Algorithm and methods of assessment the efficiency of innovative-investment projects in the field of renewable energy sources

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Abstract. The article presents a universal algorithm for evaluating the efficiency of innovative-investment projects in the field of renewable energy. A comparative analysis of methods for assessment the efficiency of implementation and development of renewable energy sources described in the research studies of the Russian and foreign authors is performed. The features and main indicators of such projects are noted. The most suitable methodology in terms of feasibility of involving renewable energy sources in a particular company, was identified for Russian realities.

1 Introduction

The analysis of the Russian and international literature has shown that today there are no integrated and well-defined algorithms of assessment of innovative-investment projects in the field of implementation and development of renewable energy sources (RES) [1-11]. There is a lack of official recommendations or federal regulations to undertake such calculations. That is, there is no specifically indicated way for Russian companies that have decided to implement this type of projects to determine economic viability. Nevertheless, some authors make attempts to create an integrated algorithm and system of indicators for a particular region where the project can be implemented.

The lack of a unified systematic approach for evaluating the efficiency of RES innovative-investment projects is a serious problem for the Russian enterprises. In addition, the lack of predicted values of technical, economic, and climatic characteristics makes such estimates difficult.

Today there is no such a document that would regulate a single algorithm for the development of a feasibility study of innovative-investment projects for the implementation and/or development of renewable energy sources (regardless of the chosen methodology for assessing efficiency). So, in this work the authors attempted to draw up a universal algorithm for assessing the economic efficiency of innovative-investment projects, highlighting in a separate block a feasibility study for the implementation of renewable energy projects. The proposed algorithm is presented in figure 1.

Since the investment component is a fundamental aspect of the RES projects we are studying, it makes sense to refer to the "Methodological Recommendations for Evaluating the Efficiency of Investment Projects", according to which the efficiency of such projects is assessed in 2 stages:

1. The financial solvency of the enterprise (financial assessment) should be determined;
2. The assessment of the economic efficiency of investment projects (economic assessment) should be carried out.

However, innovative projects are a more specific version of investment projects, which is reflected, at a minimum, in changes in possible risks from the implementation of such projects. Furthermore, such a scheme does not take into account the special technical and economic indicators of power plants along with the specific natural and climatic factors that are not inherent in traditional power plants.

Thus, in the generally accepted two-stage algorithm in Russia, we have introduced the "Technical Assessment" block, which allows us to fully evaluate the project on the use of alternative energy sources.

Particular attention in this algorithm should be given to the Feasibility Study block, since the choice of equipment and, consequently, the efficiency of the entire project depend on correctly calculated technical and environmental climatic characteristics. A technical assessment of the renewable energy investment project will help to identify the prospects and feasibility of using one or another power plant. Depending on the type of energy source selected, various indicator systems can be included in the Technical Assessment block.

In the article "The review of features of innovative-investment projects in the field of implementation and development of renewable energy sources and issues of evaluating their efficiency" [12] a list of the main operations that must be carried out when evaluating the economic efficiency of an innovative-investment project is outlined, namely:

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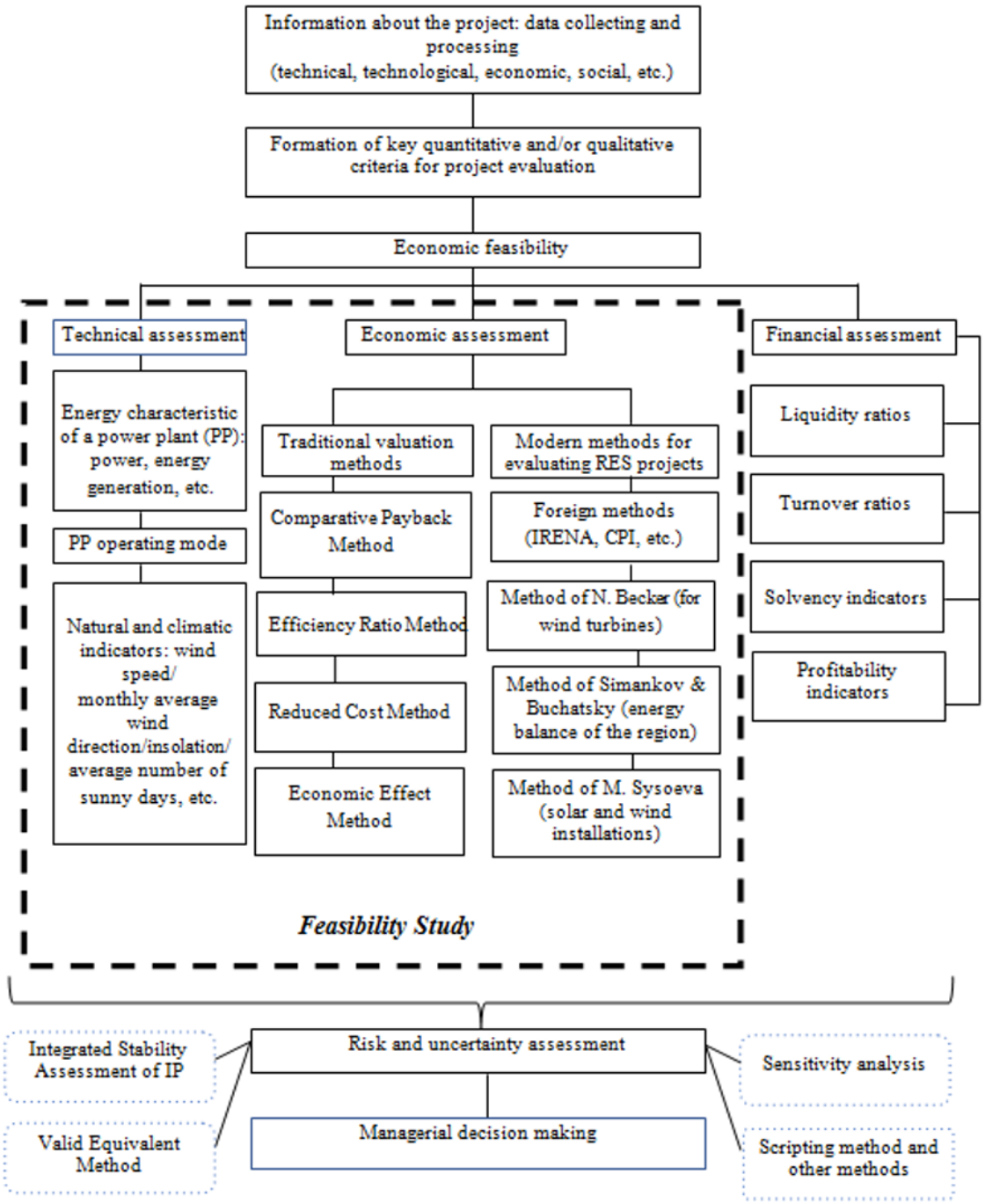

Fig. 1. Universal algorithm for assessing the economic efficiency of innovative-investment projects.

• Modeling of flows of products, resources and cash;

• Analysis of the impact of the project on business results and changes in the financial condition of the company;

• Accounting for the uncertainties and risks associated with the implementation of the project;

• Comparison of results and costs with an orientation towards achieving the required rate of return.

To implement these operations as part of the work on the algorithm, we analyzed a number of international and Russian methods for assessing the feasibility of implementing projects in the field of renewable energy.

In western countries, the practice of using renewable energy sources is much wider in comparison with that in the Russian Federation. Consequently, the experience in the field of determination of economic viability is also greater. In the EU and the USA various approaches to evaluate economic efficiency are offered by such organizations as: Climate Policy Initiative (CPI) [13], Alternative Energy Development (AED), The International Renewable Energy Agency (IRENA), etc. The techniques offered by them in most cases are based on the well-known "cost-benefit analysis" (CBA) (the analysis of expenses and benefits) which includes a set

Table 1. Comparative analysis of the Russian assessment techniques for efficiency of RES introduction and usage.

Author	**Becker N.A.**	**Sysoeva M. S.**	**Simankov V.S., Buchatskiy P.U.**
Type of renewable power engineering source	Wind energy	Sun and wind energy	The type of RES isn't specified
Source	Becker N.A. Assessment of economic efficiency of renewables' usage: on the example of wind power of Germany: Thesis for PhD in economic sciences. Moscow, 2007. – 127 p.	Sysoyeva M.S. Improving of the methodical device of assessment of cost efficiency of innovative and investment projects of introduction of alternate sources of energy: Thesis for PhD in economic sciences. Tambov, 2011. 144 p.	Simankov V.S., Buchatskiy P.Yu. Assessment of efficiency of involvement of nonconventional renewables in a regional energy balance//Bulletin of the Adygei state university. Series 4: Natural and mathematical and technical sciences. – 2012. – No. 2. – P. 1-10.
The main indicator for calculation	Environmental characteristics (average wind speed; wind turbine power; coefficient of wind turbine power reduction; availability of wind turbine; coefficient of change in air density, etc.); Streams of benefits and expenses; The cash flows connected with construction of wind power plants (the discounted cash flow, cumulative cash flow).	Capital investments for installation of the chosen generator; Annual current expenses, connected with introduction of power stations; Annual economic effect from introduction of the power station.	The sum of complete expenses in objects of RES (taking into account inflationary processes, discounting, use of credits, etc.); The discounted social income of the region; Extra-power income; The volume of tax receipts in the budget of a region; Volume of pollutions; Effect from decrease in energy deficiency, etc.
	The net present value (NPV); Internal rate of return (IRR); The discounted payback period (DPP), and other traditional indicators of assessment of investment projects.		
Features of the technique	While assessing the RES efficiency, a multicriterial estimation is used, which considers clean energy gain and aspects of energy security together with the financial characteristics. The calculation of probabilistic nature and technological special features of the process of production becomes fundamental here.	At the first stage the developed technique allows solving a problem of assessment of annual economic effect of implementation of innovative and investment projects of introduction of power stations (both in the modern conditions, and for future periods). At the second stage the system of additional indicators on the basis of cash flows taking into account specific factors of a solar and wind power engineering is used for implementing the complex assessment of cost efficiency of power stations introduction along with calculation of annual economic effect.	The integrated system of criteria, which considers expenditures for the creation of the production base of power engineering and makes it possible to estimate the efficiency of the use of systems with the nontraditional renewed sources of energy (NVIE) in the power system of region, is proposed. The estimation of the criteria in accordance with the given procedure presented is basis for developing the optimization model of involvement NVIE in the energy balance of region. Each criterion has its system of indices.

of analytical tools used for assessment of financial and economic viability of the proposed project. Some of these analytical tools are listed below: 1) ratio of expenses and benefits; 2) net present value (or the discounted cash flow); 3) internal rate of return; 4) least total cost method; 5) payback period; 6) sensitivity analysis [14].

In general, the content of the above-mentioned methods of efficiency assessment abroad and in Russia do not differ significantly, i.e. the same indicators and formulas are used for calculations with which we got

used to operate while evaluating investment projects (IP) in the Russian realities.

The American national noncommercial coalition of the public authorities and organizations, which work together for advancing the "pure" energy (Clean Energy States Alliance) suggests to study influence of RES projects on economy as part of cost-benefit analysis by means of one of the integrated modeling approaches realized via software IMPLAN, REMI, JEDI [15]. Models are developed on the basis of "input-output" model used in network programming. General principle of models' functioning works in the following way: the user working with the software product enters the required data on the considered project on implementation of installation on the basis of RES (location, commissioning date, number of turbines, size of turbines, investment and operating costs etc.), then the program estimates the annual economic influence on, for example, salary and productivity taking into account features of the region. Models are adapted only for the USA regions and can't be used for the analysis in other countries. Furthermore, this software is a commercial package.

The scientific team of Arif Malik, Mohammed Al Badi, Abdullah Al Kahali, Younis Al Nabhani, Alwarith Al Bahri Hamed Al Barhi (University n.a. the sultan Kabusa, Oman) propose to use a multicriteria approach to the assessment of projects in the field of renewable energy sources with the use of a system of decision-making support "Expert Choice" [16]. This system of decision making process is produced as a commercial product [17]. "Expert Choice" is based on the multi-criteria decision making techniques called "Analytic hierarchy process" (AHP). The AHP is a powerful and flexible decision making process to help people set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered. The assessment and final prioritization of renewable energy alternatives is accomplished using the AHP software Expert Choice. The alternatives mentioned above are evaluated under different criteria. The selected criteria are technology and sustainability, economic, environmental, planning, and Government policy and regulations. With the exception of economic criterion the other criteria are evaluated under each alternative using experts' opinion. Further the program issues the solution basing on the expert estimations according to each of the criteria.

Also there is another approach, when the following blocks depending on the criteria are analyzed for the development of the expediency of implementation the project:

- Technical estimation (generation at a power plant, resource potential, the absorptive power of network, location etc.),
- Economic estimation (cost of equipment, production cost of 1 kWh, internal rate of return, net present value, payback period etc.),
- Ecological and social estimations (changes in the environmental conditions, visual pollution, the development of local economy, employment changes, an increase in the comfort of users and others) [18].

To evaluate each block, after the calculation of the specific indicators, score system (with values from 0 to 10) is used, each criterion is assigned a weight according to this technique. The matrix for decision making is compiled after the analysis of all blocks taking into account the obtained weights. This procedure is time-consuming, and not all the proposed indicators can be calculated due to lack of information in modern Russian realities.

In this work we have also analyzed works of the following Russian researchers: Becker N.A., Sysoeva M. S., Simankov V.S., Buchatskiy P.U. These scientists propose their own modern methods, which are characterized by both general and various features.

Table 1 presents the comparative analysis of several Russian methods of assessment of efficiency of implementation and development of renewable energy sources. It is seen from this table that all methods are based on traditional assessment indicators (net present value, internal rate of return etc.). Also, all methods consider technological component of projects; however, there are differences in the set of indicators themselves.

The most suitable method for the purposes of our research is proposed by M. Sysoeva since her approach makes it possible to estimate efficiency independently of the type of the selected alternative energy source, unlike the technique of Becker N.A., which was developed only for wind power plants. The methodology proposed by Simankov V.S. and Buchatskiy P.Y. allows us to evaluate the efficiency of involving renewable energy sources in the energy balance of the region. As part of this study, we are aimed at a narrower scope, since we are considering the feasibility of involving RES in activities of a particular enterprise. In that case calculation of a number of indicators, such as, for example, the amount of tax revenues to the budget of the region, the discounted social income of the region and others, are insignificant for this study.

Thus, in our opinion the most suitable methodology to evaluate the efficiency of the innovative-investment project on implementation and development of renewable energy sources, namely, solar and wind energy, is provided by M. Sysoeva, and it can be applied within the framework of the algorithm proposed by the authors.

We should note that when calculating such projects it is important to pay special attention to environmental and social assessment, which undoubtedly is their competitive advantage in light of the latest trends in the development of the global economy. We also believe that the digital transformation of both the international and the Russian economy will give a powerful impetus to the development of the renewable energy market.

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