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Evaluating the Financial Feasibility of Renewable Energy Integration in Construction Sector

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Abstract

This important study details how economically viable renewable energy systems are in building and construction. The document begins with an intriguing discussion of renewable energy's role in sustainable development and environmental protection. For this article, a thorough literature review examines theoretical frameworks and financial analysis methods that support adding renewable energy systems to construction projects. This study examines many scholarly journals, industry reports, and conference papers using a qualitative secondary research design and the new Onion Framework. Using ideas, real-world data, financial evaluations, and case studies, layered analysis can reveal complex details about renewable energy systems' building industry profitability. A full comparison is in "Results." This section includes numbers and case studies that demonstrate the financial importance of switching to renewable energy. Show how upfront costs, payback periods, IRR, and comparative cost analyses differ between traditional and renewable energy systems using tables and figures. This research is combined with others in the discussion to explain how renewable energy systems affect construction costs. In addition to economic benefits, it suggests more research on regional differences and policy changes. This study suggests renewable energy systems in construction could be profitable. Although these systems require different initial investments, they may be cost-effective over time. It shows how important renewable energy strategy is for financially and environmentally sustainable building.

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INTRODUCTION

Renewable energy in construction promotes sustainable development and reduces climate change (Mansurova, 2021). Renewable energy sources are being explored as alternatives to traditional energy systems due to increased global environmental awareness (Dikmen and Gültekin, 2017). This paradigm shift states that the construction industry is under pressure to go green because it uses a lot of energy and harms the environment (Tenorio et al., 2015). The International Energy Agency (IEA) reported in 2022 that the building and construction sector uses 36% of global energy and emits 39% of energy-related CO₂ (IEA, 2023). These shocking numbers demonstrate how important the construction industry is and how important it is to use sustainable energy to reduce its environmental impact. The rapidly growing global renewable energy market shows how important it is for the construction industry to find environmentally friendly energy solutions. In 2022, Grand View Research

predicted that the global renewable energy market would grow to \$1.5 trillion by 2027 (GVR, 2023). Solar energy will likely drive this massive change. This massive growth indicates a large market opportunity and a global shift towards renewable energy. This study seeks to determine if renewable energy systems in building projects are financially feasible. This study examines the feasibility of adding renewable energy systems to building plans, which is most important. This evaluation will examine initial investment costs, ongoing costs, ROI, and project long-term viability.

This research is important for adding to what is already known, not just for financial effects. Renewable energy has been touted for its environmental benefits, but its financial effects, especially on building projects, are poorly understood. This conclusion was reached by 2020 World Green Building Council researchers (World Green Building Council, 2021). Statistics from these studies were promising. Their study found that adding renewable energy systems to buildings could save owners 30% over time (Zhang et al., 2022). These numbers demonstrate the potential economic benefits and the importance of thorough financial analyses in construction decision-making.

Adding interesting case studies to this research shows how the proposed solution would work in real life and save money. The net-zero energy Bullitt Centre in Seattle, Washington, had a 106% ROI in six years (WA, 2013). Smart use of solar panels, rainwater collection, and other renewable technologies made this possible. Also, Masdar City in Abu Dhabi, UAE, is an ambitious eco-city plan. Solar, wind, and geothermal energy are used extensively and it has attracted investment and boosted the economy (Masdar City, 2023). The King Abdullah Financial District in Riyadh, Saudi Arabia, has the world's largest rooftop solar PV installation. This installation reduces operational costs and supplies 25% of the district's electricity (KAED, 2023). This is another benefit of using renewable energy.

In conclusion, this study seeks to demonstrate the financial viability of renewable energy in the building industry. This study seeks to balance environmental and financial concerns. This study examines economic viability and benefits to help everyone make smart choices that will benefit the economy and environment. Research objectives aim to provide a comprehensive understanding of the financial aspects associated with integrating renewable energy into the construction sector, facilitating informed decision-making and sustainable project development.

- Examine the economic feasibility of integrating renewable energy technologies in construction projects.
- 2: Evaluate the potential cost savings and financial benefits associated with the adoption of renewable energy.
- 3: Break down the various cost components involved in renewable energy integration, including initial investment, operational, and maintenance costs.

LITERATURE REVIEW

Renewable energy systems in construction projects are supported by a strong theoretical framework with multiple methods. This framework makes integration financially feasible. Life Cycle Costing underpins this framework. Financial Analysis Methods and Sustainability Frameworks are also important. Renewable energy systems are more expensive to buy, but they are cheaper to run, saving you money over time. Widely discussed LCC tracks project costs over time. Renewable energy systems are cheaper. NPV, IRR, and Payback Period are essential for estimating

renewable energy project profits. Sustainability frameworks like the Triple Bottom Line (TBL) analysis support renewable energy by considering environmental, social, and economic impacts. In 2020, NREL found that business buildings with solar PV systems save money (Souza et al., 2023). Research indicates that solar PV systems have lower levelized costs than grid-based systems over 25 years (Barwińska-Matajowicz et al., 2023). A Swedish net-zero apartment block studied by the International Energy Agency (IEA) in 2023 had a 40% lower LCC than regular buildings (IEA, 2021). Solar PV and geothermal heat pumps were blamed.

Financial studies using net present value, internal rate of return, and payback period show renewable energy sources are viable. A 2022 Berkeley study found that a rooftop photovoltaic (PV) system in a California single-family home had a positive NPV of \$24,000 over 20 years (Wang et al., 2023). The Rocky Mountain Institute (RMI) reported 12% IRR for geothermal heat pumps and 15% for solar PV systems in US commercial buildings in 2021 (RMI, 2023). Depending on location and incentives, US home solar photovoltaic (PV) systems can pay for themselves in four to eight years, according to LBNL (EMP, 2023). Comprehensive financial studies using NPV, IRR, and Payback Period show renewable energy sources are profitable. El-Sayeh et al. (2021) and Al-Khatib et al. (2022) found positive NPV, IRR, and payback periods for grid-connected photovoltaic (PV) systems in Egyptian homes and geothermal and solar systems in Jordanian hotels. So these systems were good investments. Masdar City and the Bullitt Centre demonstrate how people can save money and reduce CO₂ emissions and energy use (Cugurullo, 2013).

Masdar City in the UAE reduced energy use by 40% and CO₂ emissions by 70% compared to regular buildings (Lau, 2022). It's clear the investment will pay off because the case study emphasises long-term economic benefits (Amer et al., 2022). Since 2013, the Bullitt Centre in Seattle has used net-zero energy and this building will save \$1.5 million over 25 years compared to others while the property's LEED Platinum certification and eco-friendly features increased its value (Isiaka and Ahmed, 2023). Statistics show renewable energy sources are becoming more popular and profitable worldwide. This also applies to construction. International Renewable Energy Agency (IRENA) predicts that 66% of ship electricity will be renewable by 2050 (IRENA, 2018). This emphasises the importance of long-term goals. The global solar photovoltaic (PV) market is expected to reach \$242.3 billion by 2026 (Haseeb Ullah Khan et al., 2023). This is because renewable energy is growing (Asghar et al., 2023). The World Green Building Council reports 18% rent increases and 23% sales increases for green buildings (USGBC, 2022). This shows that renewable energy is cost-effective.

Government policies help make renewable energy systems easier to use in construction. These policies use various methods to make cooperation more economically viable. Feed-in tariffs (FITs), tax credits, and grants lower renewable energy costs, set fixed prices, and encourage use, which boosts the economy (Raynsford, 2021). Germany's Feed-in-Tariff (FiT) programme dropped from 75 MW in 2000 to 41 GW in 2014, solar photovoltaic installations skyrocketed (Bamgbade et al., 2017). Renewable technologies are also required by energy performance standards and net metering laws. The fact that California's Title 24 standard requires all newly built homes to have solar panels has shifted the energy market towards renewable sources is intriguing (Shan, Hwang and Zhu, 2017). These policies have clearly boosted the economy by creating jobs, securing energy, and possibly lowering costs. By 2050, renewable energy will have created 42 million jobs worldwide, according to IRENA (IRENA, 2018). This growth is due to rapid sector growth. Plans to ensure energy supply

demonstrate its economic and strategic importance. For instance, Germany's renewable energy goals have reduced its dependence on Russian gas (Kibert, 2023). These effects are good, but inconsistent policies, grid integration issues, and fairness concerns remain. This means more research is needed to understand how policies affect different situations and find new ways to pay for them to lower upfront costs and share benefits more fairly. Comparing conventional and renewable energy systems in the construction industry can reveal the financial rules for each configuration. Traditional energy systems have lower start-up costs than non-traditional ones because their infrastructure and technology are accessible. Due to fuel price volatility, their operating costs can rise in areas with scarce fossil fuels. However, renewable energy systems cost more upfront due to changing technology. These systems are cheaper due to government incentives (Akram et al. 2023). They have lower operating costs because they generate their own electricity and are less dependent on fossil fuel prices.

Specialised equipment may increase maintenance costs. Case studies demonstrate renewable energy's cost savings. The National Renewable Energy Laboratory (NREL) found that solar panels save homeowners \$1,000 a year on energy bills as the panels pay for themselves in 5-10 years (NREL, 2021). The IEA also found that geothermal heating systems could cut energy costs by 50% and pay for themselves in 7-12 years in commercial buildings (IEA, 2023). Numbers show that installing one kW of capacity costs differently across technologies. Solar photovoltaic (PV) systems cost \$3-5, wind energy \$2-4, and geothermal \$5-10 per watt. Utility natural gas rates remain between \$0.5 and \$1 per watt. Solar photovoltaics (PV) (\$0.05-0.15 per kWh), wind energy (\$0.04-0.10 per kWh), and geothermal have LCOEs similar to natural gas (\$0.08-0.15) (Berardi, 2013).

Problems must be solved before adding renewable energy to construction projects. These issues arise from the complex relationship between initial costs, ROI, and case-specific studies. Despite \$3-6 per watt installation costs, solar photovoltaic (PV) systems pay for themselves within 5-12 years, giving them a financial advantage over other options (U.S. Department of Energy, 2022). Wind power projects can pay for themselves in 7-15 years, depending on turbine size and location. Wind power projects cost \$2-6 million per megawatt, although green roofs are better for the environment, they cost \$15-\$45 per square foot to install (Hu et al., 2015). This extends payback periods beyond 20 years. PV systems have good ROIs (returns on investment) of 15-20% (Saini et al., 2022). Net metering incentives make this especially true. Wind power projects can have an IRR of 8% to 15%, depending on wind availability and market conditions, however, geothermal heat pumps have 15-25% IRRs (Abdo, El-Shazly and Medici, 2023).

They have lower operating costs and may qualify for tax credits. Case studies clarify their points by illustrating these numbers. The Seattle Bullitt Centre, a LEED Platinum office building, uses almost no energy. Integrating a lot of solar PV and saving energy should save money over time. Walmart's California initiative to install rooftop solar photovoltaic systems on 340 stores has saved money as this project aims to cut energy use 20% (Vanderhelm, 2021). The Bank of America Tower in New York can reduce its carbon footprint by 40% and save money by using biogas to power its combined heat and power system (Villarroel-Schneider et al., 2022). Real-life case studies and statistical insights show how renewable energy in building projects affects finances and returns (Akram et al. 2023). This emphasises the importance of complex evaluations and situation-specific methods. Even though there is useful literature, but

there are still big gaps. Most current studies focus on specific buildings or renewable energy technologies. To do this, we must examine many construction projects and energy systems in detail. Renewable energy can save money over time, but there is little real-world research on integrated systems' lifecycle performance. To determine if renewable energy projects will make money, you must understand markets, regional differences, and other factors. To understand contextual factors that affect feasibility, more regional studies are needed.

THEORETICAL FRAMEWORKS

Real Options Theory

Real Options Theory is employed to assess the flexibility and strategic value associated with renewable energy investments in construction projects. The literature suggests that treating renewable energy investments as real options allows for the incorporation of uncertainties and the ability to adapt to changing conditions over time.

Triple Bottom Line (TBL) Framework

The Triple Bottom Line framework is utilized to evaluate the financial, environmental, and social impacts of renewable energy integration in construction. Scholars emphasize the importance of considering not only economic feasibility but also environmental and social benefits, aligning with sustainable development goals.

Life Cycle Costing (LCC)

Life Cycle Costing is applied to estimate the total costs associated with renewable energy systems throughout their lifecycle. The literature underscores the significance of considering not just upfront costs but also operational and maintenance expenses to make informed financial decisions.

FINANCIAL ANALYSIS METHODS

Net Present Value (NPV)

NPV analysis is commonly used to evaluate the profitability of renewable energy projects by comparing the present value of cash inflows and outflows. Research findings highlight the NPV as a crucial metric for determining the financial attractiveness of renewable energy investments.

Internal Rate of Return (IRR)

IRR is employed to determine the rate of return that makes the net present value of cash flows zero. The literature emphasizes IRR as a valuable metric for assessing the financial viability of renewable energy projects, particularly in comparison to the cost of capital.

Payback Period

Payback Period is used to measure the time it takes for the initial investment to be recovered through the project's cash inflows. Studies suggest that a shorter payback period enhances the financial feasibility of renewable energy projects, reducing investment risk.

Risk-adjusted Discount Rates (RADR)

RADR is introduced to account for the risks associated with renewable energy investments, adjusting the discount rate based on risk levels. Research indicates that incorporating risk-adjusted discount rates provides a more accurate representation of the financial landscape

RESULTS

Relevance of Renewable Energy in Construction

The literature consistently highlights the growing importance of renewable energy integration in construction to mitigate environmental impacts and adhere to sustainability goals. Studies emphasize that adopting renewable energy aligns with global initiatives to reduce carbon footprints and transition to cleaner, more sustainable energy sources.

Need for Financial Analysis

Financial analysis is deemed essential to assess the economic feasibility of renewable energy integration, considering the significant initial investments and long-term implications. Researchers stress the importance of employing robust financial analysis methods to provide stakeholders with a comprehensive understanding of the potential returns and risks associated with renewable energy projects in the construction sector. Theoretical frameworks and financial analysis methods, researchers and practitioners gain a holistic perspective on the financial feasibility of renewable energy integration in construction, taking into account economic, environmental, and social dimensions

METHODOLOGY

Research Design and Approach

The qualitative secondary research design determines if renewable energy in building projects is financially feasible. This method relies on reputable databases, industry reports, conference papers, and scholarly journals. This method comes from the Onion Framework. As if peeling layers, it unfolds. The goal is to reveal nuanced insights into the financial viability of renewable energy in construction. The Onion Framework's top level introduces renewable energy systems' main concepts and theories in the building industry (Khan and Shahriyar, 2023). This section examines leading theories like Life Cycle Costing (LCC), Financial Analysis Techniques, and Sustainability Frameworks for renewable energy in building projects.

Financial methods and renewable energy are explained in academic, theoretical, and industry papers. Analysis builds on understanding. As the Onion Framework moves inward, empirical studies, financial analyses, and comprehensive case studies examine the economic viability and real-world effects of adding renewable energy systems to construction projects. This step examines empirical data, financial assessments, and real-world applications. Policy, cost-effectiveness, and real-world implications are shown here. Reports, case studies, and databases with detailed financial analyses and real-world examples show how renewable energy affects construction project finances. Onion Framework organizes renewable energy construction financial viability data (Kong et al., 2023). This method builds a solid theoretical foundation from fundamental ideas and theoretical bases (the outer

layer). Evaluate with empirical, financial, and practical case studies. This gives multiple perspectives on renewable energy construction costs and viability.

DATA COLLECTION METHODS AND PROCEDURES

This study uses many carefully selected data sources to fully understand the topic. This study examines renewable energy's construction financial viability. This approach relies on academic journals and peer-reviewed articles in reputable journals. Financial analyses, case studies, and theoretical frameworks for renewable energy system integration in construction are essential. These sources provide valuable insights and validated renewable energy financial evaluation data. Industry reports and publications from reputable organisations like the World Green Building Council, IRENA, and government publications are also used. Statistics, market trends, and policy implications are useful from these sources. These sources cover the economic and regulatory environment affecting renewable energy integration in construction. These resources provide practical insights and real-world applications, keeping the study current with industry.

Even worse, the data collection strategy includes construction and renewable energy conference papers and proceedings. These papers provide current insights and trends, setting the research forward. These forums may reveal new methods, technology, and ongoing discussions about the economic benefits and challenges of renewable energy in construction. This method thoroughly reviews literature and data using multiple methods. Data is collected methodically from Science Direct, PubMed, IEEE Xplore, and Google Scholar. Sustainable energy, infrastructure, and economic viability are researched using keywords. For a comprehensive analysis, this systematic approach gathers many relevant studies and articles. A Thematic Framework organizes scholarly works in this study. This analytical tool finds case studies, cost analysis, sustainability frameworks, and policy impacts. Data is categorized and examined by theme in this framework for systematic and exhaustive analysis. This addresses the many factors that affect renewable energy construction's economic viability. To gather more relevant sources, citation tracking and snowballing are used. This method tracks references and citations in the identified literature to complete the knowledge base analysis. It also provides valuable insights and materials that strengthen the study's findings.

JUSTIFICATION

This study's method is ideal for determining if large-scale construction projects can afford renewable energy. This alignment ensures that existing information is examined methodically and carefully, which helps build subject knowledge. This method strategically uses the Onion Framework and Thematic Framework to simplify structured and disciplined investigation. These frameworks help you navigate basic ideas, empirical evidence, financial analyses, and case studies. Like peeling an onion, the Onion Framework layers research. This organises results presentation. The first layer of this methodical layering covers renewable energy basics in the building industry. To build a solid theoretical foundation, Life Cycle Costing (LCC), Financial Analysis Techniques, and Sustainability Frameworks are examined. To advance to the inner layers, empirical studies, financial analyses, and full case studies must be examined. This planned process allows for a complete assessment of renewable energy's practical, policy, and economic benefits in building projects. Meanwhile, the Thematic Framework organised and made sense of all the literature. Cost analysis,

sustainability frameworks, policy impacts, and case studies are common themes in this analytical tool. This tool organises critical analysis and source integration. Thematic categorization groups related information for a complete picture. This makes it easier to study the factors that affect renewable energy building's financial viability. Due to the methodological approach, the research question is fully understood. This method aims to show how financially viable renewable energy is in construction. This is done by carefully reviewing different levels of information, critically assessing different sources, and combining different perspectives.

RESULTS

In the results section, the business and financial effects of renewable energy in construction and building are examined. This section examines numerical data, case studies, and comparative analyses from many studies and methods. Renewable energy systems affect finances in various ways, as the article explains. Start-up costs, ROI, payback periods, and cost comparisons between renewable and traditional energy systems are emphasised. This section includes real-world numbers, proven methods, and in-depth analyses that support the study's goals and the literature review's focus on the project's financial feasibility. Construction industry stakeholders and decision-makers must understand the economic effects of renewable energy in construction projects. They need these results for useful information.

Table 1.

Renewable Energy System	Upfront Cost per Unit	Payback Period
Solar PV	\$3 - \$6 per watt	5 - 12 years
Wind Power	\$2M - \$6M per MW	7 - 15 years
Green Roofs	\$15 - \$45 per sq. ft.	>20 years

Upfront Costs and Payback Periods of Renewable Energy Systems

The table compares renewable energy system startup costs. The cost of installing solar PV systems ranges from \$3 to \$6 per watt. However, installing wind power systems costs \$2–6 million per megawatt. Despite their environmental benefits, green roofs cost more. It costs \$15–\$45 per square foot. This study confirms the literature review that renewable energy technology starting costs vary. The American Wind Energy Association (AWEA) and National Renewable Energy Laboratory (NREL) studies show that this table's cost range is accurate. These cost differences are analysed because the research method uses reliable sources and industry reports for an in-depth analysis. The accurate and complete data from academic journals, industry reports, and government publications shows that the methodology focused on them. The results demonstrate that different cost structures must be considered when determining whether renewable energy systems can be financially integrated into building projects. This comparative analysis, an important part of stakeholder decision-making, highlights the large initial investment needed to switch to renewable energy. The fact that renewable technology prices can vary greatly shows how important it is to plan and research costs before using these systems in building projects.

Table 2.

Renewable Energy System	Internal Rate of Return (IRR) Range
Solar PV	15% - 20%
Wind Power	8% - 15%

Return on Investment (ROI) in Renewable Energy Systems

Table 2 compares the ROI of several renewable energy systems. Solar photovoltaic (PV) systems have an IRR of 15% to 20%, depending on location and net metering incentives. Wind power projects can have 8% to 15% IRRs, depending on market and wind availability. IRRs for geothermal heat pumps are 15%–25%. Tax credits and lower operating costs may apply. According to the literature review, the Rocky Mountain Institute's US commercial geothermal heat pump and solar photovoltaic system study found similar internal rate of return percentages. Comparative financial performance metrics were easier to include because they were based on academic papers and real-world studies.

Using rigorous DOE and NREL data, renewable energy technology ROI metrics vary greatly. This detailed analysis shows how important it is to consider multiple financial outcomes when assessing the financial viability of adding renewable energy sources to construction projects. The ROI metrics in this table show how location, incentives, and technology affect renewable energy investment profits. It stresses the importance of stakeholders conducting thorough financial analyses and considering multiple factors before adding renewable energy systems to construction projects.

Table 3.

Case Study	Financial Outcome	Renewable Technology	Energy
Bullitt Centre, Seattle	106% ROI within 6 years	Solar PV, efficiency	energy
Walmart California Initiative	20% offset of energy consumption	Rooftop solar PV	
Bank of America Tower	40% reduction in carbon footprint	Biogas-fueled combined heat and power system	

Case Studies on Financial Viability of Renewable Energy Integration

This table compares the initial costs of renewable energy systems used in construction projects. Solar photovoltaic (PV) systems cost three to six dollars per watt and pay for themselves in five to twelve years. Wind power installations cost \$2–6 million per megawatt. These projects pay for themselves in 7–15 years. Green roofs are environmentally friendly but expensive to install. Prices range from \$15 to \$45 per square foot. This implies much longer payback times than twenty years. All literature review findings were supported by the data. The American Wind Energy Association and the Solar Energy Industries Association have found that wind power and solar photovoltaic systems have similar installation costs and payback periods. This correspondence validates this study's research method. Trustworthy sources were used to show accurate and comparable data. Table 3's upfront cost comparison is more reliable because academic papers, business reports, and government reports were used to collect the data. By listing the costs and payback times for each renewable energy system, you can see the financial issues that arise in construction projects using these technologies. This extensive study found that renewable energy system initial costs and payback times vary greatly. This emphasises the importance of considering both the environmental benefits of these systems and the high costs of incorporating them into architecture and building projects. Everyone involved in the project needs the table's detailed information to make informed decisions about using renewable energy systems in their design.

Energy System	Average Upfront Cost per kW (\$)
Solar PV	\$3 - \$6
Wind Energy	\$2 - \$4
Geothermal	\$5 - \$10
Traditional Natural Gas	\$0.5 - \$1

Comparative Cost Analysis: Traditional vs. Renewable Energy Systems

Table 4 lists renewable energy system ROI metrics for the construction industry. Solar photovoltaic (PV) systems can have IRRs of 15% to 20%, especially in favourable locations and with net metering incentives. Wind power project IRRs range from 8% to 15%, depending on wind availability and market conditions. The IRR for geothermal heat pumps is 15%–25% higher. Tax credits may apply to their lower costs. Table 4 shows literature review results. Solar PV, wind power, and geothermal heat pump system IRR ranges have been verified by NREL and the US Department of Energy. Based on established research, this study's methodology is credible and accurate for ROI. Table 4's ROI comparison benefits from meticulous data collection from peer-reviewed articles, industry reports, and government publications. The table shows these technologies' financial returns and construction investment attractiveness. Renewable energy IRR ranges should be different. Renewable energy systems' ROI levels are detailed in this analysis, proving their financial viability under certain conditions. A nuanced presentation of IRR ranges helps stakeholders understand renewable energy system financial benefits and risks, guiding construction project decision-making.

This research project's results section is crucial because it explains city buildings' complex financial issues when installing renewable energy systems. Compare upfront costs, ROI, and financial performance of traditional and renewable energy systems. Case studies and comparisons show financial complexity. A study examined whether adding renewable energy sources was financially feasible. These findings, supported by real-world evidence and financial analysis, achieve this goal. These articles discuss renewable energy's economic pros and cons. This makes smart construction decisions even more crucial. These complete results can be used for strategic planning. Everyone gains a better understanding of renewable energy's economic effects. Building practices become greener and more profitable.

DISCUSSION

Renewable energy sources protect the environment and make buildings more sustainable. The results show how this integration affects finances and match field knowledge, methods, and literature. To determine if adding renewable energy systems to construction projects would be financially viable, this study used a strict qualitative secondary research design to examine many reliable sources, including scholarly journals, industry reports, and conference papers. The study shows how hard it is to pay for things upfront and how much you can save by using renewable energy over time. These findings support El-Sayeh et al. (2021) and Al-Khatib et al. (2022): solar and wind power cost more but yield big returns. NREL found that solar PV systems in good locations have high IRRs. Berkeley found that residential solar PV systems' positive net present value (NPV) increases their financial appeal. Comparing conventional and renewable energy shows financial issues. Traditional energy systems are cheaper to start, but fuel prices fluctuate quickly. It makes sense from the

literature. Renewable energy systems cost more upfront but less over time. Research shows that renewable energy has a lower LCOE than traditional energy. The new discovery supports that. Studies used the Onion Framework and Thematic Framework. A systematic study of the many factors affecting renewable energy's construction financial viability was possible. Methodological rigour ensured a complete analysis. Theories, empirical evidence, and financial analyses were included. The study showed promising financial prospects, but there are some cautions. More research is needed to account for geographical differences, changing policies, and changing technology. The study did a great job of combining all the research, but more needs to be done to determine regional effects and how renewable energy will affect the construction industry's finances long-term. This study increases our understanding of how affordable renewable energy systems are for building projects. Results strongly suggest economic benefits despite challenges and complexities that require more research. This study shows that renewable energy makes construction greener and more profitable.

CONCLUSION

The purpose of this study is to determine whether renewable energy systems in building projects are financially feasible. The study shows that renewable energy sources like solar photovoltaic and wind power may be cost-effective over time despite higher initial investments. Well-known methods and a thorough literature review are used to do this. The results demonstrate the value of Onion Framework and Thematic Framework methods for handling different levels of information. They mention the big economic benefits but say more research is needed on regional differences and changing policy environments. This study helps determine whether renewable energy in construction is a good business decision. It shows how crucial this integration is for the construction industry's financial and environmental future

FUTURE DIRECTIONS

Technological Advancements

Explore emerging renewable energy technologies and their potential application in the construction sector. Investigate advancements in energy storage systems to address intermittent energy production and enhance the reliability of renewable sources.

Integration Strategies

Examine innovative strategies for seamlessly integrating renewable energy into construction projects. Investigate smart grid technologies and their role in optimizing energy distribution and consumption within construction sites.

Policy and Regulatory Landscape

Monitor and analyze changes in renewable energy policies and regulations affecting the construction industry. Explore the impact of evolving government incentives and subsidies on the financial feasibility of renewable energy projects.

Circular Economy Practices

Assess the feasibility of circular economy principles in construction projects, emphasizing the reuse and recycling of materials and energy. Explore financial models that align with circular economy practices in the construction sector.

Community Engagement and Social Impact

Investigate the social impact of renewable energy projects on local communities. Develop financial models that consider community engagement and social responsibility, contributing to a positive public perception.

RECOMMENDATIONS**Comprehensive Feasibility Studies**

Conduct detailed feasibility studies that encompass all aspects of renewable energy integration, including economic, environmental, and social dimensions. Ensure thorough financial assessments considering both short-term returns and long-term sustainability.

Collaboration and Partnerships

Encourage collaboration between construction firms, renewable energy developers, and financial institutions. Foster partnerships that leverage expertise in construction, energy, and finance to enhance the financial feasibility of integrated projects.

Diversification of Funding Sources

Explore diverse funding sources, including public-private partnerships, green bonds, and crowd funding, to support renewable energy integration in construction. Evaluate the financial benefits and risks associated with each funding model.

Continuous Monitoring and Optimization

Implement monitoring systems to track the performance of renewable energy systems throughout their lifecycle. Establish protocols for regular optimization and maintenance to ensure sustained financial benefits.

Training and Skill Development

Invest in training programs to enhance the skills of construction professionals in renewable energy technologies. Develop financial literacy programs to empower decision-makers in understanding the economic nuances of renewable energy projects.

Adaptation to Regulatory Changes

Stay informed about evolving regulatory landscapes related to renewable energy and construction. Develop contingency plans and adapt financial models to comply with changing regulations and policies.

Stakeholder Education and Communication

Educate stakeholders, including investors, construction teams, and local communities, about the financial and non-financial benefits of renewable energy integration. Foster transparent communication to build trust and support for sustainable construction practices. Implementing these future directions and recommendations will contribute to the ongoing success of renewable energy integration in the construction sector, fostering financial sustainability, environmental stewardship, and positive social impact.

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