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Adoption of Agile Principles for Successfully Managing Projects in Indian Energy Sector: A Literature Review

Priyamvada Mathur*

Research Scholar, Faculty of Management Studies, University of Delhi, Delhi, India.

***Corresponding author:** mathurpriyamvada@gmail.com*

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Abstract: *The energy sector is undergoing significant transformation driven by sustainability goals and technological advancements. This necessitates reevaluating project management methodologies. Traditional approaches may no longer suffice in addressing flexibility needs. Agile methodologies offer a promising alternative to enhance project performance through iterative planning, stakeholder collaboration, and team empowerment. While agile adoption presents challenges in the highly regulated Indian energy sector, hybrid models combining agile and traditional methods are emerging as balanced solutions. The selection of appropriate methodologies should be based on project-specific factors. As the sector evolves, project managers must adapt approaches to enhance agility, resilience and overall performance in addressing complex challenges.*

Introduction

The energy sector is undergoing a significant transformation, driven by a shift towards sustainability, renewable energy, and eco-friendly practices. This evolution necessitates a re-evaluation of project management methodologies, particularly in the Indian context, where rapid technological advancements and increasing energy demands are reshaping the industry landscape. Traditional project management approaches may no longer suffice in addressing the need for flexibility and adaptability in this dynamic environment. Agile methodologies, originally developed for software development, offer a promising alternative that could enhance project performance within the energy sector. These methodologies prioritize iterative planning, stakeholder collaboration, and team empowerment, enabling projects to effectively manage uncertainties and contextual complexities.

While agile project management has gained traction across various sectors, its adoption in the energy industry presents unique challenges and opportunities. The highly regulated and safety-critical nature of the energy sector poses specific barriers to agile implementation, including organizational, technological, behavioural, and regulatory constraints. However, integrating agile methods with traditional project management approaches can be beneficial. Hybrid models that combine agile's adaptability with

the structure of traditional methods are increasingly being adopted, particularly in large or complex projects. These hybrid approaches offer a balanced solution, leveraging the strengths of both methodologies to address the specific needs of energy sector projects.

The selection of an appropriate project management methodology should be based on project-specific factors. Agile methods excel in fast-changing environments, while traditional approaches may be more suitable for highly regulated industries. Future research should focus on exploring agile's applicability in non-IT sectors like energy and the long-term effectiveness of hybrid models in safety-critical industries. In conclusion, as the energy sector continues to evolve, project managers must adapt their approaches to enhance agility, resilience, and overall project performance. The integration of agile principles, either through pure agile methodologies or hybrid models, offers a promising path forward in addressing the complex challenges faced by the energy industry.

This paper seeks to explore the key drivers influencing the evolving nature of projects in the energy sector and critically assess the role of agile methodologies in enhancing project agility, resilience, and overall success.

Research Methodology

This research design explores the relationship between agile project management principles and project performance in non-IT projects within India's Energy sectors. A literature survey was conducted using databases like Scopus, Web of Science, and Google Scholar to identify research gaps and frame objectives. The search focused on keywords related to agile project management, project success, and agile adoption including "agile project management", "agile methodology", "project success factors", "agile adoption in power", "agile adoption in energy", "agile implementation". The review encompassed seminal work and recent trends in project management, covering scholarly literature, websites, and books. Primary sources included Scopus-based journals, ProQuest research library, PMI prescribed books, and project management journals. The search was limited to publications after 2000 and seminal articles before 2000 related to business, management, social sciences, and engineering.

The inclusion and exclusion criteria for each thematic area were based on a search query combining terms related to agile methodologies, project management, energy sectors, frameworks, collaboration, and performance metrics. This approach explored the subject matter across various domains and perspectives.

These queries ensured relevant literature selection. Documents were screened based on:

- **Subject Area:** Business, Management, Energy, and Multidisciplinary studies.
- **Document Type:** Only journal articles and conference papers were considered.
- **Publication Year:** The search was restricted to papers published from 2010 onwards.
- **Keywords:** Selected articles were further refined based on keyword relevance.

Following screening, 256 documents on energy sector trends, 183 on energy project characteristics, and 502 on project management methodologies were included. This approach ensures understanding of the research landscape in energy project management.

The review identified current research trends and gaps in applying Agile Project Management methodology to non-IT projects in India's Energy sectors. This analysis of literature, supported by Project Management Methodologies evolution, underscores the research area's significance. The findings will inform research objectives, guiding the study's focus on agile principles in non-traditional project environments.

Theoretical Foundations

The research is built upon existing studies and latest trends in project management. It acknowledges the maturity of project management approaches and the influence of project-specific conditions on their adoption. Practitioners and scholars acknowledge that PM approaches and related concepts have matured (Papke-Shields & Boyer-Wright, 2017). The adoption of various project management approaches for undertaking different sorts of projects is, however, influenced by project-specific conditions (Joslin & Müller, 2015). To fulfill the expectations of stakeholders and organizational objectives, project and business success indicators have been expanded from conventional deployment in accordance with the predetermined goals (Mathur et al., 2013, 2014). Considering the high failure probability of projects, firms are constantly investing in projects for long-term gains (Davis, 2017).

Energy Sector – Evolving Industry Landscape

The energy sector today is moving towards Energy Transition by switching to renewable energy sources. Also, to reduce their carbon footprint organisations are employing advanced digital technology solutions to improve the operational efficiency of existing infrastructure. The projects undertaken to set up infrastructure based on renewable energy sources and innovative business solutions; often employ technologies that are not yet completely established and are in a continuous improvement phase. Thus, increasing project complexities and often resulting in scope changes much later in the project life cycle. Other trends like globalization, hybrid workforce, post-pandemic market fluctuations, and geo-political tensions also impact the energy project environment, demanding a more agile and collaborative management approach.

An effective and efficient project management approach is essential for establishing and preserving resilience in the energy sector. It is imperative to adopt practices that are aligned to the changing project characteristics for developing a resilient energy network through improved infrastructure, implementing digital technology, innovative sustainable solutions and transition to renewable energy sources.

In this study, we examine how the trends in the energy sector are changing the project environment and redefining the project characteristics.

Drivers of Change

The adoption of Agile Project Management (APM) in the Indian energy sector is driven by a range of technological, economic, regulatory, and organizational factors. Technological progress, such as the integration of digital tools (IoT, analytics, automation), and advancements in renewable energy technologies are enhancing flexibility and driving cost efficiency, encouraging agile adoption (Park et al., 2021; Yao et al., 2021). Workforce adaptability, especially under stressors like the COVID-19 pandemic, further supports agile implementation by fostering decentralized decision-making and responsive teams (Haris et al., 2023).

Energy projects are inherently complex, often involving high-risk and failure costs. Agile practices, combined with risk assessment tools like Fuzzy Fault Tree analysis, enable proactive risk management in such contexts (Krechowicz et al., 2017). Government policies, including tax incentives and climate mandates, significantly influence project direction and execution, with agile frameworks offering flexibility to adapt to evolving regulations (Owusu-Manu et al., 2017). Public-private partnerships also benefit from agile's emphasis on collaboration.

Market demand for cleaner energy and economic incentives, such as job creation and regional development, further necessitate faster and adaptive project delivery (Park et al., 2017). Simultaneously, environmental and social responsibilities are prompting companies to embrace CSR-driven agile practices that engage stakeholders and enhance sustainability (Stjepcevic et al., 2017). Finally, effective stakeholder management and conflict resolution, facilitated through agile communication and iterative feedback, are critical for project success (Larson, 2020). Together, these drivers underscore the growing relevance of APM in India's evolving energy landscape.

The transition from traditional to non-traditional energy projects has introduced significant changes in project characteristics across multiple dimensions. These shifts reflect the growing complexity, uncertainty, and innovation within the energy sector, driven by the need for sustainability and technological advancement.

In terms of investment evaluation, traditional energy projects typically rely on established financial metrics like Net Present Value (NPV) and Internal Rate of Return (IRR). However, non-traditional projects, characterized by higher uncertainty, increasingly adopt the Real Options Approach (ROA) to enhance flexibility and decision-making (Papadimitriou et al., 2023; Santos et al., 2014). Similarly, technological integration differs significantly—while traditional projects use well-established technologies, non-traditional projects embrace advanced, emerging technologies that often require the integration of multiple energy sources (Chen et al., 2024).

Project complexity is notably higher in non-traditional projects due to the convergence of various renewable energy systems and dynamic environmental factors (Zhao et al., 2022). Furthermore, regulatory and policy influence plays a more prominent role in non-traditional projects, which are closely tied to evolving sustainability mandates and incentive schemes (Singh et al., 2024).

In terms of risk and uncertainty, traditional projects face relatively predictable risks, whereas non-traditional projects must manage greater uncertainty, offset by more adaptable financial models (Papadimitriou et al., 2023). The energy sources themselves also diverge—fossil fuels dominate traditional projects, while renewables such as solar and wind power are central to non-traditional efforts.

Additionally, environmental impact is a key differentiator. Traditional projects typically produce higher emissions, whereas non-traditional projects aim for reduced environmental footprints. This shift also reflects in project management practices—traditional models follow a sequential waterfall approach, while non-traditional projects increasingly implement Agile methods like Scrum to accommodate dynamic requirements (AlMarar et al., 2019).

Finally, cost and financial viability also vary. Although traditional projects often incur lower initial costs, their long-term environmental costs can be significant. In contrast, non-traditional projects may have higher upfront investments but benefit from long-term savings and policy incentives (Chen et al., 2024).

Collectively, these evolving characteristics underscore a broader transformation in the energy sector, moving towards sustainable, flexible, and innovation-driven project models.

Overview of Agile Principles (Agile Manifesto, Key Values, and Principles)

Agile Project Management (APM) is a flexible and iterative methodology initially developed for software development but now widely applied in diverse sectors such as marketing, finance, and construction (Brosseau, 2004; Mohan & Jayapandian, 2023; Bilal et al., 2023). At its core, APM focuses on continuous collaboration, adaptive planning, and delivering customer-centric value.

The fundamental principles of APM revolve around customer collaboration, iterative development, and responsiveness to change. Agile promotes frequent engagement with customers to ensure the project remains aligned with their needs (Mohan & Jayapandian, 2023; Highsmith, 2004). Instead of following a rigid sequence, projects are broken into short cycles known as sprints, allowing for frequent reassessment (Monteiro et al., 2023; Ministr et al., 2019). Agile teams embrace uncertainty and pivot strategies quickly in response to dynamic environments, ensuring relevance and reduced risk (Mohan & Jayapandian, 2023; Bahi et al., 2024). Furthermore, reflection and feedback are embedded into each cycle to facilitate learning and improvement (Dybå et al., 2014; Dyba & Dingsoyr, 2015).

Key practices that characterize Agile include the formation of self-managing teams that operate with autonomy and accountability (Dybå et al., 2014; Dyba & Dingsoyr, 2015). These teams aim to deliver the minimum viable product to ensure continuous value generation. APM also values redundancy in skills and continuous feedback to build team resilience. The use of visual tools such as task boards and informal, real-time communication further enhances productivity and reduces delays (Monteiro et al., 2023; Ministr et al., 2019).

The benefits of Agile are significant. Involving customers throughout the lifecycle ensures that the final product is well-aligned with expectations (Mohan & Jayapandian, 2023; Plotnikov et al., 2024). It promotes teamwork, transparency, and synergy, leading to higher collaboration and efficiency (Plotnikov et al., 2024; Senyurt et al., 2021). Agile's fast-paced, sprint-based approach facilitates quicker delivery of usable components, accelerating time-to-market (Plotnikov et al., 2024; Nelson et al., 2020). Its inherent flexibility also ensures projects can accommodate changing requirements without major disruptions (Mohan & Jayapandian, 2023; Brosseau, 2004).

However, Agile also faces challenges. The shift from traditional project management requires a cultural and operational transformation, often entailing a steep learning curve (Dybå et al., 2014; Dyba & Dingsoyr, 2015). Agile projects may suffer from unpredictability in timelines and deliverables, which can be problematic for organizations reliant on strict planning (Mohan & Jayapandian, 2023). Additionally, integrating Agile with conventional methods demands careful strategy and hybrid frameworks (Brosseau, 2004; Sanchez et al., 2019).

Today, Agile's relevance extends beyond software development. It is increasingly used in marketing and finance for campaign execution and product development (Mohan & Jayapandian, 2023; Monteiro et al., 2023), and in the construction industry to enhance stakeholder engagement and manage complexity (Bilal et al., 2023).

In summary, Agile Project Management offers a robust, adaptive framework that enhances project success by prioritizing customer value, team empowerment, and responsiveness—making it indispensable in a fast-evolving global landscape.

Selecting the appropriate project management methodology requires a context-driven approach, ensuring alignment with project complexity, industry requirements, risk factors, and resource availability.

Table 1: Project Management Methodologies

Aspect	Predictive	Hybrid	Iterative
Planning	Detailed upfront planning	Combination of both	Continuous planning
Flexibility	Low	Medium	High
Delivery	Sequential	Mixed	Incremental
Control	High	Medium	High
Adaptability	Low	High	High
Complexity	Low	High	Medium
Best Use Case	Stable, well-defined projects	Complex, varied projects	Dynamic, evolving projects

Source: Prepared by Author based on literature review

Findings

The global energy sector is undergoing significant transformations driven by technological advancements, evolving consumer preferences, and regulatory shifts. A bibliometric analysis of publications on energy trends indicates an increasing academic interest in this domain. From 2000 to 2010, the number of publications remained relatively stable. However, post-2010, research articles have grown significantly.

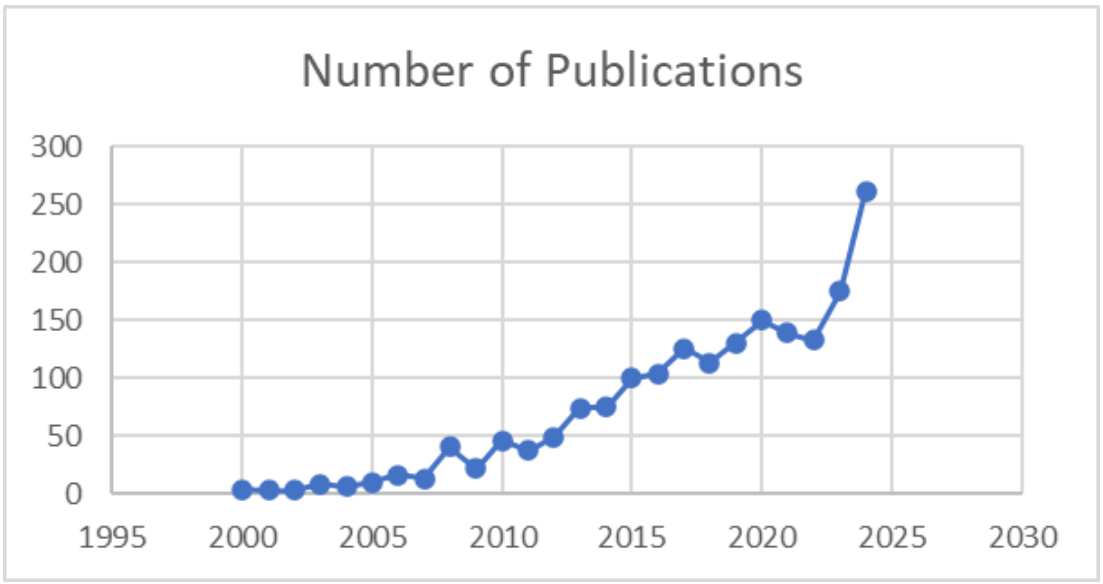

Figure 1: Number of Publications per year on Trends in Energy Sector

The emerging trends in energy projects highlight the increasing emphasis on sustainability, efficiency, and innovative business models that support the transition toward a low-carbon economy (Roy et.al., 2023). Further analysis highlighted frequent use of keywords like "climate change," "energy policy," "alternative energy," and "sustainable development" in the literature. This indicates that project managers in the energy sector need to have a broad understanding of sustainability concepts and their practical applications. The bibliometric analysis also reveals emerging research clusters relevant to project management in the energy sector, refer Figure 2.

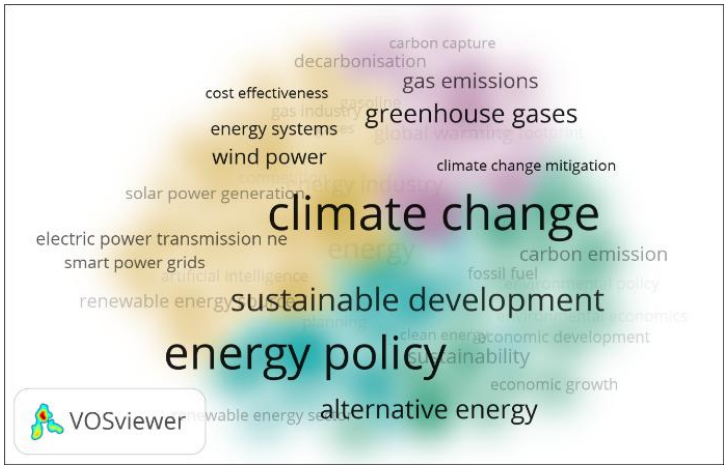

Figure 2: Keyword Clusters in the Energy Sector

Key trends shaping the energy landscape globally, were identified through in-depth review of most relevant and recent literature, refer Figure 4. As noted by Harvey (2020), there is an increasing focus on developing customer centric energy solutions leading to enhanced customer engagement and satisfaction. He also highlighted adoption of capital-light business models through innovative financing solutions and asset-light approaches, such as energy-as-a-service, leasing-based solutions, and distributed energy resources, to improve scalability and accessibility (Harvey, N. 2020).

The co-citation analysis (refer Figure 3) captures the diverse scholarly dialogue within agile project management, illustrating both foundational and emerging lines of thought in the field.

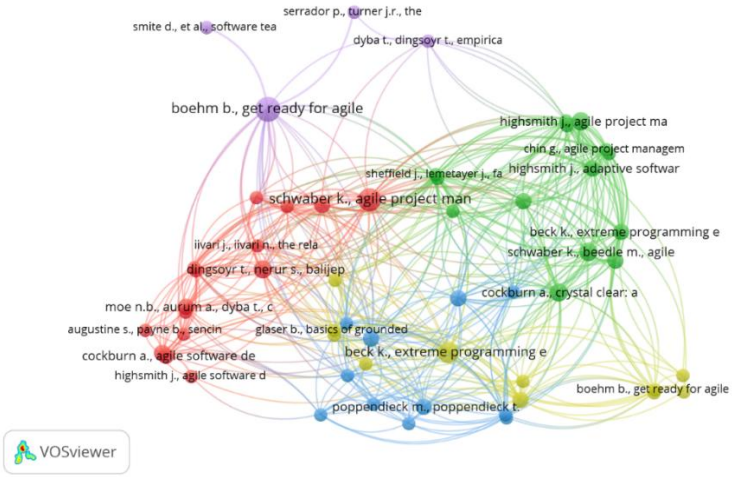

Figure 3: Co-Citation Analysis of Foundational and Emerging Research in Agile Project Management

A fundamental difference lies in its implementation context. In software development, APM relies on informal collaboration, flexible planning, and adaptive learning (Dybå et al., 2014). However, in non-software domains, applying APM is more complex due to industry-specific practices and requires considerable adjustments and financial investment, especially for small and medium-sized enterprises (Žužek et al., 2020).

Implementing APM in non-software projects presents several challenges. These include resistance to change, insufficient agile expertise, coordination issues, and inconsistent stakeholder involvement. Organizations may also face productivity dips and difficulty meeting deadlines when transitioning from traditional project management methods (Geetha et al., 2025).

To address these challenges, best practices have emerged. These include providing Agile training, securing leadership support, implementing gradual transition strategies, and ensuring effective communication. Additionally, a tailored APM framework emphasizing user involvement, documentation, knowledge repositories, and self-organizing teams can enhance planning, execution, and monitoring efficiency (Uikey & Suman, 2012).

The benefits of adopting APM in non-software settings are substantial. Agile methods contribute positively to project efficiency and stakeholder satisfaction. These outcomes are further enhanced when project goals are clearly defined and shared (Serrador & Pinto, 2015). Furthermore, APM fosters improved customer relationships and overall project performance (Ceschi et al., 2005).

In conclusion, while transitioning to APM in non-software projects requires overcoming structural and cultural barriers, adopting best practices can lead to significant improvements in performance, flexibility, and stakeholder engagement.

Challenges in Implementing Agile Principles in Energy Sector

Adopting Agile Project Management (APM) in Energy sector contexts involves navigating cultural, structural, and operational challenges. Resistance to change is a primary barrier, as teams often prefer traditional methods due to familiarity. Overcoming this requires incremental transitions supported by continuous training (Geetha et al., 2025; Prakash et al., 2024; Dumrak et al., 2020). A lack of Agile expertise is another major issue, particularly for teams unfamiliar with Agile principles. Organizations must invest in training and deploy Agile coaches to facilitate learning (Geetha et al., 2025; Mansor et al., 2016; Raharjo & Purwandari, 2020).

Poor team coordination also hinders Agile implementation since Agile depends on high collaboration levels, which are uncommon in traditional environments. Open communication, regular meetings, and team-building initiatives can address this (Geetha et al., 2025; Dumrak et al., 2020; Monteiro et al., 2023). Moreover, stakeholder engagement is often inconsistent due to limited understanding of Agile. To secure buy-in, stakeholders should be involved from the start and educated about Agile's benefits (Geetha et al., 2025; Raharjo & Purwandari, 2020).

Industries requiring extensive documentation may struggle with Agile’s minimal documentation approach. A hybrid model combining Agile flexibility with essential documentation helps bridge this gap (Prakash et al., 2024). Additionally, ineffective use of Agile tools due to unfamiliarity or misalignment can limit project success. Training and careful selection of suitable tools are key (Arya & Kulkarni, 2024).

Key strategies include ensuring leadership support, maintaining effective communication, applying hybrid approaches, and fostering continuous improvement (Geetha et al., 2025; Prakash et al., 2024; Monteiro et al., 2023). Although challenging, successful APM adoption in Energy and allied sectors is achievable with tailored strategies that address cultural resistance, skills gaps, collaboration issues, and stakeholder dynamics (Geetha et al., 2025; Dumrak et al., 2020; Raharjo & Purwandari, 2020).

Tailoring Agile principles to Energy projects involves adapting core values and practices to meet the specific needs of diverse industries such as construction, manufacturing, and services. One key strategy is customizing Agile frameworks by selecting those like Scrum, Kanban, or Lean that align well with the project context. For example, Kanban suits manufacturing due to its emphasis on workflow visualization. Roles like Scrum Master and Product Owner should also be modified or integrated with existing roles to fit organizational structures.

Incremental delivery is vital for managing risks and meeting stakeholder expectations. Projects should be broken into smaller milestones, and iterative feedback loops—via reviews or retrospectives—should be used to maintain alignment with stakeholders. Collaboration and communication can be strengthened through cross-functional teams and visual tools like boards or charts, which enhance transparency and team coordination. In energy industries where detailed documentation is often required, Agile’s minimal approach needs adjustment. Teams should strike a balance by using Agile-friendly formats, such as user stories and diagrams, that are both informative and flexible. Moreover, aligning Agile with industry standards—like safety and compliance in construction or Lean Six Sigma in manufacturing—ensures regulatory and quality adherence while maintaining agility.

Training and education are crucial to a successful transition. Tailored Agile training and a culture of continuous learning enable teams to internalize Agile values effectively. Finally, success should be measured and adapted regularly through clear metrics, including efficiency, stakeholder satisfaction, and quality indicators. These evaluations guide iterative improvements to maintain relevance and effectiveness.

In conclusion, by adapting frameworks, emphasizing phased delivery, fostering communication, tailoring documentation, aligning with industry norms, and committing to training and evaluation, Agile can be successfully applied beyond software, improving project outcomes across various sectors.

Discussion

Globally energy sector projects are affected by the changes in the external environment and the internal environment, such as evolving regulatory requirements, technological advances in solution design and implementation, growing sustainability awareness leading to increased stakeholder engagement during project design and execution (Owusu-Manu et al., 2017; Park et al., 2021; Yao et al., 2021; Larson, 2020). The shift towards renewable sources of energy and use of advanced technologies for energy distribution like smart grids, has led to increased project complexities and uncertainties leading to higher risks and stakeholder involvement (Zhao et al., 2022; Chen et al., 2024; Papadimitriou et al., 2023; AlMarar et al., 2019). These evolving project characteristics—such as client collaboration, flexibility towards changing requirements, and adaptive planning—necessitate a shift in project management methodologies. Additionally, according to contingency theory, effective project management methodology selection primarily depends on project characteristics, organisational context and project success measures (Fitzgerald et al., 2002; Lehtonen and Martinsuo, 2006). The decision between predictive, iterative, incremental, and hybrid approaches is influenced by project complexity, requirement clarity, monitoring and control needs, and adaptability to changes during execution (PMBOK, 2017). Given the increasing uncertainties in the energy sector, Agile principles are gaining prominence as they enhance responsiveness to dynamic requirements and foster continuous client engagement, ultimately ensuring sustainable long-term value.

The changing project characteristics in energy sector has led to growing interest and adoption of agile principles to address requirement uncertainties and continuous client engagement for successful delivery of sustainable value in long term. The adoption of Agile principles varies across organizations, with some principles demonstrating widespread acceptance while others exhibit moderate or minimal implementation. Agile adoption is strongest in principles directly related to product delivery and team dynamics, while principles requiring broader cultural and structural shifts, such as stakeholder collaboration and simplicity, show more variability. Given the evolving complexities of energy projects, future research should focus on refining Agile implementation strategies to enhance collaboration, adaptability, and long-term sustainability in the sector.

Conclusion

The adoption of Agile principles in the energy sector is driven by the increasing complexity and uncertainty of projects, influenced by external and internal environmental factors such as regulatory changes, technological advancements, and sustainability imperatives. While Agile methodologies offer a structured yet flexible approach to managing dynamic project requirements, their implementation varies across organizations.

Principles related to product delivery and team autonomy, such as frequent delivery of working solutions, self-organizing teams, and working software as a progress measure, exhibit the highest levels of adoption. These principles align well with the sector's need for iterative development and adaptability. However, principles requiring significant cultural and structural shifts—such as face-to-face communication and simplicity —show lower adoption rates. Challenges such as regulatory constraints, traditional hierarchical structures, and legacy systems hinder the full realization of Agile benefits.

Despite these variations, the growing interest in Agile methodologies highlights their potential to enhance project agility, stakeholder collaboration, and long-term value delivery. Future research should focus on refining Agile frameworks for better integration with the energy sector’s unique constraints, ensuring that principles promoting flexibility, sustainability, and continuous improvement are effectively institutionalized for successful project execution.

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