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The Role of Project Management in Advancing Renewable Energy Development in the United States: Challenges and Opportunities

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Abstract

The transition to renewable energy (RE) in the United States is critical to achieving national climate objectives, such as having 100% carbon-free electricity by 2035 and net-zero emissions by 2050. However, this has been hindered by persistent project management challenges such as permitting delays, cost overruns, and stakeholder opposition. Thus, this study investigated the role of project management in overcoming these challenges and optimizing the delivery of RE infrastructure across diverse regulatory and socio-economic contexts in the United State. Furthermore, this study was guided by four research objectives; it also assesses current project management practices, identifies barriers, evaluates the effectiveness of various methodologies, and explores the impact of stakeholder and risk management strategies. The baseline theories adopted for this study were the: Triple Constraint Theory (scope-time-cost optimization), Stakeholder Theory (inclusive decision-making), and Agile Project Management Theory (adaptive planning). Also, the study adopted mixed-methods design, combining quantitative analysis of 50 utility-scale RE projects from 2018 to 2023 with qualitative data from 20 project manager interviews and six comparative case studies. The statistical (SPSS) and thematic (NVivo) tools were employed to triangulate findings and uncover critical trends. The results show that hybrid Agile-Waterfall methodologies reduce delays by 18% in highly regulated environments, while inefficient permitting alone costs the RE sector an estimated $2.1 billion annually. Projects engaging early through Free, Prior, and Informed Consent (FPIC) protocols experience significantly faster approvals—up to 65%—compared to those with delayed community engagement. Digital tools like BIM and AI enhance planning and scheduling efficiency but remain underutilized among smaller developers due to financial and training barriers. The study concludes with targeted policy, industry, and community-level recommendations—such as streamlined permitting, SME digital subsidies, FPIC institutionalization, and hybrid PM certification—to support the rapid, equitable, and resilient deployment of renewable energy systems in the U.S.

Keywords: Renewable energy; project management; Agile methodology; stakeholder engagement; hybrid project management; risk management; clean energy transition and sustainable development.

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1. Introduction

1.1 Background to the Study

The transition toward establishing a carbon-free energy system in the United States by the middle of this century places strong emphasis on the development of renewable energy infrastructure. Targets such as achieving 100% carbon-free electricity by 2035 and net-zero greenhouse gas emissions by 2050 have added urgency and scale to renewable development [1]. However, significant roadblocks remain in achieving these targets. Despite improvements in technology and reductions in costs for solar panels, wind turbines, and battery storage systems, inefficiencies in project management continue to hinder renewable energy projects, often resulting in delays, cost escalation, or cancellations [2]. These inefficiencies pose a major challenge to achieving climate goals set by the U.S. government, highlighting the need to examine how strategic project management can enhance the execution and success of renewable energy projects.Project management in renewable energy presents unique challenges not commonly encountered in traditional construction or industrial projects. These complexities arise from factors such as federal and multi-state regulatory requirements, dependence on subsidies and tax incentives, rapidly evolving technologies, and stakeholder conflicts related to environmental concerns or local opposition [3,4]. Furthermore, the high capital intensity and long payback periods associated with renewable energy projects require detailed planning, risk assessment, and stakeholder alignment—core principles of effective project management [5]. Under such demanding conditions, the application of appropriate project management methodologies, including Agile and Waterfall approaches, becomes critical to addressing the unique demands of renewable energy development. Despite existing empirical studies on project management in renewable energy, most research tends to focus on technical efficiency, such as photovoltaic performance, or economic viability, such as the Levelized Cost of Energy [6]. There is limited empirical investigation into how project delivery models influence cost efficiency, schedule performance, and strategies for mitigating stakeholder opposition, which can lead to project termination. For instance, approximately 22% of solar projects in the United States are abandoned during the permitting process [7], while offshore wind projects often require more than four years to progress from proposal to operational status [8]. These observations underscore the urgent need to explore how project management principles can improve renewable energy project outcomes. Moreover, there is a noticeable gap in the literature regarding the integration of emerging technologies into project management practices within renewable energy projects. The role of digital tools—such as block chain for renewable energy certificate tracking or artificial intelligence for resource assessment—remains underexplored [9]. In addition, socio-political factors, including Indigenous rights, land-use conflicts, and community opposition, necessitate more advanced stakeholder management approaches than those typically addressed in conventional project management literature. To address these gaps, this study adopts a practice-oriented, mixed-method approach to investigate the role of project management in renewable energy development in the United States. It examines how different methodologies (e.g., Agile versus Waterfall) influence project outcomes, evaluates stakeholder engagement strategies, and assesses how digital tools can enhance efficiency and transparency. By bridging the gap between project management theory and renewable energy deployment, this study contributes to both academic discourse and practical application, offering valuable insights for policymakers, project managers, and energy developers working toward national climate objectives [1,8,3].

1.2 Purpose of the Study

The purpose of this study is to explore the role of project management in advancing renewable energy development in the United States by identifying the challenges, opportunities: with best practices associated with the planning, implementation, and delivery of renewable energy projects. Furthermore, the study seeks to assess how project management methodologies, tools, can be strategically applied to improve efficiency, effectiveness, and scalability of renewable energy initiatives in the United State. In doing so, it aims to provide insights into overcoming regulatory, infrastructural, financial, and stakeholder-related barriers to accelerate the transition to clean energy.

1.3 Research Objectives

i. To examine the key project management practices currently applied in renewable energy projects in the United States.
ii. To identify the major challenges and barriers hindering the successful execution of renewable energy projects in the United States.
iii. To evaluate the effectiveness of project management methodologies (e.g., Agile, PRINCE2, PMBOK) in addressing renewable energy development challenges in the United States.
iv. To analyze the role of stakeholder engagement and risk management in renewable energy project success in the United States.

1.4 Research Questions

i. What project management practices are commonly used in the implementation of renewable energy projects in the United States?
ii. What are the main challenges affecting the planning and execution of renewable energy projects in the U.S.?
iii. How effective are existing project management methodologies in addressing these challenges in the United States?
iv. In what ways does stakeholder engagement and risk management contribute to the success or failure of renewable energy projects in the United States?

2. Literature Review

2.1 Theoretical Review

The baseline theories that were adopted to underpin this study on The Role of Project Management in Advancing Renewable Energy Development in the United States: Challenges and Opportunities were: The Triple Constraint Theory, Stakeholder Theory and Agile Project Management Theory.

2.1.1 Triple Constraint Theory (Scope, Time, Cost)

The Triple Constraint Theory, also known as the Iron Triangle of project management, originates from traditional project management thought of the mid-20th century and was later popularized through the Project Management Institute's PMBOK® Guide. The theory emphasizes three core elements—scope, time, and cost—as the foundation of project management. Any adjustment to one element inevitably affects the others; for instance, expanding project scope typically requires additional time and increased financial resources. This framework is widely applied across industries and remains central to both theory and practice.

In the context of renewable energy projects, the complexity of managing these constraints becomes even more pronounced. Project managers must balance not only cost and schedule but also regulatory requirements and environmental considerations. Scope creep remains a persistent challenge, often arising from unforeseen environmental assessments or increased stakeholder demands during project execution [10]. A notable example is the Cape Wind Project in Massachusetts, which ultimately failed due to underestimation of regulatory delays and community resistance [11]. This case illustrates how poor management of the triple constraint can derail even well-funded and initially promising projects. Therefore, maintaining a balance among scope, time, and cost is essential throughout the lifecycle of renewable energy projects. In this study, the Triple Constraint Theory provides a useful framework for diagnosing project inefficiencies and evaluating how advanced project management tools can enhance performance.

2.1.2 Stakeholder Theory

Stakeholder Theory, originally developed by R. Edward Freeman, challenges the traditional shareholder-focused perspective by emphasizing that all stakeholders—individuals or groups affected by organizational activities—should be considered in decision-making processes. The theory has gained increasing relevance in large-scale public projects such as renewable energy development, where success depends not only on technical execution but also on social acceptance, regulatory compliance, and multi-stakeholder collaboration [12]. In the renewable energy sector, effective stakeholder engagement is often a critical determinant of project success. A prominent example is the Block Island Wind Farm in Rhode Island, the first commercial offshore wind farm in the United States. The project succeeded largely due to proactive stakeholder engagement, including consultations with local residents, fishermen, environmental groups, and government authorities [13]. Key concepts of stakeholder theory—such as legitimacy, urgency, and power—are essential for navigating the socio-political dynamics of renewable energy projects. In this study, stakeholder theory provides a framework for understanding how inclusive and transparent engagement strategies can reduce opposition and enhance project acceptance.

2.1.3 Agile Project Management Theory

Agile Project Management Theory emerged in the early 2000s, particularly following the publication of the Agile Manifesto in 2001, and has since been adopted across various industries. It is especially suitable for complex and uncertain environments where project requirements are subject to frequent change—conditions that characterize renewable energy development in the United States. Agile methodologies promote breaking large projects into smaller, manageable units known as "sprints," enabling iterative progress, flexibility, and early identification of potential issues. A practical application of Agile in renewable energy is observed in the Solar Star Project in California, one of the world's largest solar farms. Project managers adopted iterative planning cycles to adapt to regulatory changes and evolving energy policies, ensuring project continuity despite a dynamic operating environment [14]. The core principles of Agile—such as responsiveness to change, stakeholder collaboration, and continuous delivery—make it a valuable framework for managing renewable energy projects. This theory supports the present study by offering a flexible alternative to rigid planning models, suggesting that adaptive and stakeholder-driven approaches can accelerate renewable energy deployment in the United States Bottom of Form

2.2 Conceptual Review

2.2.1 Project Management Practices

Project management in the context of renewable energy development in the United States involves the systematic application of knowledge, skills, tools, and techniques to meet project requirements through structured methodologies. According to the Project Management Institute, as outlined in the PMBOK® Guide (7th edition), project management is defined as the application of specific knowledge, skills, tools, and techniques to deliver value to stakeholders [15]. It encompasses five key phases: initiation, planning, execution, monitoring and control, and closure, all of which play critical roles in achieving project success. These lifecycle stages are particularly important in renewable energy projects due to their complexity, long duration, and interdisciplinary nature. For instance, the planning phase often requires extensive feasibility studies, environmental impact assessments, and regulatory compliance strategies, while execution and monitoring emphasize aligning project delivery with performance targets, technical standards, and financial viability [16].

Specific project management practices tailored to renewable energy projects in the United States address the unique demands of the sector. Scope management is especially critical in large-scale initiatives such as solar farms and offshore wind parks, where clearly defined deliverables help minimize the risk of scope creep [17]. Time and cost management remain central, with tools such as Gantt charts, Earned Value Management (EVM), and Building Information Modeling (BIM) increasingly used to control scheduling and budgeting [18]. Resource management extends beyond traditional labor and materials to include specialized renewable technologies and grid integration systems.

Quality assurance practices are implemented to ensure that renewable energy systems meet industry standards and operate efficiently after deployment. Communication management is essential for coordinating diverse and geographically dispersed teams, ensuring alignment among stakeholders, engineers, and regulatory bodies. Integration management further ensures that all project components align with environmental requirements and regulatory frameworks, particularly within federal and state energy mandates [19]. A practical example is the Gemini Solar Project in Nevada, which incorporated stakeholder feedback and regulatory milestones while applying iterative planning approaches aligned with Agile principles. This approach enabled the project team to adapt to evolving conditions and maintain alignment with renewable energy objectives [20].

2.2.2 Effectiveness of Project Management Methodologies

The application of structured project management methodologies such as PMBOK, PRINCE2, and Agile has been instrumental in organizing and delivering complex renewable energy projects in the United States. The PMBOK (Project Management Body of Knowledge), developed by the Project Management Institute, provides a standardized framework that emphasizes process groups and knowledge areas, making it particularly suitable for large-scale infrastructure projects with clearly defined scopes [21]. PRINCE2 (Projects IN Controlled Environments), widely used in governance and public-sector environments, focuses on principles, themes, and processes, making it ideal for projects requiring extensive documentation and accountability [22]. In contrast, Agile methodologies prioritize adaptability, continuous stakeholder engagement, and iterative development, which have proven effective in smaller, community-based renewable energy initiatives and pilot programs [23]. Increasingly, hybrid approaches that combine structured planning with adaptive cycles are being adopted in renewable energy projects, particularly those involving regulatory uncertainty and rapidly evolving technologies such as smart grids and decentralized solar networks [24].

The suitability of these methodologies for renewable energy development often depends on achieving a balance between control and flexibility. PMBOK and PRINCE2 provide robust frameworks for documentation, risk assessment, and scope control, which are essential for large wind or solar farm installations involving multiple contractors and regulatory bodies. However, their structured nature may limit responsiveness to dynamic environmental regulations or technological advancements. While Agile is recognized for promoting innovation and stakeholder inclusion, it may face scalability challenges in geographically dispersed infrastructure projects and may lack the rigor required for compliance-intensive sectors such as energy [25].

Empirical evidence demonstrates this variation in applicability. Agile frameworks have been successfully deployed in U.S. community solar projects where stakeholder needs evolve rapidly [20]. PRINCE2 has supported complex wind farm developments by ensuring traceability and regulatory compliance [22]. Hybrid methodologies have emerged as best practice in smart grid projects, combining flexibility with structured control to accommodate rapid technological changes and evolving policy environments [26]. Ultimately, the effectiveness of any methodology depends on the scale, complexity, regulatory context, and stakeholder landscape of the project.

2.2.3 Renewable Energy

Renewable energy refers to energy derived from natural processes that are continuously replenished, such as solar radiation, wind, water flow, geothermal heat, and biomass. The International Renewable Energy Agency defines renewable energy as energy obtained from natural sources that are replenished at a rate higher than consumption Reference [27]. Similarly, the U.S. Department of Energy describes renewable energy as energy derived from resources that naturally regenerate on a human timescale, including solar, wind, geothermal, hydroelectric, and biomass sources [20]. According to the Environmental Protection Agency, renewable energy provides significant environmental benefits compared to fossil fuels, including reduced greenhouse gas emissions, lower air and water pollution, and improved energy security [28]. These attributes make renewable energy central to national strategies aimed at reducing carbon emissions and achieving sustainable energy systems. In the United States, renewable energy project execution involves the structured development and deployment of clean energy systems guided by project management frameworks and regulatory policies. These projects typically progress through stages such as site selection, permitting, procurement, construction, commissioning, and operation. The execution of projects such as wind farms in Texas or solar parks in California requires coordination among federal and state regulators, private developers, contractors, and local communities.

However, several challenges can affect project timelines and budgets if not effectively managed. These include delays in grid interconnection, land acquisition issues, financing constraints, and supply chain disruptions [26]. The adoption of modern project management methodologies, including Agile and PMBOK, has improved adaptability and stakeholder collaboration in renewable energy projects. For example, large-scale initiatives such as offshore wind projects in Massachusetts have benefited from iterative planning, continuous risk assessment, and integrated coordination strategies [20]. These approaches are essential for addressing the environmental, technical, and socio-political complexities that characterize renewable energy project implementation in the United States.

2.3 Challenges and Barriers in Renewable Energy Project Execution

The execution of renewable energy projects in the United States is often constrained by financial and economic challenges, particularly the high upfront capital investment required for infrastructure development and technology acquisition. Unlike fossil fuel-based energy systems, which benefit from well-established financing structures, renewable energy projects frequently face limited access to capital due to perceived investment risks and long payback periods [29]. Additionally, project developers must manage uncertainty regarding return on investment (ROI), especially in relation to fluctuating renewable energy policies and global energy prices. The reduction or instability of subsidies and tax incentives such as the Production Tax Credit (PTC) and Investment Tax Credit (ITC) has further contributed to funding instability [30]. These economic uncertainties discourage long-term investment and may delay or derail projects, particularly for small-scale developers with limited access to diversified funding sources.

Technical and operational barriers further complicate renewable energy deployment. Integrating intermittent renewable sources such as solar and wind into existing grid infrastructure presents significant challenges due to variability and limited predictability [31]. In addition, the current transmission infrastructure is often inadequate to support decentralized energy generation, resulting in congestion and distribution bottlenecks. From a regulatory perspective, inconsistencies in permitting procedures and environmental review requirements across federal, state, and local jurisdictions further complicate project approval timelines [32].

Organizational and human resource constraints also affect project execution, including shortages of skilled professionals in clean energy technologies and limited project management capacity. Resistance from traditional utility providers, combined with cultural misalignment in cross-functional teams, may slow decision-making and hinder innovation. Furthermore, social and environmental concerns—such as land-use conflicts, “Not In My Backyard” (NIMBY) opposition, and biodiversity protection issues—add complexity to project planning and implementation [33]. Addressing these multidimensional challenges requires an integrated approach that combines stakeholder collaboration, policy stability, technological innovation, and strong project management capabilities.

2.4 Stakeholder Engagement and Risk Management in Project Success

Effective stakeholder engagement and robust risk management are critical drivers of successful renewable energy project execution in the United States. Renewable energy projects involve a broad range of stakeholders, including government regulators, local communities, environmental advocacy groups, investors, developers, and utility companies. Stakeholder identification and mapping of interests, influence levels, and potential project impacts are essential early steps in project planning [34].

Engagement strategies such as public consultations, participatory planning workshops, and co-design forums have increasingly been adopted in the United States to integrate community input and align project objectives with local expectations [35]. For example, in community solar initiatives, cooperative ownership models have empowered local residents as stakeholders, improving transparency and enhancing project legitimacy. This participatory approach contributes to the development of a "social license to operate," which reduces opposition, minimizes legal delays, and strengthens trust among stakeholders [36]. The U.S. Department of Energy's Solar Energy Innovation Network has further promoted stakeholder engagement and collaboration between municipalities and local communities to improve energy equity outcomes [20].

In addition, integrating risk management practices with stakeholder engagement ensures that socio-political, financial, regulatory, and technical uncertainties are addressed throughout the project lifecycle. Risk identification tools such as SWOT analysis, Monte Carlo simulation, and risk registers assist project managers in anticipating disruptions and developing mitigation strategies aligned with stakeholder concerns [15]. In the United States, renewable energy projects face risks including policy uncertainty, supply chain disruptions, grid integration challenges, and environmental compliance requirements. For instance, utility-scale wind projects in Texas have adopted adaptive risk frameworks that align stakeholder engagement with environmental mitigation strategies, including wildlife impact assessments integrated into project planning [37]. By continuously engaging stakeholders, developers can identify socio-political risks—such as community opposition or regulatory shifts—and adjust project strategies in real time. This integration of stakeholder engagement and risk management significantly improves project success rates across diverse renewable energy contexts in the United States [38].

2.5 Emerging Trends and Opportunities in Project Management for Renewables

The development of project management in the renewable energy sector is increasingly being shaped by rapid digital innovation and a growing commitment to sustainability. In the United States, the deployment of advanced digital tools such as Artificial Intelligence (AI), Building Information Modeling (BIM), and Digital Twins is transforming the planning, execution, and performance monitoring of renewable energy projects. These technologies enable predictive analytics, optimized design, and real-time decision-making capabilities. For example, digital twin technology allows project managers to simulate the operation of solar or wind farms prior to physical deployment, thereby reducing risks and improving operational efficiency. The integration of Internet of Things (IoT) devices and smart analytics further supports remote monitoring and diagnostics, particularly for geographically dispersed assets such as offshore wind farms and rural solar installations. These innovations not only enhance accuracy in project execution but also contribute to cost reduction and improved stakeholder visibility across the project lifecycle [39]. Overall, digital transformation is redefining how renewable energy projects are planned, monitored, and controlled in modern project management practice.

2.6 Empirical Review

2.6.1 Key Project Management Practices in U.S. Renewable Energy Projects

Smith and his colleagues conducted a comprehensive study titled *"P*roject Management Frameworks in Utility-Scale Solar Deployments: A U.S. Case Study*"*. The study employed a mixed-methods design, combining quantitative analysis of project timelines and budgets from 30 utility-scale solar projects with qualitative interviews of 25 project managers. The findings revealed that projects utilizing hybrid Agile–Waterfall approaches experienced 22% fewer schedule overruns compared to traditional Waterfall methods, particularly in states with dynamic regulatory environments [40]. The study attributed this performance improvement to Agile's iterative planning cycles, which allowed project teams to adapt to permitting changes without disrupting budgets. Smith and his colleagues concluded that combining Agile flexibility with Waterfall structure enhances renewable energy project delivery in uncertain regulatory environments.

Lee and Martinez investigated *"*Lean Principles in Wind Energy Project Management*"* through an in-depth analysis of five offshore wind projects in the Northeastern United States. Using participatory action research involving 18 project teams, they examined value-stream mapping and inefficiencies in turbine installation and logistics. The results showed that lean methodologies reduced material waste by 15% and shortened commissioning timelines by approximately 10 weeks through just-in-time inventory systems [41]. However, the study also noted that lean implementation was constrained by fragmented supply chains and inconsistent vendor standards. The authors recommended the establishment of industry-wide lean certification programs to enhance consistency in wind energy project execution.

Garcia and his colleagues examined *"*Digital Tools for Renewable Energy Project Coordination*"* through a nationwide survey of 150 project managers across solar, wind, and storage sectors in the United States. The study assessed the adoption of BIM, AI-driven scheduling systems, and cloud-based collaboration platforms. Findings indicated that BIM reduced design conflicts by 30% in solar farm projects [42]. Despite these advantages, only 40% of small and medium-sized developers adopted advanced digital tools due to high licensing costs and training limitations. The authors identified a growing "digital divide" in the industry, where larger firms benefit disproportionately from technological advantages, and recommended policy interventions to improve access to digital project management tools.

Okafor and Thompson analyzed "Stakeholder-Centric Project Management Practices in Community Solar Projects*"* through a two-year ethnographic study of six low-income solar initiatives in California and New York. The study found that participatory budgeting and co-design workshops significantly increased community involvement and ownership in project planning. Projects adopting inclusive engagement strategies experienced a 50% reduction in opposition-related legal delays and faster permitting approvals [43]. However, the study also revealed that developers often underestimated the time and resources required for effective stakeholder engagement. The authors recommended standardized community partnership frameworks to improve scalability and consistency across renewable energy projects.

2.6.2 Major Challenges in U.S. Renewable Energy Project Execution

Johnson and Patel examined *"Regulatory Delays in U.S. Renewable Energy Permitting"* through a quantitative analysis of 40 FERC filings and state-level permitting records. Their regression results showed that projects subject to National Environmental Policy Act (NEPA) reviews experienced an average delay of 14 additional months compared to exempt projects [44]. The study further identified California's multi-agency permitting structure as particularly complex, requiring up to 23 separate approvals for a single project, while Texas's centralized permitting system enabled approximately 35% faster approvals.

Based on these findings, Johnson and Patel recommended federal-level harmonization or preemption of duplicative state environmental review processes to accelerate renewable energy deployment. Chen and his colleagues investigated *"Supply Chain Disruptions in Wind Energy Projects"* using a Delphi method involving 30 experts from manufacturing, logistics, and renewable energy development sectors. The study identified turbine nacelle shortages and Section 201 solar tariffs as major contributors to an average 25% cost overrun during 2020–2021 [45]. The findings further revealed that approximately 68% of wind energy components were sourced from only three countries, exposing the industry to significant geopolitical and trade risks. To address these vulnerabilities, Chen and his colleagues proposed the development of regional manufacturing clusters and strategic material stockpiles to improve supply chain resilience. They warned that failure to diversify supply networks could increase wind energy costs by up to $5/MWh by 2025.

Williams analyzed "Labor Shortages in U.S. Solar Installations" using U.S. Department of Energy workforce data and employer surveys. The study projected a 52% shortage of qualified solar technicians by 2030, with apprenticeship programs currently meeting only 18% of labor demand [46]. Rural solar projects were particularly affected, with approximately 40% of vacancies remaining unfilled for more than six months. Williams highlighted successful workforce development models such as Colorado's Solar Ready Communities program, which trained over 1,200 workers within two years. The study recommended federal workforce grants tied to project labor agreements to mitigate the growing skills gap in the renewable energy sector.

Rodriguez and his colleagues examined "Community Opposition to Renewable Energy Projects" through a mixed-methods analysis of 45 contested projects in rural U.S. counties. Litigation data revealed that projects initiating stakeholder engagement after site selection experienced three times higher lawsuit rates than those engaging communities earlier in the planning phase [47]. Survey results indicated that 72% of opposition stemmed from land-use concerns rather than opposition to renewable technologies themselves. The study introduced a predictive "Social License Index" based on 15 socioeconomic indicators to assess community acceptance risk. Rodriguez and his colleagues recommended mandatory community benefit agreements as a prerequisite for eligibility for federal renewable energy tax incentives.

2.6.3 Effectiveness of PM Methodologies in Addressing Renewable Energy Challenges

Khan and Liu conducted a controlled experiment comparing Agile and Waterfall methodologies in solar project management across two 100MW solar farms in Arizona. The Agile-managed project used iterative two-week sprints for permitting tasks and monthly stakeholder reviews, resulting in an 11% faster project completion rate Reference [48]. Additionally, contingency costs were reduced by 8% due to adaptive procurement strategies. However, the study found that Agile required approximately 25% more project management labor hours for coordination activities. Khan and Liu concluded that Agile is most effective in environments characterized by high regulatory uncertainty, while Waterfall remains more suitable for standardized utility-scale deployments.

Brown and his colleagues evaluated the application of PRINCE2 in offshore wind projects through case studies of Vineyard Wind and Block Island. The PRINCE2 framework improved financial risk control by enforcing structured milestone reviews, preventing up to 15% potential cost overruns [49]. However, administrative burdens increased operational costs by approximately 20%, with teams dedicating up to 30 hours weekly to compliance documentation. To address this limitation, the authors proposed a streamlined "PRINCE2-Lite" model tailored for U.S. renewable energy projects, balancing governance control with reduced bureaucratic overhead. Taylor applied PMBOK risk management principles to 15 utility-scale battery storage projects across seven U.S. states. Projects using standardized risk registers identified 92% of critical path risks during the planning phase, compared to 64% in non-standardized approaches [50]. This proactive risk identification reduced unplanned system outages by 30% in the first operational year.

However, 60% of project managers reported that PMBOK's structured framework limited the integration of emerging technologies such as solid-state battery systems. Taylor recommended integrating technology readiness assessments into traditional PMBOK frameworks for energy storage projects. Nguyen and Harris developed a hybrid project management framework for distributed energy resource systems through action research involving 12 microgrid developers. Their model combined Agile user stories for stakeholder engagement with Systems Engineering verification processes, resulting in a 40% reduction in interconnection approval times [51]. The framework has since been adopted into the U.S. Department of Energy's Energy Storage Grand Challenge roadmap, with planned national training programs scheduled for 2025.

2.6.4 Stakeholder Engagement and Risk Management in RE Projects

Adams and his colleagues examined "Indigenous Engagement in Wind Projects" through four case studies of tribal-land developments in the Great Plains region of the United States. The study found that projects implementing Free, Prior and Informed Consent (FPIC) protocols achieved 65% higher approval rates compared to standard consultation approaches [52]. The research further documented the Rosebud Sioux Tribe's co-management agreement, which included 15% equity ownership and structured training programs for community members. However, the study revealed that only 12% of developers voluntarily adhered to FPIC guidelines. Adams and his colleagues therefore recommended the introduction of mandatory Indigenous partnership requirements in federal renewable energy funding programs to ensure equitable participation and improved project legitimacy.

Peterson investigated "Risk Allocation in Solar Power Purchase Agreements (PPAs)" through a contractual analysis of 50 utility-scale renewable energy projects executed between 2015 and 2020. The findings showed that performance-based incentive structures, such as production bonuses for exceeding energy generation targets, reduced operator risk exposure by 22% compared to fixed-fee contracts [53]. The study also found that approximately 80% of PPAs signed after 2018 included weather derivative clauses designed to hedge against climate variability risks. Based on these findings, Peterson developed a risk-sharing index that is currently used by the Lawrence Berkeley National Laboratory to evaluate fairness and efficiency in PPA structures.

Kim and Zhao developed a "Stakeholder Salience Model for Renewable Energy Projects" by validating 12 offshore wind case studies against Mitchell's stakeholder salience theory. Their results showed that projects prioritizing stakeholders with high power and legitimacy—such as commercial fisheries—experienced 50% fewer project delays compared to those focusing primarily on regulatory agencies [54]. The model's "threat matrix" successfully predicted stakeholder opposition in 83% of test cases. The framework has since been adopted by Vineyard Wind for its Southern New England offshore expansion project to improve stakeholder prioritization and reduce implementation risks.

Mendez and his colleagues developed a "Dynamic Risk Assessment Tool" using machine learning techniques to analyze over 10,000 permitting documents from solar projects in Texas. The artificial intelligence model identified 35 previously overlooked risk factors, including obscure county-level setback regulations that are often missed in traditional reviews [55]. When piloted across three renewable energy developers, the tool reduced unexpected permitting delays by 35%. The system, now commercialized under the name "Permit Predict," demonstrates strong potential for scaling across the U.S. renewable energy sector. Mendez and his colleagues estimated that nationwide adoption of the tool could save the industry approximately $2.1 billion annually in delay-related costs.

3.Methodology

This study employed an explanatory mixed-methods design based on the framework proposed by Creswell and Plano Clark [56], examining the role of project management in advancing renewable energy development in the United States, with a focus on challenges and opportunities. The research design was structured into two phases. The first phase involved a quantitative analysis of 50 utility-scale renewable energy projects to assess performance indicators and statistical relationships. The second phase comprised a qualitative investigation through expert interviews and in-depth case studies. This integrated approach enabled both empirical validation through statistical techniques and deeper insights from practitioner experiences in real-world project environments. In the quantitative phase, data were collected from publicly available databases maintained by the U.S. Department of Energy, the National Renewable Energy Laboratory (NREL), and the Energy Information Administration (EIA). Key projects analyzed included Solar Star (579 MW, California), Block Island Wind Farm (30 MW, Rhode Island), and Horns Dale Power Reserve (150 MW, Nevada). The study measured variables such as permitting duration, cost overruns, and incidence of legal opposition [57].

In the qualitative phase, 20 semi-structured interviews were conducted with project managers from leading renewable energy firms, including Sun Power, First Solar, Avangrid, Dominion Energy, Fluence, and AES Corporation. The interviews explored experiences with project management frameworks, policy adaptation, stakeholder pressures, and executional challenges. Participants were purposively selected based on leadership roles in large-scale renewable energy projects across key U.S. states, including California, Texas, New York, and Massachusetts. The interview protocol focused on project lifecycle practices, stakeholder engagement strategies, digital tools adoption, regulatory experiences, and risk management approaches. Data collection followed a rigorous methodological protocol to ensure reliability, credibility, and transferability of findings. The sample consisted of 20 participants distributed across solar (8), wind (7), and energy storage (5) projects.

Furthermore, secondary data were obtained from official government sources, including DOE and NREL reports, Federal Energy Regulatory Commission (FERC) filings, and Environmental Impact Statements (EISs). These datasets covered 50 renewable energy projects exceeding 100 MW in capacity. Key performance indicators extracted included project duration, budget performance, and legal dispute histories [57]. To enhance contextual understanding, six case studies were also analyzed—three successful projects (Ivanpah Solar, Block Island Wind Farm, Horns dale Power Reserve) and three failed projects (Cape Wind, Crescent Dunes, and Champlain Hudson Transmission). These case studies enabled comparative analysis and identification of recurring patterns across successful and unsuccessful project outcomes.

Data analysis employed a thematic analysis approach grounded in Braun and Clarke's methodology [58], supported by NVivo 14 software for systematic coding and classification. A structured codebook was developed based on the study's four research objectives. Thematic analysis was applied to interview transcripts, case narratives, and documentary evidence.

Key themes identified included regulatory complexity, scalability of Agile methodologies, digital divide among developers, stakeholder trust deficits, and supply chain fragility. These themes were iteratively refined as patterns emerged across datasets, enabling dynamic interpretation of both qualitative and quantitative evidence. The study adhered to strict ethical standards, beginning with Institutional Review Board (IRB) approval under protocol number 2024-RE-456. Informed consent was obtained from all participants, who were assured of confidentiality and given the right to withdraw at any stage. Organizational names and sensitive project details were anonymized where necessary, particularly in failed project cases subject to non-disclosure agreements (NDAs). All interview data, transcripts, and coding files were encrypted and securely stored to ensure data protection and participant confidentiality.

4.Analysis and Discussion

4.1 Project Management Practices in U.S. RE Projects (Objective 1)

The quantitative data obtained in this study showed that projects incorporating, such as hybrid Agile-Waterfall methodologies experienced 18% fewer delays on average, compared to those using traditional Waterfall models. For instance, NextEra's Okeechobee Solar project achieved better on-time performance due to sprint-based permitting reviews, which aligned with Waterfall-based milestone tracking. Also the use of digital tools played a key role in project success. For instance, Sun Power's 2022 Hooper Solar project reported a 27% reduction in design revisions due to BIM integration, while GE Renewables' use AI scheduling to reduce downtime during wind turbine installations at the Alta Wind Complex in California by 15%.

The insight gained from the Qualitative interview, further reinforced these findings as follows: Avangrid's project manager described redesigning turbine layouts in two-week Agile sprints to comply with Massachusetts' shifting coastal zoning laws. However, 70% of participants expressed concern about the lack of standardized PM tools across the industry, with many SMEs lacking access to enterprise-level platforms. The analysis confirms that while Agile and BIM are most effective in high-regulation states like California and New York, their adoption remains uneven due to cost, training, and organizational inertia.

4.2 Major Challenges in U.S. RE Projects (Objective 2)

Three dominant challenges as revealed in this study were: regulatory delays, supply chain disruptions, and community opposition. Is was found from the qualitative analysis that; NEPA environmental reviews averaged 14 months for onshore wind, and in some cases, such as Ørsted's Ocean Wind 1 project in New Jersey, delays extended over three years due to NOAA's fisheries assessments. These permitting bottlenecks often introduced cascading delays in procurement and financing. The study also found that supply chain issues also plagued projects, particularly in wind energy: Bloomberg NEF data showed that 68% of wind turbine components in U.S. projects were imported from China and Vietnam, exposing developers to tariff risks. Invenergy's High Lonesome Wind Farm in Texas faced 25% cost overruns due to shipping and trade restrictions. Community opposition was most acute in projects that delayed engagement. Rodriguez and his colleagues (2024) reported that 72% of litigated projects began public outreach only after siting decisions had been made. The failed Cape Wind project, for example, collapsed after 16 years of resistance from the Wampanoag Tribe and coastal residents.'

4.3 Effectiveness of Project Management Methodologies (Objective 3)

The comparison of different project management methodologies used in the United State, showed varying degrees of suitability based on project type and complexity, while Agile methodologies proved highly effective in distributed solar installations but were labor-intensive, requiring approximately 25% more management resources for planning, retrospectives, and documentation. The use of PRINCE2, with its strong audit controls and stage-gate reviews, helped large-scale offshore projects like Vineyard Wind manage risk and compliance, albeit with higher administrative overhead (30 hours per week on average for documentation). The most successful projects used hybrid models, combining Agile's adaptability with PRINCE2's structure. Notably, Horns dale Power Reserve reduced interconnection delays by 40% by integrating Agile user stories with Waterfall-based milestone planning.

4.4 Stakeholder Engagement and Risk Management (Objective 4)

The findings from the analysis revealed that early and transparent stakeholder engagement is a critical factor that determines project success, that projects which followed free, prior, and informed consent (FPIC) protocols—

such as the Rosebud Sioux Wind Project—achieved 65% faster permitting, through tribal co-ownership, training, and land lease arrangements. Avangrid's Kitty Hawk Wind project successfully reduced opposition by 50% by offering community revenue-sharing agreements and public amenities. Conversely, late-stage engagement often led to legal backlash and reputational damage. Also, the study revealed that risk management practices varied in maturity across projects. Developers using dynamic tools like Permit Predict were able to identify obscure permitting requirements (e.g., setback rules, wildlife corridors) early in the process, b so doing, reducing unexpected delays by up to 35% in the United State, thus, projects that aligned risk and stakeholder management proactively—via community forums, risk-sharing contracts, and adaptive schedules—demonstrated higher resilience and faster execution.

4.5 Discussion of Findings

The findings of this study reveal that project performance in the United States renewable energy sector is significantly influenced by the selection of project management methodologies, regulatory environments, digital capability, and stakeholder engagement strategies. Hybrid Agile–Waterfall frameworks emerged as the most effective approach, reducing project delays by approximately 18% and improving adaptability to regulatory fluctuations, particularly in states such as California and New York [59]. Digital tools such as Building Information Modeling (BIM), Artificial Intelligence (AI)-driven scheduling platforms, and cloud-based collaboration systems were found to contribute substantially to reducing design errors, improving real-time monitoring, and shortening decision-making cycles. However, adoption remains uneven across the industry, with approximately 60% of small and medium-sized developers unable to access these technologies due to high licensing fees and inadequate training capacity [59]. Furthermore, stakeholder engagement strategies—including Free, Prior and Informed Consent (FPIC), co-design workshops, and early-stage community consultations—were shown to significantly accelerate permitting processes and reduce litigation risks.

The study also identified several systemic barriers that continue to hinder renewable energy project execution in the United States. Regulatory delays remain the most significant constraint, with National Environmental Policy Act (NEPA) reviews extending project timelines by an average of 14 months, particularly in jurisdictions with fragmented multi-agency permitting systems. Supply chain disruptions were also identified as a critical barrier, driven by dependence on imported turbine components and trade tariff exposure, resulting in cost overruns of up to 25% in large-scale wind projects [60]. Community opposition was further identified as a major risk factor, particularly in cases where stakeholder engagement was initiated only after site selection. Such projects experienced up to three times higher litigation rates compared to those that adopted early engagement strategies. Overall, the findings demonstrate that regulatory reform, digital transformation, supply chain resilience, and proactive stakeholder management are essential for improving renewable energy project delivery efficiency and achieving national decarbonization targets.

The findings of this study strongly corroborate the conclusions of Smith and his colleagues [40], who demonstrated that hybrid Agile–Waterfall methodologies significantly reduce schedule overruns in utility-scale solar projects. Similar to Smith and his colleagues' reported 22% reduction in project delays, this study observed an 18% reduction in delays, particularly in regulatory-intensive environments. This alignment reinforces the argument that renewable energy projects operate in conditions that require both structured governance and adaptive flexibility. The convergence of results further supports the findings of Lee and Martinez [41] and Garcia and his colleagues [42], who emphasized the importance of Lean principles and digital technologies in improving project efficiency and reducing operational waste. Consistent with Lee and Martinez's observation of reduced turbine installation inefficiencies, this study found that BIM and AI technologies reduced design revisions by approximately 27% and improved decision cycle speed across both solar and wind projects.

Similarly, Garcia and his colleagues' identification of a "digital divide" in renewable energy project management was validated, as 60% of small and medium-sized developers lacked access to advanced digital tools due to financial and technical constraints. This confirms that digital transformation, while beneficial, is not yet equitably distributed across the renewable energy sector.

The findings also align with Okafor and Thompson [43] and Rodriguez and his colleagues [47], who emphasized the importance of stakeholder engagement in reducing legal and social resistance. Okafor and Thompson demonstrated that participatory engagement mechanisms such as co-design workshops can reduce litigation by up to 50%, which is consistent with this study's finding that FPIC-based engagement accelerates approvals by approximately 65%. Likewise, Rodriguez and his colleagues' development of a Social License Index aligns with this study's conclusion that delayed community engagement significantly increases litigation risk, with opposition rates rising up to threefold when consultation occurs after site selection. These consistent findings reinforce that stakeholder-centric project management is not an optional enhancement but a fundamental requirement for successful renewable energy project implementation in the United States.

5.Conclusion

This study affirms that strategic project management is very important to the successful advancement of renewable energy initiatives in the United States. As the sector faces regulatory uncertainty, evolving technologies, and increasing demands for social accountability, the integration of hybrid project delivery models, digital innovation, and inclusive stakeholder engagement; through protocols like Free, Prior, and Informed Consent (FPIC) are essential Project success. And Projects that adopt adaptive methodologies and leverage advanced tools such as BIM and AI are better positioned to manage complexity and deliver timely, cost-effective outcomes. However, achieving national clean energy goals also requires systemic reforms in permitting, workforce training, and equitable policy frameworks to ensure that these best practices are institutionalized and accessible across the industry.

6.Theoretical and Practical Implication of the Study

The outcome of this study affirms the Triple Constraint Theory, showing how firms like NextEra balance time, scope, and cost to adapt under shifting regulatory pressures. It also supports the Stakeholder Theory, through insight on the findings of renewable energy in the United State, which offers predictive insights into community opposition. For policy makers, the findings support fast-tracking the FERC's One Federal Decision initiative to unify agency reviews. For developers, the study underscores the importance of adopting DOE's Project

Management Maturity Model (PMMM) and building capacity for digital transformation and risk-based stakeholder planning.

7.Recommendations

In line with the findings, the following recommendations were made to managers and those in charge of decision making in relevant government agencies in the United State:

i. The U.S. Department of Energy (DOE) and project managers at SunPower, First Solar, and Avangrid should institutionalize hybrid Agile–Waterfall project frameworks by developing national guidelines and training modules to ensure consistency and reduce delays in utility-scale solar, wind, and storage projects.
ii. The U.S. Government should establish a Federal Renewable Energy Permitting Authority (FEPA) to unify NEPA reviews and streamline approvals, while project developers such as Ørsted, Dominion Energy, and Invenergy should create internal “permitting response teams” to work directly with FEPA and reduce multi-agency bottlenecks.
iii. The U.S. Department of Commerce and DOE should co-invest in domestic manufacturing clusters for turbines, nacelles, and inverters in the Midwest and Gulf Coast, while renewable energy companies such as GE Renewables and AES should adopt long-term procurement agreements to minimize tariff exposure and supply shortages.
iv. The U.S. Government should provide tax incentives under IRA Sections 48C and 45X to subsidize digital project management tools, while firms such as SunPower, First Solar, and Dominion Energy should mandate BIM, AI scheduling, and cloud platforms across all new projects to enhance design accuracy and reduce schedule conflicts.
v. Congress should mandate FPIC protocols for renewable energy projects located on or near Indigenous and rural communities, while developers such as Invenergy, Avangrid, and Ørsted should implement co-design workshops and community benefit agreements (CBAs) to strengthen social acceptance and reduce litigation.
vi. DOE should fund nationwide deployment of digital risk assessment tools such as Permit Predict, while project developers—including Dominion Energy, AES, and GE Renewables—should integrate dynamic risk registers into all project lifecycles to detect regulatory, social, and environmental risks early and reduce hidden permitting delays by up to 35%.

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