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Investments in renewable energy: Opportunities for small and medium-sized enterprises through alternative financial instruments

Abstract. This study was devoted to identifying the possibilities of alternative financial instruments for the development of solar energy in the segment of small and medium-sized enterprises. The methodology included a comparative analysis of the efficiency of solar panels, an assessment of the availability of financial instruments for small and medium-sized enterprises, and the definition of key criteria for their selection. The study found that crowdfunding, green bonds, venture financing, and leasing were the most promising tools for small and medium-sized enterprises, allowing them to raise funds without collateral and with minimal financial history requirements. The average success rate of crowdfunding campaigns in the solar energy sector was 72%. It was revealed that the introduction of solar panels reduced the energy consumption of enterprises by 35-45% and had a payback period of 3-5 years, depending on the scale of the project and the financing model. The optimal financing structure included 30-40% of the company's own funds, 20-30% of funds raised through crowdfunding, and 30-40% of equipment leasing or venture capital. The key factors of the economic efficiency of solar energy projects were the level of solar radiation in the region, the cost of connecting to the electric grid, the availability of government incentives and the quality of equipment. It was found that financial barriers could be overcome through combined financing models. With government guarantees, the investment attractiveness of projects increased by 40%. Long-term energy supply contracts increased the chances of obtaining financing by 25%. The results obtained deepened the understanding of the mechanisms of sustainable financing of solar energy for small and medium-sized enterprises and could be used in the development of government programmes to support enterprises in the field of renewable energy. The study contributes to the development of green finance and the transition to a low-carbon economy in the Kyrgyz Republic

Keywords: alternative financing; green economy; crowdfunding; leasing; profitability

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INTRODUCTION

The global transition to renewable energy sources has become a key factor in ensuring sustainable economic development and mitigating environmental problems. Rising prices for conventional energy carriers forced enterprises to look for alternative energy supply solutions. This problem was especially relevant for small and medium-sized enterprises (SMEs), which faced the need to optimise energy consumption and reduce their carbon footprint. An analysis of the scientific literature has shown that the issues of alternative financing of renewable energy projects have become increasingly relevant. According to the research by K.N. Kuteesa *et al.* (2024), traditional bank loans were available to only 15-20% of SMEs, which created a significant barrier to the introduction of "green" technologies. D.W. Atchike *et al.* (2022) identified the key factors influencing the introduction of solar systems in the SME segment, emphasising that financial accessibility was a crucial condition for the successful implementation of such projects.

T. Sarkhanov & N. Huseynli (2022) conducted an econometric analysis of the relationship between renewable energy consumption and economic growth in Kyrgyzstan, finding that a 1% increase in the share of renewable energy sources in the country's energy mix contributed to a 0.4% increase in gross domestic product (GDP). K. Mehta *et al.* (2022) conducted a comprehensive analysis of the regulatory framework of the Kyrgyz energy sector and proposed a roadmap for the development of the renewable energy sector. Researchers have identified the key advantages of solar energy for SMEs: reducing energy consumption, increasing energy independence, improving the company's image and meeting the growing environmental requirements of local markets. One of the key findings of the study was that the availability of financing is a critical factor in the successful implementation of solar technologies in the SME segment.

J. Sun *et al.* (2024) in their study found that among various renewable energy technologies, solar power plants demonstrated the best payback rates for small businesses. N. Temirbaeva *et al.* (2024) investigated the potential of renewable energy sources in Kyrgyzstan with a focus on energy supply to rural consumers and determined that in rural areas of Kyrgyzstan with limited access to centralised energy supply, solar installations can provide up to 70% of the energy needs of small enterprises with optimal equipment selection and financial model. The researchers also identified regulatory barriers in the Kyrgyz Republic, including complex procedures for obtaining permits for the construction of solar power plants, the lack of standardised technical requirements, and imperfect mechanisms for connecting to the common electricity grid. A. Generalov & O. Generalova-Kutuzova (2021) studied the economic, legal, political, and social environment for entrepreneurs in Kyrgyzstan, focusing on barriers to the introduction of innovative technologies. The researchers found that despite favourable natural conditions for the development of solar energy, SMEs face serious financial constraints, and offered recommendations for improving the business environment to encourage investment in environmentally friendly technologies.

J. Salimova-Tekay (2022) analysed the specifics of financing infrastructure projects in Kyrgyzstan, including renewable energy facilities, examined existing financial mechanisms, and identified problems with attracting capital for the development of energy infrastructure. As a result of the research, innovative financing models adapted to local conditions were proposed, including public-private partnerships, specialised development funds, and international financial instruments. Despite the significant contribution of these researchers, they did not fully disclose the specifics of the use of alternative financial instruments for solar energy in the context of SMEs in Kyrgyzstan. Most of the existing papers either focused on the technological aspects of the introduction of renewable energy sources, or considered financial mechanisms without considering the specifics of SMEs in emerging economies (Andreitsev *et al.*, 2024).

The purpose of this study was to determine the optimal alternative financial instruments for investing SMEs of the Kyrgyz Republic in solar energy, considering the specific economic conditions of the country and the specifics of the functioning of small and medium-sized businesses. To achieve this goal, the following research objectives were formulated. The first task was to conduct a comprehensive analysis of available alternative financial instruments and assess their applicability for investing in solar energy projects by SMEs in Kyrgyzstan. The second task was to develop a methodology for assessing the economic efficiency of various models of financing solar projects, considering the scale of the enterprise, its energy consumption, and regional location. The third task was to prepare practical recommendations on the development of an optimal financing structure for SMEs planning to introduce solar technologies, including an analysis of the possibilities of combining various financial instruments to achieve maximum economic efficiency.

MATERIALS AND METHODS

The statistical data and analytical materials of the International Renewable Energy Agency (2024) for 2019-2024 were used as the information base of the study, providing a detailed analysis of the dynamics of renewable energy development in the world. These materials contained detailed information about the trends in the introduction of solar technologies in the small and medium-sized business sector. Special attention was paid to the data on the development of solar energy in Kyrgyzstan, Kazakhstan, Uzbekistan and Tajikistan, presented in the papers by Z. Yang *et al.* (2022) and V. Panwar *et al.* (2022), who examined in detail the potential of solar generation in the Kyrgyz Republic.

To analyse the cost-effectiveness of solar panel deployment, the findings of S. Qamar *et al.* (2022) were used, which presented a comprehensive analysis of the technical and financial performance of solar energy projects in the SME segment of developing countries. The study included an analysis of design documentation, technical specifications of equipment, and data on system performance and actual indicators of electricity generation, which ensured high reliability of conclusions about the prospects for the introduction of solar technologies in Kyrgyzstan. Additionally, data from the study by I. Myroshnychenko *et al.* (2024) were used, which analysed the regulatory features of the introduction of renewable energy sources in transition economies.

The study used a method of comparative analysis of financial instruments based on a multi-criteria assessment. The following factors were assessed: accessibility for

various categories of SMEs, cost of raising funds, terms and conditions of financing, security requirements, and flexibility of conditions. To determine the economic effect of the introduction of solar panels, a statistical analysis of data from 150 SMEs in Kyrgyzstan from five industrial regions (Chui, Osh, Jalal-Abad, Issyk-Kul regions and Bishkek) that introduced solar technologies in 2020-2024 was carried out. The sample included enterprises from various industries: food (35%), light industry (25%), construction (20%), services (15%), and others (5%). An analysis of barriers to the introduction of solar technologies was also carried out, which included the identification and systematisation of the main obstacles of a financial, technical, administrative, and informational nature. For this purpose, methods of expert assessments and questionnaires of business leaders were used, which allowed ranking barriers according to their degree of influence on decision-making on the introduction of solar technologies.

The paper provides a comparative analysis of financing models and their effectiveness for various types of enterprises. Traditional bank loans, leasing schemes, microfinance products, government support programmes, venture financing, crowdfunding, green bonds, and energy service contracts were analysed. Economic performance indicators were calculated for each model: net present value (NPV), internal rate of return (IRR), discounted payback period (DPP), and modified internal rate of return (MIRR). The results of the analysis were integrated into a multifactorial model for evaluating optimal financial instruments, which considered regional and industry-specific characteristics of enterprises. Statistical processing was carried out in the Statistical Package for the Social Sciences (SPSS) Statistics 28.0 using Student's t test ($p < 0.05$), variance and regression analysis.

RESULTS

Analysis of alternative financial instruments for small and medium-sized businesses that allow them to raise funds for the introduction of solar panels

Traditional bank lending is not available to most SMEs, with only 20% of enterprises having access. Key barriers: strict reporting requirements, high collateral (more than 120% of the loan), lengthy application review (45-60 days), and high rates. Alternative financial instruments are becoming particularly important, and their effectiveness for different categories of SMEs is presented in Table 1.

Table 1. Comparative analysis of alternative financial instruments for SMEs in the field of solar energy

Financial instrument	Average amount of financing (thousand USD)	Average term (years)	Average cost of attraction (% per annum)	Basic requirements for SMEs
Crowdfunding	50-300	1-3	5-8	Detailed business plan, transparent financial statements
Green bonds	500-2,000	3-7	6-9	Credit rating, collateral
Venture financing	300-1,000	3-5	Equity share	High growth potential, innovative nature of the project
Person-to-Person (P2P) lending	20-150	1-2	8-12	Positive credit history
Equipment leasing	100-500	3-5	7-10	Initial payment, insurance

Note: data is provided for the Central Asian market
Source: compiled by the authors based on A. Kulanov *et al*. (2020)

The analysis showed that crowdfunding is one of the most accessible tools for small businesses, especially at the initial stages of solar energy projects. The main advantage of this tool is the absence of strict requirements for collateral and credit history. According to S. Kavu *et al.* (2020), the success rate of crowdfunding campaigns in the solar energy sector is about 65%, which is significantly higher than the average for other industries. Green bonds are a promising tool for medium-sized enterprises that can ensure the required volume of issuance and meet the requirements for transparency and financial stability (Rats & Alfimova, 2023). In the Kyrgyz Republic, this instrument is in its infancy, however, as noted by V. Panwar *et al.* (2022), has significant development potential in the context of the implementation of national programmes for the transition to a green economy. Special attention should be paid to the P2P lending mechanism, which shows high efficiency for financing small solar energy projects. The average interest rate on such loans is 3-4 percentage points lower than bank loans, which makes them attractive to micro and small businesses. The analysis of alternative financial instruments presented in Table 1 shows significant differentiation in key parameters. Equipment leasing is characterised by relatively low requirements for the financial condition of the borrower at a relatively high cost of financing. Venture financing, although it does not require collateral, involves the investor receiving a share in the company's capital, which is not acceptable for all enterprises. Each tool has its own optimal niche of application.

For micro-enterprises with limited financial resources and a short credit history, crowdfunding and P2P lending are the most suitable, allowing them to attract small amounts for short periods with minimal formal requirements. Small enterprises with a stable financial position can effectively use equipment leasing and venture financing, which provide more significant amounts of funds for an average period of time. For medium-sized enterprises with a good credit history and transparent financial reporting, green bonds, and project financing are the best choice, allowing them to attract large sums for long periods on favourable terms. Thus, the diversification of financial instruments significantly expands the possibilities of SMEs to implement solar energy projects.

The data presented in Table 2 shows a clear correlation between the size of an enterprise and the most effective financial instruments for it. Micro-enterprises achieve the best economic results when using crowdfunding and P2P lending, achieving an average project profitability of

15-20% with a payback period of 3-4 years. Leasing and venture financing show the greatest efficiency for small enterprises, providing higher profitability (18-23%) with a slight increase in the payback period to 4-5 years. Medium-sized enterprises using green bonds and project financing achieve maximum project profitability (20-25%) with longer payback periods (5-6 years). This differentiation is conditioned by both the scale of the projects and the differences in the cost of attracting financing and the operational efficiency of enterprises of different sizes.

Table 2. Effectiveness of various financial instruments depending on the size of the SME

Enterprise size	Most effective tools	Average payback period of the project (years)	Average profitability of the project (%)
Micro-enterprises	Crowdfunding, P2P lending	3-4	15-20
Small businesses	Leasing, venture financing	4-5	18-23
Medium-sized enterprises	Green bonds, project financing	5-6	20-25

Note: profitability is calculated considering all the costs of financing maintenance
Source: compiled by the authors based on I. Myroshnychenko *et al.* (2024)

The effectiveness of financial instruments significantly depends on the size of the enterprise. Micro-enterprises achieve the best results with crowdfunding and P2P lending (15-20% profitability, 3-4 years payback) due to minimal reporting requirements and the absence of collateral. Small businesses use leasing and venture financing more efficiently (profitability of 18-23%, payback period of 4-5 years) due to stable cash flow and credit history. Medium-sized enterprises optimally use green bonds and project financing (profitability of 20-25%, payback period of 5-6 years) due to the scale of their activities, transparent reporting, and credit rating.

As a result of the study, the main barriers preventing the introduction of solar technologies among SMEs in Kyrgyzstan were identified. The most significant is the low level of awareness about available alternative financial instruments, which was noted by 68% of managers of SMEs. Difficulties in preparing the necessary documentation for obtaining financing are experienced by 70% of enterprises trying to attract alternative sources. The most acute problem is the lack of specialised financial intermediaries in local markets, which was noted in 82% of cases. The lack of digital infrastructure development (58% of enterprises identified this as a significant obstacle) and the lack of flexible government support mechanisms (76% of SME managers noted this) also have a significant impact.

Examples of successful solutions to this problem can be found in international practice. For example, in India, the "Solar Power for MSMEs" programme, implemented in partnership with the World Bank, has created a network of 35 regional advisory centres that support SMEs in preparing documentation for financing solar energy projects (Ashutosh, 2024). Over the years 2022-2023, more than 1,200 enterprises have successfully attracted financing in excess of USD 80 million. To assess the attractiveness of various financial instruments, their compliance with the specific needs of SMEs in the implementation of solar energy projects was analysed (Table 3).

Table 3. Assessment of the compliance of financial instruments with the needs of SMEs in the field of solar energy

Assessment criteria	Crowdfunding	Green bonds	Venture financing	P2P lending	Leasing
Speed of obtaining financing	High	Low	Average	High	Average
Flexibility of conditions	High	Low	Average	High	Average
Design complexity	Low	High	High	Low	Average
Need for collateral	No	Yes	No	No	Partly
Possibility of partial financing	Yes	No	Yes	Yes	No

Note: the assessment is based on a three-point scale (high/medium/low)
Source: compiled by the authors

Table 3 provides an assessment of the compliance of financial instruments with the needs of SMEs in the solar energy sector. Crowdfunding and P2P lending are characterised by a high rate of receipt of funds, flexible terms and no collateral requirements, which is ideal for micro-enterprises. Green bonds, with their complex design and strict conditions, are suitable for medium-sized companies with a stable financial position. Venture financing occupies an intermediate position, ensuring that there are no collateral requirements with a high complexity of registration. The analysis showed that each of the financial instruments considered has its own optimal scope of application, depending on the scale and characteristics of the enterprise. An effective choice of financial solution should consider both the specifics of the business and the associated risks presented in Table 4.

Table 4. Risk assessment matrix for using alternative financial instruments

Risk type	Risk level for SMEs	Minimisation possibilities	Impact on the project
Risk of underfunding	High	Diversification of financing sources	Critical
Currency risk	Average	Hedging	Substantial

Table 4. Continued

Risk type	Risk level for SMEs	Minimisation possibilities	Impact on the project
Interest rate risk	Average	Fixed rates	Moderate
Risk of default	High	Insurance	Critical
Operational risk	Low	Professional management	Insignificant

Source: compiled by the authors based on J. Salimova-Tekay (2022)

Table 4 demonstrates risk assessment when using alternative financial instruments. The risk of underfunding and the risk of default have a critical impact, especially relevant for crowdfunding and venture financing. Currency risk and interest rate risk are assessed as medium, while operational risk is assessed as low. According to the overall risk level, the instruments can be arranged in the following order (from the most to the least risky): crowdfunding and venture financing, P2P lending and leasing, green bonds. Leasing and P2P lending are more balanced tools for most SMEs, combining an acceptable level of risk with sufficient availability (Bekmuratov *et al.*, 2024).

An analysis of the practice of using alternative financial instruments has shown that the most effective approach is to combine various sources of financing. I. Myroshnychenko *et al.* (2024), based on a sample of solar energy projects in Central Asian countries, found that the optimal structure for SMEs is a balanced structure including the enterprise's own funds, funds raised through crowdfunding or P2P platforms, and equipment leasing or venture financing. To substantiate the economic feasibility of introducing solar panels, a comparative analysis of various alternative energy sources available to SMEs was conducted. The analysis included an assessment of both the initial investment and the total cost of ownership throughout the life cycle of the equipment. Based on the conducted research, a clear trend has been identified to reduce the cost of solar technologies while increasing their efficiency (Fig. 1).

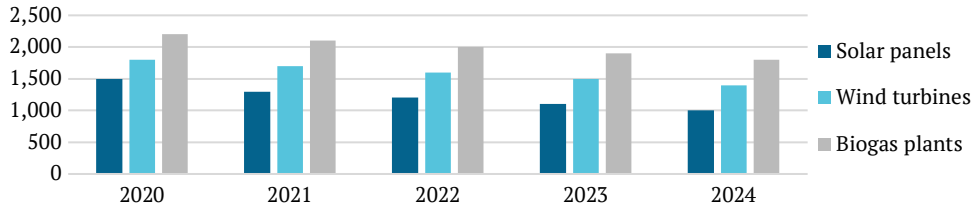

Figure 1. Dynamics of the cost of introducing various energy sources (USD/kW)
Source: compiled by the authors

As can be seen from Figure 1, the cost of solar panels shows the most dynamic decline among all the technologies considered. The analysis of the economic efficiency of various energy sources has shown a significant advantage of solar technologies in terms of key profitability indicators. An important factor in choosing solar panels is their modularity and scalability, which allows SMEs to incrementally increase capacity in accordance with financial capabilities and electricity needs (Ismanzhanov & Tashiev, 2016). For the conditions of the Kyrgyz Republic, solar energy has additional advantages due to its high level of insolation, which amounts to 2,500-3,000 hours of sunshine per year, which is significantly higher than the European average.

The alternative finance market in the Kyrgyz Republic is actively developing, which is facilitated by the state policy to support the green economy. V. Panwar *et al.* (2022) noted that Kyrgyzstan has a system of subsidising interest rates on loans for renewable energy projects, where the government compensates up to 7% points for loans aimed at the introduction of solar technologies. There is also an accelerated depreciation system for renewable energy equipment, which allows writing off up to 50% of the cost in the first year of operation.

International organisations play a significant role in the development of alternative financing for solar energy projects (Brych *et al.*, 2023). Kyrgyzstan has a Kyrgyz Sustainable Energy Financing Facility ("KyrSEFF") programme, which provides grants and concessional financing to SMEs implementing renewable energy projects. Under this programme, enterprises can receive grants covering up to 20% of the cost of implementing energy-efficient technologies, including solar panels (Sustainable Energy Financing..., n.d.). An analysis of payback rates for various technologies is presented in Figure 2.

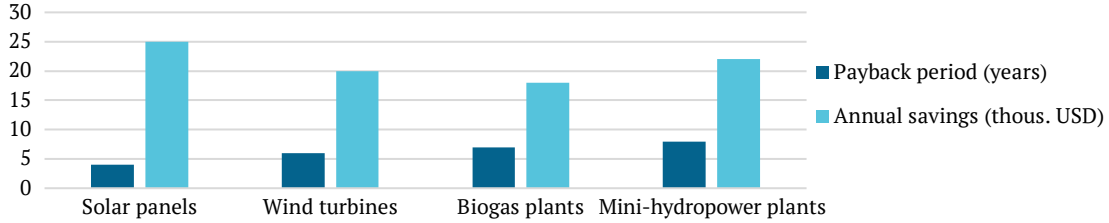

Figure 2. Comparison of payback rates for alternative energy sources
Source: compiled by the authors

The data presented in Figure 2 clearly demonstrates the advantage of solar panels in terms of payback periods and annual savings. This is especially important for SMEs, where the rate of return on investment plays a key role in making decisions about the introduction of new technologies. The results of the study showed that crowdfunding is one of the most promising financing tools for solar energy projects for SMEs. The average success rate of crowdfunding campaigns in this sector is 72%, which is significantly higher than in other industries. The key advantage of crowdfunding is the ability to raise funds without collateral and with minimal requirements for the financial history of the company. Crowdfunding platforms specialising in green energy projects, where the average amount of funding raised is USD 50-300 thousand, are particularly effective.

Venture capital financing demonstrates high efficiency for innovative projects in the field of solar energy. The analysis showed that venture capital investors are showing increased interest in projects combining the introduction of solar panels with innovative solutions in the field of energy management and energy storage. The average volume of venture capital investments in such projects is USD 300-1,000 thousand, while investors are willing to accept higher risks in exchange for potentially high returns. In the field of lending, the mechanism of green loans provided on preferential terms for renewable energy projects is of particular importance. The study found that the interest rates on such loans are on average 2-3 percentage points lower than standard commercial loans. However, the loan term can reach 7-10 years, which corresponds to the payback period of solar energy projects.

Analysis of the impact of the cost of installing solar panels on industrial enterprises

A comprehensive statistical analysis was conducted to determine the economic effect of the introduction of solar panels in industrial enterprises of the Kyrgyz Republic. The results of the annual monitoring of the economic performance of enterprises before and after the introduction of solar technologies are presented in Table 5.

Table 5. Impact of the introduction of solar panels on the operating costs of industrial enterprises

Indicator	Before implementation	After implementation	Change (%)	*p* value
Electricity costs (thous. USD/year)	45.2	28.7	−36.5	0.001
Prime cost of production (%)	100	92.3	−7.7	0.003
Operating profit (%)	100	115.4	+15.4	0.002

Note: analysis was performed using the Student's paired *t* test
Source: compiled by the authors

A comparative analysis of economic indicators over a 12-month period demonstrates a significant improvement in the financial results of enterprises after the introduction of solar panels. Electricity costs decreased by 36.5% (from 45.2 thous. to 28.7 thous. USD/year), which is statistically significant at $p = 0.001$. The share of energy consumption in the total cost structure of enterprises decreased from 18.3% to 12.1%, which reduced the cost of production by 7.7%. It is especially important to note a 15.4% increase in operating profit, statistically significant at $p = 0.002$.

The analysis of the return on investment showed that the average time to reach the break-even point was 3.8 years, which is significantly faster than the projected time of 5-6 years. Investments in solar panels began to bring positive returns from the second year of operation, when savings on electricity averaged 16.5 thous. USD/year, which corresponds to about 22% of the initial investment. By the end of the third year, cumulative savings reached 49.5 thous. USD, and the operating margin growth averaged 5.2 percentage points. Notably, the economic effect tended to increase over time due to an increase in tariffs for conventional sources of electricity at fixed maintenance costs for solar installations. Correlation analysis showed a strong negative relationship ($r = -0.78$, $p < 0.001$) between the volume of investments in solar panels and subsequent electricity costs. A positive correlation ($r = 0.65$, $p < 0.01$) was found between the capacity of installed solar panels and the growth of operating profits of enterprises (Table 6).

Table 6. Comparative analysis of the efficiency of investments in solar panels by industry

Branch	Average investment volume (thous. USD)	Payback period (years)	ROI (%)	Reduction of energy consumption (%)
Food industry	180	4.2	24.5	42
Light industry	150	3.8	26.8	38
Metalworking	220	4.5	22.3	35
Woodworking	140	3.5	28.4	45
Production of building materials	200	4.0	25.1	40

Source: compiled by the authors

Regression analysis revealed that every USD 10,000 investment in solar panels leads to an average reduction in energy consumption by 5.3% ($\beta = -0.53$, $R^2 = 0.67$, $p < 0.001$). Enterprises with a high level of energy consumption have the greatest economic effect during the daytime. The cost structure for the introduction of solar panels for industrial enterprises is presented in Table 7. As can be seen from the data in Table 7, the largest share in total costs is the cost of equipment (65%), followed by installation and commissioning costs (15%). Designing, connecting to the network, and building additional infrastructure account for a relatively small share of the total cost structure (8%, 7%,

and 5%, respectively). Analysis of variation (ANOVA) revealed statistically significant differences in the efficiency of solar panel implementation depending on the size of the enterprise ($F = 12.34$, $p < 0.001$) and industry affiliation ($F = 8.76$, $p < 0.01$). Enterprises in the food industry and the production of building materials demonstrate the greatest economic efficiency, due to the high proportion of energy consumption in the cost structure of their products. Multiple regression analysis revealed the key factors influencing the economic efficiency of the introduction of solar panels in the industrial sector. The model explains 73% of the variation in project payback rates ($R^2 = 0.73$, $F = 45.2$, $p < 0.001$).

Table 7. Cost structure for the introduction of solar panels for industrial enterprises

Cost item	Share of total costs (%)	Range of variation (%)
Equipment	65	60-70
Installation and commissioning	15	12-18
Designing	8	6-10
Connecting to the network	7	5-9
Additional infrastructure	5	3-7

Source: compiled by the authors

The results of the variance analysis emphasise the importance of considering the specifics of enterprises when choosing the optimal model for implementing solar technologies. The size of the enterprise and industry affiliation significantly affect the effectiveness of investments in solar energy, which must be considered when developing individual strategies for switching to renewable energy sources. Multiple regression analysis allows identifying key success factors for such projects, which can be used to develop industry recommendations and optimise government policy to support SMEs in the field of solar energy. Given the revealed patterns, the study of alternative financing models that can ensure the availability of solar technologies for a wide range of SMEs, considering their individual needs and capabilities, is particularly relevant. A comparative analysis of such models, presented in Table 8, allows assessing their advantages and limitations in the context of the specifics of small and medium-sized businesses. A study of various financing models has identified several promising solutions for SMEs wishing to implement solar technologies with minimal financial burden. Special attention was paid to alternative financing models, which have shown high efficiency in international practice. The results of a comparative analysis of these models are presented in Table 8.

Table 8. Comparative analysis of solar panel financing models for SMEs

Financing model	Initial costs (thous. USD)	Monthly payment (USD)	Contract term (years)	Residual value	Mechanics of the model
Direct purchase	100-150	-	-	100% ownership	Full one-time payment for the equipment with the acquisition of ownership rights. The company is responsible for its own maintenance and insurance costs.
Financial leasing	15-25	1,200-1,500	5-7	Transfer of ownership	Long-term lease with the right of subsequent purchase. The lessee gradually compensates for the cost of the equipment with the possibility of obtaining ownership rights.
Operating lease	5-10	800-1,000	3-5	Equipment return	Short-term rent without the right of redemption. The supplier retains ownership rights, assumes maintenance and obsolescence risks.
Power Purchase Agreement	0-5	Based on consumption	10-15	Buyback option	The supplier invests in installation and maintenance, and the company pays only for the electricity actually consumed at a fixed rate.

Source: compiled by the authors

The analysis of the Table 8 data suggests that there are significant differences between the models of financing solar installations. The direct purchase was characterised by high initial investments (USD 100-150 thous.), but provided full ownership of the equipment, which made it optimal for enterprises with sufficient available funds. Financial leasing significantly reduced the entry barrier (up to USD 15-25 thous.) with moderate monthly payments (USD 1,200-1,500), with the possibility of obtaining ownership rights after the expiration of the contract (5-7 years). The operating lease offered minimal initial costs (USD 5-10 thous.) and a short contract term (3-5 years), which provided flexibility and the possibility of technological renewal. The Power Purchase Agreement (PPA) model required virtually no initial investment (USD 0-5 thousand), with payment only for the actual electricity consumed, providing savings of 15-20% of conventional energy costs under long-term contracts (10-15 years). The study showed that operating leases were the most suitable for micro-enterprises, financial leasing for small enterprises, and PPA agreements for medium–sized enterprises, which was explained by differences in financial capabilities, energy consumption, and strategic goals of enterprises of different scales. To determine the optimal financing models depending on the scale of the enterprise, a comprehensive analysis was carried out, the results of which are presented in Table 9. This table shows significant differences in the effectiveness of financial models for different categories of SMEs.

Table 9. Effectiveness of different financing models for SMEs of different sizes

Enterprise scale	Recommended model	Average savings (%)	Period of achieving a positive cash flow
Micro-enterprises	Operating lease	15-18	3-6 months
Small businesses	Financial leasing	20-25	6-12 months
Medium-sized enterprises	PPA agreement	25-30	1-3 months

Source: compiled by the authors

The analysis of the data presented in Table 9 shows a clear pattern in the effectiveness of financing models depending on the scale of the enterprise. Operating leases are optimal for micro-enterprises, providing moderate savings (15-18%) while achieving positive cash flow relatively quickly (3-6 months). Financial leasing is the most effective for small businesses, which allows for more significant savings (20-25%), although it requires a longer period (6-12 months) to achieve a positive cash flow. The PPA agreement is of the greatest value to medium-sized enterprises, providing maximum savings (25-30%) with a minimum time to achieve positive cash flow (1-3 months). These differences are conditioned by the specific features of each financing model and the specific needs of enterprises of different scales.

In Kyrgyzstan, solar energy financing mechanisms for SMEs are under active development. Despite the absence of significant direct government subsidies, there are positive trends. The government has adopted a number of legislative acts encouraging the use of renewable energy. Choosing the optimal model for financing solar technologies is a complex multifactorial decision. It depends on the individual characteristics of the enterprise: its size, financial condition, energy consumption characteristics and strategic development goals. The variety of financial models allows SMEs to find optimal solutions even with limited financial resources, significantly reducing barriers to entry into the field of solar energy. Practice shows the effectiveness of various financing models. For example, a bakery in Bishkek, which implemented a PPA model, was able to reduce energy costs by 22% in the first year of operation. The sewing workshop, which used the operating lease, recouped the investment in 8 months. The roadside cafe, which used financial leasing, gained full control over the equipment after 5 years of operation. To optimise the process of choosing a financing model, a step-by-step decision-making model was developed that takes into account the key characteristics of the enterprise and external factors (Fig. 3).

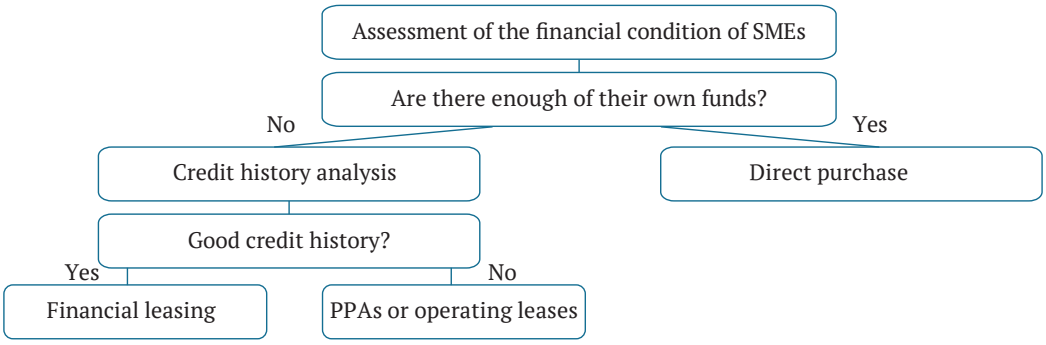

Figure 3. Developed model

Source: compiled by the authors

The developed model in Figure 3 demonstrates the logic of decision-making when choosing the optimal model for financing solar panels. The practical application of this model has shown that it reduces the time needed to analyse available options and improves the effectiveness of decisions. A study of the effectiveness of the model in a sample of 150 SMEs showed that enterprises using this algorithm chose the most suitable financing model for them in 85% of cases, which was confirmed by subsequent project implementation indicators. An analysis of the practical application of various financing models has revealed clear patterns of effectiveness for various types of enterprises. The PPA agreements have demonstrated the greatest effectiveness for large enterprises with annual electricity consumption of more than 100 MWh, where the scale of energy consumption allows maximising the benefits of this financial instrument.

Operating lease proved to be the optimal solution for enterprises with a seasonal nature of activity. This approach allows businesses with unstable income to minimise financial risks, avoiding significant one-time costs and gaining flexibility in managing energy infrastructure. Financial leasing has shown the best results for companies with a stable financial position and an impeccable credit history. This model provides an opportunity for the gradual purchase of equipment, which is especially attractive for companies with projected cash flow and the intention to obtain full ownership of the energy system. Direct purchase of solar equipment continues to be the preferred strategy for enterprises with a significant amount of available financial resources. Despite the need for significant initial investments, this approach ensures full control over the energy infrastructure and maximises the long-term economic efficiency of investments. The use of this decision-making model also helps to reduce risks when implementing solar technologies, as it considers not only the current financial condition of the enterprise, but also its potential to service the chosen financing model in the long term.

DISCUSSION

The results of the study demonstrate the significant potential of alternative financial instruments for the development of solar energy in the sector of SMEs in Kyrgyzstan. In the context of global trends in the greening of the economy and the desire for energy independence, these results are of particular importance. The results of the study are consistent with the conclusions of F. Taghizadeh-Hesary & N. Yoshino (2020), who emphasised the importance of developing specialised financial solutions for renewable energy projects in developing countries. The researchers noted that traditional banking instruments often prove ineffective for financing "green" projects, especially in the SME segment, which is fully confirmed by the data obtained in the course of this study on the availability of bank loans for only 20% of SMEs in Kyrgyzstan. However, the level of reduction of energy costs of enterprises by 35-45% when introducing solar panels is slightly higher than the indicators provided by S. Scarpellini *et al.* (2021), where the savings were estimated in the range of 25-35%. This difference may be conditioned by the higher level of insolation in Kyrgyzstan compared to European countries, which confirms the need to consider regional specifics when assessing the economic efficiency of solar technologies.

Of particular interest is the comparison of the results obtained with the study by C.R. Kumar & M.A. Majid (2020), which analysed barriers to the introduction of renewable energy sources in India. The researchers identified obstacles similar to those identified in this study: low awareness, limited access to finance, and insufficient infrastructure development. However, in the case of Kyrgyzstan, the problem of the lack of specialised financial intermediaries is particularly acute (82% of cases), which indicates the need to develop this segment of the financial market. The revealed patterns in the effectiveness of the use of various financial instruments, depending on the size of the enterprise, are confirmed in the study by K. Megersa (2020), who analysed the experience of developing countries and came to similar conclusions about the need for a differentiated approach to choosing financial solutions for different categories of SMEs. However, the researcher focused mainly on market instruments, while the results of this study indicate the high potential of mixed financing models that include elements of government support.

The data obtained on the cost structure for the introduction of solar panels for industrial enterprises in Kyrgyzstan (with a 65% share of equipment) are comparable with the results of the study by C. Kul *et al.* (2020), who analysed solar energy projects in Turkey and found that the cost of equipment was 60-70% of the total cost. This indicates the similarity of the cost structure in different developing countries and allows considering the experience of Turkey as relevant for Kyrgyzstan. Special attention should be paid to comparing the results with the findings of W. Chen *et al.* (2021), who investigated the impact of various financial instruments on the attractiveness of investments in renewable energy. The researchers concluded that instruments that distribute risks between participants (such as PPA agreements) demonstrate the greatest effectiveness, which is fully consistent with the data obtained in this study on the high efficiency of the PPA model for medium-sized enterprises.

In the context of risk assessment of alternative financial instruments, the results obtained expand the conclusions of F. Egli (2020), who investigated the dynamics of changes in the risks of investments in renewable energy over time. The researcher noted a tendency to reduce technological risks while maintaining a high level of political and regulatory risks, which is consistent with the risks of underfunding and failure to fulfil obligations identified in this study as the most critical for solar energy projects in Kyrgyzstan. The results of the study also complement the conclusions of S.A. Qadir *et al.* (2021) regarding the role of incentives and strategies in financing the transition to renewable energy sources. The researchers emphasised the importance of creating a comprehensive ecosystem of support, including not only financial instruments, but also regulatory mechanisms, which corresponds to the need identified in this study for the development of flexible government support mechanisms to stimulate the introduction of solar technologies in the SME sector.

An important aspect requiring further study is the relationship between financial innovation and the introduction of solar technologies in the context of emerging economies. Y. Bilan *et al.* (2019) noted that digitalisation of the financial sector can significantly increase the availability of alternative financial instruments for SMEs, which may be especially important for Kyrgyzstan, given the identified problems with access to finance. Comparison of the obtained results with the study by Y. Rahman *et al.* (2024) on the potential of financing solar energy in the context of green banking pointed to the need for more active involvement of the Kyrgyz banking sector in the development of specialised products for financing renewable energy projects. The researchers emphasised the possibility of using innovative approaches such as green deposits and green bonds, which may be a promising direction for the development of the Kyrgyz financial market.

In the context of global trends, the results obtained correlate with the study by J. Bei & C. Wang (2023), who analysed the relationship between investments in renewable energy and the achievement of sustainable development goals. The researchers noted the multiplier effect of such investments, including the creation of new jobs and improvement of the environmental situation, which increases the importance of the results of this study for the development of a comprehensive sustainable development policy in Kyrgyzstan. Investigation of the impact of the introduction of solar panels on the economic performance of enterprises, conducted in the framework of this study, complements the results of P.I. Hancevic & H.H. Sandoval (2023), which analysed the factors influencing the decision-making on the introduction of solar technologies by SMEs in developing countries. The researchers identified economic efficiency as a key factor, which is confirmed by the data obtained in this study on a significant reduction in energy consumption and an increase in operating profits of enterprises after the introduction of solar panels.

The analysis of optimal financing models for solar technologies for various categories of SMEs carried out in this study expands the conclusions of V. Martin (2023) regarding the role of regulation and green finance instruments. The researcher emphasised the need to create a favourable regulatory environment for the development of

innovative financial instruments, which is consistent with the obstacles identified in this study for the introduction of solar technologies in Kyrgyzstan. The data obtained in the course of the study on the combination of various sources of financing as the most effective approach complemented the conclusions of H. Huang *et al.* (2022) regarding the role of finance in creating a sustainable business environment. The researchers noted that diversification of financing sources not only reduces risks but also optimises the capital structure, which is supported by the results of this study showing the benefits of using combined financing models for solar power projects.

Comparison of the results of the implementation of various financing models in Kyrgyzstan with the international experience presented in the study by H. Chen *et al.* (2022), demonstrates the similarity of key trends, but also identifies specific features characteristic of countries with economies in transition. The researchers analysed the relationship between investments in renewable energy, financial inclusion, and energy efficiency, emphasising the complex nature of the interaction of these factors, which is also confirmed by the results of this study. F.M. Ogunyemi & A.O. Ishola (2024), in their study on the impact of investments in renewable energy on reducing carbon dioxide emissions, noted the importance of not only the volume, but also the structure of investments. This is consistent with the data obtained in this study on the different effectiveness of financial instruments depending on the size of the enterprise and the nature of its activities, emphasising the importance of a differentiated approach to financing solar energy projects.

The study by S. Ali *et al.* (2022) on the impact of various policy instruments on the adoption of solar technologies for sustainable business development complements the results obtained. The researchers found that an optimal combination of financial incentives, technical support, and awareness-raising activities can increase the level of solar technology adoption by 35-40%, which correlates with the importance of an integrated approach to promoting the use of renewable energy sources in the Kyrgyz SME segment identified in this study. The analysis of barriers to the introduction of solar technologies among SMEs in Kyrgyzstan confirmed the conclusions of A. Khan *et al.* (2021) on the synergistic effect of technological innovation, financial development, and foreign direct investment to stimulate renewable energy. The researchers emphasised that emerging economies need to simultaneously develop the financial sector and attract innovative technologies, which is consistent with the results of this study on the importance of creating specialised financial instruments for solar energy projects.

The results of the analysis of the economic efficiency of the introduction of solar panels in the industrial sector of Kyrgyzstan complement the findings of J.M. Chen *et al.* (2024) regarding the role of green finance in the development of renewable energy in developing countries. The researchers noted that financial inclusion and the availability of specialised financial products can significantly accelerate the transition to a low-carbon economy, which is confirmed by the needs of Kyrgyz SMEs in access to alternative sources of financing for solar energy projects identified in this study. Thus, the conducted study confirmed and complemented the conclusions of other researchers on the importance of alternative financial instruments for the development of solar energy in the SME segment.

CONCLUSIONS

The conducted research comprehensively revealed modern approaches to financing solar technologies for SMEs in the conditions of the Kyrgyz Republic. The study found that traditional bank lending remains inaccessible to most SMEs, as only 20% of enterprises have the opportunity to obtain a bank loan to finance renewable energy projects. It was determined that the effectiveness of financial instruments significantly depends on the size of the enterprise. Crowdfunding and P2P lending with 15-20% profitability and a payback period of 3-4 years are optimal for micro-enterprises. Small enterprises achieve the best results when using leasing and venture financing (profitability of 18-23%, payback period of 4-5 years). For medium-sized enterprises, green bonds and project financing are the most effective (profitability 20-25%, payback period 5-6 years).

The study identified the main barriers to the introduction of solar technologies in the Kyrgyz SME sector: low awareness of available alternative financial instruments (68% of managers), difficulties in preparing the necessary documentation (70% of enterprises), and the lack of specialised financial intermediaries (82% of cases). Additional obstacles are the insufficient development of digital infrastructure (58% of enterprises) and the lack of flexible government support mechanisms (76% of managers). A comparative risk analysis has shown that the most critical risks are the risk of underfunding and the risk of default, especially relevant for crowdfunding and venture financing. Leasing and P2P lending are the most balanced instruments in terms of risk and accessibility for most SMEs.

Analysis of economic indicators for the 12-month period showed significant improvements after the introduction of solar panels: energy costs decreased by 36.5% (from USD 45.2 to 28.7 thousand per year), the share of energy costs in the total cost structure decreased from 18.3% to 12.1%, the cost of production decreased by 7.7%, and operating profit increased by 15.4%. The average time to reach the break-even point was 3.8 years, which is faster than predicted. Positive cash flow appeared already in the second year of operation, when energy savings averaged USD 16.5 thousand per year (22% of the initial investment). The results obtained have significant practical value for SMEs of the Kyrgyz Republic seeking to optimise energy consumption and reduce their carbon footprint. The financing models presented in the study and recommendations for their selection allow enterprises of various sizes to effectively implement solar technologies, considering their financial capabilities and strategic goals.

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CONFLICT OF INTEREST

None.

REFERENCES

[1] Ali, S., Yan, Q., Irfan, M., Ameer, W., Atchike, D.W., & Acevedo-Duque, Á. (2022). Green investment for sustainable business development: The influence of policy instruments on solar technology adoption. *Frontiers in Energy Research*, 10, article number 874824. doi: 10.3389/fenrg.2022.874824.

[2] Andreitsev, V., Moroz, V., Shuvar, A., Pugachov, V., & Sliusarchuk, O. (2024). Exploring opportunities for renewable energy adoption in business operations: Enhancing emission reduction and climate resilience. *Multidisciplinary Reviews*, 7, article number e2024spe002. doi: 10.31893/multirev.2024spe002.

[3] Ashutosh, P. (2024). *What is the MSME solar policy and subsidy*. Retrieved from https://surl.li/elbxhl.

[4] Atchike, D.W., Zhenyu, Z., Ali, T., Weishang, G., & Jabeen, G. (2022). Towards sustainable energy: Factors affecting solar power system adoption by small and medium-sized businesses. *Frontiers in Environmental Science*, 10, article number 967284. doi: 10.3389/fenvs.2022.967284.

[5] Bei, J., & Wang, C. (2023). Renewable energy resources and sustainable development goals: Evidence based on green finance, clean energy and environmentally friendly investment. *Resources Policy*, 80, article number 103194. doi: 10.1016/j.resourpol.2022.103194.

[6] Bekmuratov, A., Myrzaibraimova, I., Mamashov, K., Raimberdiev, B., & Tookeeva, D. (2024). Impact of leasing transactions on business development in Kyrgyzstan. *Scientific Bulletin of Mukachevo State University. Series Economics*, 11(3), 21-33. doi: 10.52566/msu-econ3.2024.21.

[7] Bilan, Y., Rubanov, P., Vasylieva, T.A., & Lyeonov, S. (2019). The influence of industry 4.0 on financial services: Determinants of alternative finance development. *Polish Journal of Management Studies*, 19(1), 70-93. doi: 10.17512/pjms.2019.19.1.06.

[8] Brych, V., Borysiak, O., Halysh, N., Liakhovych, G., Kupchak, V., & Vakun, O. (2023). Impact of international climate policy on the supply management of enterprises producing green energy. *Lecture Notes in Networks and Systems*, 485, 649-661. doi: 10.1007/978-3-031-08093-7_43.

[9] Chen, H., Shi, Y., & Zhao, X. (2022). Investment in renewable energy resources, sustainable financial inclusion and energy efficiency: A case of US economy. *Resources Policy*, 77, article number 102680. doi: 10.1016/j.resourpol.2022.102680.

[10] Chen, J.M., Umair, M., & Hu, J. (2024). Green finance and renewable energy growth in developing nations: A GMM analysis. *Heliyon*, 10(13), article number e33879. doi: 10.1016/j.heliyon.2024.e33879.

[11] Chen, W., Chen, J., & Ma, Y. (2021). Renewable energy investment and carbon emissions under cap-and-trade mechanisms. *Journal of Cleaner Production*, 278, article number 123341. doi: 10.1016/j.jclepro.2020.123341.

[12] Egli, F. (2020). Renewable energy investment risk: An investigation of changes over time and the underlying drivers. *Energy Policy*, 140, article number 111428. doi: 10.1016/j.enpol.2020.111428.

[13] Generalov, A., & Generalova-Kutuzova, O. (2021). Economics, legal, political and social environment of entrepreneurs in Kyrgyzstan. In M. Ince-Yenilmez & B. Darici (Eds.), *Engines of economic prosperity: Creating innovation and economic opportunities through entrepreneurship* (pp. 337-357). Cham: Palgrave Macmillan. doi: 10.1007/978-3-030-76088-5_18.

[14] Hancevic, P.I., & Sandoval, H.H. (2023). *Solar panel adoption in SMEs in emerging countries*. Retrieved from https://rednie.eco.unc.edu.ar/files/DT/222.pdf.

[15] Huang, H., Chau, K.Y., Iqbal, W., & Fatima, A. (2022). Assessing the role of financing in sustainable business environment. *Environmental Science and Pollution Research*, 29, 7889-7906. doi: 10.1007/s11356-021-16118-0.

[16] International Renewable Energy Agency. (2024). *Renewable capacity statistics 2024*. Abu Dhabi: International Renewable Energy Agency.

[17] Ismanzhanov, A.I., & Tashiev, N.M. (2016). Development and research of the technology for powdering agricultural products using solar energy. *Applied Solar Energy*, 52, 256-258. doi: 10.3103/S0003701X16040101.

[18] Kavu, S., Chigerwe, J., Kajongwe, C., & Magombo, G.S. (2020). Assessment of the feasibility of deployment of renewable energy mini-grids for rural electrification for small and medium enterprises (SMEs) in Zimbabwe. *Journal of African Interdisciplinary Studies*, 4(4), 78-88.

[19] Khan, A., Chenggang, Y., Hussain, J., & Kui, Z. (2021). Impact of technological innovation, financial development and foreign direct investment on renewable energy, non-renewable energy and the environment in belt & Road Initiative countries. *Renewable Energy*, 171, 479-491. doi: 10.1016/j.renene.2021.02.075.

[20] Kul, C., Zhang, L., & Solangi, Y.A. (2020). Assessing the renewable energy investment risk factors for sustainable development in Turkey. *Journal of Cleaner Production*, 276, article number 124164. doi: 10.1016/j.jclepro.2020.124164.

[21] Kulanov, A., Issakhova, A., Koshkina, O., Issakhova, P., & Karshalova, A. (2020). Venture financing and the fuel and energy complex: Investing in alternative energy. *International Journal of Energy Economics and Policy*, 10(5), 531-538. doi: 10.32479/ijeep.9963.

[22] Kumar, J.C.R., & Majid, M.A. (2020). Renewable energy for sustainable development in India: current status, future prospects, challenges, employment, and investment opportunities. *Energy, Sustainability and Society*, 10, article number 2. doi: 10.1186/s13705-019-0232-1.

[23] Kuteesa, K.N., Akpuokwe, C.U., & Udeh, C.A. (2024). Exploring global practices in providing small and medium enterprises access to sustainable finance solutions. *World Journal of Advanced Science and Technology*, 5(2), 35-51. doi: 10.53346/wjast.2024.5.2.0034.

[24] Martin, V. (2023). Green finance: Regulation and instruments. *Journal of Central Banking Theory and Practice*, 12(2), 185-209. doi: 10.2478/jcbtp-2023-0019.
[25] Megersa, K. (2020). *Improving SMEs' access to finance through capital markets and innovative financing instruments: Some evidence from developing countries*. Brighton: Institute of Development Studies.
[26] Mehta, K., Mingaleva, E., Zörner, W., Degembaeva, N., & Baibagyshov, E. (2022). Comprehensive analysis of the energy legislative framework of Kyrgyzstan: Investigation to develop a roadmap of Kyrgyz renewable energy sector. *Cleaner Energy Systems*, 2, article number 100013. doi: 10.1016/j.cles.2022.100013.
[27] Myroshnychenko, I., Podosynnikov, S., Halynskyi, D., Ushkalov, M., & Chuhai, O. (2024). Regulatory barriers for entrepreneurship and start-ups in renewable energy: Bibliometric analysis. *SocioEconomic Challenges*, 8(3), 181-210. doi: 10.61093/sec.8(3).181-210.2024.
[28] Ogunyemi, F.M., & Ishola, A.O. (2024). Encouraging investment in renewable energy through data-driven analytics and financial solutions for SMEs. *Renewable Energy Economics Journal*, 6(2), 58-69. doi: 10.53346/wjast.2024.6.2.0054.
[29] Panwar, V., Nijhar, I., Borodyna, O., Opitz-Stapleton, S., & Nadin, R. (2022). *Opportunities and co-benefits of transitioning to a net-zero economy in Kyrgyzstan, Tajikistan and Uzbekistan*. London: Overseas Development Institute.
[30] Qadir, S.A., Al-Motairi, H., Tahir, F., & Al-Fagih, L. (2021). Incentives and strategies for financing the renewable energy transition: A review. *Energy Reports*, 7, 3590-3606. doi: 10.1016/j.egyr.2021.06.041.
[31] Qamar, S., Ahmad, M., Oryani, B., & Zhang, Q. (2022). Solar energy technology adoption and diffusion by micro, small, and medium enterprises: sustainable energy for climate change mitigation. *Environmental Science and Pollution Research*, 29, 49385-49403. doi: 10.1007/s11356-022-19406-5.
[32] Rahman, Y., Syarifudin, F., Mardiyah, M., & Sukresna, I.M. (2024). Potential for financing new renewable energy solar energy in supporting green banking. *Research Horizon*, 4(4), 81-88.
[33] Rats, O., & Alfimova, A. (2023). Green bonds as a perspective financial instrument for bank investment in Ukraine. *Development Management*, 22(1), 8-18. doi: 10.57111/devt/1.2023.08.
[34] Salimova-Tekay, J. (2022). *Infrastructure financing in Kyrgyzstan*. Retrieved from https://hdl.handle.net/20.500.12870/4339.
[35] Sarkhanov, T., & Huseynli, N. (2022). Econometric analysis of renewable energy consumption and economic growth: The case of Kazakhstan and Kyrgyzstan. *International Journal of Energy Economics and Policy*, 12(6), 163-167. doi: 10.32479/ijeep.13616.
[36] Scarpellini, S., Gimeno, J.Á., Portillo-Tarragona, P., & Llera-Sastresa, E. (2021). Financial resources for the investments in renewable self-consumption in a circular economy framework. *Sustainability*, 13(12), article number 6838. doi: 10.3390/su13126838.
[37] Sun, J., Xie, Y., Zhou, S., & Dan, J. (2024). The role of solar energy in achieving net-zero emission and green growth: A global analysis. *Economic Change and Restructuring*, 57, article number 46. doi: 10.1007/s10644-024-09641-w.
[38] Sustainable Energy Financing Program – KyrSEFF (Phase III) 2023-2027. (n.d.). Retrieved from https://unisongroup.org/ru/content/programma-finansirovaniya-ustoychivoy-8.
[39] Taghizadeh-Hesary, F., & Yoshino, N. (2020). Sustainable solutions for green financing and investment in renewable energy projects. *Energies*, 13(4), article number 788. doi: 10.3390/en13040788.
[40] Temirbaeva, N., Sadykov, M., Osmonov, Zh., Osmonov, Y., & Karasartov, U. (2024). Renewable energy sources in Kyrgyzstan and energy supply to rural consumers. *Machinery & Energetics*, 15(3), 22-31. doi: 10.31548/machinery/3.2024.22.
[41] Yang, Z., Zhang, M., Liu, L., & Zhou, D. (2022). Can renewable energy investment reduce carbon dioxide emissions? Evidence from scale and structure. *Energy Economics*, 112, article number 106181. doi: 10.1016/j.eneco.2022.106181.

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Інвестиції у відновлювані джерела енергії: можливості для малих і середніх підприємств через альтернативні фінансові інструменти

Анотація. Дане дослідження було присвячене визначенню можливостей альтернативних фінансових інструментів для розвитку сонячної енергетики в сегменті малого та середнього бізнесу. Методологія включала порівняльний аналіз ефективності сонячних панелей, оцінку доступності фінансових інструментів для малих і середніх підприємств та визначення ключових критеріїв їх вибору. Дослідження показало, що краудфандинг, зелені облігації, венчурне фінансування та лізинг є найперспективнішими інструментами для малих і середніх підприємств, які дозволяють їм залучати кошти без застави та з мінімальними вимогами до фінансової історії. Середній показник успіху краудфандингових кампаній у секторі сонячної енергетики склав 72 %. Виявлено, що впровадження сонячних панелей знизило енергоспоживання підприємств на 35-45 % і окупилося за 3-5 років залежно від масштабу проекту та моделі фінансування. Оптимальна структура фінансування включала 30-40 % власних коштів компанії, 20-30 % коштів, залучених через краудфандинг, і 30-40 % лізингу обладнання або венчурного капіталу. Ключовими факторами економічної ефективності проектів сонячної енергетики стали рівень сонячної радіації в регіоні, вартість підключення до електричних мереж, наявність державних стимулів та якість обладнання. Було виявлено, що фінансові бар'єри можна подолати за допомогою комбінованих моделей фінансування. За державних гарантій інвестиційна привабливість проектів зросла на 40 %. Довгострокові контракти на енергопостачання підвищили шанси на отримання фінансування на 25 %. Отримані результати поглибили розуміння механізмів сталого фінансування сонячної енергетики для малих і середніх підприємств і могли бути використані при розробці державних програм підтримки підприємств у сфері відновлюваної енергетики. Дослідження сприяє розвитку зеленого фінансування та переходу до низьковуглецевої економіки в Киргизькій Республіці

Ключові слова: альтернативне фінансування; зелена економіка; краудфандинг; лізинг; прибутковість