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MANAGEMENT OF INVESTMENTS IN THE RENEWABLE ENERGY SECTOR OF THE REPUBLIC OF MOLDOVA

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CONCEPTUAL FRAMEWORK OF THE RESEARCH STUDY

The topicality and importance of the reseaerch. The overlapping of the current pandemic, economic, and energy crises is leading to a profound investment recession that will result in a decade of transformation for international production. In the context of the socio-technological transition towards new economic cycles and the need to adapt to and combat climate change, the urgency of debating the efficiency of political-economic models for managing investments oriented towards the renewable energy sector is evident, arising from numerous angles of analysis of circular economy concepts as well as sustainable development. The growth of economies and the improvement of social development levels are based on investment processes that entail innovation, technological advancement, and digitalization [42]. The efficient management of investments oriented towards renewable energy sources (RES) is attracting increasing attention among academic communities, managers, and policymakers, especially due to attempts to readdress modern economic operating models, integrate sustainable development concepts into countries' economic development cycles, and adopt innovative approaches to market failures.

In the Republic of Moldova, the RES energy sector represents an immature and underdeveloped market within the national energy system, indicating that the sector holds significant potential for growth and attracting foreign direct investments. In 2020, the renewable energy segment in the Republic of Moldova held a share of around 30% (equivalent to 877 thousand toe) of total energy supplies, or 24.3% (equivalent to 694 thousand toe) of the total final energy consumption. More than 98% of the renewable energy segment is represented by solid biofuels used in rural residential sectors for heating, which is a clear indicator of the immaturity of the sector. However, in recent years, there has been significant development in the sector considering that the Republic of Moldova was granted the candidate country status for EU accession, higher levels of funding from the international organizations, more assertive government promotion, and private sector commitment. This indicates that the market is ready to direct its investments towards the renewable energy sector. Thus, the comprehensive research of theoretical and practical aspects aimed at improving the management models of investments in the renewable energy sector of the Republic of Moldova, as well as identifying existing bottlenecks and substantiating the priority directions for their modernization, acquires national strategic importance. Similarly, aligning with international development trends by identifying the mechanisms and policy instruments capable of improving the operational and development frameworks of the renewable energy sector in the Republic of Moldova could generate new models for managing investments in this sector.

The theoretical and methodological basis of the research: The research was based on well-known scientific works of foreign economists such as: Turner G., Joskow P.L., Roots S., Wiltshire M., Sterman, J. D., Meier P., Vagliasindi M., Imran M., Meyer N.I., Komendantova N., etc. Additionally, the author also referred to the works of

Romanian economists such as Atănăsoaie P., Zmeureanu R., Pătraşcu, R., Răducanu C., and Dumitrescu, I.S., as well as Russian economists such as Maximova V.F., Goncearenco L.P., Oleinicov E.A., Berezin V.V., Kalinnikova E.V., etc., and local economists such as Stratan A., Hîncu R., Cobzari L., Bajura T., Botnari N., Albu S., Timuș A., Ungur C., Grosu V., and others, for a comprehensive overview of the existing literature in the field. For sector evaluations, the author consulted the national strategies: "The Energy Strategy of the Republic of Moldova until 2030" and "The National Development Strategy of the Republic of Moldova until 2030," which outline the targets, development paths, and development plans for planned actions. The author also relied on additional informational support from legislative and normative acts in the field of renewable energy, reports and publications of the National Bureau of Statistics (NBS), as well as methodological studies elaborated by the World Bank (WB), the European Commission, the International Energy Agency (IEA), the International Renewable Energy Agency (IRENA), the United Nations Conference on Trade and Development (UNCTAD), the Intergovernmental Panel on Climate Change (IPCC), etc.

The purpose of this research study is to conduct a comprehensive and in-depth investigation of theoretical and practical aspects, as well as management methods of investments in the renewable energy sector. This aims to outline the main risks and advantages, substantiate the priority directions for modernizing the management of investments in renewable energy in the Republic of Moldova, aligned with the international development trends. To achieve the proposed goal, the following **research objectives** have been outlined:

- researching and completing the conceptual and methodological framework for managing investments in the field of renewable energy and identifying its particularities;
- analyzing the experience of European countries in managing investments from renewable sources and identifying best practices relevant to the Republic of Moldova;
- researching the risks underlying the investment decision-making system to implement management models in renewable energy adapted to the country's socio-economic context;
- identifying and applying a system of indicators that determine and evaluate the investment management of renewable energy markets;
- proposing suggestions for the development of the legislative and normative framework of the Republic of Moldova and adopting modern market management tactics to facilitate the large-scale integration of RES generations.

The important scientific problem addressed: the argumentation of the theoretical and methodological framework of investment management in the renewable energy sector that allowed for the identification of mechanisms, economic and socio-technological factors determining the sector's development directions, and the expected economic outcomes from attracted investments.

The research hypothesis: The investment management of the renewable energy sector is determined by the functionality of the mechanisms operating with investments, the risk profile, and the applied models. Thus, by adapting these to the economic context and the energy market profile of the country, a better absorption and management of potential investments oriented towards the RES energy sector of the Republic of Moldova will be conditioned.

Methods of research: to achieve the proposed objectives within the research, complex and systemic research techniques were applied, involving a variety of instruments and scientific research methods: *the method of observation and analysis* was used to study the stages of strategic management and the main aspects of market forecasting management; *the method of induction, deduction, and synthesis* allowed for the identification of interconnections between the phenomena under investigation; *the historical method* was used to study the stages of development of the energy sector as well as the field of investment management knowledge; *the graphical method* was used to present data in the form of figures and graphs; *quantitative and qualitative analysis methods* were applied to analyze the market indicators in the renewable energy sector; *the SWOT analysis method* was used to identify the strengths and weaknesses in the path of investments and the risks associated with the development of renewable energy sources in the Republic of Moldova; *the method of heuristic extrapolation of statistical data* was used, allowing for the prediction of the evolution of demand indicators for energy based on the analysis of the previous periods.

The scientific research includes the following elements of **scientific novelty and originality**:

- the development of the theoretical and methodological basis of investment management in the field of renewables by systematizing economic concepts of investments, investment management, and strategic management specific to renewable markets;
- the substantiation of a new conceptual interpretation for renewable energy management in line with new directions for promoting investments in this segment;
- the elaboration of a risk profile for energy markets based on renewable sources through the analysis of best practices from other countries, the study of socio-economic and technological trends, and the national policy framework;
- the elaboration of a system of benchmark factors determining energy demand forecasts, systematized for short, medium, and long term based on European practices;
- the configuration of the potential structure of the renewable energy segment in the Republic of Moldova through economic, institutional, and policy diagnostics in the field based on relevant indicators that can be used to analyze and monitor investment management in the renewable energy sector under the conditions of the domestic market;

- the elaboration of an integrated decision-making model for information and the development of the regulatory framework for promoting investments in renewable energy;
- the development of recommendations for improving the management of investments in renewable energy in the Republic of Moldova by forecasting the evolution of energy demand and energy intensity levels for some sectors, including proposals for adjusting the regulatory framework in the field.

Approval of the scientific results. The theoretical and methodological approaches in the work have been presented in ten scientific articles published in peer-reviewed and indexed scientific journals in both the Republic of Moldova and abroad. They were also disseminated at international conferences organized within the National Institute for Economic Research; the Center for Financial and Monetary Research "Victor Slăvescu", the Romanian Academy, Bucharest; the Institute of Economic and Social Research "Gh. Zane" from Iași, Romania, and published in reviewed collections of papers. The theoretical studies and results of the thesis were presented in six reports and approved by the World Federation of Scientists.

Keywords: economic growth, investment management, renewable energy, sectoral policies, investment risks, foreign direct investment.

CONTENT OF THE THESIS

The Chapter I "Theoretical foundations of investment management in the renewable energy sector" contains a systematization of theories and concepts, as well as existing methodological approaches in the literature, that highlights the topicality of the thesis and the particularities of investment management models in the renewable energy sector. The author analyzes the main stages of evolution of management and investment management concepts, as well as those of energy systems on the other hand.

The most severe economic recessions that have influenced global economic development rhythms have been based on crises in energy markets. An example in this regard is the energy crisis in 2022, which resulted in a significant inflation increase in most European countries. Thus, the challenges of the COVID-19 pandemic and the effects of the economic-energy crisis have prompted governments, businesses, and the population to urgently adjust their economic profile, businesses, and behavior to the sustainable development model, instituting policies and instruments that facilitate the transition to a green economy. To achieve uninterrupted sustainable economic development, economies (including the Republic of Moldova) require a favorable climate for advancement that supports the development of renewable energy markets, reduces technological costs, and attracts investments (especially foreign direct investments) aligned with the needs of energy transition. We also mention the need for efforts to improve the energy efficiency levels of the economy (by reducing energy demand and increasing energy efficiency of final consumption, including making structural changes to economies) as well as energy intensity. The analysis of the situation

in the thesis field has allowed us to formulate the following elements of the scientific approach:

- The major importance attributed to investments is determined by their undeniable contribution to economic growth, social prosperity, and technological progress.
- The last 30 years have witnessed a fundamental transition in the approach to investment management oriented towards industries based on production infrastructure (including renewable energy production).
- The fragmented theoretical, methodological, and practical treatment of investment management in renewable energy imposes several barriers and risks in strengthening and developing the field.
- Renewable energy sources have demonstrated the most consistent and stable dynamics of development in the energy sector during the pandemic shock, amplifying their role in the global decarbonization journey of economies as well as the role that the sector could play in providing jobs for a rapid economic recovery.
- At the core of economic processes, and especially in energy-intensive industries, are considered the costs of energy production, reflecting the availability and access to energy resources at the national and regional levels, the distance from energy supply markets, the costs of transporting imported energy, the levels of energy intensity of the national economy, the national energy logistics system and infrastructure, the balance between energy supply and demand levels, the types of contracts used in the energy market, etc.
- The practice of developing the RES segment in the EU has applied the liberalization of the energy market by excluding monopolies and encouraging competition and competitiveness, which has attracted larger volumes of investment from the private sector and the development of RES technologies.
- With the introduction of regulations that reward economies of scale and the removal of market entry barriers, investment behavior has made a significant leap reflected in technological transitions with impressive dynamics and much more pronounced competition. This confirms that the investment rate of companies aligns with the economic and financial regulatory regime of the renewable market.
- The developments of energy markets and the modern delineation of their subsectors have conditioned the deepening of studies and research that aim to develop investment management models in the energy sector that would respond to the problems of socio-technological transition of energy markets (transitional management) through **planning, optimization, and development of energy markets.**
- Renewable energy investment management tends towards continuous adaptation to market conditions and capitalizes on the basis of socio-technological transitions in the energy sector. Thus, an evolution of renewable energy investment management tactics is outlined, stemming from socio-technological transitions that lead to large-scale transformations when market penetration barriers are overcome and innovative niches

are supported politically and technologically. Eventually, a chain of developments is achieved that requires political interventions capable of maintaining the industry's growth trend; otherwise, only incremental transformations of the sector can be advanced.

- The application of management models and mechanisms requires a thorough and adequate approach to the economic and sectoral context to attract investments in the renewable energy sector, consolidate the sector by diversifying the energy supply sources of the Republic of Moldova, ensuring an appropriate methodological and policy framework in this respect.

Investment management aligns with the concept of strategic management as it involves the component of adapting to market conditions to maximize competitive advantages. According to the definition proposed by the American economist Frank J. Fabozzi, *investment management* is a process of "managing monetary resources", which refers specifically to the management of financial investments, including the strategy and tactics of managing a portfolio of financial instruments [10, p.1]. In Lucia Gujuman's approach, investment management is "a creative process of managing resources, coordinating activities and organizational processes to control and direct investments towards achieving planned objectives" [14, p.18]. The approach to real investments through project management that emerged in the middle of the 20th century strengthens the existing theories of investment management, consolidating the directions that explain **the management of investment costs, the cost-benefit relationship, and the profitability-risk relational models, forming a solid theory in the field of investment management** [22]. Thus, the author proposed the following adapted definition of investment management oriented towards energy markets:

Investment management in energy markets is a set of interconnected and co-integrated processes, models, and tools used for the development, implementation, and continuous adaptation of systemic energy policies and strategies that meet the directives for environmental protection, energy efficiency, and security issued by international and national organizations.

To efficiently attract investments on RES market segments requires identifying an effective and achievable market development policy and going through the stages of identifying existing bottleneks at the level of various local, regional, and national contexts (see Figure 1.1.). In the context of investment management oriented towards energy markets, balanced policy decisions must go through the stages of information to identify the factors that need to be attracted in adapting the regulatory frameworks of the RES sector.

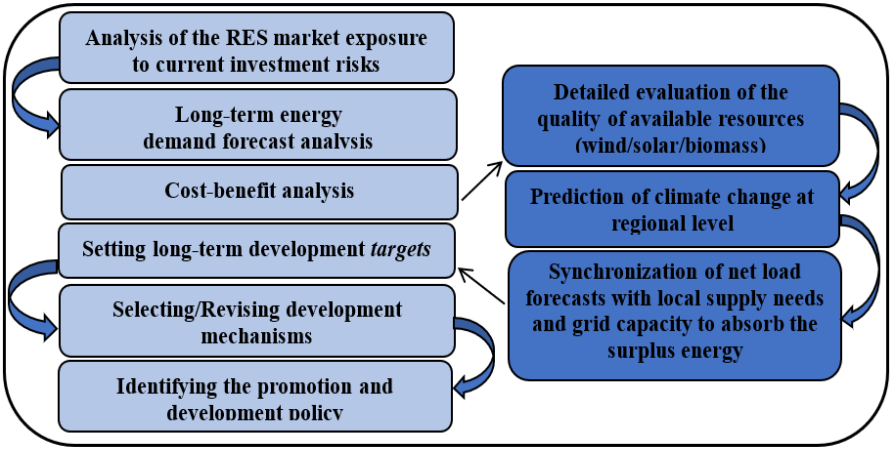

Figure 1.1. Model for identifying the promotion and development policy of the RES market

Source: realized by the author

A cost-benefit analysis as well as investment risk assessment are crucial in the strategic information for future regulatory frameworks [25]. While in the context of the continuous growth of global energy demand, it becomes imperative to include long-term energy demand forecasting

In **Chapter II** of the thesis, **"Methodological and management toolkit for RES integration into the energy markets",** the author presents a comprehensive analysis of international policies and practices to support and promote investments in RES markets. The review of international best practices aims to identify optimal policy mixes for adapting developments models to the context of the national economy. In this section, the risks affecting the development of RES markets have been systematized. The author has also identified and systematized the models for managing the RES market using the energy supply-demand analysis, and energy planning and forecasting methods.

In the pressing conditions of the socio-technological transition, large-scale development of renewables requires a diversified targeting of investors, including corporate entities (e.g. electricity distributors), financial institutions (e.g. pension funds, insurance companies, international financial institutions, etc.), and small-scale investors (households), leading to a diversification of cognitive barriers among investors. Directive 2009/28/EC of the EU mentions that a "support scheme" is any instrument or mechanism that promotes the use of energy from renewable sources by reducing the costs of producing a certain type of energy, increasing the price at which it can be traded, or increasing the volume of this type of energy procured. Therefore, the totality of innovative **mechanisms and instruments** currently operating in the RES energy

markets, grouped in different combinations, form different development climates for renewable energy markets (see Figure 1.2.).

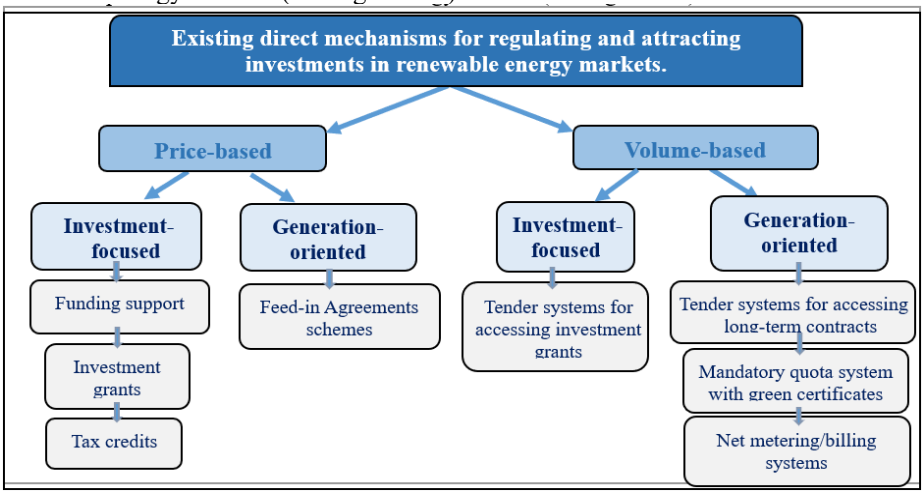

Figure 1.2. Direct regulatory mechanisms for managing RES investments
Source: realized by the author based on the classification of Haas R., et al. [15, pp.1012]

By applying direct regulatory mechanisms in various combinations, policies promoting renewables are outlined, which can catalyze the transition processes towards modern smart portfolios and, respectively, towards circular economies. Promoting renewables through regulatory mechanisms involves the direct or indirect involvement of the state in the socio-technological transition management of the energy sector, based on setting ambitious long-term and short-term energy targets. Direct state involvement targets the rapid and immediate promotion of smart energy, while indirect state involvement ensures consistent climates for the long-term strategic maintenance and development of green energy.

After a thorough review of the multitude of instruments and mechanisms for managing the energy sector, particularly RES, the author concluded that the Feed in Premiums (FIP)-variable mechanism is a price-based mechanism oriented towards generation. It represents an innovative result of experimenting with policy approaches applied to the RES sector, which can lead to the industrialization of this segment and, at the same time, address the climate stability objectives of modern economies. Efficient socio-technological transition management of renewable markets requires both the public and private sectors to identify and manage the **risks** involved in the investment process. As a result, a market risk profile will translate into certain market profitability levels, which, depending on the perceptions and types of investors engaged in this market, will shape the investment attractiveness of the RES market. Consequently,

market portfolios and certain levels of investment in renewable energy will develop. Following an in-depth analysis of the risks facing RES markets, *seven main categories of risk that disrupt investment flows into these markets have been identified:*

1. **Financial risks of RES markets** [20], [18]
2. **Regulatory risks of RES policies** [36]
3. **RES market risks** [13], [19]
4. **Technological and operational risks specific to the RES market** [32], [27]
5. **Social acceptance risks** [11], [32]
6. **Environmental risks associated with RES markets** [17], [30] [26]
7. **Country risks** [12]

In seeking an even-handed approach to eliminating the risks of integrating RES technologies into modern energy systems, it is essential to address the entire system of modern instruments and technologies used in these markets, starting from the idea of periodically redesigning the policies imposed: "special attention should be paid when an instrument should be replaced with another and when a technology should be abandoned" [7]. At the microeconomic level, a good practice for managing risks among managers is to diversify portfolios of RES activities with positively correlated assets and establish portfolio management. Evaluating incentives and risk reduction tools requires careful analysis of their effectiveness, taking into account the limited experience in transferring and managing risks from smart energy markets and conceptualizing "an approach that monitors the interaction between financing and regulatory elements at different stages of the value chain" [43]. Currently, a wide range of risks threatening RES markets are absorbed by insurance markets, while other risks influencing large-scale RES projects are absorbed by international financing institutions engaged in mobilizing private capital towards renewable investments. The Table 1.1. classifies the investment risks operating on the RES markets and their management during operational processes.

Table 1.1. Risk Matrix according to the management model

No.	Transferable Risks	Controllable Risks	Pertinent Risks
1.	Country risks	Social acceptance risks	Environmental risks
2.	Market partnership risks	Refinancing risks	
3.	Market policy failure risks	Capital shortfall risks	
4.	Transaction delay/disruption	Risks of moral wear	
5.	Risks of sudden policy changes	Non-dispatchability risks	
6.	Monetary risks	Price volatility risks	
7.	Currency risks	Liquidity management risks	
8.	Manufacturing, transport and construction risks	Risks of excessive energy demand	
9.		Risks of excessive energy supply	

Source: realized by the author

The risks present in the RES market are largely manageable and transferable through innovative management methods, facilitating market development from niche

to pre-commercial stages, and subsequently to large-scale commercial diffusion. There are risks that can be easily absorbed from RES markets through insurance markets and national public institutions, while other risks can be addressed through innovative management maneuvers depending on technological specifics. The major problem in reducing risks associated with the renewable energy market is the lack of insurance products, which manifests as an under-stimulation of the insurance market to generate products adapted to the needs of the RES market [40]. Despite the significant reduction in investment costs in RES markets, project financial costs (capital costs and debt costs) continue to be a significant barrier in terms of initial allocations for large-scale projects. While a financial incentive can be effective in reducing financial costs, it may be politically inaccessible due to the involvement of unjustified public expenditures. The issue of high initial costs and capital shortfall risks can be addressed through direct and indirect public intervention incentives, such as capital subsidies, grants, investment tax credits, and loans. In developing countries, RES markets can benefit from the opportunity of engaging in concessional loans for RES projects from public financing institutions, which involves reducing interest rates or extending loan terms. However, project developers can also involve hybrid structures that combine two financial instruments to improve risk transfer and reduction. Partial loan guarantees provided by international development banks could provide local banks with the reliability they need to issue loans requested by RES markets.

The greatest constraints in forecasting energy/electricity demand include not only the availability and cost of available fuel sources, according to classical models, but also evaluations of regulations, limitations of networks and power generators, market purchasing power, changes in demand structure, technological progress, and, most importantly, the environment. The specialized literature is generous regarding case studies that investigate the investment models of RES portfolios implemented in different regions of the world. (Schwerhoff G., and Sy M. [39], Schinko T. and Komendantova N., [38]; Abdullahi D., Suresh S., Renukappa S. and Oloke D., [1]; Movilla S., Miguel L.J. and Blázquez L.F., [29]), or for different renewable energy technologies (from English: renewable energy technologies - RET) (A. Shaktawat A. and Vadhera S., [41] (hydroelectric); Schiera D.S., Minuto F.D. , Bottaccioli L., Borchiellini R. and Lanzini A., [37], Campoccia A., Dusonchet L., Telaretti E. and Zizzo G., [5] (photovoltaic); Qiu D., Dinçer H., Yüksel S., Ubay G.G., [34] (wind)). There is also a series of research papers that assess the major barriers to large-scale investments in RES and associated risk management practices (Egli F., 2020; Kitzing L., [9], Liu X. and Zeng M., [24]; Nasalciuc I. [31]), that can be used to plan policy adjustments. At the same time, there are very limited studies evaluating and applying different investment management models in RES power plants at the macro level (Lee A.H., Kang H.Y. and Huang, T.T., [23]), investment planning (Cohen J.J, Azarova V., Kollmann A., Reichl J., [6]) and environmental planning (Dato P., [8]). These gaps can be addressed by selecting and adapting models to the energy sector, considering the expected effects, energy

market profile/design, portfolio of managed energy sources, economic structure, and socio-economic situation. For an in-depth study on the management of integrating RES into the national energy portfolio, I reviewed the specialized literature (Kleinpeter M., [21], Prasad R.D., Bansal R.C., Raturi A., [33]) which determines and identifies **the investment management models in the energy sector.** These can be used to identify and design the resources needed to implement various state policies in the sector, to substantiate and plan investment attraction, as well as to identify scenarios for the development of the national energy portfolio in order to efficiently balance energy demand and supply at different stages of energy transitions. At the same time, the use of these models can define and substantiate the establishment of policies aimed at promoting energy transition. The author proposes the following classification of investment management models focused on the transition to integrating RES:

I. Models for analyzing and forecasting energy demand

II. Models for energy supply planning

III. Energy optimization models

IV. Models for reducing greenhouse gas emissions

The paper analyzes energy demand analysis and forecasting models to provide qualitative findings that would inform the development of RES market development policies and identify national-level development targets, as the transition to circular economies and portfolios based on renewable sources occurs in the context of identifying technical and feasible opportunities for integrating green energies. The literature encompasses a variety of energy market management models using methods of energy supply-demand analysis, energy planning, and forecasting. In the context of initiating the analysis of demand management models for energy, it is important to mention that these models are primarily based on observing historical demand trends, taking into account the rate of demand growth, demand elasticity, and energy intensity.

Rate of demand growth – indicator that measures the growth rate of energy demand either from one year to another or from one period to another. Therefore:

$$\mathbf{a = (E_t{+}1 - E_t)/E_t} \qquad \textbf{(2.1)}\ [35]$$

where: a – annual increase in demand; $Et+1$ – energy consumption in year $t+1$; and E_t – energy demand in year t. And:

$$\mathbf{E_{T1} = E_{T0}\,(1 + a_g)\,(T_1 - T_0)} \qquad \textbf{(2.2)}$$

$$\mathbf{a_g} = \left(\frac{E_{T1}}{E_{T0}}\right)^{1/(T_1 - T_0)} - 1 \qquad \textbf{(2.3)}$$

where: E_{T1} – demand for energy in the period $T1$; E_{T0} – demand for power in T_0 period; a_g – annual growth rate.

Elasticity of demand – indicator that measures the variation of demand (in %) under conditions where the determining variable changes by 1%. In economic analysis, the variables of elasticity most often used are - economic activity (GDP), price and income. The demand elasticity indicator can be measured by using the correlation of the

annual growth rate of energy consumption and the determining variable or through the lens of econometric correlations related to time series data.

$$\mathbf{e_t} = \frac{\Delta^{EC_t}/_{EC_t}}{\Delta^{I_t}/_{I_t}} \qquad \textbf{(2.4)} \quad [35]$$

where: t – is a given period of time; EC – energy consumption; I – the determining variable of energy consumption such as GDP, value added, price, income, etc.; and Δ – the change of the variable.

Usually, GDP growth shows a positive correlation with the increase in demand for energy, i.e. in a situation where the growth of GDP is greater than 1% the demand is elastic in relation to the gross domestic production and in a situation where the elasticity is $0<e_{PIB}<1$, the demand is considered inelastic.

Energy Intensity – a descriptive indicator that describes the trends in the evolution of energy efficiency from a macroeconomic perspective (measures the amount of energy required (aggregated or disaggregate) per unit of economic production).

$$\mathbf{IE_t} = \frac{\sum_{i=1}^{n} E_{it}}{I_t} \qquad \textbf{(2.5)} \quad [35]$$

where: E_{it} - energy consumption for each type of energy in year t

The energy intensity indicator characterizes the economic efficiency of the use of primary/final energy and to a limited extent the technical efficiency. Usually experts in the field, representatives of public opinion, etc. debate the subject of energy intensity considering that its values are unquestionable truths. According to IEA data from 2022 [16], in recent years the rate of the energy intensity improvement of world economies has reached about 1.2% while in 2021 recorded less than half of the 2020 average because of the COVID-19 pandemic crisis.

Energy transition processes are directly depending on market saturation levels at certain stages and quantitative forecasts of long-term energy demand. The integration of RET technologies in energy portfolios adaptation to future market needs is based on forecasts of long- and medium-term energy demand. Forecasts of long- and medium-term energy demand depend on a number of factors that need to be considered by the market players and operators. Below the author proposes a systematization of these factors, (see Figure 1.3. and 1.4.) considering that they influence the results of evaluations in a different way. Figure 1.3. evaluates the vulnerability of the energy market to scheduled transitions as well as to factors that can interfere spontaneously, requiring deep processes of evaluation for a realistic planning of future energy supplies. Thus, in the long term, the market will react to strategic decisions of transformation or transition of the country's energy portfolio. Depending on how the researched market factors manifest, the dynamics in the energy market will present differently.

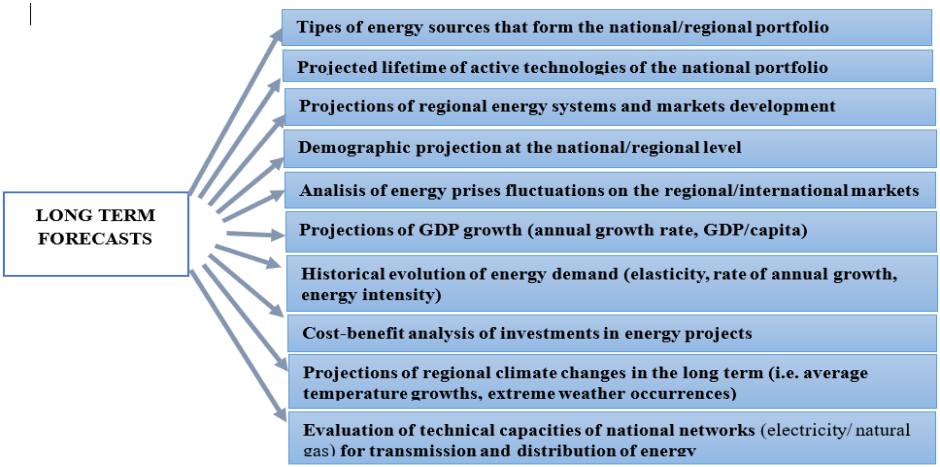

Figure 1.3. The system of factors captured in the long term forecast of energy demand

Source: realized by the author

The medium-term demand forecasts, on the other hand, allow the planning and negotiation of the terms and conditions of operation of RES plants in the medium term so that operational costs are minimized (see Figure 1.4.).

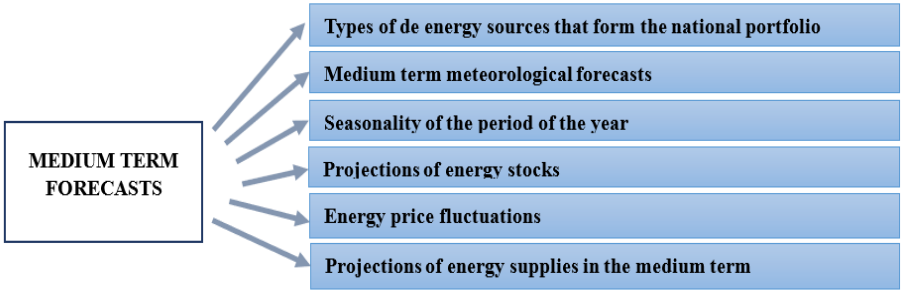

Figure 1.4. The system of factors captured in the medium term forecast of energy demand

Source: realized by the author

The short-term forecasts, however, guide the operational management of the RES plants and aims at supplying the day ahead market of the demand for energy. This type of forecast is based on a remodeling of historical average volumes corresponding to the same day of previous years, considering the elements and factors that may intervene in the short term that would deviate from the volumes of energy usually demanded by the market (e.g.: holidays declared by a state in a certain year and which were not

holidays in previous years will change the behavior of consumers and will modify the structure of the demand for energy expected for that day).

Energy demand management is aimed at eliminating the peak demand for energy as well as the efficiency of energy use at the level of different economic sectors. Effective energy demand management would give the system the advantages of more careful planning of energy supply volumes and, respectively, planning the necessary market transactions in the medium and long term, targeting the most favorable market conditions. **The models of energy demand analysis and forecasting** are mainly focusing on scaling up the historical demand for energy (using indicators such as demand growth rate, demand elasticity as well as energy intensity) informing about the evolutionary stage of the socio-technological transition of the market and providing a foundation for the development of the macro-energetic portfolios of countries.

Analysis of Energy Demand through Decomposition. The literature (Ang, B. W., & Zhang, F. Q., [2], and Ang, W. B. [3]) includes a series of research papers that pursue the analysis of the forecast of energy demand. Studies show that the analysis of energy demand forecast can be determined using the decomposition method by identifying changes in the economy using the following three factors:

1. **changes in technological efficiency of energy use at sectoral level;**
2. **changes in structure of economic activities; or**
3. **changes at economic activity level.**

The model uses explanatory indicators in detailing descriptive trends (energy intensity) to support the energy demand forecasting in the medium and long term [35]. In the case of the analysis of changes in the total energy demand, we have:

$$\mathbf{E = Q \sum \left(\frac{E_i}{Q_i}\ \frac{Q_i}{Q}\right) = Q \sum IE_i S_i} \qquad \textbf{(2.13)}\ [5]$$

where: IE_i – energy intensity at sector level i (e.g. rate of energy consumption relative to economic production of the sector); S_i – the structure of sector i (e.g. the contribution of sector production i to the total production of the economy); Q – total productivity of the economy; Qi – productivity of sector i; E – total energy consumption; E_i – the energy consumption of sector i.

The model follows the contribution of the two factors (energy consumption per GDP and the structural changes of the economy) to the changes in the energy intensity of economies and is based on the calculation formula of energy intensity.

Chapter III of the paper, **"Directions for the Development of Investments in Renewable Energy Sources in the Republic of Moldova and their Management"**, provides a review and diagnosis of the current situation in the renewable energy sector in the Republic of Moldova. At the same time, is described and tested a system of evaluation and forecasting indicators for the development potential of the renewable energy market in the Republic of Moldova. The author offers solutions to the problems and challenges identified in the process of improving investment management in the renewable energy sector in the Republic of Moldova for better absorption of investments directed towards this sector. Additionally, a SWOT analysis of integrating RES sources into the national energy systems is presented to provide a comprehensive overview of all

economic, technical, and sociological aspects for risk control planning required in the processes to be undertaken.

The Republic of Moldova ranks among the countries with a deficient level of energy security, positioning itself on the 61 place out of 91 countries in 2022, according to the World Energy Council's Energy Trilemma Index. At the same time, the signing of the Association Agreement with the European Union in 2014 established secure frameworks for political and economic collaboration. Furthermore, after obtaining candidate status for EU accession in 2022, Moldova's commitment to transposing regulatory frameworks for various economic sectors has increased. Moldova is oriented towards an economy based on agro-industrial production, retail and services. However, the country's economic balance is negative, largely due to the imports of approximately 70% of primary energy resources. Moldova has minor coal, oil, and natural gas resources, and moderate hydropower potential. Consequently, the country's dependence on energy imports (mainly from Russia, Ukraine, and Romania) is high, posing continuous challenges to energy supply security and failing to ensure uninterrupted, unconditional access to energy in necessary quantities and at affordable prices in various forms and technologies. According to data from 2020, Moldova's economy exhibited an energy intensity of 90 tons of oil equivalent per million USD, exceeding the global average energy intensity value of 78 tons of oil equivalent per million USD by 15%. These technical deficiencies, coupled with legislative gaps and the lack of stable government frameworks in the RES market, mediate an accentuated investment reluctance directed towards the RES technologies, perceiving high risk levels of the development climate. The energy sector represents one of Moldova's most significant national vulnerabilities, both in terms of security and economic aspects. This is due to the legacy of a vertically integrated energy system that has not been rehabilitated in the last 30 years and operates under conditions of marginal efficiency.

The dynamics on the regional markets in the recent period have further exacerbated the economical and energetic situation of the country due to the energy crisis in Europe induced by rising energy prices and supply disruptions associated with the initiated war in Ukraine by Russia. The factors directly causing this exacerbation are multi-criterial and multidimensional, primarily considering the country's 100% dependence on fuel imports for the automotive market, 75% dependence on natural gas transactions conducted on external markets, and 80% dependence on electricity imports (including imports from the Transnistrian region). In addition to these factors, there is also the issue of the market's dependence on a major gas supplier (Gazprom), and respectively, on the Trans-Siberian gas pipeline that transits Ukraine. The Republic of Moldova does not control either electricity production or the balancing of the energy system, which is carried out by Ukraine or Romania. Thus, Moldova reports a high dependence of approximately 76% on imported energy (electricity, gas, and oil) from regional markets.

Despite several recent reforms (changes to the Electricity Law, regulations related to the balancing of the electricity grid and the market for ancillary services, cross-border trade, and diversification of electricity supply, establishment of the natural gas trading platform in Moldova by the Romanian Commodities Exchange, etc.), the energy sector of the Republic of Moldova does not perform at the necessary levels in terms of market development (especially the natural gas and electricity segments) and interconnection with regional energy systems. The lack of market diversification and interconnections with regional electricity and gas markets provides suppliers with leverage to exert strong economic and geopolitical pressure, which may limit the entry of new operators into the market.

The Republic of Moldova has adopted the European mechanism for strategic development and considers this path of economic and political adjustment as a national priority until 2030. Statistical data from the National Bureau of Statistics (NBS) shows that the Republic of Moldova's final energy demand increased on average by 1-2% per year during the period from 2011 to 2021, reaching the level of 2,924 thousand toe in 2021 (see Figure 1.5.). After 2019, gross domestic consumption decreased due to the COVID-19 pandemic's impact on the stagnating economy, reaching a level of 2,670 thousand toe in 2020. In 2021, after relaunching the economic processes, energy consumption reached the highest level since 2010, and in 2022, due to the global energy crisis and the war in Ukraine, it decreased again to 2,592 thousand toe.

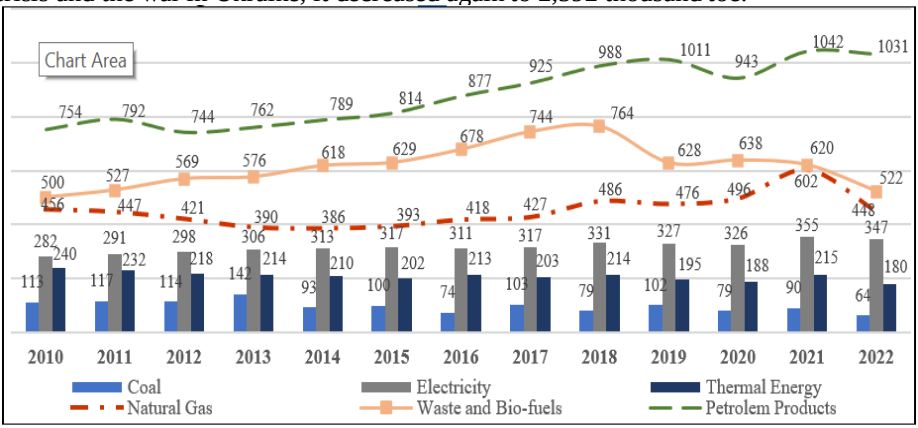

Figure 1.5. Final energy consumption of Republic of Moldova during 2010-2022, thousand toe

Source: realized by the author based on data from the NBS

The analysis of the data from Figure 1.5. shows that the energy consumption mix has changed over the period 2010-2022, with coal consumption decreasing by approximately 20.35%, while thermal energy consumption decreased by 10.42%. On the other hand, natural gas consumption increased by about 32.02%, electricity consumption

by 25.89%, biofuels and waste consumption by 24%, and petroleum product consumption by 38.20%. Aggregate final energy consumption increased by 579 thousand toe, or 24.69%, during the analyzed period. In the context of a sharp demographic decline, increases in energy consumption may indicate either urbanization trends or processes of industrialization and economic growth. In Republic of Moldova's case, the increase in final energy consumption signifies a combination of both processes evolving simultaneously over the period.

To assess the exposure of the RES market in the Republic of Moldova to existing investment risks, it is necessary to conduct a SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis, which will provide an overview of all economic, technical, and sociological aspects considered in shaping national policies and regulatory frameworks (see Figure 1.6.).

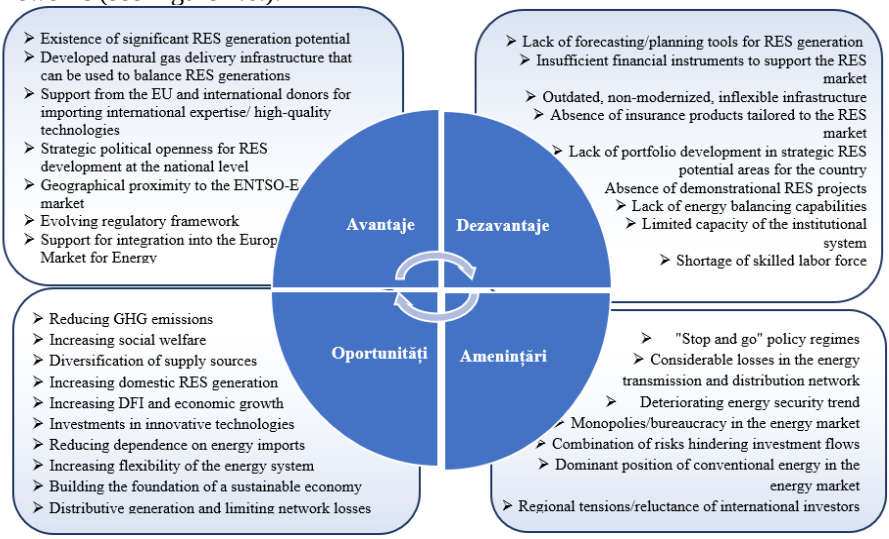

Figure 1.6. SWOT analysis of the investment climate and risks associated with the development of RES in the Republic of Moldova

Source: realized by the author

According to the SWOT analysis conducted by the author, we can establish that most types of risks documented earlier are active in the Republic of Moldova's investment climate associated with the existing RES market, given the immaturity of the local energy market and existing operating systems. As observed, the opportunities for developing the RES market are of strategic importance for the socio-economic development of the Republic of Moldova, generating an expansion of development in the chain of national industries and economic sectors. Moldova needs to adopt a more advantageous position in negotiating the futures/forward contracts, prioritize investments in software and hardware forecasting tools for RES generation for more

efficient short-term supply planning (intra-day and day-ahead markets), and plan energy volumes to be purchased from spot markets. The transition to active integration of renewables requires rigorous management at the short-term generation level and system balancing in conditions of emerging energy surplus/deficit in the grid, analysis, and planning of the medium-term market considering the seasonality of energy surplus/deficit (especially electricity) and the increasing integration of fluctuating energy volumes with prioritization of dispatchability of energy from RES sources (must-run). Another challenge in establishing and operating energy system management models is the integration of ancillary services and energy storage technologies. Moldova must transition to advanced energy market structures by activating risk mitigation tools that either reduce average capital investment costs or increase profitability levels to assume higher risks through subsidies, grants, incentives, financial drivers, etc. However, considering the existing market conditions and circumstances in Moldova, reducing the investment costs required for the launch of new RES plants (capital costs and debt costs) will represent a significant driver for initial widespread allocations. Although in the Republic of Moldova, the costs and risks related to social acceptance issues are considered minimal, they will intensify considering the government's active promotion of RET technologies on the energy markets and, consequently, increasing pressure on affected communities.

Forecast analysis of energy demand in the medium and long term in the Republic of Moldova

The approach based on historical trends is analysing the historical data and the use of energy demand forecasting methods. Observing the historical trends of energy demand in the Republic of Moldova serves as the main basis for folowing and evaluating future levels of demand growth, demand elasticity, and energy intensity rates. Table 1.2. presents the analisys of historical trends in energy demand evolution and projecting growth forecasts for 2025 and 2030 years, based on data published by the NBS in the period from 2010 to 2021. To identify the average annual growth rate of final energy consumption and to determine the levels of final energy/electricity consumption by 2025 and 2030 years, are used the (2.1) and (2.3) relationships. As observed, by applying the historical trends analysis in final energy consumption demonstrates a continuation of energy consumption growth by 10.74% towards 2025 year and by 22.19% towards 2030 year. The trends indicate a 1.99% annual growth in energy demand considering the current demographic trends and economic development rates.

Table 1.2. The forecast of energy demand growth trends in the Republic of Moldova for the 2025 and 2030 years

Indicators	2011	2013	2015	2017	2019	2021	Forecasted levels	2025	2030
GDP (M USD)	8 414	9 497	7 745	9 670	11 970	13 680		16 812	21 755
Total final consumption (thousand tep)	2 406	2 390	2 455	2 719	2,739	2,924		3 164	3 491
Final electricity consumption(MWh)	3 384	3 559	3 687	3 687	3 803	4 129		4 472	4 942
Annual growth rate of final energy consumption	-	-0,003	0,014	0,052	0,004	0,033			
Annual growth rate of final electricity consumption	-	0,025	0,018	0	0,016	0,042			
Annual growth rate of GDP	-	0,062	-0,097	0,117	0,113	0,069			
Average annual growth rate of final energy consumption (r_1)									**0,01989249**
Average annual growth rate of final electricity consumption (r_2)									**0,02016983**
Average annual growth rate of GDP									**0,52897438**

Source: authors calculations based on NBS and WB data [44]

Thus, for the pessimistic scenario, we consider the shares of renewable energy (24.3%) in the gross final energy consumption (2,857 thousand toe) of 2020 year, which are considered as reference data, and apply the average annual growth rate of final energy consumption (see Figure 1.7). To further assess the growth rate of renewable energy demand in the medium term (by 2025) and long term (by 2030), we will consider:

- The influx of foreign direct investments as percentage of GDP, which sets an annual target of 3.5% until 2026 and 4% by 2030 year (National Development Strategy (NDS) 2030).
- The target GDP annual growth rate of 3.5% until the 2030 year as per the NDS.
- The target installation of 410 MW of new electric RES capacity by the year 2025, mainly from wind and photovoltaic sources (amendment to Government Decision HG 401/2021).

Furthermore, aiming at determining the elasticity of energy demand (Ee) in the Republic of Moldova, according to equation (2.4), considering the selected elasticity variables (in our case - economic activity (GDP)), we will identify the type of economic policy pursued by decision-makers regarding new investments and prioritized economic activities. Applying the equation (2.4), we obtain E_{PIB} = 0.177/0.385=0.46 and respectively an elasticity of type 0 <E_{PIB} <1; hence the result that demand is relatively inelastic with respect to GDP. This explains that the Republic of Moldova tends to consume relatively uniform quantities of energy compared to GDP growth levels, as it does not invest significantly in expanding the economy or in new industrial activities and processes, prioritizing instead the assurance of higher levels of energy demand from consumers in the residential sector. A projected annual GDP growth of 3.5% in the SND

until 2030 will be directly reflected in the levels of gross energy consumption, including RES (See Figure 1.7).

The results show that applying the average annual growth rate of final energy consumption, the trend of gross final renewable energy consumption by 2030 increases by 21.77% compared to 2020 levels. We will consider this forecast as pessimistic since a realistic one would take into account the projected economic development rates and future needs of the country.

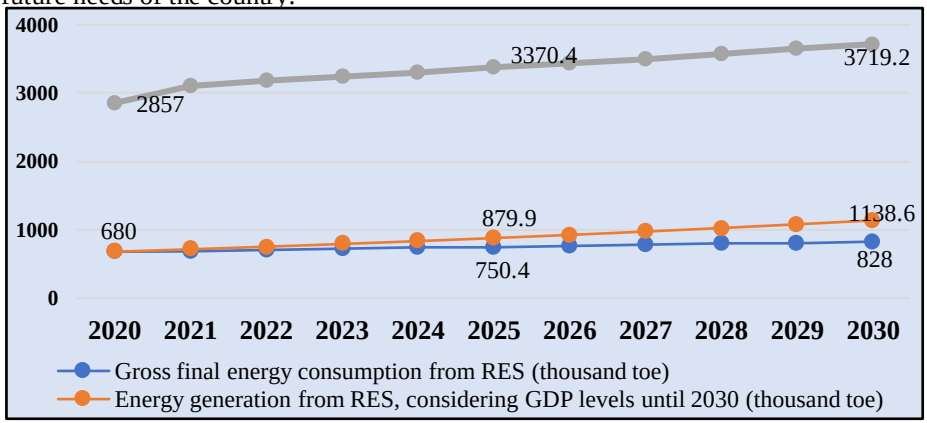

Figure 1.7. Forecast of gross final renewable energy consumption by 2030, th. toe
Source: author's calculations based on the NBS and WB data [44]

An optimistic scenario would consider the future targets set for renewable energy shares in gross final energy consumption by 2025/2030. Based on the above, the author proposes extracting the electricity segment from the forecasts and projecting them until 2025 and 2030, considering (See Figure 1.8.):

- The historical average annual GDP growth rate of 5,29% during the period of 2011-2021years;
- The EU's target of 34% generation from RES in final electricity consumption (by 2025 year) and 38% (by 2030 year);
- The current regional and international energy crisis urges the need to identify funding sources for investments in new RES plants, that will develop actively until 2025 year;
- The undeveloped potential of Moldova's energy from RES sources amounts to approximately 27 GW of total capacity (IRENA, 2019);
- Distributive RES generation leads to little losses in the electrical network, respectively we consider the electricity generation from RES sources equal to its consumption;
- During 2025-2030 years, the generation of electricity from RES sources will slow down due to the existing electricity network and balancing infrastructure limitations.

The optimistic and moderate scenarios of the proposed forecast anticipate reaching ambitious yet realistic levels of integration of RES technologies into both energy consumption and generation, at the sectoral and residential levels. According to this scenario, RES energy consumption would increase by 29.40% by 2025 and by 67.44% by 2030.

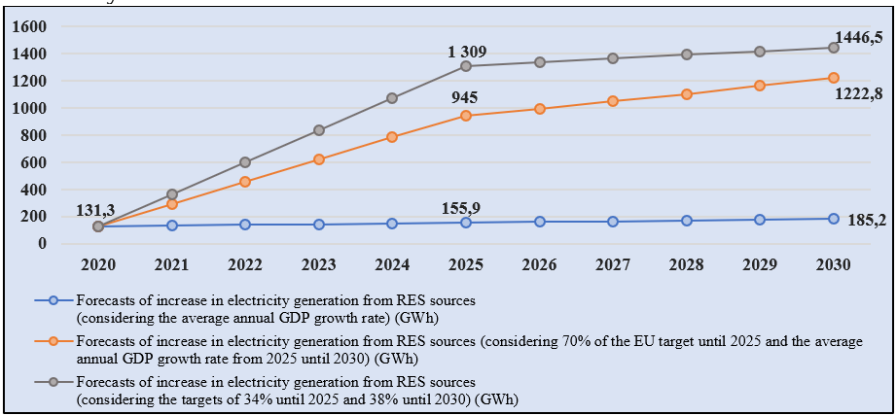

Figure 1.8. Forecasts of RES electricity generation growth considering the optimistic, medium and pessimistic scenarios

Source: author's calculations based on NBS and the WB data

It is worth mentioning that the current power system and infrastructure can absorb the proposed volumes of intermittent energy, whereas maintaining the same ambitious levels of RES integration after 2025 is conditioned by ambitious investments in the modernization and adjustment of the national energy infrastructure. Forecasts for the development of the RES segment in the Republic of Moldova signal the emergence of a considerable investment need to be attracted by 2025 and by 2030. Thus, achieving the target of 38% generation from RES in final electricity consumption would require direct investments in the range of $450-$920 million USD, depending on the selected technologies and the formed mixes.

To understand the extent to which certain segments of the economy of the Republic of Moldova are energy consumers, it is necessary to measure the energy intensity indicator of various national economic sectors according to equation 2.5 (from Chapter II). Considering that the present study aims to identify the economical and energy performance of the Moldovan economy's sectors, we will use final energy consumption as an input indicator for calculating the energy intensity of economic sectors, to disregard the energy losses from the transportation network and those associated with the energy production cycles. The used NBS data reflects the quantities of final energy required for economic production in the industrial, agricultural, and retail and services sectors whereas the World Bank (WB) data reflects the GDP levels in the Republic of Moldova over the years (See Table 1.3.). As we can observe, the aggregated

final energy intensity at the economy level shows a decreasing trend of 33.17% during the period from 2011 to 2021 years.

Table 1.3. The evolution of energy intensity levels of Moldova's economy for 2011-2021 years

Sector/Indicator	2011	2013	2015	2017	2019	2021
Final Energy Consumption (thousand toe)	2 406	2 390	2 455	2 719	2 739	2 924
GDP (M USD)	8 414	9 497	7 745	9 670	11 970	13 680
Total Energy Intensity (EI) (toe/GDP unit)	**0,285**	**0,251**	**0,317**	**0,281**	**0,229**	**0,214**
Final Energy Consumption of the Agricultural Sector (thousands toe)	69	64	74	107	123	161
Agricultural Sector GDP (M USD)	957,5	1 096,9	891,4	1 109,1	1 217,3	1 421,4
Agricultural Sector EI (toe/GDP unit)	**0,072**	**0,058**	**0,083**	**0,096**	**0,101**	**0,096**
Final Energy Consumption of the Industrial Sector (thousands toe)	235	257	209	217	234	245
Industrial Sector GDP (M USD)	1 759,4	2 051,3	1 757,3	2 114,8	2 696,8	2 819,4
Industrial Sector EI (toe/GDP unit)	**0,134**	**0,125**	**0,119**	**0,103**	**0,087**	**0,081**
Final Energy Consumption of the Retail and Services Sector (thousands toe)	277	259	260	267	272	290
Retail and Services Sector GDP (M USD)	4 507,4	5 014,4	4 097,1	5 144,4	6 502,1	7 503,5
Retail and Services Sector EI (toe/GDP unit)	**0,061**	**0,052**	**0,063**	**0,052**	**0,042**	**0,037**

Source: author's calculations based on the NBS and the WB data

The obtained results suggest that the Republic of Moldova is undergoing transitions in the development and specialization of the national economy, including changes in the economic structure, with the dominant engine of economic growth being the retail and services sector. Thus, the analysis identified a decrease in energy intensity of 64.86% for the retail and services sector and 39.55% for the industrial sector. Similarly, in the case of the industrial sector, which contributed on average more than 20% to the total GDP of the Republic of Moldova, the evidence shows a 60.25% increase in the sector's GDP volume. For the retail and services and industrial sectors, we can talk about achieving improved economic productivity based on the implementation of energy management solutions and technologies, and a possible migration to less energy-intensive economic activities, which enhances economic efficiency. A trend of increasing energy intensity in the agricultural sector by 34.5% has been identified, given a 48.45% increase in the GDP volume poured into the total GDP, but also a historical decrease of 1% in contributions to total GDP. In this case, we can discuss about an astringent need to integrate efficient technologies and processes while maintaining high standards of labor competitiveness, as well as product quality and compliance with European and international standards and to aggressively develop market linkages to facilitate trade and investment, especially under the DCFTA trade liberalization agreement with the EU.

The energy shortages that the Republic of Moldova faces and its high dependence on energy imports raises the urgent need for decoupling of conventional

energy consumption from economic production processes. Monitoring the energy intensity of economies is a tool that provides valuable data for informing energy sector management policies and development strategies towards transitions focused on less energy-consuming activities, more active RES generation, and higher energy efficiency levels (see Figure 1.9).

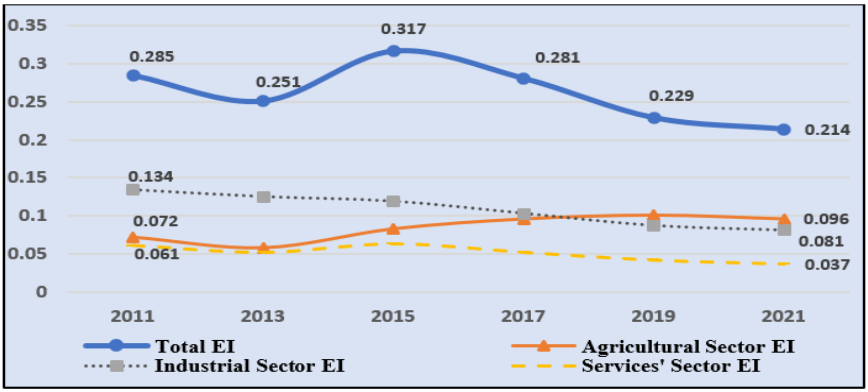

Figure 1.9. The evolution of Moldova's energy intensity levels for 2011-2021 years
Source: author's calculations based on the NBS and WB data

As observed in Figure 1.9, during the period 2011-2021, the intensity of the Moldovan economy shows a trend of economic productivity improvement by 24.91%, with a continuous trend of improvement of 32.49% during the period of 2015-2021 years. This trend is primarily driven by the industrial and retail and services sectors' performances, while the agricultural sector records an increase in energy intensity of approximately 33.33%. The results confirm that the Republic of Moldova is part of the group of former socialist countries that still exhibit characteristics of economies inherited from the Soviet era and are in the process of restructuring their economies. The decreasing trend in final energy intensity is expected to align with the values recorded in developed European countries as the national economy transitions toward the structure and models of western economies.

Analysis of energy demand in the Republic of Moldova using decomposition method

Despite the observed trends in improving the energy intensity of the economy, enterprises in the Republic of Moldova have made very little progress in terms of efficiency and competitiveness. A study by the WB found a negative total factor productivity in both the industrial and agricultural sectors between 2003 and 2011, with modest progress recorded in the retail and services sector [45], [46]. The main obstacles facing the economy of the Republic of Moldova include political instability, corruption, unprepared educated workforce, as well as limited access to financing [4]. The results identified at the level of economic intensity can be explained by changes in the

technological efficiency of energy use at the level of economic sectors, changes in the structure of economic activities, or changes at the level of economic activities (see Table 1.4).

The analysis of energy demand includes the indicator of total factor productivity of the economy, which refers to measurements of production processes outputs at the level of economic sectors and their efficiency. For the analysis of changes in total energy demand across the three economic sectors of the country, equation 2.13 was used (see Chapter II). Thus, as we can observe, in terms of changes in the technological efficiency of energy use (*I*) in the retail and services sector, there is a growth of 320.17%, while in the industrial sector, the indicator registered an increase by 12-fold. In the retail and services sector, the improvement of the indicator was thanks to the active adoption of modern and technologically efficient technologies. In the industrial sector, the processes underlying the improvement in energy efficiency exhibited a greater amplitude, attributed to both the active adoption of efficient technologies and the optimization of resource allocation. The agricultural sector experienced a regression of 231.65% during the period, primarily due to underdeveloped measures for mitigating risks associated with limited access to irrigation, meteorological factors, and the limited adoption of innovative agricultural technologies with efficient energy consumption.

Table 1.4. Analysis of Moldova's energy efficiency of economic sectors production processes

	2011	2013	2015	2017	2019
Total Productivity Factor (Q)*	0,94	0,98	0,95	1,0	1,03
$S_{i(agriculture)}$	11,38	11,55	11,51	11,47	10,17
$S_{i(industry)}$	20,91	21,60	22,69	21,87	22,53
$S_{i(retail\ and\ services)}$	53,57	52,80	52,98	53,20	54,32
$EI_{i\ (agriculture)}$	0,072	0,058	0,083	0,096	0,101
$EI_{i\ (industry)}$	0,134	0,125	0,119	0,103	0,087
$EI_{i\ (retail\ and\ services)}$	0,061	0,052	0,063	0,052	0,042
$I_{(agriculture)}$	-	-0,158	-0,153	0,241	0,524
$I_{(industry)}$	-	-0,191	-0,517	-1,203	-2,367
$I_{(retail\ and\ services)}$	-	-0,466	-0,352	-0,851	-1,958
$S_{(agriculture)}$	-	0,009	0,024	0,037	-0,085
$S_{(industry)}$	-	0,085	0,279	0,353	0,453
$S_{(retail\ and\ services)}$	-	-0,039	-0,081	-0,089	-0,042
$Q_{(agriculture)}$	-	0,027	0,048	0,121	0,205
$Q_{(industry)}$	-	0,108	0,135	0,247	0,392
$Q_{(retail\ and\ services)}$	-	0,110	0,167	0,304	0,456

Source: author's calculations based on the NBS and WB data[1]

[1] *Note: The University of Groningen database was used for the total productivity factor indicator (https://www.rug.nl/ggdc/productivity/pwt/)

At the same time, the indicator of changes in the structure of economic activities *(S)*, registered a de-operationalization of economic processes in the agricultural sector, stemming from a lack of adaptation of the sector to modern and innovative market structures, as well as a systemic approach based on outdated methods and processes. The industrial sector has experienced a remarkable improvement in the structure of economic activities, with an increase of 432.94%, indicating an active adaptation of economic activities to modern market trends, as well as continuous monitoring and evaluation of economic processes to intervene at the level of economic activities. The retail and services sector registered a slight decrease of 7.69% in the efficiency of the adopted structure of economic activities which is not significant and does not affect the other indicators. The retail and services sector made the most notable progress during the period of 2005-2010 years, maintaining relatively constant levels of efficiency after 2011 year.

Currently, the Republic of Moldova faces a critical need to rehabilitate its energy security by interconnecting with regional infrastructure and markets, as well as by adhering to international treaties and conventions on clean energy and climate change prevention. In the context of modest growth of national energy demand and risks related to climate change, the identification of new policies and efficient models for energy production from ecological sources that can adapt effectively to future market conditions becomes imperative. The RES market in the Republic of Moldova is immature, considering the late initiation of market regulation policies and the "stop and go" policy regimes involved in the energy transition process. Even though the national legislative framework is mainly outlined, the implementation of existing policies is delayed in yielding the expected results. This is a clear indication that the market does not perform at the anticipated level due to the existence of political and economic barriers that entail additional risks. The long-term energy security of the country can be strengthened by building the domestic capacities and diversifying the energy imports. We consider that the current priorities of the energy sector in the Republic of Moldova are:

- Building own power plants and expanding the capacity of high-voltage interconnection networks between Moldova and Ukraine, and Moldova and Romania;
- Joining and becoming an active trader on southeastern electricity and gas markets of the European Union;
- Creating conditions for genuine competition for the cheapest electricity;
- Full liberalization of the gas and electricity markets;
- Strengthening the gas and electricity transport networks;
- Improving the energy efficiency of the economy and the public sector;
- Developing RES and system balancing capacities;
- Establishing a short-term electricity trading market (day ahead/intraday).

To ensure the transition of Moldova's energy sector from a system dependent on imported conventional energy sources to one that operates at high levels of

independence in energy generation and operation, two priority processes need to be addressed: the transition to a flexible power system that integrates intermittent energy generation and the establishment of political and institutional frameworks that absorb potential shocks and risks from RES markets, mobilize, and attract investments for the development of RES plants. In an attempt to address these two priorities, a series of interventions are necessary throughout the process (see Figure 1.10).

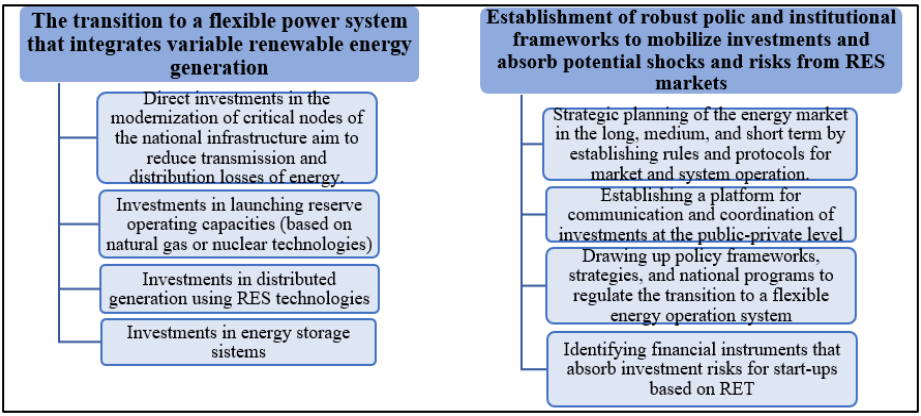

Figure 1.10. Processes for integrating RES generations into the Moldovan energy system

Source: realized by the author

From the analysis of the above figure, it becomes that during the socio-technological transition towards modern energy systems, investments attracted to the energy sector, especially in the electricity segment, both from the private sector and donors, need to be targeted towards strategically identified national urgencies. These urgencies should aim to reduce transmission and distribution losses through direct investments in the modernization of critical nodes in the national infrastructure, promote responsible energy consumption, catalyze private sector engagement, and promote diversification and efficient energy generation from local sources. The geopolitical pressure faced by the Republic of Moldova, including energy supply issues, disrupts country's attempts and efforts to improve national economic growth and social welfare, weakening its competitiveness in attracting foreign direct investments. For a smooth transition of Moldova's energy system towards European operating structures and models, based on intensive integration of RES generations, it is imperative to target energy system development towards investments that interconnect national operating systems with other systems in the region, introduce integrated management systems, encourage adoption of energy efficient technologies by the economic sector businesses, develop reserve capacities as balancing sources, and modernize critical nodes in the national infrastructure.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

The conceptual and methodological study of investment management in RES outlines a scientific area that is still underexplored by the scientific research. At the same time, the significant importance of understanding the investment field, management, policy frameworks, risk taxonomy, and management models related to RES markets is determined by the imperative need to ensure energy security, involving policies and managerial tactics to increase energy efficiency across economic sectors and enhance the competitiveness of products and the economy per general. The work has achieved the initially set objectives for theoretical, systemic, and methodological validation of the proposed topic. The results of the methodological and empirical study can lead to the following conclusions:

- Investment management, approached from a theoretical perspective, solidifies the causal relationship between the investment phenomenon and strategic management, by highlighting the peculiarities of economic, social, technological, and policy nature that define this notion for the renewable energy sector.
- Following the evaluation of the RES energy sector in the Republic of Moldova, the existence of the problem regarding the poor management of investments in this sector was found and validated. Thus, in order to formulate a contemporary vision of the investment management of the energy RES sector, a systematization of the specialized literature that addresses the main theories, postulates, concepts and models, as well as international practices of investment management has been carried out. Similarly, the managerial profile of sector-level investments for the development and diversification of the renewable energy portfolio was analyzed, the strategic diagnosis of the Renewable Energy sector in the Republic of Moldova was carried out, and the adaptation and application of the methodology for assessing the degree of development of the RES sector was followed through the argumentation of causal relations and identification of the factors that would drive the sector development.
- Following the assessment of the RES energy sector in the Republic of Moldova, the problem of deficient investments management in this sector was identified and validated. The main theories, postulates, concepts, and models, as well as international investment management practices identified and systematized by the author based on the review of specialized literature, allowed for the identification of a modern perspective on the investment management in the RES sector.
- The examination of the investment managerial profiles that drive the expansion and diversification of renewable energy portfolios, and the assessment of the Republic of Moldova's renewable energy sector development, allowed for adapting and implementing a methodology to assess the level of development in the RES sector. This involved establishing causal relationships and pinpointing factors that could promote sectoral growth.
- The identified trends in the area of renewable energy development and allocation of investments towards more sustainable and efficient energy markets indicate that the

Republic of Moldova must accelerate the transition process towards the integration of RES generations, considering that the progress in this direction depends on public and sectoral policies, management models and the set of managerial tools applied to absorb and manage investments.

- The proposed methodology for forecasting energy demand and evaluating the energy intensity of economic sectors can be applied for efficiency estimations and result justifications to assist decision-makers in developing management policies and promoting investments in RES, based on modern RET technologies for energy production (especially electricity generation).
- The potential of RES investments can be calibrated using methodological tools based on indicators, factors, and correlations between them.
- The variety of risks operating on RES markets is impressive, and the existing multitude of instruments and mechanisms implemented in different countries confirm the effectiveness and the maturity of the advanced markets.
- To efficiently attract investments to the RES segment it is necessary to identify an effective and feasible market development policy and navigating through the stages of identifying existing blockages at the local, regional, and national levels.
- Based on the results obtained following the assessment of the current situation on the energy segment, we conclude that stimulating investment activity directed towards RES markets can contribute to transitioning to advanced market structures and that implementing clear and coherent policies to support the sector can efficiently capitalize on this potential.
- Republic of Moldova's energy sector is based on a partially monopolized system, and the RES market is still at an emergent stage, with low penetration levels but significant potential thanks to the density of available resources (wind/solar/biomass). The transition towards energy markets based on diversified supply portfolios (especially those based on RES generation) is of strategic importance for the Republic of Moldova, considering its dependence on natural gas imported from the Russian Federation.
- Over the past 5 years, the renewable energy market in the Republic of Moldova has occasionally experienced growth, but it is characterized by a worsening and expanding risk profile, which limits the investment potential directed to this market. To achieve increased investor interest, there is a viable mix of direct regulatory and investment attraction mechanisms in the RES markets (e.g., auction systems for accessing long-term contracts, net billing system).
- In the Republic of Moldova, the investments in large-scale RES projects are constrained by the absence of required balancing capabilities for RES generation from the national grid. Thus, strategic priorities for the country include investments in expanding infrastructure interconnections with regional markets and enhancing internal electricity market balancing capacities.

- The lack of electrical transport and distribution infrastructure in areas with high potential, as well as a deficient approach to the development of distributed energy supply planning, represent obstacles that slow down the adoption at scale of RET technologies in energy markets.
- The application of energy demand analysis and forecasting models to the Republic of Moldova's portfolio has demonstrated a positive trend in terms of improving consumption efficiency across economic sectors. Estimates indicate that the highest levels of efficiencies of energy use and sectoral GDP production levels, are recorded in the retail and services sector and industrial sectors.

Solving the major research problem has allowed the author to formulate recommendations that can be implemented at various levels. Thus, **the proposals for central market regulatory authorities (government and other empowered bodies)** are as follows:

- To advance the development of the RES market in Moldova, by preventing issues related to local market energy deficit, safeguarding the interests of economic agents and citizens, and serving as an important source of investment for the country's economic development, it is necessary to attract FDI by promoting innovative market reforms and advancing an agenda of market liberalization, as well as ensuring fair competition on the sector.
- Continue the agenda of local energy market integration and development coordination of the and interconnection of the with regional markets, diversification of the supply sources on the natural gas and electricity segments and prioritization of the appropriate conditions for improving energy efficiency and developing local energy infrastructure.
- Use of the proposed model of informing and identifying the promotion and development policy for the RES market to attract targeted FDI investment volumes.
- Introduction of a system of indicators to inform the efficiency of RES investments' management considering the country's legal framework and financial environment.
- Considering the replacement of the FIT mechanism with a variable FIP to incentivize producers to generate electricity during peak hours when the demand levels are higher. In the context of the Republic of Moldova, this instrument will mitigate additional risks related to inflation, fossil fuel-based energy prices, and ensure the feasibility of social costs.
- Identification and promotion of strategic locations for the development of wind, solar, or biomass RES projects (where the national grid is easily adaptable to ensure electricity transportation/distribution, considering environmental and local factors, and where there is advantageous availability of resources) for strategic dimensioning and building of national generation capacities coupled with the development of national grid balancing reserves based on energy storage technologies and/or natural

gas, nuclear energy technologies, and attracting FDI in implementing necessary investments for project implementation.

- Establishment of a coordination platform for developing the insurance market products tailored to the specific needs and progress of the RES market in the Republic of Moldova.
- Implementation of fiscal credit mechanisms or providing grants or subsidies to attract investments from RES developers.
- State intervention is necessary to attract investments towards the adoption of modern and innovative RET technologies, as well as to enhance energy consumption efficiency in the agricultural sector, which would contribute to the long-term sustainability of the sector.
- Establishing regulations and operating protocols for market transition towards scaling up RES generation and establishing integrated operating models for Moldova's energy systems.
- Involvement of the government in partially guaranteeing loans offered by development banks to engage in lending/refinancing of RES markets' operators.
- Facilitation of the processes of obtaining permits for the installation of RES projects and adjusting the regulatory framework to ensure the connection to the electricity grid.
- Easing the access to training and certification services for RES producers and improving the standards for providing these services. This will lead to enhancing the workforce's capabilities for better comprehensiveness of EU energy market mechanisms, use of industry-specific software and hardware tools, management of data collection, and operation of energy trading transactions on international platforms.

At the level of local public administrations it is important to:

- Involve the local stakeholders at early stages in the democratic processes of discussing the benefits of developing RES projects around subject communities.
- Ensure the implementation of necessary measures by local public administrations to streamline the development processes of nationally significant RES projects near communities by identifying and removing barriers (e.g., plant connection to the grid, acquiring land for the installation, etc.).
- Oversee the business development of the agricultural sector and encouraging technological advancements as well as efficiency improvements in operational processes to contribute to the energy consumption efficiency of the sector at the national level.
- Monitor electricity consumption and identifying necessary measures to encourage energy consumption outside peak hours to maintain grid voltage levels and ensure local grid balancing.

For the academic platform the recommendations aim to:

- The development of studies in the field, considering the application of the research results, to fill in the gaps existing in the literature on investment management, sectorial management, project management, etc., which would be beneficial for students, master's, and doctoral candidates. The results are launching various research directions and can be focused on risk profile as more investment projects in renewable energy are implemented, and on energy demand forecasts and renewable energy segment development forecasts as the integration of renewables into the national portfolio progresses.
- Improvement of the mapping of available resource densities (wind/solar/biomass) based on on-site measurements. These will serve as incentives for the private sector to attract investments under conditions of high project bankability forecasts.
- Development of climate evolution models for the next 10-20 years to inform the early planning of national energy system development for enhanced funding management and prioritization.
- Advocating for increased allocations from the state budget for R&D of the RES sector field to provide advanced consultancy and mentoring services to both the government and the private sector in the development of the RES market.

At the private sector level, it is imperative to:

- Build the capacities for electricity storage as well as grid balancing based on natural gas and/or nuclear energy in strategic locations across the country.
- Design distributive planning of electricity power generation by identifying economically and geographically energy-consuming zones (e.g., free economic zones) that also have wind/solar potential to attract investments in RES markets across the country.
- Invest in short-term software and hardware forecasting systems for electricity generation from RES sources to inform the intra-day and day-ahead markets' needs. This will ensure a better coordination of conventional generations with RES generations, prioritizing renewable energy to achieve maximum yields (must run), while conventional sources fill the necessary supply levels. Additionally, it would allocate resources for production, limiting additional costs associated with energy purchased from the intraday market.
- Involve consulting agencies in ensuring the support and mentoring of decision makers (public authorities, investors) in adequate scaling of RES plants at the level of different communities/needs.
- Provide daily support to electricity producers from RES sources by issuing early warnings of bad weather incidents. This would reduce the operational and maintenance costs as well as the risks of ceasing the operational activity of the power plants.
- Development of preferential lending products by banking institutions tailored to the financing and refinancing needs of RES assets.

Considering the recent events in the energy sector, particularly in the field of renewable energy sources (RES), the authorities of the Republic of Moldova must urgently develop the domestic energy system to allow for national economic progress. They must also promote and unlock the progress of the RES sector to ensure a safer and more efficient energy security for the country. The conclusions and recommendations put forward by the author contain the necessary elements for decision-makers to intervene promptly and effectively in the energy/RES market and ensure its continuous development by attracting FDI and enhancing investment management.

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ADNOTARE

la teza de doctor în ştiinţe economice cu tema **„ Managementul Investiţiilor în Sectorul Energiei Eegenerabile al Republicii Moldova”,**

Irina Nasalciuc, Chişinău, 2024

Teza este structurată în introducere, trei capitole, concluzii generale şi recomandări, bibliografie din 198 surse, 20 anexe, 158 pagini text de bază, 43 figuri, 6 tabele.

Cuvinte cheie: creștere economică, managementul investiţiilor, energie regenerabilă, politici sectoriale, riscuri investiţionale, investiții străine directe.

Domeniul de studiu al tezei îl constituie managementul investițiilor în domeniul energiei regenerabile.

Scopul lucrării constă în cercetarea complexă și profundă a aspectelor teoretico-practice, a metodelor de management a investiţiilor în sectorul energiei regenerabile, pentru a contura principalele riscuri și avantaje în fundamentarea direcţiile prioritare de modernizare ale managementului investiţiilor energiei regenerabile în Republica Moldova aliniate tendinţelor de dezvoltare internaţionale.

Obiectivele studiului constituie cercetarea și completarea bazei teoretico-metodologice a managementului investiţiilor în sectorul energiei regenerabile; studierea bunelor practici ale ţărilor Europene în domeniul surselor regenerabile; analiza și identificarea riscurilor ce stau la baza sistemului decizional eficient vizând implementarea modelelor de management a investiţiilor energiei regenerabile, realizarea previziunii consumului final de energie generate din surse regenerabile și testarea intensităţii energetice la nivelul sectoarelor economice.

Noutatea şi originalitatea ştiinţifică: dezvoltarea bazei teoretico-metodologică a managementului investiţiilor în domeniul energiei regenerabile; argumentarea indicatorilor de referință pentru analiza și monitorizarea managementului investiţiilor energiei din surse regenerabile în condiţiile pieţei autohtone; elaborarea modelului decizional integrat de informare și dezvoltare a cadrului normativ național aferent investiţiilor în regenerabile; identificarea și sistematizarea riscurilor relevante sectorului energiei regenerabile din țară și formularea recomandărilor de perfecționare a managementului investiţiilor în sectorul energiei regenerabile al Republicii Moldova.

Rezultatul obținut care contribuie la soluționarea unei probleme ştiinţifice importante rezidă în argumentarea cadrului teoretic și metodologic al managementului investiţiilor în sectorul energiei regenerabile, care a consolidat instrumentarul economic și managerial ce determină direcţiile de dezvoltare ale sectorului și a evaluat rezultatele economice din valorificarea investițiilor atrase pentru a asigura formarea tacticii de management a investițiilor în sectorul energiei regenerabile al Republicii Moldova**.**

Semnificația teoretică: dezvoltarea aparatului noțional și metodologic cu noi abordări și modele de management investițional în sectorul energiei regenerabile, argumentarea sistemului de indicatori identificați pentru prognoza evoluției pieței energiei din Republica Moldova.

Valoarea aplicativă a lucrării: rezultatele pot fi utilizate în evaluarea gradului de maturitate al pieței energiei regenerabile și îmbunătățirea cadrului de reglementare a sectorului; atragerea și valorificarea investițiilor și dezvoltarea pieței energiei regenerabile. Totodată, rezultatele pot fi integrate în cadrul disciplinelor investiții, managementul investițiilor și managementul proiectelor investiționale pentru studierea profundă a sectorului energiilor regenerabile.

ANNOTATION

for the doctoral thesis in economic sciences with the topic **"Investment Management in the Renewable Energy Sector of the Republic of Moldova"**,

Irina Nasalciuc, Chisinău, 2024

The thesis is structured as follows: introduction, three chapters, general conclusions and recommendations, bibliography of 198 titles, 20 annexes, 158 pages of basic text, 43 figures, and 6 tables.

Keywords: economic growth, investment management, renewable energy, sectoral policies, investment risks, direct foreign investment.

The field of study of the thesis is economics and management in the field.

The purpose of the thesis lies in the complex and detailed research of the theoretical and practical aspects of the management models of renewable energy investments to outline the main risks and advantages in establishing the priority directions of developing the renewable energy investments' management in the Republic of Moldova, aligned with international best practices.

The objectives of the study are to research and broaden the theoretical and methodological basis of investment management in the renewable energy sector; evaluation of the best practices of European countries in the field of renewable sources; the analysis and identification of the risks underlying the effective decision-making system aimed at the implementation of renewable energy investment management models, forecasting the final consumption of energy generated from renewable sources and testing the energy intensity at the level of economic sectors and the economy as a whole.

Scientific novelty and originality: the development of the theoretical and methodological basis of investment management in the field of renewable energy; testing of reference indicators for the analysis and monitoring of investment management of energy investments in the field of renewable energy considering the conditions of the domestic market; the development of the integrated decision-making model to inform the development of the national normative framework related to investments in renewables; identifying and systematizing risks relevant to the country's renewable energy sector and formulating recommendations for improving the investment management in the renewable energy sector of the Republic of Moldova.

The obtained results that contribute to identifying solutions for an important scientific problem lie im the consolidation of the theoretical and methodological framework evidence of investment management in the renewable energy sector, which has identified the economic and managerial instruments that determine the development directions of the sector and has evaluated the economic outcomes resulting from the attracted investments to ensure the effective design of investment management tactics in the renewable energy sector of the Republic of Moldova**.**

The theoretical significance: the development of the notional and methodological apparatus with new approaches and models of investment management in the renewable energy sector, the argumentation of the system of identified indicators for forecasting the evolution of the energy market in the Republic of Moldova.

Applicative value of the work: the results can be used in assessing the maturity of the renewable energy market and improving the regulatory framework of the sector; attracting and capitalizing on investments and developing the renewable energy market. At the same time, the results can be integrated within the disciplines of investments, investment management and investment project management for the in-depth study of the renewable energy sector.

АННОТАЦИЯ

к диссертации доктора экономических наук на тему "**Управление Инвестициями в Секторе Возобновляемых Источников Энергии Республики Молдова**",

Ирина Насальчук, Кишинэу, 2023 г.

Структура диссертации: работа состоит из введения, трех глав, общих выводов и рекомендаций, списка литературы из 198 источников, 20 приложений, 158 страниц основного текста, 43 рисунков, 6 таблиц.

Ключевые слова: экономика, управление инвестициями, возобновляемая энергия, отраслевая политика, инвестиционные риски.

Область исследования диссертации: управление инвестициями в секторе возобновляемой энергии.

Цель исследования заключается в комплексном и глубоком исследовании теоретико-практических аспектов, методов управления инвестициями в сфере возобновляемой энергии, с целью выявления основных рисков и преимуществ, обоснования приоритетных направлений модернизации управления инвестициями в возобновляемые источники энергии в Республика Молдова, соответствующих международным тенденциям развития.

Задачи исследования состоят в исследовании и доработке теоретико-методологической базы управления инвестициями в секторе возобновляемой энергии; изучении опыта европейских стран в области возобновляемых источников энергии; анализе и выявлении рисков для обеспечения эффективной системы принятия решений, направленных на реализацию моделей управления инвестициями в возобновляемые источники энергии, прогнозирование конечного потребления энергии из возобновляемых ресурсов и тестирование эффектов на уровне секторов и экономики в целом.

Научная новизна и оригинальность: разработка теоретико-методологических основ управления инвестициями в сфере возобновляемых источников энергии; аргументация контрольных показателей для анализа и мониторинга управления инвестициями в возобновляемые источники энергии в условиях внутреннего рынка; разработка интегрированной модели принятия решений для информирования и разработки национальной нормативной базы, связанной с инвестициями в возобновляемые источники энергии; выявление и систематизация рисков, характерных для сектора возобновляемой энергии в стране, и формулирование рекомендаций по совершенствованию управления инвестициями в секторе возобновляемых источников энергии Республики Молдова.

Полученный результат, который способствует решению важной научной проблемы заключается в обосновании теоретико-методологических основ менеджмента инвестиций в секторе возобновляемых источников энергии, которые позволили консолидировать экономический и управленческий инструментарии, определяющие направления развития сектора и оценить экономические результаты от освоения инвестиций для разработки в будущем тактики управления и инвестиционных стратегий в секторе возобновляемых источников энергии в Республике Молдова**.**

Теоретическая значимость: методологическая разработка методик управления инвестициями в секторе возобновляемых источников энергии, аргументация системы выявленных показателей для прогнозирования эволюции энергетического рынка Республики Молдова.

Практическая значимость: результаты могут быть использованы при оценке рынка возобновляемых источников энергии и совершенствовании нормативно-правовой базы сектора; привлечении, освоении инвестиций и развитие рынка возобновляемых источников энергии. Также результаты могут быть интегрированы в дисциплины: инвестиции, управление инвестициями и управление инвестиционными проектами для углубленного изучения сектора возобновляемых источников энергии.

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