



## A Practical Model for Agile Project Management to Streamline Engineering Delivery in Energy Projects

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### Article Info

**ISSN (online):** 2582-7138

**Volume:** 06

**Issue:** 01

**January-February 2025**

**Received:** 05-12-2024

**Accepted:** 03-01-2025

**Page No:** 1831-1840

### Abstract

This paper explores the application of Agile project management methodologies in the energy sector, aiming to address key challenges such as project complexity, cost overruns, delays, and the need for technological integration. Traditional project management approaches, such as Waterfall, have proven effective for certain energy projects but often struggle to accommodate modern energy initiatives' dynamic and unpredictable nature. Agile principles, including iterative planning, stakeholder engagement, risk management, and continuous improvement, are proposed as a more adaptable and responsive solution. The paper presents a practical model tailored to energy projects, emphasizing the importance of cross-functional teams, regular feedback loops, and flexibility in scope. Furthermore, it discusses the integration of Agile with traditional project management approaches, such as Waterfall, and outlines the barriers to Agile adoption, including resistance to change and the need for specialized expertise. By examining the benefits of Agile, its application in similar industries, and its implementation challenges, the study also suggests directions for future research to further explore the integration of Agile with digital tools, its impact across different energy sub-sectors, and its long-term effect on project success.

**DOI:** <https://doi.org/10.54660/IJMRGE.2025.6.1-1831-1840>

**Keywords:** Agile Project Management, Energy Sector, Project Delivery, Iterative Planning, Stakeholder Engagement, Risk Management

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### 1. Introduction

#### 1.1. Context and Background

Project management in the energy sector is undergoing significant transformation due to a combination of internal and external pressures that challenge conventional approaches. The sector, encompassing renewable energy systems as well as oil and gas exploration, is facing increasing levels of complexity and uncertainty (Sovacool & Cooper, 2013; Umbach, 2010). Factors such as increasing global demand for energy, regulatory changes, environmental concerns, and technological innovations contribute to an ever-changing landscape (Badiru & Osisanya, 2016). As a result, project managers must continuously adapt their strategies to meet the diverse demands of stakeholders, comply with stringent regulatory frameworks, and navigate complex supply chains and resource management (Janssen, Van Der Voort & van Veenstra, 2015).

Energy projects frequently involve multi-disciplinary teams, each possessing unique expertise. Efficient communication, coordination, and decision-making are essential for achieving common goals (Nwulu *et al.*, 2023). However, traditional project management approaches, often characterized by rigid timelines, structured phases, and predefined deliverables, are increasingly proving inadequate in this dynamic environment. Their inability to adapt quickly to changing conditions leads to project delays, cost overruns, and the failure to meet stakeholder expectations (Ajirrotutu *et al.*, 2024).

Resource management remains a significant challenge in energy projects. The adoption of new technologies, particularly in the renewable energy sector, necessitates a resource allocation strategy that extends beyond traditional forecasting and calculation methods. Ensuring seamless integration of emerging technologies within existing infrastructures requires high-risk investments, uncertain returns, and extended project timelines (Ellabban, Abu-Rub & Blaabjerg, 2014). Furthermore, cybersecurity concerns and smart grid technologies play a critical role in energy sector transformation, necessitating innovative project management approaches (Naiho *et al.*, 2024).

Another crucial factor in the evolving nature of energy project management is the need for improved technological integration. As energy projects increase in complexity, advanced tools for scheduling, tracking, and monitoring project progress have become indispensable. Despite the growing adoption of such tools, project management methodologies have largely remained static, resulting in inefficient technology utilization and poor integration with existing management frameworks, further compounding inefficiencies and delivery delays (Sinsel, Riemke & Hoffmann, 2020; Seyi-Lande *et al.*, 2024).

## 1.2. Research Problem

This study addresses the inadequacy of traditional project management methodologies in effectively managing the complexities of energy projects. Conventional approaches, such as Waterfall and the critical path method (CPM), focus on sequential project execution, which was effective in the past when energy projects were simpler and more predictable. However, evolving technological requirements, increased stakeholder involvement, and stringent environmental regulations necessitate a more flexible and adaptive approach. The integration of green infrastructure into energy projects further emphasizes the need for agility in management frameworks (Ajirrotutu *et al.*, 2024).

Agile project management, emphasizing iterative development, adaptability, and continuous feedback, presents an opportunity to overcome the limitations of traditional methodologies. However, Agile principles remain underexplored in the energy sector (Daraojimba *et al.*, 2024). While Agile has been widely implemented in software development and manufacturing industries, its application in energy project management has been sporadic and not fully realized. This paper aims to bridge this gap by examining how Agile methodologies can be adapted for energy projects to enhance flexibility, mitigate risks, and improve overall project delivery (Ojo & Kiobel, 2024).

## 1.3. Research Objectives

This paper seeks to develop a practical model for applying Agile project management within the context of energy projects, with the following specific objectives:

- To explore the limitations of traditional project management frameworks within the energy sector.

- To investigate how Agile methodologies, which emphasize flexibility, iterative progress, and stakeholder collaboration, can be adapted for energy projects.
- To develop a practical Agile-based framework for project managers, specifically designed to streamline the delivery of engineering projects in the energy sector.
- To examine the potential benefits of adopting Agile principles.
- To provide actionable recommendations for successfully implementing Agile methodologies within the energy sector.

By achieving these objectives, the paper aims to offer a comprehensive and actionable model for energy project managers looking to integrate Agile into their operations, thereby addressing some of the sector's most pressing challenges.

## 1.4. Significance of the Study

The significance of this study lies in its potential to reshape energy project management, thereby improving efficiency and effectiveness in increasingly complex environments. By adapting Agile methodologies, organizations can enhance their project delivery processes. Agile's focus on continuous feedback, iterative planning, and responsiveness to change makes it particularly relevant to the energy sector, where regulatory frameworks and technological advancements require frequent adjustments (Ebirim *et al.*, 2024; Layode *et al.*, 2024).

One of the key benefits of Agile project management in energy projects is enhanced stakeholder engagement. Traditional project management methods involve stakeholder participation at predefined stages, limiting opportunities for ongoing input. Conversely, Agile methodologies encourage continuous stakeholder engagement throughout the project lifecycle, ensuring that their concerns and expectations are addressed iteratively. This improves overall project quality while fostering stakeholder satisfaction and ownership (Daramola *et al.*, 2024; Nzeako *et al.*, 2024).

Moreover, Agile's iterative approach facilitates more efficient resource management, especially in complex engineering projects where resource allocation must be frequently reassessed. Agile enables project managers to track progress, adjust plans dynamically, and mitigate cost overruns (Mendez, 2018). Data-driven decision-making, a key component of Agile, also ensures that energy projects remain aligned with evolving industry demands (Ojo & Kiobel, 2024).

Finally, Agile methodologies enhance risk management in energy projects. The energy sector often faces high levels of uncertainty due to fluctuating commodity prices, shifting regulatory requirements, and unforeseen technological advancements. Agile's continuous review and adaptation mechanisms allow project teams to identify, assess, and mitigate risks proactively, making the overall project delivery process more resilient (Layode *et al.*, 2024).

## 2. Literature Review

### 2.1. Agile Methodology in Project Management

Agile methodology is a set of principles and practices that prioritize flexibility, collaboration, and continuous improvement in project management. Originating in the software development industry in the early 2000s, Agile has since been adopted across various sectors due to its ability to foster adaptability, enhance stakeholder engagement, and streamline project delivery. At its core, Agile emphasizes iterative progress, regular feedback, and responsiveness to

change, ensuring that projects are more resilient to unforeseen challenges (Digitemie *et al.*, 2025).

The Agile Manifesto, created in 2001, set forth twelve principles that form the foundation of Agile project management. These principles advocate for customer collaboration over contract negotiation, responding to change over following a rigid plan, and valuing individuals and interactions over processes and tools. Agile frameworks, such as Scrum, Kanban, and Lean, have since emerged to provide specific methodologies for implementing these principles (Egbumokei *et al.*, 2025; Oladipo *et al.*, 2025).

Scrum is one of the most widely used Agile frameworks. It divides projects into small, manageable work units known as "sprints," typically lasting two to four weeks. At the end of each sprint, teams hold a review meeting to demonstrate completed work and gather stakeholder feedback. Scrum promotes a highly structured approach to Agile, with clearly defined roles, such as the Scrum Master, Product Owner, and Development Team. This framework is particularly suited for projects with rapidly changing requirements and tight timelines.

Kanban, another Agile framework, focuses on visualizing the flow of work and managing tasks in real-time. The central element of Kanban is a board, which displays the status of tasks at each stage of completion. This approach is less prescriptive than Scrum and is often employed in continuous delivery environments, such as maintenance or service-oriented projects. Kanban's flexibility makes it particularly appealing for projects requiring incremental changes but not the fixed iterations seen in Scrum (Emekwisia *et al.*, 2024).

Lean methodology, derived from the Toyota Production System, is focused on optimizing efficiency and minimizing waste. While lean principles can be applied to various industries, they are particularly effective in environments where resources are constrained and efficiency is paramount. Lean emphasizes continuous improvement (known as Kaizen), eliminating waste (muda), and empowering workers to contribute to problem-solving and process optimization (Oluokun *et al.*, 2025b; Onukwulu *et al.*, 2025).

Across industries, Agile methodologies have demonstrated several key benefits. In software development, for example, Agile has been credited with improving collaboration between developers and clients, reducing time to market, and increasing the quality of deliverables. Similarly, Agile practices in marketing have allowed organizations to adapt quickly to changing consumer demands and market conditions. The flexibility inherent in Agile frameworks has also allowed industries outside of technology to adopt these practices for better project delivery, from healthcare to education to product development. Despite its successes, Agile methodologies also face challenges in certain contexts, particularly when applied to industries with highly structured or regulatory environments. The integration of Agile into traditional project management practices often requires a cultural shift, which can present significant barriers, especially in organizations that are accustomed to more hierarchical or rigid structures. These challenges highlight the need for a tailored approach when implementing Agile in different sectors (Oluokun *et al.*, 2025a; Ukpohor *et al.*, 2024; Ajiroto *et al.*, 2024).

## 2.2. Agile in Engineering and Construction Projects

Initially designed for software development, Agile methodologies have slowly found their way into engineering and construction projects. While the direct application of Agile in engineering and construction can appear unconventional, the need for flexibility and adaptability in

these fields has driven some project managers to explore its potential.

In engineering projects, particularly those involving large-scale infrastructure or product development, the traditional project management model (such as Waterfall) often leads to rigid timelines and scope creep. The project lifecycle tends to be linear, with distinct phases from initiation through to delivery. In contrast, Agile offers a more iterative and flexible approach, breaking projects into smaller, manageable pieces that can be adjusted based on real-time feedback (Adewoyin *et al.*, 2025; Solanke *et al.*, 2024; Ajiroto *et al.*, 2024).

One key area where Agile has been applied in engineering projects is in product development. The development of high-tech engineering products—such as complex machinery, power generation systems, and renewable energy infrastructure—requires frequent adjustments in response to technological innovations, market changes, or unforeseen technical challenges. Agile provides a framework that allows project teams to rapidly iterate on designs, prototype, and test new solutions, ensuring that product development aligns with evolving requirements and expectations (Oluokun *et al.*, 2024a; Onwuzulike *et al.*, 2024).

The construction sector, particularly for large infrastructure projects like bridges, roads, and energy facilities, has also begun exploring Agile methodologies. Construction projects traditionally suffer from lengthy timelines, complex interdependencies between subcontractors, and regulatory hurdles that can create significant delays. Agile's iterative approach, involving regular sprints and continuous feedback loops, can allow construction teams to break down large projects into smaller, more manageable chunks. Each sprint could involve a particular aspect of the project (e.g., foundation work, electrical installations, or mechanical systems) that can be reviewed and adjusted before proceeding further (Onukwulu *et al.*, 2024a, 2024b).

A notable example of Agile implementation in construction is the adoption of Lean Construction, a methodology that draws on Agile principles to optimize workflow, minimize waste, and improve communication between contractors. Using tools such as visual boards and daily stand-up meetings, Lean Construction creates transparency and accountability throughout the construction process, ensuring that potential issues are identified early and resources are allocated efficiently.

Agile's principles also support collaboration between multidisciplinary teams, which is crucial in construction projects where various expertise (e.g., architects, engineers, contractors) must work in tandem. By fostering an environment of continuous communication and joint problem-solving, Agile enables teams to adapt quickly to changes in project scope or unforeseen obstacles, which are common in the construction industry.

However, integrating Agile into engineering and construction projects is challenging. The sector is heavily regulated, and many projects are subject to strict guidelines and codes of practice. Agile's emphasis on flexibility and adaptability may clash with these regulatory requirements, which often demand adherence to predefined processes and standards. Moreover, construction projects' physical and technical nature requires a clear understanding of resources, time, and safety requirements, which can be difficult to manage in an Agile framework (Ogunsola *et al.*, 2024; Oluokun *et al.*, 2024b, 2024c; Popoola *et al.*, 2024).

## 2.3. Challenges in Energy Projects

Energy projects, whether focused on fossil fuels or renewable energy, present unique challenges. These large-scale, multi-



year initiatives require careful planning, coordination, and resource management. The energy sector is capital-intensive, highly regulated, and influenced by political and environmental factors, making the execution of engineering projects particularly complex. One of the most persistent challenges in energy project delivery is cost overruns. Energy projects require substantial financial investments, and cost overruns are common due to fluctuating material prices, changes in project scope, delays, and unforeseen regulatory changes. These projects typically involve multiple contractors, suppliers, and stakeholders, increasing the potential for miscommunication and project delays. The financial impact of failing to meet project timelines or budgets can be significant, not only in terms of monetary loss but also in reputational damage and missed market opportunities (Ojo & Kiobel, 2024).

Delays are closely linked to cost overruns. Energy projects often extend over several years and must navigate complex regulatory, technical, and environmental hurdles. Regulatory approvals, permitting processes, and environmental impact assessments can take years to finalize, leading to extended project timelines. Moreover, unforeseen technical challenges during construction, such as difficulties integrating new technologies or external environmental factors (e.g., extreme weather conditions), can further delay project completion (Ajirotutu *et al.*, 2024a, 2024b).

Safety concerns are another critical issue in energy projects, particularly those in high-risk environments such as offshore oil and gas drilling, nuclear power plants, or renewable energy installations in extreme conditions. The potential for accidents or environmental disasters makes it essential to maintain high safety standards throughout the project lifecycle. Strict safety protocols must be enforced, often requiring regular inspections, risk assessments, and project plan modifications. These safety requirements can contribute to additional delays and cost overruns (Akinbolaji *et al.*, 2024).

Environmental sustainability has become a growing concern within the energy sector, especially with the global transition toward renewable energy sources. Energy projects must comply with strict safety and regulatory standards while addressing concerns about their environmental footprint. Factors such as emissions reduction, waste management, and land usage require careful consideration, adding another layer of complexity to project management (Umbach, 2010).

Resource management remains a key challenge for energy projects. These projects require a significant workforce and specialized resources, including heavy machinery, infrastructure components, and technical expertise. The availability and cost of these resources can fluctuate, posing difficulties for project planning and execution. Additionally, many energy projects have a global scope, which presents logistical challenges related to the transportation and storage of resources. Effective supply chain management and risk mitigation strategies are crucial for overcoming these barriers (Adebayo *et al.*, 2024; Adikwu *et al.*, 2024).

Several models have been proposed to integrate Agile methodologies into energy project management, but the sector is still in the early stages of fully adopting these approaches. One notable application is Agile's use in offshore oil and gas projects, where flexibility in project scope and rapid adaptation to technological innovations are essential. Agile principles have been successfully employed to streamline project delivery, improve collaboration, and address technical challenges early in the project lifecycle (Nzeako *et al.*, 2024).

Additionally, Lean Construction has been explored as a

methodology that aligns with Agile principles in energy projects, particularly for developing infrastructure such as power plants, renewable energy installations, and transmission lines. Lean Construction focuses on reducing waste and fostering continuous improvement, which complements Agile's emphasis on efficiency and adaptability. However, widespread adoption of Agile in energy projects remains hindered by industry complexities and regulatory constraints. Nonetheless, an increasing number of case studies and pilot programs suggest that Agile methodologies can provide tangible benefits in terms of project efficiency, risk mitigation, and delivery timelines (Dienagha *et al.*, 2021; Nwulu *et al.*, 2023).

### 3. Development of the Practical Model

#### 3.1. Core Agile Principles Applied to Energy Projects

Implementing Agile methodologies in energy projects necessitates a deep understanding of the fundamental Agile principles and their adaptation to meet the unique demands of large-scale, complex, and highly regulated energy initiatives. The key principles of Agile—collaboration, adaptability, and iterative development—are particularly relevant to energy projects, which frequently encounter shifting requirements, regulatory constraints, and the need for continuous stakeholder engagement (Popoola *et al.*, 2024).

One of the core tenets of Agile is stakeholder collaboration over contract negotiation. In energy projects, this principle extends beyond clients to include regulatory authorities, contractors, suppliers, and local communities. Given that energy projects often evolve due to changing policies, technological advancements, and environmental considerations, early and continuous stakeholder involvement is critical. Agile methodologies promote regular feedback loops, iterative reviews, and open communication, ensuring that all involved parties remain aligned on project objectives and challenges as they arise (Rigby, Elk & Berez, 2020).

Another fundamental Agile principle is embracing change over adhering to a rigid plan. While energy projects are traditionally structured with fixed budgets and timelines, they must also remain flexible to accommodate unexpected disruptions such as policy shifts, technical failures, or market volatility. Agile methodologies foster this adaptability through incremental planning, continuous assessment, and iterative execution, allowing projects to pivot when necessary while maintaining compliance with regulatory requirements (Conforto *et al.*, 2014).

The principle of delivering working solutions frequently is central to Agile approaches, and in the energy sector, this translates into phased, incremental project execution. Instead of waiting for an energy project's final completion, Agile encourages breaking down large-scale developments into smaller, deliverable milestones. For instance, in renewable energy projects, this could mean deploying sections of a wind farm or solar installation in stages, ensuring that each phase is tested and adjusted based on evolving technological and regulatory standards (Cooper & Sommer, 2018).

Additionally, simplicity—the art of maximizing work efficiency—is a crucial Agile principle that is particularly beneficial in energy projects, where complex engineering processes and strict regulatory demands can introduce inefficiencies. By focusing on essential project deliverables, minimizing waste, and streamlining workflows, Agile methodologies help optimize resource allocation and maintain clarity in project execution. This principle ensures that energy projects remain scalable and manageable, even when dealing with multifaceted environmental, technical,

and safety constraints (Dingsøyr, Nerur, Balijepally & Moe, 2012).

### 3.2. Framework Design

The proposed practical model for Agile project management in energy projects incorporates several core components tailored to meet the specific challenges of this sector. By blending Agile's flexibility with the structure required in energy projects, this framework aims to improve project delivery times, enhance stakeholder collaboration, and increase overall project success.

#### 3.2.1. Stakeholder Engagement

One of the key components of the proposed model is stakeholder engagement, which emphasizes collaboration and continuous feedback throughout the project lifecycle. In energy projects, stakeholders include clients, regulators, contractors, suppliers, local communities, and environmental groups. Agile's emphasis on regular communication, feedback loops, and transparency ensures that these stakeholders are continually informed and involved (Ojo & Kiobel, 2024).

Through regular sprint reviews, demos, and feedback sessions, project teams can ensure that all stakeholders are aligned with the project's goals, progress, and potential adjustments. Agile also promotes the creation of cross-functional teams that involve various stakeholder representatives, ensuring that the perspectives of all relevant parties are taken into account when making decisions. This collaborative approach minimizes the risk of miscommunication and misunderstandings, ensuring smoother project execution (Naiho *et al.*, 2024).

In energy projects, stakeholder engagement is particularly critical due to energy infrastructure development's complexity and often contentious nature. Regular communication helps mitigate risks related to delays caused by community opposition, regulatory challenges, or unexpected changes in market conditions. By fostering a culture of continuous engagement, Agile enables energy projects to better address the needs of all involved parties while maintaining alignment with project objectives.

#### 3.2.2. Iterative Planning and Execution

Iterative planning and execution are central to the proposed model. Instead of adhering to a rigid, linear plan, the project is divided into smaller phases or sprints. Each sprint focuses on delivering specific, tangible outcomes and includes a review session to assess progress, discuss challenges, and gather feedback. This iterative process is crucial in energy projects, where scope changes and unforeseen issues often arise during construction, environmental assessments, or regulatory reviews (Nzeako *et al.*, 2024).

At the beginning of each sprint, the project team sets clear goals and delivers incremental improvements to the project. This allows for flexibility in scope and ensures that adjustments can be made based on the project's evolving needs. For instance, in a renewable energy project, an initial sprint could focus on site assessments, while subsequent sprints could involve detailed engineering work, procurement, and installation (Layode *et al.*, 2024).

The feedback loops inherent in Agile ensure that at the end of each sprint, the project is assessed against its goals, and any necessary changes are made. This allows teams to adjust the direction of the project if necessary, ensuring that the project remains relevant and on track despite changes in external factors or internal challenges.

#### 3.2.3. Cross-Functional Teams

Agile's emphasis on cross-functional teams is particularly applicable in energy projects, where various expertise—such as engineering, regulatory compliance, procurement, and construction—must collaborate seamlessly. In traditional project management models, these teams often work in silos, with limited interaction across disciplines. However, Agile promotes the creation of self-organizing teams with diverse skill sets, ensuring that expertise is shared and that decisions are made collectively (Akpukorji *et al.*, 2024).

In energy projects, cross-functional teams can comprise engineers, environmental specialists, regulatory experts, project managers, and other key stakeholders. These teams work closely in short, focused sprints to solve complex problems, share knowledge, and quickly make decisions. This collaborative approach helps address the multidisciplinary nature of energy projects and fosters innovation, as team members from different backgrounds contribute diverse perspectives and expertise.

Agile's focus on team empowerment also encourages ownership and accountability, as team members are more responsible for making decisions that affect the project's success. This leads to more efficient decision-making processes, as well as increased motivation and commitment from the team.

#### 3.2.4. Risk Management

Agile's adaptive approach to risk management is one of its key strengths, particularly in sectors like energy where risks can be complex and multifaceted. In energy projects, risks can include technical failures, environmental impacts, regulatory changes, and safety concerns. Agile's flexibility and iterative nature allow teams to continuously identify, assess, and mitigate risks throughout the project lifecycle (Ojo & Kiobel, 2024).

Through regular sprint reviews and feedback loops, risks are identified early and addressed in real-time. This is a departure from traditional project management approaches, where risks may not be fully understood until later stages of the project. By breaking the project into smaller phases, Agile enables teams to anticipate and respond to risks as they arise, minimizing their impact on the overall project timeline and budget (Layode *et al.*, 2024).

Agile's emphasis on transparency also plays a key role in risk management. Stakeholders are kept informed about potential risks and the strategies to mitigate them, ensuring that all parties are aligned in their understanding of project challenges and solutions.

#### 3.2.5. Continuous Improvement

The principle of continuous improvement is central to Agile, as it encourages teams to regularly reflect on their processes and performance, learn from their mistakes, and strive for better outcomes. In the context of energy projects, this means that at the end of each sprint, project teams assess the project deliverables and the processes used to achieve them. This could include evaluating communication and collaboration, identifying inefficiencies, and implementing corrective actions (Nzeako, 2020).

In energy projects, continuous improvement is particularly valuable in maintaining safety standards, optimizing resource allocation, and adapting to changes in regulatory or environmental conditions. By embedding a culture of learning and refinement into every project phase, Agile ensures that teams are always striving for efficiency and effectiveness, which is crucial in the complex, high-stakes environment of energy project delivery.

### 3.3. Tailoring Agile to Energy Projects

Energy projects face unique challenges that require careful consideration when adapting Agile frameworks. Traditional Agile models, such as Scrum or Kanban, may need to be tailored to accommodate energy projects' highly regulated, technical, and safety-conscious nature. Compliance with legal, environmental, and safety standards is non-negotiable in energy projects. Therefore, the flexibility inherent in Agile must be balanced with the need for strict adherence to these regulations. For instance, while the project may follow an iterative process, each sprint must be carefully planned to ensure that all regulatory and safety requirements are met before proceeding to the next phase (Ojo & Kiobel, 2024).

Similarly, safety standards in energy projects often require detailed planning and adherence to risk management protocols. While emphasizing flexibility, Agile frameworks can be adapted to incorporate these requirements. For example, safety reviews can be integrated into each sprint review session, ensuring that risks are continually assessed and mitigated in accordance with safety protocols.

Finally, scalability is another consideration. Large-scale energy projects, such as those involving renewable energy infrastructure, can be complex and span multiple years. Tailoring Agile frameworks to support large teams, multiple locations, and long-term objectives requires adapting Agile's iterative processes to manage large-scale initiatives without sacrificing flexibility. This might involve scaling up the Scrum framework to incorporate multiple Scrum teams working on different components of the project or using Kanban to visualize and track progress across different teams and workstreams. By leveraging data-driven decision-making, Agile methodologies can ensure that energy projects remain adaptable and aligned with evolving industry demands (Ojo & Kiobel, 2024).

## 4. Discussion and Application

### 4.1. Benefits of the Model

The proposed Agile model provides several substantial advantages for energy project management, addressing common challenges such as stakeholder coordination, regulatory compliance, and the integration of emerging technologies. These benefits are particularly relevant in the energy sector, where projects often involve high levels of complexity, long timelines, and unpredictable market conditions.

One of the primary benefits of the Agile model is enhanced flexibility and adaptability. Energy projects operate in dynamic environments influenced by market fluctuations, regulatory changes, and unforeseen technical or environmental challenges. Agile's iterative approach enables teams to quickly adjust project scope, timelines, and strategies, ensuring responsiveness to evolving conditions. This flexibility is particularly critical in the energy sector, where sudden shifts—such as new government policies or disruptions in the supply chain—can significantly impact project execution. By embedding adaptability into project lifecycles, the Agile framework ensures that energy projects remain aligned with current industry demands and external changes (Kadenic & Tambo, 2023).

Another key advantage is improved stakeholder engagement. Traditional project management models often limit stakeholder involvement to specific milestones or final review phases, leading to misalignment and potential conflicts. In contrast, Agile emphasizes continuous collaboration and iterative feedback, fostering ongoing dialogue with regulators, contractors, suppliers, and community representatives. In energy projects, this means

frequent engagement with key stakeholders, allowing them to monitor progress, provide timely feedback, and influence critical decisions. Regular sprint reviews help prevent misunderstandings, mitigate risks, and build trust among all involved parties, ultimately leading to smoother project execution (Dingsøyr, *et al.*, 2012).

Risk management is another crucial area where Agile provides significant value. Energy projects often face risks related to technical failures, environmental concerns, and evolving compliance requirements. Traditional risk management approaches tend to assess risks primarily during the initial planning stage, with limited room for adjustments. Agile, on the other hand, adopts a proactive and adaptive risk management strategy, continuously evaluating and addressing risks throughout the project lifecycle. By leveraging iterative cycles and regular sprint assessments, Agile enables teams to identify potential risks early, implement corrective actions, and minimize disruptions. This dynamic risk management approach ensures greater resilience against unforeseen challenges and reduces the likelihood of costly delays or failures (Cobb, 2011).

Additionally, Agile promotes faster project delivery and cost efficiency. By dividing large projects into smaller, incremental phases, teams can achieve tangible outcomes more quickly, avoiding bottlenecks that often occur in traditional project management. Agile's emphasis on short-term, achievable goals ensures continuous progress, preventing stagnation—a common issue in energy projects where unexpected delays can result in substantial financial losses. Moreover, the iterative approach allows teams to identify inefficiencies early, optimize resource allocation, and reduce waste, leading to improved cost-effectiveness and sustainable project execution (Rigby, Elk & Berez, 2020).

Finally, Agile fosters a culture of continuous improvement, ensuring that teams consistently refine their processes and enhance project outcomes. Agile methodologies encourage ongoing reflection, stakeholder feedback, and lessons learned, helping teams adapt to industry advancements and regulatory updates. Given the rapid technological evolution within the energy sector—including advancements in renewable energy, grid modernization, and smart infrastructure—Agile's emphasis on iterative learning equips organizations with the agility needed to incorporate new innovations, improve operational efficiency, and enhance project quality (Cooper & Sommer, 2018).

### 4.2. Case Studies and Practical Examples

The successful application of Agile methodologies in industries outside of energy provides valuable insights into how Agile can be leveraged to improve project delivery in the energy sector. While the use of Agile in energy projects is still emerging, several industries—particularly engineering, construction, and infrastructure—have seen positive results from Agile adoption. One notable example of Agile's application in construction is the Sydney Opera House redevelopment project. This large-scale infrastructure project utilized Agile principles, including iterative planning, stakeholder collaboration, and continuous feedback loops, to address unforeseen challenges and meet evolving requirements. The project benefited from Agile's focus on flexibility, allowing for more adaptive and efficient decision-making in response to shifting priorities and emerging technical difficulties. Although the project faced significant pressure to deliver within strict time and budget constraints, Agile's iterative approach allowed the team to break down complex tasks into smaller, more manageable components, ultimately ensuring that the project was completed on time.



and to specification (Leonard, 2023).

Similarly, Agile methodologies were incorporated in the construction of the San Francisco Bay Area Rapid Transit (BART) extension to address the challenges of coordinating multiple stakeholders, managing complex construction processes, and ensuring compliance with regulatory requirements. The iterative planning and frequent feedback loops enabled project teams to better manage stakeholder expectations, assess risks, and respond to regulatory changes. Agile's emphasis on cross-functional collaboration and regular updates allowed for smoother integration of multiple disciplines, such as engineering, construction, and regulatory compliance, helping to mitigate delays and budget overruns (Akinsooto, Ogundipe & Ikemba, 2024; Oluokun *et al.*, 2024b; Onita *et al.*, 2023).

Although these examples originate from the construction sector, their underlying principles are highly relevant to energy projects, particularly large-scale infrastructure initiatives such as power plants, renewable energy installations, and grid modernization efforts. Similar to construction and infrastructure projects, energy projects require coordination among multidisciplinary teams, adherence to stringent regulatory frameworks, and adaptation to rapidly evolving technologies. In this context, Agile methodologies—emphasizing collaboration, flexibility, and continuous improvement—offer significant advantages (Østergaard *et al.*, 2020).

There have been early signs of Agile adoption in the oil and gas industry, particularly in software development and project management for digital transformation initiatives. Companies have used Agile to improve the delivery of technology solutions such as predictive maintenance systems, which help reduce downtime and increase operational efficiency. By breaking down the development process into smaller, iterative phases, these projects have seen improved time-to-market, reduced development costs, and more frequent feedback from end-users, all of which are crucial for driving innovation in the energy sector.

### 4.3. Challenges in Implementation

Although the advantages of Agile methodologies in energy projects are well-documented, their implementation is fraught with challenges. One of the most significant barriers to Agile adoption is resistance to change. Many energy companies have long relied on traditional project management frameworks such as Waterfall and Prince2, which emphasize rigid planning, extensive documentation, and long-term project cycles. The transition to Agile—an iterative and flexible model—can be perceived as disruptive, particularly by employees and stakeholders who are accustomed to structured workflows. Concerns over uncertainty, frequent reevaluation, and the perceived loss of control may lead to resistance, making it difficult for organizations to embrace Agile practices (Rigby, Elk & Berez, 2020).

Another major hurdle is the lack of Agile expertise within the energy sector. Agile requires specialized skills, including iterative planning, stakeholder collaboration, and cross-functional teamwork—competencies that many project managers and energy professionals may not possess. The limited exposure of the energy industry to Agile principles further complicates its adoption. As a result, organizations must invest in Agile training programs, hire professionals with Agile experience, or collaborate with external consultants to bridge the skill gap and successfully implement Agile methodologies (Standahl Johannessen & Karlsen, 2024).

Beyond technical expertise, cultural transformation poses a significant challenge. Agile is not merely a project management methodology; it represents a shift in organizational mindset and operational structure. Unlike traditional hierarchical models, where decision-making is top-down, Agile promotes self-organizing teams, decentralized decision-making, and continuous stakeholder engagement. For companies accustomed to rigid command-and-control structures, adapting to Agile's collaborative and dynamic approach can be daunting. Successful adoption requires leadership support, cultural buy-in, and organizational training to encourage a more adaptive, team-oriented approach to project execution (Omarova & Fuentes, 2023).

Despite these challenges, a viable solution lies in hybrid project management approaches, which blend Agile with traditional methodologies such as Waterfall and Prince2. In this model, Agile is incorporated into specific phases of the project while maintaining the overall structure and predictability of conventional methods. A common approach is the stage-gate model, where a project progresses through defined phases, with Agile used within each phase to facilitate iterative planning, stakeholder feedback, and continuous improvement. This hybrid approach ensures that energy projects maintain predictability, compliance, and risk control while benefiting from Agile's adaptability and responsiveness to change (Arefazar *et al.*, 2022).

Agile project management tools can be used alongside traditional project management software. For example, a project team might use Agile tools such as Scrum boards or Kanban boards to manage the day-to-day execution of tasks, while also using Waterfall or Prince2 for high-level planning and milestone tracking. This combination ensures that the project remains aligned with both the long-term objectives and the dynamic, iterative requirements of the energy sector (Adikwu *et al.*, 2024; Elete *et al.*, No date).

## 5. Conclusion and Recommendations

### 5.1. Summary of Key Findings

The exploration of Agile project management in the energy sector reveals significant opportunities for improving project delivery and overcoming traditional challenges. The literature review highlighted the evolving nature of project management within the energy industry, especially regarding technological integration, complex stakeholder environments, and regulatory constraints. Traditional project management methodologies, such as Waterfall, have been effective for certain energy projects but often fall short when handling modern energy initiatives' dynamic and unpredictable nature.

One of the key findings from the review is that Agile methodologies, specifically frameworks like Scrum and Kanban, offer an ideal solution for managing the complexity and uncertainty in energy projects. These frameworks focus on iterative progress, continuous stakeholder collaboration, and adaptability, which can significantly enhance project efficiency and delivery times. Agile's emphasis on flexibility is particularly important in the energy sector, where projects often face unforeseen challenges such as regulatory changes, technological advances, and shifting market dynamics. The findings suggest that Agile's ability to quickly pivot, adjust scope, and integrate feedback at each stage can reduce delays and costs, providing better alignment with evolving project goals.

Moreover, developing the practical Agile model for energy projects underscores the importance of certain core principles. Key principles like stakeholder engagement,

iterative planning, risk management, and continuous improvement are crucial for energy project success. Agile methodologies enhance the delivery process by incorporating regular feedback loops and empowering cross-functional teams, which improve collaboration and problem-solving across various project stages. Additionally, the model's emphasis on adaptive risk management ensures that projects are more resilient in the face of unforeseen challenges, which is especially beneficial in the energy sector where risks can be technical, environmental, or regulatory.

The discussion and application of the proposed model further reinforced these insights, showing how Agile could address some of the most critical issues facing energy projects today, such as delays, budget overruns, and communication breakdowns among stakeholders. Case studies from other industries, such as construction and infrastructure, demonstrated how Agile principles have already improved project outcomes in large-scale initiatives, providing a blueprint for successful implementation in energy projects. However, challenges related to resistance to change, lack of Agile expertise, and organizational culture shift remain significant barriers to Agile adoption, which could limit its widespread use in the energy sector.

In summary, the key findings suggest that Agile project management has the potential to revolutionize the way energy projects are planned, executed, and delivered. It provides a more dynamic and responsive framework that is better suited to the challenges of today's complex and fast-evolving energy landscape. While traditional project management methods have their place, integrating Agile principles offers significant advantages, especially in improving project timelines, stakeholder satisfaction, and risk management.

## 5.2. Implications for Energy Project Managers

For energy project managers, adopting Agile principles can significantly enhance the efficiency and success of their projects. However, transitioning to Agile requires careful planning, training, and cultural adjustment. One of the first steps in adopting Agile is for project managers to educate and train their teams on Agile methodologies, ensuring that all stakeholders understand its benefits, tools, and processes. A deep understanding of Agile frameworks such as Scrum and Kanban will empower teams to use these tools effectively, ensuring that projects are executed with maximum flexibility and responsiveness.

A critical recommendation is to embrace iterative planning and execution in energy projects. Project managers should move away from rigid, linear plans and instead focus on defining clear goals for short-term sprints, which will allow teams to deliver incremental value. This approach reduces the risk of overcommitting to unrealistic timelines and provides flexibility to adjust project deliverables as new information emerges. Energy projects, which are often subject to unexpected regulatory changes, technological innovations, or unforeseen challenges, benefit greatly from this iterative approach. Managers should prioritize setting up regular sprint reviews and feedback loops to ensure that progress is constantly evaluated and redirected when necessary.

Moreover, engaging stakeholders early and often is paramount in Agile project management. Project managers should ensure that stakeholders, including regulatory bodies, contractors, and local communities, are not just consulted at the project's initiation but are involved throughout its lifecycle. Agile's emphasis on continuous feedback helps build strong relationships with stakeholders and ensures that the project remains aligned with their needs, expectations,

and concerns. Energy projects often involve multiple stakeholders with competing interests, so maintaining an open line of communication through Agile practices can mitigate risks related to scope changes, delays, and cost overruns.

Another recommendation is to build cross-functional teams that integrate diverse skills and expertise across the engineering, environmental, regulatory, and financial sectors. In Agile, teams work closely to solve problems and adapt to emerging challenges, promoting collaboration and enhancing decision-making. This collaboration is crucial for energy projects, as they often require the integration of specialized knowledge in areas such as engineering design, environmental impact assessments, and regulatory compliance. Project managers should ensure that team members from various disciplines work together in an Agile framework, allowing for greater innovation, quicker problem-solving, and better resource allocation.

Finally, project managers should prioritize risk management using Agile's adaptive processes. Agile helps teams identify risks early through regular reviews and feedback sessions, allowing managers to address them before they become critical issues. In energy projects, risks such as technical failures, safety concerns, and regulatory changes can have significant consequences. With Agile, these risks can be monitored and managed throughout the project lifecycle, rather than being addressed only at predefined project milestones. Project managers should encourage proactive risk management, enabling their teams to pivot quickly and mitigate risks as they arise.

## 5.3. Future Research Directions

While the findings and recommendations presented in this paper highlight the potential benefits of Agile for energy projects, there is still much to explore in this emerging field. Future research should focus on integrating Agile with other modern project management tools and technologies, such as digital project management platforms and AI-driven analytics. These technologies can complement Agile by providing real-time data analysis, predictive insights, and automation, further enhancing the flexibility and adaptability of project teams. Research could examine how Agile integrates with these tools and its impact on project outcomes in energy projects, particularly in terms of efficiency, cost savings, and resource management.

Another area for future research is the impact of Agile on different energy sub-sectors. Energy projects span various industries, including oil and gas, renewable energy, power generation, and grid modernization. Each sub-sector has its unique set of challenges, regulations, and market dynamics. Research could investigate how Agile methodologies can be tailored to the specific needs of each sub-sector, and whether its effectiveness varies based on the type of energy project. For instance, projects in renewable energy, which are often subject to stringent environmental regulations and technological advancements, may benefit from Agile's iterative planning and flexibility more than traditional energy projects with more rigid requirements.

Moreover, future studies could explore the long-term impacts of Agile adoption on project outcomes, such as overall project success rates, stakeholder satisfaction, and cost-efficiency. While Agile's short-term benefits are well-documented, the long-term effects on project delivery and sustainability in the energy sector remain an area for further exploration. Research could track the performance of energy projects that have adopted Agile methodologies over several years, comparing them with projects that used traditional



project management methods. This longitudinal study would provide deeper insights into the overall effectiveness of Agile in the energy sector and could help refine its application in future projects.

Lastly, organizational culture and change management is another important area for further investigation. Successful Agile adoption often requires a significant shift in organizational culture, which can be a barrier for many energy companies. Research could focus on identifying the most effective strategies for overcoming resistance to change and fostering an Agile mindset within organizations that are accustomed to traditional project management practices. This could involve studying the experiences of companies that have successfully integrated Agile and determining the key factors that contributed to their success.

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