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Insurance Programs in the Renewable Energy Sources Projects

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Abstract: The development of projects using renewable energy sources (RES) necessitates the development of insurance programs and systems. This involves identifying and assessing the risks of renewable energy projects in the transition to new types of energy, determining typical corporate and specific risks, the need and content of the main types, forms of insurance contracts, assessing the financial condition, and choosing insurance organizations and reinsurance programs. This article focuses on the formation of such insurance programs, their interaction with industrial safety systems and ensuring corporate participation in achieving sustainable development goals; as well as selection and assessment of the insurer financial stability and the insurance RES programs economic efficiency.

Keywords: insurance programs; renewable energy sources; formation of insurance RES programs; selection and assessment of the insurer financial stability

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1. Introduction

Energy is an integral part of the functioning of any economy in the world [1]. This is the basis for economic development from stimulating economic growth [2,3] to consumption levels [4] and innovation [5]. The optimal development of various types of energy is very important for the economy, and for the environment, and for the quality of life of people. The process of humanity's transition to alternative energy sources is a complex, not always optimal, often expensive path; modern systems at both the macro and micro levels demonstrate that the practice of renewable energy sources is already systematically present in the companies and organizations at all levels.

Changing energy sources fully meets the principles of sustainable development, when a compromise between the environment, the development of the economy and society is important [6]. There are various definitions of sustainable development. Sustainable development involves the harmonious use of resources, investment, technological progress and institutional development, that support the ability to meet human needs and aspirations [7,8]. A more common definition has been defined in the World Commission on Environment and Development's 1987 Brundtland report "Our Common Future" as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [9]. Energy security plays an important role in the process of sustainable development, a state in which all (or most) residents and enterprises in the state have access to sufficient energy resources at affordable prices, which for the foreseeable future are free from the risk of serious supply disruptions [10]. Energy security satisfies basic human needs, but how this is achieved determines whether sustainability principles are being satisfied.

Energy security in the scientific community is analyzed, among other things, from the point of view of ecology, infrastructure security, energy independence of countries and the efficiency of energy sources use, its role in the economy or the search for new energy technologies [11]. Changes in the energy sector are driven by new technologies, consumer environmental awareness and regulatory pressures. On the one hand, these are incentives for a low-emission economy; on the other, they bring restrictive environmental standards and the need to adapt to optimal technologies [12–14].

Energy is a sector that directly affects quality of life and economic growth. Environmental impact, air and water pollution, and waste generation can have negative consequences. In the article by Khovankov, J., Vavrek, R. [15] evaluates the influence of the energy growth factor and the production of greenhouse gases on the study of flow separation; the issue of using renewable energy sources in the EU countries is given great attention. The results of the analysis highlighted the sharing of energy resources and the sharing (measured in GDP) of greenhouse gas emissions. On the other hand, an increase in the volume of renewable energy sources in most countries with economic growth, where the demand for environmental protection is increasing, leads to a development characterized by both economic growth and improved environmental quality. The authors' analysis points to spatial randomness both within the EU and at the country level.

A separate group of studies is devoted to the risk assessment of innovative enterprises. For example, Pukala R., (2016), in the article "Use of neural networks in risk assessment and optimization of insurance cover in innovative enterprises, Engineering Management in Production and Services" [16], presents the results of a study on the use of artificial neural networks to quantify the risks associated with the activities of an innovative enterprise and to optimize its insurance coverage to minimize the likely financial losses when they materialize. The results of the simulation for a given set of variables (Kohonen's network, including activation of 51 input variables) made it possible to determine the probability of the threats. The results of the analysis made it possible to determine the optimal insurance coverage for an innovative company. The research results touched upon the theory of risk, entrepreneurship and insurance; the analytical apparatus was recommended as an auxiliary tool in corporate risk management.

We know of publications on risk management issues, including those related to renewable energy projects, in particular, the formation and methods of assessing the effectiveness of systems; the results of colleagues who investigated interconnected corporate insurance risks and their assessment of the insurance of innovative projects [17–32]. The study of Pukala R., Petrova, M. (2019) [33] is devoted to the possibility of using the AHP method in the process of making managerial decisions on the choice of sources of financing for innovations by mining enterprises. Companies operating in an unstable competitive market environment are looking for new tools and solutions to support and optimize their activities. The presented methodology is a tool for choosing sources of financing for an enterprise to increase competitiveness; in particular, supply agreements as the best method for financing innovations in mining companies.

Complex research by Kirillova, N.V. [34–38] was devoted to the formation, maintenance and development of corporate insurance systems and risk management in various sectors of the economy, including metallurgy, energy, and credit; in these works, special attention was paid to the identification of insurance risks, the requirements for insurers and the assessment of their ability to participate in insurance programs.

In the article by Pukala, R. and others [39], the issues of assessing projects of renewable energy sources and the results of the implementation of insurance programs in projects are compared with the indicators of a project without the use of insurance. Calculations of the assessment of the value of assets are given, provided that the individual risks of the project are insured. This work continues to research the need for and the possibility of developing corporate insurance systems in projects using renewable energy sources. However, while earlier we only considered and compared the possibility of using insurance in risk management of renewable energy projects, the purpose of this paper is to present the results of identifying specific insurance risks, the formation of typical approaches to the development of the complex corporate insurance systems, insurance programs content, and the choice of insurers in projects using renewable energy sources.

2. Materials and Methods

Consider the need, content and specifics of insurance programs for projects using renewable energy sources, if any.

The authors have carried out multiple comprehensive studies of corporate insurance systems, based, first of all, on corporate insurance systems of large metallurgical complexes, as well as on insurance systems of other industries:

- energy;
- oil and gas production and processing;
- telecommunication systems;
- credit systems; and
- insurance systems.

Based on the results of the data of many years of research and the practical experience of the authors, it is possible to draw proven well-grounded conclusions about the need to determine the content and development of insurance systems in the following aspects (Figure 1).

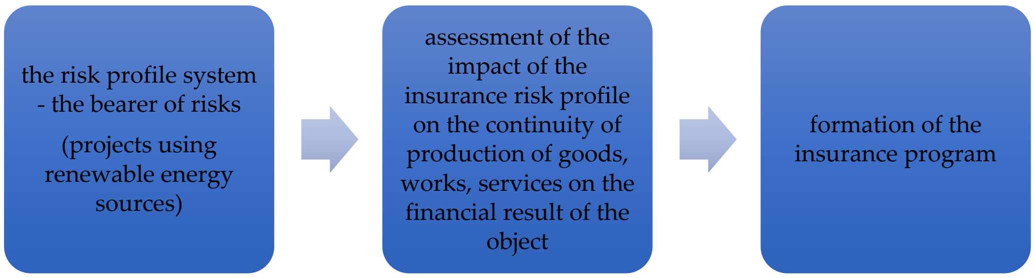

Figure 1. The content and development of insurance systems in the RES projects. Source: authors own design.

Formation of the risk profile of the facility/system—the bearer of risks—in our case, these are projects using renewable energy sources:

- identification of systemic and non-systemic risks of the consumer;
- identification and assessment of insurance risks; and
- assessment of the frequency, severity, spread of damage, and the possibility of cumulation of insurance risks.

The subject of risk management is the identification of risks and appropriate actions in relation to them, as well as the goal of ensuring maximum and lasting benefits from all activities of the enterprise. First of all, it is about understanding the potential positive and negative consequences of all factors that can affect the organization, and about taking measures to increase the likelihood of success and reduce the likelihood of failure and uncertainty regarding the achievement of the goals [16]. Moreover, empirical work has shown that risk management helps to stop the negative consequences of risk, since it helps smooth out the volatility of cash flows after risk (among many [17–19]).

In connection with constantly emerging new threats, as well as the complexity of business entities, the literature postulates integrated risk management, understood as risk management throughout the company [20,21].

Risk management is the identification, evaluation, and prioritization of risks (defined in ISO 31000 as the effect of uncertainty on objectives), followed by coordinated and economical application of resources to minimize, monitor, and control the probability or impact of unfortunate events [22], or to maximize the realization of opportunities.

In general, risk management is a process that begins with the identification and assessment of exposure to risk, followed by the selection of the most effective methods (strategies) of risk management [23]. Possible strategies include both methods of controlling physical risk (avoiding threats or reducing the likelihood or size of losses) and financial control (self-financing or transferring the consequences of risk realization to other organizations, including the insurer) [24].

Insurance companies constantly deal with various modifications of risk, and, as a result, they have to constantly check its size and the level of potential, often with very high losses. Taking into account the changing spectrum and scale of negative events in the functioning of modern enterprises, the determination of their insurability is of particular importance. Risk insurance can be viewed in two dimensions:

- the possibility of accepting the consequences of events on the part of the insurer; and
- ensuring the broadest possible protection of the policyholder/insured.

Establishing limits on coverage would give insurance companies room for growth. In turn, for the insured, this would show the limits of insurance coverage, which would highlight the risks, the consequences of which they are obliged to bear themselves.

In the case of renewable energy sources, we can identify key areas of risk that can be insured (Table 1).

Table 1. Areas of risk associated with the construction and operation of renewable energy sources.

№	Types of Risk	Risk Characteristic	Possibility (+) of Insurance
1	Build and test	Risk of property damage or the possible third-party liability arising during construction or the testing of new plants (insurance terminology).	(+)
2	Business and strategic	Risk affecting the viability of the business, such as the risk of technological obsolescence.	(−)
3	Ecological	Risk of environmental damage caused by the installation and liability arising from such damage.	(−)
4	Financial	The risk of insufficient access to capital.	(−)
5	Market	The risk of an increase in prices for goods and other resources or a decrease in the price of electricity sold.	(−) (+)
6	Operating	Risk of unplanned plant shutdown, for example due to unavailability of resources, plant damage or component failure, including cyber threats.	(+) (−)
7	Political/regulatory	Risk associated with changes in government policies, such as subsidy policies, that affect the profitability of the enterprise.	(−)
8	Weather	Risk of reduced electricity generation due to lack of wind or sunlight.	(−) (+)

Source: authors own design.

According to D. Mayers and C.W. Smith [40], the benefits of risk management, analyzed from an enterprise insurance perspective, can be viewed in three main areas:

- reducing the costs of bankruptcy;
- reduction of the tax burden; and
- positive impact on the company's investments by eliminating the problem of underinvestment.

In addition, based on the assumptions of the expected utility theory, as pointed out by K. Borch [41], insurance can be considered in the category of the equivalent of certainty. In this context, it should be emphasized that insurance, due to its effectiveness, low cost and possible additional benefits (for example, assistance or inclination, awareness of insurance coverage, to make non-standard business decisions), is the best method for transferring risks from an entrepreneur's point of view.

However, the mere fact that a business is using insurance coverage does not define the role of insurance in risk management in startups. In this case, it is very important to choose the right insurance products, taking into account the individual needs of the company. The key point in this regard should be the optimal choice of the scope of insurance coverage, aimed at obtaining tangible financial benefits for the company, which includes, among other things:

- increasing the possibility of raising capital;
- the possibility of increasing financial leverage;
- a decrease in the cost of capital;
- avoidance of expenses related to a temporary bad financial situation or bankruptcy;
- obtaining tax benefits; and
- ensuring the stability of funds allocated for the company's strategic investments.

The threats to renewable energy sources depend on the phase of the asset's life cycle, and insurance companies offer a range of products that can be used at different stages (Table 2).

Table 2. Examples of insurance products offered at different stages of life.

Life Phase	Examples of Insurance Products
Specifications, design, construction, testing, commissioning, revisions	• Construction All Risks (CAR)/Erection All Risks • Delay in Start Up (DSU)/Advance Loss of Profit (ALOP)
Operation—operation and maintenance	• Operating All Risks/Property Physical Damage • Machinery Breakdown (MB) • Business Interruption and machinery loss of profits (MLOP) • Operators Extra Expense • General/Third-Party Liability

Source: authors own design based on [35].

The study Vavrek, R. [42] presented multi-criteria methods identified as a suitable tool for a comprehensive assessment of a set of alternatives; a group of methods, including the Ideal Solution Similarity Ordering Preference (TOPSIS) technique, which, in practice, is often associated with the use of several subjective and objective methods to determine the weights of selected indicators. Differences are given between the results achieved using various methods for determining the weights of cost indicators; the choice of an adequate method of weighting indicators significantly affects the overall results of the TOPSIS method. The coefficient of variation method clearly identifies the subjects in significant positions; the method of average weight does not take into account the structure of the data and their variability, emphasizing the equality of all indicators. The results obtained using the standard deviation methods and the statistical variance procedure are comparable with the results obtained for the same weights of individual indicators; that is, the method of average weight. Therefore, based on the overall results of the study to determine the input weights for the purposes of the TOPSIS method, the authors recommend using the standard deviation method.

The authors analyzed the risks of OJSC Magnitogorsk Iron and Steel Works [43] in terms of frequency, damage, accidents; this base is combined with the base of expert assessments for the main and auxiliary industries (for example, experienced metallurgists know that the metal structures of the shop must not withstand the load and collapse, but there has not been such a case yet and there is no such case in the base). For the formation, a continuous survey (seven periods) of specialists and craftsmen was carried out (Figures 2–4).

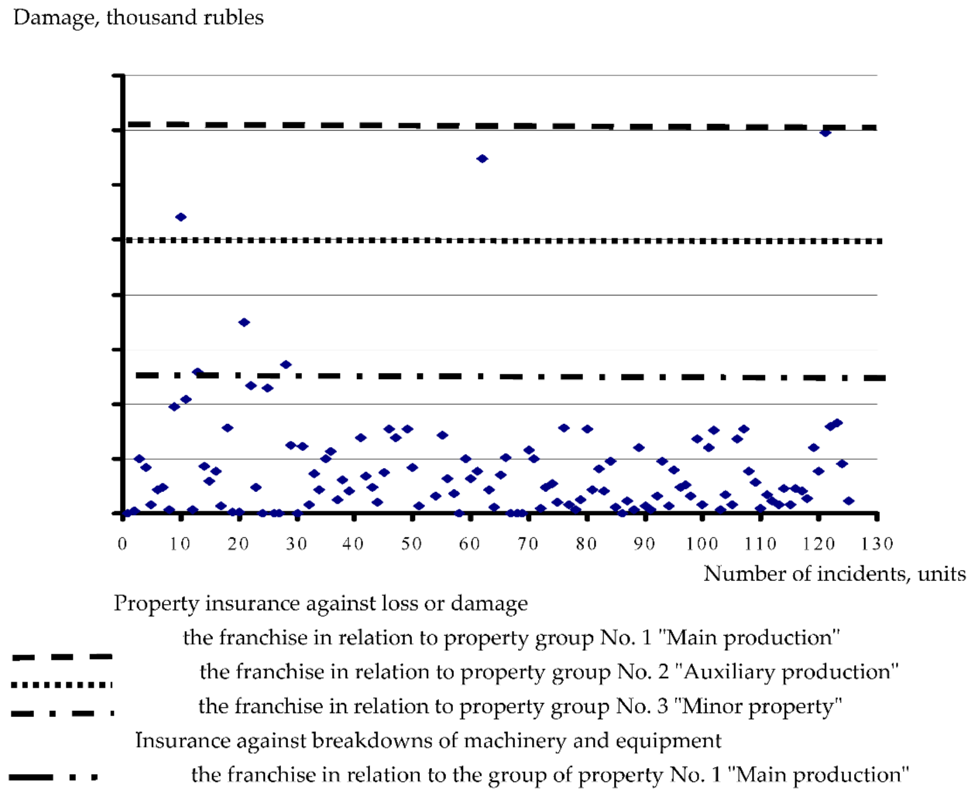

Figure 2. Damage (thousand rubles) depending on the number of incidents (units). Source: authors own design.

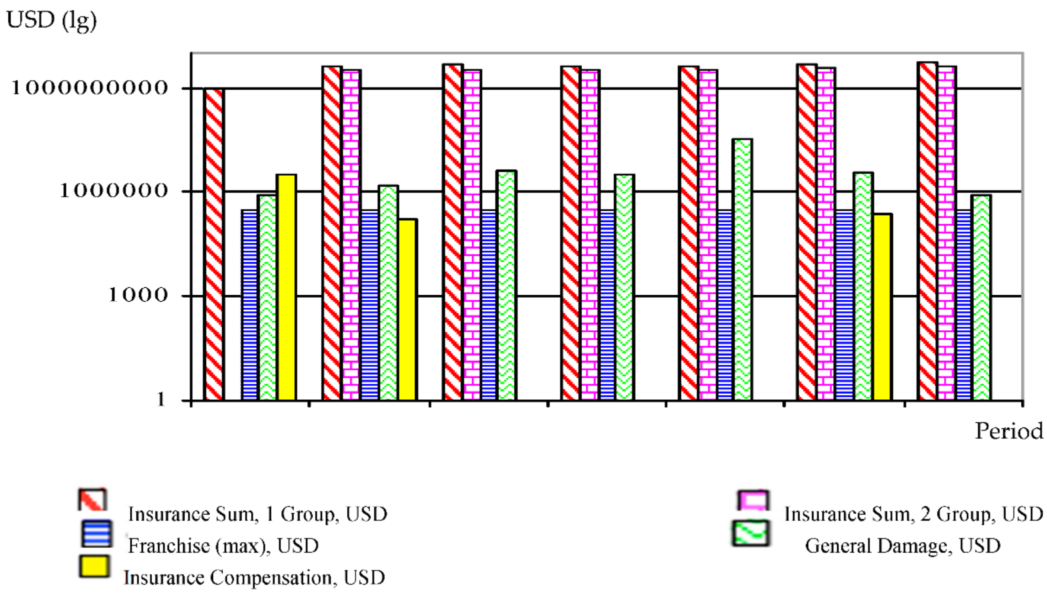

Figure 3. Insurance sum, franchises, insurance compensations and general damages, per year (logarithmic scale), thousand rubles. Source: authors own design.

The final stage of the differentiation mechanism is to determine the economic effect, differentiated by units, workshops, and technologies (depending on the values of the actually revealed maximum and total damage/forecast losses) by the following factors:

- franchises by property groups; and
- changes in insurance coverage, and changes in insurance and reinsurance coverage (in shares, by company).

The presented mechanism allows you to determine and differentiate the net cash flow for insurance, to identify the need and the possibility of changing insurance coverage with a change in deductibles and liability limits. In order to determine differentiated liability limits, depending on the level of operational risks, using the software, the databases of actual damages, expert assessments of the likelihood and severity of the consequences of the implementation of risks by units and workshops of divisions, the conditions of insurers, reinsurers of a clean energy project, and based on the methodology for identifying the financial condition, insurers determine the optimal levels of insurance coverage.

Assessment of the impact of the profile of insurance risks on the continuity of production of goods, works, and services, from the financial result of the object includes several mandatory stages, which are usually carried out sequentially for each technological process by risk management structures.

I. Distribution and assessment of impact by types of production of goods/works/services (for example, main and auxiliary production or lines).
II. Distribution and assessment of risk complexes, if possible, to compensate for damages by own funds (self-insurance).

Regardless of the life cycle of an RES organization, the availability of insurance products offered by insurance companies is diverse, and also depends on the type of energy source (Table 3). There is a clear advantage of well-available products for wind farms, where an increase in coverage and a decrease in insurance premiums are also observed in terms of insurance [44].

Table 3. Risks on the type of energy source.

Risk Categories	Construction All Risk	Resource Supply/Exploration	Property Damage	Machinery Breakdown	Business Interruption	Delay in Start Up/Advanced Loss of Profits	Defective Part/Technology Risk	Contractors Overall Risk	General Third-Party Liabilities
Wind (onshore)									
Wind (offshore)									
Solar PV				n/a					
Wave/tidal									
Geothermal									
Biogas									
Small Hydro				n/a					
Biomass									

Increasingly comprehensive and competitive cover
Broad cover
Partial cover–some gaps in cover, limited capacity, high premium/deductibles
Very limited cover—restrictive terms and conditions, many exclusion
No cover available from traditional insurance markets

Source: United Nations Environment Program, Financial Risk Management Instruments for Renewable Energy Projects [44].

This table confirms that non-systemic risks may be exposed to greater management, including through insurance methods; at the same time, risks external to organizations are also less manageable, including with the help of insurance.

III. Distribution and assessment of risk complexes according to the degree of impact on the continuity of production of goods/works/services.
IV. Distribution and assessment of risk complexes to assess the effectiveness of insurance programs (retro-assessment).
V. Distribution and assessment of risk complexes according to the degree of impact on the financial result.

Formation of the insurance program:

- formation of a complex of insurance risks based on the results of clause 2 "Assessment of the impact of the insurance risk profile on the continuity of production of goods, works, services; on the financial result of the object";
- determination of the insurance values of objects—carriers of risk (recovery, balance sheet, residual, market and the moment of the formation of the program);
- determination of values and their recognition as insurance for voluntary forms of insurance can be based on the ratio of indicators: insurance premium (depending on the insured amount, which, in turn, is based on the accepted insurance value)/insurance damage/insurance payments—an example of calculations;
- formation of a complex of insurance risks for compulsory types of insurance (OSAGO, civil liability in the operation of hazardous production facilities, certain types of professional liability depending on the specifics of production and technology).

The Allianz Risk Barometer 2019 annual survey of risk managers, brokers, insurance professionals and Allianz experts identified the top five business risks for the renewables energy sector (Table 4) [45].

Table 4. Top 5 risks in renewable energy.

Rank	Risk	2018 Rank	Trend
1	Business interruption (incl. supply chain disruption)	2	Up
2	Natural catastrophes (e.g., storm, flood, earthquake)	1	Down
3	Changes in legislation and regulation (e.g., trade wars and tariffs, economic sanctions, protectionism, Brexit, Euro-zone disintegration)	3	=
4	Cyber incidents (e.g., cybercrime, IT failure/outage, data breaches, fines and penalties)	4	=
5	New technologies (e.g., impact of increasing interconnectivity, nanotechnology, artificial intelligence, 3D printing, autonomous vehicles, blockchain)	New	Up

Source: Allianz Risk Barometer 2019. Allianz Global Corporate & Specialty [44].

This approach can be applied both in the systems of the metallurgical industries (which have been investigated), and in other systems [45].

VI. Budgeting of insurance by compulsory types (by cost, type, production).
VII. Calculation of the effectiveness of insurance contracts (taking into account unrealized insurance risks); budgeting of a comprehensive insurance.
VIII. Formation of technical specifications and announcement of a competition for insurers.
IX. Holding a competition for insurers (including reinsurance programs); choice of insurance program strategies (with and without reinsurance levels, only direct insurance), for example, based on the results of stochastic modeling using software Risk Explorer Solutions [46], comparison of the expected profit, when the insurance premium rate is changing for different situations (with an excess of loss and proportional) (Figure 4).

Risk Explorer Solutions software is based on stochastic modelling, currently used primarily by insurers; it is supposed to justify the need for its use for policyholders (the results will be presented in a separate work).

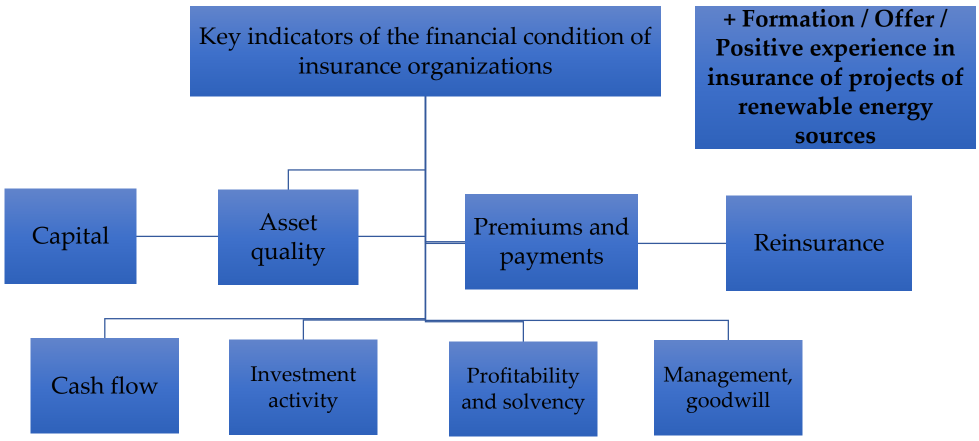

Figure 4. The key indicators of the financial condition insurance organizations—participants of the insurance program for renewable energy sources. Source: authors own design.

X. Assessment of insurers—participants of insurance programs by key indicators (including insurance brokers and reinsurers)—and work and assessment key financial indicators.

3. Results

Insurance can play an important role in supporting investment in renewable energy projects by giving financial protection from delays or damage during the fabrication, transport, construction, and operational stages of a renewable energy project—whether for technical reasons, human error, or the forces of nature. However, in order to bear risk in return for a premium, an insurer must have sufficient information to be able to estimate, with a sufficient degree of accuracy, the likelihood and severity of losses from the insured events. Most renewable energy projects do not have the required statistical data for measuring probability distributions and correlations between random loss events. Wind energy projects are the technology with which the insurance industry has most experience and capacity to respond at present. However, a standard insurance product for most renewable energy projects have underwriting restrictions. Typically, insurance is arranged on a case-by-case basis and normally entails comparatively higher prices and restrictive terms and conditions, including partial or limited cover.

The main new results of this study are the identification of the main processes for the formation of insurance programs for clean energy sources, including the determination of coverage limits and franchises, depending on the complexes of identified insurance risks, the significance of technology for the continuity of processes, empirical and expert data, and the specifics of risk profiles of projects using clean sources energy.

As a result, we received formalized business processes for risk assessment, identification of insurance risks with the specifics of renewable energy projects, and terms of reference for insurance organizations with a certain budget for insurance in the context of technological lines, production facilities, compulsory and voluntary forms, and types of insurance. In accordance with the received terms of reference, it is necessary to announce a competition among insurers to participate in the insurance program under the specified conditions.

The study presents the formalization of the implementation of insurance programs in the technological and organizational structures of a metallurgical holding (Russia), taking into account the possible specifics of clean energy projects. Typical stages of risk identification and assessment, identification of risk concentration zones, their impact on the continuity of technological processes and financial results, and typical approaches to the formation of insurance programs allow the application of the proposed procedures in most clean energy projects. The selection of insurers for such programs, determination of their financial condition and the required insurance capital for participation in such programs will be presented in a separate publication.

4. Discussion

The results obtained can be used by large corporate structures implementing projects with renewable energy sources; for example, the fuel and energy complex now developing in Russia [47]. However, this does not exclude the adaptation of the developed approach to single projects of medium and small businesses; for example, the construction and operation of small biomass power plants, wind and solar facilities, and small hydroelectric power plants. Such projects are being implemented with more or less success in Russia, despite the presence of large, developed energy systems that also develop the infrastructure of renewable energy sources.

This is a definite challenge for the insurance market, where there is no special complex programs for projects of renewable energy sources and single insurance products are still offered. Single insurance products include the so-called "box" products with a minimum standard set of risks that are suitable for a large number of policyholders and do not take into account the specifics of complex technologies and organizations.

The results obtained are applicable in the implementation of the objectives of the integrated risk management system, approved by the standards in the field of risk management of renewable energy projects:

- assessing the risk of default by insurance companies—counterparties in documentary and programmatic terms;
- calculating the aggregate limit of own retention of each insurance company, depending on the risk indicator of this insurance company in documentary and programmatic terms;
- determining differentiated franchises depending on the level of production risk in documentary and programmatic terms;
- determining differentiated limits of liability depending on the level of industrial risk in documentary and programmatic terms;
- determining a differentiated set of risks for various types of property and property rights in documentary terms; and
- determining the insurable value for various types of property in documentary terms.

In insurance programs for renewable energy projects, along with classic insurance products, special attention should be paid to the identification, assessment and insurance of little-studied, specific risks in the types of insurance of construction and installation risks, environmental risks, liability risks, and continuity of production processes (power supply).

In the development of renewable energy insurance programs, it is important to integrate and interact with emergency response programs (industrial safety), sustainable development goals, budgeting, and preventive programs of insurers (ecosystems). Preventive measures by insurers are usually aimed at reducing the unprofitableness of insured amounts, when improving the safety of facilities reduces the frequency of risks (financed by insurers).

5. Conclusions

Renewable energy projects are developing at the macro and micro levels, and almost all large companies have structural divisions and projects (solar, wind and hydropower stations in energy holdings, the use of biomass for energy generation in agricultural holdings, etc.). On the other hand, insurance programs are already widely used by corporate insurers, including in the energy sector (with a significant remark—this practice is not yet as well adapted for medium and small businesses as it is for large holdings). The insurance market, insurance types, forms and products are mature enough to offer all the coverage options needed. The third aspect of the necessary interaction is the possibility and validity of embedding such insurance systems into technological systems to achieve the goals of sustainable development of enterprises and economies. However, so far, insurance and technological aspects interact quite spontaneously; for the formation of effective insurance systems for renewable energy, it is necessary to formalize the regulatory and financial bases for assessing the risks of renewable energy projects with the definition of their specific risks, and formation and development of insurance programs of projects.

In the development of corporate risk management systems, it is necessary to take into account the strategic direction of the insurance market; for example, in Russia, the voluntary form of insurance dominates. At the same time, it is the projects of renewable energy sources that almost always contain elements and structures that fall under the compulsory insurance of hazardous production facilities. Identifying the optimal ratio of compulsory and voluntary types of insurance in insurance projects of renewable energy sources, as well as justifying the use of certain stochastic models to calculate the required capital of insurers for such projects (for example, with the Risk Explorer Solutions software), will be the subject of the next work.

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