

# Smart Grid Applications and Blockchain Technology in the AI Era

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**Abstract:** The integration of Smart Grid Applications and Blockchain Technology has emerged as a potential solution to enhance energy management's efficiency, security, and transparency in the energy industry. Smart Grid Applications utilize advanced technologies to optimize the generation, distribution, and consumption of electricity, while Blockchain Technology offers a decentralized and distributed ledger system that can facilitate secure and transparent transactions. This review paper analyses the existing literature on Smart Grid Applications and Blockchain Technology to identify the potential benefits and challenges associated with their integration in the energy industry. The key benefits of this integration include the ability to facilitate secure and transparent transactions, enable peer-to-peer energy trading, and support the integration of various Distributed Energy Resources (DERs) into the grid. However, challenges associated with the lack of standardization, interoperability issues, and scalability concerns associated with blockchain technology need to be addressed. The successful implementation of Smart Grid Applications and Blockchain Technology in the energy industry will require collaboration between industry stakeholders, regulators, policymakers, and standard-setting organizations. Future research is needed to explore the potential of these technologies in addressing specific energy management challenges. The findings of this review suggest that integrating Smart Grid Applications and Blockchain Technology can transform the energy industry and create new opportunities for innovation.

**Keywords:** Smart Grid, Blockchain Technology, Decentralization, Distributed Energy Resources (DERs), Energy Trading.

## 1. Introduction

Integrating Smart Grid Applications and Blockchain Technologies can revolutionize the energy industry by providing a more efficient, secure, and transparent platform for energy management, especially in the artificial Intelligence (AI) era. AI can significantly support this type of application, given the technological advances we are experiencing nowadays and the AI learning facilitators [1]. The Smart Grid integrates various Distributed Energy Resources (DERs), including renewable energy sources, energy storage systems, and electric vehicles, into the grid. On the other hand, Blockchain technology offers a decentralized and distributed ledger system that can facilitate secure and transparent transactions without intermediaries. By combining these technologies, energy trading and management can be more streamlined and automated, allowing for peer-to-peer (P2P) energy trading, smart contracts, and grid management.

Additionally, using blockchain technology in the energy industry can help enhance cybersecurity and ensure interoperability between various systems and technologies. The growing energy demand, the increasing adoption of renewable energy sources, and the need for efficient energy management have led to significant changes in the energy industry. Smart Grid Applications and Blockchain Technology are emerging as potential solutions to enhance energy management's efficiency, security, and transparency.

Smart Grid Applications utilize advanced technologies such as sensors, communication networks, and data analytics to optimize electricity generation, distribution, and consumption. Integrating Smart Grid Applications can improve the reliability and resiliency of the energy grid and enable more efficient management of energy resources.

Blockchain Technology, on the other hand, offers a decentralized and distributed ledger system that can enhance the security and transparency of energy transactions. Using blockchain technology in the energy industry can facilitate secure and transparent transactions, enable peer-to-peer (P2P) energy trading, and support the integration of various Distributed Energy Resources (DERs) into the grid. The integration of Smart Grid Applications and Blockchain Technology has the potential to transform the energy industry and create new opportunities for innovation. However, implementing these technologies in the energy industry faces several challenges that must be addressed. These challenges include the lack of standardization, interoperability issues, and scalability concerns associated with blockchain technology. Furthermore, regulatory and policy frameworks need to be developed to support the implementation of these technologies in the energy industry. In this review paper, we aim to analyze the existing literature on Smart Grid Applications and Blockchain Technology to identify the potential benefits and challenges associated with their integration in the energy industry. We discuss the key benefits, including secure and transparent transactions, P2P energy trading, and support for DERs, and identify the challenges that need to be addressed to ensure the successful implementation of these technologies. Finally, we provide recommendations for future research and policy development to support the integration of Smart Grid Applications and Blockchain Technology in the energy industry.

## **2. Amount of Previously Published Work**

The topic of Smart Grid Applications and Blockchain Technology has gained increasing attention in recent years, with a growing number of research papers, articles, and reports published on the subject. A search on academic databases, such as IEEE Xplore, Google Scholar, and ScienceDirect, reveals a significant body of work on the topic. These studies explore the potential benefits and challenges associated with the integration of Smart Grid Applications and Blockchain Technology, and investigate various use cases of blockchain technology in the energy industry, including P2P energy trading, smart contracts, and grid management. Moreover, several research studies have focused on addressing the cybersecurity and interoperability concerns associated with the integration of these technologies. Overall, the significant amount of previously published work on Smart Grid Applications and Blockchain Technology highlights the growing interest in these technologies and their potential to transform the energy industry.

## **3. Applications for Smart Grids and Blockchain Technology**

In this review paper, we searched academic databases, including IEEE Xplore, Google Scholar, and ScienceDirect, using the keywords "Smart Grid Applications" and "Blockchain Technology." The search was conducted in May 2023, and we included studies published between 2018 and 2023. We excluded studies that were not written in English or were not available in full text.

We analyzed the selected studies to identify the potential benefits and challenges associated with the integration of Smart Grid Applications and Blockchain Technology, as well as the various use cases of blockchain technology in the energy industry. We also examined the cybersecurity and interoperability concerns associated with the integration of these technologies. The studies were analyzed and synthesized to provide an overview of the current

state of research on the topic and to highlight the key considerations for successful implementation of Smart Grid Applications and Blockchain Technology in the energy industry. The quality of the selected studies was evaluated based on their relevance to the research questions, methodology, and data analysis. We used a narrative synthesis approach to analyze and synthesize the findings of the selected studies. The results of the analysis were presented in the form of a narrative review, which provides a comprehensive overview of the current state of research on Smart Grid Applications and Blockchain Technology.

#### **4. Discussion**

The results of our review indicate that Smart Grid Applications and Blockchain Technology offer significant potential for transforming the energy industry by enhancing the efficiency, security, and transparency of energy management. The key benefits associated with the integration of these technologies include the ability to facilitate secure and transparent transactions, enable P2P energy trading, and support the integration of various Distributed Energy Resources (DERs) into the grid. However, the implementation of Smart Grid Applications and Blockchain Technology in the energy industry faces several challenges that need to be addressed. The lack of standardization and interoperability issues between different blockchain platforms are significant challenges that need to be addressed. Additionally, the scalability concerns associated with blockchain technology may limit its adoption in large-scale energy systems. Furthermore, the regulatory and policy frameworks need to be developed to support the implementation of these technologies in the energy industry. Addressing these challenges will require collaboration between industry stakeholders, regulators, policymakers, and standard-setting organizations. Furthermore, there is a need for further research to explore the potential of these technologies in addressing specific energy management challenges, such as demand response and energy storage.

Overall, integrating Smart Grid Applications and Blockchain Technology can transform the energy industry by improving efficiency, security, and transparency. However, successful implementation will require addressing the challenges identified in this review, developing supportive regulatory and policy frameworks, and further exploring the potential of these technologies in addressing specific energy management challenges. The potential benefits of integrating Smart Grid Applications and Blockchain Technology in the energy industry have been widely recognized in previous studies, and our review confirms this trend. In particular, the secure and transparent transactions enabled by blockchain technology and the P2P energy trading enabled by smart grid applications have been highlighted as significant benefits. Additionally, integrating DERs into the grid is seen as an important way to improve energy management efficiency. However, the challenges associated with the implementation of these technologies cannot be ignored. Standardization and interoperability issues between different blockchain platforms and scalability concerns have been identified as the main challenges that need to be addressed. Furthermore, the regulatory and policy frameworks need to be developed to support the implementation of these technologies in the energy industry.

To overcome these challenges, industry stakeholders, regulators, policymakers, and standard-setting organizations must collaborate to develop solutions. Further research is also needed to explore the potential of these technologies in addressing specific energy management challenges, such as demand response and energy storage. Overall, the integration of Smart Grid Applications and Blockchain Technology has the potential to transform the energy industry by improving efficiency, security, and transparency. However, successful implementation will require addressing the challenges identified in this review, developing supportive regulatory and policy frameworks, and further exploring the potential of these technologies in addressing specific energy management challenges [17]-[18].

## **5. Results**

Our literature review identified a significant body of work on the potential benefits and challenges associated with integrating Smart Grid Applications and Blockchain Technology. The studies analyzed in this review highlight the potential of these technologies to transform the energy industry by enhancing energy management's efficiency, security, and transparency. The key benefits associated with integrating Smart Grid Applications and Blockchain Technology include facilitating secure and transparent transactions, enabling P2P energy trading, and supporting integrating various Distributed Energy Resources (DERs) into the grid. Moreover, blockchain technology offers a decentralized and distributed ledger system that can enhance the cybersecurity of the energy grid. However, several challenges need to be addressed to ensure the successful implementation of these technologies in the energy industry. These challenges include the lack of standardization, interoperability issues, and the need to address the scalability concerns associated with blockchain technology. Additionally, the regulatory and policy frameworks need to be developed to support the implementation of Smart Grid Applications and Blockchain Technology in the energy industry. Overall, the studies analyzed in this review demonstrate the potential of Smart Grid Applications and Blockchain Technology to transform the energy industry. However, successful implementation will require addressing the challenges identified in this review and developing a supportive regulatory and policy framework.

Recent studies have also demonstrated the potential of Smart Grid Applications and Blockchain Technology to support the transition to renewable energy sources. By facilitating P2P energy trading and enabling the integration of renewable energy sources into the grid, these technologies can reduce the reliance on traditional energy sources and support the growth of renewable energy markets. Furthermore, the use of blockchain technology can enable the development of new business models, such as virtual power plants and energy communities, which can enhance the efficiency and resilience of the energy system. Another significant challenge that needs to be addressed is the energy consumption associated with blockchain technology. The energy-intensive process of verifying and adding new transactions to the blockchain has raised concerns about the environmental impact of blockchain-based energy systems. Nevertheless, recent research has proposed several approaches to address this issue, such as using renewable energy sources for mining and developing more energy-efficient consensus algorithms. Overall, the integration of Smart Grid Applications and Blockchain Technology has the potential to revolutionize the energy industry by enhancing the efficiency, security, and transparency of energy management, supporting the transition to renewable energy sources, and enabling the development of new business models. However, the successful implementation of these technologies requires addressing the identified challenges and developing a supportive regulatory and policy framework.

## **6. Conclusion**

In conclusion, our review of the literature indicates that the integration of Smart Grid Applications and Blockchain Technology offers significant potential for transforming the energy industry by enhancing the efficiency, security, and transparency of energy management. The key benefits associated with the integration of these technologies include the ability to facilitate secure and transparent transactions, enable P2P energy trading, and support the integration of various Distributed Energy Resources (DERs) into the grid. However, the implementation of Smart Grid Applications and Blockchain Technology in the energy industry faces several challenges that need to be addressed. These challenges include the lack of standardization, interoperability issues, and scalability concerns associated with blockchain technology. Addressing these challenges will require collaboration between industry stakeholders, regulators, policymakers, and standard-setting organizations. Overall, the

integration of Smart Grid Applications and Blockchain Technology has the potential to transform the energy industry and create new opportunities for innovation. However, successful implementation will require addressing the challenges identified in this review and developing a supportive regulatory and policy framework. Further research is needed to explore the potential of these technologies in addressing specific energy management challenges.

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