

Private Equity Investment in Renewable Energy Infrastructure: Financing, Technology Costs, Investment Risk, and Regional Determinants

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Abstract: The study investigated private equity and private investment in renewable energy infrastructure by considering investment size, financing structure, renewable energy technologies, regional investment patterns, and key drivers of investment decisions. The analysis used a descriptive approach across 8 stages to assess global Private Participation in Infrastructure (PPI) investment and the factors influencing renewable-energy investment. Results showed that in 2023, global PPI investment increased from USD 87.1 billion through 324 projects to USD 100.7 billion through 315 projects in 2024. The energy sector was the largest PPI sector, with USD 67.9 billion in 217 projects. Debt contributed 68% of PPI financing, and equity-like sources contributed 31%, with private equity accounting for around 30.6% of total PPI investment. Renewable energy remained a major focus of energy-sector investment, although the share of renewable electricity-generation projects supported by development finance institutions dropped from 56% in 2019 to 16% in 2024. East Asia and the Pacific topped the investment regionally with USD 56.959 billion, followed by Latin America and the Caribbean at USD 21.865 billion and Sub-Saharan Africa at USD 7.918 billion. Globally, development finance institutions participated in 34 per cent of PPI projects, compared with 64 per cent in Sub-Saharan Africa, 88 per cent in the Middle East and North Africa, and 82 per cent in Europe and Central Asia. Investment attractiveness was affected by technology costs, with solar photovoltaic and onshore wind having relatively competitive leveled costs of electricity. The results indicate that investment in renewable energy is co-

determined by technology costs, financing conditions, revenue certainty, policy support, capital structure and investment risk. It is therefore imperative to strengthen risk-mitigation mechanisms and financing conditions to increase private equity participation in renewable-energy infrastructure.

Keywords: private equity; renewable energy; energy infrastructure; private investment; project finance; investment risk; financing conditions; development finance; renewable-energy technologies; Sub-Saharan Africa.

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1.0 Introduction

The worldwide shift towards renewable energy has moved energy infrastructure from a public-sector responsibility to an increasingly attractive option for private and institutional capital. This change is driven by the need to cut greenhouse-gas emissions, enhance energy security, extend electricity access, meet rising energy demand, and reduce reliance on fossil fuels. As a result, renewable-energy infrastructure—this including solar photovoltaic (PV), wind, hydropower, battery storage and other low-carbon technologies—is becoming an increasingly significant element of long-term infrastructure investment portfolios. Newell and Marzuki (2024) regard renewable-energy infrastructure as an important asset class in the move towards lower-carbon economies and show that its investment features must be taken into account

together with those of other infrastructure sectors and asset classes (Newell & Marzuki, 2024).

The quick growth in the use of renewable energy has likewise raised the need for private financing. Since renewable-energy projects are usually capital-intensive and involve a large amount of spending before they start operating, while income is earned gradually over the long span of their asset lives, access to equity, long-term debt and suitable risk-sharing arrangements is essential for the development of such projects. According to evidence from the International Renewable Energy Agency (IRENA), private finance has made up a major part of investment in renewable energy, especially in more established technologies like solar photovoltaics. As a result, the future growth of renewable energy will depend not only on technological advances and government spending but also on the capacity of financial markets to attract private capital.

Private equity has become especially relevant in this area of financing. Unlike traditional lending, it offers risk-bearing capital which can be used to back project development, corporate expansion, acquisitions, restructuring and portfolio consolidation. Moreover, private-equity investors are able to provide managerial know-how, operational capabilities and skills in financial structuring. Gandhi *et al.* (2025), in their examination of private-equity investment in the renewable-energy sector in India, found that investors were drawn to both the global macroeconomic trends and the sector's growth potential. The study, which was based on interviews with 40 executive-level practitioners and a review of the relevant literature, revealed that investors typically made use of existing developer platforms, control platforms and infrastructure investment trusts as their means of investment. Even though there are risks involved in investing in renewable energy, investors still remained optimistic regarding their ability to achieve attractive risk-adjusted returns by means of

suitable asset selection and active management (Gandhi, 2025).

The appeal of renewable-energy infrastructure is also due to the large decrease in technology costs. As capital costs fall, project efficiency improves and technology matures, making renewable-energy projects more economically competitive. This is significant for private-equity investors since lower project costs can boost expected cash flows and investment returns, on the condition that revenue and regulatory risks stay under control. Yet a reduction in technology costs does not remove the risk of investment. Renewable-energy investments are still vulnerable to policy uncertainty, changes in electricity market conditions, currency fluctuations, interest rate variations, grid constraints, curtailment, variability of resources and counterparty risk.

These risks are especially significant in emerging and developing economies. Even though these economies usually possess considerable renewable-energy resources together with a rapidly increasing demand for electricity, they can also have weaker regulatory institutions, underdeveloped financial markets, restrictions on foreign exchange and insufficient transmission infrastructure. According to Baumli & Jamasb (2020), in their evaluation of private investment in African renewable-energy infrastructure, investor confidence in the effectiveness of regulation was a major concern. Moreover, their multi-criteria analysis showed that non-financial factors, such as institutional conditions and policy instruments, make a significant contribution to explaining the challenges relating to private investment in Africa (Baumli & Jamasb, 2020). Recent research has placed even more emphasis on the relationship between private investment and institutional conditions. According to Mundonde & Makoni (2025), who analysed data from 28 countries over the period 1996 to 2024 using a panel autoregressive distributed lag approach, long-term renewable-energy PPP



financing was found to be significantly linked with GDP per capita, inflation dynamics, energy-transmission efficiency and institutional quality. The results show that better regulatory and institutional conditions can increase the appeal of renewable-energy markets to private investors (Mundonde & Makoni, 2025). The situation in Africa is of particular significance since the continent has to deal at the same time with problems relating to energy access, the financing of infrastructure and sustainable development. In many African countries the lack of reliable electricity has restricted industrial productivity and economic development, and since the population and urbanisation trends are expected to grow, future demand for electricity will also increase. Private capital could therefore play a role in narrowing the gap in infrastructure financing. However, investors need to be confident that the projects will produce predictable returns during the period of their investment.

Nigeria is a significant example in this wider African situation. The nation's electricity system still suffers from serious problems in generation, transmission and distribution, which means there is a big opportunity market for investment in energy infrastructure. Yet investors encounter difficulties due to foreign-exchange volatility, regulatory uncertainty, the liquidity of the electricity market, existing infrastructure deficits and the lack of long-term domestic financing. According to the additional material provided in this study, financing for energy infrastructure in Nigeria has gradually moved from a model mainly based on government funding to one that involves a mix of financing from private investors, development-finance institutions, bilateral agencies and blended-finance mechanisms. The report also states that project finance is an important arrangement for large-scale generation projects and that blended and results-based finance are appropriate for renewable-energy and off-grid development. It is therefore important for investors as well as

for governments, regulators and development-finance institutions to understand the factors which influence private investment in renewable-energy infrastructure. If policymakers have a clearer understanding of the factors that determine investment, they will be in a position to draw up financing arrangements and risk-reduction tools which are capable of attracting private capital and at the same time improve the bankability and sustainability of renewable-energy projects.

1.2 Literature Review

1.2.1 Private Equity and Renewable-Energy Investment

Private equity holds a special place in the financing of renewable energy because it brings together financial capital and active ownership along with investment management. When renewable-energy companies and infrastructure projects are being developed and constructed, they often need a large amount of equity before they start producing steady operating cash flows. Private equity funds can supply this kind of capital and at the same time aim to make a return by means of dividends, asset appreciation, refinancing, acquisitions or by carrying out exits.

Gandhi and others in 2025 present one of the most directly relevant of the recent studies into private equity and renewable energy. The study carried out in India looked at the motivations, perceptions, strategies and investment behaviour of private-equity investors by means of interviews with 40 senior practitioners. The results show that investors are increasingly seeing renewable energy as an attractive infrastructure opportunity even though it has a complex risk profile. They employed a number of methods, such as making investments in existing developer platforms, setting up control platforms and investing via infrastructure investment trusts. The study also found that investors saw potential for value creation in various parts of the electricity value chain (Gandhi *et al.*, 2025).



The Indian example is especially pertinent to developing economies since it shows how private-equity investment can develop as renewable-energy markets mature. Instead of just supplying capital to individual projects, investors are able to put together portfolios, combine companies and actively manage their assets in order to improve risk-adjusted returns. This method may therefore enable investors to diversify the risks associated with individual projects while taking advantage of economies of scale.

The performance of renewable-energy infrastructure as an asset class is no more uniformly better than that of conventional infrastructure. Newell & Marzuki (2024) looked at global listed renewable-energy infrastructure during the period Q1 2009 to Q4 2022 and compared its risk-adjusted performance with that of other infrastructure sectors and the major asset classes. They discovered that listed renewable-energy infrastructure had underperformed both the other infrastructure sectors and the major asset classes during the period in question, even though it did offer portfolio diversification benefits. Furthermore, they noted more favourable performance features for non-listed infrastructure funds (Newell & Marzuki, 2024).

The importance of this finding lies in the fact that private equity typically consists of investments in non-listed companies. The fact that the performance of renewable infrastructure differs between listed and non-listed companies implies that conclusions drawn exclusively from public market performance might not properly reflect the features of private infrastructure investments.

The decisions of private investors are affected by both financial and non-financial factors; financial considerations include expected returns, capital costs, the availability of debt and certainty of revenue, while perceived risk is influenced by regulatory quality, political

stability, institutional effectiveness and policy credibility.

Baumli & Jamasb (2020) specifically applied a fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) approach in order to examine the factors which determine private investment in African renewable-energy infrastructure. Their results showed that investor confidence in the effectiveness of regulatory measures was the main concern influencing investment decisions and they also pointed out local capacity building and policy instruments as important means of addressing institutional constraints (Baumli & Jamasb, 2020).

The role of institutional quality has also been shown by Mundonde and Makoni (2025). In their study of renewable-energy PPP financing in 28 countries, they found that institutional quality, energy-transmission efficiency, GDP per capita and inflation dynamics had a significant influence on long-term renewable-energy investment. The results indicate that improving the overall institutional and macroeconomic environment is just as important as giving project-specific financial incentives (Mundonde & Makoni, 2025).

Recent evidence from developing countries also shows that private-sector development plays a role. In a study of the BRICS economies, Haloui, *et al.* (2025) employed a GMM panel vector autoregressive model and method-of-moments quantile regression and found that private-sector development had a positive and persistent association with investment in renewable energy. Moreover, their analysis revealed a significant causal link between private-sector development, energy-security risks and investment in renewable energy.

The fact that private-sector development and investment in renewable energy can support each other indicates that better private-sector institutions can lead to greater capital mobilisation, while expanding renewable-energy markets will provide new opportunities



for private enterprises, financial institutions and infrastructure investors.

The development of financial markets is also an important factor affecting investment in renewable energy. Lou *et al.* (2025) used macroeconomic and financial data to look at investments in green energy in China from 2015 to 2022 and applied the Fully Modified Ordinary Least Squares (FMOLS) method. The results indicated a strong positive relationship between the issuance of green bonds and investment in renewable energy; however, in their empirical model private investment through public equity (PIPE) showed a negative relationship with renewable energy investment, pointing to the possibility that different types of private capital may have different relationships with the development of renewable energy (Lou *et al.*, 2025)

The fact is significant for this study since it shows that the term *private investment* includes a variety of financial instruments and investment strategies; private equity, PIPE, project finance, institutional investment and PPP financing should not therefore be regarded as equivalent forms of capital.

Credit-risk reduction is also a financial approach which can affect private-sector involvement. Akomolehin *et al.* (2025) looked at credit-risk mitigation in financing for green energy and talked about warranties, insurance and credit enhancements as ways of improving the bankability of projects and lowering financial risk. Their analysis stressed that the effectiveness of risk-mitigation mechanisms is dependent on regulatory stability, market conditions and supportive policy frameworks (Akomolehin *et al.*, 2025).

The fact is that the mere availability of capital is not enough to ensure investment in renewable energy; investors also have to be able to evaluate, distribute and reduce project and country risks.

Since risk is a key aspect of infrastructure investment, renewable-energy projects in particular have high initial capital costs and

long investment periods (Egli, 2020). Steffen (2020) showed that the investment risk and risk premiums associated with renewable-energy projects changed considerably over time as the technologies matured and the markets developed. Moreover, risks arising from policy decisions, electricity prices, resource availability, curtailment and technology can all affect the expected financial performance of renewable-energy assets.

Emerald Publishing points out that Newell & Marzuki (2024) have further shown that renewable-energy infrastructure can offer benefits in terms of portfolio diversification even if its individual performance is less appealing than that of some other infrastructure sectors. This indicates that investors may place value on renewable-energy assets not just on the basis of the returns they generate directly but also because of the role they play in achieving overall portfolio diversification.

Gandhi *et al.* (2025) offer a complementary view from the standpoint of private-equity investors. According to their interviews, the investors may accept considerable sector risks since they think that active investment selection and management can lead to attractive risk-adjusted returns. Based on their findings, investment performance goes beyond its technological features but factors such as the investor's capabilities, the quality of the assets selected, the management strategy, the financing structure and the exit opportunities are strong determinants of the returns actually achieved.

The literature on investment is now going beyond considerations that are purely financial. Dirma *et al.* (2024) claim that when assessing investments in renewable energy there has usually been a focus on techno-economic and environmental criteria and yet too little attention has been paid to distributional impacts, accessibility, vulnerability and equity. Their review suggests that equity should be incorporated into investment decisions



alongside standard financial and technical criteria.

The fact that this view is significant in the context of private-equity investment is because the decisions taken can affect not just the financial results but also energy access, employment, affordability and the way benefits are distributed. In emerging economies, investments in renewable energy can lead to important social advantages, especially when such projects enhance electricity access in communities that have been neglected. It is necessary, however, that the financial goals of private investors be properly aligned with wider public development objectives.

The literature that has been reviewed shows considerable advances in our understanding of investment in renewable energy, but there are still some important gaps.

In the first place, current research often looks at investment in renewable energy as a whole rather than making a distinction between private equity and all the other types of private finance. For instance, while studies on public-private partnership financing, green bonds, private-sector development and institutional investment offer valuable insights they do not always reflect the particular behaviour of private-equity investors. It is important to draw the distinction since private equity generally entails active ownership, investment management, portfolio construction and clearly defined exit strategies.

Second, a great deal of the current empirical evidence is specific to individual countries. Gandhi *et al.* (2025) give a detailed account of private-equity investment behaviour in India, whereas Lou *et al.* (2025) concentrate on China. Even though these studies offer valuable evidence, their results cannot be automatically extended to African or other emerging markets since the institutional, financial and regulatory environments differ greatly.

Thirdly, African studies have found regulatory effectiveness and institutional quality to be important determinants of investment, but there

is relatively little empirical research that combines financial, institutional, infrastructure and risk variables when evaluating private investment in renewable energy. Baumli and Jamasb (2020) show the significance of non-financial factors, and Mundonde and Makoni (2025) highlight the importance of institutional quality and macroeconomic conditions. Yet there is still gap concerning the introduction of more integrated empirical analysis of investment outcomes.

Fifth, the existing literature has not adequately taken into account the increasing significance of risk-mitigation mechanisms when assessing private investment empirically. Measures such as guarantees, credit enhancements, insurance, blended finance and public-private risk-sharing arrangements can change the risk-return features of renewable-energy projects. Further research is needed to determine how these mechanisms influence private investment participation and financing outcomes.

It is also necessary to give greater empirical attention to developing economies since it is there that the gap in renewable-energy investment is most evident, especially in African economies, where although the renewable resources are considerable private investment can be hindered by institutional, financial and infrastructure risks. There is also a difference between investment attractiveness and actual investment performance which merits further investigation. Research looking at investor perceptions highlights the factors that investors find important, whereas studies of performance look at returns and diversification. However, a relatively small number of studies link the determinants of investment with measurable outcomes from infrastructure investment.

This study looks at investments in renewable-energy infrastructure from the point of view of private capital, focusing on the factors that drive investment, the ways in which it is financed, the risks involved and the results of the investments. Instead of considering all



types of private finance to be the same, it acknowledges the special features of private-equity involvement while at the same time placing that involvement within the wider renewable-energy infrastructure financing environment.

Specifically, the study seeks to evaluate the relationship between renewable-energy infrastructure characteristics and investment outcomes. This study aims to empirically examine the determinants, financing features, risk factors and investment results connected with private participation in renewable-energy infrastructure, with a special focus on the implications for private-equity investment.

1. examine the pattern and characteristics of private investment in renewable-energy infrastructure;
2. assess the financial and institutional factors influencing private investment decisions;
3. identify the principal risks affecting private-equity and other private investments in renewable-energy infrastructure; and
4. assess the role of financing and risk-mitigation mechanisms in improving the attractiveness of renewable-energy infrastructure to private investors.

The study is important to private-equity investors since it offers a framework for understanding the financial, institutional and infrastructure factors which affect decisions about investing in renewable energy. By identifying the main factors that determine the attractiveness of an investment, investors will be able to screen projects, evaluate country risk, structure their portfolios and develop suitable risk-management strategies.

The study is likewise of interest to governments and energy regulators. Since renewable-energy infrastructure needs huge amounts of capital, the resources available from the public sector are probably not sufficient to meet the level of investment required by the energy transition and the

growing demand for electricity. Knowledge of the factors that influence private investment can help policymakers in drawing up reliable regulatory frameworks, suitable incentives, bankable methods of procuring projects and arrangements for sharing risks.

The results can be used by development finance institutions when designing blended finance facilities, guarantees, credit enhancement mechanisms and other tools which are able to draw in private capital into more risky renewable energy markets.

The study is especially important for African economies since there is a shortage of energy access alongside a great deal of renewable-energy potential. If we understand the institutional and financial conditions which attract private investment, this will help in the development of strategies aimed at eliminating the gaps in infrastructure financing and at increasing electricity access.

The study makes a contribution to the academic literature by combining private-equity investment, renewable-energy infrastructure, financing conditions, institutional quality and investment risk within a single analytical framework. This is significant since recent studies have generally looked at these different aspects separately. It thus offers a foundation for more integrated empirical research into renewable-energy investment.

Finally, the study has significance for sustainable development and energy transition policy. Renewable-energy investment can contribute simultaneously to energy security, economic development, employment creation and emissions reduction. However, these benefits depend on the availability of sustainable financing. Improving the conditions under which private capital enters renewable-energy infrastructure can therefore support both financial and development objectives.

2.0 Materials and Methods

2.1 Research Design



The study used a quantitative approach based on secondary data, this being reinforced by a systematic review of peer-reviewed empirical literature and official energy and finance datasets. This method was chosen since investment in renewable-energy infrastructure consists of large-scale projects spread over different countries and technologies and thus secondary project-level and country-level databases are especially useful for empirical analysis.

The main datasets and sources of evidence were the World Bank's Private Participation in Infrastructure (PPI) database and IRENA's databases and reports on the costs and investments related to renewable energy. The World Bank PPI database keeps records of infrastructure projects in low- and middle-income countries which include private participation and offers information regarding the projects' characteristics, the private sponsors, the equity and debt, the technology, the capacity, the investment, the financial closure and government support. [Private Participation in Infrastructure](#)

2.2 Data Sources

The study employed three main types of secondary information.

The data from the World Bank's PPI database was used as the main source of information on infrastructure investment. This database covers projects involving private participation in the areas of electricity generation, transmission and distribution. The classification of electricity generation technologies in the database comprises solar PV, solar CSP, wind, hydropower, natural gas, biomass, biogas, geothermal and other technologies. [Private Participation in Infrastructure](#)

The renewable-energy data from IRENA shows that its renewable-cost database includes project-level information relating to the major renewable technologies. By 2024 it had data on over 25,000 projects in the fields of renewable generation and storage technologies. [IRENA](#)

Tsk, financing costs and the development of renewable energy were established on the basis of peer-reviewethe development of renewable energy were established on the basis of peer-reviewed studies. Special attention was paid to those studies which used panel datasets and empirical project-level evidence.

2.3 Variables

The principal variables considered in the analysis are shown in the flow chart (Fig. 1). The World Bank's database separates total equity from total investment; it is important to note that total equity may consist of contributions from both public and private sponsors. It follows that total project investment should not be automatically regarded as private-equity investment.

2.4 Analytical Approach

For project-level quantitative analysis, investment intensity may be expressed as:

The analysis was conducted in three main stages. In the first stage, a descriptive analysis was carried out to identify the general characteristics and trends in private infrastructure investment. In the second stage, an analysis was performed to examine investment trends and the factors influencing investment patterns. In the third stage, the analysis was conducted to identify the differences between renewable-energy technologies and the major determinants of investment. The literature review was conducted to identify the investment determinants linked to the investment decisions of the firm. Finally, the results were incorporated into an investment framework linking technology cost, financing conditions, the policy environment, and investment risk.

$$II = \frac{I}{C} \quad (1)$$

where II represents the investment intensity, I is the total project investment in million USD, and C is the installed capacity in MW. The LCOE relationship can be expressed conceptually according to equation 2



$$LOC = \frac{\sum_{t=0}^n \frac{I_t + O_t}{(1+r)^t}}{\frac{E_t}{(1+r)^t}} \quad (2)$$

where I_t stands for investment expenditure, O_t for operating expenditure, E_t for the electricity generated and r the discount rate

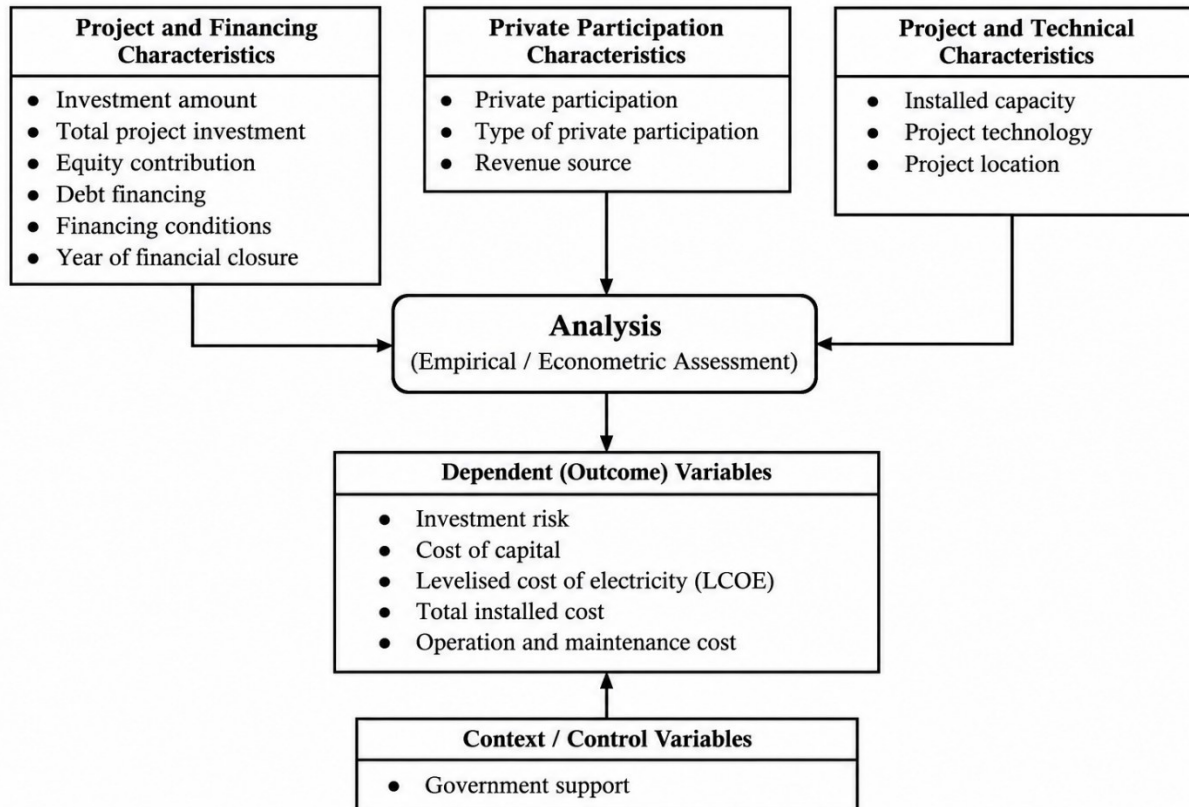


Fig. 1: Framework of Variables for the Analysis of Renewable-Energy Infrastructure Investment

. For private investors this formulation is especially important since the cost of capital influences the economic appeal of capital-intensive renewable projects.

2.5 The reliability of the data and its limitations

The World Bank indicates that its PPI database is made up from information which is publicly available and as a result may include omissions or discrepancies; it also adds that smaller projects are more likely to be underrepresented since they receive less coverage in the public sources.

Moreover, the PPI database gives figures for total project investment and not just for private-equity investment. Since Private Participation in Infrastructure it follows that the current analysis regards the PPI data as indicating private participation in renewable-energy infrastructure, not asserting that all the investment recorded refers to private-equity funds.

3.0 Results and Discussion

The results of the analysis are presented in Tables 1–7. The analysis includes descriptive and comparative evidence regarding private participation in infrastructure, together with technology-related evidence on the costs and performance of renewable energy. The results are interpreted in the context of the study's main objective, which is to examine how technology costs, financing



conditions, private participation, government support, and investment risk affect the attractiveness of investment in renewable-energy infrastructure.

3.1 General Pattern of Investment in Private Infrastructure

The initial stage of the analysis involved a descriptive evaluation of the principal analytical aspects employed in the study. As indicated in Table 1, global Private Participation in Infrastructure (PPI) investment rose to USD 100.7 billion in 2024, compared with USD 87.1 billion in 2023. The 2024 investment represented a 16% increase over the 2023 value and was approximately 20% higher than the five-year average of USD 83.7 billion from the preceding period. Although investment increased, the number of projects declined from 324 projects in 2023 to 315 projects in 2024, indicating that the increase was mainly associated with the size of individual projects rather than an increase in the number of projects. The World Bank also reported that 2024 was the first year since the COVID-19 period in which PPI investment exceeded USD 100 billion.

The energy sector was the main contributor to this investment pattern, receiving USD 67.9 billion across 217 projects. This amount represented approximately two-thirds of total PPI investment. The finding demonstrates the importance of energy infrastructure in attracting private capital and supports the selection of renewable-energy infrastructure as the principal sector examined in this study.

The concentration of investment in energy also indicates that infrastructure investors continue to regard electricity generation and associated assets as significant long-term investment opportunities. However, the analysis demonstrates that the investment environment cannot be explained merely by project size. Rather, the financing structure, technology, geographical location, government intervention and risk allocation collectively influence the attractiveness of infrastructure projects. The analytical framework therefore considers investment outcomes as the result of interactions among technology economics, financing conditions, policy support and investment risk.

3.2 Scale of Investment, Financing Structure and Private Participation

The investment characteristics presented in Table 2 provide further evidence of the structure of private infrastructure investment. Total PPI investment of approximately USD 100.7 billion distributed across 315 projects gives an average investment of approximately USD 319.7 million per project. The energy sector received approximately USD 67.9 billion across 217 projects, giving an average investment of approximately USD 312.9 million per energy project.

The financing structure is particularly important in understanding private-equity involvement. Approximately 68% of PPI financing took the form of debt, while 31% was equity-like financing. In monetary terms, the debt component amounted to approximately USD 68.48 billion, while the equity-like component amounted to approximately USD 31.22 billion. Private equity accounted for approximately 30.6%, equivalent to about USD 30.81 billion.

The dominance of debt demonstrates that renewable-energy infrastructure investment remains highly dependent on leveraged financing arrangements. Nevertheless, the substantial private-equity component indicates that private investors are willing to assume ownership and project risks where expected returns and risk-adjusted cash flows are adequate.

The financing structure also affects the cost of capital. Although debt financing can reduce the immediate amount of equity required, high interest rates, currency risks and country risk can increase the overall weighted cost of capital. Conversely, greater equity participation may improve financial resilience but may also result in investors requiring higher returns.



Table 1. Summary of Analytical Procedures and Main Results

Analytical Stage	Analysis Conducted	Principal Numerical Result
Stage 1: Descriptive analysis	A descriptive analysis of global private infrastructure investment was conducted.	Private infrastructure investment totalled USD 100.7 billion through 315 projects in 2024, compared with USD 87.1 billion through 324 projects in 2023.
Stage 2: Comparison of investment in various infrastructure sectors	Investment across various infrastructure sectors was compared.	The energy sector received USD 67.9 billion from 217 projects and was the largest PPI sector in 2024.
Stage 3: Financing analysis	An analysis of the financing structure of private infrastructure investment was conducted.	Debt made up 68% of PPI financing, while equity-like sources accounted for 31%. Private equity provided about 30.6% of total PPI investment.
Stage 4: Comparison of renewable-energy technologies	Renewable-energy technologies were compared in terms of power-generation capacity and energy investment.	Solar PV made up 53% of power-generation capacity, while wind accounted for 34% of energy investments, according to the World Bank's 2024 assessment.
Stage 5: Assessment of renewable-energy investment	Participation in renewable-energy projects was assessed.	Renewable-energy projects still accounted for the majority of PPI investments in the energy sector, while the share of renewable electricity-generation projects supported by DEFI s fell from 56% in 2019 to 16% in 2024.
Stage 6: Comparison of investment climates in different regions	Investment climates across different regions were compared.	EAP: USD 56.959 billion for 99 projects; LAC: USD 21.865 billion for 95 projects; SSA: USD 7.918 billion for 47 projects; ECA: USD 7.748 billion for 38 projects; SAR: USD 5.724 billion for 28 projects; and MENA: USD 491 million for 8 projects.
Stage 7: Assessment of investment risk and financing conditions	Investment risk and financing conditions were assessed through development-finance participation.	DEFI s participated in 34% of PPI projects worldwide in 2024, compared with 64% in SSA, 88% in MENA, and 82% in ECA.
Stage 8: Integrated analysis	Technology cost, financing, policy and investment risk were integrated into the analytical framework.	Financing costs remain a major factor determining renewable-energy project viability, together with revenue certainty, capital structure and macroeconomic conditions.



Table 2. Quantitative Assessment of Investment Characteristics

Variable	Measurement/Result	Unit
Total PPI investment, 2024	100.7 billion	USD billion
Average PPI investment/project	319.7	USD million/project
Total energy-sector investment	67.9 billion	USD billion
Average energy-sector investment/project	312.9	USD million/project
Equity contribution	31%, approximately 31.22 billion	% / USD billion
Debt financing	68%, approximately 68.48 billion	% / USD billion
Private-equity contribution	30.6%, approximately 30.81 billion	% / USD billion
International debt	47%, approximately 47.33 billion	% / USD billion
Local debt	22%, approximately 22.15 billion	% / USD billion
Commercial debt	29%, approximately 29.20 billion	% / USD billion
Multilateral debt	14%, approximately 14.10 billion	% / USD billion
Bilateral/institutional debt	0.6%, approximately 0.60 billion	% / USD billion
Public equity	0.4%, approximately 0.40 billion	% / USD billion
Government subsidy	0.8%, approximately 0.81 billion	% / USD billion
Private participation	Minimum 20% for most PPI projects; minimum 5% equity for divestitures	%
Installed capacity	Solar PV constituted 53% of power-generation capacity	%
Project technology	Solar PV 53%; wind 34% of energy investments	%
Year of financial closure	2024 for the reported annual PPI results	Year
Project location	58 countries recorded PPI investment commitments	Countries
Type of private participation	Greenfield, brownfield, divestiture, management/lease	Categories
Revenue source	Electricity sales/purchase agreements, tariffs and other project-specific revenue mechanisms	Categories
Government/DEFI support	34% of all PPI projects received DEFI support	%
Investment risk	DEFI-supported projects: 34% globally; 64% SSA; 88% MENA; 82% ECA	% of projects
Cost of capital	Financing cost identified as a key determinant and varies by country, technology and financing structure	%
LCOE – solar PV	0.043	USD/kWh
LCOE – onshore wind	0.034	USD/kWh
LCOE – hydropower	0.057	USD/kWh
LCOE – offshore wind	0.079	USD/kWh
LCOE – geothermal	0.060	USD/kWh
Installed cost – solar PV	691	USD/kW



Installed cost – onshore wind	1,041	USD/kW
Installed cost – offshore wind	2,852	USD/kW
Installed cost – hydropower	2,267	USD/kW
Installed cost – geothermal	4,015	USD/kW
O&M cost – solar PV	13.1	USD/kW/year
Financing composition	68% debt; 31% equity; 30.6% private equity	%

The findings therefore support the view that financing conditions are a major determinant of the attractiveness of renewable-energy investment.

3.3 Renewable-Energy Technology and Cost Competitiveness

The figures in Table 3 demonstrate considerable differences in the economic characteristics of renewable-energy technologies. In 2024, solar PV recorded 452.1

GW of new global capacity additions, representing 77.8% of the total 582 GW of renewable capacity added during the year. Wind added approximately 114.3 GW, while hydropower added approximately 9.3 GW. Thus, solar PV was by a substantial margin the leading technology in terms of new renewable-energy deployment.

Table 3. Quantitative Comparison of Renewable-Energy Technologies

Technology	2024 Indicator	LCOE (USD/kWh)	Total Installed Cost (USD/kW)	Capacity Factor (%)	Private-Finance Indicator	Investment-Risk Implication
Solar PV	452.1 global additions	0.043	691	17.4	83%	Mature technology with relatively low technology risk, but subject to financing, grid and curtailment risks
Onshore wind	105.7 GW	0.034	1,041	36.0	>60%	Mature technology with relatively low LCOE but exposed to resource, permitting, grid and financing risks
Offshore wind	Increasing deployment	0.079	2,852	41.0	>60%	Higher capital intensity and construction and supply-chain risks



Hydropower	Major established technology	0.057	2,267	53.0	3%	High capital requirements and substantial environmental, permitting and construction risks
Geothermal	Established but geographically restricted	0.060	4,015	82.0	32%	High exploration and resource risk and high capital intensity

Hydropower recorded a global weighted-average LCOE of USD 0.057/kWh and an installed cost of approximately USD 2,267/kW. Its relatively high capital cost implies greater financing requirements and longer construction-period exposure. Nevertheless, hydropower offers the advantages of relatively high capacity factors and dispatchability. Its investment attractiveness therefore cannot be evaluated solely through LCOE. Investors in hydropower are particularly sensitive to interest rates, construction risk, project duration and government guarantees.

The wider evidence shows that renewable energy is highly cost competitive. According to the information presented, 91% of new utility-scale renewable capacity commissioned in 2024 generated electricity at a cost lower than the cheapest newly installed fossil-fuel option.

This strengthens the economic case for private investment in renewable infrastructure because declining technology costs reduce the revenue required to achieve acceptable investment returns.

3.4 Regional Distribution and Investment Opportunities

The regional results presented in Table 4 show substantial differences in private infrastructure investment. East Asia and the Pacific (EAP) recorded the highest level of investment, amounting to approximately USD 56.959 billion across 99 projects. Latin America and the Caribbean (LAC) followed with USD 21.865 billion across 95 projects. Sub-Saharan Africa (SSA) recorded approximately USD 7.918 billion across 47 projects, while Europe and Central Asia (ECA) recorded USD 7.748 billion across 38 projects.

Table 4. Distribution of Private Infrastructure Investment by Region, 2024

Region	PPI Investment (USD million)	Number of Projects	Investment/Project (USD million)	PPI as % of Regional GDP	Change from 2023
East Asia & Pacific (EAP)	56,959	99	575.3	0.27%	+11%
Europe & Central Asia (ECA)	7,748	38	203.9	0.77%	+91%
Latin America & Caribbean (LAC)	21,865	95	230.2	0.36%	+36%



Middle East & North Africa (MENA)	491	8	61.4	0.02%	−83%
South Asia (SAR)	5,724	28	204.4	0.13%	−38%
Sub-Saharan Africa (SSA)	7,918	47	168.5	0.39%	+133%
Total	100,705	315	319.7	—	+16%

The EAP result is particularly notable because its average project investment was approximately USD 575.3 million, considerably higher than the overall PPI average of approximately USD 319.7 million. This indicates that investment in the region was concentrated in relatively large infrastructure projects. By contrast, SSA had an average project investment of approximately USD 168.5 million, indicating a greater prevalence of smaller investment commitments.

Although its absolute investment volume was smaller, SSA experienced a 133% increase in PPI investment compared with the previous year. This is significant for renewable-energy investment in Africa because it indicates a rapidly expanding investment environment. However, the relatively low average project size may reflect continuing constraints associated with project preparation, access to financing, currency risk, institutional capacity and perceived country risk.

The regional differences further demonstrate that technology cost alone cannot explain investment patterns. Countries with similar solar or wind resources may attract substantially different levels of private capital because of differences in political stability, exchange-rate conditions, regulatory certainty, power-purchase agreements, transmission infrastructure and access to concessional finance. The results therefore support the study's integrated framework in which technology cost interacts with the policy and financing environment.

3.5 Financing Structure and Its Implications for Private Equity

The financing structure presented in Table 5 demonstrates the importance of debt and equity in infrastructure investment.

Table 5. Financing Structure of PPI Investment, 2024

Financing Component	Share (%)	Approximate Value (USD billion)
Debt	68.0	68.48
Equity	31.0	31.22
Unclassified/other	1.0	1.01
Total	100.0	100.70
International debt	47.0	47.33
Local debt	22.0	22.15
Commercial debt	29.0	29.20
Multilateral debt	14.0	14.10
Bilateral/institutional debt	0.6	0.60
Public equity	0.4	0.40
Government subsidy	0.8	0.81
Private equity	30.6	30.81

The predominance of debt demonstrates substantial dependence on leveraged financing arrangements. While leverage can enhance equity returns where projects generate stable cash flows, it can also increase financial risk when revenues are uncertain or financing costs rise.

The 30.6% private-equity share is particularly important because it demonstrates that private investors are not simply providing contractual services but are directly participating in project ownership and risk bearing. The substantial private-equity contribution therefore provides



evidence of an active market for private capital in infrastructure.

For renewable-energy projects, the sustainability of this financing structure depends strongly on revenue predictability. Long-term power-purchase agreements, feed-in arrangements, auctions, contracts for difference and other revenue-support mechanisms can reduce revenue uncertainty and improve debt capacity. Conversely,

projects exposed to merchant electricity markets may require larger equity contributions because investors face greater electricity-price volatility.

3.6 Development-Finance Support and Investment Risk

The results in Table 6 demonstrate the relationship between development-finance participation and investment risk.

Table 6. Development-Finance Support and Investment Risk

Region	PPI Projects	Projects with DEFI Support	DEFI-Supported Projects (%)
East Asia & Pacific	99	10	10%
Europe & Central Asia	38	31	82%
Latin America & Caribbean	95	~17	18%
Middle East & North Africa	8	7	88%
South Asia	28	~11	39%
Sub-Saharan Africa	47	~30	64%
Global	315	~107	34%

Approximately 34% of PPI projects worldwide received support in the form of development finance or export finance. This proportion was considerably higher in several regions, reaching 82% in ECA, 64% in SSA and 88% in MENA.

The high level of support in SSA is particularly significant because it demonstrates the continuing importance of development-finance institutions in mobilising private capital in higher-risk markets. Such support can be provided through guarantees, concessional loans, credit enhancement and other risk-sharing measures. These mechanisms can reduce the risks that private investors are unwilling or unable to assume independently.

The results provide evidence that investment risk can be partly transformed through appropriate financial and institutional arrangements. Development-finance participation can lower perceived risk and

improve project bankability, thereby enabling projects to achieve financial closure.

This is particularly important for renewable-energy infrastructure in Africa. A project may possess excellent solar or wind resources but remain financially unattractive if investors face currency-convertibility risks, poor utility creditworthiness, uncertain tariffs, inadequate transmission infrastructure or unpredictable regulatory conditions. Under such circumstances, government guarantees and development-finance instruments may be more important than further reductions in technology costs.

3.7 Attractiveness of Renewable-Energy Deployment and Investment

The renewable-energy indicators presented in Table 7 support the economic case for private investment. In 2024, global renewable-energy capacity additions amounted to 582 GW, of which solar PV accounted for 452.1 GW and wind for 114.3 GW.



The figures demonstrate that investment in renewable energy has moved beyond being a minor specialist activity and has become an important component of global electricity infrastructure.

Table 7. Indicators of Investment in Renewable Energy

Indicator	Result
Global renewable-energy capacity additions, 2024	582 GW
Solar PV additions	452.1 GW
Wind additions	114.3 GW
Solar PV share of renewable-energy additions	77.8%
Solar PV global capacity at end-2024	≈1,859 GW
Global weighted-average solar PV LCOE	USD 0.043/kWh
Global weighted-average onshore wind LCOE	USD 0.034/kWh
Global weighted-average hydropower LCOE	USD 0.057/kWh
Solar PV installed cost	USD 691/kW
Onshore wind installed cost	USD 1,041/kW
Offshore wind installed cost	USD 2,852/kW
Renewable capacity with lower LCOE than cheapest new fossil alternative	91%
Fossil-fuel costs avoided by renewables in 2024	USD 467 billion

By the end of 2024, global installed solar PV capacity had exceeded 1,859 GW, while its global weighted-average LCOE was USD 0.043/kWh. Onshore wind was even more competitive, with an LCOE of USD 0.034/kWh, while hydropower recorded USD 0.057/kWh.

Cost reductions are especially significant for private-equity investors because declining LCOE can improve project margins, reduce the revenue required for financial viability and reduce exposure to wholesale electricity-price

fluctuations. However, the results also demonstrate that the cost advantage of renewable technologies varies among countries. Differences in permitting, grid constraints, balance-of-system costs, financing costs and supply-chain conditions contribute to regional variations.

The investment decision should therefore not be based exclusively on global technology averages. Investors must consider country-specific LCOE, cost of capital, currency risk, revenue arrangements, grid availability and policy stability.

3.8 Integrated Interpretation of Technology Cost, Financing and Risk

The renewable-energy investment results presented in Tables 1–7 reflect a combination of technical, financial, institutional and geographical factors. Technology cost determines the basic economic attractiveness of a project, whereas financing conditions determine whether that project can be converted into a bankable investment.

The findings demonstrate a clear distinction between technology competitiveness and investment competitiveness. Although onshore wind and solar PV have highly competitive global LCOEs, a project with a low LCOE can still fail to attract private capital if financing costs are high, revenues are uncertain or regulatory risks are substantial. Conversely, government guarantees, development-finance participation and stable power-purchase agreements can make projects financially viable even where technology costs are relatively high.

The results for SSA are particularly significant. The region recorded USD 7.918 billion in PPI investment, with annual growth of 133%, demonstrating considerable scope for expansion. At the same time, the 64% participation rate of development-finance institutions indicates that risk mitigation remains an important requirement.

This means that the renewable-energy investment gap in Africa cannot be closed



simply through reductions in the prices of solar panels, turbines or batteries. Improvements are also required in the investment environment, including predictable regulation, reliable off-takers, currency-risk mitigation, stronger transmission infrastructure and access to long-term financing.

The findings therefore support the following investment framework:

Technology cost → Financing conditions → Perceived investment risk → Private-capital mobilisation

Although lower technology costs increase potential project returns, the extent to which those returns are realised depends on financing costs and the broader policy environment.

3.9 Implications for Private-Equity Investment in Renewable Energy

The results have several implications for private-equity investors. First, the continued decline in renewable-energy costs is creating a more attractive underlying investment environment. The fact that 91% of newly commissioned utility-scale renewable capacity in 2024 was cheaper than the cheapest new fossil-fuel option provides evidence of improving economic fundamentals for renewable energy.

Second, in markets where conventional project debt is constrained, private equity is likely to play a particularly important role. Equity can absorb construction, market and regulatory risks that lenders may be unwilling to assume. The 30.6% share of PPI financing attributed to private equity demonstrates that private capital remains important in infrastructure development.

Third, investors need to differentiate among renewable-energy technologies. Solar PV has a relatively low installed cost and strong deployment momentum; onshore wind has the lowest global LCOE; hydropower has different system-value characteristics but requires greater capital commitments; while offshore wind and geothermal remain relatively capital-

intensive. These differences provide opportunities for portfolio diversification.

Finally, the high development-finance participation rates observed in SSA and other regions indicate that blended-finance structures can play an important role in mobilising private equity. Public guarantees, concessional finance and risk-sharing mechanisms can reduce the risk premium demanded by private investors and consequently improve the financial viability of renewable-energy projects.

3.10 Overall Discussion

Overall, the seven tables provide consistent evidence of a transition toward a more investment-oriented renewable-energy sector. The increase in global PPI investment to USD 100.7 billion, the dominance of energy infrastructure at USD 67.9 billion, the 30.6% private-equity contribution, and the continued decline in renewable-energy generation costs collectively indicate that renewable energy has become an increasingly important destination for private infrastructure capital.

Nevertheless, the results demonstrate that cost competitiveness alone is insufficient to guarantee investment. The substantial regional differences in PPI investment and development-finance participation show that country and institutional conditions continue to influence capital allocation. Renewable-energy projects therefore require an investment environment that combines competitive technology costs with predictable policy, credible revenue mechanisms, appropriate risk allocation and affordable long-term financing. The principal finding of the study is that private-equity investment in renewable-energy infrastructure is best understood as the outcome of an interaction among technology economics, financing structure, government support and investment risk. The rapid growth of solar PV and wind demonstrates the importance of declining technology costs, while the financing and regional results demonstrate that institutional and financial conditions determine how effectively these technological advantages



translate into actual investment. This provides the empirical basis for the investment framework proposed in the study.

4.0 Conclusion

This study investigated determinants of private equity investments in renewable energy infrastructure, including financing structure, technology costs, investment risk, regional investment patterns, and policies and development finance. The results show that renewable energy infrastructure has become an increasingly significant target for private funding. The amount of global private infrastructure investment rose to USD 100.7 billion through 315 projects in 2024 from USD 87.1 billion through 324 projects in 2023, while the energy sector was estimated at USD 67.9 billion with 217 projects, thus becoming the largest PPI sector. Furthermore, the study shows that the financing structure plays a vital role in investment decision-making. Debt accounted for 68% of PPI financing, equity-like sources stood at 31%, and private equity made up 30.6% of total PPI investments. This means that private equity investors continue being key sources of risk-bearing capital in case of expensive renewable energy projects. Another significant factor influencing investment attractiveness was the issue of technology economics. The competitive generation costs of solar PV and onshore wind allowed for expanding in these areas. However, it should be said that the cost of technology does not affect investment outcome alone. Such factors as revenue certainty, cost of capital, capital structure, government support, macroeconomic environment, regulatory environment, and investment risk altogether define the bankability of a project. Different regions provide additional proof of the significance of investment conditions. Sub-Saharan Africa showed USD 7.918 billion through 47 projects and strong growth; however, the significant involvement of DEFI indicates that risk management tools are still

necessary. On the global scale, 34% of PPI projects involved DEFI, while in Sub-Saharan Africa, it was 64%.

The study concludes that the expansion of private-equity investment in renewable-energy infrastructure can only be through the inclusion of an integrated approach, that operates through the combination of competitive technology costs, affordable financing, predictable revenue mechanisms, effective government policies, and appropriate risk-sharing arrangements.

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Data shall be made available upon request

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All components of the work were carried out by the author

