(REVIEW ARTICLE)

Agile project management in smart grid design: Comparative insights from Africa and the United States

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Abstract

The transition to smart grid technologies represents a critical evolution in modern power systems, driven by the need for enhanced efficiency, reliability, and sustainability. This article explores the integration of agile project management principles within the context of smart grid design and deployment. By examining the foundational concepts of agile methodologies and their application in smart grid projects, this study highlights the benefits of iterative development, stakeholder collaboration, and rapid adaptation to technological advancements. A comparative analysis of agile practices in Africa and the United States reveals unique regional challenges and opportunities, emphasizing the importance of tailored approaches. Furthermore, emerging trends such as the convergence of agile with artificial intelligence, cybersecurity, and digital twin technologies are discussed, showcasing the future potential of these methodologies in advancing smart grid innovations. Despite the inherent complexities and security concerns, the adoption of agile practices offers significant advantages, including enhanced flexibility, efficient resource utilization, and improved stakeholder engagement. The findings underscore the necessity for a balanced approach, combining agile methods with traditional project management to navigate the multifaceted landscape of smart grid development. This study provides valuable insights and recommendations for stakeholders aiming to leverage agile principles to create resilient, user-centric, and future-proof energy systems.

1. Introduction

Electric grids globally are undergoing a significant transformation, with a growing emphasis on integrating smart grid technologies (1). This shift is particularly pronounced in Africa and the United States, where both regions face unique challenges and opportunities in transitioning to more intelligent and efficient power systems (2) (3).

In smart grid implementation, agile project management principles have emerged as a promising approach. While agile methodologies are becoming popular in various sectors, including smart grid development, their origins are in the Information Technology industry. The term "Agile Project Management" gained prominence in 2001 with the Agile Manifesto, a collaborative effort by IT professionals and theorists that challenged traditional project management

techniques, especially for projects marked by uncertainty and a rapidly changing business environment (4). The Agile Manifesto emphasized:

- Individuals and interactions over processes and tools
- Working software over comprehensive documentation
- Customer collaboration over contract negotiation
- Responding to change over following a plan

These values represented a significant shift from the traditional, linear waterfall model of project management, paving the way for more flexible and iterative approaches (4).

In this evolving landscape, agile project management has emerged as an effective strategy for navigating the complexities of smart grid design and implementation (5). Agile methodologies, which prioritize iterative development, flexible adaptation, and close collaboration with stakeholders, offer a compelling framework for addressing the unique demands of smart grid projects (1).

1.1. Purpose and Scope of the Review

This review paper examines the role of agile project management in smart grid design and implementation, focusing on comparative insights from Africa and the United States.

The paper explores the following key areas:

- The fundamental characteristics and benefits of agile project management, and how they align with the unique requirements of smart grid development.
- The challenges and obstacles encountered in adopting agile approaches within the context of smart grid projects, particularly in the African and U.S. contexts.
- Case studies and best practices showcasing the successful application of agile project management in smart grid initiatives across the two regions, highlighting lessons learned and factors contributing to their success.
- The evolving role of stakeholder engagement, collaboration, and change management within the agile smart grid project landscape.

By examining these aspects, this paper aims to provide a comprehensive understanding of the synergies between agile project management and smart grid design, while also identifying the unique regional nuances and considerations that shape the implementation of these strategies.

2. Methodology

A comprehensive literature search was conducted using various academic databases, including Scopus, IEEE Xplore, and Google Scholar, to identify relevant peer-reviewed journal articles and conference proceedings. The search terms included combinations of "agile", "project management", "smart grid", "Africa", and "United States".

The selected sources were carefully analyzed to extract key insights regarding the characteristics, benefits, and challenges of adopting agile project management in smart grid initiatives across the two regions.

3. Overview of Smart Grid Technology

The core of the smart grid concept revolves around integrating advanced information and communication technologies into traditional power grid infrastructure (6). These technologies enable the bidirectional flow of information and energy, allowing for real-time monitoring, control, and optimization of the entire grid system (7). This holistic approach facilitates the seamless integration of renewable energy sources, enhances grid reliability and efficiency, and actively engages consumers in managing their energy consumption and production (3). By merging digital technologies with the conventional power grid, smart grids modernize and transform the way electricity is generated, distributed, and utilized.

3.1. Key Components of Smart Grid Technology

3.1.1. Advanced Metering Infrastructure (AMI)

Advanced metering infrastructure allows for two-way communication between utilities and consumers. This bidirectional communication enables real-time data collection, analysis, and informed decision-making to optimize energy distribution and consumption (8). Through the integration of smart meters, utilities can gather detailed information on energy usage patterns, while consumers receive real-time feedback and insights to make more informed choices about their energy use. This enhanced visibility and control over energy flows enable utilities to better manage grid operations, identify and address inefficiencies, and integrate renewable energy sources more effectively. Ultimately, AMI underpins the transition toward a more intelligent, responsive, and consumer-centric power grid.

3.1.2. Distributed Energy Resources (DERs)

Distributed energy resources, such as solar photovoltaic systems, wind turbines, and energy storage solutions, are crucial elements of smart grid technology. The ability to integrate these resources into the grid in a coordinated and intelligent manner is a defining characteristic of the smart grid (9) (10). Smart grid technologies enable the seamless incorporation of renewable energy sources, contributing to the overall sustainability and resilience of the power system.

3.1.3. Sensor Networks and Advanced Analytics

Sensor networks and advanced analytics capabilities are essential components of smart grid technology. These systems provide enhanced visibility and real-time insights into grid operations, empowering utility providers to proactively monitor and manage the power grid (11) (12) (13). With sensor networks continuously gathering data from various points across the grid and advanced analytics algorithms processing this information, utilities can gain a deeper understanding of grid performance, identify potential issues, and enable predictive maintenance strategies (13). This helps prevent and mitigate outages, optimize asset utilization, and improve the overall efficiency and reliability of the power system. The integration of these smart grid technologies enables a more proactive and data-driven approach to grid management, enhancing the resilience and responsiveness of the power grid.

By leveraging these smart grid technologies, power utilities and grid operators can address pressing challenges such as improving energy efficiency, integrating renewable energy sources, enhancing grid reliability, and empowering consumers to make informed decisions about their energy use.

4. Agile Project Management Concepts

Agile project management is an iterative and adaptive approach to project delivery that emphasizes collaboration, flexibility, and continuous improvement (14). Unlike traditional waterfall methodologies, which follow a linear and sequential process, agile project management embraces a more iterative and incremental approach to project development.

4.1. Core Principles of Agile Project Management

- Iterative and Incremental Development: Agile projects are broken down into smaller, manageable iterations or sprints, each with a defined scope and timeline (15). This allows for rapid feedback, testing, and the incorporation of changes throughout the project lifecycle.
- Collaboration and Communication: Agile teams work closely together, with regular meetings and constant communication to ensure alignment, shared understanding, and the ability to adapt to changing requirements (16).
- Adaptability and Flexibility: Agile approaches embrace change and encourage teams to be responsive to evolving needs, rather than rigidly adhering to a predefined plan (16).
- Customer/User Involvement: Agile methodologies prioritize the active involvement of customers or end-users throughout the project, ensuring that the final product or service aligns with their needs and expectations (17).
- Continuous Improvement: Agile teams regularly reflect on their processes and performance, identifying areas for improvement and implementing changes to enhance the effectiveness of their workflows (15).

4.2. Agile Frameworks and Methodologies

Agile project management encompasses various frameworks and methodologies, each with unique characteristics and applications. Some of the most widely adopted agile frameworks include:

- Scrum: A popular agile framework that organizes the development process into short, iterative sprints, focusing on cross-functional teamwork, regular check-ins, and the delivery of incremental value (18) (19).
- Kanban: A visual project management approach that emphasizes the continuous flow of work, focusing on limiting work-in-progress and identifying and addressing bottlenecks (20).
- Extreme Programming (XP): An agile software development methodology that emphasizes practices such as pair programming, test-driven development, and continuous integration to deliver high-quality software (21).
- Lean: An agile approach that focuses on minimizing waste, streamlining workflows, and delivering value to customers as efficiently as possible (22).

These agile frameworks and methodologies share common principles and practices, but each offers unique advantages and may be more suitable for certain types of projects or organizational cultures. Now that we've established a basic understanding of agile project management, let's explore its specific applications and benefits within the context of smart grid design.

4.3. Agile Project Management in Smart Grid Design

The application of agile project management principles in smart grid design has emerged as a promising approach to navigate the complexities and uncertainties inherent in this domain (5) (23).

Agile methodologies, such as Scrum and Kanban, emphasize iterative and incremental development, close collaboration with stakeholders, and rapid adaptation to changing requirements (17). These principles align well with the dynamic nature of smart grid projects, which often involve the integration of multiple technologies, the coordination of diverse stakeholders, and the need to respond to evolving customer needs and regulatory changes.

In the context of smart grid design, agile project management offers several key benefits:

- Flexible and Responsive Adaptation: Agile approaches enable project teams to quickly pivot and adapt to emerging technological advancements, regulatory shifts, and changing customer preferences, ensuring the smart grid solution remains relevant and effective.
- Collaborative Stakeholder Engagement: Agile methodologies foster close collaboration among utility providers, technology vendors, policymakers, and end-users. This collaboration facilitates a shared understanding of requirements and the co-creation of smart grid solutions.
- Incremental Deployment and Continuous Improvement: Agile project management supports the gradual, iterative deployment of smart grid components. This approach allows for continuous testing, feedback incorporation, and optimization of the overall system.
- Rapid Prototyping and Experimentation: Agile practices encourage the rapid development and testing of prototypes. This enables project teams to validate assumptions, gather user feedback, and refine the design before full-scale implementation.
- Enhanced Visibility and Transparency: Agile methodologies prioritize transparency, regular progress reporting, and the visibility of project status. This helps stakeholders to align and make informed decisions throughout the smart grid development lifecycle.
- Efficient Resource Utilization: Agile practices emphasize the effective allocation and management of resources. This reduces waste and ensures that project efforts are focused on the most valuable and impactful initiatives.

By leveraging these agile principles and practices, smart grid projects can more effectively manage the inherent complexities and dynamic requirements of modern power systems, ultimately delivering more resilient, efficient, and user-centric solutions.

4.4. Agile Strategies in Smart Grid Development: Africa and U.S. Perspectives

A comparative analysis of smart grid initiatives in Africa and the United States reveals both similarities and disparities in the adoption and application of agile project management practices (2) (3).

In Africa, the deployment of smart grid technologies has been largely driven by the urgent need to address critical energy access and reliability issues across the continent (2). Agile approaches have been instrumental in enabling rapid prototyping, testing, and refinement of smart grid solutions tailored to the diverse socioeconomic and geographic contexts found in different regions (5) (3).

For example, in Tunisia, the implementation of community-coupled microgrids has leveraged agile principles to foster close collaboration between utility providers, local communities, and technology vendors. This approach has enabled the rapid development and deployment of tailored smart grid solutions that address the unique challenges and requirements of individual communities, while also promoting local stakeholder engagement and ownership (2). Similarly, the Rural Electrification Agency (REA) project in Nigeria has successfully utilized agile methodologies to tailor solutions for off-grid communities, demonstrating the flexibility and responsiveness of this approach in addressing diverse energy access challenges (24) (25). Eskom's microgrid project in South Africa is another notable example, where agile practices have been leveraged to enable the gradual deployment and continuous enhancement of smart grid infrastructure, leading to improved grid stability and reduced power outages (26). Likewise, Kenya Power's Smart Metering Project has embraced agile principles to implement a phased rollout of smart meters, enabling the utility to gather feedback, optimize system performance, and gradually expand deployment to reduce electricity losses and improve billing accuracy (27).

The adoption of agile methodologies has allowed project teams to quickly adapt and iterate on smart grid designs to better suit the unique challenges faced by African nations. This includes tailoring solutions to remote, off-grid communities, as well as accommodating varying levels of existing infrastructure and technological familiarity among end-users (28). The collaborative nature of agile practices has also facilitated close engagement with local stakeholders, ensuring the co-creation of smart grid initiatives that are responsive to community needs and constraints.

Through this iterative, user-centric approach, African smart grid projects have been able to overcome barriers to technology adoption and produce more impactful, sustainable solutions better integrated into the local context (29). The agility and flexibility inherent in these methodologies have been crucial for navigating the complexities of smart grid deployment across the diverse markets and landscapes of the African continent.

By contrast, in the United States, the smart grid transformation has been characterized by a more comprehensive and coordinated effort, often spearheaded by large utility companies and government initiatives (1). For example, Pacific Gas and Electric (PG&E) has leveraged agile project management to enhance the integration of smart technologies into the grid infrastructure, enabling more efficient data collection, analysis, and decision-making (30). Southern California Edison's Smart Grid Project has also embraced agile practices to facilitate the smooth integration of renewable energy sources, optimizing communication between the utility and customer/resource providers during the interconnection process. This has enabled the optimization of solar energy production control (31). PECO's Smart Grid Project has similarly utilized agile methods to streamline the rollout of advanced metering infrastructure and grid automation technologies, offering improved visibility and control for both utility and customer (32) (33) (34). Similarly, the smart grid projects in Austin, Texas, and Ontario, Canada, have demonstrated the benefits of agile approaches in streamlining coordination among multiple stakeholders, including utility providers, IT systems, and end-users (30).

In these North American contexts, agile practices have facilitated the seamless integration of smart grid components, optimization of existing infrastructure, and responsive adaptation to evolving customer needs and regulatory requirements. This coordinated approach has enabled utilities in the U.S. to leverage agile methodologies to rapidly test and deploy smart grid solutions at scale while maintaining alignment with national energy policies and regulations. The agile mindset has helped these large-scale projects remain nimble and responsive, despite the inherent complexity of modernizing the power grid across the vast and diverse American landscape.

Despite regional differences, the commonalities in the application of agile principles, such as the emphasis on collaboration, iterative development, and continuous improvement, have emerged as key factors in the successful implementation of smart grid initiatives in both Africa and the United States (7) (1) (2) (3). While African projects benefit from agility in adapting to diverse and often underdeveloped infrastructure, U.S. initiatives demonstrate the advantages of integrating agile practices into large-scale, technologically advanced frameworks.

As the global energy landscape continues to evolve, the insights gleaned from this comparative analysis of agile project management in smart grid design can inform best practices, foster cross-regional knowledge sharing, and contribute to the development of more resilient, sustainable, and user-centric power systems (7) (1). By examining the successes and challenges in both regions, stakeholders can leverage agile methodologies to optimize smart grid implementations worldwide.

4.5. Innovations and Future Trends in Agile Practices in Smart Grid Design

Looking ahead, the adoption of agile project management in smart grid design is poised to evolve and embrace new innovations that will further enhance the adaptability, responsiveness, and effectiveness of these critical infrastructure projects.

4.5.1. Integration with Emerging Technologies

The convergence of agile with data analytics and artificial intelligence is opening up new frontiers in smart grid management. Agile's iterative nature aligns well with the experimental and data-driven approaches often employed in AI and machine learning projects (35) (36) (37). By adopting agile principles, smart grid operators can accelerate the development and deployment of AI-powered solutions for grid optimization, predictive maintenance, and demand response programs. This integration of agile and AI has the potential to unlock significant efficiency gains and enhance the reliability of smart grids.

4.5.2. Open Innovation and Co-Creation

Moreover, the convergence of agile practices with the principles of open innovation and co-creation can further strengthen stakeholder engagement and foster the development of more inclusive, community-driven smart grid solutions (2). By involving a diverse range of stakeholders, including utility providers, consumers, and technology developers, agile methodologies can facilitate the co-creation of solutions that are tailored to meet the specific needs of different communities.

4.5.3. Cybersecurity Integration

As smart grids become more reliant on data exchange and remote monitoring, ensuring robust cybersecurity is paramount. Agile methodologies, with their emphasis on iterative development and continuous testing, can be instrumental in building secure smart grid systems from the ground up (38) (39). By incorporating security considerations into each sprint and leveraging automated security testing tools, agile teams can proactively identify and mitigate vulnerabilities, enhancing the overall resilience of the grid.

4.5.4. Scaling Agile for Large-Scale Deployments

Another crucial aspect of future agile adoption in smart grids lies in scaling agile methodologies to accommodate the complexity of large-scale deployments. While agile has proven effective in smaller, contained projects, adapting its principles to projects involving numerous stakeholders, diverse technologies, and geographically dispersed teams requires careful planning and execution. Frameworks like Scaled Agile Framework (SAFe) and Large-Scale Scrum (LeSS) offer guidance on scaling agile practices without compromising on its core values of collaboration, flexibility, and continuous improvement (40) (41) (42).

Overall, the future of agile in the smart grid sector is bright, characterized by continuous innovation and adaptation. By embracing emerging trends such as integrating agile with cybersecurity, leveraging AI and data analytics, and effectively scaling agile for large-scale deployments, the smart grid industry can harness the full potential of agile methodologies to build more resilient, efficient, and future-proof power systems. The ongoing evolution of agile practices will play a crucial role in addressing the challenges and opportunities of modernizing the global energy infrastructure.

5. Challenges and Opportunities for Agile Adoption in Smart Grid Projects

While the adoption of agile project management has demonstrated numerous benefits in the development and deployment of smart grid technologies, there are also several challenges and considerations that must be addressed.

5.1. Challenges

- Complexity of Smart Grid Systems: The inherent complexity of smart grid systems, which often involve the integration of multiple technologies, stakeholders, and regulatory frameworks, is a primary challenge (23). The scale and interdependencies of these systems can make it difficult to implement agile practices, which prioritize flexibility and rapid iteration. Coordinating the various components and ensuring they work seamlessly together requires meticulous planning and robust management.
- Long-term Nature and Security Requirements: Smart grid investments are typically long-term and require robust security measures. The agile mindset, which favors rapid deployment over extensive planning and risk

mitigation, can sometimes conflict with the need for comprehensive security and reliability (32). Balancing agile approaches with the rigorous demands of critical infrastructure security is essential but challenging.
- Cultural and Organizational Shifts: Traditional utility and energy companies often operate with rigid, waterfall-based project management approaches. Transitioning to an agile mindset requires significant change management and capacity-building efforts. Overcoming resistance to change and fostering an environment that embraces flexibility and continuous improvement can be difficult and time-consuming.

5.2. Opportunities

- Rapid Prototyping and Testing: Agile practices facilitate the rapid prototyping and testing of new technologies, allowing utilities and grid operators to quickly adapt to evolving customer needs, regulatory changes, and technological advancements. This rapid iteration enables the continuous refinement and optimization of smart grid solutions.
- Cross-functional Collaboration: The emphasis on cross-functional collaboration and continuous feedback can foster greater stakeholder engagement and alignment. This holistic approach ensures that smart grid solutions are user-centric and address the needs and constraints of all stakeholders, from utility providers to end-users (7) (2).
- Incremental Implementation and Risk Mitigation: The agile approach allows for incremental implementation, reducing the risks associated with large-scale smart grid deployment. This method enables project teams to pivot or course-correct as needed, ensuring that projects remain on track and can adapt to unforeseen challenges.
- Enhanced Flexibility and Responsiveness: As the energy landscape continues to transform, the flexibility and responsiveness inherent in agile methodologies can be a crucial asset. Agile practices enable utilities to navigate the complexities of smart grid design and deployment more effectively, ensuring that systems remain adaptable and resilient.

6. Conclusion and Recommendations

The integration of agile project management principles within the smart grid domain presents both challenges and opportunities for utilities, grid operators, and technology providers. While the inherent complexity of smart grid systems and the need for robust security and reliability measures can pose barriers to the adoption of agile practices, the benefits of increased flexibility, rapid prototyping, and stakeholder engagement are compelling.

To effectively harness the potential of agile in smart grid design, stakeholders should consider the following recommendations:

- Explore Hybrid Approaches: Blend agile practices with traditional project management methods to balance the need for long-term planning, security, and reliability with the benefits of rapid iteration and adaptation. A hybrid approach can leverage the strengths of both methodologies to achieve optimal outcomes.
- Foster a Culture of Collaboration and Continuous Improvement: Invest in change management initiatives and capacity-building to promote an agile mindset among project teams and organizational leadership. Encourage a culture that values collaboration, transparency, and continuous improvement.
- Leverage Emerging Technologies: Integrate agile with data analytics, artificial intelligence, and other enabling technologies to enhance decision-making, grid optimization, and predictive maintenance capabilities. These technologies can provide valuable insights and facilitate more informed, data-driven project management.
- Scale Agile Methodologies Effectively: Adopt frameworks and practices that support the scaling of agile approaches to accommodate the complexity and scope of large-scale smart grid deployments. Scaled Agile Framework (SAFe) and Large-Scale Scrum (LeSS) offer valuable guidance for managing large, multifaceted projects.
- Invest in Training and Capacity Building: The United States has a more established pool of Agile-trained professionals, whereas Africa may require significant investment in training and capacity building to effectively implement agile methodologies in smart grid projects.

By addressing the challenges and capitalizing on the opportunities presented by agile project management, the smart grid industry can unlock new levels of efficiency, resilience, and innovation, ultimately paving the way for a more sustainable and future-proof energy landscape.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

References

[1] Agüero JR, Takayesu E, Novosel D, Masiello R. Grid modernization: challenges and opportunities. Elsevier BV. 2017 May;30(4):1–6.

[2] Taouil K, Jellad T, Chtourou Z. Community-coupled microgrids for the implementation of a smart grid in Tunisia. Inderscience Publ. 2014 Jan;10(3/4):183–183.

[3] Husain T, Kamruzzaman K. Priority areas for Bangladesh: Roadmap to 2041 as Developed Country. 2020 Dec;277–80.

[4] Azanha A, Argoud ARTT, Camargo JB de, Antoniolli PD. Agile project management with Scrum. Emerald Publ Ltd. 2017 Jan;10(1):121–42.

[5] Alsaigh R, Mehmood R, Katib I. AI explainability and governance in smart energy systems: A review [Internet]. Vol. 11, Frontiers Media. 2023. Available from: https://doi.org/10.3389/fenrg.2023.1071291

[6] Farooq S, Zahoor W ul. Smart grid-energizing towards a greener future. 2015 Jun; Available from: https://doi.org/10.1109/pgsret.2015.7312184

[7] Jahn C, Weigell J, Borremans A, Lepekhin A. Smart Grid – the concept, trends and stakeholders' analysis. 2019 Jan; Available from: https://doi.org/10.2991/icdtli-19.2019.88

[8] Le TN, Chin WL, Truong DK, Nguyen TH. Advanced Metering Infrastructure Based on Smart Meters in Smart Grid [Internet]. 2016. Available from: https://doi.org/10.5772/63631

[9] Ghasemi A, Shojaeighadikolaei A, Hashemi M. Combating Uncertainties in Wind and Distributed PV Energy Sources Using Integrated Reinforcement Learning and Time-Series Forecasting [Internet]. Cornell University. 2023. Available from: https://arxiv.org/abs/2302.14094

[10] Tailor R, Čonka Z, Kolcun M, Beňa Ľ. Design of Management Systems for Smart Grid. 2021.

[11] Sahin D, Güngör VÇ, Hancke GP, Hancke GP. Wireless sensor networks for smart grid: research challenges and potential applications [Internet]. Cambridge University Press. 2012. p. 265–78. Available from: https://doi.org/10.1017/cbo9781139013468.012

[12] Thilakarathne NN, Kagita MK, Lanka S, Ahmad H. Smart Grid: A Survey of Architectural Elements, Machine Learning and Deep Learning Applications and Future Directions [Internet]. Cornell University. 2020. Available from: https://arxiv.org/abs/2010.08094

[13] Islam S, Zografopoulos I, Hossain MT, Badsha S, Konstantinou C. A Resource Allocation Scheme for Energy Demand Management in 6G-enabled Smart Grid. 2023 Jan; Available from: https://doi.org/10.1109/isgt51731.2023.10066396

[14] Dybå T, Dingsøyr T. Agile Project Management: From Self-Managing Teams to Large-Scale Development. 2015 May; Available from: https://doi.org/10.1109/icse.2015.299

[15] Alami A, Krancher O, Paasivaara M. The journey to technical excellence in agile software development. Elsevier BV. 2022 Oct;150:106959–106959.

[16] Zayat W, Şenvar Ö. Framework Study for Agile Software Development Via Scrum and Kanban. World Sci [Internet]. 2020 Jun;17(04). Available from: https://doi.org/10.1142/s0219877020300025

[17] Koi-Akrofi GY, Koi-Akrofi J, Matey HA. Understanding the Characteristics, Benefits and Challenges of Agile it Project Management: A Literature Based Perspective. 2019 Sep;10(5):25–44.

[18] Raunak MS, Binkley D. Agile and other trends in software engineering. 2017 Sep; Available from: https://doi.org/10.1109/stc.2017.8234457

[19] Ebirim W, Montero DJP, Ani EC, Ninduwezuor-Ehiobu N, Usman FO, Olu-lawal KA. THE ROLE OF AGILE PROJECT MANAGEMENT IN\nDRIVING INNOVATION IN ENERGY-EFFICIENT HVAC\nSOLUTIONS. 2024.

[20] Waheed MA, Muhammed S, Sherjeel I, Muhammed AA, Adnan K. A Review of Popular Agile Software Development Technologies [Internet]. Vol. 08, OMICS Publishing Group. 2018. Available from: https://doi.org/10.4172/2165-7866.1000245

[21] Lassenius C, Dingsøyr T, Paasivaara M. Agile Processes in Software Engineering and Extreme Programming [Internet]. Springer Science+Business Media. 2015. Available from: https://doi.org/10.1007/978-3-319-18612-2

[22] Yadav RP, Mittal ML, Jain R. Lean practices in software development projects: A literature review. Am Inst Phys [Internet]. 2019 Jan; Available from: https://doi.org/10.1063/1.5123966

[23] Allahvirdizadeh Y, Moghaddam MP, Shayanfar H. A survey on cloud computing in energy management of the smart grids. Wiley [Internet]. 2019 Jul;29(10). Available from: https://doi.org/10.1002/2050-7038.12094

[24] Ugwoke B, Adeleke A, Corgnati SP, Pearce JM, Leone P. Decentralized Renewable Hybrid Mini-Grids for Rural Communities: Culmination of the IREP Framework and Scale up to Urban Communities. Multidiscip Digit Publ Inst. 2020 Sep;12(18):7411–7411.

[25] Salihu TY, Akorede MF, Abdulkarim A, Abdullateef AI. Off-grid photovoltaic microgrid development for rural electrification in Nigeria. Elsevier BV. 2020 Jun;33(5):106765–106765.

[26] Onwunta OEK, Kahn MTE. Smart Grid Concept and Developments: The Relevance to South Africa. 2014.

[27] Alotaibi IM, Abido MA, Khalid M, Savkin AV. A Comprehensive Review of Recent Advances in Smart Grids: A Sustainable Future with Renewable Energy Resources. Multidiscip Digit Publ Inst. 2020 Nov;13(23):6269–6269.

[28] Ezekwugo JU, Ibe A, Nteegah A. Optimization of Integrated Energy Systems in a Developing Economy using Technology. 2022 Jan;14(1):1–11.

[29] Kabuya KI, Ajayi O, Bagula AB. Smart Cities and Villages: Concept Review and Implementation Perspectives in Developing Cities [Internet]. Cornell University. 2024. Available from: https://arxiv.org/abs/2402.09284

[30] King C, Strapp J. Software Infrastructure and the Smart Grid [Internet]. Elsevier BV. 2012. p. 259–88. Available from: https://doi.org/10.1016/b978-0-12-386452-9.00011-5

[31] Energy.gov [Internet]. [cited 2024 Jul 26]. PROJECT PROFILE: Southern California Edison (ENERGISE). Available from: https://www.energy.gov/eere/solar/project-profile-southern-california-edison-energise

[32] Momoh JA. The Smart Grid: An Introduction [Internet]. 2018. p. 351–66. Available from: https://doi.org/10.1002/9781119521129.ch15

[33] Amaral HLM do, Souza AN de, Gastaldello DS, Fernandes F, Vale Z. Smart meters as a tool for energy efficiency. 2014 Dec; Available from: https://doi.org/10.1109/induscon.2014.7059413

[34] Pritchard G. Reading Deeper. IEEE Power Energy Mag. 2010 Nov;8(6):85–7.

[35] Massaoudi M, Refaat SS, Abu-Rub H. On the Pivotal Role of Artificial Intelligence Toward the Evolution of Smart Grids [Internet]. 2021. p. 359–420. Available from: https://doi.org/10.1002/9781119422464.ch15

[36] Azad S, Sabrina F, Wasimi SA. Transformation of Smart Grid using Machine Learning. 2019 Nov; Available from: https://doi.org/10.1109/aupec48547.2019.211809

[37] Xie L, Huang T, Zheng X, Liu Y, Wang M, Vittal V, et al. Energy system digitization in the era of AI: A three-layered approach toward carbon neutrality. Elsevier BV. 2022 Dec;3(12):100640–100640.

[38] Selga JM, Corral G, Zaballos A, Pozuelo RM de. Smart Grid ICT Research Lines out of the European Project INTEGRIS. 2014 Jun;6(2):93–93.

[39] Anzalchi A, Sarwat AI. A survey on security assessment of metering infrastructure in Smart Grid systems. 2015 Apr; Available from: https://doi.org/10.1109/secon.2015.7132989

[40] Kaur K, Jajoo A, Manisha. Applying Agile Methodologies in Industry Projects: Benefits and Challenges. 2015 Feb; Available from: https://doi.org/10.1109/iccubea.2015.166

[41] Uludağ Ö, Philipp P, Putta A, Paasivaara M, Lassenius C, Matthes F. Revealing the state of the art of large-scale agile development research: A systematic mapping study. Elsevier BV. 2022 Dec;194:111473–111473.

[42] Adewale Wasiu Adegboyega, Emmanuel Chigozie Ani, Stephen Opeyemi Oladunni, Abrar Shahriar Pramanik. Project management tools in renewable energy integration: A review of U.S. perspectives. Eng Sci Technol J. 2024 Jul 28;5(7):2364–78. Available from: https://doi.org/10.51594/estj.v5i7.1359