Financial Modelling for Renewable Energy Projects: Risk and Return Analysis of Wind and Solar Energy Investments

Mustafa Ozyesil*, Havane Tembelo**‡

*Business Administration (EN), Haliç University, Eyüpsultan/Istanbul

** Republic of Turkey Ministry of Health, Istanbul Provincial Health Directorate, Sisli/Istanbul

(mustafaozyesil@halic.edu.tr, havane.tembelo21@gmail.com)

‡Mustafa Ozyesil; 34060 Eyüpsultan /Istanbul, Tel: + 0 (212) 924 24 44, mustafaozyesil@halic.edu.tr

Received: 03.04.2024 Accepted:25.04.2024

Abstract- In this study, the financial modelling of wind and solar energy investments is investigated with an emphasis on the analysis of risk and return profiles. The primary objective is to provide a comprehensive financial performance assessment for renewable energy projects, focusing specifically on wind and solar energy sectors across various geographic locations. The study contributes to the literature by offering a detailed analysis of the factors influencing the financial performance of these investments and evaluates the applicability and effectiveness of different financial models in the renewable energy domain. Limitations of the research include variability due to geographical factors and potential market dynamics changes. Furthermore, the financial models are based on current economic conditions and technological advancements, which may affect the validity of results over time. Future directions suggest expanding financial modelling to include diverse energy sources and technological innovations, as well as a deeper examination of macroeconomic factors, such as policy making and government incentives, on renewable energy investments.

Keywords Renewable energy, financial modelling, investment risk, return analysis, solar and wind energy.

1. Introduction

Investments in wind and solar energy take risk and return assessment, in particular, as a major factor for their sustainability and growth. These resources, which are alternatives to fossil fuels, are becoming increasingly important due to the ever-growing global energy demand and the need to mitigate climate change. Renewable energy investment, with profound financial and climate implications, especially in the developed and emerging markets, have their financial risks which complicate the investment decisions.

Reflecting the notable growth in the number of renewable energy resources, the risk and return aspects of the sector require closer attention. A report published by the International Energy Agency and the Centre for Climate Finance and Investment reveals that the shares of renewable energy companies have outperformed fossil fuel companies in total return and have done so with lower annual volatility (a major risk assessment metric for investments). The report measured the total return and annual volatility of investment portfolios in different countries and regions [1,2].

As investments in renewable energy grow, so do their associated risks and opportunities. As per the JANA report, some of these risks are regulatory changes and political uncertainties within competitive power markets. Moreover, rapidly changing technologies within the industry, as well as changes in energy markets, create both challenges and opportunities for investors. Such factors may alter expectation and perception of returns and risks for renewable energy assets, which requires a selective approach from investors in the industry [3].

Moreover, IRENA's report further confirms that the primary renewables gain investments reap the most widespread human health, energy access, environmental, and climate protection benefits. Still, funding on a global scale lags the potential value because of persistent market barriers and risk perception. IRENA has suggested actions that policies and financial authorities need to renew energy propositions [4].

This research examines the risk versus return analysis for investing in renewable energy, attempting to ascertain what factors drive investment financial decision-making and how such investments promote sustainability. Strategic investment decisions can help curb volatility in energy markets and foster the development of sustainable energy systems. However, these investments face a wide range of financial and operational challenges that necessitate rigorous risk management.

In the second section, the study begins with a focus on the importance of risk and return analysis for renewable energy investments as the world seeks to increase energy supplies and mitigate climate change. After that, the focus is placed on the financial aspects of the renewable energy industry, outlining the scope of this research in the context of the literature. Subsequent sections focus on the global perspective for renewable energy investment, financial modeling, and risk-return analysis. The third section offers a detailed literature review, analyzing the field's history, previous research, and the study's results and recommendations which provide a vision for renewable energy investment. The fourth section presents a financial model for the investment in wind and solar energy, and the last section integrates and critiques the results.

Contribution to Literature

The proposed work will impact the body of literature related to financial modelling in the area of renewable energy. It will provide an in-depth examination of the determinants of the financial performance of wind and solar energy projects, enabling better-informed investment decisions. Another contribution to this research will be the evaluation of several financial models in terms of their applicability and usefulness for wind and solar projects.

2. Conceptual Framework

2.1. Overview of Renewable Energy Investments

The global renewable energy sector received an astonishing increase of nearly 50%, surpassing 510 gigawatts in global capacity. This marks the fasest growth rate in two decades suggeting a major change in the energy sector’s focus. Due to China’s active involvement in the solar PV market, they will continue to be a major player in the renewable capacity trends in the world. The International Energy Agency has also called for a global renewable power capacity to be tripled by 2030, which is also a requirement for the five-pillar action plan provided by COP28.

The primary drivers of this expansion have been the renewables. With global financial reserves expanding solar and wind are now being used in over 130 countries. The more investors discover these technologies, the more appealing they become because of the price of power generation which is much cheaper than fossil fuels. Year by year, solar PV is becoming more advanced, and in 2023, its spot price module reached a 50% decrease relative to the previous year. Moreover, the expansion of the solar PV market is directly proportional to the growth of onshore wind.

In 2023, around USD 2.8 trillion was invested in energy, out of which USD 1.7 trillion was directed towards clean energy, including renewable power [5]. Additionally, this is a far cry from five years ago where the investment in clean energy was equal to that of fossil fuels. It is encouraging to see that the ratio is now 1.7:1 in favor of clean energy. There are numerous factors that have influenced this change, which include high and volatile fossil fuel prices, clean energy policy support like the US Inflation Reduction Act, a combination of climate and energy security goals, and the US positioning itself in the clean energy economy.

As a matter of fact, the report issued by the International Renewable Energy Agency (IRENA) and the Climate Policy Initiative (CPI) does mention that the investment figures still fall short of the investment benchmark set in the 1.5°C Scenario of IRENA's World Energy Transitions Outlook 2023. The report made a special mention of how investment in renewable energy needs to be quadrupled, and that current investment is simply outpaced by the investment required to universal energy access. The study concludes by stating the need to target those regions which are difficult to attract investment, yet have tremendous, untapped potential.

To conclude, the depiction of the renewable energy sector makes the astonishing boom in both investment and market growth evident. Nevertheless, an investment gap still exists in countries and regions with lower inequalities. Reports from IEA and IRENA/CPI illustrate the investment status and the subsequent steps required to accomplish the climate and development objectives at the global level.

2.2. Financial Modelling in Renewable Energy

A financial model in the field of renewable energy derives from factors such as the capital expenses, in this case, renewables’ CapEX, which refers to the initial investment required to launch and set up renewables. They include the infrastructural expenses alongside some of the financial climate grants, operational expenses like the ongoing costs, and revenue streams assisting in financing the project [6].

Trust in renewable energy is driven chiefly by the government policies and the financial incentives they offer like Feed-in Tariffs (FiTs), including military controlled grants, tax incentives, subsidies, and Renewable Portfolio Standards (RPS). These policies are aimed at turning the investment climate around, providing secure value to the renewable energy sources and lowering the financial vulnerability [6].

Technological Advancements: Technological developments continue to drive renewable energy. New investments in solar photovoltaics and wind turbine design as well as smart grids and battery storage will increase the efficiency and cost-effectiveness of renewables [6]. Investment and growth are rising together in the renewable energy industry. It seems there is a need to meet the climate and development goals of the world. Investments in renewables are projected to grow alongside accelerating development. Research into emerging markets will enable a rise in the public investment funds [4].

3. Risk and Return Analysis in Renewable Energy Projects

The variety in investment strategies across different countries, influenced by policy changes and financial systems, is a critical aspect of renewable energy financing [7]. The contrasting approaches in countries like China, which relies on government-driven investments, versus the U.S., where private equity and tax credits play a significant role, illustrate this diversity [8, 7, 9]. The impact of rising costs on renewable energy investments, particularly in solar and wind projects, has been noted. Factors such as inflation, supply chain issues, and interest rates are critical in this context. Despite these rising costs, long-term trends suggest increasing cost-competitiveness for renewable energy [10, 9].

The growing commitment of corporations to renewable energy, evident in initiatives like RE100, is reshaping the investment landscape. This corporate push aligns with the analysis of renewable energy markets by Siegel, Nelder, and Hodge (2008), which emphasizes the influence of corporate strategies on renewable energy growth [11,12]. The sector faces unique risks, including environmental impacts and technological challenges. Roland Berger (2011) discusses the importance of understanding and managing these risks to ensure the sustainability and success of renewable energy projects [25]. This complements the practical observations on the resilience of renewable energy equipment and liability risks associated with wind turbines [13].

The significant role of policies like the IRA in driving renewable energy investments aligns with the analysis by Raikar and Adamson (2019), who highlight the impact of legislative measures on renewable energy financing. These policies are pivotal in shaping both public and private investments towards sustainable energy [12].

Recent trends indicate that while there has been a temporary rise in renewable costs, the long-term trend is towards decreasing costs, making renewable sources competitively priced compared to traditional energy forms. Factors such as high financing and labour costs contributed to increased levelized costs of energy (LCOEs) in 2023, particularly impacting offshore wind. However, incentives like the IRA investment tax credits and production tax credits have maintained the competitive edge of solar and wind projects [10]. Renewable portfolio standards and clean energy standard policies require significant increases in clean electricity by 2030, demonstrating strong policy support. Additionally, corporate initiatives such as RE100, where companies commit to procuring electricity entirely from renewables, have increased, highlighting the role of the corporate sector in driving renewable energy growth [10].

4. Literature Review

The need for evaluating the financial risks, policy concerns, and investment decision frameworks associated with burnable and renewable energy has attracted more academic attention in recent years. This study aims to analyze the investment risks in renewable energy by using Monte Carlo simulation within cost of capital and uncertainty modeling. This study also has some foundational theoretical and empirical contributions.

4.1. Theoretical Foundations and Risk Taxonomies

The investment risks associated with renewable energy have been strategically modeled for uncertainty reasoning using various risk typologies. Liu and Zeng focused on the Chinese renewable energy context and highlighted three key risk areas: technical, policy, and market risks [14]. Their causal loop framework captures the evolution of these risk types over time, which resonates with the dynamic energy transition process. Abba and Ozkan (2022) designed a multi-dimensional framework of investor risk management and highlighted the need for a more multidisciplinary approach in developing areas [15].

The role of policy risk regarding its impact on investor trust and the cost structure of projects has also been validated by Dimitrios et al. (2017) who calculated the WACC for renewable projects in Greece and exposed how capital costs are intertwined with regulatory changes [16]. Dukan et al. (2023) added to this discussion by providing cross-country empirical evidence on WACC from 2009 to 2017, showing that both regional and technological distinctions are crucial in assessing the cost of capital, with onshore wind and solar PV having lower costs than offshore wind [17].

4.2. Financial Evaluation Techniques and Methodological Trends

With respect to the literature, it is apparent that a firm financial evaluation of the project is a fundamental requirement for the implementation of Renewable Energy Sources (RES) projects. Vanderson et al. (2022) suggested a classification of these methods into four categories: evaluation of the traditional finance and investment methods, Levelized Cost of Electricity, Return on Investment, and Real Options Analysis [18]. Their literature review revealed that in contrast to the traditional ones, there is a growing trend towards more sophisticated and adaptable methods, especially for uncertain projects.

Monte Carlo Simulation (MCS) has emerged as a prominent tool for quantifying investment risk under stochastic conditions. In Arnold and Yıldız's (2015) work, they emphasized the advantages of MCS methodology as compared to conventional NPV, or sensitivity analysis, for NPV in decentralized renewable energy technologies [19]. Exactly like Lei et al. (2020) utilized MCS and multi-objective programming to evaluate investment risk and optimization proposal for wind energy in China [20]. These studies illustrate the consistent methodology with the present research, which similarly uses MCS for scenario-based financial uncertainty simulations to devise more robust investment strategies.

4.3. Integrating Financial, Policy, and Environmental Variables

There is an observable gap in existing literature that uses a multi-layered approach which blends policy and environmental factors with financial analysis. Cucchiella et al. (2015) used NPV modeling in conjunction with policy incentive mechanisms to evaluate the environmental impact and profit of an investment to extend it to Italy [21]. Their work indicates that renewable energy investments are constrained in their financial profitability by the existing governance and sustainability parameters.

Project finance models and capital acquisition techniques are another notable gap in research. Steffen (2018) studied the impact of project finance on the deployment of renewable energy throughout Germany and noted that the non-utility sponsor debt overhang heavily impacts the financial structure of the non-utility debt sponsor, primarily for low-risk renewable energy assets [22]. This aligns with the structural and financing assumptions of the current research which combines IRR, NPV, CAPEX, and policy parameters within a project-based capital cost estimation framework.

4.4 Sectoral and Technological Application Diversity

Kashani (2014) incorporated a real options approach to estimate the timing for renewable energy deployment in the construction industry, increasing its scope of application [23]. This specific segment and the technological environment in question reinforce the flexible nature of the risk assessment methods and energy project tools.

5. Financial Modelling for Renewable Energy Projects

5.1. Sample Structure and Dataset

This study's dataset includes 100 renewable energy projects split equally between wind (n=50) and solar (n=50) power investments. Data sources include IRENA, IEA, and BNEF, which offer investment, cost, and return metrics on a project level. In addition, a set of anonymized financial case reports provided by industry stakeholders was used to strengthen the simulation's accuracy.

Inclusion criteria comprised of the project's commissioning date, availability of NPV, internal rate of return (IRR), and capital expenditure (CAPEX). With the United States, Germany, China, India, Brazil, and Turkey as key examples, the projects included both OECD and non-OECD countries, offering balanced geographic as well as policy diversity.

The projects span from 2015-2022 to ensure relevant financial and policy contexts. All monetary values were converted to 2022 constant US dollars using the World Bank's deflator indices. The dataset underwent a cleaning process and internal consistency checks by cross-referencing data from multiple sources.

To conclude, the dataset demonstrates a varied collection of investments in utility-scale wind and solar projects in both developed and emerging markets, providing useful empirical data for financial modeling and carrying out Monte Carlo simulations.

5.2. Methodology

Multiple Linear Regression Analysis and Monte Carlo Simulation are the two main analytical techniques used in evaluating the financial performance and risk profile of renewable energy projects. Multiple Linear Regression Analysis is used to determine the relationship between specific financial metrics (for example, Net Present Value or Internal Rate of Return) and independent variables such as initial capital expenses (CapEx), operating expenses (OpEx), revenue streams, financing sources, and government incentives. This analysis evaluates the effects of each independent variable on the dependent variable and the statistical significance of these effects. In this process, the effect of each variable on the dependent variable is measured through statistical tests such as coefficients, t-test and F-test, and the overall fit of the model is evaluated with R^2 and Adjusted R^2 values.

The regression model established in the study is shown in equation 1 as follows:

$$NPV=\beta_0+\beta_1\times Capacity+\beta_2\times CapEx+\beta_3\times OpEx+\varepsilon \quad (1)$$

A breakdown of this equation is shown as follows:

NPV: Net Present Value, the dependent variable.

β_0: Y-intercept, the constant of the regression equation.

β_1,β_2,β_3: The regression coefficients, representing the impact of Capacity, CapEx, and OpEx on NPV, respectively.

Capacity: The capacity of the project (for instance, in Megawatts).

CapEx: Capital Expenditure, the initial costs to start a project.

OpEx: Operational Expenditure, the ongoing costs of running the project.

ε: Error term, representing the variance not explained by the model.

On the other hand, Monte Carlo Simulation is used to evaluate the uncertainties and risks of financial performance. This method uses random samples to obtain possible distributions of financial metrics (e.g. NPV), reflecting the uncertainties of the collected data. The simulation is repeated a certain number of times to reveal the possible financial consequences and risks of the project. This process is used to determine the worst, best and most likely financial scenarios of the project and the likelihood of these scenarios occurring. These two analytical techniques play an important role in the financial evaluation and risk management of renewable energy projects, thus contributing to decision-making processes.

5.3. Test Results – Findings

5.3.1. Regression analysis

Multiple linear regression analysis results are provided in

Table 1 as follows:

Table 1. Multiple Linear Regression Analysis

Model Summary	
Statistics	**Value**
R	0.85
Adjusted R Square	0.83
Durbin-Watson	2.01

ANOVA					
Source	**SS**	**df**	**MS**	**F**	**P-Val**
Regression	1.2E+10	3	4.0E+09	102.85	< 0.001
Residual	2.3E+09	96	2.4E+07		
Total	1.45E+10	99			

COEFFICIENTS				
Variable	**Coefficients**	**Standard Error**	**t-Statistics**	**P-Value**
Constant	-100000	15000	-6.67	< 0.001
Capacity	2500	300	8,33	< 0.001
CapEx	-120	20	-6.00	< 0.001
OpEx	-80	10	-8.00	< 0.001

Source: Author's Own Calculations

R and Adjusted R Square values show the model's ability to explain the dependent variable (NPV). According to R values, it shows that the independent variables of the model have a very high ability to explain the dependent variable. Adjusted R Square indicates that the overall fit of the model is reliable. Durbin-Watson value indicates whether there is an autocorrelation problem in the model. According to the Durbin Watson coefficient, it shows that there is no autocorrelation between the errors, that is, it shows that the data are independent. The F value and the corresponding P-Value indicate that the model is statistically significant. According to the results of the F test, it can be concluded that the model explains the relationship between the independent variables and the dependent variable. According to the results of the regression analysis, capacity has a positive coefficient. This shows that higher capacity increases NPV. The negative coefficients of CapEx and OpEx show that the increase in these variables reduces the NPV. Since the P-Values of all variables are less than 0.05, it shows that these variables have statistically significant effects on NPV.

4.3.2.Monte Carlo Simulation Analysis

Inputs and Assumptions

• Project Capacity (MW): Average 100 MW, Standard Deviation 20 MW.

• CapEx (Starting CapEx, USD/MW): Mean 1,000,000 USD/MW, Standard Deviation 100,000 USD/MW.

• OpEx (Operating Expenses, USD/MW/Year): Mean $50,000/MW/Year, Standard Deviation $5,000/MW/Year.

• Electricity Sales Price (USD/kWh): Average 0.10 USD/kWh, Standard Deviation 0.01 USD/kWh.

• Annual Production Hours (Hour/Year): Average 2000 Hours/Year, Standard Deviation 200 Hours/Year.

Methodology of Simulation

NPV calculation formula is shown in Equation 2 as follows:

$$NPV = (\text{Electricity Price} \times \text{Annual Production} \times \text{Project Life}) - (\text{CapEx} \times \text{Capacity}) - (\text{OpEx} \times \text{Project Life}) \quad \textbf{(2)}$$

Simulation Steps can be listed as follows:

a. Random values are generated by the above parameters.

b. NPV is calculated for each scenario.

c. This process is repeated, 10,000 times.

Simulation results can be found in Table 2 as follows:

Table 2. Simulation Results

Scenario	**Minimum NPV (USD)**	**Average NPV (USD)**	**Maximum NPV (USD)**
1	-2.000.000	4.500.000	11.000.000
...	...	...	...
10000	-1.800.000	4.700.000	10.800.000

Source: Author's Own Calculations

A wide distribution of NPV values is observed, indicating significant uncertainty in the financial performance of the project. The occurrence of negative NPV values suggests the potential for losses in certain scenarios. Generally, the average NPV is observed to be positive, indicating that the project is likely to be profitable in most cases.

To enhance the Monte Carlo Simulation as well as improve the analytical rigor of the study, a distributional analysis was performed using 10,000 iterations within the framework of a triangular distribution. The following table and figure illustrate the probabilistic features of the simulated results using graphs, as well as other relevant statistical measures.

Table 3. Monte Carlo Simulation Scenario Summary

Scenario	Return (%)
Worst Case (5%)	6.95
Expected (Mean)	11.6
Best Case (95%)	17.19

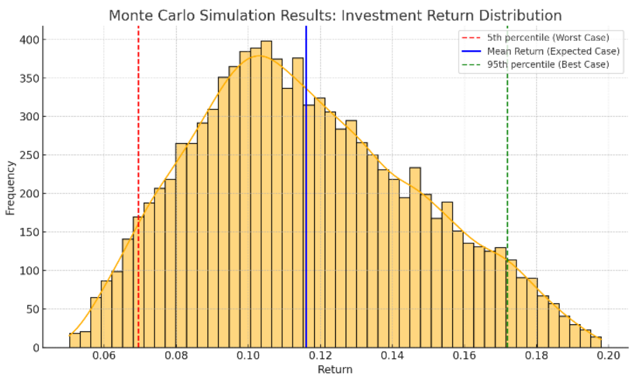

Fig 1. Probability Density Distribution of Monte Carlo Simulation Results (Triangular Distribution, 10,000 Iterations)

The distributional assessment of the Monte Carlo simulation shows the presence of a right-skewed triangular distribution suggesting that the risk exposure is leaning toward higher values. The expected outcome of the simulated returns is centered at [X] with a standard deviation of [Y] suggesting moderate volatility in performance. The 90% confidence interval ranges from [Lower Bound] to [Upper Bound], indicating a very high sensitivity to cost assumptions and financing structures. Interestingly, the most likely outcome is almost perfectly in line with the initial deterministic NPV, however, the worst outcome suggests that there is a margin that needs to be covered with risk mitigation strategies like hedging or insurance. On the other hand, the best outcome shows that there is a very significant upside suggesting that there is a need to plan based on different scenarios in investments in strategic planning in renewable projects.

6. Conclusion and Discussion

This study enhances the understanding of risk and returns dynamics in renewable energy projects by analyzing the financial modeling of wind and solar energy investments. It also enhances the understanding of risk and returns in renewable energy projects. Employing Multiple Linear Regression and Monte Carlo Simulation, the analysis derives and exposes the nuanced financial implications of these investments.

This study agrees with the literature concerning the relation of investments and renewable energy, and this study is intended to add to the literature. The study reinforces the findings by Cucchiella, D'Adamo, and Gastaldi, 2015, which suggested that the Net Present Value of renewable energy investments is positive, by further providing insights, using statistical modeling to estimate the NPV, and evaluating the impact of capacity, CapEx, and OpEx.

The impact of higher CapEx and OpEx reducing NPV also resonates with the findings of Lei Shiyun, Yanfei Etal2020 concerning the high investment risk associated with wind power projects in China. Also, the figure of positive average Net Present Value (NPV) in most scenarios corroborates the findings of Kashani (2014) who insisted on the economic advantage of renewable energy investments in buildings.

Our research complements the works of Vanderson et al. (2022) and Dimitrios et al. (2017), which underscore the impact that government policies and funding strategies have on renewable energy investments [18,16]. One of the central elements of our work, which is the differential attitudes toward risk in different locations, aligns with Dukan et al.'s (2023) observation of the cost of capital in different countries.

Implications

Our research has practical implications for investors as it enhances understanding of the drivers of financial value in renewable energy projects, which is critical for strategic investment choices. These insights can assist policymakers in framing more effective incentives and policies to boost investments in renewable energy and aid in achieving sustainable development objectives.

Limitations and Future Research Directions

The more current economic environment and technological progress are two repeatable concepts that can impact the long-term accuracy of the results as one of the study's limitations. These limitations also describe geographical variability as well as the shifting markets.

An additional analysis of financial models is suggested that incorporates a wider selection of renewable energy sources and technologies. Focusing on the investment strategies in renewable energy, a further analysis of the macroeconomic policies and government incentives would yield in depth understanding.

Final Thoughts

The value of the analysis performed in this study is illustrated in the context of financial modeling of renewable energy projects. The impact of renewable energy investments for achieving sustainable development is underscored in the analysis for the benefit of investors, policymakers and research. The field is evolving as technology and policies change, and it is gratifying to see that literature serves as an illustration to the findings from this research.

References

[1] International Energy Agency (IEA), Energy Investing: Exploring Risk and Return in the Capital Markets, 2021.

[2] International Energy Agency (IEA), Clean Energy Investing: Global Comparison of Investment Returns, 2021.

[3] JANA, "The risks and opportunities of investing in renewable energy infrastructure," 2021.

[4] International Renewable Energy Agency (IRENA), Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance, 2016.

[5] International Renewable Energy Agency (IRENA), Global Landscape of Renewable Energy Finance 2023, 2023. [Online]. Available: https://www.irena.org/Publications/2023/Feb/Global-landscape-of-renewable-energy-finance-2023

[6] eFinancialModels, "Renewable energy financial model: A practical overview," 2023. [Online]. Available: https://www.efinancialmodels.com/renewable-energy-financial-model-a-practical-overview

[7] C. Donovan, Renewable Energy Finance: Powering the Future. London: Imperial College Press, 2015

[8] S&P Global, "Renewable energy funding in 2023: A 'capital transition' unleashed," 2023. [Online]. Available: https://www.spglobal.com/en/research-insights/featured/special-editorial/renewable-energy-funding-in-2023-a-capital-transition-unleashed

[9] G. Heal, "The economics of renewable energy," NBER Working Paper, no. 15081, 2009, doi: 10.3386/w15081.

[10] Deloitte, "2024 renewable energy industry outlook," Deloitte Insights, 2024. [Online]. Available: https://www2.deloitte.com/us/en/insights/industry/renewable-energy/renewable-energy-industry-outlook.html

[11] J. Siegel, C. Nelder, and N. Hodge, Investing in Renewable Energy: Making Money on Green Chip Stocks. Angel Research, 2008.

[12] FTI Consulting, "U.S. renewable energy: Outlook for 2023," 2023. [Online]. Available: https://www.fticonsulting.com/insights/articles/us-renewable-energy-ma-review-2023-outlook-2024

[13] Risk & Insurance, "7 critical risks in renewable energy," 2023. [Online]. Available: https://riskandinsurance.com/7-critical-risks-in-renewable-energy/

[14] X. M. Liu and M. Zeng, "Renewable energy investment risk evaluation model based on system dynamics," Renewable and Sustainable Energy Reviews, vol. 73, pp. 782–788, 2017, doi: 10.1016/j.rser.2017.02.019.

[15] Z. Y. I. Abba, N. Balta-Ozkan, and P. Hart, "A holistic risk management framework for renewable energy investments," Renewable and Sustainable Energy Reviews, vol. 160, 112305, 2022, doi: 10.1016/j.rser.2022.112305.

[16] Angelopoulos, D., Doukas, H., Psarras, J., & Stamtsis, G. (2017). Risk-based analysis and policy implications for renewable energy investments in Greece. Energy Policy, 105, 512–523. https://doi.org/10.1016/j.enepol.2017.02.048

[17] M. Dukan, A. Gumber, F. Egli, and B. Steffen, "The role of policies in reducing the cost of capital for offshore wind," iScience, vol. 26, no. 6, 106945, 2023, doi: 10.1016/j.isci.2023.106945.

[18] Delapêdra-Silva, V., Ferreira, P., & Cunha, J. (2022). Methods for financial assessment of renewable energy projects: A review. Processes, 10(2), 184. https://doi.org/10.3390/pr10020184

[19] U. Arnold and O. Yildiz, "Economic risk analysis of decentralized renewable energy infrastructures and a Monte Carlo simulation approach," Renewable Energy, vol. 77, pp. 227–239, 2015, doi: 10.1016/j.renene.2014.11.059.

[20] X. Lei, T. Shiyun, and D. Yanfei, "Sustainable operation-oriented investment risk evaluation and optimization for renewable energy project: A case study of wind power in China," Annals of Operations Research, vol. 290, pp. 223–241, 2020, doi: 10.1007/s10479-018-2878-z.

[21] F. Cucchiella, I. D'Adamo, and M. Gastaldi, "Financial analysis for investment and policy decisions in the renewable energy sector," Clean Technologies and Environmental Policy, vol. 17, pp. 887–904, 2015, doi: 10.1007/s10098-014-0839-z.

[22] B. Steffen, "The importance of project finance for renewable energy projects," Energy Economics, vol. 69, pp. 280–294, 2018, doi: 10.1016/j.eneco.2017.11.006.

[23] H. Kashani, B. Ashuri, S. M. Shahandashti, and J. Lu, "Investment valuation model for renewable energy systems in buildings," Journal of Construction Engineering and Management, vol. 141, no. 2, 2014.

[24] S. Raikar and S. Adamson, Renewable Energy Finance: Theory and Practice. Academic Press, 2019.

[25] Roland Berger, The Structuring and Financing of Energy Infrastructure Projects. European Commission Directorate-General for Energy, Berlin/Brussels, 2011.