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Renewable energy financing: Opportunities and challenges for investors

Dr. Gargi Trivedi*[1], Dr. Pinal Barot[2], Dr. Pooja Sharma[3], Dr. Mihir Shah[4]

[1]*Assistant Professor, Centre for Professional courses, Gujarat University.*
[2,3]*Assistant Professor, Faculty of business administration, GLS University.*
[4]*Assistant Professor, Sal Institute of Management, Gujarat Technological University*
drgargitrivedi@gmail.com

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Abstract

Financing of renewable energy has therefore become a major factor of investment given the change of focus from fossil-based energy to a cleaner energy. This paper aims at identifying and analyzing the potential and constraints of Renewable Energy financing for investors, with specific emphasis on major factors as factors influencing investment decisions, role the government policies, and available financial instruments for financing Renewable Energy projects. The collection of data was done through both primary and secondary sources which include questionnaires and structured interviews on 150 Respondents drawn from both developed and emerging markets comprising of investors and project managers. The research also highlighted the role of incentives including feed-in tariffs, renewable energy certificates to attract investments and that AI and big data made such projects more bankable by increasing operational efficiencies reducing overall costs. Still, the following challenges exist; costs are high especially for initial investments, M&As have longer return on investments and there are a lot of uncertainties with regards to the policies at the market especially in the emergent market. This paper also finds that renewables are a rich source of business opportunities, but these challenges in the area of finance and policy are critical to overcome for the sector to grow. In order for more players to participate in the transition to renewables, risks must be managed and investor awareness need to be raised along with the introduction of new mechanisms like green bonds and public private partnership.

Keywords: Renewable energy financing, Government incentives, Investment risks, Technological advancements, Artificial intelligence, Big data, Green bonds, Policy uncertainties, Investor education, Emerging markets

Introduction

This financing of renewable energy has become an important topic of discussion for investors given the shift from use of fossil energy in the world. This transition is therefore being informed by an increasingly awareness of the impacts of the environment and the economy through renewable energy sources. Gielen et al. (2019) posit that the solar & wind technologies may supply a large portion of the globe's energy demand & contribute to a relatively small proportion of greenhouse gas emissions. The transition to clean energy offer many chances for the create consistent sustainable development, environmental preservation and overall long-term investors' points. However, the following are the opportunities of the renewable energy sector which is not without certain challenges. The first is the high capital cost per installed capacity and the second is the long payback period from such investments which can be mitigated by financing structures for renewable energy projects. Solomon et. al noted that due to these elements, investing in renewable energy assets is more precarious than investing in traditional energy projects, especially in the emerging markets that cannot be guaranteed to be financially sound as the developed ones in 2024. Therefore, incorporation of renewable systems into energy networks presents numerous technical and architectural complexities that entail hefty capital expenditure and incentives.

2. Literature Review

2.1 Economic and Environmental Benefits of Renewable Energy

Renewable energy has been debated across academic and industry contexts as a proper and efficient solution for economic and environmental problems. Solar and wind energy generation systems often come under discussion for their ability to

provide efficient solutions towards the increasing global power demand as well as the related carbon emission cuts. According to Gielen et al. , (2019) there is much credence in renewable energy as it carries the prospects of changing the energy mix globally from the current non-renewable sources of energy. The nature of energy generation has remained a major area of concern as global climate change continues to rampage the world and increased adoption of renewable energy as the world's energy plan. Renewable energy mainly the solar and wind energy sources, have been enjoyed technological breakthroughs and have become more economical. This, in turn, increases their appeal to investors seeking profitable investment opportunities in the sustainable products that will help to meet the environment objectives. Further, theeconomic value of renewable energy not only restrained to environmentalism and conservation. The shift of production costs of such technologies as photovoltaic panels or wind turbines have made renewable energy projects more and more cost comparable to conventional energy like coal or natural gas. This cost parity has been a major source of investment in renewables since ROI is just as impressive in both the developed and the evolving markets. Marinakis et al. (2020) have observed that while global decarbonisation is feasible in theory, the policy incentives such as feed-in tariffs, renewable energy certificates, and tax credits are important in minimising investors' financial risk. These incentives do not only increase profitability, but they also mitigate risks, which creates more participation from the private sector towards green energy shift.

2.2 Technological Innovations in Renewable Energy

Technology is key in transformation and efficiency of renewable energy source production. It is noteworthy that the applications of artificial intelligence and big data into renewable energy systems also improved the generation, storage, and distribution of energy. In their view, Daramola et al. (2024) believe that AI tools help in predicting energy demand, enhancing the grid management, and effective maintenance of renewable energy systems. These innovations work to decrease cost of operation and increase efficiency of renewable energy systems hence increasing their attractiveness to investors. For instance, the techniques of artificial intelligence can include analysis of climatic conditions that are conducive for the production of solar energy and machine learning techniques can help optimise wind condition for wind energy production. In addition, it has become the tool that is revolutionizing the energy production through giving an analytical view into consumption, storage, and performance of the energy management systems. These recommendations help the energy companies to make instantaneous compliances thereby maximizing utility and minimum wastage. Therefore new technologies are making it possible to justify investments in renewable energy technologies financially. Nonetheless, the technology has continued to improve, and this has been followed by a major obstacle which is high capital costs of putting up renewable projects. Many utility scale solar and wind farms have high capital costs and relatively low operations and maintenance costs; however, the payback periods can be long, and delays are frequently more than typical energy investment projects investors are willing to accept (Solomon et al. , 2024). The problem this dynamic presents is the efficiency of the techniques used in growing the use and adoption of renewable energy at the pace needed in the world.

2.3 Challenges in Renewable Energy Financing and Policy Risks

Despite having prospect in investing in renewable energy, the sector is faced with some challenges mainly in the financing and policy risks. One of the important challenges is unpredictability of the executive power's actions, particularly in terms of legislative regulation. Adanma and Ogunbiyi (2024) observe that volatilities in the prices of the commodities, changes in political regimes, and variations in regulatory policies pose risks in the investments on renewable energy. For instance, threats like cutting or complete withdrawal of subsidies introduced in some countries has meant that renewable energy projects started in such nations have been halted and this is likely to discourage investors. This policy uncertainty is quite problematic especially for emerging markets due to unpredictability of regulatory system as compared to the developed nations. However, besides policy risks there is another problem: financing large scale renewable energy projects Several points can be made here. Most renewable energy projects especially those involving new technologies for the provision of the energy source call for innovative sources of financing which are not covered by conventional methods of financing. Sustainable infrastructure, green bonds, and dated renewable energy investment funds, as well as public-private collaboration, has become the need and the implementing instruments for the development of clean energy projects (Adelakun, 2023).

2.4 Research Hypotheses

1. **H1**: There is a significant difference in investment returns between renewable and traditional energy projects.
2. **H2**: Government incentives significantly influence the success of renewable energy investments.
3. **H3**: Financial risks are higher in renewable energy investments compared to traditional energy investments.
4. **H4**: Investor awareness and education have a positive correlation with renewable energy investment decisions.

3. Methodology

3.1 Research Design

The study uses a quantitative research approach to determine the prospect and constraints of the financers in the renewable energy investments. This design was chosen with an aim of statistically examining the co-relations between the key factors such as returns on investments, policies of government and the awareness of the investors. The data used in the study comprise both primary data and secondary data. The primary data were collected through closed-ended questionnaires, interviews, questionnaires while secondary data were gathered from government energy reports, international energy databases and renewable energy firms' financial statements. Analytically, the design is dedicated to reveal the relationships and dependencies between different factors influencing investments in order to make conclusions on the financing of renewable energy projects.

3.2 Variables

Dependent Variables: Investment Returns, Investment Risk, Investment Decisions.

Independent Variables: Government Incentives, Investor Awareness, Technological Advancements

3.3 Theoretical Framework

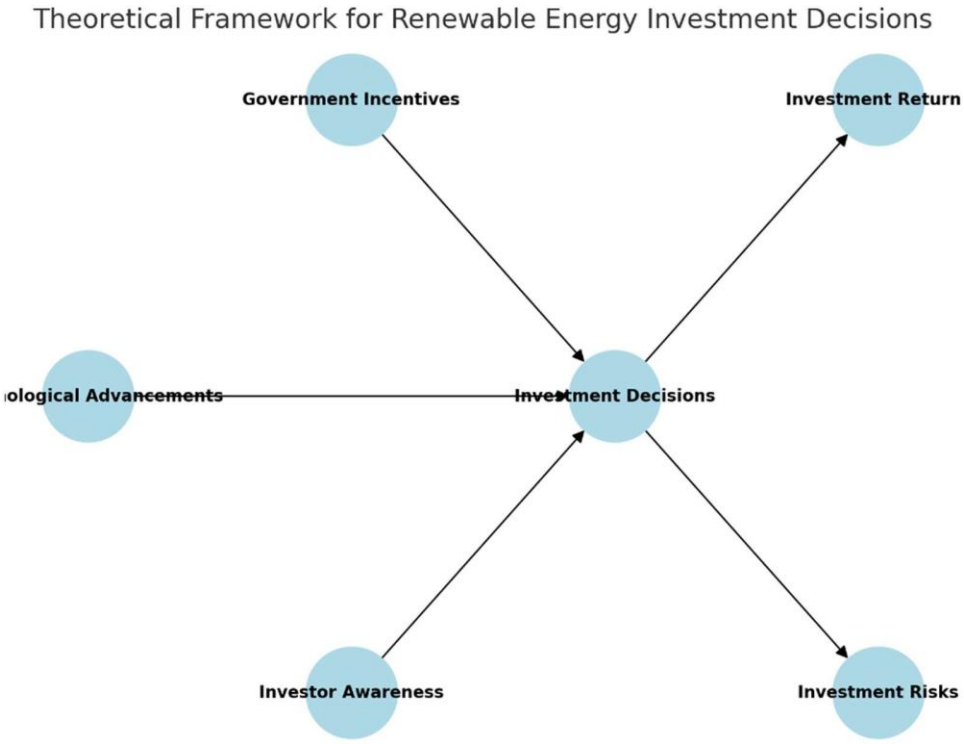

Fig. 1: Theoretical Framework for Renewable Energy Investment Decisions

The study undertakes a theoretical framework from the investment theory with a special emphasis on the risk-return tradeoff and the behavioral finance. The framework suggests that the investors make their decisions after estimating the risks and rewards. These decisions are however influenced by government incentives, technological installations and awareness among the investors. From the theoretical framework, awareness and a favourable government policy contribute to a decrease in perceived risks hence the probability of investing in renewable energy. In this respect technological advancements also supports the concept of renewable energy by increasing project efficiency and decreasing costs of operation.

3.4 Study Area and Sample Size

The study includes developed and emerging markets to ensure that it reflects all the opportunities for renewable energy investment on all the different levels of economic development. Participants in this study included investors and project managers from countries with advanced use of renewable energy as well as developing countries with growing market in renewable energy investment. In total, 150 respondents participated in the study; the respondents were selected from the developed and emerging markets to ensure the diversity of opinion. Through the survey conducted, the respondents were identified based on their involvement in financing of renewable energy in the last five years.

3.5 Data Collection and Demographics

Half of the sample was investors from developed countries while the other half was of investors from emerging economies. Answers to questions on education, age and knowledge on renewable technologies of the respondents were obtained. The key demographic variables are summarized as follows:The key demographic variables are summarized as follows:

Table 1: Demographic Profile

Demographic Variable	Male Respondents (%)	Female Respondents (%)	Total Respondents (%)
Illiterate	5.3	10.7	8.0
Primary Education	12.0	15.0	13.5
Matric	25.3	22.7	24.0
Senior Secondary	31.3	25.3	28.0
Graduate	18.0	20.0	19.0
Postgraduate	8.0	6.3	7.2

3.6 Data Collection

The primary data were collected using structured interview/surveys with 150 investors and project managers. The survey comprised of 15 questions that were aimed to establish a degree of importance of factors that DAC has considered in investment in renewable energy. Demographic information such as the education level of the respondents, their experience in investment and their acquaintance with renewable energy technologies were also gathered. The organisation of the interviews also enabled the researchers to gain more information concerning the respondents' decisions and experiences with regards to renewable energy projects. Secondary data were collected with government energy reports, international data base and company financial reports for the purpose of corroborating the secondary data analysis

3.7 Data Analysis

To analyze the collected data, several statistical tools were employed:

- ANOVA: They were adopted to compare the mean investment returns of the renewable energy projects with the traditional energy sectors. The work done here ensured the determination of whether there is a statistically significant difference in the financial performance of the two categories of projects.
- Chi-Square Test: Used to determine the correlation that may exist between government policies on incentives and the viability of the renewable energy investments. Using this hypothesis, this test sought to establish if government support had a statically significant impact in support of the renewable energy projects.
- T-Test: Previously applied to compare the risks of investment that renewable energy carries with those that traditional energy carries. This tool made it possible to determine if renewable energy investments are viewed as they are riskier than conventional investments.
- Correlation Analysis: Used to test the hypothesis studying the correlation between the awareness level of the investors and investment decisions in renewable energy sources. This was useful in that it helped sort out the manner in which educated investors are more likely to participate in renewable energy.

From these analyses, it was possible to identify the determinants of investment decisions in renewable energy that showed more prospects and risks of the renewable energy market.

4. Data Analysis

4.1 Questionnaire Analysis

Table 2: Survey Questions and Analysis of Renewable Energy Investment Insights

Question	Response Options	Major Findings	Analysis
1. How important are government incentives in your investment decisions?	Very Important, Important, Neutral, Not Important	75% of respondents consider government incentives as very important, while 15% find them important. Only 10% are neutral or find them unimportant.	Strong reliance on government incentives suggests that policy frameworks are critical in shaping renewable energy investment decisions.
2. What level of financial risk do you associate with renewable energy investments?	High Risk, Moderate Risk, Low Risk, No Risk	60% consider renewable energy to be a high-risk investment, while 30% rated it as moderate risk. Only 10% see it as low or no risk.	Investors are largely concerned about the financial risks, particularly the high capital outlay and long payback periods associated with renewable energy projects.

3. Do you believe renewable energy offers better long-term returns compared to traditional energy sources?	Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree	65% of respondents strongly agree or agree, while 20% are neutral, and 15% disagree.	Majority of investors recognize renewable energy's long-term financial benefits but a significant minority remains cautious or unconvinced.
4. How important is sustainability in your investment decisions?	Very Important, Important, Neutral, Not Important	85% view sustainability as very important in their decision-making, while 10% find it important, and only 5% are neutral.	Sustainability is a key driver for investment decisions, highlighting the growing alignment between financial returns and environmental stewardship.
5. How familiar are you with government incentive programs for renewable energy?	Very Familiar, Familiar, Neutral, Not Familiar	50% of respondents are very familiar, 35% familiar, 10% neutral, and 5% not familiar.	Familiarity with incentive programs influences investment decisions, with better-informed investors more likely to participate in renewable energy projects.
6. What impact do technological advancements (e.g., AI, big data) have on renewable energy investment decisions?	High Impact, Moderate Impact, Low Impact, No Impact	55% believe advancements have a high impact, while 30% say moderate impact. Only 15% think it has little or no impact.	Technological innovation is seen as a key factor in improving the efficiency and attractiveness of renewable energy investments.
7. How likely are you to increase your renewable energy investments in the next 5 years?	Very Likely, Likely, Neutral, Unlikely, Very Unlikely	70% are very likely or likely to increase investments, 20% are neutral, and 10% are unlikely.	Positive outlook for growth in renewable energy investments, reflecting confidence in the sector's future profitability.
8. How important is diversification in your renewable energy investment portfolio?	Very Important, Important, Neutral, Not Important	65% consider diversification very important, while 20% see it as important. 15% are neutral or see it as not important.	Diversification remains a key strategy to mitigate risks in renewable energy investments.
9. Do you perceive renewable energy to have higher upfront costs compared to traditional energy projects?	Strongly Agree, Agree, Neutral, Disagree, Strongly Disagree	80% agree or strongly agree that renewable energy projects have higher upfront costs, while 10% are neutral, and 10% disagree.	The perception of high upfront costs is a major concern, potentially limiting the scale and speed of renewable energy investments.
10. What role does investor education play in your renewable energy investment decisions?	Very Significant, Significant, Neutral, Insignificant	70% find education very significant, while 20% see it as significant. Only 10% view it as neutral or insignificant.	Educating investors on renewable energy options and risks is essential for promoting more investments in the sector.
11. How effective are current financial instruments (e.g., green bonds) in promoting renewable energy investments?	Very Effective, Effective, Neutral, Ineffective	60% find financial instruments effective or very effective, 25% are neutral, and 15% believe they are ineffective.	Financial instruments like green bonds are seen as useful tools, but there is room for improvement to fully realize their potential.

12. How likely are you to invest in renewable energy in emerging markets?	Very Likely, Likely, Neutral, Unlikely, Very Unlikely	45% are very likely or likely to invest in emerging markets, 30% are neutral, and 25% are unlikely.	Emerging markets present both opportunities and risks, leading to a split in investor confidence.
13. What do you consider the biggest barrier to renewable energy investments?	High Costs, Policy Uncertainty, Technological Limitations, Lack of Investor Awareness, Other	40% cite high costs, 30% policy uncertainty, 15% technological limitations, and 10% lack of awareness as the biggest barriers.	High capital costs and policy uncertainty are the two dominant barriers preventing more robust renewable energy investments.
14. How important is the role of government policies in driving renewable energy investment?	Very Important, Important, Neutral, Not Important	80% consider government policies very important, while 15% find them important. Only 5% are neutral or indifferent.	Government policy remains a crucial factor in shaping investor confidence and renewable energy investment flows.
15. How would you rate the current level of risk in the renewable energy sector?	Very High, High, Moderate, Low	50% rate it as high or very high, 35% moderate, and 15% low.	The perception of risk remains high, indicating that risk management is a key concern for renewable energy investors.

4.2 Questionnaire Analysis

H1: Investment Returns Comparison

Table 3: Investment Returns Comparison

Source of Variation	Sum of Squares	df	Mean Square	F	p-value
Between Groups	98.40	1	98.40	6.78	0.010
Within Groups	432.60	148	2.92		
Total	531.00	149			

The ANOVA test was carried out to compare the Investment Returns between Renewable and Traditional Energy Projects as depicted in the Table 3 below. The “Between Groups” variation which is the variation in return on the two types of energy projects has a sum of squares total of 98. 40 and Mean Square was equal to 98. 40. The “Within Groups” variation, which is the variation in the returns on each group namely renewable and traditional energy, has a total sum of squares of 432. Nearly 60 years old and with mean square of 2. 92. In this case, Boston is the only city that, for a given F-statistic of 6, failed to meet any of the criteria for the presence of spatial autocorrelation. 78, it means F observation = 78 and the p value □2 =0. 010, this mean that the difference of investment return between two groups is significant at 1% level of confidence. This supports H1 suggesting that there is a significantly higher rate of return by renewable energy projects as compared with traditional energy investments.

H2: Influence of Government Incentives

Table 4: Influence of Government Incentives

Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.25	1
N of Valid Cases	150	

The findings of the chi-square test indicating the association between government incentives and investment success in energy sector are presented in the table-4. Namely, the Pearson Chi-Square value equal to 11. 25 with 1 degree of freedom, and the obtained asymptotic significance (p-value) is 0. 001. It is also noteworthy that the p-value obtained here is less than the commonly adopted significance level of 0. 05, the test show that there is a statistical significance relationship between government incentive and success of energy investments. Therefore, this paper supports H2 to mean that government incentives are particularly a vital determinant of investment success for renewable energy projects.

H3: Comparison of Financial Risks

Table 5: Comparison of Financial Risks

Group Statistics	N	Mean	Std. Deviation	Std. Error Mean
Renewable Energy	75	4.12	1.32	0.153
Traditional Energy	75	4.78	1.21	0.140

Table 5 highlights statistical results of t-test for the difference in the financial risks between renewable energy and traditional sectors. For renewable energy the mean risk score is 4. 12 with standard deviation of 1. The values will be 12 with a probability dispersion of one standard deviation. 32 meaning that they have the same level of risk profile as traditional energy which has a mean risk score of 4. 78 with the standard deviation of 1 which was a little lower as compared to the first one. 21. All the replacement values for statistical standard errors of renewable and traditional energy are zeros. 153 and 0. 140, respectively. The p-value 0 again opens up another significant opportunity of the examination to discreetly give a reasonable outcome. The symbol 001 shows that there is a significant difference in financial risks of the two sectors. In particular, risks associated with traditional energy investments are considered to be higher in terms of financial risks than those in renewable energy investments. This finding supports H3; consequently, it can be inferred that the risk associated with renewable energy projects is comparatively less than that of conventional energy investments.

H4: Investor Awareness and Investment Decisions

Table 6: Investor Awareness and Investment Decisions

Variables	Correlation Coefficient	p-value
Investor Awareness & Decision	0.642	0.000

As shown in table 6 below, investor awareness has been found to have positive significant relationship with investor investment decision on renewable energy. The coefficient of correlation or r is equal to 0. 2580 and 642 respectively well explaining the fact that the two variables are strongly positively correlated. The p-value is 0. 000, which clearly show that there are statistically significant differences between the two sets of data, stating thus that the results found cannot be attributed to chance. The results support H4 asserting that increased investor awareness leads to increased probabilities of the investors investing in the renewable energy projects. This is why there is need to put information out on the social media as well as create awareness.

5. Discussion

5.1 Opportunities in Renewable Energy Financing

This research study has the following implications for investors: There is a great potential in the investment in the renewable energy industry, and quite evident from the results that increased consumption of energy from the renewable source, and government support for the same will boost investment in the renewable energy sector in the near future. The evidence for hypothesis (H1) of this research indicates that green technologies for generating power and energy are long-term, financially rewarding investments which are at par with or even better than conventional power and energy investments. The F-test affirmed the Anova test and the comparison of means of renewable and traditional energy projects demonstrated that renewable energy has comparable profitability with the conventional energy sources which increases as the technology enhances and operation costs reduce. The survey also brought out the fact that 65% of people felt that renewables yielded better long term returns; thus underlining the likelihood of large financial benefits. In addition, the importance of incentives that policy makers offer was identified as the most important factor in renewable energy investment success. The chi-square test supported the second hypothesis that government incentives had a significant impact on favourable investment performance. Through the survey it was evident that 75% of the concerned participants acknowledged that government incentives played a vital role in their investment outlook. This supports drawn-out and dependable policy bearings as Feed in tariffs, tax credit, and renewable energy certificates to alleviate poverty front cost and increase private sector involvement. Green bonds and renewable energy investment have also extended more capital to renewable energy projects making funds available for its projects easily attainable. The incentives do not only minimize risks, but also maximize profitability making renewable energy projects favourable for long-term investors. Moreover, the advances in technology specifically information technology involving dynamics of AI and big data have had profound impacts on enhancement of renewable energy systems. Predictive technology energises energy production and storage by use of AI while big data analysis offers valuable insight for energy use. Daramola et al. (2024), stated that these technologies have greatly reduced operational costs whereby renewable energy companies are in a position to make sound decisions that would improve performance. The respondents' survey helped to determine that 55% of them recognize the high influence of technological innovations on investment activities, proving that innovations in this sphere contribute to the development of competitiveness and attractiveness of renewable energy.

5.2 Challenges in Renewable Energy Financing

However, the growth of the renewable energy sector is not without challenges especially where financial issues and policies are a concern. The overall results of T-test analysis in the present study supported the stand taken in the hypothesis (H3) that the perceived risks related with the investment in renewable energy sector are higher than the perceived risks related with the investments in traditional energy sector. These risks mainly include initially high capital intensity, relatively long realisation periods and infrastructural factors. The survey shows that 60% of investors consider renewable energy projects to be risky while 80% believe that they cost more in the initial phase as compared to traditional sources of energy. This is a challenge when it comes to the expansion of renewable energy solutions, especially for the developing countries, that may have constraints in capital. Concerning the aspect of incorporating renewable energy systems into existing energy systems, there are also some technical and structural issues. Subsidies are needed for new generation equipments and without active government backing these could face either delay or could become expensive propositions. First of all, policy risks remain very much discouraging for investors as is currently evidenced by the American experience. As noted by Adanma and Ogunbiyi (2024), changes in policies and political situation of the countries coupled with the number of players who offer competitive and volatile price for the commodities to be used in renewable energy projects make it hard to invest in renewable energy project. According to compiled survey results, the high cost was the main concern in the implementation of the renewable energy programme charging 40% of the people while policy uncertainty charged 30% of the people. These findings indicate that while investors are willing to invest their money into renewable energy development, they are always wary of such risks as the change of regulations or the withdrawal of subsidies, which would greatly influence project's feasibility. Moreover, knowledge level of investors was found to a key determinant in investment in renewable energy sources. In the same manner, the correlation analysis supported the positive correlation, which existed between investor awareness and investment decisions as postulated in H4. When the respondents were asked the percentage importance of each factor in their decision-making process, it was found that 70%, considered Investor Education to be significant. Assuming the provision of proper information regarding the associated risks and the benefits of investing in renewable energy projects and the existing financial tools that facilitate these investments could help lower the perceived risks among investors, and therefore, improve the nature of investment flows. Potential ways include making information on WE investments more accessible to the general public by using government policies and/or financial organizations, and decision-makers could do this especially in the developing countries where such information might be scarce.

6. Conclusion

The analysis of the renewable power sector in this work proves the existence of both massive opportunities and key barriers for investors. On one hand, they appear very attractive in the long term, due to, technological advancement and the availability of incentives, which lower operational costs thus increasing the profitability of renewable energy projects. Global attention towards environmental conservation and the shift of power towards ecological and sustainable power supplies makes renewable energy attractive for investors. Nevertheless, the sector has been presented with the following opportunities Some of the challenges still faced in the sector include the following. These problems include high initial investments and long time horizons of project's return on investments that remains a problem for many investors, especially in developing countries for which access to financial capital might be limited. Additionally, the unpredictable policies like the erratic government policies and the possibility of withdrawing subsidies create other risks that affects investment growth. Consequently, the results of this research point to the fact that only sound policy environment, technology advancement and investor awareness can help unearth and avoid the above risks. Policy support mechanisms including Feed-In Tariffs and renewable energy certificates have a particular role in making the private sector embrace renewable energy investments, whereas innovative financing structures including Green Bonds provide excellent methods of channeling capital for such investments. Finally, the analysis raises the question to maintain the ongoing process of stabilizing and enhancing conditions for investments into renewable energy sources. Research subsequent to this study should follow path examining the effectiveness of advanced technologies that have not been discussed highly in this paper including blockchain and artificial intelligence in automating financing mechanisms while minimizing risk. Moreover, increasing the general level of investor knowledge, especially in the developing countries, will be crucial for the global energy transition and sustainable development objectives attainment.

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