is characterized by an individual level of risk which affects the final cost of the RES project.

This method includes five steps, as shown in Fig. 1.

The following indicators are used as the key pointers for RES project cost estimation:

- *Weighted average cost of capital (WACC)* shows how the cost of project financing changes under the influence of support mechanisms.
- *Economic capital (risk capital)* shows how the amount of capital required to cover project risks changes in case of default [14], [15].

Possible additional indicators are presented in Table 3.

Table 1: Mechanisms of state support for RES.

Mechanism	*Short description and features*		*Common occurrence*	*Influence on the development of RES in selected countries*
Feed-in tariff	Fixed tariff (usually for small RES objects)	Price is fixed by the state above the average market price	France, Austria, Latvia, Lithuania, Bulgaria, Ireland, Luxembourg, Greece, Hungary, Slovakia, China, Russia	Within 13–15 years, Austria becomes one of the EU leaders in RES utilization (hydro and bioenergy) thanks to preferential tariffs
Feed-in premium	Preferential tariff depending on market electricity prices (usually for large RES facilities)			
Trading of renewable energy certificates	Assignment of quotas of RES consumption	Market participants undertake obligations for the production, transmission or distribution of renewable energy	Sweden, Poland, Romania, Russia	In Sweden, the acquisition of renewable energy certificates led to RES share in total generation exceeding 50%
Tenders and auctions	Competitive form of selection of projects for the supply of electricity under specified conditions	Aimed only at supporting large projects	Almost all EU countries, UK	Lower energy costs for end users
Solar obligations	Support for the production of heat energy using only solar energy	List of documents regulating the obligations as to the volume of heat production	Denmark, Greece, France, Germany, Ireland, etc.	Introduction of solar thermal energy into district heating systems. Wider use of geothermal plants
Technology-neutral obligations	Support for heating technologies			
Grants, preferential loans, tax incentives	One-time support to compensate investors for initial investment costs (on a competitive basis). Tax benefit for 1 kWh of energy produced by the RES facility, provided for up to 10 years (production tax credit)		Almost all EU countries, UK	Growing number of large renewable energy projects
Green subsidies	Aimed at supporting environmental activities within RES projects		Almost all countries	Improved environmental sustainability of RE
Development of cooperation between EU countries	Based on the “Covenant of Mayors for climate and energy” – the mechanisms of mutual assistance in achieving EU targets		All EU countries	Energy efficiency improvements, 40% reduction in emissions
Renewable Heat Premium Payment	Payments to households for the buying of appropriate equipment		UK	Used for the first time in the world to support RE heat
Renewable Heat Incentive	Households or enterprises that install small-scale heating systems receive a fixed amount determined by the thermal performance of the RES installation		UK	
Cooperation between EU and non-EU countries	Enabling legislative and financial policies, loans, subsidies and grants, tax incentives		All EU countries	Creation of agencies working on the principle of “one window” to assist in implementation of business startups in the field of RES
Green Patent Pilot Program	Acceptance of patent applications in the field of RES		USA	Acceleration of acceptance of applications for patents in the field of RES
Centers of Energy Innovations	Involving the best experts to team-based interdisciplinary projects for the development of clean energy technologies		USA	Growing expert engagement

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Table 2: Features of investors in the global RES market.

Type of investors	*Degree of involvement*	*Level of risk acceptance*	*Required level of income*	*Duration of participation in the project*
Large power-generating companies	Creation of subsidiaries for the development of RES projects	All risk acceptance – preference for long-term projects	Estimate the cost of energy produced	Involved at all stages of the project, long-term investors
Municipal power -generating companies (MPGC)	State-provided incentives for participation	Partial risk acceptance – participation in joint projects with experienced developers, minimizing the borrowed funds, work on the geographic location of the MPGC	7–9% per annum	Involved at all stages of the project, long-term investors
Original equipment manufacturer independent energy producers	Holding a controlling stake	Striving for high risk and high profitability		Participate in design, construction and operation of power plants
Producers	Investment in projects for the sale of equipment	Selection of economically viable projects only		Up to 2–3 years after commissioning
Infrastructure investment funds	Passive investors, joint participation with experienced operators	Risk avoidance – work in well-known markets, with trusted investors, joint participation with experienced operators, complex risk management procedures	6–15% per annum	From installation launch phase until full repayment of investments
Private investment funds	Active investors, providing financial, engineering and contact expertise	Accept high risks – non-recourse loans, capital-intensive projects	15–25% per annum	Investment stage, completion of construction within 3–7 years
Pension capital funds and insurance companies	Full control of the assets	Conservative risk – conservative use of borrowed funds, the desire to ensure greater profitability and work with mature technologies	5–10% per annum	Start of participation is at the time of commissioning before the end of the asset life cycle (20–30 years)
YieldCos	Acquisition and ownership of RES project assets in the form of a separate company	High sensitivity to risks, almost no use of borrowed funds, transfer of individual risks to insurance companies	Debt rate	Construction phase and up to three subsequent years to reach the set level of profitability
Green bonds	Debt financing of low-carbon technologies	Existence of risks due to lack of strict legislation for their regulation	Average market rate	Entire lifecycle
Asset-backed securities	Formation of a pool of assets in RES projects, conversion of illiquid assets into a portfolio of traded securities	Risk reduction is based on diversification of funding sources	Average market rate	Differ in terms of release dates

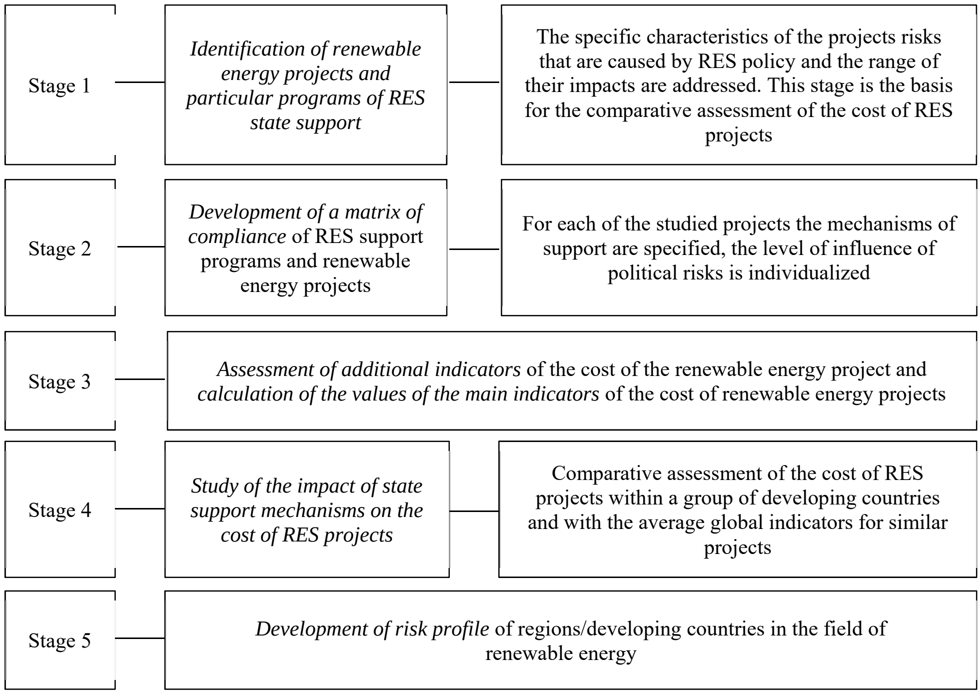

Figure 1: Estimation method for state support impact on the cost of RES projects.

Table 3: Additional indicators of projects' cost evaluation.

Main indicators	*Weighted average cost of capital*	*Economic capital*
Additional indicators	– Debt/equity ratio – Cost of debt (CoD) – Cost of equity (CoE) – Return on equity (RoE)	– Probability of default (PD) – Loss given default (LGD) – Exposure at default (EAD) – Maturity (M)

Evaluation of WACC is based on eqn (1) [2], [16]:

$$WACC = \frac{E}{C} \cdot ROE + \left(1 - \frac{E}{C}\right) \cdot (1 - T) \cdot r, \tag{1}$$

where E is Equity Capital; C is total investments; T is the relevant tax rate for the project; and r is the interest rate.

For the purposes of this study, *RoE* is used as an additional indicator and is calculated using two equations. On the one hand, the calculation is based only on the financial statements according to eqn (2):

$$RoE = \frac{NI}{E}, \tag{2}$$

where *NI* is net income.

On the other hand, the calculation is based on eqn (3) from the position of relation to risk [2], [17]:

$$RoE = R_f + \beta \cdot (R_m - R_f), \qquad (3)$$

where R_f is risk-free rate; β is a measure of risk for diversified investors; and $(R_f - R_m)$ is risk premium.

The brief characteristics of additional indicators for economic capital calculations, as well as methods of its evaluation, are presented in Domnikov et al. [14], [18], [20] and Mokhov et al. [15], [19]. The final assessment of *economic capital* is carried out according to the eqn (4), which is based on the Merton–Vasicek method [20]:

$$EC = EAD \cdot LGD \cdot (N \cdot \left(\frac{N^{-1}(PD)+\sqrt{R} \cdot N^{-1}(\alpha)}{\sqrt{1-R}}\right) - PD), \qquad (4)$$

where EC is economic capital; N is the function of standard normal distribution; R is the correlation coefficient of the indicators of the project with the general economic situation; and α is reliability level.

4 COST EVALUATION OF RUSSIAN PROJECTS FOR RENEWABLE ENERGY

The main mechanism of support for renewable energy in Russia is the selling of RES power through the annual competitive selection of investment projects (Agreements for the Supply of RES Capacity (CSA (Capacity Supply Agreement) contracts)) [11]. This mechanism is aimed at achieving the target of 4.5% of production and consumption of renewable energy in Russia by 2024. In this paper, I will assess how the competitive selection mechanism affects the cost of projects.

The selection targets for 2014–2020 determine the priority areas for renewable energy in Russia [10], [21]:

- wind energy: 3.6 GW;
- solar energy: 1.52 GW;
- small hydroelectric power: 0.75 GW.

4.1 Brief description of renewable energy projects

The Russian projects selected for evaluation are outlined in Table 4; they match the state priority areas of RES development, and detailed descriptions of the projects can be found in publications by the Analytical Center under the Government of the Russian Federation [22], PJSC “RusHydro” [23] and JC “Fortum” [24].

4.2 Practical evaluation of the costs of renewable energy projects

In accordance with the presented method, the costs of Russian renewable energy projects are estimated based on WACC (see section 4.2.1) and economic capital (see section 4.2.2) adjusted to the impact of state support mechanisms.

4.2.1 Estimation of WACC of renewable energy projects

The input data for the estimation of the WACC of RES projects are presented in Table 5.

The results of the evaluation of the WACC of RES projects are presented in Table 6.

Table 4: Characteristics of evaluated Russian renewable energy projects.

Project characteristics	*Orsk solar power plant*	*Binary block on Pauzhetskaya geothermal power plant*	*Wind power plant in Ulyanovsk*
Company-initiator	PJSC "T Plus"	PJSC "RusHydro"	JC "Fortum"
Economic region	Ural	Far Eastern	Volga region
Installed capacity, MW	40	Increase of station capacity by 2.5	35
Year of commissioning	2015	2012	2018
Term of putting into operation, years	2	2	2
Project budget, mln. euro	35	7	65
Type of state/regional support	CSA contract	CSA contract	CSAcontract, regional support, tax benefits
Scheme of financing	Project finance		
Share of borrowed capital, %	80	60	70
Cost of borrowed capital (r), % per annum	11.18	11.13	12.20
Credit rating	BB+		
Level of reliability (α)	95.125		

Table 5: Components of the WACC assessment of RES projects.

Additional characteristics	*Orsk solar power plant*	*Binary block on Pauzhetskaya geothermal power plant*	*Wind power plant in Ulyanovsk*
Average return on equity (RoE) of company-initiator during period of project realization, %	24.52	3.79	11.7
Relevant tax rate for the project (T), % *without state support*	20	20	20
Relevant tax rate for the project (T), % *with state support*	20	20	15
Risk-free rate (R_f) *with state support*	8.0	8.21	9.53
β *with state support* [2], [17]	1.20	1.00	1.45
Risk premium $(R_f - R_m)$, % [2], [17] *with state support*	3.8		
Average RoE of company-initiator during period of project realization, % *with state support*	3.44	4.41	4.02

Table 6: Estimation of WACC and indicator changes for RES projects.

Project title	*Orsk solar power plant*	*Binary block on Pauzhetskaya geothermal power plant*	*Wind power plant in Ulyanovsk*
WACC, % *without state support*	12.06	6.86	10.34
WACC, % *with state support*	75.96	181.74	127.86
ΔWACC, %	+63.9	+174.88	+117.52
ΔRoE, %	–21.08	+0.62	–7.68
ΔRelevant tax rate, %	0	0	–5

WACC: weighted average cost of capital; RoE: return on equity.

The calculations showed that the value of WACC for each project increased several fold. In practice, this means that the cost of project financing under the influence of support mechanisms has become higher. The level of risk caused by state support for renewable energy is too high and reduces the effectiveness of such projects. Expert assessment of WACC for EU countries using the example of wind power [17] showed that its value varies between 5% and 13%. Russian projects show similar values only in the absence of state support (7–12%).

4.2.2 Assessment of the economic capital of RES projects

The input data for the assessment of the economic capital of the projects studied are presented in Table 7.

Table 7: Components of economic capital assessment of RES projects.

Additional characteristics	*Orsk solar power plant*	*Binary block on Pauzhetskaya geothermal power plant*	*Wind power plant in Ulyanovsk*
Probability of default (PD), % *without state support*	15	10	12
Probability of default (PD), % *with state support*	7	3	6
Loss given default (LGD), %	76.7	62.9	70.2
Exposure at default (EAD), mln. euro (includes loan value, interest paid, return on equity)	44.73	8.11	80.66
Maturity (M) *without state support*	3.27	3.34	3.31
Maturity (M) *with state support*	3.40	3.58	3.43
Correlation coefficient of the indicators of a project with the general economic situation (R)	0.25	0.2	0.35

The impact of state support on the size of the projects' economic capital reduces the probability of default of projects. The probability of default of projects before getting state support is estimated based on the statistical distribution of data from similar projects, after using state support – on the basis of expert evaluation.

The results of the economic capital assessment are presented in Table 8.

The correspondence between the changes in economic capital, probability of default and maturity are presented in Table 9.

Thus, state support led to the growth of the economic capital of each RES project by about 11 million euros. This amount is a quantitative assessment of the possible losses from the risks associated with state support. Despite the fact that the key indicator of the probability of default has been more than halved in each case, the maturity (the penalty for the duration of the investment cycle) has increased by an average of 10%. This indicates an increase in the impact of risks associated with the state impact on the development of each of the RES projects and of political uncertainty.

5 CONCLUSIONS

It is widely known that high rates of renewable energy development are achieved mainly due to active state support. Developing countries, along with developed countries, use a wide range of investment support measures for the development of renewable energy technologies, from direct grants and tax benefits to trading of renewable energy certificates and quotas for renewable energy. However, such state policy is accompanied by specific risks, which are mainly due to the instability of such programs, a high level of financial dependence, etc.

Table 8: Evaluation of RES projects' economic capital.

Project title	*Orsk solar power plant*	*Binary block on Pauzhetskaya geothermal power plant*	*Wind power plant in Ulyanovsk*
Economic capital, mln. euro *without state support*	95.36	15.33	164.93
Economic capital, mln. euro *with state support*	108.48	17.71	182.56
Δ economic capital, mln. euro	+13.12	+2.38	+17.63
Changes in economic capital as the budget share, %	37.5	34	27.1
Changes in economic capital in the share of borrowed capital, %	46.9	56.7	38.7

Table 9: Changes in indicators of the economic capital of RES projects.

Project title	*Orsk solar power plant*	*Binary block on Pauzhetskaya geothermal power plant*	*Wind power plant in Ulyanovsk*
Δ economic capital, mln. euro	+13.12	+2.38	+17.63
Δ probability of default, %	–8	–7	–6
Δ maturity	+0.13	+0.24	+0.12

The study of the impact of state support mechanisms on the cost of projects was carried out using the example of projects for the construction of solar power, wind power plants and a binary block at a geothermal station being implemented in developing countries. The results showed that the initial theoretically estimated appropriateness of state-provided incentives for the industry is accompanied by a negative quantitative assessment. Thus, a comprehensive assessment of WACC found a rise in the cost of capital projects in the range of 6–26 times. The capital required to cover project risks increased 1.13 times. In the aggregate, this indicates that there is no positive effect from the state incentives for renewable energy. By contrast, state stimulation programs for RES development in EU countries has the opposite (not negative) effect. Consequently, measures to support renewable energy in developing countries are not producing the necessary results, thus reducing the investment attractiveness of renewable energy projects in those countries, given their high economic instability.

Further directions of the research are related to the development of a methodology for the integrated assessment of the effectiveness and suitability of state support for RES in developing countries, quantitative assessment of the relevant risks, and improvement of the methodology for assessing competition in the global energy market. Future research should allow for the comprehensive study of not only the social attractiveness but also the economic attractiveness of RES projects in different regions, to assess the investment potential of different regions and companies in the sector, and to identify the stage at which RES projects no longer need state support.

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